Soils of the Vineyards of the Hall's Gap District

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SECTION 1 - SCOPE AND PURPOSE OF THE INVESTIGATION

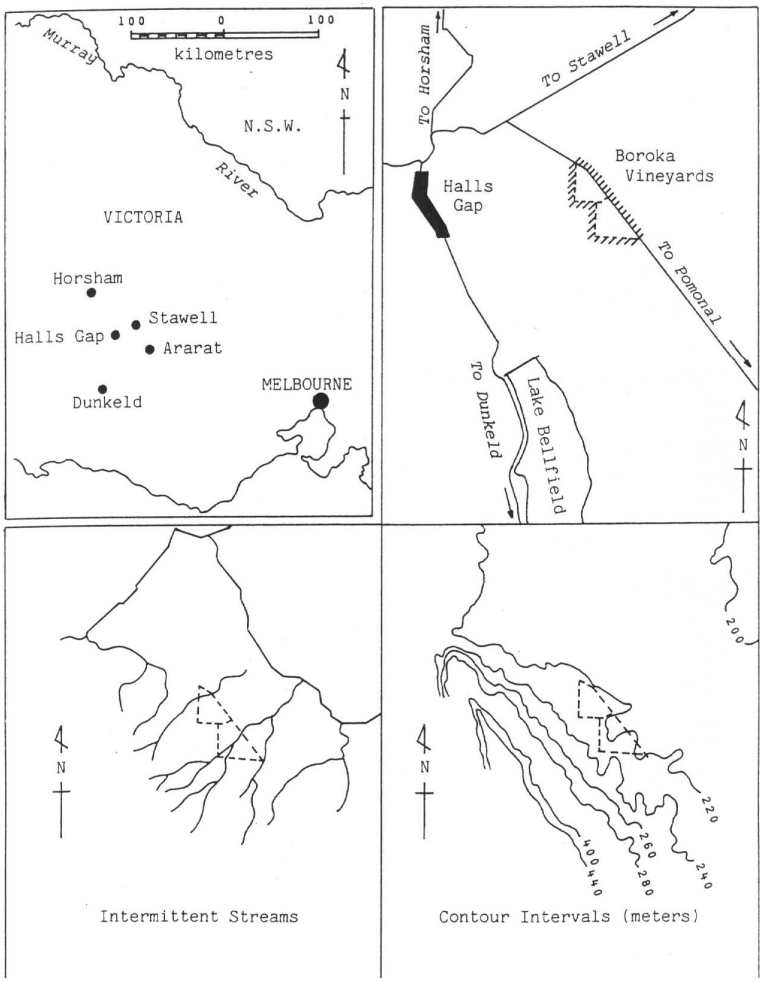
The Great Western and District Viticultural Association, representing the wine-grape growers in the Stawell, Ararat and Avoca districts indicated that in recent years the overall grape production in several vineyards has markedly declined owing to a fall in vine vigour. Variability in vine performance, differences in topography and relief, earlier reconnaissance survey work and local experience all suggest considerable variation in critical soil properties. Some of these properties may require special soil management practices if plantings are to remain viable. Since it is likely that such special management practices will be specific to different soils, it is appropriate to identify and locate (ie. classify and map) the various soils of the relevant areas.

The Victorian Department of Agriculture has conducted a soil survey aiming at describing and mapping the distribution of the various soil types used for growing grapevines in the shires of Stawell and Ararat. The field operation of the survey was carried out during autumn and spring, 1980.

The present report summarises the soil data and other relevant information obtained for the vineyards surveyed in the Halls Gap area. In this survey, nine different soils have been recognised and shown on a soil map. In addition to having adverse properties, some of these soil types occur on topographical positions unfavourable for the optimum performance of grapevines.

It is envisaged that the data included in this report will form the basis for initiating future soil-water-plant studies with the overall objectives of maximising wine-grape production in Western Victoria.

Figure 1: Locality Plan



SECTION 2 - GENERAL INFORMATION ABOUT THE AREA

2.1 Area and Location

The area surveyed is about 80 hectares located near Halls Gap, about 240 kilometres west north-west of Melbourne (Figure 1). It comprises allotments 66 and 67 in the Parish of Boroka, Shire of Ararat, County of Borung. The main areas included in the survey are vineyards and some pasture lands for which future vine planting is considered. Plantings included in allotment 66 are commercially known as Boroka Vineyards.

2.2 Climate

Because of the importance of the soil-climate interaction to the productivity of grapevines, main climatic elements are summarised below. For these summaries, weather data for selected stations relevant to the study area were obtained from up-to-date computer records supplied by the Bureau of Meteorology, Melbourne. However, of these stations, Stawell was the only one which recorded weather elements other than rainfall. Additionally, on-property rainfall records over the past eight years were available for the surveyed vineyards.

(a) Rainfall

The survey is located in an area with marked elevation differences which significantly affect the rainfall distribution. On average however, the surveyed vineyards receive an annual rainfall of about 790 mm. Usually 70-75% of these rains fall during the April-October period and the average amounts received during the remaining months are fairly even. Table 1 below, illustrates the distribution pattern of the long-term average rainfall through the year, using the data recorded at selected stations relevant to the surveyed area.

TABLE 1 - Average Rainfall (mm)* at Selected Stations near the Study Area

Station and no. of years of rainfall records	J	F	M	A	M	J	J	A	S	O	N	D	Year
Bellellen (77)	27	35	31	42	59	65	71	69	59	54	43	32	588
Halls Gap (90)	33	40	40	61	97	118	110	118	101	86	65	49	918
L. Lonsdale (68)	25	32	26	40	61	63	73	69	59	56	41	33	578
Pomonal (67)	27	35	34	50	72	95	87	86	76	68	50	40	720
Stawell (116)	26	31	30	40	54	62	57	59	55	52	40	31	537
Wartook Res. (91)	38	39	40	63	95	104	113	109	96	64	61	48	889
On-Property (8)	46	37	29	61	82	73	98	87	101	99	44	33	790

* Calculated, using RAINFALL data available for all years of record.

Data listed in Table 1 indicate that the distribution trend of the monthly rainfall averages through the year is fairly common for all selected stations. For the purpose of a diagrammatic presentation of the rainfall distribution (Figure 2) however, these stations have been separated into three groups according to their annual rainfall averages, i.e.

Group 1 : Bellellen, Lake Lonsdale and Stawell
Group 2 : Pomonal
Group 3 : Halls Gap and Wartook Reservoir

N.B. Due to the inadequate number of years for the On-Property records, they have been excluded from the grouping.

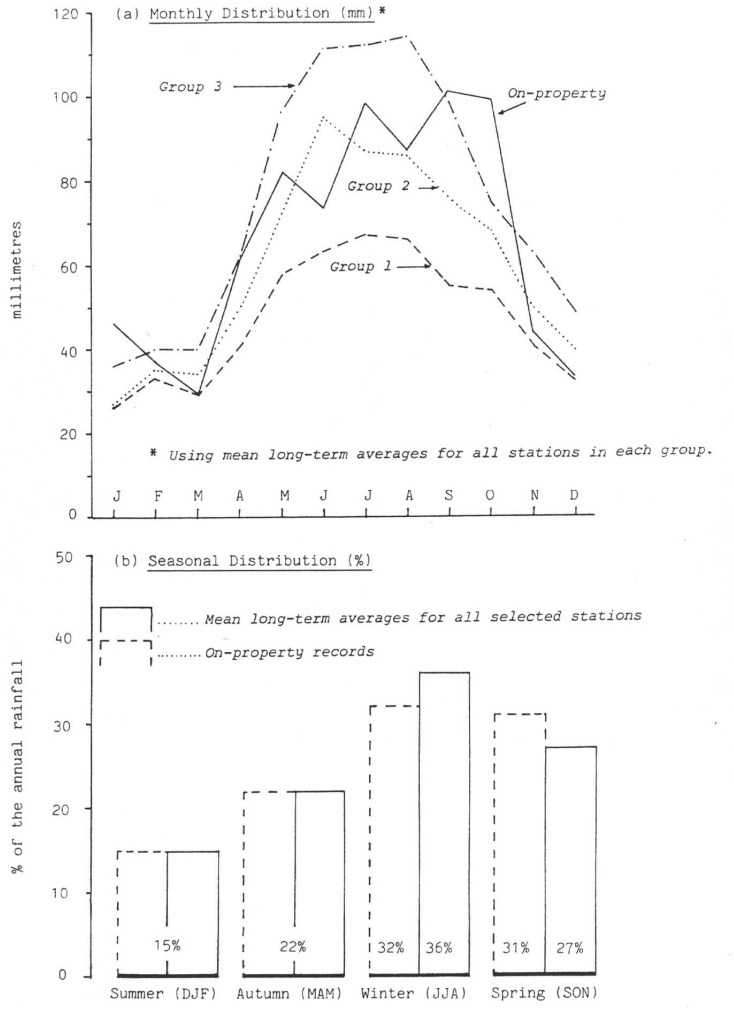


Figure 2: Distribution of the Annual Rainfall

(b) <u>Temperature</u>

Generally, the area has cool winters and hot summers. January and February are, usually, the hottest months of the year and July is the coolest. Temperatures fall rapidly during the autumn months and then more gradually with the onset of winter. Distribution pattern of the minimum temperatures through the year usually follows that of the maximum temperatures (Figure 3). Table 2, below, lists the long-term average temperature data obtained for Stawell.

TABLE 2 - Temperature Data* at Stawell

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Max ^{o}C	28.4	28.0	25.0	19.8	15.7	12.7	12.1	13.5	16.4	19.5	22.9	26.3
Min ^{o}C	12.8	13.2	11.5	9.0	6.9	4.8	4.1	4.8	6.1	7.7	9.6	11.4
Mean ^{o}C $^{\#}$	20.6	20.6	18.3	14.4	11.3	8.8	8.1	9.2	11.3	13.6	16.3	18.9

* Average 69 years

$^{\#}$ ½ (Max. + Min.)

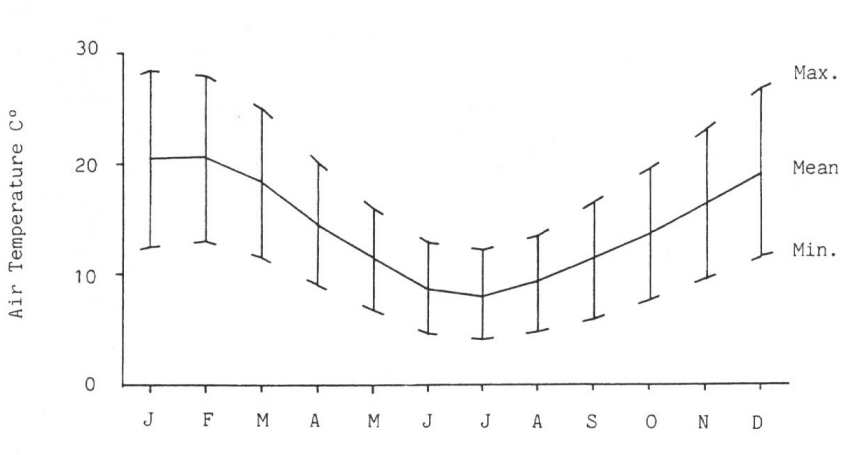


Figure 3: Average Monthly Temperatures at Stawell

(c) Relative Humidity

The aridity of the climate depends on total rainfall, temperature, and relative humidity. As for temperature, the relative humidity at 9 am approximates the mean value for the day (24 hours). The relative humidity at 3 pm, occurring around the warmest part of the day on the average, is representative of the lowest daily values. Similarly, the daily maximum relative humidity is usually in the early morning when air temperature is at a minimum. Table 3 and Figure 4, below, illustrate the distribution pattern of the relative humidity averages through the year, using the data recorded at Stawell.

TABLE 3 - Average Relative Humidity at Stawell*

Month	9 am		3 pm	
	Average	Range	Average	Range
	%	%	%	%
January	58	42 – 81	34	23 – 42
February	62	44 – 81	36	25 – 50
March	67	47 – 84	42	36 – 48
April	75	64 – 90	51	44 – 70
May	83	71 – 95	61	52 – 71
June	88	74 – 97	68	60 – 74
July	88	75 – 99	69	61 – 74
August	83	68 – 94	61	52 – 68
September	76	63 – 89	56	42 – 65
October	67	43 – 88	51	31 – 66
November	62	42 – 83	44	31 – 53
December	58	43 – 82	36	30 – 44

* Using available data for all years of record since 1905.

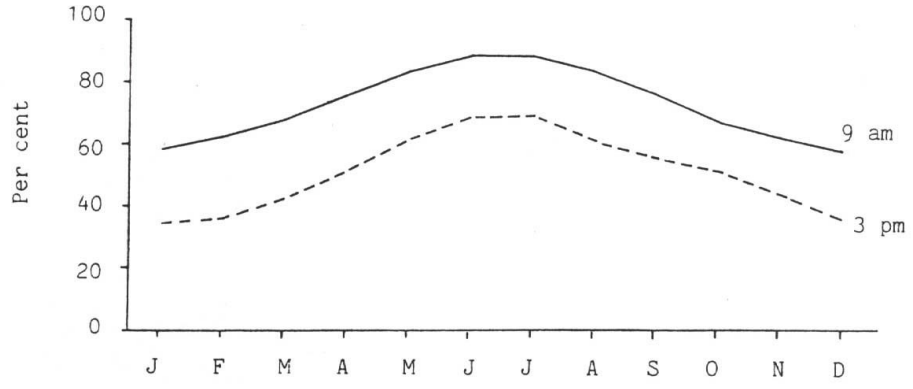


Figure 4: Average Relative Humidity of Stawell

(d) Frost

Light frosts usually occur when air temperatures drop below 2.2°C, while severe frosts are commonly associated with 0°C or lower. At Stawell, several frosts are common each year during the cooler period (May-October), although in some nearby locations, light frosts may occur as early as April and as late as November. Severe frosts however, do not usually occur in months other than June, July and August. Air temperature records indicate that the average frost-free period at Stawell is 258 days (Table 4, below).

TABLE 4 - Frost Data at Stawell*

Average Number of Frost Days												Year	Frost-free Period **
J	F	M	A	M	J	J	A	S	O	N	D		
0	0	0	0	2	7	8	5	3	1	0	0	26	258

* Using temperature data (number of days of 2.2°C or lower) available for all years of record since 1965.

** Period between last and first temperature of 2.2°C or lower in two successive years. Data listed in this column are from the Resources Survey, Wimmera Region (1951).

(e) Wind

Wind is a highly variable element, especially when blowing over a mountainous landscape similar to that adjacent to the area surveyed. The climatic records available (since 1965) indicate that at Stawell a yearly average of four days of strong wind (> 25 knots) occur in October, November, December and February (1 day/month).

(f) Sunshine and Radiation

There is a strong negative correlation between cloudiness and duration of bright sunshine. Also, like sunshine, global (short wave) radiation is affected by cloudiness, but to a different degree. Records of sky cloudiness available for Stawell, are summarised below (Table 5) in order to be used as a guide indicating the intensity and duration of sunshine and radiation in the study area.

*TABLE 5 - Sky Cloudiness Data for Stawell**

Element	J	F	M	A	M	J	J	A	S	O	N	D
Number of clear days ϕ	12	13	10	8	4	4	3	3	4	6	6	9
Number of cloudy days $\phi\ \phi$	6	5	7	11	15	14	16	14	12	11	10	8
Mean cloud cover (oktas):												
- @ 9 am	3	3	3	4	5	5	5	4	4	4	4	3
- @ 3 pm	3	3	4	5	6	6	6	6	5	5	4	4

* Using available data for all years of record since 1908.

ϕ Less than $^2/_8$ cloud cover.

$\phi\ \phi$ Greater than $^6/_8$ cloud cover.

SECTION 3 - SOIL SURVEY METHODS

3.1 Soil Mapping

Aerial photographs at a scale of 1:8,800 were used in this survey. Interpretations of their photo-patterns and phototones were examined before attempting the field work. In the field, observations were made regarding the landscape, topography and soils. The soils were described from borings, using a spade and a 10 cm diameter Jarret soil auger. Changes in topography and soils, aided by photo-interpretations were the basic criteria in delineating map unit boundaries.

The soils were mapped in the field on the basis of soil series, type and phase. A soil series consists of one or more soil types which have essentially similar profiles, particularly as regards subsoil conditions, but differ in the texture of the surface soil. A soil type may include one or more soil phases wherein a particular feature such as depth of surface soil or stoniness is emphasised. The soil types and their corresponding series have been given similar names, for example, Bellellen series has one type, Bellellen sandy loam. Stony profile and soft surface phases occur within this soil type.

Some areas with rapid changes over small distances, however, were mapped as complexes. Similarly, due to the scale of mapping, no attempt was made to separately map the gully soils which were found to be particularly variable. On the other hand, soils of limited occurrence in the area surveyed have been regarded as "minor soil types" and referred to by number, for example, Minor Type 1 (M.T.1).

Detailed descriptions were obtained for selected sites representing the mapping units. These descriptions included topography, condition of the surface soil and the morphological features of a 100 cm soil profile. At some sites, however, boring was abandoned at shallower depths due to the presence of rocks. Profile samples were collected for subsequent laboratory examination and the soils were classified using the Factual Key Classification System (Northcote, 1979).

On average, the density of the recorded sites was about 3 ha/site. It should be appreciated, however, that any unit shown on the soil map may have, intermixed with its main soils, small areas of other soil types or phases, but not to a greater extent than one tenth of the occurrence.

3.2 Sampling

3.2.1 Soil Sampling

At each site, samples were collected from the main morphological horizons of the soil profile. All samples were dried at 40^{o}C (forced draught) for 48 hours before being sub-sampled and prepared for the various physical and chemical analyses.

At selected sites, representing the different soil types, separate samples were taken from the surface layer (0-7.5 cm) for the determination of bulk density and degree of stoniness.

3.2.2 Water Sampling

In late spring-early summer, water samples were collected from all existing water sources currently used, or considered for future use, for irrigating the vineyards. These samples were analysed to assess their salinity levels.

3.3 Analyses

Listed below are the various determinations conducted on the soil and water samples with a reference to the methods used. Full details of the analytical methods, however, are described in the "Chemical Methods Handbook" published by the Division of Agricultural Chemistry, Department of Agriculture (Vic.), except where indicated otherwise.

3.3.1 Soil Analyses

(a) ***Surface soils (0-7.5 cm)***

On these soils, bulk density was determined using soil cores and the method outlined by McIntyre and Loveday (1974). Mineral fractions coarser than 2 mm were sieved and weighed. Their volume was estimated (a density of 2.7 was assumed). On the fine earths (soil material < 2 mm), water retentions at -15 bar (approximately 'Wilting Point') and $-^1/_3$ bar (approximately 'Field Capacity') were determined as outlined by McIntyre (1974) using a ceramic plate pressure unit (Soil-Moisture Equipment Co., California).

(b) ***Soil profile samples***

All profile samples were analysed for pH, electrical conductivity (EC) and chloride contents using a 1:5 soil (< 2 mm aggregates) – water suspension shaken for one hour. A glass electrode was used for the pH determinations and a conductivity cell and meter for the EC. Chloride, as % sodium chloride was determined by the electrometric titration method (Best, 1931).

Water retentions at -15 bar and $-^1/_3$ bar were also determined on all soil samples.

Aggregate structural stability was determined on 3-5 mm soil aggregates using the Emerson (1967) and Loveday (1974) dispersion tests.

(c) ***Representative soil profiles***

For each soil type, a representative soil profile was chosen for additional analyses; i.e.

- Particle – size Analysis – Estimating the distribution (%) of coarse sand, fine sand, silt and clay – sized fractions in the soil mass, using the Plummet balance method.

- Total Nitrogen (surface soil horizon only) – The Kjeldahl method was used.

- Organic Carbon (surface soil horizon only) – The wet combustion method of Walkley and Black was used. Results have been multiplied by an empirical recovery factor of 1.25.

- Exchangeable Cations – Basically the extraction method of Tucker (1974) was used for the removal of soluble salts and for leaching the cations, but at least three extractions were carried out for removal of soluble salts. The extractant used was 1 M. NH_4Cl in 60% alcohol at pH 8.5

In the leachate calcium, magnesium and potassium were determined by atomic absorption spectrophotometry, and sodium was determined by flame emission spectrophotometry. The individual cations have been expressed as milligram equivalents per 100 g of soil.

- Exchangeable Acidity – This is Mehlich's barium chloride – triethylamine method (reference point pH 8.0), using the modification of Peech et al. (1962). This method is applicable only to soils below pH 8.0.

- pH – This was determined by the glass electrode using a 1 to 5 soil water extract.

3.3.2 Water Analyses

The water samples were analysed for the following:-
- Electrical Conductivity (Total Soluble Salts)
- Chloride
- Soluble Cations (Calcium, Magnesium and Sodium)

SECTION 4 - SURVEY RESULTS

4.1 The Soils

Three different soil types and four phases, grouped under three soil series, were recognised in the survey. Also, two minor soil types of limited occurrence in some parts of the vineyards have been described.

Table 6 lists all the soil units mapped in the survey. The main morphological features of these units are outlined below, using modal profile descriptions in order to allow for the variability that will occur within each unit. The average values for physical and chemical properties are also listed for each soil unit using the analytical data obtained for all profiles recorded in that unit. For comparison, the data listed are those for the surface (0-7.5 cm) soil layer and three standard depths down the soil profile, i.e.

- depth A : 0-10 cm
- " B : The uppermost 30 cm segment of the clayey subsoil
- " C : 60-90 cm, unless augering was abandoned at a depth shallower than 90 cm.

Figure 5 diagrammatically present the average values for the soil types with regard to physical properties of their surface soils (0-7.5 cm) and Figure 6 shows the particle size distribution for selected profiles (0-100 cm).

TABLE 6 - Soil Units Mapped in the Survey

Series	Types	Phases
Boroka	. Boroka sandy clay loam	- Deep surface & stony profile
Bellellen	. Bellellen sandy loam	- Stony profile - Soft surface
Halls Gap	. Halls Gap sandy loam	- Non-stony profile
- -	Minor Soil Type –1 Minor Soil Type –2	- -

Although the occurrence of each soil in the survey area has been mapped separately, one complex unit was used to map the varied soils in the gully floors and the slight depressions. Soils of these areas recurred over short distances and included the following types:

- Halls Gap (non-stony profile)
- Minor Soil type –1
- Minor Soil type –2

The approximate area of each mapping unit (% of the total area surveyed) is listed in Table 7.

TABLE 7 - Distribution of the Mapping Units

Mapping Units	Area % (approx.)
Boroka Series	
Boroka sandy clay loam	3
" " " " (deep surface & stony profile)	2
Bellellen Series	
Bellellen sandy loam	10
" " " (stony profile)	27
" " " (soft surface)	5
Halls Gap Series	
Halls Gap sandy loam	23
Soil Complex	
Varied soils in gullies and slight depressions	30
	100

Detailed descriptions of selected soil profiles representing the mapping units are included in Appendix I and the analytical data of these profiles are listed in Appendix II. Figure 8, the soil map, shows the areal distribution of the various mapping units in the survey and the locations of the representative soil profiles

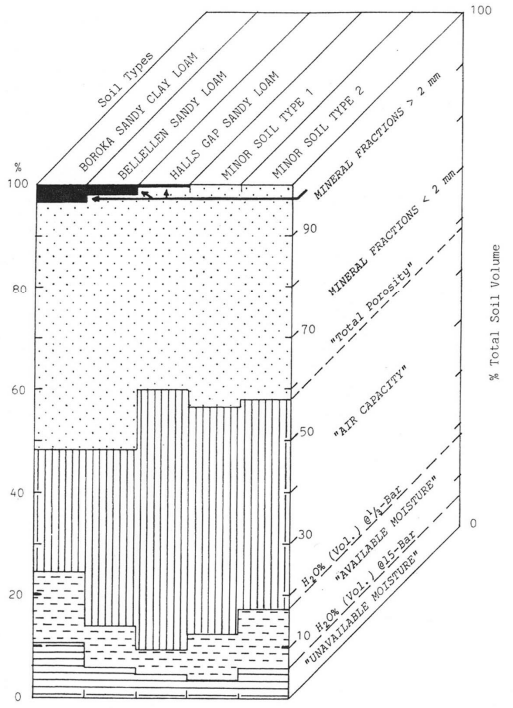


Figure 5: Physical Properties of the Surface Soils (0-7.5 cm)

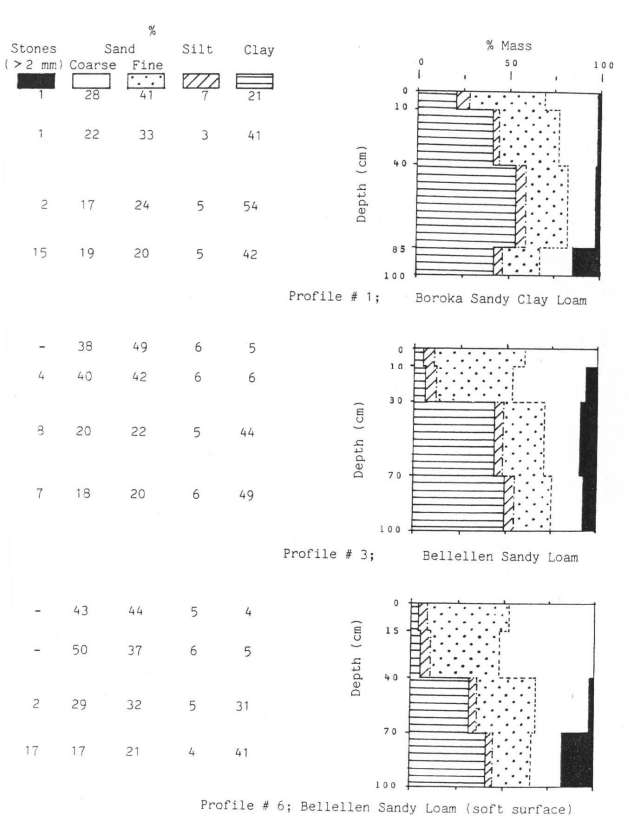


Figure 6: Particle Size Distribution for Selected Profiles

ΔΔΔΔ ***Boroka Series***

Soils included in this series have distinct texture contrasts between hard setting surface soil horizons and moderately to strongly pedal clayey subsoils. The uppermost subsoil layer, that is at least 15 cm thick, is whole-coloured and yellow. In the present survey, this series includes one soil type and one phase.

Boroka Sandy Clay Loam (BK scl)

Distinguishing Features

Surface Soil:

- 10-15 cm thick
- Brown to dark reddish brown
- Sandy clay loam
- A_2 "subsurface soil horizon" is absent

Subsoil:

- Strong brown to yellowish red gradually becoming mottled with red at about 35-45 cm. In the deep subsoils the degree of mottling increases and some gleyed colours may occur.
- Sandy clay
- Decomposed ferruginous sandy parent materials usually occur at about 70 cm and the soil profile often becomes impenetrable to a hand auger at about 80-100 cm due to bedrock.

Soil Inclusions:

- Trace to slight amounts of ferruginous concretions usually occur throughout the soil profile. Light amount however, may be found in the deep subsoils.

Analytical Data

(i) Analytical data for the surface soil (0-7.5 cm):

Stoniness (mineral fractions > 2 mm)	%	3.2
Bulk Density		
- Total soil material	g cm^{-3}	1.39
- Stoneless soil material	g cm^{-3}	1.26
Total Porosity	%	48.3
Void Ratio		0.97
Air Capacity	%	24.1
Moisture Retention		
- @ 15-Bar	%	7.8
- @ $^1/_3$-Bar	%	17.4

(ii) Analytical data for selected depths down the profile:

Depth	pH	Total Soluble Salts	Sodium Chloride *	Moisture Retention	
				@ 15-Bar	@ $^1/_3$-Bar
		%	%	%	%
A	6.2	0.017	-	8.6	18.0
B	5.9	0.011	-	16.1	23.3
C	6.1	0.007	-	18.7	24.8

* The dashes recorded in this column indicate negligible amounts of sodium chloride.

Occurrence

Boroka sandy clay loam is commonly found on the upper parts of the Grampian undulating lower outwash slopes.

Phases:

Deep surface and stony profile

- The depth to the clayey subsoil is 25-30 cm.
- A non-bleached A2 horizon may be present.
- Light to moderate amounts of stones occur throughout the subsoils.
- On average, the stone content of the surface layer (0-7.5 cm) is about 7%.
- Commonly occurs on the intermediate slopes.

ΔΔΔΔ ***Bellellen Series***

Soils included in this series have distinct texture contrasts between apedal surface soil horizons and moderately to strongly pedal clayey subsoils. The uppermost subsoil layer, that is at least 15 cm thick, is mottled and dominantly yellow. The surface soils are commonly hardsetting. In the present survey, this series includes one soil type and two phases.

Bellellen Sandy Loam (BL sl)

Distinguishing Features

Surface Soil:

A_1 horizon:

- Hardsetting when dry
- 10-15 cm thick
- Brown to dark greyish brown
- Sandy loam

A_2 horizon:

- About 20 cm thick (range 10-25 cm)
- Strong brown to very pale brown, conspicuously bleached
- Loamy sand to sandy loam

Subsoil:

- Mottled yellowish brown (or brownish yellow) and red. The red colours increase gradually with depth.
- Medium clay (with some sand), changing gradually to sandy clay in the deep subsoils.

Soil Inclusions:

- Trace to slight amounts of ferruginous concretions may occur at any depth of the soil profile.

Analytical Data

(i) Analytical data for the surface soil (0-7.5 cm):

Stoniness (mineral fractions > 2 mm)	%	1.8
Bulk Density		
- Total soil material	g cm^{-3}	1.39
- Stoneless soil material	g cm^{-3}	1.34
Total Porosity	%	48.5
Void Ratio		0.96
Air Capacity		34.6
Moisture Retention		
- @ 15-Bar	%	4.4
- @ $^1/_3$-Bar	%	10.0

(ii) Analytical data for selected depths down the profile:

Depth	pH	Total Soluble Salts	Sodium Chloride *	Moisture Retention	
				@ 15-Bar	@ $^1/_3$-Bar
		%	%	%	%
A	6.2	0.012	-	4.8	9.8
B	6.0	0.012	-	13.8	21.4
C	6.2	0.016	-	17.7	25.7

* The dashes recorded in this column indicate negligible amounts of sodium chloride.

Occurrence

Bellellen sandy loam commonly occurs on the intermediate parts of the Grampian undulating lower outwash slopes.

Phases:

(a) Stony profile

- Upon drying-out, the surface soil sets hard.
- The depth to the clayey subsoil is 30-40 cm.
- The A_2 horizon is 15-25 cm thick.
- Varied amounts of ferruginous concretions occur throughout the soil profile. Higher amounts (light to moderate) are usually common in the subsoils.
- On average, the stone content of the surface layer (0-7.5 cm) is about 3%.
- Usually occurs on the upper slopes.

(b) Soft surface

- Over the complete range of soil moisture content, the surface soil remains soft (non-hardsetting).

- The total depth to the clayey subsoil is 40-45 cm.
- The A_2 horizon is 25-35 cm thick.
- Occurs on the intermediate and upper parts of the slopes.

ΔΔΔΔ ***Halls Gap Series***

Soils included in this series have distinct texture contrasts between hard setting surface soil horizons and weakly pedal (or pedal) clayey subsoils. The uppermost subsoil layer, that is at least 15 cm thick is mottled and dominantly yellow. In the present survey, this series includes one soil type and one phase.

Halls Gap Sandy Loam (HG sl)

Distinguishing Features

Surface Soil:

A_1 horizon:
- Slightly compacted (firm)
- 20-30 cm thick
- Dark greyish brown to very dark grey
- Sandy loam

A_2 horizon:
- About 70 cm thick (range 50-90 cm), usually consists of more than one subsurface soil layer.
- Brown, yellowish brown or pink. Bleaching occurs at various depths and is usually conspicuous in the zone immediately above the clayey subsoil.
- Loamy sand.

Subsoil:
- Mottled strong brown and very pale brown or light grey
- Sandy clay

Soil Inclusions:
- Occasionally, trace amounts of ferruginous concretions occur in the A_1 horizons.
- The A_2 horizons are usually stony throughout with maximum concentrations of gravel (moderate amounts) occurring at various depths.
- In the subsoils, the amounts of stones decrease to slight or trace.

Analytical Data

(i) Analytical data for the surface soil (0-7.5 cm):

Stoniness (mineral fractions > 2 mm)	%	0.3
Bulk Density		
- Total soil material	g cm^{-3}	1.09
- Stoneless soil material	g cm^{-3}	1.07
Total Porosity	%	59.6
Void Ratio		1.50
Air Capacity	%	50.2
Moisture Retention		
- @ 15-Bar	%	4.2
- @ $^1/_3$-Bar	%	8.6

(ii) Analytical data for selected depths down the profile:

Depth	pH	Total Soluble Salts	Sodium Chloride *	Moisture Retention	
				@ 15-Bar	@ $^1/_3$-Bar
		%	%	%	%
A	5.6	0.008	-	3.7	6.9
B	6.7	0.017	-	8.8	13.8
C	6.2	0.005	-	3.4	6.5

* The dashes recorded in this column indicate negligible amounts of sodium chloride.

Occurrence

In the surveyed area, Halls Gap sandy loam is commonly found on the intermediate and upper slopes.

Phases:

Non-stony profile

- Only trace amounts of ferruginous concretions may occur in the subsoils.
- Trace or slight amounts of dark reddish brown 'coffee rock' fragments usually occur in some parts of the A_2 horizons.

ΔΔΔΔ **Minor Soil Types**

Discussed below are two minor soil types, none of which fitted the descriptions of any of the soil types mentioned above. Because of the limited extent of both minor types, the following descriptions and analyses have been generally based on only few observations. The two minor types occur, mixed with other varied soils, in gullies and shallow depressions.

Minor Soil Type 1 (M.T.1)

Distinguishing Features

- Duplex texture profile, i.e. distinct texture contrasts between the surface soils and the clayey subsoils.
- Condition of the surface soil is hardsetting.
- The A_1 (surface soil horizon) is about 30 cm thick, dark greyish brown to very dark grey sandy loam.
- The A_2 (subsurface soil horizon) is 10-15 cm thick, brown, conspicuously bleached, sandy loam.
- The B horizons (the clayey subsoils) are whole-coloured yellowish brown or brown sandy clay. Mottled red-colours occur at depth.
- Few, if any, peds are evident in the clayey B horizons.
- Occasional amounts of ferruginous concretions may occur in the deep subsoils.
- Generally the soil profile is deep (> 100 cm) and is almost stone-free.

Analytical Data

(i) Analytical data for the surface soil (0-7.5 cm):

Stoniness (mineral fractions > 2 mm)	%	0.1
Bulk Density		
- Total soil material	g cm^{-3}	1.17
- Stoneless soil material	g cm^{-3}	1.17
Total Porosity	%	56.7
Void Ratio		1.31
Air Capacity	%	43.9
Moisture Retention		
- @ 15-Bar	%	3.1
- @ $^1/_3$-Bar	%	10.9

(ii) Analytical data for selected depths down the profile:

Depth	pH	Total Soluble Salts	Sodium Chloride *	Moisture Retention	
				@ 15-Bar	@ $^1/_3$-Bar
		%	%	%	%
A	5.8	0.009	-	4.2	13.1
B	6.0	0.006	-	6.1	15.2
C	6.2	0.004	-	6.9	16.2

* The dashes recorded in this column indicate negligible amounts of sodium chloride.

Minor Soil Type 2 (M.T.2)

Distinguishing Features

- Duplex texture profile, i.e. distinct texture contrasts between the surface soils and the clayey subsoils.
- Condition of the surface soil is hardsetting.
- The A_1 (surface soil horizon) is 10-15 cm thick, brown sandy clay loam.
- The A_2 (subsurface soil horizon) is 60-80 cm thick, brown to yellowish brown, conspicuously bleached when dry, loamy sand to sandy loam.
- A compacted strongly bleached massive capping (10-20 cm thick) often occurs at the junction between the A_2 and B horizons.
- The B horizons (the clayey subsoils) are mottled brown (or yellowish brown) and greyish brown sandy clay, moderately pedal.
- Only trace amounts of ferruginous concretions may occur in the subsoils.
- Generally the soil profile is deep (> 100 cm) and is almost stone-free.

Analytical Data

(i) Analytical data for the surface soil (0-7.5 cm):

Stoniness (mineral fractions > 2 mm)	%	0.0
Bulk Density		
- Total soil material	g cm^{-3}	1.13
- Stoneless soil material	g cm^{-3}	1.13
Total Porosity	%	58.1
Void Ratio		1.39
Air Capacity	%	40.7
Moisture Retention		
- @ 15-Bar	%	5.1
- @ $^1/_3$-Bar	%	15.4

(ii) Analytical data for selected depths down the profile:

Depth	pH	Total Soluble Salts	Sodium Chloride *	Moisture Retention	
				@ 15-Bar	@ $^1/_3$-Bar
		%	%	%	%
A	6.1	0.042	-	4.2	14.3
B	6.4	0.010	-	10.2	22.5
C	6.5	0.006	-	9.0	18.2

* The dashes recorded in this column indicate negligible amounts of sodium chloride.

4.2 The Irrigation Water

Quality aspects were determined on water samples from three sources used for irrigating parts of the surveyed vineyards. Two of these sources were dams and the third was a bore. The

locations of the three water sources are shown on Figure 7 with a reference indicating the areas they currently irrigate. Analytical data obtained for the water samples are listed in Table 8, below.

TABLE 8 - Analytical Data for Water Samples

Sample Reference	EC *	TSS **	Cl^- ***	Soluble Cations				SAR $\phi\phi$
				Ca^{++}	Mg^{++}	Na^+		
	µS/cm	ppm	ppm	m.e/l	m.e/l	m.e/l	$\%\phi$	
Dam # 1	166	138	37	0.12	0.43	1.09	66.5	2.08
Dam # 2	224	176	79	0.15	0.38	1.57	74.8	3.05
Bore	964	641	315	0.15	1.86	6.15	75.4	6.13

* Electrical Conductivity at 20°C.
** Total Soluble Salts.
*** Chlorides as sodium chloride (common salt).
ϕ Sodium Percentage = $100\ (Na^+)/Ca^{++} + Mg^{++} + Na^+$
$\phi\phi$ Sodium – Adsorption – Ratio = $Na^+/\sqrt{(Ca^{++} + Mg^{++})/2}$

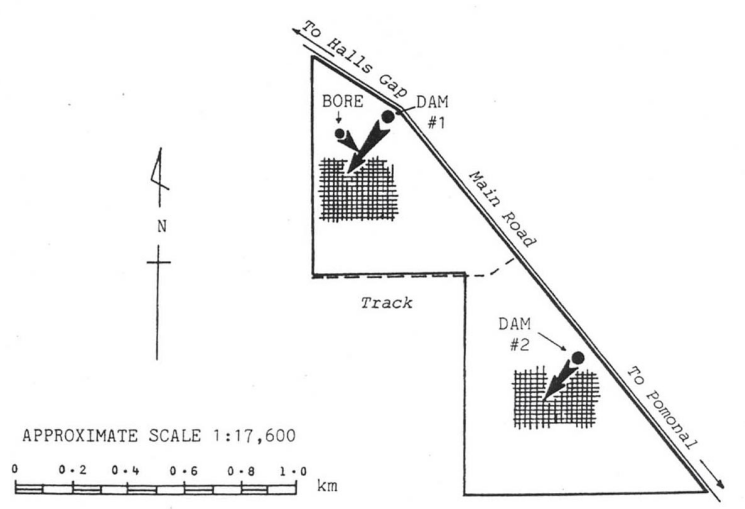


Figure 7 - Locations of Irrigation Water Sources and the Areas They Currently Irrigate

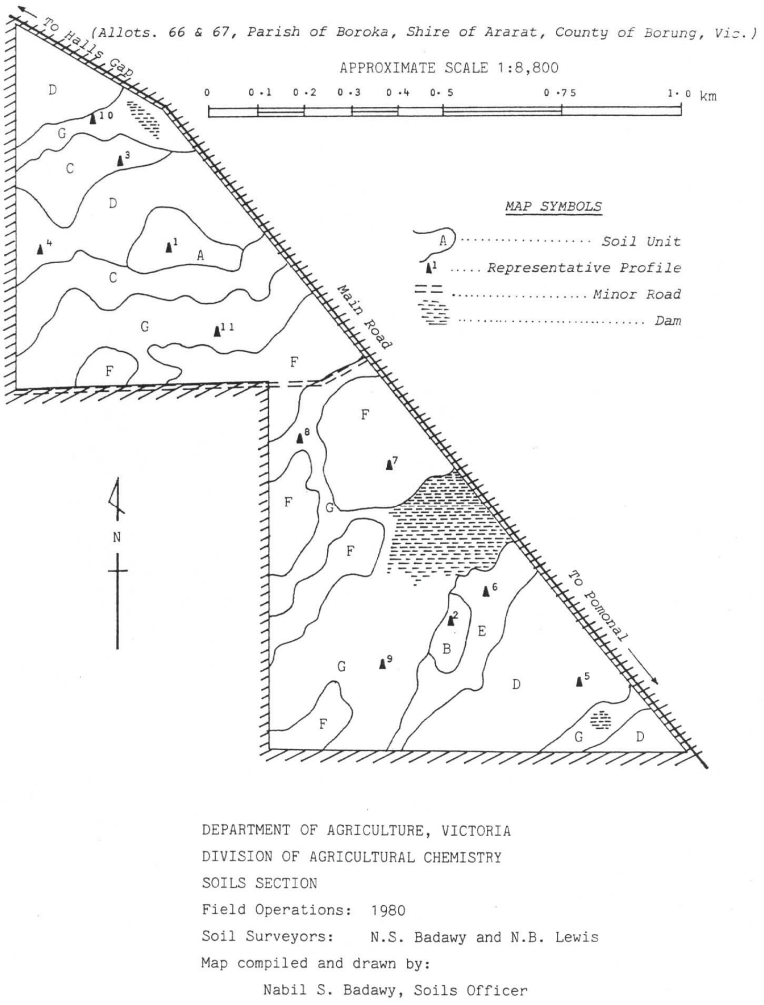


Figure 8 - Soil Map of the Vineyards of the Halls Gap District

LEGEND

(i) Mapping Units

Unit	Soils
A	Boroka sandy clay loam [BK scl]
B	Boroka sandy clay loam (deep surface & stony profile) [BK scl (d & s)]
C	Bellellen sandy loam [BL sl]
D	Bellellen sandy loam (stony profile) [BL sl (s)]
E	Bellellen sandy loam (soft surface) [BL sl (nhs)]
F	Halls Gap sandy loam [HG sl]
G	Soil Complex "varied soils in gullies and shallow depressions"; including: - Halls Gap sandy loam (non-stony profile) [HG sl (ns)] - Minor soil type 1 [M.T.1] - Minor soil type 2 [M.T.2]

(ii) Representative Profiles

Map Reference	Report Reference	Soil Classification	
		PPF (Northcote '79)	Soil Type
Δ 1	Prof. # 1	Dy 2.11/SCL (10 cm)	BK scl
Δ 2	Prof. # 2	Dy 2.11/SCL (25 cm)	BK scl (d & s)
Δ 3	Prof. # 3	Dy 3.41/SL (30 cm)	BL sl
Δ 4	Prof. # 4	Dy 3.41/SL (40 cm)	BL sl (s)
Δ 5	Prof. # 5	Dy 3.41/LS (30 cm)	"
Δ 6	Prof. # 6	Dy 5.41/SL (40 cm)	BL sl (nhs)
Δ 7	Prof. # 7	Dy 3.81/SL (80 cm)	HG sl
Δ 8	Prof. # 8	Dy 3.81/SL (90 cm)	HG sl (ns)
Δ 9	Prof. # 9	Dy 3.82/LS (120 cm)	"
Δ 10	Prof. # 10	Dy 2.81/SL (40 cm)	M.T.1
Δ 11	Prof. # 11	Dy 3.41/SCL (80 cm)	M.T.2

REFERENCES

Anon (1961) – Resources Survey, Wimmera Region. Central Planning Authority, Government of Victoria.

Best (1931) – Trans. 4th Int. Congr. Soil Sci. 3: 162.

Emerson, W.W. (1967) – A classification of soil aggregates based on their coherence in water. Aust. J. Soil Res. 5 : 47-57

McIntyre, D.S. (1974) – Water Retention and the Moisture Characteristics. In 'Methods for Analysis of Irrigated Soils' ed. J. Loveday, pp 43-62 Techn. Commun. No. 54 Commonw. Bur. Soils. Comm. Agr. Bureaux.

McIntyre, D.S. and Loveday, J. (1974) – Bulk Density. In 'Methods for Analysis of Irrigated Soils' ed. J. Loveday, pp 38-42 Techn. Commun. No. 54 Commonw. Bur. Soils. Comm. Agr. Bureaux.

Northcote, K. H. (1979) – 'A Factual Key for the Recognition of Australian Soils'. 4th Edition. (Rellim: Glenside, S.A.).

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The author extends his sincere thanks to all of these people.

APPENDIX I - DESCRIPTION OF REPRESENTATIVE SOIL PROFILES

Boroka Sandy Clay Loam

Profile # 1

Profile Reference: WM 13/5
Topography: Top of a gentle slope.
Soil Classification: Dy 2.11/SCL (10 cm)
Soil Description:

Surface Soil

0 – 10 cm; brown (7.5YR4/4m) sandy clay loam; apedal, hard setting; hard (dry), slight friable (moist), non-plastic and slightly sticky (wet); trace amounts of ferruginous concretions; sharp boundary to:

Subsoil

10 – 40 cm strong brown (7.5YR5/8m) sandy medium clay; moderate fine and medium angular blocky structure; smooth-ped fabric; hard (dry), slight friable (moist), moderately plastic and sticky (wet); trace amounts of ferruginous concretions; gradual boundary to:

40 – 85 cm; as above but; mottled strong brown (7.5YR5/8m) and red (2.5YR4/8m); slightly hard (dry), friable (moist); clear boundary to:

85 – 100 cm^{+}; as above but; mottled strong brown (7.5YR5/8m), reddish brown (5YR4/4m) and light brownish grey (2.5Y6/2m); light amounts of ferruginous concretions.

Boroka Sandy Clay Loam (Deep Surface & Stony Profile)

Profile # 2

Profile Reference: WM 13/13
Topography: Mid-moderate slope.
Soil Classification: Dy 2.11/SCL (25 cm)
Soil Description:

Surface Soil

0 – 10 cm; brown (7.5YR4/4m) sandy clay loam; apedal, hard setting; slightly hard (dry), friable (moist), non-plastic and slightly sticky (wet); trace amounts of ferruginous concretions; sharp boundary to:

10 – 25 cm; as above but; yellowish red (5YR5/6m); sharp boundary to:

Subsoil

25 – 55 cm yellowish red (5YR5/6m) and some medium clay (sandy), moderate fine and medium angular blocky structure; smooth-ped fabric; slightly hard (dry), friable (moist), plastic and sticky (wet); moderate amounts of ferruginous concretions; clear boundary to:

55 – 80 cm; as above but; mottled yellowish red (5YR5/6m), dark red (2.5YR3/6m) and pale brown (10YR6/3m); bedrock (or a hardpan) at 80 cm.

Bellellen Sandy Loam

Profile # 3

Profile Reference:	WM 13/1
Topography:	Mid-moderate slope.
Soil Classification:	Dy 3.41/SL (30 cm)
Soil Description:	

Surface Soil

0 – 10 cm;	brown (10YR5/3m) sandy loam; apedal, hard setting; soft (dry), friable (moist), non-plastic and non sticky (wet); sharp boundary to:
10 – 30 cm;	light yellowish brown (10YR6/4m) conspicuously bleached very pale brown (10YR7/3d) loamy sand; apedal, massive; moderately hard (dry), moderately friable (moist), non-plastic and non-sticky (wet); trace amounts of ferruginous concretions; sharp boundary to:

Subsoil

30 – 70 cm	mottled brownish yellow (10YR6/8m) and red (2.5YR4/6m) medium clay (sandy); moderate fine angular blocky structure; smooth-ped fabric; moderately hard (dry), moderately friable (moist), plastic and sticky (wet); slight amounts of ferruginous concretions; gradual boundary to:
70 – 100 cm^{+};	as above but; the red increases and the soil texture becomes more sandier (i.e. sandy medium clay).

Bellellen Sandy Loam Stony Profile)
(two representative profiles)

(A) Profile # 4

Profile Reference:	WM 13/4
Topography:	Top of a very gentle slope.
Soil Classification:	Dy 3.41/SL (40 cm)
Soil Description:	

Surface Soil

0 – 10 cm;	yellowish brown (10YR5/4m) sandy loam; apedal, hard setting; soft (dry), friable (moist), non-plastic and non sticky (wet); slight amounts of ferruginous concretions; sharp boundary to:
10 – 40 cm;	as above but; brownish yellow (10YR6/6m) conspicuously bleached very pale brown (10YR7/4d); the amounts of stones increase to moderate; clear boundary to:

Subsoil

40 – 60 cm	mottled yellowish brown (10YR5/8m) and light reddish brown (2.5YR6/4m) sandy light clay (gritty), moderate fine and medium sub-angular blocky structure; smooth-ped fabric; slightly soft (dry), slightly friable (moist), slightly plastic and moderately sticky (wet); light amounts of ferruginous concretions; gradual boundary to:
60 – 90 cm;	as above but; strong brown (7.5YR5/8m) and some red medium clay (sandy); gradual boundary to:

90 – 100 cm^{+}; as above but; mottled strong brown (7.5YR5/8m) and red (2.5YR4/6m).

(B) Profile # 5 (Bellellen Sandy loam 'Stony profile')

Profile Reference: WM 13/17
Topography: Mid-gentle slope.
Soil Classification: Dy 3.41/LS (30 cm)
Soil Description:

Surface Soil

0 – 15 cm; dark greyish brown (10YR4/2m) loamy sand; apedal, hard setting; soft (dry), friable (moist), non-plastic and non sticky (wet); trace amounts of ferruginous concretions; sharp boundary to:

15 – 30 cm; as above but; brownish yellow (10YR6/6m) conspicuously bleached very pale brown (10YR7/4d); sharp boundary to:

Subsoil

30 – 60 cm mottled brownish yellow (10YR6/8m) and red (2.5YR4/6m) medium clay (sandy); moderate fine and medium sub-angular blocky structure; smooth-ped fabric; slightly soft (dry), friable (moist), moderately plastic and sticky (wet); light amounts of ferruginous concretions; clear boundary to:

60 – 90 cm; as above but; mottled yellowish brown (10YR5/8m), red (2.5YR4/6m) and light yellowish brown (10YR6/4m); the amounts of stones increase to moderate; gradual boundary to:

90 – 100 cm^{+}; as above but; mottled yellowish brown (10YR5/8m), light grey (2.5Y7/2m) and dark red (2.5YR3/6m).

Bellellen Sandy Loam (Soft Surface)

Profile # 6

Profile Reference: WM 13/12
Topography: Upper-very gentle slope.
Soil Classification: Dy 5.41/SL (40 cm)
Soil Description:

Surface Soil

0 – 15 cm; dark greyish brown (10YR4/2m) sandy loam; apedal, loose; soft (dry), very friable 'loose' (moist), non-plastic and non-sticky (wet); sharp boundary to:

15 – 40 cm; light yellowish brown (10YR6/4m) conspicuously bleached white (10YR8/2d) loamy sand; apedal, massive; slightly hard (dry), friable (moist), non-plastic and non-sticky (wet); clear boundary to:

Subsoil

40 – 70 cm mottled yellowish brown (10YR5/8m) and yellowish red (5YR5/8m) medium clay (sandy); moderate fine and medium angular blocky structure; smooth-ped fabric; slightly hard (dry), friable (moist), plastic and sticky (wet); trace amounts of ferruginous concretions; clear boundary to:

70 – 100 cm^{+}; as above but; mottled light yellowish brown (10YR6/4m), red (2.5YR4/6m) and strong brown (7.5YR5/8m) sandy medium clay; light amounts of ferruginous concretions.

Halls Gap Sandy Loam

Profile # 7

Profile Reference: WM 13/21
Topography: Upper-very gentle slope.
Soil Classification: Dy 3.81/SL (80 cm)
Soil Description:

Surface Soil

0 – 30 cm; very dark grey (10YR3/1m) sandy loam; apedal, slightly compacted (hard setting); soft (dry), very friable (moist), non-plastic and non sticky (wet); trace amounts of ferruginous concretions; clear boundary to:

30 – 70 cm; as above but; mottled brown (10YR5/3m) and strong brown (7.5YR5/8m) sporadically bleached very pale brown (10YR7/3d) loamy sand; moderate to heavy amounts of ferruginous concretions; sharp boundary to:

70 – 80 cm; as above but; pink (7.5YR7/4m) conspicuously bleached white (10YR8/2d); the amounts of stones decrease to light; sharp boundary to:

Subsoil

80 – 120 cm^{+}; mottled strong brown (7.5YR5/8m) and very pale brown (10YR7/3m) sandy medium clay; weakly pedal; slightly hard (dry), friable (moist), moderately plastic and sticky (wet); trace amounts of ferruginous concretions.

Halls Gap Sandy Loam (Non-Stony Profile)
(two representative profiles)

(A) Profile # 8

Profile Reference: WM 13/18
Topography: Gully floor.
Soil Classification: Dy 3.81/SL (90 cm)
Soil Description:

Surface Soil

0 – 30 cm; very dark greyish brown (10YR3/2m) sandy loam; apedal; slightly compacted (hard setting); soft (dry), friable (moist), non-plastic and non sticky (wet); clear boundary to:

30 – 60 cm; as above but; brown (7.5YR5/2m) conspicuously bleached pinkish grey (7.5YR7/2d) loamy sand; clear boundary to:

60 – 90 cm; as above but; light reddish brown (5YR6/3m) conspicuously bleached pinkish grey (5YR7/2d); sharp boundary to:

Subsoil

90 – 120 cm^{+}; mottled strong brown (7.5YR5/6m) and light grey (10YR7/1m) heavy clay; weakly pedal; hard (dry), non-friable (moist), very plastic and sticky (wet); trace amounts of ferruginous concretions.

(B) Profile # 9 (Halls Gap sandy loam 'Non-stony profile')

Profile Reference: WM 13/24
Topography: Lower moderate slope (slight gully).
Soil Classification: Dy 3.82/LS (120 cm)
Soil Description:

Surface Soil

0 – 20 cm; dark grey (10YR4/1m) loamy sand; apedal, slightly compacted (hard setting); soft (dry), friable (moist), non-plastic and non sticky (wet); clear boundary to:

20 – 60 cm; as above but; light yellowish brown (10YR6/4m) conspicuously bleached very pale brown (10YR7/3d); clear boundary to:

60 – 90 cm; brown (7.5YR4/4m) with fragments of dark reddish brown "coffee rocks" (5YR3/2m) loamy sand; apedal; massive; slightly hard (dry), moderately friable (moist), non plastic and non sticky (wet); clear boundary to:

90 – 120 cm; as above but; yellow (10YR7/6m) and strong brown conspicuously bleached white (10YR8/2d); soft (dry), friable (moist); clear boundary to:

Subsoil

120 – 135 cm^{+}; mottled strong brown (7.5YR5/8m) and light grey (10YR7/2m) sandy clay; weakly pedal; slightly hard (dry), moderately friable (moist), slightly plastic and sticky (wet).

Minor Soil Type 1

Profile # 10

Profile Reference: WM 13/10
Topography: Gully floor.
Soil Classification: Dy 2.81/SL (40 cm)
Soil Description:

Surface Soil

0 – 30 cm; very dark grey (10YR3/1m) sandy loam; apedal, hard setting; soft (dry), friable (moist), non-plastic and non sticky (wet); sharp boundary to:

30 – 40 cm; as above but; pale brown (10YR6/3m) conspicuously bleached light grey (10YR7/2d); slightly soft (dry); clear boundary to:

Subsoil

40 – 70 cm; yellowish brown (10YR5/8m) sandy light clay; weakly pedal; slightly hard (dry), moderately friable (moist), slightly plastic and sticky (wet); gradual boundary to:

70 – 100 cm^{+}; as above but; mottled yellowish brown (10YR5/8m) and red (2.5YR4/8m) sandy medium clay; occasional amounts of ferruginous concretions.

Minor Soil Type 2

Profile # 11

Profile Reference:	WM 13/8
Topography:	Gully floor.
Soil Classification:	Dy 3.41/SCL (80 cm)
Soil Description:	

Surface Soil

0 – 10 cm;	brown (10YR4/3m sandy clay loam; apedal, hard setting; slightly soft (dry), friable (moist), non-plastic and non-sticky (wet); sharp boundary to:
10 – 60 cm;	as above but; pink (7.5YR7/4m) conspicuously bleached white (5YR8/1d) loamy sand; occasional amounts of ferruginous concretions; clear boundary to:
60 – 80 cm;	as above but; mottled pink (7.5YR7/4m), strong brown (7.5YR5/8m) and brownish yellow (10YR6/6m) conspicuously bleached white sandy clay loam; clear boundary to:

Subsoil

80 – 100 cm^{+};	mottled strong brown (7.5YR5/8m) and greyish brown (10YR5/2m) sandy medium clay; moderate coarse columnar structure breaking into medium angular blocky smooth-faced peds (smooth-ped fabric); hard (dry), non-friable (moist), plastic and sticky (wet); trace amounts of ferruginous concretions.

APPENDIX II - ANALYTICAL DATA FOR REPRESENTATIVE PROFILES

Depth (cm)	Field Texture (1)	pH	T.S.S (%) (2)	Chloride "as NaCl" (%) (3)	Total N (% ad)	Org. C (% ad)	Exchangeable Cations "milliequivalents per 100g soils					Aggregate Stability		Moisture (%)	
							Ca	Mg	K	Na	H	Class (4)	Index (5)	-15 Bar (6)	$-^{1}/_{3}$ Bar (7)
PROFILE # 1; BOROKA SANDY CLAY LOAM; Dy 2.11/SCL (10 cm)															
0 – 10	SCL	5.8	0.022	-	0.101	2.00	2.0	1.1	0.6	0.2	7.8	3	7	7.9	19.0
10 – 40	SC (m)	5.8	0.007	-			1.0	2.1	0.3	0.1	7.1	3	1	12.5	21.0
40 – 85	SC (m)	5.9	0.007	-			0.7	3.4	0.3	0.2	7.5	5	0	17.7	25.0
85 – 100	SC (m)	6.0	0.007	-			0.3	4.0	0.3	0.2	6.4	5	0	17.2	24.5
PROFILE # 2; BOROKA SANDY CLAY LOAM (Deep Surface & Stony Profile); Dy 2.11/SCL (25 cm)															
0 – 10	SCL	6.6	0.013	-	0.185	2.80	5.3	1.0	0.5	0.3	8.1	3	4	9.3	17.0
10 – 25	SCL	8.0	0.086	0.010			3.2	0.8	0.2	0.2	3.8	3	6	8.1	14.1
25 – 55	MC (s)	5.9	0.014	-			1.7	3.2	0.2	0.2	10.0	3	8	19.7	25.5
55 – 80	MC (s)	6.3	0.006	-			0.7	4.1	0.3	0.3	8.0	5	0	19.8	24.9
PROFILE # 3; BELLELLEN SANDY LOAM; Dy 3.41/SL (30 cm)															
0 – 10	SL	6.2	0.006	-	0.054	1.10	1.0	0.5	0.2	0.1	3.4	3	4	4.1	10.3
10 – 30	LS	6.1	0.003	-			0.5	0.5	0.2	0.1	3.0	3	6	4.0	9.1
30 – 70	MC (s)	6.1	0.007	-			1.0	2.8	0.5	0.3	7.9	5	0	18.6	25.8
70 – 100	SC (m)	6.1	0.009	-			0.8	3.6	0.5	0.3	7.8	5	0	20.6	28.0
PROFILE # 4; BELLELLEN SANDY LOAM (Stony Profile); Dy 3.41/SL (40 cm)															
0 – 10	SL	5.9	0.004	-	0.058	1.10	0.8	0.3	0.2	0.1	6.3	3	5	3.8	8.9
10 – 40	SL (gr)	5.9	0.004	-			0.4	0.6	0.1	0.1	3.3	3	6	4.2	8.9
40 – 60	SC (lt)	5.9	0.010	-			0.7	2.2	0.2	0.1	6.8	5	0	12.9	22.9
60 – 90	MC (s)	5.7	0.009	-			0.7	2.9	0.3	0.3	8.9	5	0	19.5	26.5
90 – 100	MC (s)	5.8	0.010	-			0.8	3.1	0.2	0.3	9.1	5	0	19.3	27.5

Depth (cm)	Field Texture (1)	pH	T.S.S (%) (2)	Chloride "as NaCl" (%) (3)	Total N (% ad)	Org. C (% ad)	Exchangeable Cations "milliequivalents per 100g soils					Aggregate Stability		Moisture (%) @	@
							Ca	Mg	K	Na	H	Class (4)	Index (5)	-15 Bar (6)	-1/3 Bar (7)
PROFILE # 5; BELLELLEN SANDY LOAM (Stone Profile); Dy 3.41/LS (30 cm)															
0 – 15	LS	6.3	0.011	-	0.167	2.40	2.1	0.5	0.3	0.2	7.7	3	4	5.1	11.5
15 – 30	LS	7.8	0.053	0.010			1.8	0.5	0.1	0.1	2.2	3	4	6.2	10.5
30 – 60	MC (s)	6.0	0.015	-			1.4	2.1	0.2	0.1	7.2	5	0	15.1	19.4
60 – 90	MC (s)	6.3	0.017	-			0.9	4.1	0.2	0.3	8.2	5	0	22.5	27.3
90 – 100	MC (s)	6.3	0.019	-			0.6	4.4	0.2	0.4	8.0	3	4	23.0	27.9
PROFILE # 6; BELLELLEN SANDY LOAM (Soft Surface); Dy 5.41/SL (40 cm)															
0 – 15	SL	6.5	0.007	-	0.109	1.60	2.6	0.2	0.2	0.1	4.9	3	7	3.8	11.6
15 – 40	LS	6.0	0.003	-			0.4	0.1	0.1	0.1	0.9	3	7	1.8	8.5
40 – 70	MC (s)	5.5	0.013	-			0.8	1.4	0.2	0.2	5.8	5	0	9.4	23.9
70 – 100	SC (m)	6.1	0.010	-			0.2	3.7	0.2	0.3	7.6	5	0	16.0	30.4
PROFILE # 7; HALLS GAP SANDY LOAM; Dy 3.81/SL (80 cm)															
0 – 30	SL	4.9	0.007	-	0.103	3.00	0.5	0.2	0.1	0.1	17.4	3	4	6.0	12.0
30 – 70	LS	5.6	0.005	-			0.3	0.3	0.1	0.1	9.1	3	3	7.6	13.0
70 – 80	LS	6.0	0.004	-			0.2	0.7	0.1	0.1	4.7	3	6	5.4	12.2
80 – 120	SC (m)	6.3	0.006	-			0.1	2.3	0.2	0.1	2.6	5	0	6.6	15.9
PROFILE # 8; HALLS GAP SANDY LOAM (Non-stony Profile); Dy 3.81/SL (90 cm)															
0 – 30	SL	5.7	0.006	-	0.085	1.50	0.3	0.2	0.1	0.1	5.9	3	8	4.4	9.4
30 – 60	LS	6.0	0.002	-			0.1	0.1	0.1	0.1	0.8	2	13	2.6	8.0
60 – 90	LS	6.5	0.003	-			0.2	0.2	0.1	0.1	0.0	2	10	2.4	6.4
90 – 120	HC	6.2	0.033	-			0.8	4.8	0.1	0.6	5.0	3	8	17.2	25.6

Depth (cm)	Field Texture (1)	pH	T.S.S (%) (2)	Chloride "as NaCl" (%) (3)	Total N (% ad)	Org. C (% ad)	Exchangeable Cations "milliequivalents per 100g soils					Aggregate Stability		Moisture (%)	
							Ca	Mg	K	Na	H	Class (4)	Index (5)	-15 Bar (6)	$-^1/_3$ Bar (7)
PROFILE # 9; HALLS GAP SANDY LOAM; (Non-stony Profile); Dy 3.82/LS (120 cm)															
0 – 20	LS	6.8	0.019	-	0.108	1.90	0.9	0.3	0.1	0.1	3.5	3	8	4.1	7.2
20 – 60	LS	6.5	0.006	-			0.3	0.2	0.1	0.1	1.3	3	8	1.7	6.8
60 – 90	LS	6.2	0.006	-			0.1	0.4	0.1	0.1	4.6	3	2	4.3	6.8
90 – 120	LS	6.6	0.005	-			0.2	0.6	0.1	0.1	1.4	3	6	3.9	8.6
120 – 135	SC	7.5	0.024	-			0.7	1.3	0.1	0.1	1.1	3	6	7.0	12.0
PROFILE # 10; MINOR SOIL TYPE 1; Dy 2.81/SL (40 cm)															
0 – 30	SL	5.7	0.006	-	0.062	1.20	0.4	0.4	0.2	0.2	5.7	3	4	3.3	12.0
30 – 40	SL	6.0	0.002	-			0.2	0.2	0.1	0.1	2.4	3	6	2.4	10.2
40 – 70	SC (lt)	6.1	0.003	-			0.1	1.1	0.1	0.2	4.3	3	8	5.8	14.8
70 – 100	SC (m)	6.5	0.004	-			0.1	1.8	0.1	0.2	2.9	3	4	7.2	16.4
PROFILE # 11; MINOR SOIL TYPE 2; Dy 3.41/SCL (80 cm)															
0 – 10	SCL	6.0	0.045	-	0.093	1.70	0.6	0.6	0.3	0.3	4.9	3	5	4.0	15.2
10 – 60	LS	6.0	0.006	-			0.2	0.2	0.1	0.1	0.5	3	6	1.6	10.1
60 – 80	SCL	6.3	0.004	-			0.2	1.5	0.1	0.2	1.5	3	8	6.5	15.4
80 – 100	SC (m)	6.3	0.009	-			0.2	3.9	0.2	0.5	3.6	3	3	9.1	21.9

(1) Field Texture; see Appendix III for definitions and symbols used.

(2) Total Soluble Salts (%) = Electrical Conductivity $(\mu S/cm)$ x 3.3 x 10^{-4}

(3) The dashes recorded in this column indicate negligible amounts of sodium chloride

(4) Aggregate Stability Class (Emerson 1967)

(5) Aggregate Dispersion Index (Loveday 1974)

(6) Moisture (%) at –15 Bar; approximately "Wilting Point", see Appendix III.

(7) Moisture (%) at $-^1/_3$ Bar; approximately "Field Capacity", see Appendix III.

APPENDIX III- DEFINITION OF SOIL TERMS

AGGREGATE STABILITY
The stability of the soil aggregate to water falling as rain or applied as irrigation. Many types of aggregate stability tests are available; two of which are those described by Emerson (1967) and Loveday (1974).

AMOUNTS
As used here, with reference to soil inclusions, the different terms and their percentages are as follows:- occasional (<1) – trace (1-5) – slight (6-15) – light (16-35) – moderate (36-70) – heavy (>70).

APEDAL
Means that in the moderately moist to the moist state, none of the soil material occurs in the form of peds; it is either massive or single grain and when disturbed separates into fragments or primary particles (see pedality).

BLEACHED
Describes a soil horizon which has become pale in colour owing to leaching. Two degrees of bleaching are recognised as follows:-

The conspicuous bleach: in which 80% or more of the soil horizon is bleached.
The sporadic bleach: in which less than 80% of the horizon is bleached.

COLOUR AND MOTTLING
Munsell Soil Colour Charts, 1973 Edition, are used in identifying soil colour names and their Munsell notations.

Munsell colour notations refer to moist soils; the suffix "d" indicates the colour of the dry soil (e.g., 10YR7/1d).

Some soil samples show more than one colour. The matrix (dominant) colour is always recorded first, followed by the sub-dominant colours.

When a sub-dominant colour is recorded only by name (i.e., without its Munsell colour notation) it indicates the failure of this particular colour to qualify for mottling, either by area or by colour difference, for the purpose of the Factual Key classification.

CONDITION OF SURFACE SOIL
Refers to the natural condition of the surface soil and its reaction to the usual wetting and drying cycle. Cultivation will often alter the condition of surface soil, but most conditions will reform when the soil is left undisturbed.

DUPLEX SOIL PROFILE
Refers to the soil profile showing a marked difference in texture between the surface and subsoil horizons. Texture contrast must be at least one and a half texture groups between A and B horizons (Northcote, 1979).

FERRUGINOUS CONCRETIONS
More or less rounded nodules of variable size and composed mainly of iron oxide.

FIELD CAPACITY
The percentage of water remaining in a soil two or three days after having been saturated and after free drainage has practically ceased. The $^{1}/_{3}$ bar percentage (using < 2 mm sieved soil samples) is used only as a rough estimate to the field capacity.

FACTUAL KEY CLASSIFICATION
Refers to the soil classification system as described in "A Factual Key for the Recognition of Australian Soils", 4th Edition, by Keith H. Northcote, 1979.

For the duplex (D) soil profile, the Principal Profile Form (P.P.F) is extended to indicate other important soil properties. For example, Dr 2.23SCL (14 cm) means a Dr 2.23 soil having a sandy clay loam surface with a 14 cm depth to the clayey subsoil. For the gradational (G) soils, additional suffix is only given to indicate the texture of the surface horizons.

FRIABLE
Refers to Soil Consistence

HARDPAN
A hardened and/or cemented horizon in or below the soil profile.

HARD-SETTING
A surface soil is considered to be hard-setting when it becomes hard and apparently apedal on periodic drying out.

MASSIVE
Structureless (i.e. "apedal"). The soil material is coherent.

PAN (= SOIL PAN)
See Hardpan.

PED
An individual natural soil aggregate.

PEDAL
See Soil Pedality.

PLASTIC
Refers to Soil Consistence.

SMOOTH FABRIC (= SMOOTH-PED FABRIC)
Peds are evident, and characteristically more than 50 per cent of them are smooth-aced, that is, have a general lac condition on their surfaces.

SOIL BOUNDARIES
The boundary between soil horizons defines the nature of the change from one horizon to that below. In this report it is specified by the measure of the thickness (or width) of the transition zone between horizons thus:

- Sharp (or Abrupt) = boundary < 2 cm wide.
- Clear = boundary is 2 – 5 cm wide.
- Gradual = boundary is 5 – 10 cm wide.
- Diffuse = boundary > 10 cm wide.

SOIL CONSISTENCE
Comprises the attributes of soil material that are expressed by the degree and kind of cohesion and adhesion or by the resistance to deformation or rupture. It is markedly affected by the moisture state of the soil. Terms used for consistence include: loose, soft, hard, friable, non-friable, plastic and sticky.

SOIL HORIZON
A layer of soil, more or less parallel to the land surface, similar throughout and recognisably different from the material above and below. The horizon may be distinguished by differences in one or more of the following characteristics: colour, texture, structure, consistence, mottling, organic matter content and the presence of visible products of weathering and leaching such as calcium carbonate, gypsum, iron oxide and ferruginous concretions. The following horizons in the soil profile may be recognised:

Surface or A Horizon: The surface layer of the soil in which organic matter has accumulated and which may be partly leached of clay and soluble material. It may be divided into two or more sub-horizons as follows :

A_1 horizon: The surface soil more or less darkened by organic matter – a zone of maximum biological activity.

A_2 horizon: A sub-surface layer lower in organic matter than the A_1 and, in consequence, usually lighter in colour. It is the zone of maximum leaching.

Subsoil or B Horizon: Situated below the surface or A horizon and is usually heavier in texture than that horizon. The B horizon represents the zone of accumulation of clay and other materials, including calcium carbonate and iron oxides.

SOIL MORPHOLOGY
The physical constitution of the various horizons and their arrangement in the soil profile.

SOIL PEDALITY
Refers to the relative proportion of peds in the soil, as follows:

Highly pedal (= pedal): in the moderately moist to the moist state, one-third or more of the soil material consists of peds.

Weakly pedal: in the moderately moist to the moist state, less than one-third of the soil material consists of peds.

Non-pedal (= apedal): essentially no recognisable peds.

SOIL PROFILE
This is the vertical section of a soil exposing the sequence of horizons from the surface to an arbitrary depth. For the purpose of this report, soil profiles were only discussed with regard to their A and B horizons.

SOIL REACTION TREND
Indicates the general direction of pH changes down the profile, eg.

Acid trend: The pH values are, for the surface soil, lower than 7.0, and for the deep subsoil, less than 6.5.

Neutral trend: The pH values are, for the surface soil, between 5.0 and 8.0, and for the deep subsoil, between 6.5 and 8.0.

Alkaline trend: The pH values are, for the surface soil, higher than 5.0, and for the deep subsoil, higher than 8.0.

SOIL STRUCTURE
Describes the way in which the primary soil particles are arranged into soil aggregates (peds).

SOIL TEXTURE
Soil texture is a measure of the behaviour of a small handful of soil when moistened to sticky point (approximately to field moisture capacity), kneaded into a ball and then pressed out between thumb and forefinger. It is strongly influenced by clay contents and is affected by other properties, including clay mineral type, organic matter, oxides, carbonates and exchangeable cations. Texture is described in terms of texture grades some of which are listed below:-

LS = loamy sand	CL = clay loam
Cys = clayey sand	FSCL = fine sandy clay loam
SL = sandy loam	SC = sandy clay
FSL = fine sandy loam	LC = light clay
lt SCL = light sandy clay loam	MC = medium clay

L = loam
SCL = sandy clay loam
M-HC = medium to heavy clay
HC = heavy clay

Other Qualifying Symbols
(s) = sandy
(gr) = gritty
(fs) = fine sandy
(h) = heavy
(lt) = light

STICKY
Refers to Soil Consistence.

TOTAL SOLUBLE SALTS
Total Soluble Salts % = Electrical Conductivity $(\mu S/cm)$ x 3.3 x 10^{-4} .

WILTING POINT
The water content of a soil when indicator plants growing in that soil wilt and fail to recover when placed in a humid chamber. Often the 15-bar percentage is used as an approximation to the wilting point.