TECHNICAL HANDBOOK No. 6

A FIELD GUIDE TO SOIL AND SITE DESCRIPTION IN ZIMBABWE

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A GUIDE TO SOIL AND SITE DESCRIPTION IN ZIMBABWE

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CONTENTS

1. Introduction

1.1. Preface

This guide is intended for the use of those involved in describing soils in Zimbabwe. It's main purpose is to ensure standardisation of form, content and descriptive detail by providing easy reference to class limits of standard soil properties. Also included is a certain amount of explanation to aid understanding of these properties, (what precisely is being measured and how they interrelate), and assist soil description in areas where confusion may arise. Also included, in an Appendix, are miscellaneous data to which a soil surveyor may make useful reference.

The properties and class limits described are those used by the Pedology and Soil Survey Section of the Department of Research and Specialist Services and the Planning Branch of the Department of Agricultural, Technical and Extension Services. Most have been in use for many years but a few have been recently introduced, derived from the two main international systems in use; those of the United States Department of Agriculture (USDA) and the Food and Agriculture Organization of the United Nations (FAO).

Where abbreviations are commonly used in description they have been placed in brackets after the class name.

1.2 Soil Survey Methodology

Methodology is not the subject of this publication and it is not intended to do more than state the nature of the problem for the sake of completeness.

The aim of soil survey is to map soils. Very few soil properties are to be observed at the surface of the land and to observe more, holes have to be dug. If two holes exhibit different soils then a boundary separating them can be drawn on a map. If the holes are only 50m apart the boundary, presented on a map at quite large scale, will be accurate. If the holes are 1 500m apart however, there are three options open to the surveyor; reduce the scale of the map until the distance on the map is negligible; put in more holes to ascertain precisely the position of the boundary; make use of features of vegetation and landform to interpolate the position of the boundary.

The latter, however, can only be done when the relationships between the relevant aspects of the environment have been proved.

Thus, if the situation is seen in terms of the time required to survey an area, this will depend on the soil complexity, the required map scale, the nature of environmental relationships and accessibility of the area. Some relevant figures relating to survey rates at different scales are presented in Table 3 in the Appendix (5.2). In many parts of Zimbabwe environmental relationships are well developed enabling these survey rates to be increased.

1.3. Soil and Site Description

The reason for mapping soils is, either directly or indirectly, evaluation in terms of potential land use. While it is possible, during specific purpose surveys, to describe only those properties known to relate to the intended land use, and to ignore other properties and the sum of inter-related properties which constitutes the soil, this is not generally recommended. If the cost of mounting a soil survey is justified it will usually be false economy to do less than obtain a comprehensive picture of the soils of the area. Even so soils can be described at different levels of detail and there is a balance to be struck. For most purposes it would be neither practical nor would it contribute towards an understanding of the soils, to spend many hours describing every shade of mottle, measuring every void, describing weatherable minerals with a 20x magnification lens or searching minutely for signs of clay illuviation. What is usually required is accurate description of the main soil properties.

The amount of space allocated to free text is limited on most profile description forms and free text is often important in emphasising the salient features of a soil. A sketch of the profile is also often instructive and standard symbols can be devised to indicate different features. The reverse of the profile card can be used for these purposes. If one wishes to take pictorial representation a stage further a sheet of transparent plastic can be pinned across the profile and the horizon and main features marked on with a felt pen. The drawing can then be reduced to an appropriate size. A soil description should enable a qualified reader, unfamiliar with the soil, to obtain a clear picture of the profile in terms of the sequence and form of the horizons and their genetic relationships. Any device or technique which adds to the standard description and contributes towards this is acceptable. The objective of the exercise is to convey information, and soil description which leaves relevant questions unanswered has failed in its purpose.

Soil is only one attribute of land affecting its evaluation. Others are climate and landform, and certain characteristics of the latter must be assessed in the field as part of the site evaluation. Vegetation should also be recorded in as much detail as possible because of its value as an indicator of soil and site properties. Even if botanical species cannot be identified a physiognomic classification can be given.

The land surface is usually described before the soil profile; therefore site description precedes soil description in the following text.

2. Site Description

2.1. Landform

Landform includes everything to do with the shape of the land surface, with the exception of microrelief which comes under surface features. In order to convey a true impression of landform the site, i.e. the area within a radius of 30m of the soil pit, must be described within the context of the geography of the surrounding area. The latter can be described from field and air photographic observations in terms of landform type and shape. The site can be described according to its position within the landform type.

Landform type		*Definition*
Interfluve	:	Area of low relief between drainage lines
Plain	:	Generally flat surface
Plateau	:	Elevated generally flat surface bounded on at least one side by an escarpment.
Hill	:	Elevated area of limited extent.
Mountain	:	More elevated and steeper than hill.
Range of hills	:	
Range of mountains	:	
Ridge	:	Elongated hill
Escarpment	:	Abrupt descent at edge of plateau.
Pediment	:	Planar sloping footslope to higher ground
Alluvial (colluvial) fan	:	Outwash deposit.
Floodplain	:	Area of active alluvial deposition

Terrace	:	Older floodplain – not active.
Valley bottom	:	Low lying area associated with drainage line.
Depression	:	Local run-off receiving area without outlet.

Landform types may be simple or compound, e.g. a plain may consist of a succession of interfluves and valley bottoms with occasional depressions i.e. an interfluve plain with depressions. Identification of landform type is subjective in many cases, and in some, is connotative of landscape processess. It should therefore be treated with caution, particularly when carried out by an inexperienced observer. Where the observer is in doubt landform type may be disregarded and landform shape alone recorded.

Landform Shape		*Definition*	
Flat or almost flat	:	Slopes	< 2%
Gently undulating	:	Steepest slopes	2–5%
Undulating	:	Steepest slopes	5–8%
Rolling	:	Steepest slopes	8–12%
Hilly	:	Steepest slopes with moderate elevation	12–30%
Steeply dissected	:	Steepest slopes with moderate elevation	> 30%
Mountainous	:	Steepest slopes with great range of elevation	> 30%

The first four classes above correspond to the slope limits for irrigability classes A to D according to the system used in Zimbabwe (Appendix 5.12).

Other landform descriptors which may be used are drainage pattern and dimensions of the landform type.

Site positions are usually concave, convex, planar or irregular; upper, mid, lower or footslopes; crest, edge, middle, etc. as appropriate. The site aspect may be given and the order of the stream to which the slope is graded.

Slope across the site may be classified as follows:

Flat or almost flat	:	0–2%
Gently sloping	:	2–5%

Sloping	:	5–12%
Moderately steep	:	12–30%
Steep	:	30–55%
Very steep	:	>55%

An adequate site description would be sloping, convex mid-slope within a rolling interfluve plain; or, gently sloping, concave lower sloper on a gently undulating plateau. The former would be automatically irrigability class D, should irrigability be a consideration, while the latter would be class B, soil conditions permitting.

2.2 Vegetation

Vegetation can be described in physiognomic (structural appearance) or floristic (species composition) terms, or both. Most soil surveyors will have some knowledge of species, but probably not enough to always carry out a full floristic description. Also many surveys are carried out during the time of year when identification of many species is particularly difficult. Physiognomic description however can always be applied to any natural vegetation. The following system is a simplified form of that devised for the International Biological Programme in Zimbabwe by Boulton and Woodall.

Forest : Crowns and peripheries overlap allowing very little sunlight to penetrate. Trees taller than 5m with several layers. Little grass cover.

Can be subdivided into evergreen and deciduous.

Thicket : Crowns and peripheries touch or overlap allowing little sunlight to penetrate. Plants generally under 5m with occasional taller trees. Tangled and impenetrable.

Can be subdivided into unlayered, having only shrubs, and layered, containing occasional larger trees.

Woodland : Crowns or peripheries separated by 1 to 10 metres, forming a definite canopy but allowing some direct sun and diffused light to penetrate. Light grass cover.

The term "woodland" can be prefixed by the following:

Tree	:	taller than 5m.
Tall shrub	:	from 3 to 5m.
Medium shrub	:	from 0,5 to 3m.
Dwarf shrub	:	under 0,5m.

Open woodland : Crowns and peripheries separated by 10 to 100 metres. A canopy is formed only where there are clumps of trees or shrubs. Grass is the most important lower layer, but is always visually subordinate to the woody vegetation.

The term "open woodland" can be prefixed as for "woodland."

Wooded grassland : Composed mainly of grass with scattered trees and shrubs, sometimes in clumps. Crowns are often more than 100 metres apart.

Wooded grassland can similarly be described as being with trees, tall shrubs, medium shrubs, or dwarf shrubs.

Grassland : Dominated by grasses with occasional sedges and herbs. No woody plants taller than the grass.

Can be further described as dense or sparse and long or short.

Semi-desert : Plants so widely scattered that the landscape is dominated by the surface of the ground and not the vegetation. The nature of any plants can be described.

Marsh : Land either permanently or periodically wet, dominated by grass or grass-like vegetation.

Pictorial profiles of the vegetation formations, and a list of vegetation indicator species in relation to soils, are presented in Appendices 5.5. and 5.6.

In a cultivated area the nature of the cultivation should be given.

2.3 Surface Features

Any significant surface features within the site area should be noted. Many are associated with microrelief differences and their properties can be described in the following terms. The use of free text rather than fixed classes is preferable for true description of many such features.

Rock outcrops	:	Lithology, orientation, dimensions, frequency
Boulders, stones, gravel	:	Lithology, shape, dimensions, frequency
Termite mounds	:	Colour. texture, dimensions, frequency
Gilgai	:	Dimensions
Cracks	:	Width, distance apart, pattern
Crust formation	:	Extent of development
Sheet wash	:	Extent of development in terms of root exposure, sediment accumulation upslope of obstacles, pedestal formation, sedimentation in micro-depressions.
Rills	:	Dimensions and frequency
Gulleys	:	Dimensions and frequency
Efflorescences	:	Type and extent
Bare surface	:	Any characteristics
Sink holes	:	Dimensions and frequency
Faunal activity	:	Dimensions and frequency of holes and casts
Human activity	:	Dimensions of furrows, ridges, etc.

3. Soil Description

3.1. Introduction

Whereas representative descriptions of soil types are made in vertical section in a pit, the soil types are defined in general terms, and their areal extent determined, on the basis of descriptions of cylindrical cores of a column of soil extracted by augering from the surface. Auger description, considered here, is briefer than pit description with which the following text is mostly concerned, because the number of soil properties which can be described in an auger sample is limited, due to the physical disruption caused by the augering. In a moist soil of low bulk density disruption may not be great, but in a hard, compact, dry soil considerable force is required to penetrate and extract the soil, which may be ground to powder in the process. Because of the disturbance only general observations of structure, consistence, mottling, permeability and drainage can be made. It is more important to identify accurately horizon depths, colours, textures, stone content (where extractable), or depth to compaction, poor drainage conditions, stone, weathering rock or a calcareous layer.

Some surface soils are too hard and dry or loose, to auger, but entry into the subsoil may be aided by digging a shallow pit and augering at the base. Other stratagems to aid augering are pouring water down the auger hole, or compacting the loose, powdered soil within the auger head of a bucket-type auger so that it may be extracted from the hole without losing the contents.

Care is needed in estimating horizon depths. Depths of features such as stone can, of course, be measured in the auger hole, but soil horizon changes are usually assessed from the entire soil column laid out on the ground. It is usual then to ascribe fixed depths to the contents of each auger, but this may be erroneous. A loose and moist, or wet soil may compact within the auger head extracting a much greater depth than in a hard and compact soil which the auger has to grind up. The surveyor should also watch for slumping and infilling of the hole in loose or wet soils.

Some care is also necessary when making inferences about the effective depth of stony soils. Augers will not penetrate stony material, unless the stone is quiet small, and a single large stone will stop an auger. On many occasions pit inspection of areas provisionally mapped as shallow or stony phase has shown the stone content to be negligible.

3.2. Horizons

Little attention is paid to the nomenclature of horizonation in Zimbabwe because of generally poor horizon differentiation, and because the Zimbabwe classification system takes no account of diagnostic horizons. We are being asked increasingly to relate our soils to the FAO and USDA systems, however, so the internationally accepted system of master horizon definitions and qualifying suffixes is included in abbreviated form.

Master horizons

H : At least 20 percent organic matter in a mostly water saturated surface organic layer.

O : At least 35 percent organic matter in a well drained surface organic layer.

A : A surface mineral horizon containing humified organic matter.

E : A mineral horizon showing concentration of sand and silt due to loss of silicate clay, iron or aluminium. Connotes eluviation.

B : A mineral horizon with soil structure, forming beneath the above horizons, often influenced by illuvial concentration of clay, iron, aluminium or humus, or residual sesquioxide accumulation.

C : Unconsolidated material from which the solum is assumed to have formed.

R : Continuous coherent rock.

Transitional or intergrade horizons are permitted.

Qualifying suffixes

b : buried horizon

c : concretionary material

g : mottled

h : accumulation of organic matter

k : accumulation of calcium carbonate

m : strongly cemented

n : accumulation of sodium

p : ploughed or tilled

q : accumulation of silica

r : strongly reduced

s : sesquioxide accumulation

t : illuvial clay accumulation

w : alteration in situ

x : fragipan

y : accumulation of gypsum

z : accumulation of soluble salts

No more than two suffixes are normally used for one horizon.

3.3. *Depth*

The depth to the lower boundary of each horizon above weathering rock, or 150 cm, whichever is less, should be recorded. It is particularly important that physical constraints to root development be identified and the crop rooting depth above the constraint be noted. The constraint may be a gravel layer, soil compaction, a fluctuating water table or rock. The decision must be made in the field, subjective though it may be. It will be much more subjective made in the office several weeks later.

For descriptive purposes the following soil depths apply.

Deep	:	> 150 cm
Moderately deep	:	100–150 cm
Moderately shallow	:	50–100 cm
Shallow	:	40–50 cm
Very shallow	:	25–40 cm
Extremely shallow	:	< 25 cm

3.4. *Horizons Boundaries*

The nature of the vertical soil change between two horizons can be described in terms of the depth over which the change occurs, and the topography of the boundary, viz:

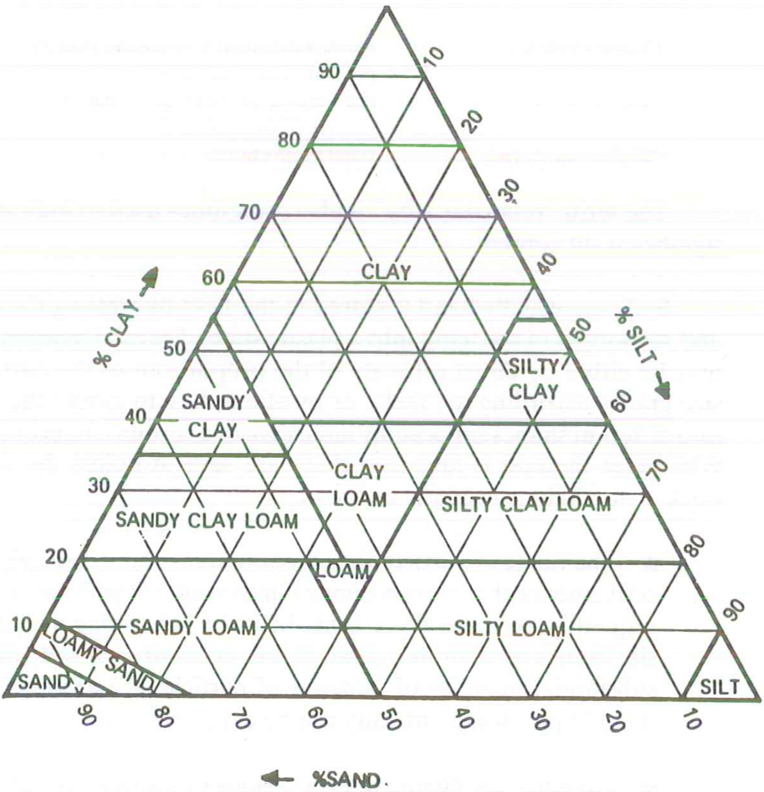
Abrupt (ab)	:	boundary <2 cm wide
Clear (cl)	:	boundary 2–5 cm wide
Gradual (gr)	:	boundary 5–12 cm wide
Diffuse (di)	:	boundary > 12 cm wide
Smooth (sm)	:	level boundary
Wavy (wa)	:	with pockets, width > depth
Irregular (ir)	:	with pockets, depth > width
Broken (br)	:	discontinuous boundary

3.5. *Texture*

The texture of a soil is an assessment of the particle size distribution of the mineral fraction having particle diameters of no greater than 2 mm (2000µm). This, known as the fine earth, is sub-divided into sand, silt and clay, with the sand further sub-divided into size classes of coarse, medium and fine. The form of sub-division varies between countries though the upper limits of coarse sand and clay size are usually constant. The separates, or particle size grades, used in Zimbabwe are:

Coarse sand	:	2,0 mm (2000 μm) – 0,5 mm (500 μm)
Medium sand	:	0,5 mm (500 μm) – 0,2 mm (200 μm)
Fine sand	:	0,2 mm (200 μm) – 0,02 mm (20 μm)
Silt	:	0,02 mm (20 μm) – 0,002 mm (2 μm)
Clay	:	< 0,002 mm (2 μm)

The relative proportions of sand, silt and clay place a soil into a particle size or textural class according to a triangular diagram. There are almost as many different triangular diagrams in use throughout the world as there are soil survey organizations, and the one in use in Zimbabwe is shown below.



For descriptive purposes all textural class names are prefixed by terms indicating the content and size of stone or coarse material, (see section on stones). The sandy classes, from sand to sandy clay, are also prefixed coarse, medium or fine according to the nature of the sand fraction.

% stone content		*Gravel (2–20 mm)*	*Stones (20–200 mm)*	*Boulders (> 200 mm)*
2–15	:	slightly gravelly (sg)	slightly stony (ss)	bouldery (b)
15–50	:	gravelly (g)	stony (s)	bouldery (b)
50–90	:	very gravelly (vg)	very stony (vs)	very bouldery (vb)

In a soil with more than 90 percent coarse material the fine earth is disregarded and the material becomes simply gravel, stones or boulders. With less than 2 percent coarse material, the latter is disregarded.

Coarse sandy (c)	:	coarse sand equal to or greater than 25 percent of the total sand.
Fine sandy (f)	:	fine sand equal to or greater than 60 percent of the total sand.
Medium sandy (m)	:	other proportions.

The term "relatively silty" is also sometimes used to indicate a significant silt content.

Soils are usually hand textured in the field by wetting the soil and working it in the hand into a plastic state. Textural assessment may be either by direct estimate of the proportions of the particle size grades according to "feel", or by attempting to mould the soil into different shapes supposedly indicative of a certain composition. Whichever method is favoured there are several points the field worker should be constantly aware of.

★ The range of particle sizes is continuous and it is simply for convenience that we sub-divide it into sand, silt and clay. Consequently, whereas there is no difficulty separating a median silt from a median fine sand, if one encounters a soil with a substantial quantity of material of particle size around 0,02 mm (20 µm) some difficulty can be expected.

★ Similarly the changing proportions of particle size grades across the triangular diagram are continuous, and whereas one may easily distinguish between a median clay loam and a median sandy clay loam, a soil located on the boundary will have intermediate properties.

The largest coarse sand grain is one hundred times larger in diameter than the smallest fine sand grain, therefore coarse sandy soils feel vastly different to fine sandy soils. A fine sand feels "heavier" than a coarse sand but a coarse sandy clay feels "heavier" than a fine sandy clay with the same content of sand and clay. This is because far fewer coarse sand grains than fine sand grains occur in a given percentage of sand. "Feel" is affected by the larger surface area of the smaller particles.

★ Clay activity can have a profound effect on the "feel" of a soil. A highly active clay fraction feels heavier, stickier and more plastic than a less active clay, which may feel light and "fluffy" due to the micro-aggregating effect of aluminium and iron oxides. This results in overtexturing (over-estimation of clay content) of some soils of the former type and under-texturing of others of the latter, where the disruptive effect of hand texturing is insufficient to overcome the micro-aggregate binding or cementing processes in these highly weathered soils.

★ Another result of such micro-aggregation is the sponge effect of prolonged and gradual uptake of water as the soil is worked in the hand over an extended period. The micro-aggregation gradually breaks down and the soil feels progressively heavier.

★ Salts present in the soil can interfere with field texturing. High carbonate levels can affect aggregation and also impart a silty feel to the soil, and high levels of exchangeable sodium can result in dispersed structures almost impermeable to added water.

★ High organic matter levels, particularly at the surface, can impart a silty feel to the soil, confusing the textural assessment.

The accuracy of field texturing is gauged by comparison with laboratory analysis. However, these data cannot always be taken at face value. Different dispersion techniques will obtain different results. Ultrasonic vibration will result in higher clay figures than mechanical stirring, and normal dispersion procedures may not always bring about complete dispersion of strongly micro-aggregated soils, resulting in low clay figures. The preparation procedure prior to analysis can also affect analysis results. Grinding the soil can fracture stones into sand, crush any but the hardest concretions of iron or calcium carbonate and increase the finer sand at the expense of coarse. What in the field appeared to be a gravelly clay may become a coarse sandy loam following over-vigorous treatment and the creation of a large amount of sand. Standardizing grinding procedures is not easy, even with some understanding of soil properties. The amount of force necessary to grind up a heavy clay will pulverize most coarse material and if that amount of force is not used clay aggregates will remain behind on the 2 mm sieve to appear as gravel on the analysis sheet for a soil in which no coarse material was noted in the field.

The parameters of particle size classes are given below.

		Clay %	*Sand %*	*Silt %*
Clay (C)	:	>40	<45	<45
Sandy clay (SaC)	:	35–55	45–65	<20
Sandy clay loam (SaCL)	:	20–35	45–80	<35
Sandy loam (SaL)	:	<20	50–88	<50
Loamy sand (LS)	:	<12	75–93	<25
Sand (S)	:	<7	>84	<16
Clay loam (CL)	:	20–40	20–45	15–40
Loam (L)	:	10–20	40–50	30–40
Silty clay (SiC)	:	40–55	<20	40–60
Silty clay loam (SiCL)	:	20–40	<40	40–80
Silty loam (SiL)	:	<20	<50	>40
Silt (Si)	:	<10	<10	>90

For comparison purposes the widely used USDA textural classification system is included in Appendix 5.7. It will be seen that both particle size grades and textural classes are different to the Zimbabwe system. This is significant when soils are being correlated with the international classification systems. In particular Zimbabwean fine sand may be American silt, making fine sandy soils loamy soils in the American system.

3.6 *Colour*

Colour is obtained from the Munsell soil colour charts, or the Japanese equivalent which conforms with Munsell but carries additional colours. Although colour notation is the same the names of colours differ, so for descriptive purposes the Munsell nomenclature has been adopted.

Soil colour varies with moisture content, and ideally, to describe soil colour, the dry and moist colours of the ped interior should be given. Unless the soil in the field appears dry, however, only a moist colour is given in practice. To do this the soil is wetted and the colour noted when visible moisture films have disappeared. The colours of other features such as surface coatings of ped faces and voids, and mottles, should be noted where they are significant.

When describing a mottled soil there is a school of thought which regards as the matrix the colour which occupies the greatest surface area. This may be convenient, as it can be difficult on occasion to identify the true matrix colour, but it is not very helpful when pedogenetic considerations are an issue, and can be misleading to someone trying to "interpret" the profile description at a later date. The matrix is either the material of which the soil was composed prior to mottling processes, or the residual material from which mobile constituents have been removed. It is usually the colour most closely related to the colour of the horizon above, unless a discontinuity is suspected. There are occasions when the matrix cannot be identified either because a wide range of different colours occurs, or the colours occur in fine and close association. Mineral weathering can produce such mottling in parent material in which a matrix has not yet developed. These soils can be described as variegated and either the main colours given or described in general terms. Alternatively the colour of a streak of moistened soil on a sheet of white paper can be noted. Incipient mottling, associated for instance with a slight drainage restriction, where colour variations are slight and diffuse, may be given a general colour.

When assessing mottling on a profile face care should be taken that the face is not smeared. Also, in the case of strongly structured, soils, that not only coated ped faces are visible, as mottling in the ped interior will not be evident. In such a case, where spatial organization of colour variation occurs, it should be emphasized.

Mottles are described according to abundance, size and contrast as well as colour, viz:

Abundance (%)	*Size (mm) along greatest dimension*	*Contrast*
Few (f) < 2	Extremely fine (xf) < 1	Faint (f)
Common (c) 2–20	Very fine (vf) 1–2	Distinct (d)
Many (m) 20–40	Fine (f) 2–5	Prominent (p)
Very many (vm) > 40	Medium (m) 2–15	
	Coarse (c) > 15	

For abundance either the class or the actual percentage can be given using the figure in Appendix 5.8.

Contrast definitions are:

Faint	:	only evident on close examination, Munsell colours of matrix and mottle not far apart.
Distinct	:	not striking but readily seen.
Prominent	:	striking, with matrix and mottle Munsell colours far apart.

Where symbols are used they must be used in the sequence shown above to avoid confusion.

3.7 *Consistence*

Consistence is an assessment of the resistance to physical disruption or deformation of individual soil aggregates in a structured soil, or soil clods in an unstructured soil. Together with structure it gives some idea of the tractability of the soil and is assessed in the field according to the moisture content, whether dry, moist or wet.

Texture, clay type and bulk density are the main factors affecting the consistence of an uncemented soil. Cemented layers are considered separately. There is no universal relationship between consistence and structure, but both are related to other soil properties, particularly clay content and type. In general therefore high clay contents, particularly of high activity clays, lead to strong structures and very hard consistences. Sandy soils are usually softer and more poorly structured. However, a strong structure carries no automatic implication of a "strong" (meaning hard) consistence For instance, strong surface crumb structures are often soft or slightly hard, as relatively little physical force is required to overcome the aggregating forces, which are probably due to the effect of organic residues. In a similar manner "loose" applies only to single-grain material with no observable coherence. A soil which is so well structured that peds fall away from the pit face is not "loose". The individual peds are probably quite hard.

In a strongly structured soil identifying and extracting peds for assessment of consistence presents no difficulty. In a poorly structured or unstructured soil the size of the piece of soil extracted will depend on the force used and will be the determining factor in assessing consistence. Chipping out small, easily crushed fragments of massive soil will give a misleading impression of consistence, and descriptions of slightly hard, massive sandy clay loams should be regarded with suspicion.

The consistence classes are:

Dry (d) consistence

Loose (l)	: non coherent
Soft (s)	: fragile, crushes under very gentle pressure
Slightly hard (sh)	: crushes under moderate pressure
Hard (h)	: barely crushable between finger and thumb but readily broken
Very hard (vh)	: cannot be hand crushed, broken in hands with difficulty.
Extremely hard (xh)	: cannot be broken in hands.

Moist (m) consistence

Loose (l)	: non coherent
Very friable (vfr)	: crushes under slight pressure
Friable (fr)	: crushes under gentle to moderate pressure
Firm (f)	: crushes between finger and thumb under strong pressure
Very firm (vf)	: barely crushable between finger and thumb
Extremely firm (xf)	: cannot be hand crushed, must be broken

Wet (w) consistence

This is assessed in relation to the properties of stickiness (extent of adhesion to other objects) and plasticity (ability to adopt and retain alternative shapes under stress)

Stickiness:

Non-sticky (ns)	: does not adhere to hand
Slightly sticky (ss)	: adheres slightly but removes cleanly and does not stretch when digits are parted.
Sticky (s)	: moderate adhesion and stretch characteristics
Very sticky (vs)	: adheres and stretches strongly

Plasticity:

Non plastic (np)	: No wire formable
Slightly plastic (sp)	: little effort required to form fragile, easily broken, wire.
Plastic (p)	: moderate effort required to form wire of moderate flexibility
Very plastic (vp)	: Considerable effort needed to form strong, flexible wire.

3.8 *Cemented layers*

Cemented layers or horizons are those in which the soil matrix is impregnated and bonded by a dissimilar material. Soil properties, particularly consistence, are affected. Consistence terms are:

Weakly cemented	: hard but brittle, – can be broken by hand
Strongly cemented	: cannot be broken by hand but is easily broken with a hammer.
Indurated	: substantial force and a hammer required.

As with an unstructured soil the size of the piece of material tested will affect its behavoiur.

When a horizon is so strongly cemented that its properties become those of the cementing agent rather than the cemented material other descriptors are necessary. Terms are available connoting the nature of the cementing material, e.g.

Duripan	: cemented by silica
Petrocalcic horizon	: cemented by calcium carbonate
Petrogypsic horizon	: cemented by gypsum
Petroferric horizon	: cemented by iron compounds

Other terms describe the continuity of the layer and its structure.

Continuity

Continuous	: unbroken

Discontinuous	:	fractured but orientation preserved
Broken	:	disrupted and disorientated
Structure		
Massive	:	no recognized structure
Vesicular	:	sponge – like, voids may be filled with softer material.
Pisolitic	:	cemented spherical concretions
Nodular	:	cemented irregular concretions
Platy	:	planar, layered horizontally

3.9 *Structure*

Structure describes the way in which primary soil particles associate to form larger units, i.e. the way in which they bond together, or cohere, due to their mechanical, electrical and chemical properties. Consistence measures the physical force necessary to overcome this coherence.

Soils vary in coherence from non-coherent to strongly coherent. Those that are non-coherent are single grain sands, or only form micro-aggregates not discernible to the naked eye. Their consistence is, by definition, loose. Those that are coherent may show a tendency for particles to cluster together to form aggregates. The strength of internal bonds, reflected in the degree of discreteness of the aggregates, is expressed in the grade of structure. Other structural attributes are size and shape. Many coherent soils show little or no tendency to ped formation and indeed, in extreme cases, their coherence may be due to dispersive forces rather than aggregative. Such soils are described as structureless or apedal and can be further described as being from weakly to strongly coherent (massive). These terms are complemented by consistence descriptions increasing hardness or firmness. Massive soils are often dispersive and have a high bulk density. The poor internal structure of large aggregates in high clay activity soils may also be due to this process.

Structural properties are assessed in the field by observing the way in which the soil mass disrupts when disturbed. An initial glance at the spoil heap alongside the pit will give a good indication of what to expect. The description of strongly structured soils presents no difficulty. The individual peds are apparent. It is with regard to weaker structured soils that an understanding of the pedological processes involved are necessary for good description. If when looking at a freshly dug profile, definite aggregation is not seen, it should not be automatically concluded that structure is absent. In a moist soil the process of digging will have smoothed the profile face and obscured most morphological features. Careful hacking out, and manual examination of clods, allowing the soil to break along lines of weakness, may reveal structure. If the profile can be left to dry out before description any structure will often be exposed, but excessive drying, particularly in a high clay activity soil, may give a false impression of structure never achieved under natural conditions. The truly structureless soil, apart from exhibiting no clear structures or organization of soil particles, fractures completely at random depending on the forces to which it is subjected.

Compound and mixed structures are common. Compound structures commonly occur in better and larger structured soils which may have secondary structures within the primary, and can be described for instance as strong, coarse angular blocky breaking to moderate, fine subangular blocky. Similarly, the internal structure of large aggregates can be described as massive. Mixed structures commonly occur in surface horizons as a result of human and biotic activity. The commonest are spheroidal structures associated with plant roots, and platy structures resulting from surface micro-sedimentation processes, both interspersed with blocky structures of varying grade and size.

Compact is a term often used loosely to achieve emphasis in description of "very hard" soils. It implies a higher bulk density than would normally be expected in such a soil. The term is usually applied to strongly coherent structureless or weakly structured soils and may be seen as drawing attention to possible water permeability and aeration problems.

The above discussion concerns uncemented soils. Cementation is the binding together of the soil mass by a dissimilar material. Where cementation occurs descriptive terms are the same but the nature of the cementation must be described. (See section on cemented layers).

Structural terms and definitions are as follows:

Grade:

Structureless or apedal : no observable aggregation or no definite

		orderly arrangement of natural lines of weakness. Subdivided on the basis of coherence into:
single grain (sg)	:	non coherent
weakly coherent (wc)	:	disrupts under gentle pressure
moderately coherent (mc)	:	disrupts under moderate to strong pressure
strongly coherent (sc) or massive	:	clods can barely be broken by hand
Weak structure (w)	:	poorly formed indistinct peds barely observable in place. When disturbed soil breaks into few whole peds, many broken peds and unaggregated material.
Moderate structure (m)	:	well-formed, moderately durable peds that are evident but not distinct in undisturbed soil. When disturbed most peds remain intact with little unaggregated material.
Strong structure (s)	:	peds are distinct in undisturbed soil, do not adhere to adjacent peds and are sufficiently, durable to withstand displacement.

Very weak (vw) and very strong (vs) sub-divisions may be used for emphasis.

Definitions of size and shape are given in Table 1.

The structural dimensions refer to:

platy	:	the vertical thickness,
prismlike	:	the largest dimension in the horizontal plane,
spheroidal and blocklike	:	the largest cross-sectional dimension in any plane.

Actual dimensions of aggregates and pictorial representations of structural shapes are shown in Appendices 5.9. and 5.10.

Descriptively, structure is presented in the form grade, size and type (or shape), i.e. strong, medium subangular blocky (s.m. sab).

3.10 *Cutans*

Cutans is the technical term for skins or oriented coatings on the surfaces of some part of the soil body. The coatings usually consist of colloidal substances, such as clays, organic matter or sequioxides, deposited by water movement, the process of illuvia-

	TYPE (Shape and arrangement of peds)						
Size	Platelike with one dimension (the vertical) limited and greatly less than the other two; arranged around a horizontal plane; faces mostly horizontal	Prismlike with two dimensions (the horizontal) limited and considerably less than the vertical; arranged around a vertical line; vertical faces well defined; vertices angular		Blocklike; polyhedronlike, or spheroidal, with three dimensions of the same order of magnitude arranged around point.			
				Blocklike; blocks or polyhedrons having plane or curved surfaces that are casts of the molds formed by the faces of the surrounding peds.		Spheroids or polyhedrons having plane or curved surfaces which have slight or no accommodation to the faces of surrounding peds	
		Without rounded caps.	With rounded caps	Faces flattened; most vertices sharply angular.	Mixed rounded and flattened faces with many rounded vertices.	Relatively non-porous peds.	Porous peds.
	Platy (pl)	Prismatic (pr)	Columnar (col)	Angular blocky (ab)	Subangular blocky (sab)	Granular (gr)	Crumb (cr)
Very fine (vf)	< 1mm	< 10mm	< 10mm	< 5mm	< 5mm	< 1mm	< 1mm
Fine (f)	1 to 2mm	10 to 20mm	10 to 20mm	5 to 10mm	5 to 10mm	1 to 2mm	1 to 2mm
Medium (m)	2 to 5mm	20 to 50mm	20 to 50mm	10 to 20mm	10 to 20mm	2 to 5mm	2 to 5mm
Coarse (c)	5 to 10mm	50 to 100mm	50 to 100mm	20 to 50mm	20 to 50mm	5 to 10mm	> 5mm
Very coarse (vc)	> 10mm	> 100mm	> 100mm	> 50mm	> 50mm	> 10mm	

tion. More specific names are available for cutans of different composition, but it will suffice to describe separately, in the remarks column, the nature of the coatings. Little attention has been paid in Zimbabwe to the presence or absence of cutans because the pedological process of which they are diagnostic is not well developed in this country, and the resulting profile forms are not significant in terms of land use. They are included here because the main international classification systems do make use of them.

Cutans are obvious where they are of a different material or a different colour to the material they are coating. Then their colour, nature, extent, thickness and location can be described. This is commonly the case in sandy soils where, in addition to grain coatings, "bridges" between grains may occur. In heavier textured soils coatings, are less apparent. Also most heavy textured soils expand and contract, to greater or lesser extent, with moisture changes. On expansion interstitial voids (cracks) close up and the soil mass is under pressure causing pressure faces to develop where adjacent aggregates or clods have been compressed against each other. Pressure faces resemble cutans in that they are oriented coatings, but with the orientation caused by compression rather than illuviation. The extreme examples of pressure faces are slickensides in vertisols. In these soils very high pressures develop which are relieved by vertical heaving leading to the typical gilgai surface microrelief. In the process adjacent subsoil bodies shear diagonally leaving smooth, shiny, striated faces at 30° to 60° angles to the horizontal.

Commonly used descriptive terms are:

Colour	: according to Munsell	
Extent	: patchy	: small scattered patches
	broken	: extensive cover
	continuous	: complete cover
Thickness	: thin	: underlying surface features apparent
	thick	: underlying surface totally obscured.
Nature	: clay, sesquioxides, organic matter, manganese compounds. silica, salts.	
Location	: sand grains, horizontal ped faces, vertical ped faces, pores.	

3.11 *Stones*

The term "stone" or "coarse material" is used for any "hard" mineral material larger than 2 mm diameter along its greatest axis (as opposed to "fine earth" which is less than 2 mm diameter). A stone is any mineral material which, because of its hardness, cannot become part of the plant rooting medium, even after wetting, ploughing or ripping. Stones can occur individually or in horizons of considerable thickness; with uniform or mixed lithology, size and shape; and due to rock weathering or pedogenic residual or accumulation processes associated with landform and soil development. Pedogenic stones are termed concretions.

Strongly cemented layers such as petroferric horizons, are described separately (section 3.8).

Volume percentages can be obtained fairly accurately from the surface area plates in Appendix 5.8 or estimated according to the abundance classes for each size class, shape and lithological type. Care should be taken when assessing a profile face as the tendency is to overestimate, particularly in a light textured soil where fine earth may fall away exposing a misleadingly large surface area of stone. Note that the stone percentage obtained during laboratory analysis is a weight percentage obtained after drying and grinding, and that these data need to be treated with some reserve, as explained in the section on texture.

In addition to lithology, or composition, the following descriptive terms are used.

Abundance %	*Size (mm)*	*Shape*
Few (f) 2–15	Fine gravel (fg) 2–6	Rounded (r)
Common (c) 15–50	Coarse gravel (cg) 6–20	Subrounded (s)
Many (m) 50–90	Small stones (ss) 20–60	Angular (a)
Very many (vm) > 90	Large stones (ls) 60–200	
	Small boulders (sb) 200–600	
	Large boulders > 600	

Other shapes may be used if necessary.

A description would read; common, small stones of angular quartz. (c, ss, a, quartz).

3.12 *Roots*

Root distribution is often very irregular and therefore difficult to describe. It can be a guide to certain soil conditions, such as water and nutrient availability, aeration, toxicities and compaction, but inferences should be drawn with caution, particularly in cultivated soils. Iron staining along root channels is a sign of anaerobism during some part of the year.

A general quantitative assessment is made using the terms:

nil	
occasional	(o)
few	(f)
fairly numerous	(fn)
numerous	(n)
very numerous	(vn)

Size classes in diameter (mm) are the same as for crumb structures.

very fine (vf)	<1
fine (f)	1–2
medium (m)	2–5
coarse (c)	>5

Use in sequence of abundance before size.

3.13 *Permeability and Drainage*

Permeability and drainage are related properties to do with soil wetness and its causes. The permeability of a soil, or layer, is its ability to transmit water (or air). In the natural state it is a constant soil property (under set moisture conditions) measurable as hydraulic conductivity. The internal drainage status of a soil is a vaguer concept and may be defined as its state of wetness over an extended period. It is decided by the sum of all the properties of the site, including the soil, which affect the internal water relationships of the soil. It therefore varies with climatic change and topographic position. In extreme topographic positions non-soil site factors may be dominant in their effect on drainage. It is not unusual to find poorly drained, but highly permeable, soils in low-lying areas receiving run-off or affected by a high water table, or conversely, poorly permeable soils which are well-drained in sites which receive little water or which shed most of their received water. In intermediate positions soil permeability is usually the most important property affecting drainage, and in flat areas, lacking a high water table, it assumes total control.

Both drainage and permeability are important properties affecting land use, and can be changed, either beneficially or adversely, by different land use practices. Poor permeability in the upper soil, perhaps induced by tillage, can be improved by deep ploughing, ripping or the addition of structural amelioratives. Lower subsoil impermeability is less easily overcome and careless irrigation of such soil will worsen the drainage state and may introduce salinity. Poorly drained soils which are permeable can be artificially drained, to lower the water table, or prevent the development of a perched water table.

The drainage state, in terms of the degree, frequency and duration of wetness, can be related to characteristic colour changes, which may be described and form the basis of drainage classes. The relationship between wetness and colour change due to anaerobic processes is qualitative only, as the precise nature of the change is soil and site specific. Permeability, though quantifiable, is more difficult to assess routinely in the field, and the standard procedure of noting the rate of water acceptance of a dry ped or clod is of debatable value, particularly as it is intended to relate to saturated hydraulic conductivity. However, signs of drainage restriction always alert the observer to possible permeability limitations. Particular difficulty arises in identifying permeability problems in well-drained soils, where, presumably the combination of restricted permeability and low rainfall, or low rainfall acceptance, is insufficient to cause wetness severe enough to bring about colour changes indicative of poor drainage. Also some soils, such as vertisols, do not readily undergo the colour changes associated with wetness and anaerobism. Poor soil structure and high bulk density are the key to recognition of such soils, which, if recommended for irrigation without qualification could lead to rapid deterioration.

Classes and guidelines for assessing permeability and drainage are given below. In soils where poor drainage conditions are due to permeability limitations, permeability and drainage classes should be approximately the same. They may diverge where non-soil site factors are significant or where poor permeability occurs in well-drained soils.

Permeability Classes

P7. Excessively rapid permeability. Open gravel without soil, and very coarse and gravelly sands.

P6. Rapid permeability. Medium and coarse grained sands and loamy sands and most ferrallitic sandy loams to sandy clay loams, and many red ferrallitic clays.

P5. Good permeability. Reddish brown siallitic sandy loams to sandy clay loams, red fersiallitic clays usually with grades of structure not stronger than moderate subangular blocky and most yellowish red medium textured horizons in which structure is not stronger than weak subangular blocky.

Although highly variable the lower limit of hydraulic conductivity measurements appears to be of the order of 9 mm per hour.

P4. Slightly restricted permeability. Some brown siallitic sandy loams, some reddish brown siallitic sandy clay loams. The use of this class does not have a significant bearing on the assessment of irrigable values. It is merely used to distinguish slight differences in permeability intermediate between P5 and P3. In this connection it is often useful to indicate a gradual change from P5 to P3.

P3. Moderately restricted permeability. Greyish brown, somewhat compact or dense siallitic sandy loams, reddish brown siallitic sandy clays with angular blocky structure, many brown sticky clays on lower slopes in regions of moderately high rainfall, and most moderately soft weathering rock horizons, usually with tongues of soil-like material.

Although variable, most hydraulic conductivity measurements are of the order of 2 to 5 mm per hour.

P2. Severely restricted permeability. Siallitic brown or grey sticky clays with pronounced angular blocky structure, and black vertisol sub-soils with slickensides in regions of low rainfall, and granite weathering rock horizons with mottled, sticky, clayey soil-like material.

Hydraulic conductivity measurements range from about 0,2 to 2mm per hour.

P1. Relatively impermeable. Most sodic horizons, gleys and horizons with marked prismatic structure.

Hydraulic conductivity measurements are made using a 2,5cm head of free water.

Drainage classes

D7. Excessively well drained. Soil with permeability class 7 and no colour changes indicative of wetness.

D6. Very well drained. Soil with permeability class 6 and no colour changes indicative of wetness.

D5. Well drained. Most medium to fine textured soils with no colour changes indicative of wetness.

D4. Moderately well drained. Some colour variegation not definable in terms of mottling. Lower subsoil horizons may be slightly paler than those above.

D3. Moderately poorly drained. Subject to partial water-logging irregularly for periods of short duration, more often because of poor permeability rather than a fluctuating water table. Iron segregation mottles are small, occupy a low surface area or do not contrast strongly with the matrix.

D2. Poorly drained. Regularly subject to alternating oxidising and reducing conditions, due usually to a fluctuating water table. The matrix is pale in colour with low chroma, and contrasts strongly with frequent, well-developed iron segregation mottles. Root channel staining may occur.

D1. Very poorly drained. Wet for a large part of the year. Colours are neutral or pale greys, blues, olives and greens with little mottling due to almost total reduction or depletion of iron. Organic matter accumulates at the surface and iron staining may occur in root channels.

It should be noted that morphology resulting from iron reduction and mobilization is largely irreversible, and that fossil or relict poorly-drained profile forms will persist even though their environment is no longer wet.

For irrigability assessment the horizon permeability and drainage classifications are used to obtain the irrigable value of the soil, according to Table 6 in Appendix 5.11.

3.14 *Concentrations*

Concentrations are deposits within the soil of substances which have been mobilized and concentrated or precipitated by chemical processes. Depending on the substances and the history of the soil, such deposits may range from soft, diffuse mottles, separable only on grounds of colour, through harder and more physically discrete aggregations, to hard stones. The latter, due to their pedogenic origins, are termed concretions, or sometimes nodules, but are separated and considered as stones. The remainder are all considered as concentrations, though they may, due to convention and usage, be described elsewhere, as under mottles. Concentrations may also intergrade to cutans in certain cases, although they are three – dimesional bodies and cutans are basically two – dimensional.

The commonest form of concentration is the red or brown accumulation of iron oxides occurring in the subsoils of wetter soils through *redox* processes and generally described under mottles. For this reason no separate column for concentration description appears on the profile description form used in Zimbabwe and other types of concentration must be described in the remarks column. The commonest of these are manganese compounds and carbonates. The former can be described as mottles but are not usually, as their black colour is fairly standard and is difficult to match in the Munsell colour book.

Concentrations can be described in terms of composition, hardness, shape, size and abundance. The last two should conform with the classes used for mottle description. Carbonates may also occur as finely divided particles or in pseudomycelial form, when more subjective description is necessary. The former may be tested for and estimated according to the effervescent reaction of the soil mass to dilute hydrochloric acid, as either slight, moderate or strong. Total content, purity and the degree of fine division affect the reaction, and it should be noted that magnesium carbonate is far less reactive than calcium.

Other concentrations which may occur are other salts and dispersed organic matter in sodic soils, and it is these which tend to intergrade with cutans.

3.15 *Voids or Pores*

Voids or pores are spaces in the soil mass which are filled with air or water. They are not usually described in Zimbabwe but are attracting increasing attention from field workers in other parts of the world. The following is a simplified form of description based on abundance, size and type.

Surface Area Abundance

Few	:	1 to 50 per square decimeter, or 1 to 3 per square inch.
Common	:	50 to 200 per square decimeter, or 3 to 14 per square inch.
Many	:	>200 per square decimeter, or >14 per square inch.

Size mm (Diameter of tubular and vesicular voids, width of interstitial).

Size classes are the same as for crumb structures and roots.

Very fine	:	<1
fine	:	1–2

Medium	:	2–5
Coarse	:	>5

Type

Vesicular	:	approximately spherical or ellipsoidal in shape
Tubular	:	extended cylindrical shape with approximately circular cross section.
Interstitial	:	Occurring between grains, peds or clods, complementary to the soil structure.

3.16 *Parent Material*

In most cases this will be partly weathered rock and the main decision to be made will be whether the material is basically soil or rock, i.e. whether it's properties are predominantly soil properties and can be described as such, or not. If they are, a standard or abbreviated soil description can be made accordingly, qualified by any free text description of lithology, mineralogy and weathering state thought necessary. If not the rock may be described in terms of geology, and again additional information regarding state of weathering, hardness and fracture pattern may be included.

Even in a deep, virtually completely weathered soil unweathered or partly weathered minerals may be identified and provide some indication of parentage.

Acknowledgement

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5. Appendix

5.1. *Definition of land classes*

Agricultural land can obviously be classified in a number of different ways depending on the objectives of the classification. Specific classification can be made, for instance, in respect of suitability for irrigation, or perhaps in regard to suitablility for a specific crop, or for any other purpose.

In land-use planning, as practised in Zimbabwe, the planner is concerned with the capability of the land to produce permanently, under specific uses and treatments. The objective of classification is therefore the systematic arrangement and grouping of different kinds of land to show their most intensive safe use and indicate their management requirements and to show the permanent hazard attached to the use of the land, in terms of increasing degree of limitation of use.

Eight land capability classes are recognised and these may be divided into three land capability divisions. Table 2 illustrates how the land classes and divisions are arranged in order of decreased adaptability and freedom of choice of uses.

Class I

Land with few or no limitations or hazards. With good management is suitable for long continued cropping with no (or only simple) conservation practices.

Soils are deep or moderately deep and naturally well drained with a stable structure and good working properties. Slopes are only slight and the only limitations are those of maintenance of soil structure and fertility.

Class II

Land subject to moderate limitations or hazards. It is suitable for cropping with adequate protection measures, which may sometimes include special management practices and/or regular ley rotations.

Limitations may include one or more of the following: moderate susceptibility to erosion; moderate slopes; moderately shallow

Land Capability Class		Increased intensity of use									Land Capability Division
		Wildlife	Forestry	Limited Grazing	Moderate Grazing	Intensive Grazing	Limited Cultivation	Moderate Cultivation	Intensive Cultivation	Very Intensive Cultivation	
Increased limitations and hazards. Decreased adaptability and freedom of choice of uses	I	W	F	LG	MG	IG	LC	MC	IC	VIC	Arable land
	II	W	F	LG	MG	IG	LC	MC	IC		
	III	W	F	LG	MG	IG	LC	MC			
	IV	W	F	LG	MG	IG	LC				
	V	W	F	LG	MG	IG					Grazing land
	VI	W	F	LG	MG						
	VII	W	F	LG							
	VIII	W									No agricultural value

soil depth; slightly unfavourable surface physical characteristics; inadequate permeability in the lower root zone or moderate wetness existing as a permanent land character.

Such land needs normal moderate conservation practices which will depend on the limiting characteristics, but will include both moderate mechanical and biological conservation methods in varying combinations.

Class III

Land subject to severe limitations or risk of damage, which is suitable for cropping only with the application of intensive protection measures and/or with special practices which may include long ley rotations with short cropping periods.

Limitations may include: moderately steep slopes; high susceptibility to erosion; soils of low moisture retaining capacity; moderately shallow and shallow soils; intractable texture; inadequate permeability in the lower root zone; unfavourable physical characteristics in the surface soil or moderate wetness.

Combinations of intensive measures are required to use the land permanently. Such measures as adequate mechanical protection; soil conserving rotations incorporating grass; the maintenance of adequate cover whilst under tillage; drainage and other measures would be used in combination, depending on the limitations.

Class IV

Land subject to very severe permanent limitations or hazards, suitable for row-cropping only occasionally in long ley rotations, or for use under perennial vegetation.

Limitations may include: steep slopes; shallow soils, or soils of very low water retaining capacity; high erodibility; unfavourable characteristics in the surface soil; and severe, but correctable, wetness.

The use of this land for row-cropping is limited to once in every four to six years. Complex and intensive protection measures and practices would be required during the time under cultivation.

Class V

Watercourses and land subject to severe, permanent wetness limitations which normally preclude cultivation.

Vleis and watercourses subject to severe wetness not usually corrected and best left under permanent vegetation. Cultivated only with very special practices and measures.

Class VI

Land which has such severe soil and/or slope limitations that cropping must be excluded, but which is productive under perennial vegetation and then only moderately subject to deterioration.

Limitations include: very steep slopes; very shallow soil; physical hazards of rock outcrops, unevenness, etc.

Its use is one of permanent grassland, which, with sound methods of veld management, can provide good grazing or hay. This land may also be suitable for afforestation, orchard or plantation crops.

Class VII

Land which has such severe soil and/or slope limitations as to exclude cultivation, and which is limited in its production and highly susceptible to deterioration.

The limitations are similar but more severe than those limiting Class VI with consequently reduced productivity and increased hazard.

It is suitable only for rough grazing, and in some instances for afforestation.

Class VIII

Land which has excessive limitations of soil, relief, wetness, etc.

It will be noted that while Class I land could be put to the uses noted for Classes II and III, etc. Class VIII land has only the one use. A high class is capable of the uses noted for those below it, but a lower class is not capable of being put to one of the uses noted for a high class.

Table 3. *Mapping scales and survey rates*

Area in Hectares	Map Scales 1 : 2 500 Map size (cm)	No. obs.	Man days	1 : 5 000 Map Size (cm)	No. obs.	Man days	1 : 10 000 Map Size (cm)	No. obs.	Man days	1 : 25 000 Man Size (cm)	No. obs.	Man days	1 : 50 000 Map Size (cm)	No. obs.	Man days
20	16 × 20	160	5												
40	32 × 20	320	10												
60	24 × 40	480	15												
80	32 × 40	640	20												
100	40 × 40	800	25	20 × 20	200	10									
200	40 × 80	1 600	50	20 × 40	400	20									
500	80 × 100	4 000	125	40 × 50	1 000	50	20 × 25	250	12						
1 000				40 × 100	2 000	100	20 × 50	500	25						
2 000				80 × 100	4 000	200	40 × 50	1 000	50	16 × 20	160	9			
5 000							50 × 100	2 500	125	20 × 40	400	23			
10 000							100 × 100	5 000	250	40 × 40	800	46	20 × 20	200	13
15 000										60 × 40	1 200	69	30 × 20	300	20
20 000										80 × 40	1 600	92	40 × 20	400	27
25 000										100 × 40	2 000	115	50 × 20	500	33
30 000										60 × 80	2 400	138	30 × 40	600	40
40 000										80 × 80	3 200	184	40 × 40	800	53
50 000										100 × 80	4 000	230	50 × 40	1 000	67
100 000													50 × 80	2 000	133
Survey rate	4 ha/man day			10 ha/man day			40 ha/man day			220 ha/man day			750 ha/man day		
Obs. density	8/ha			2/ha			1/2 ha			1/12½ ha			1/50 ha		
Grid square	35 m			70 m			140 m			350 m			700 m		
Min mappable area	156 m²			625 m²			2 500 m²			1½ ha			6¼ ha		

5.3 *Contour spacing and slope on 1 : 50 000 maps*

Table 4.

Vertical interval 50 ft.		Vertical interval 20 m.	
Inter-contour distance (icd) (mm)	Slope (%)	Inter-contour distance (mm)	Slope (%)
1	30	1	40
2	15	2	20
3	10	3	13,3
3,8	8	4	10
		5	8
	Irrigability Class D		
4	7,5	6	6,7
5	6	7	5,7
6	5	8	5
	Irrigability Class C or S		
7	4,3	9	4,4
8	3,8	10	4
9	3,4	15	2,7
10	3	20	2
15	2		
	Irrigability Class B		
> 15	< 2	> 20	< 2
	Irrigability Class A		
% Slope = 30 ÷ icd		% Slope = 40 ÷ icd	

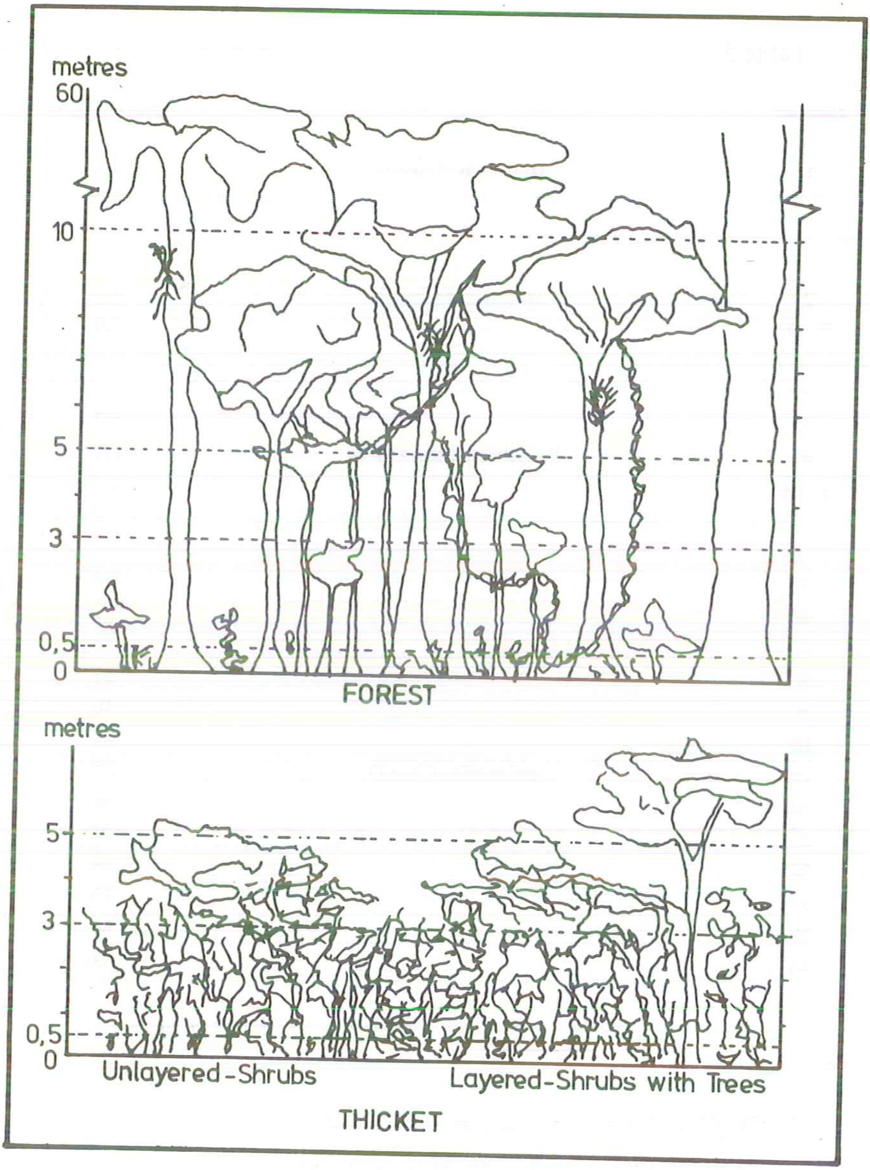
5.4 *Slope conversions*

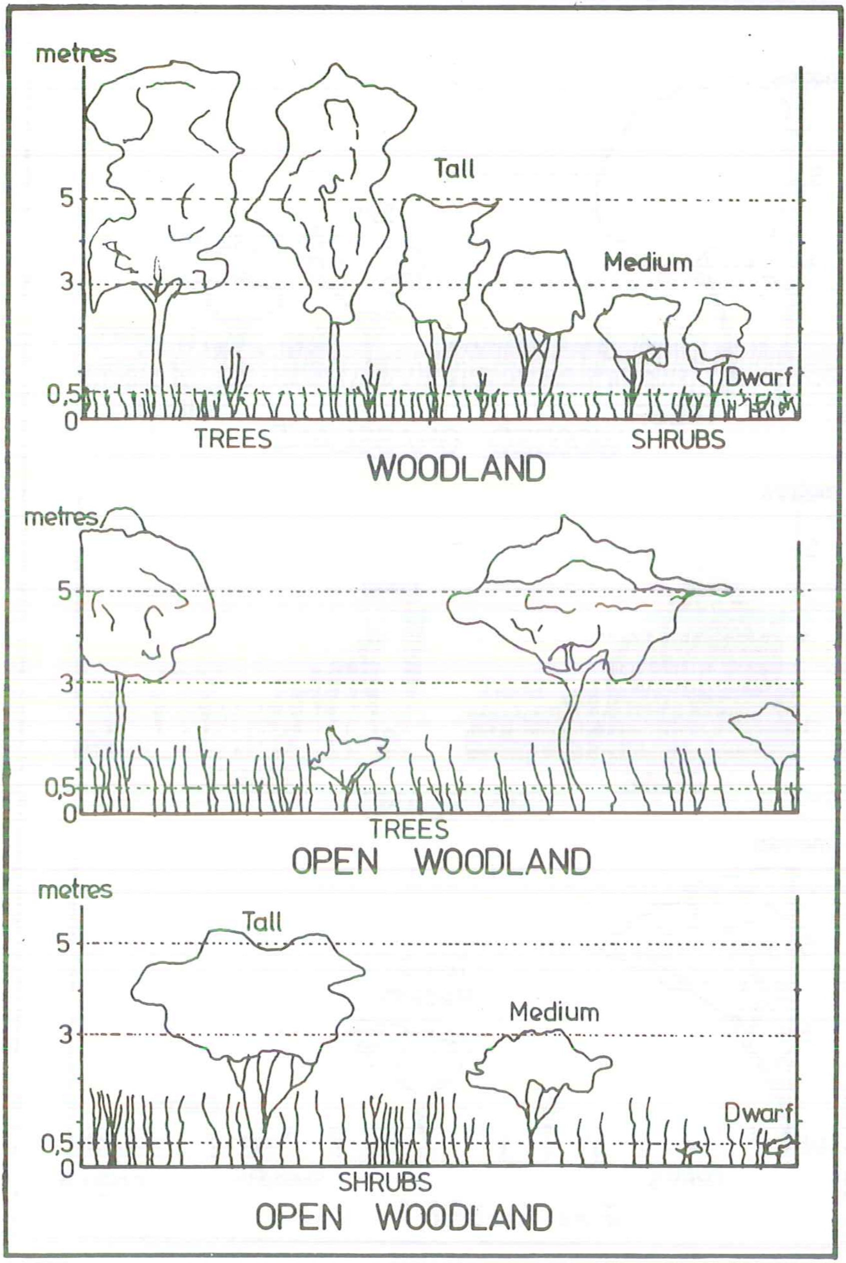
Table 5.

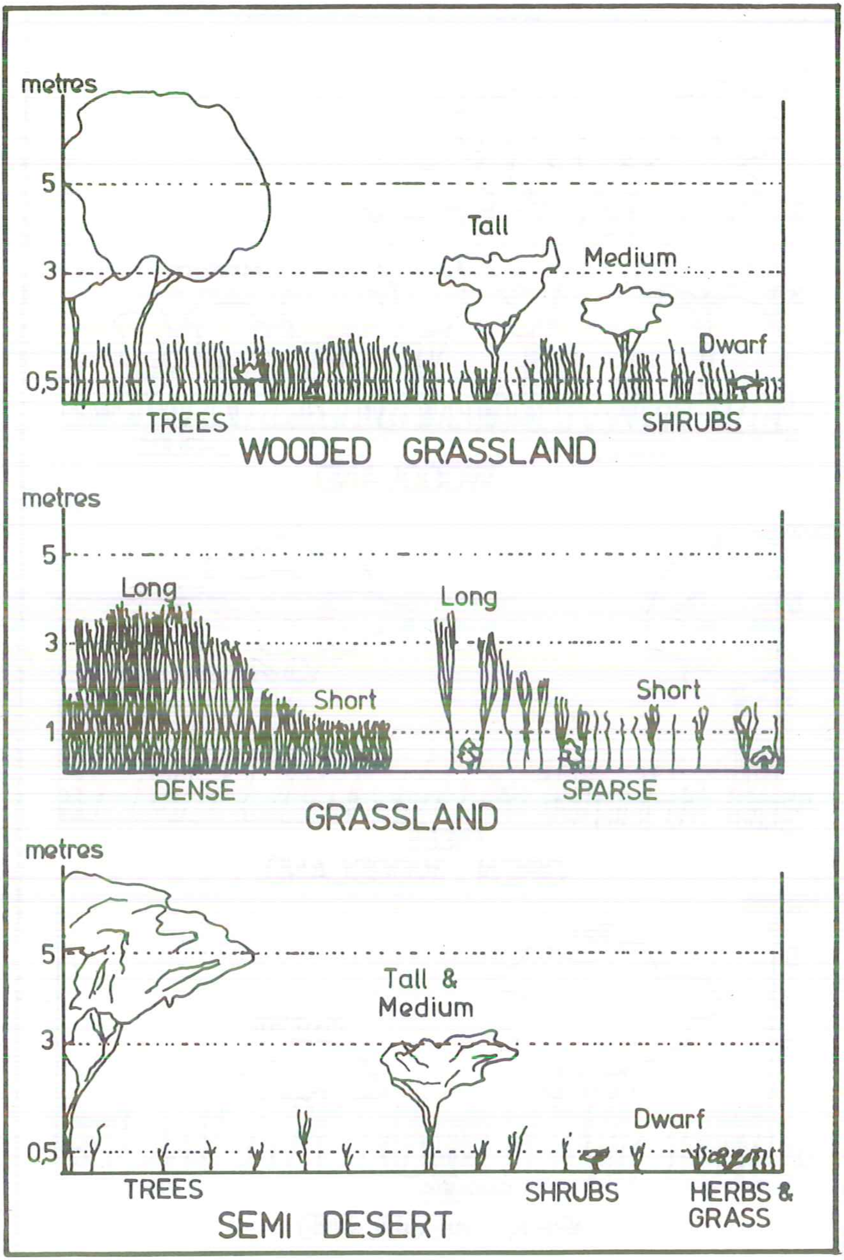
Degrees		*Percentages*
1	Irrigability Class A	1,8
1° 9′		2,0
2	Irrigability Class B	3,5
2° 52′		5,0
3		5,2
4	Irrigability Class C or S	7,0
4° 34′		8,0
5		8,8
6		10,5
7		12
8		14
9		16
10		18
15	Irrigability Class D	27
20		36
25		47
30		58
35		70
40		84
45		100

5.5 *Profiles of major vegetation formations*

These are shown in the following three figures.


metres
60
10
5
3
0,5
0
FOREST
metres
5
3
0,5
0
Unlayered-Shrubs
Layered-Shrubs with Trees
THICKET


metres
Tall
5
3
Medium
0,5
0
Dwarf
TREES
SHRUBS
WOODLAND
metres
5
3
0,5
0
TREES
OPEN WOODLAND
metres
Tall
5
3
Medium
Dwarf
0,5
0
SHRUBS
OPEN WOODLAND


metres
5
3
0,5
Tall
Medium
Dwarf
TREES
SHRUBS
WOODED GRASSLAND
metres
5
3
1
Long
Long
Short
Short
DENSE
SPARSE
GRASSLAND
metres
5
3
0,5
Tall &
Medium
Dwarf
TREES
SHRUBS
HERBS &
GRASS
SEMI DESERT

5.6 *Vegetation indicator species*

Acacia albida (white thorn). Occurs in hot areas on siallitic alluvial soils. Particularly prominent on sandy soils.

Acacia tortilis (umbrella thorn), *Euphorbia ingens* (candelabra tree) and *Albizzia harveyi* woodland. Occurs on deep, permeable, medium textured, siallitic alluvium or colluvium in hot areas. Subsoils are calcareous.

Acacia xanthophloea (fever tree). Dominant on periodically wet, sodic or saline/sodic low-lying sites in hot areas.

Afzelia quanzensis (pod mahogany). Indicator of very sandy soils.

Baikaea plurijuga (mufuti teak). Indicator of regosols.

Brachystegia boehmii (mufuti). Becomes numerous on shallow or gravelly soils.

Brachystegia spiciformis (msasa) *Julbernardia globiflora* (mnondo) woodland. Occurs on well drained soils in the higher rainfall areas.

Burkea africana (false ash). Occurs commonly on light textured soils, particularly on granite soils around Harare.

Colophospermum mopane (mopane). Xerophytic and shallow rooting, occurs widely in the lowveld. At higher altitudes it occurs in physiologically dry sites, where deep rooting is restricted in some way, or in sodic areas.

Combretum apiculatum (russet combretum). Is dominant on shallow sandy siallitic soils in the Sabi-Limpopo basin.

Combretum elaeagnoides. Component of "Jesse" thicket. Dominance indicates deep, well-drained, predominantly sandy siallitic soils.

Combretum fragrans (ternate combretum). Local dominance indicates fairly deep, medium textured soils with compaction and impeded drainage in subsoils.

Diplorhynchus condylocarpon (rubber tree). Dominance indicates ultra-basic rocks. Tolerant of chromium and nickel.

Hyphaene benguellensis (vegetable ivory, ilala palm). Associated with alkalinity in hot areas, is well-grown on deep soils but stunted on eroded sodic or periodically wet soils.

"Jesse" thicket. Deep well-drained sandy soils.

Monotes glaber. Dominance indicates periodically wet light textured soils.

Parinari curatellifolia (muhacha, hissing tree, mobola plum). Except in the eastern districts marked occurrence indicates a fluctuating high water table particularly on granites.

Protea (sugar bush) and *Strychnos* (monkey orange) spp. Often found on leached sandy soils of the high veld.

Syzygium guineense, (water-berry). Except in eastern districts are associated with *P. curatellifolia* but in wetter areas.

Syzygium huilense (dwarf water-berry). Hardly distinguishable from *S. guineense*.

Terminalia sericea (mangwe, silver tree, yellow-wood). Indicator of very sandy soils.

Uapaca kirkiana (mahobohobo, wild loquat). Dominant on well drained shallow and gravelly soils.

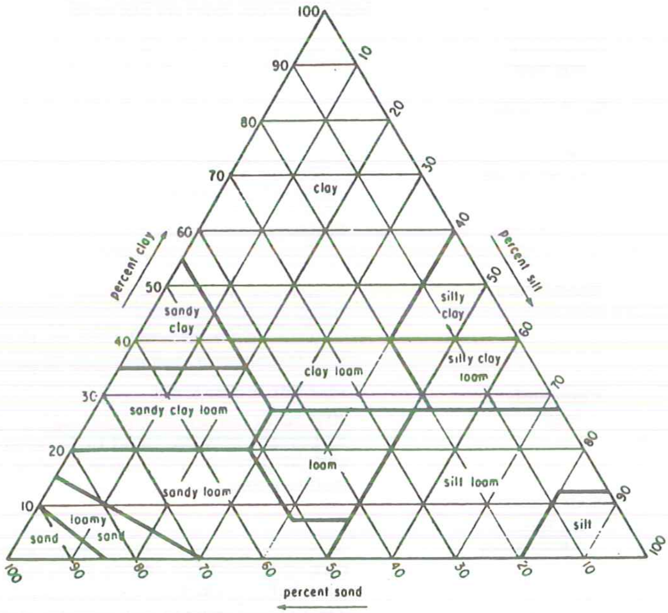
Xeromphis obovata. Local dominance indicates very shallow, often stony sandy soils.

5.7 *The USDA Soil Texture System*

Size limits of soil separates.

Very coarse sand	:	2,0 mm (2000µm)	–	1,0 mm (1000µm)
Coarse sand	:	1,0 mm (1000µm)	–	0,5 mm (500µm)
Medium sand	:	0,5 mm (500µm)	–	0,25 mm (250µm)
Fine sand	:	0,25 mm (250µm)	–	0,10 mm (100µm)
Very fine sand	:	0,10 mm (100µm)	–	0,05 mm (50µm)
Silt	:	0,05 mm (50µm)	–	0,002 mm (2µm)
Clay	:	<0,002 mm (2µm)		

Textural classes.



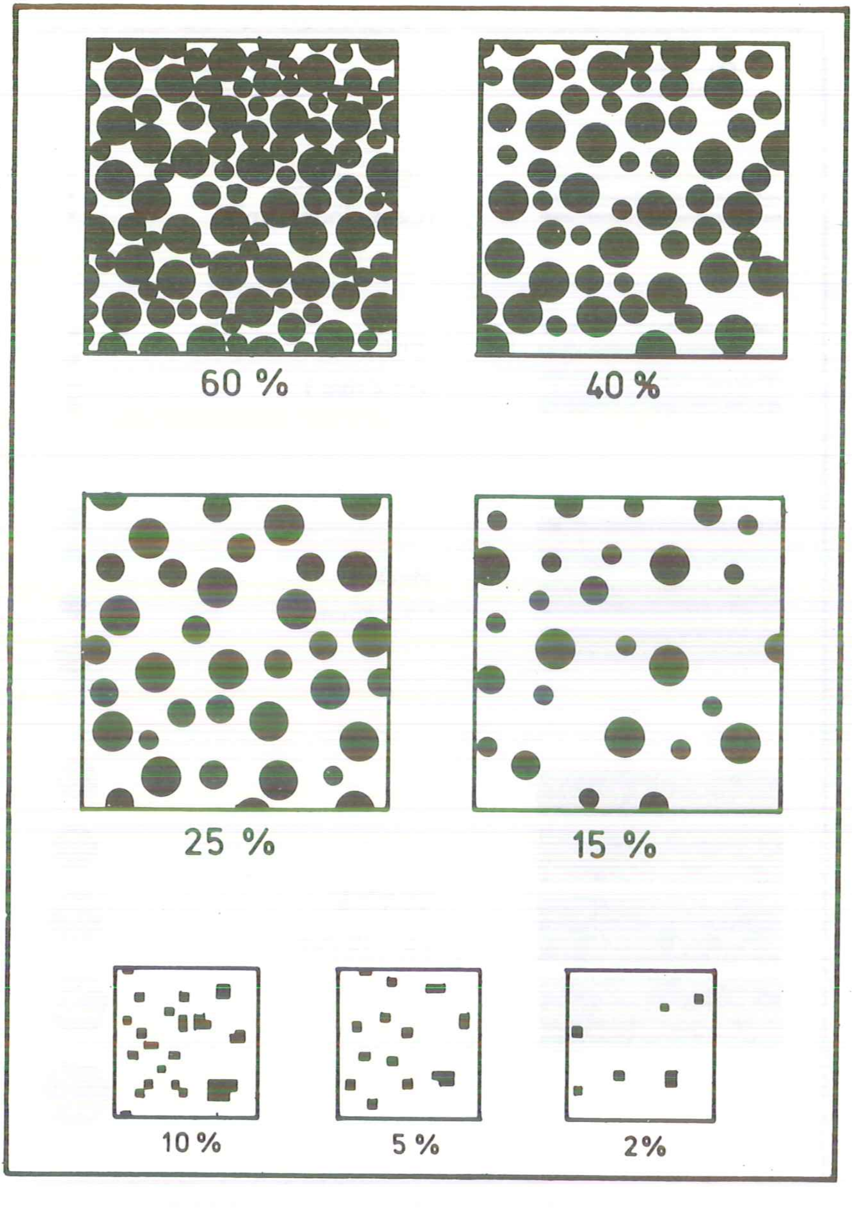
The subdivisions of sandy textural classes are defined as follows:

Sands:

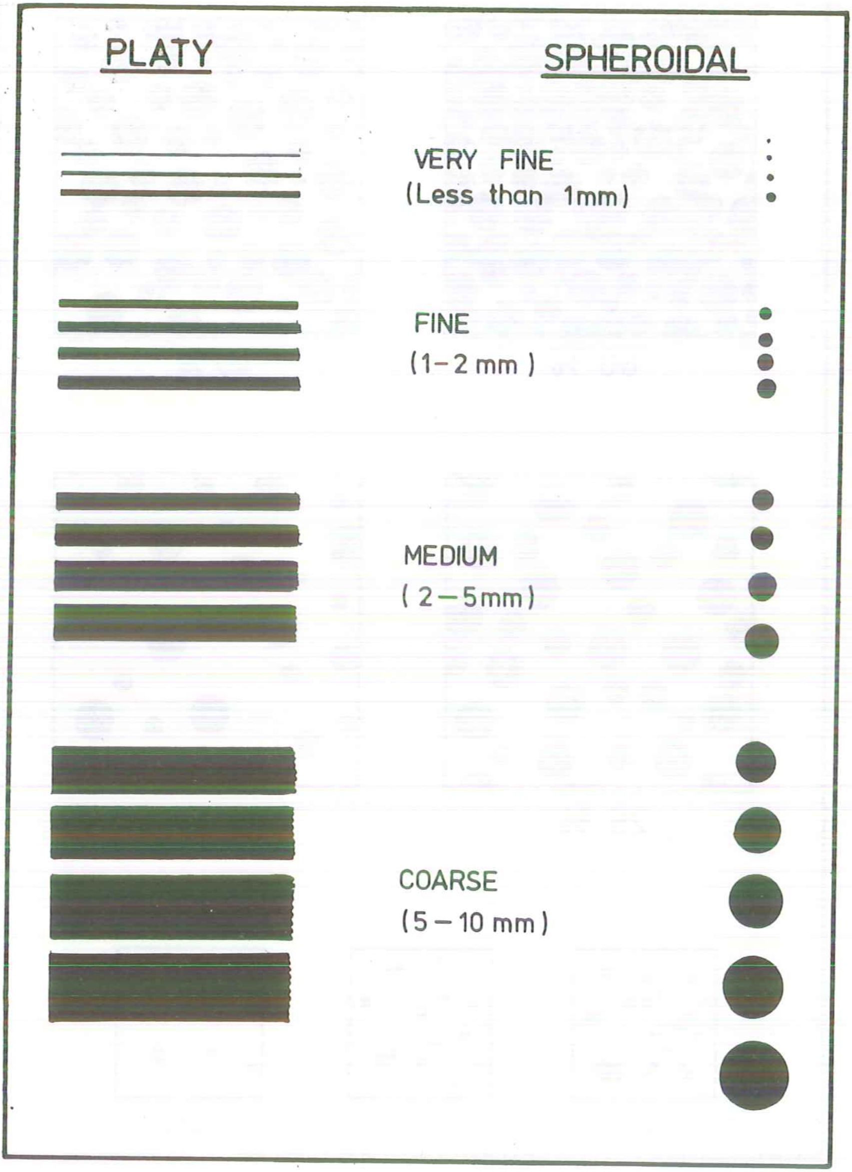
Coarse sand	:	25 percent or more very coarse and coarse sand, and less than 50 percent any other one grade of sand.
Sand	:	25 percent or more very coarse, coarse and medium sand, and less than 50 percent fine or very fine sand.

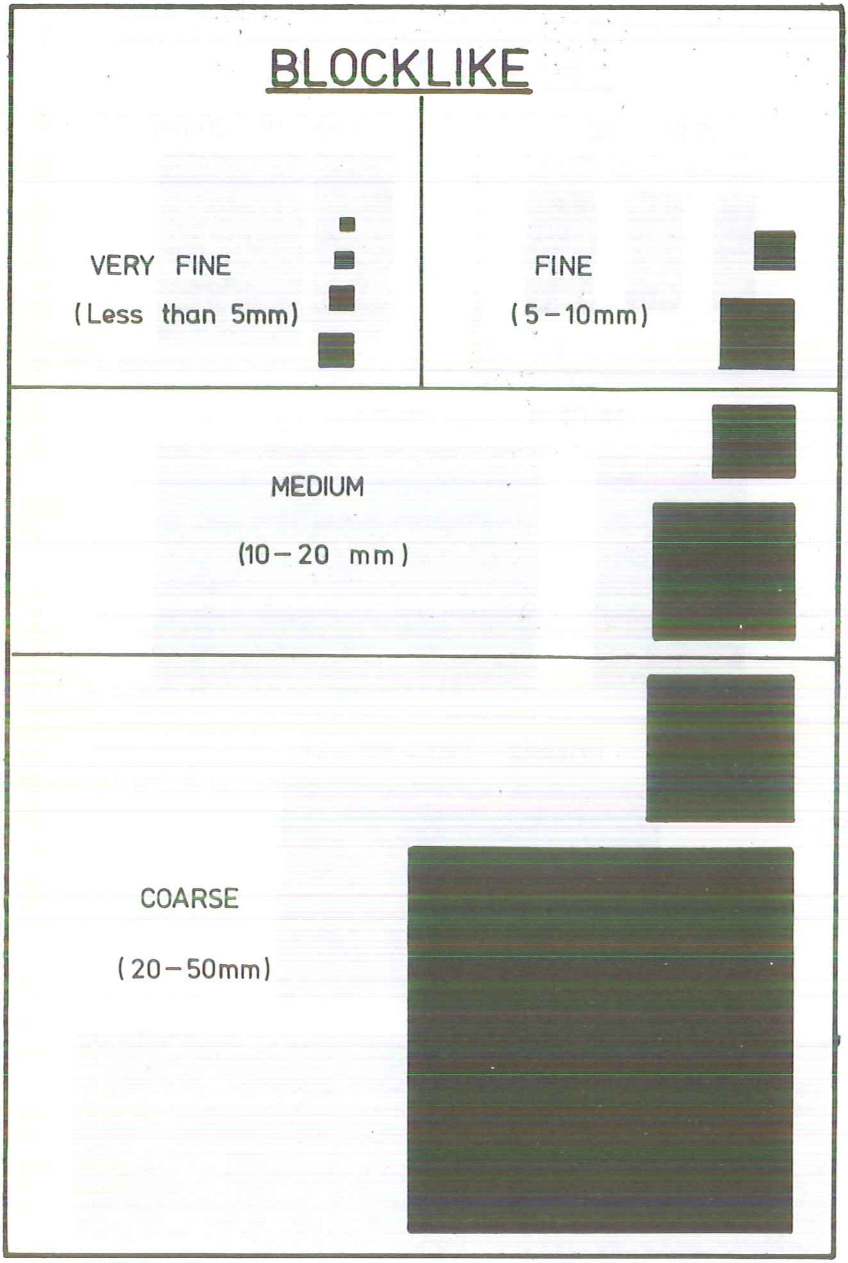
Fine sand	: 50 percent or more fine sand or less than 25 percent very coarse, coarse and medium sand and less than 50 percent very fine sand.
Very fine sand	: 50 percent or more very fine sand.
Loamy sand:	
Loamy coarse sand	: 25 percent or more very coarse and coarse sand, and less than 50 percent any other one grade of sand.
Loamy sand	: 25 percent or more very coarse, coarse and medium sand, and less than 50 percent fine or very fine sand.
Loamy fine sand	: 50 percent or more fine sand or less than 25 percent very coarse, coarse and medium sand and less than 50 percent very fine sand.
Loam very fine sand	: 50 percent or more very fine sand.
Sandy loams:	
Coarse sandy loam	: 25 percent or more very coarse and coarse sand and less than 30 percent very fine or fine sand.
Sandy loam	: 30 percent or more very coarse coarse and medium sand, but less than 25 percent very coarse sand, and less than 30 percent very fine or fine sand.
Fine sandy loam	; 30 percent or more fine sand and less than 30 percent very fine sand or between 15 and 30 percent very coarse, coarse and medium sand.
Very fine sandy loam	: 30 percent or more very fine sand or more than 40 percent fine and very fine sand, at least half of which is very fine sand and less than 15 percent very coarse, coarse and medium sand.

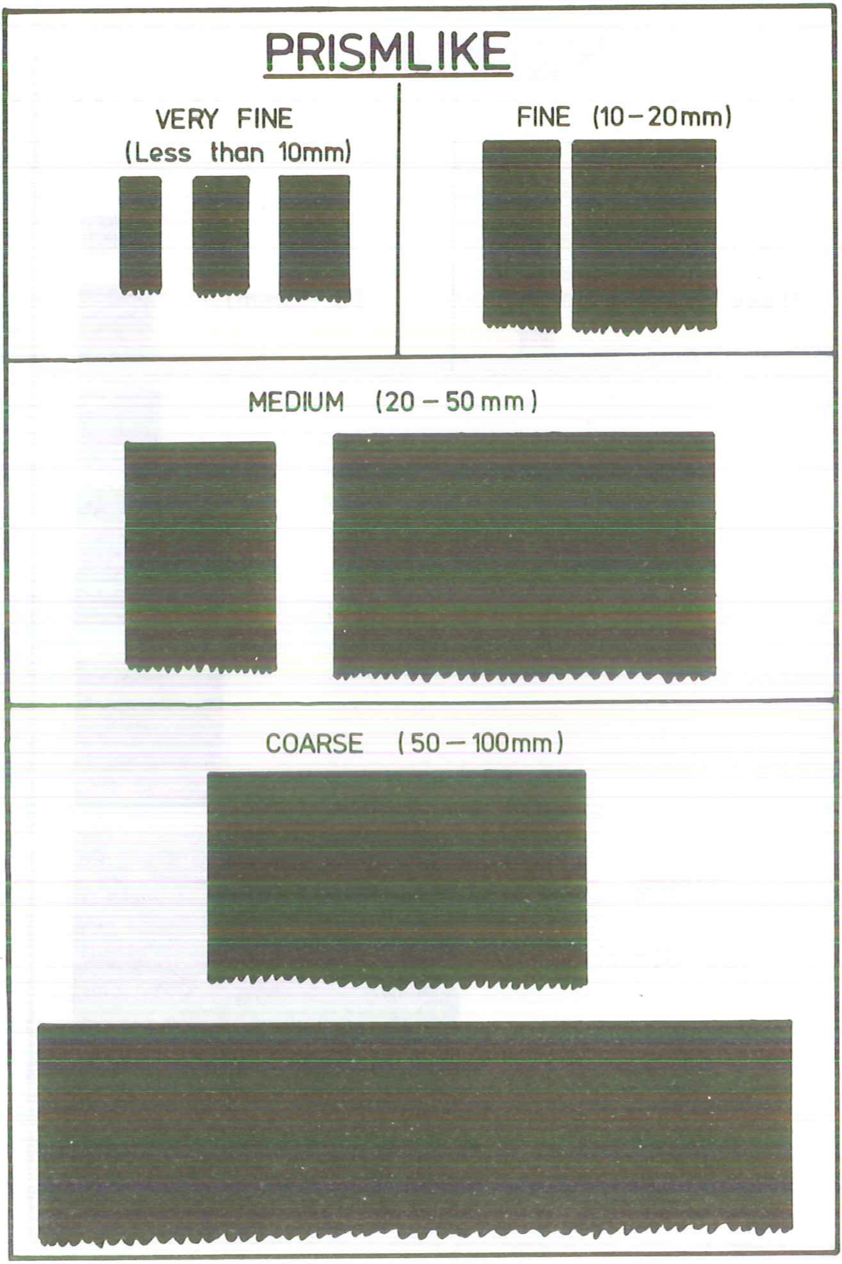
5.8 *Mottles and stone surface area percentage*



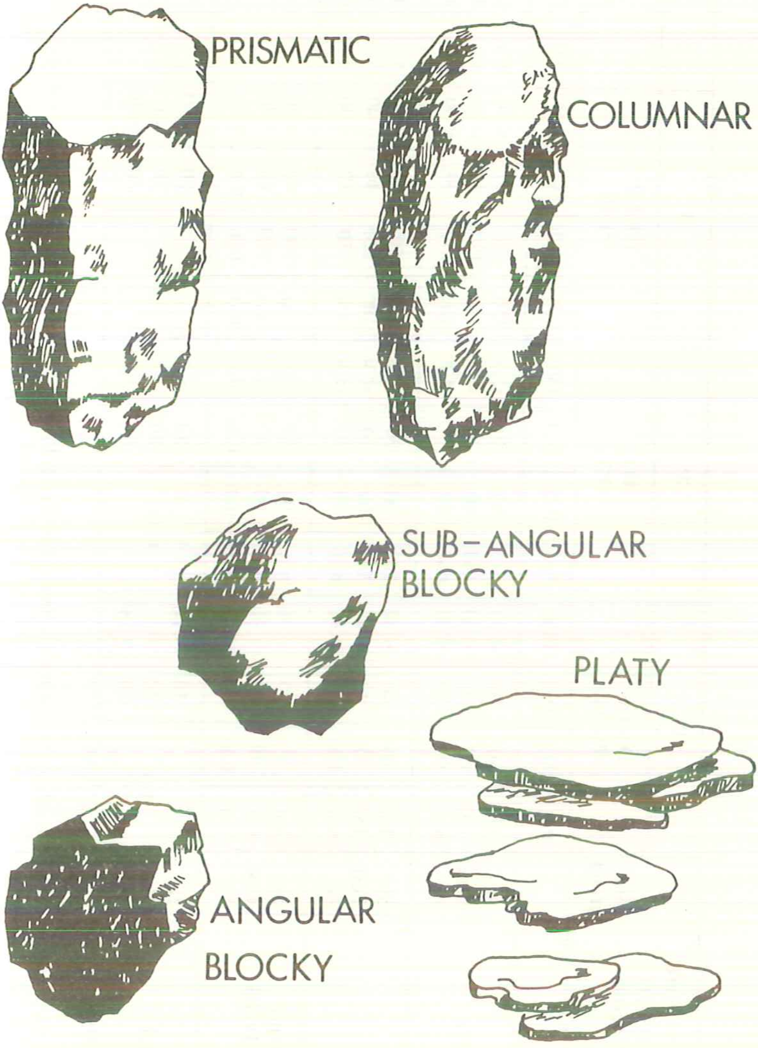
5.9 *Structural sizes*




BLOCKLIKE
VERY FINE
(Less than 5mm)
FINE
(5–10mm)
MEDIUM
(10–20 mm)
COARSE
(20–50mm)


PRISMLIKE
VERY FINE
(Less than 10mm)
FINE (10–20mm)
MEDIUM (20 – 50 mm)
COARSE (50 — 100mm)

5.10 *Structural shapes*



5.11 *Irrigable values of soils*

Irrigability values of soils in relation to texture, classification and rooting depth limitations

Table 6

Average texture of soil horizons permitting root growth	Soil group	1* D4–D6 P4–P6				2* D3 P3				3 D1–D2 P1–P2				4 P1 Sodic			
		IV1	IV2	IV3	IV4	IV1	IV2	IV3	IV4	IV1	IV2	IV3	IV4	IV1	IV2	IV3	IV4
C to SaCL	Si	120	50	30	< 30	90	30	20	< 20	150	90	30	< 30	n.a.	150	60	< 60
	Fesi	120	60	30	< 30	120	40	20	< 20	180	120	30	< 30	n.a.	150	60	< 60
	Fe	n.a.	90	30	< 30	n.a.	60	20	< 20	n.a.	150	30	< 30	n.a.	n.a.	n.a.	n.a.
SaL	Si	150	60	40	< 40	180	60	30	< 30	180	90	40	< 40	n.a.	150	60	< 60
	Fesi	150	75	40	< 40	180	60	30	< 30	180	120	40	< 40	n.a.	150	60	< 60
	Fe	n.a.	120	40	< 40	n.a.	90	30	< 30	n.a	150	40	< 40	n.a.	n.a.	n.a.	n.a.
Micaceous vf S and vf LS	Si	n.a.	90	40	< 40	n.a.	90	30	< 30	n.a.	150	40	< 40	n.a.			
	Fesi	n.a.	90	40	< 40	n.a.	90	30	< 30	n.a.	150	40	< 40				
	Fe	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.				
S and LS	Si	n.a.		50	< 50	n.a.		50	< 50	n.a.		50	< 50	n.a.		60	<60
	Fesi			50	or			50	or			50	or			60	< 60
	Fe			50	> 180			50	> 180			50	>180			n.a.	n.a.

Maximum permitted surface depths of medium and coarse grained sand and loamy sand: IV1 – 10 cm, IV2 – 40 cm, IV3 – 90 cm.

★ Column 1 gives minimum depths of soil required to provide adequate AWC. Should the depth of soil permitting root growth in soils of Column 2 be less than the corresponding depth in Column 1, the soils should be down-graded according to the depths in Column 1.

Column 1 Depth of well drained soil (D4 – D6) with unrestricted or only slightly restricted permeability (P4 – P6).

Column 2 Depth to a moderately poorly drained (D3) horizon of moderately restricted permeability (P3). These horizons are not limiting to root growth and contribute to AWC.

Column 3 Depth to a poorly or very poorly drained (D1 – D2) horizon, or one with permeability severely restricted or relatively impermeable (P1 – P2). These horizons are limiting to root growth.

Column 4 Depth to a relatively impermeable sodic (P1) horizon. This horizon is limiting to root growth.

Si = Siallitic; FeSi = fersiallitic; Fe = ferrallitic.

5.12 Irrigability land classification

Areas and portions of areas within a proposed irrigation project are put into one of the following irrigability classes:

Class A. Suitable for irrigation without special precautions or practices, and capable of sustained productivity.

Class B. Suitable for irrigation with special precautions or practices. Sustained productivity is attainable with good management and maximum efficiency in the use of irrigation water; however, the risks are greater owing to moderate soil and/or topographical limitations, and special care is necessary; corrective measures may be recommended, according to the nature of the limitations.

(Land in this class is always recommended for irrigation but attention is drawn to some limitation, for example, lower available water capacity than the ideal and/or to the danger of waterlogging and possible salinization of lower slope soils in which case the provision of drains in the vicinity of diffuse natural drainage lines may be advocated. Most of the land classified as being suitable for irrigation in Zimbabwe falls into this class.)

Class C. Of very restricted suitability for irrigation: confined to specific types of crops and practices, owing to severe soil and/or topographical limitations.

(Only certain soils that fall into this class may be recommended for irrigation, for instance some of the vertisols in the west of Zimbabwe where rainfall is appreciably higher than in the south-eastern Lowveld and where such soils are prone to wetness in summer. Such soils may be recommended for wheat in winter when the amount of water they receive can be controlled. A further instance is colluvial soils which are excessively stony near the base of hills and therefore unsuitable for normal crops. On such soils orchard crops or perennial crops that require a minimum of tillage may be recommended.)

Class S. Excessively pervious sands of very restricted suitability, owing to inadequate available water capacities, unavoidable high water losses, and low inherent fertility.

(The soils in this class are only very rarely recommended for irrigation. Irrigation is not likely to give economic crop returns due to leaching of applied nutrients which in turn may result in low pH values and an even lower fertility status.)

Class D. Unsuitable for normal irrigation, owing to excessive soil and/or topographical limitations. Suitable for rice in some instances.

The irrigability class assigned to an area is based on an evaluation of the predominant irrigable values of the soils within it in conjunction with the slope of the land and its position in relation to the surrounding topography. In very broad terms irrigable values of one on land with less than 2 percent slope correspond to Class A. Irrigable values of two on land with slopes up to 5 percent correspond to Class B, irrigable values of three on land with slopes up to 8 percent correspond to Class C, and irrigable values of four on land with slopes also up to 8 percent correspond to Class S. However, the assigning of irrigable classes to areas is also inescapably bound up with the scale of mapping, and since it is unusual to find areas of appreciable extent in which all profiles have the same irrigable value the correlation between irrigable values and irrigability class described above cannot always be rigidly applied.

In Zimbabwe the scales of mapping most frequently used to show irrigable soil potential are 1 : 12 500 and 1 : 25 000 for semi-detailed surveys or 1 : 50 000 for reconnaissance type surveys. At these levels of mapping the inter-relationship between irrigablility class, irrigable value and topography, given in tabular form below, may be used as a general guide.

Irrigability class	*Profile irrigable values*	*Topography*
Class A	More than 90 percent I.V.1, remainder mainly I.V.2.	Less than 2 percent uniform slopes.
Class B	More than 80 percent I.V.2, or better. (If more than 20 percent poorer than I.V.2, separate demarcation is necessary, or if this is not possible, the poorer undifferentiated component must be indicated.)	Less than 5 percent slope, relatively uniform, or less than 3 percent if slopes not uniform. Appreciably steeper slopes permitted only on orthoferrallitic soils.
Class C	More than 80 percent I.V.3. (If more than 20 percent I.V.2 or better on slopes of less than 5 percent, separate demarcations or indication of undifferentiated better component is necessary.)	Less than 8 percent.

Class S	More than 80 percent I.V.4. (If more than 20 percent I.V.2 or better on slopes of less than 5 percent separate demarcation or indication of undifferentiated better component is necessary.)	Less than 8 percent.

5.13 *Field estimation of available water capacity (AWC)*

The following figures are provisional. They may change and will certainly be refined as more information becomes available. They are included so that an approximate figure for *AWC* can be obtained when necessary. The figures are percentages, or millimetres of water per 10 centimetre depth of soil.

	Siallitic	*Fersiallitic*	*Ortho-ferrallitic*
Sand	7	6	5
Loamy sand	9	8	7
Sandy loam	11–13	10–12	10
Sandy clay loam	12–16	11–14	10
Sandy clay	14	12–14	11
Clay	13	12	11–12

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