QUEENSLAND
DEPARTMENT
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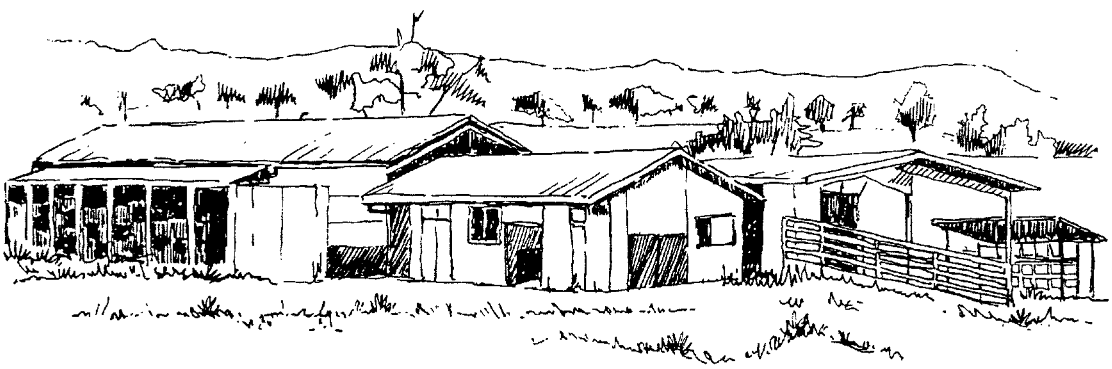
QR85001

SOILS OF THE MUTDAPILLY RESEARCH STATION

B. POWELL, D. E. BAKER AND N. G. CHRISTIANOS



QUEENSLAND DEPARTMENT OF PRIMARY INDUSTRIES

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B. Powell
Land Resources Branch

D.E. Baker and N.G. Christianos
Agricultural Chemistry Branch

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Queensland Department of Primary Industries
GPO Box 46
Brisbane 4001.

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1. INTRODUCTION

The Queensland Department of Primary Industries Mutdapilly Research Station occupies a 378 ha area between Mutdapilly in the west, across the Warrill Creek flats to Weber's Road in the east. Mutdapilly is located on the Cunningham Highway approximately 15 km south of Ipswich in south-east Queensland (Figure 1).

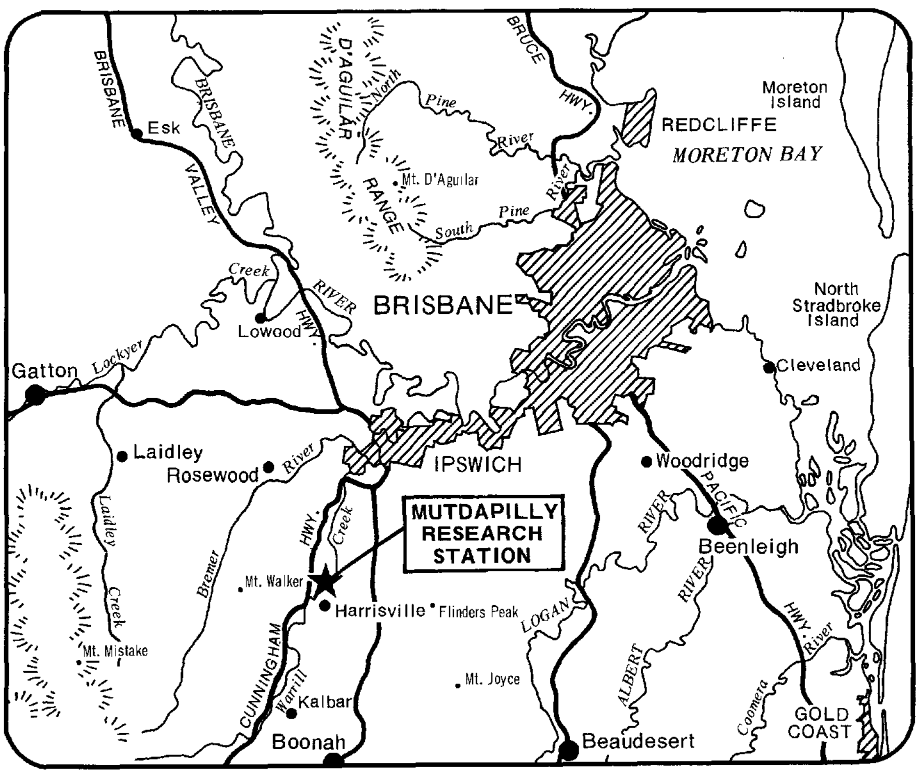

Figure 1. Locality Plan

Research Stations Branch of the Department requested a soil survey to help in the selection of experimental plots which are best located on relatively uniform soil areas. This soil survey assesses the soils variability on the Research Station and provides additional soil information to supplement that already available from Greasley and Venz (1980) on land use planning of the Research Station.

2. PHYSICAL ENVIRONMENT

2.1 Climate

The Mutdapilly Research Station has a summer dominant rainfall pattern (see Figure 1) with 53% of the mean annual precipitation falling between December and March inclusive. Mean annual rainfall is 806 mm*, although this has varied from 358 mm in 1926 to 1 410 mm in 1947.

Summers are warm to hot with maximum temperatures usually ranging from 28 to 33°C+. During winter, minimum temperatures commonly range from 2 to 11°C. Frosts are possible from May to September inclusive, but are most common during June, July and August.

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* Harrisville Recording Station, Bureau of Meteorology

\+ Amberley Recording Station, Bureau of Meteorology

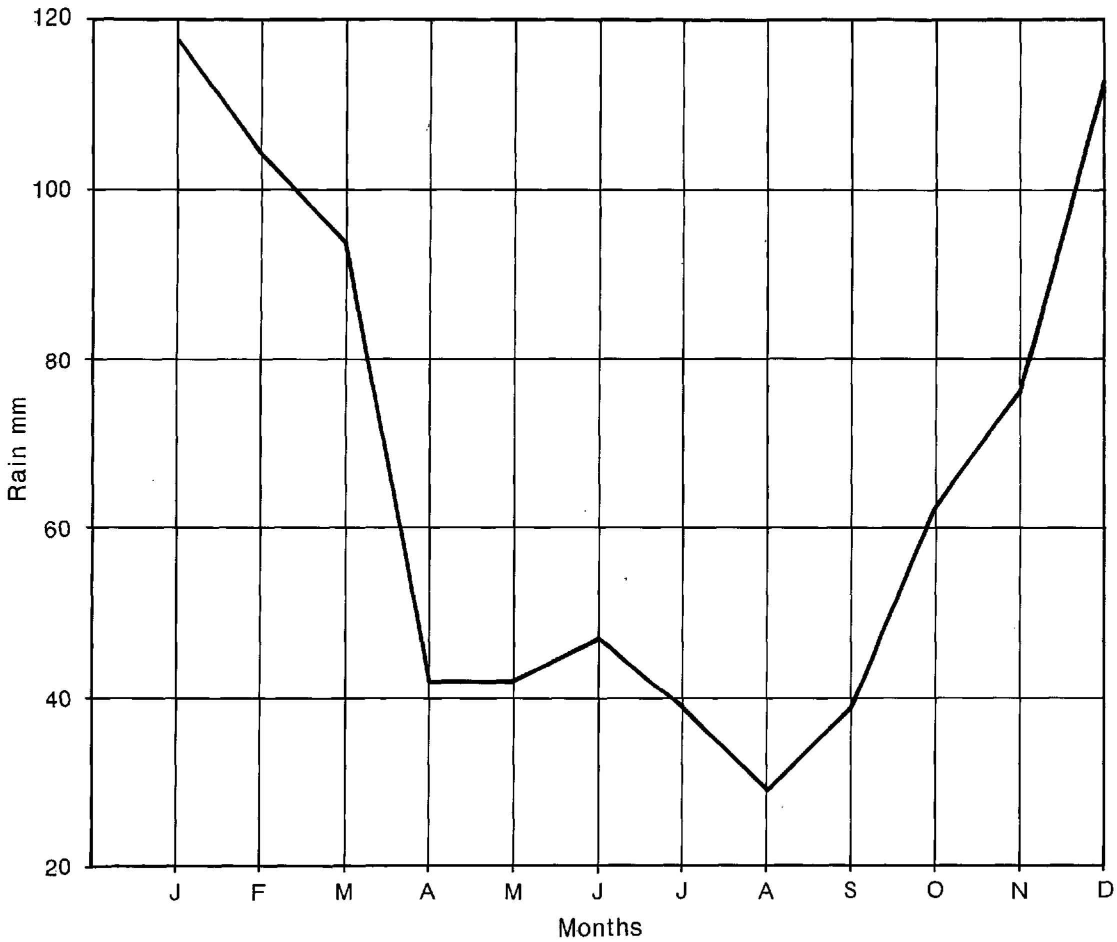

Figure 2. Harrisville 1896-1978
Mean Monthly Rainfall (mm)

2.2 <u>Geology and Topography</u>

Cranfield *et al* (1976), in their 1 : 250 000 scale geology map identify two geological formations on the Research Station.

One is the extensive creek flats developed on the Quaternary alluvium of Warrill Creek (east and west branch). Dark to grey medium to heavy clay alluvium is underlain by thick brown to dark grey silty clay, derived from erosion of the shale and siltstone predominant in the Walloon Coal Measures. A band of sandy clay mixed with sand and gravel separates this from the sandstone/shale beds beneath. Queensland Water Resources Commission records show that depth to sandstone/shale is in the order of 20 m.

It is postulated that the east branch of Warrill Creek has cut into the existing floodplain as there is little evidence of levee bank development and only a small area of lighter textured soils associated with creek bank alluvium. Locally, the alluvium merges laterally with hillwash alluvium-colluvium.

These flats are bordered on both sides by low rounded hills (1 to 7% slopes) derived from the Walloon Coal Measures of Jurrassic age. The sequence comprises mudstone, siltstone, shale, sandstone and thin coal seams. Outcrop is generally poor and restricted to the more resistant beds. The sandstone is soft, friable, fine to medium grained, lithic or feldspathic and partly calcareous. The mudstone, siltstone, and shale are interbedded with coal seams and lenses of calcareous mudstone. Some occurrences of calcareous concretions and impure limestone are known. Fragments of mudstone, siltstone, sandstone, shale and gravel have been found in cores in the Mutdapilly school block and the area from the Workshop to the office.

In the Fassifern Valley, the Walloon Coal Measures are intruded by Tertiary hypabyssal rocks, ranging in composition from trachyte to dolerite. Included in this range are microsyenite, phonolite, comendite, pantellerite, andesite, olivine analcite and teschenite. On the station a small area of microsyenite has weathered to the Churchbank soil. The microsyenite is dark grey and fine grained and occurs as either massive bodies or thin sub-horizontal sills throughout the area.

2.3 Vegetation

Common and scientific names of all species identified on the station are given in Appendix 3.

Of the 378 ha which comprise the research station, 193 ha is thinned open-forest with native pasture, while the remaining 185 ha was cleared for cultivation.

The tree layer of the open-forest is dominated by blue gum *(Eucalyptus tereticornis)* with narrow-leaved ironbark *(E. crebra)* subdominant, and patchy occurrences of Moreton Bay ash *(E. tessellaris)* and silver-leaved ironbark *(E. melanophloia)*. A well-developed tree layer dominated by river sheoak *(Casuarina cunninghamiana)* can be found along the banks of Warrill Creek together with weeping bottlebrush *(Callistemon viminalis)*. Other shrub or tree species found on the station include quinine berry *(Petalostigma pubescens)* and *Acacia* species.

The ground layer is mainly comprised of native grasses with blue grasses (*Bothriochloa* and *Dichanthium* species) and *Eragrostis* species dominant. Some areas have been colonised by pasture species such as paspalum (*Paspalum longifolium* or *P. dilatatum*), Rhodes grass (*Chloris gayana*) and setaria (*Setaria anceps*). Thick stands of Johnson grass (*Sorghum halepense*), Noogoora burr (*Xanthium pungens*) and spear thistle (*Cirsium vulgare*) have developed on old cultivation paddocks.

3. SOIL SURVEY METHOD

A total of 206 soil profiles were described and classified at sites located on a 100 x 200 m grid. Additional soil inspections were carried out where necessary to establish soil boundaries. Use was also made of soil profile descriptions generously provided by Mr B. Venz. Soil profiles were then grouped on the basis of similar morphology and topographic position into soil profile classes.

Soils were mapped at a scale of 1 : 10 000 into areas with one soil profile class dominant or two soil profile classes co-dominant. Dominant or co-dominant soil profile classes occupy at least 70% of the mapping unit. Minor impurities of other, often adjacent soil profile classes can occur in up to 30% of the mapping unit.

During the survey, 11 soil profile classes were identified and mapped. One additional soil profile class, Evans, was found only in minor proportions in the Weber and Furnival mapping units. Evans was unmappable at this scale but common enough to be identified as a separate soil profile class (Appendix 1).

Soil profile class names follow those already given to soils of the region by Paton (1971) and Powell (1979). New soil profile classes were given names of local significance.

4. SOILS - MORPHOLOGY AND CLASSIFICATION

Over half the station consists of heavy dark to grey cracking clays of the extensive Warrill Creek alluvial flats. There is little evidence of levee bank development and associated lighter textured soils suggesting that the east branch of Warrill Creek has cut into the existing floodplain with minor depositions of alluvium. Locally the alluvium merges laterally with hillwash alluvium-colluvium.

The remaining undulating low hills are dominated by brown cracking clays on the Mutdapilly School block and by solodics on the Workshop - Office area. The deeper soils are of mudstone/shale origin where as on feldspathic sandstone or on microsyenite intrusions shallower soils have developed. A sandier acid soil (Evans) is found in small areas near the office, developed from more siliceous sandstone beds.

4.1 Morphology

Detailed descriptions of soil morphology are provided in Appendix I. The general features of the soils are described below.

4.1.1 Soils of the alluvial plains

These soils are usually deep, dark to grey brown, medium to heavy clays which become dark or grey, calcareous and alkaline with depth. Manganese accumulations are found through the profile, commonly to within 15 cm of the surface. Close to the creek banks the soils are of slightly lighter texture in the surface and may be distinctively layered. Most of the soils are self-mulching, periodically cracking clays with granular to angular blocky surface structure becoming exclusively angular blocky in the subsurface and lenticular at depth.

Gilgais are absent or weakly to moderately developed. There are no obvious morphological differences between gilgai mound and depression soils nor with non-gilgaied soils. In broader depression areas the soils are poorly drained and have surface root mottles and commonly have a neutral soil reaction trend.

At depths > 5 m, alluvial layers of brown sandy clays, silty clays, sands, loams and gravels are found.

4.1.2 Cracking clays of the undulating low hills*

These clays have dark, grey-brown or brown, self-mulching, periodically cracking surfaces and neutral to alkaline subsoils. The alkaline subsoils usually contain accumulations of carbonate at depth.

The shallower clays usually have a brown to red-brown subsoil although a dark clay layer 5 to 15 cm thick is occasionally found immediately above the weathered rock C horizon. This is possibly the result of surface soil falling down large cracks during extended dry periods. The deep clays also include dark grey and/or yellow subsoils. Manganese accumulations are generally present in the subsoil.

The structure of the surface soils are typically granular to angular blocky becoming angular blocky and then lenticular with depth.

These clays are underlain by feldspathic sandstones, siltstones and shales of the Walloon Coal Measures.

* The undulating low hills (defined by McDonald *et al* 1984) are equivalent to the undulating plains described by Powell (1979) at Kalbar.

4.1.3 Hardsetting surface soils of the undulating low hills

These are mostly duplex soils with the exception of a small area of uniform or gradational texture (clay loam/clays) profiles.

The duplex soils have a grey-brown sandy loam to clay loam surface horizon usually with a sporadic or conspicuously bleached A_2 horizon beneath. Abruptly underlying the A_2 horizon is a coarse angular blocky, grey-brown, brown to yellow-brown neutral to alkaline subsoil.

Depth to subsoil is extremely variable (5 to 40 cm) with the sandier soils tending to be deeper.

Less commonly the duplex soils have mottled subsoils and/or have acid reaction trends. These variations appear to be unrelated to landscape position and are probably due to parent material differences.

4.2 Classification

Soils are classified on the map reference into great soil groups (Stace *et al* 1968) and principal profile forms (Northcote 1979).

All the cracking clay soil profile classes have ranges of soil colour that place them across the boundary of two great soil groups.

Representative soil profiles analysed in the laboratory and described in Appendix 2 are also classified according to Soil Taxonomy (Soil Survey Staff 1975).

Soil horizons are classified for engineering purposes according to the Unified Soil Classification (Olson 1973). The clay soils of the alluvial plains are CH material (except for small areas of Normanby with upper horizons of CL). Similarly, the cracking clays of the uplands are CH but the hardsetting soils have SM to SC surface horizons and dominantly CH subsoils.

These Unified Soil Classes have the following soil properties:

CL inorganic clays of low to medium plasticity and low liquid limit

CH inorganic clays of high plasticity, high shrink-swell, high liquid limit

SM sand and silt mixtures, low plasticity

SC sand and clay mixtures, plastic

4.3 Key to soil profile classes

Soil profile classes may be identified by using the following key.

4.3.1 Soils of the alluvial plains

(i) Dark fine sandy clay non-cracking surface..........NORMANBY
Dark or grey-brown cracking light to heavy clay surface See (ii)

(ii) Surface horizon is mottled........................FASSIFERN
Surface horizon is whole coloured..................See (iii)

(iii) Light to light medium clay surface texture.........MULLER
Medium to heavy clay surface texture...............CYRUS

4.3.2 Soils of the undulating low hills

4.3.2.1 Cracking clay surface

Profile less than 80 cm to weathered rock..........See (i)
Profile deeper than 80 cm to weathered rock........See (ii)

(i) Brown to red-brown clay subsoil....................PENNELL
Dark clay subsoil becoming grey at depth...........WARUMKARIE

(ii) Brown to red brown clay subsoil....................McGRATH
Dark, grey or yellow-grey clay subsoil.............KULGUN

4.3.2.2 Hardsetting non cracking surface

Surface texture clay loam or heavier...............See (i)
Surface texture sandy loam to sandy clay loam......See (ii)

(i) Gradual change to brown clay subsoil...............CHURCHBANK

Sporadic bleach at abrupt boundary to brown or yellow-brown clay subsoil.......................YELLUNGA

(ii) Sporadically bleached A_2 horizon present...........FURNIVALL
Conspicuously bleached A_2 horizon present..........See (iii)

(iii) Bleached A_2 horizon is mottled.....................WEBER
Bleached A_2 horizon is whole coloured..............EVANS

5. SOILS - CHEMICAL AND PHYSICAL PROPERTIES

5.1 General

Soil profiles were sampled for detailed laboratory characterization from the 6 most important of 12 soil profile classes observed on the Mutdapilly Research Station (Table 1). These 6 soil profile classes represent about 78% of the 378 ha occupied by the Station. Location of the 8 sampling sites are shown on the accompanying 1 : 10 000 soils map.

Table 1. Details of description of sampled soil profile classes

Soil profile class and site number	Great soil group	Area %	Area (ha)	Brief description of soil profile class
SOILS OF THE ALLUVIAL PLAINS				
CYRUS (R1)	Black earth	41.8	160	Black earth - grey clay weak to strong gilgai, occasionally evident in uncultivated areas on alluvial plains.
CYRUS (R2) (Gilgaied-phase)	Grey clay	6.4	24.6	Same as R1.
CYRUS (R3)	Black earth	41.8	160	Same as R1.
FASSIFERN (R4)	Wiesenboden	6.1	23.1	Mottled dark and grey clay, weak gilgai often present in uncultivated areas of alluvial plains.
SOILS OF THE UNDULATING LOWHILLS (UPLANDS)				
McGRATH (R5)	Brown clay	9.2	34.8	Brown clay, black earth often present in upper and mid slope positions.

Table 1. Details of description of sampled soil profile classes (cont.)

Soil profile class and site number	Great soil group	Area %	(ha)	Brief description of soil profile class
SOILS OF THE UNDULATING LOWHILLS (UPLANDS)				
PENNELL (R6)	Brown clay	8.2	31.0	Brown clay present in upper and mid slope positions.
FURNIVALL (R7)	Solodic soil	2.6	9.8	Grey and brown solodic with moderate hard-setting surfaces.
KULGUN (R8)	Black earth	3.9	14.7	Grey clay - black earth present between low hill, crests or alluvial-colluvial fans of uplands.

Soil profile classes not sampled were Normanby and Muller of the alluvial plains and the duplex soils (Churchbank, Yellunga, Weber and Evans).

Each profile was sampled in 10 cm increments to 150 cm. A bulk surface sample (0-10 cm, composite of 10 subsamples from within 10 m of the profile) was also collected for surface fertility assessment. Details of laboratory analyses performed on profile segments and on the bulk surface samples are outlined in Table 2. Soil methods employed, and general interpretations of the chemical and physical data obtained have been summarized by Bruce and Rayment (1982). See Appendix 4 for interpretation chart. Full analytical results are detailed for type profile descriptions in Appendix 2. For ease of profile comparison, these results are further tabulated in Table 3. Differences and similarities found amongst the soil profile classes examined are highlighted as follows.

Table 2. Soil analysis performed at various profile sample depths

Sample/profile segment	Soil tests
All samples (10 cm increments to 150 cm)	pH, chloride, electrical conductivity (EC).
Bulk 0-10 cm and profile 10-20 cm	organic carbon (org-C), total nitrogen (tot-N), acid-extractable phosphorus (P), bicarbonate-extractable phosphorus (P), extractable potassium (K).
Profile 0-10, 20-30, 50-60, 80-90 cm	dispersion ratio, particle size analysis (PSA), exchangeable cations, CEC, total P, total K, total sulphur (S), - 1/3 bar moisture, -15 bar moisture, air dry moisture (ADM), phosphate-extractable S.
Profile 110-120 cm	as for profile to 90 cm but excluding dispersion ratio, - 1/3 bar moisture and -15 bar moisture.
Profile 140-150 cm	as for profile to 90 cm but excluding dispersion ratio and phosphate-extractable S.

5.2 pH

Surface soil pH values (0-10 cm) were generally rated as slightly acid with only the duplex Furnivall being classified as strongly acid (pH 5.6). Profile trends (Table 3) are for all soils to increase in alkalinity with depth. The most strongly alkaline pH of 9.9 was found in the 140-150 cm segment of the Kulgun soil, while pH values of 8.7 or greater occurred in at least one segment of all sampled profile classes except for Pennell and Fassifern. These high pH levels suggest the presence of carbonates and strongly sodic conditions.

A strong linear relationship was confirmed between field pH and laboratory pH as follows:

$$\text{Laboratory pH} = 0.58 + 0.937 \text{ field pH } (r^2 = 0.89^{**};\ n = 45).$$

This is similar to results obtained by Baker *et al* (1983) and Steinhardt and Mengel (1981).

5.3 Salinity

Chloride and electrical conductivity (EC) levels provide an indication of soluble salts present in the soils. Results of these tests are provided in Table 3.

Apart from the Fassifern and Pennell soil profiles, appreciable amounts of chloride were detected, particularly in subsurface horizons.

Maximum chloride concentration was recorded in the duplex Furnivall soil with a level of 0.197% in the 60-70 cm segment. Furnivall and Kulgun soils have peak chloride concentrations in the profile at 70 and 80 cm respectively. The peak chloride concentrations in these two soil profile classes together with their poor structure and observed low hydraulic conductivities indicate the probable depth of wetting (McCown *et al* 1976). According to criteria of Northcote and Skene (1972) both Furnivall and Kulgun profiles are classified as saline.

Relationship for all soils between EC and chloride was EC = 0.04 + 5.86 Cl%, (r^2 = 0.96**, n = 121) which is similar, to the results obtained when using the theoretical relationship EC = 6.64 Cl% when all salts present are NaCl (Richards, 1954). On this evidence it is assumed that Na^+ and Cl^- are the dominant soluble ions.

5.4 Exchangeable cations, CEC, sodicity and dispersion

Cation exchange capacity (CEC) was determined on these soils using alcoholic 1 M NH_4Cl at pH 8.5 (method 2.11.3, Bruce and Rayment 1982). CEC levels are high in all soils (range 21-69 m. equiv/100 g, mean 54 m. equiv/100 g). This indicates a high capacity to retain nutrient cations for plant nutrition and usually infers high soil water holding capacity.

CEC of the sampled profiles for soils of the alluvial flats range from 53-69 m. equiv/100 g while the upland soils are more variable. For these the CEC range is 21-61 m. equiv/100 g. Higher clay contents of the soils of the alluvial plains combined with parent material effects would have influenced these values. For example, the Furnivall solodic has the lowest CEC of 21 m. equiv/100 g in the 0-10 cm sample, indicating the coarser texture of its A horizon (clay content 17%).

Magnesium and calcium dominate the exchange complex of all soils but magnesium is usually present in greater quantities than calcium for all soils except Fassifern and Pennell (Table 5). Calcium to magnesium ratios listed in Table 5 show that Kulgun and Furnivall are soils containing the largest relative amounts of magnesium. The lowest ratio is 0.29 for Kulgun. However, the lowest absolute levels of exchangeable calcium and magnesium were found in the Furnivall surface soil with levels of 3.7 and 5.8 m. equiv/100 g respectively.

Table 3. Analytical data for selected soil profiles, Mutdapilly Research Station

Soil Profile	pH	E.C.	Water Sol.	ppm Extr. P		Org. C	Tot. N	Exchangeable Cations§					ESP	Total P	Total K	Total S	PO_4 = Ext. S	DTPA Trace Elements				Particle Size Analysis %				Air Dry	Ratios	
Class/Depth	1:5	1:5	Cl %	Acid	Bicarb	(W & B)		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CEC		%	%	%		Fe	Cu	Mn	Zn	Coarse Sand	Fine Sand	Silt	Clay	Moisture	CEC/clay	C/N§§
	H_2O	dS/m	% (O.D)†	mg/kg (A.D)		% C(O.D)	% N(O.D)	m. equiv/100 g (O.D)							% (O.D)		mg/kg (A.D)††	mg/kg (A.D)				% (O.D)				%		
Cyrus (R1)																												
0-10	6.2	0.14	0.006	78	43	2.5	0.21							0.049	0.19	0.041	50+	91	3.1	2.6	1.0	2	4	17	73	7.2		12
10-20	6.6	0.08	0.004	10	11	2.1	0.19																					
20-30	7.2	0.07	0.004					34	29	2.8	0.14	69	4	0.026	0.11	0.018	9.5					2	3	8	87	8.3	0.84	
50-60	8.1	0.13	0.016					33	29	4.4	0.12	65	6	0.020	0.10	0.015	8.5					2	3	9	84	8.3	0.78	
80-90	8.6	0.34	0.052					31	33	5.6	0.11	63	8	0.016	0.12	0.009	8.5					2	4	12	84	7.4	0.75	
110-120	8.7	0.65	0.102					28	34	6.0	0.12	62	9	0.018	0.13	0.007	0.3					5	5	10	78	7.1	0.79	
140-150	8.6	0.80	0.141					26	33	6.5	0.15	61	9	0.021	0.19	0.007						3	4	12	77	7.6	0.79	
Cyrus (R2)																												
0-10	6.4	0.06	0.005	21	23	2.6	0.20	16	29	2.1	0.63	67	3	0.051	0.38	0.031	5.5	268	68	3.2	1.2	6	5	14	75	7.9	0.89	13
10-20	6.8	0.05	0.005	4	4	1.2	0.10																					
20-30	7.2	0.02	0.011					24	41	3.8	0.40	66	5	0.027	0.30	0.015	3.0					3	6	10	83	8.6	0.80	
50-60	7.8	0.31	0.054					26	90	5.3	0.28	64	8	0.026	0.31	0.011	1.5					2	6	14	79	8.2	0.81	
80-90	8.3	0.38	0.065					24	42	6.0	0.38	65	9	0.024		0.039	1.5					2	7	14	79	7.6	0.82	
110-120	8.7	0.41	0.066					21	39	5.7	0.30	62	9	0.027	0.37	0.009	2.0					1	7	14	75	7.8	0.83	
140-150	9.0	0.37	0.051					15	30	4.4	0.24	45	9	0.112	1.02	0.006						1.	29	30	45	5.3	1.0	
Cyrus (R3)																												
0-10	6.4	0.12	0.013	96	217	3.8	0.29	16	20	2.3	1.2	55	4	0.148	1.05	0.041	6.5	282	51	3.2	2.2	6	5	26	59	6.4	0.93	13
10-20	6.7	0.13	0.017	115	127	1.7	0.14																					
20-30	6.6	0.20	0.032					20	25	4.9	0.65	56	9	0.117	1.00	0.020	3.5					2	4	23	66	6.8	0.85	
50-60	7.1	0.32	0.055					25	27	8.3	0.41	57	15	0.109	0.92	0.015	2.5					2	6	23	68	6.6	0.84	
80-90	8.2	0.31	0.046					26	29	9.9	0.31	59	17	0.106	0.97	0.010	2.5					2	4	23	68	6.6	0.87	
110-120	8.7	0.22	0.034					24	30	12	0.35	60	20	0.083	0.86	0.008	3.0					3	3	20	71	6.3	0.85	
140-150	8.9	0.30	0.039					21	31	13	0.35	60	22	0.035	0.47	0.006						2	4	17	75	7.0	0.80	
Passifern (R4)																												
0-10	6.1	0.04	0.004	103	306	2.9	0.26							0.128	1.20	0.027	6.0	290	18	2.1	2.5	5	6	27	56	6.5		11
10-20	6.4	0.04	0.004	166	192	1.3	0.14																					
20-30	6.7	0.03	0.004					29	21	0.76	1.2	56	1	0.105	1.08	0.012	2.5					3	5	24	68	7.2	0.82	
50-60	7.3	0.03	0.004					29	20	1.2	0.34	54	2	0.084	1.06	0.008	2.0					2	4	27	66	6.9	0.82	
80-90	7.2	0.05	0.008					32	24	1.5	0.38	58	2	0.105	1.00	0.008	1.5					2	5	26	66	7.3	0.88	
110-120	7.4	0.05	0.008					32	22	1.2	0.28	54	2	0.109	1.08	0.006	2.0					2	6	34	57	6.8	0.95	
140-150	7.4	0.04	0.006					32	23	1.2	0.32	53	2		1.07	0.006						2	5	34	57	7.1	0.93	
McGrath (R5)																												
0-10	6.3	0.04	0.004	19	18	3.0	0.25	11	13	0.54	0.84	40	1	0.059	0.27	0.039	5.0	115	106	2.4	1.4	14	20	20	42	4.7	0.95	12
10-20	6.8	0.03	0.003	3	5	1.5	0.11																					
20-30	7.3	0.08	0.011					19	26	3.0	0.30	50	6	0.031	0.22	0.019	6.0					6	12	13	68	6.8	0.74	
50-60	8.2	0.35	0.067					19	30	5.5	0.23	49	11	0.016	0.18	0.016	4.0					7	12	15	65	6.0	0.75	
80-90	8.7	0.38	0.064					17	28	5.6	0.16	44	12	0.164	0.38	0.017	4.0					14	12	24	49	5.3	0.90	
110-120	9.3	0.38	0.069					17	33	6.1	0.16	47	12	0.025	0.78	0.013	3.5					2	4	27	67	5.2	0.70	
140-150	9.0	0.42	0.067					19	41	8.9	0.19	61	14	0.014	0.52	0.010						2	2	17	76	6.9	0.80	
Pennell (R6)																												
0-10	6.6	0.10	0.004	158	126	5.6	0.42	18	14	0.21	2.4	45	1	0.116	0.35	0.066	11	184	70	2.7	9.6	11	13	21	52	5.3	0.87	13
10-20	6.5	0.05	0.002	20	27	2.4	0.23																					
20-30	6.8	0.03	0.001					26	22	0.43	1.2	51	1	0.047	0.20	0.028	12					5	10	11	70	6.2	0.73	
50-60	7.6	0.04	0.002					28	26	0.96	0.28	51	2	0.028	0.09	0.013	11					11	13	13	60	6.9	0.85	
Furnivall (R7)																												
0-10	5.6	0.05	0.005	46	36	1.8	0.13	3.7	5.8	0.15	0.69	21	1	0.061	0.37	0.028	8.0	281	30	1.2	2.8	26	45	9	17	1.9	1.2	14
10-20	6.0	0.04	0.007	15	18	1.1	0.07																					
20-30	6.4	0.14	0.023					9.0	20	2.5	0.19	36	7	0.028	0.26	0.017	9.0					18	30	8	43	3.6	0.84	
50-60	8.7	1.10	0.192					17	36	8.0	0.11	53	14	0.024	0.36	0.019	7.0					7	20	11	62	5.8	0.85	
80-90	8.8	1.00	0.197					17	40	9.9	0.25	61	15	0.013	0.80	0.007	4.0					1	21	16	60	6.4	1.0	
110-120	9.0	0.96	0.176					15	37	8.8	0.30	56	15	0.021	0.99	0.004	2.5					1	25	24	50	6.5	1.1	
140-150	8.3	0.74	0.138					14	36	9.0	0.35	54	16	0.027	1.17	0.003						3	30	23	39	5.4	1.4	
Kulgun (R8)																												
0-10	6.6	0.08	0.009	68	54	2.0	0.14	7.3	9.1	2.2	0.44	34	6	0.049	0.19	0.041	1.5	161	59	1.4	1.6	10	33	20	34	3.1	1.0	14
10-20	6.9	0.13	0.016	30	19	1.6	0.11																					
20-30	7.5	0.28	0.045					10	15	6.8	0.19	38	18	0.026	0.11	0.018	8.0					9	26	20	45	3.8	0.82	
50-60	8.5	0.68	0.88					10	22	13	0.25	45	28	0.020	0.10	0.015	4.0					7	22	16	53	4.4	0.81	
80-90	8.9	0.86	0.86					10	23	15	0.29	53	28	0.016	0.12	0.009	2.0					6	19	19	57	4.9	0.88	
110-120	9.7	0.72	0.72					12	31	21	0.40	62	34	0.018	0.13	0.007	3.5					5	13	27	53	5.7	1.11	
140-150	9.9	0.78	0.78					9.3	32	21	0.47	60	35	0.021	0.14	0.007						6	38	23	27	5.2	2.11	

† oven dry

†† air dry

§ from alcoholic 1 M NH_4Cl @ pH 8.5

§§ W & B carbon : Total N

Base saturation of 0-10 cm segments ranged from 48 to 68% (mean 60%). The low base saturation of surface soils is probably associated with overestimates of soil CEC and underestimates of exchangeable calcium and magnesium.

Overestimates of CEC occur because of the high negative charge density induced in acidic soils by high pH (8.5) and high electrolyte concentration of the extractant. The alcoholic NH_4Cl at pH 8.5 extractant also results in divalent cations such as calcium and magnesium being held more strongly by the higher negative charge on the exchange complex or by precipitation.

Below the 10 cm segment the base saturation ranges from 88% to fully saturated (mean 99.4%). As soil pH tends to be more alkaline with depth and lower in organic matter, results reported for subsurface segments are likely to reflect actual soil conditions.

Exchangeable sodium percentage (ESP) or sodicity is defined as percent exchangeable sodium compared to the CEC.

The degree of sodicity has been interpreted by Northcote and Skene (1972). Soils classified as strongly sodic (ESP > 15) have generally poorer physical properties including a tendency to lose aggregation and disperse readily in water. Such soils tend to have poorer permeability, poor aeration and surface crusting, all of which are undesirable for plant growth. Profile ESP levels are listed in Table 5.

For clay soils of the Burdekin district, ESP values could be predicted from soil pH (Baker *et al* 1983). For all soils, at all depths in this study, a similar relationship ($ESP = a\ pH^b$) was derived. The associated regression constants (a, b) and coefficient of determination (r^2) are compared in Table 4 with those found in the Burdekin. For Mutdapilly soils, pH values corresponding to ESP levels of 6 and 15 are 7.7 and 8.9 respectively.

Table 4. Comparison of regression constants (a, b) and coefficients of determination for relationship ESP = a pH^b

		Burdekin	Mutdapilly
Regression constants	a	1.935×10^{-5}	3.895×10^{-5}
	b	6.205	6.094
Coefficient of determination $(r^2)^+$		0.61^{**}	0.59^{**}
Number of determinations		288	43

\+ Corrected for degrees of freedom

** $P < 0.01$

A measure of soil dispersion by means of a dispersion ratio (Rl) (% (silt + clay) dispersed/% total (silt + clay)) has been used to estimate the potential for clay dispersion. Baker (1977) used values of 0.6 to indicate low potential dispersion and values > 0.8 for high potential dispersion of soils. From Table 5, soils with the greatest potential to disperse are Kulgun and Cyrus (R3). Coincidentally, Kulgun has the highest ESP throughout the profile of any soil (Table 5). For this soil, ESP values greater than 6 in the surface, calcium/magnesium ratios less than one (range 0.24 - 0.8), and high dispersion ratios are indicative of a soil on which poor plant performance and poor physical conditions can be expected.

A Cyrus profile on the Fletcher block (R3) was also strongly sodic at depth, thought to be due to its location. This occurs between two low lying areas associated with the Fassifern soil profile class (refer soil map) possibly resulting in restricted groundwater movement. Because Ca/Mg ratios in this profile are approximately unity, its soil physical conditions is likely to be superior to those of Kulgun and Furnivall soils, the latter having similar ESP but low Ca/Mg ratios.

5.5 Available Water

Two methods were used to calculate the upper and lower water storage limits associated with plant available water capacity (PAWC). The first was by difference (- 1/3 bar - -15 bar, $PAWC^1$), the second by the regression method of Shaw and Yule (1978), ($PAWC^2$). These estimates are given in Table 6.

Table 5. Calcium/magnesium ratio, base saturation, ESP, dispersion ratio for soil profiles analysed

		Soil test			
S.P.C.	Depth (cm)	Ca/Mg	B.S.+	Dispersion ratio	ESP*
CYRUS (R1)	0-10	-	-	0.50	-
	20-30	1.2	88	0.71	4
	50-60	1.1	94	0.81	6
	80-90	0.94	100	0.71	8
	110-120	0.82	100	-	9
	140-150	0.79	100	0.71	9
CYRUS (R4)	0-10	0.6	66	0.51	3
	20-30	0.6	97	0.65	5
	50-60	1.5	100	0.75	8
	80-90	1.8	100	0.73	9
	110-120	1.9	98	-	9
	140-150	2.0	100	0.77	9
CYRUS (R3)	0-10	0.8	68	0.71	4
	20-30	0.8	79	0.78	9
	50-60	0.9	99	0.94	15
	80-90	0.9	10	0.99	17
	110-120	0.8	10	-	20
	140-150	0.7	10	0.99	22
FASSIFERN (R4)	0-10	-	-	0.56	-
	20-30	1.4	87	0.68	1
	50-60	1.5	88	0.51	2
	80-90	1.3	98	0.71	2
	110-120	1.5	97	-	2
	140-150	1.4	99	0.76	2
McGRATH (R5)	0-10	0.9	58	0.38	1
	20-30	0.7	90	0.62	6
	50-60	0.6	100	0.70	11
	80-90	0.6	100	0.77	12
	110-120	0.5	100	-	12
	140-150	0.5	100	0.75	14
PENNELL (R6)	0-10	1.3	72	0.33	1
	20-30	1.2	92	0.40	1
	50-60	1.1	100	0.50	2
FURNIVALL (R7)	0-10	0.6	48	0.56	1
	20-30	0.5	84	0.66	7
	50-60	0.5	100	0.53	14
	80-90	0.4	100	0.56	15
	110-120	0.4	100	-	15
	140-150	0.4	100	0.45	16
KULGUN	0-10	0.8	56	0.74	6
	20-30	0.7	83	0.92	18
	50-60	0.5	99	0.99	28
	80-90	0.4	92	0.98	28
	110-120	0.4	100	-	34
	140-150	0.3	100	0.89	35

ALL VALUES ON 105°C OVEN DRY BASIS

+ B.S. = Base Saturation 100 (Ca + Mg + Na + K)/CEC

* ESP = Exchangeable Sodium Percentage

Table 6. Plant available water capacity (oven dry basis) by two methods (cm)

	Soils of alluvial plains			Soils of the undulating low hills (uplands)				
	Cyrus (R1)	Cyrus Gilgaied (R2)	Cyrus (R3)	Fassifern	Pennel	Kulgun	McGrath	Furnivall
PAWC[1]	31	31	30	26	26	28	23	21
PAWC[2]	12.6	14.7	12.1	14	10.5	11.6	10.5	10.2

1 = -1/3 bar less -15 bar water contents converted to volumetric water. Differences summed over rooting depth. Rooting depth is the depth of maximum salt concentration.

2 = Method of Shaw and Yule (1978).

There was good agreement between our results for PAWC[2] and those obtained for soils elsewhere. Gardner and Coughlan (1982) for Burdekin soils reported field measured PAWC for cracking clay soils of (10.4 to 12.8 cm) while Shaw and Yule (1978) at Emerald found a range of 7.4 to 13 cm for cracking clays.

Soils of the alluvial plains have higher PAWC[2] levels than do soils of the uplands. This correlates with the lower clay contents of upland soils and suggests that these soils would require more frequent irrigation than the alluvial soils. The shallow Pennell soil would need to be carefully managed, if irrigated, to avoid excess ponding and runoff.

As indicated by Gardner and Coughlan (1982), soils with poor physical characteristics, such as the Kulgun and Furnivall soils, would have to be modified by agricultural practices such as deep ripping and/or gypsum incorporation. If this occurred, an increased PAWC[2] probably would result. Gardner and Coughlan (1982) showed for a similar strongly sodic duplex soil in the Burdekin, that after massive profile disruption the irrigation frequency needed for that soil was halved. Similar results would be expected on Kulgun and Furnivall soils here.

5.6 Particle size distribution and clay activity

Clay, silt, fine sand and coarse sand contents within soil profiles are listed for all soils in Table 3. Maximum clay content of 84% was found in the Cyrus R1 profile while the minimum of 17% was found in the 0-10 cm A horizon of the Furnivall sodic duplex soil.

Clay contents of the clay soils of the alluvial plains are high (range 59-84%) throughout the profile. In contrast clay soils of the uplands have lower clay content (34-52%) in the surface (0-10 cm). At depth, they range from 57-68% with silt contents higher than those of the soils of the alluvial plains. In general, when there is a decrease in clay content there is a corresponding increase in silt levels with Kulgun and Furnivall profiles the exception. With the latter the change in clay percentage is inversely related to sand content. Total sand content is highest in Kulgun and Furnivall soils.

Clay activity (CEC/clay) ratios exceed 0.73 and indicate the presence of expanding clay minerals with smectite likely to be dominant.

5.7 Total phosphorus, potassium, sulphur

Total phosphorus levels range from medium to very high in the surface (0-10 cm) soils. In the 10-20 cm zone total P is rated as low. The highest levels were found for the Cyrus R3 and Fassifern R4 sites which have similar values in the upper 60 cm. Thompson and Beckman (1959) suggested that phosphorus contents in soils is probably reflecting phosphorus in parent material. This seems to be the case for these two sites.

In the upper metre of the profiles sampled the 0-10 cm segment had higher total P than the rest of the profile probably reflecting the contribution of organic P and fertilizer additions. An exception is the McGrath profile which has by far the highest total P measured at any depth of 0.164% in the 85-90 cm zone. Organic carbon was measured for this segment and was 0.8%. A dark layer observed in the field morphology description corresponded to this depth and is a possible reflection of the depth to which surface soil particles have fallen down the soil cracks in dry periods. This theory is further confirmed by the presence of dark veins observed in the field extending from the surface to the 85-90 cm depth.

Total potassium levels in all profiles are rated as low with the major exceptions being the Cyrus R3 and Fassifern soils. These soils are rated as high. This is most certainly due to soil parent material effects similar to those suggested by Thompson and Beckman (1959) for total P as the Cyrus R3 and Fassifern are derived from basalt while the other Cyrus alluvials are derived from the Eastern Walloon Coal Measures.

Total sulphur levels are medium in the surface 0-10 cm to low to very low at depth. Andrew *et al* (1974) suggested a level less than 0.013% in the 0-10 cm sample as an indicator of deficiency of this element. A better indicator is sulphate-sulphur (see section 5.9).

Carbon, nitrogen and sulphur ratios have been calculated for other Queensland soils by Crack and Isbell (1970), Probert (1977) and Reid and Baker (1984). Table 7 has ratios for the 0-10 cm soils of this survey. Probert found for 55 soils of North Queensland, a ratio of 135:10:1.14.

Table 7. C:N:S ratios for 0-10 cm of the sampled profiles

SOIL PROFILE CLASS	C:N:S
Cyrus R1 Black Earth	115:10:1.8
Cyrus R2 Grey Clay	126:10:1.6
Cyrus R3 Black Earth	133:10:1.5
Fassifern Wiesenboden	112:10:1.1
McGrath Brown Clay	121:10:1.6
Pennell Brown Clay	133:10:1.7
Furnivall Solodic Soil	138:10:2.1
Kulgun Black Earth	136:10:1.9

These results indicate low C:N ratios. In addition the relatively high organic sulphur levels are characteristic of alkaline clays as compared to more strongly leached soils, Blakemore *et al* (1968).

5.8 Soil Fertility

Soil fertility data and ratings for the 0-10 cm segment for all soil groups are listed in Table 3. The surface soil pH ranges from 5.6-6.6. As most pH values are in the range 6.0-6.5 most essential soil nutrients would be plant available. Lime applications may be required on the Furnivall soil (pH 5.6) to bring its pH closer to the more desirable range suggested by Baker and Rayment (1983).

Extractable phosphorus (P) was measured by means of a dilute acid solution (acid extractable P) and a bicarbonate solution (bicarbonate extractable P). High values were obtained for most soils (36-105 ppm acid extractable P, 36-258 ppm bicarbonate extractable P). The exception was McGrath with 13 ppm acid extractable P and 19 ppm bicarbonate extractable P. The low values of P availability associated with McGrath are at such levels that P response in pasture legumes can be expected, Rayment and Bruce (1979a).

All soils decrease rapidly in acid and bicarbonate extractable P in the 10-20 cm zone though the levels for Cyrus (R3) and Fassifern are still very high. As well, levels of Total P (Table 3) are much higher for these soils than for others.

As both acid and bicarbonate indexes of P availability give similar results (Table 3) either could be used for fertility assessment. However, Rayment and Bruce (1979)[a,b] preferred bicarbonate extractable P for white clover based pastures in South East Queensland.

Indexes for predicting soil potassium availability have been proposed by a number of workers (Young 1976, Crack and Isbell 1970). These vary according to soil type but a figure of 0.2 meq/100 g for sandy soils and 0.2-0.4 meq/100 g for clays have been proposed. Based on these criteria, no potassium deficiency is expected on any soil examined as most range from medium to high levels.

Carbon and nitrogen in 0-10 cm are medium to high with a sharp decrease in the 10-20 cm sample. Carbon to nitrogen ratios range from 11 to 14 which is typical for fertile soils of the area and a nett mineralisation of nitrogen would be expected to occur. Under cropping, organic carbon levels are likely to decrease as a result of ploughing, erosion and mineralisation.

Copper and zinc levels are medium to high. A possibility of deficiency exists for the Cyrus R1 and R2 soils with increased phosphate applications if poorer quality irrigation waters are used. Copper is adequate in all soils.

Levels of DTPA extractable manganese range from 17-101 ppm. Rayment and Verrall (1980) have shown that for white clover these levels should not cause toxicity problems. While a level of manganese of 60 ppm is thought optimum, levels of greater than 20 ppm may be detrimental to sensitive plants such as french beans.

Phosphate extractable sulphate sulphur (SO_4-S) profile levels were determined for all soils at depths to 120 cm with full results listed in Appendix 2. Sulphur status is marginal to deficient at sites R2, R3 (Cyrus), Fassifern and Kulgun. The higher levels of Cyrus R1 probably represent fertilizer additions.

No significant contribution to soil SO_4-S levels are likely from irrigation waters on the station as only trace amounts of sulphate have been found in all underground water supplies so far tested (R. Shaw, pers. comm).

White *et al* (1981) proposed a SO_4-S level of less than 3.5 ppm in 0-80 cm profile as an indication of S deficiency for field crops. Rayment (1983) has proposed critical levels for some pasture species. He suggested a 6 ppm level for white clover in the 0-10 cm sample, 4.5-4.7 ppm for Green Desmodium and 3.7 ppm for Siratro. Under these conditions, SO_4-S would be limiting for clover on Cyrus (R1) and Fassifern, while all pasture species and crops would suffer from deficiency on Kulgun.

6. LAND USE

6.1 Alluvial plains

The soils of the alluvial flats suffer from the major limitation of flooding, which can cause erosion, siltation and waterlogging. The minor channel bench soil Normanby is commonly inundated while soils on the main plain are usually flooded every 2-5 years. The lighter textured Muller soil profile class is, despite a tendancy to surface crusting, the best soil on the plains for cropping, because of its good water entry and internal drainage characteristics. Unfortunately, it covers only a small area of land fringing the eastern branch of Warrill Creek.

The medium to heavy clay soils (Cyrus and Fassifern) which dominate the alluvial plain suffer from limitations of slow surface drainage, workability, slow water entry, impeded internal drainage and high wilting points. The lower lying depression areas (Fassifern soil dominant) may suffer from surface waterlogging for long periods.

The persistance of surface water following rain or irrigation will impede timely cultivation, pest control, harvesting and grazing. Surface runoff could be improved by the implementation of a drainage programme and precision levelling.

Choice of crop and pasture species are limited to those tolerant of heavy, slowly permeable clay soils e.g. white clover, cereal crops. Winter frosts from May to September will also limit plant species choice.

6.2 Undulating low hills

With slopes of 2-7% throughout, the upland soils are very vulnerable to erosion. Shallower soils such as Pennell and Churchbank are particularly at risk. Bedrock has already been exposed under cropping on Wood's block, behind the Mutdapilly school. Provided contour banks are installed, the clay soils (Pennell, Kulgun and McGrath) are suitable for cropping but suffer from problems of workability. Kulgun and McGrath may also have problems with gilgai microrelief, reduced water entry and internal drainage while Pennell is shallow and stony in patches.

The duplex soils (Weber, Furnivall, Yellunga, Evans) have limitations of surface crusting and compaction and impeded internal drainage above the clay subsoil. The sandier surface soils (Weber and Evans) also suffer from low plant available water capacity and low fertility. The sampled Furnivall profile was found to have high subsoil salinity indicating the need for more salt tolerant plant species for this soil profile class. Given the above limitations, the texture contrast soils are seen to be less suitable for dryland cropping and best used as pasture land. However, the more fertile, high plant available water capacity duplex soils e.g. Furnivall and Yellunga, may have some potential for occasional cropping.

The highly sodic soils of the uplands (Kulgun, Warumkarie, Furnivall and Yellunga) would probably require deep ripping combined with gypsum incorporation to improve their physical properties for cropping.

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APPENDIX 1

DETAILED MORPHOLOGICAL DESCRIPTIONS OF SOIL PROFILE CLASSES

Notes:

General: Soil Profile classes are presented in the same order as in the map reference.

Soil Profile Morphology:

(i) The most commonly observed range of profile attributes are described, together with less frequent variations outside this range.

(ii) The soil profile diagram indicates upper and lower depth limits of each horizon.

(iii) Horizon Nomenclature : As per McDonald (1977).

(iv) Colour : Moist colours were recorded using the Revised Standard Soil Colour Chart (Oyama and Takehara, 1967).
: Names are those of McDonald (pers comm) based on the value/chroma rating system of Northcote (1979).

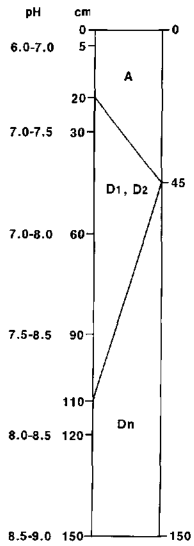
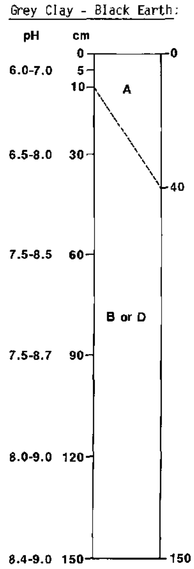
(v) Texture : As defined in Northcote (1979).

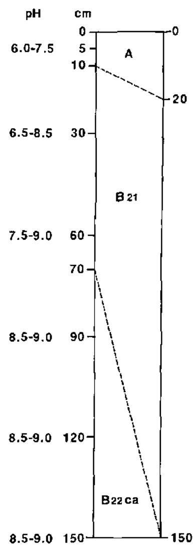
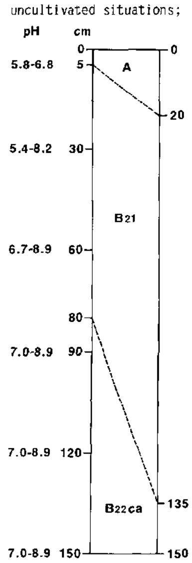
(vi) Structure : As per Soil Survey Manual (Soil Survey Staff 1951).

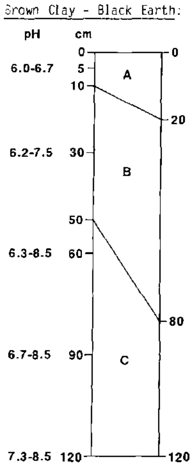
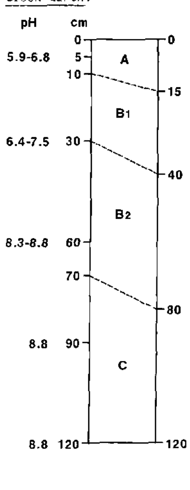
(vii) Consistence and Horizon Boundaries : As per McDonald *et al* (1984).

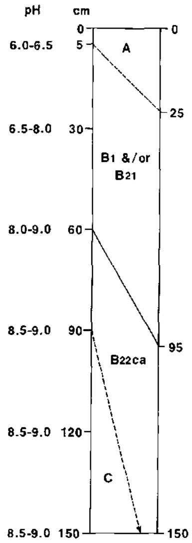
(viii) Field pH : As per Raupach and Tucker (1959) and Soil Survey Staff (1951).

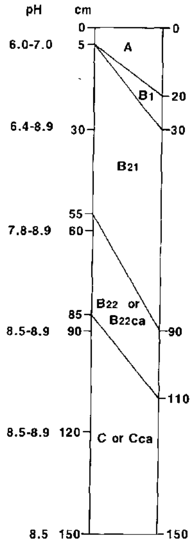
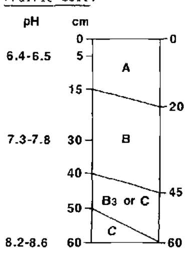
(ix) Horizon Boundary : A continuous line indicates an abrupt or clear boundary, while a broken line indicates a gradual or diffuse boundary.

Soil Profile Class	P.P.F.(S)	Soil Profile Class Description		Physiography	Natural Vegetation
Normanby	Uf6.32	Prairie Soil - Alluvial Soil: 	A horizon: a hardsetting surface with dark (10YR 3/2); fine sandy clay; moderate fine granular; hard (dry). D_1 horizon: dark (10YR 3/2); fine sandy clay loam; moderate medium granular; slightly hard to hard (dry). D_2 or D_3 horizon: dark (10YR 3/2) with faint yellow mottling above Dn horizon; fine sandy clay loam or fine sandy clay; massive to moderate medium prismatic; slightly hard to hard (dry). These horizons may be absent. Dn horizon: (n = 2 to 4) : dark (10YR 3/2); light medium clay; strong fine angular blocky; trace amounts of manganiferous concretions and commonly small amounts of carbonate.	Alluvial plain Lower terraces and immediate banks of Warrill Creek.	Creek banks of bottle brush Moderately to strongly developed ground layer of blue grasses.
Miller	Ug5.24 Ug5.1 Ug5.16 Ug5.17	Grey Clay - Black Earth: 	A horizon: weakly to moderately self-mulching, moderately cracking surface; dark (10YR 2/1, 3/1-2, 7.5YR 3/1-2) to grey (10YR 4/2) to grey brown (7.5YR 4/2); light to light medium clay; moderate fine to medium granular or angular blocky; hard (dry). B horizon: dark (10YR 2/1-2, 3/1-2) to grey (10YR 4/1-2); light medium to medium heavy clay; moderate medium to coarse angular blocky becoming lenticular at depth; very hard to extremely hard (dry); trace to small amounts of manganiferous concretions and/or soft ferruginous segregations; occasionally a trace of concretionary carbonate at depth. Subhorizons due to texture, structure and concretions common. D horizon: similar to B horizon but only clearly evident where grey brown A or B horizon clearly or sharply overlies a darker horizon (Alluvial Soils). Variants: (i) mottling may be evident in profiles from lower lying sites. (ii) brown sandy clay D-horizon present at 130 cm. (iii) alluvial banding evident below 60 cm.	Alluvial plain Narrow areas of main flood plain close to eastern branch of Warrill Creek.	Open forest of blue gums. Moderately to strongly developed ground layer of bluegrasses.

Soil Profile Class	P.P.F.(S)	Soil Profile Class Description	Physiography	Natural Vegetation
Cyrus	Ug5.16 Ug5.1 Ug5.28 Ug5.24	Black earth - Grey clay: Weak to strong nuram alpha gilgai ocassionally evident in uncultivated situations: mound and depression have similar morphology.  A horizon: moderately self-mulching, moderately cracking surface with dark (10YR 2/1-2, 3/1-2) to grey (10YR 4/1); medium to medium heavy clay; strong fine granular to moderate medium angular blocky; very hard (dry); occasionally a trace of manganiferous concretions. B21 horizon: dark (10YR 2/1, 3/1-2) to grey (10YR 4/1-2); medium to heavy clay; moderate to strong medium angular blocky or lenticular; very hard to extremely hard (dry); usually trace to small amounts of manganiferous concretions and commonly trace amounts of soft ferruginous segregations. Subhorizons of concretions common. B22ca horizon: grey (10YR-2.5Y 4-5/1-2); medium to heavy clay; moderate to strong coarse lenticular breaking to medium and fine lenticular; very hard to extremely hard (dry); trace to moderate amounts of carbonate concretions; manganese concretions and soft ferruginous segregations common. Subhorizons of concretions common. Variants: (i) carbonate may occur in a dark (10YR 3/1) B horizon. (ii) carbonate may not occur in top 150 cm of the profile. This variant is more common in gilgai depressions and close to creek lines.	Alluvial plain Extensive areas in intermediate position between creek lines and uplands.	Open forest of blue gums Moderately to strongly developed ground layer of bluegrasses.
Fassifern	Ug5.16 Ug5.1 Ug5.24 Ug5.28	Wiesenboden - Mottled Grey Clay: Weak nuram alpha gilgai occasionally evident in uncultivated situations; mound and depression have similar morphology.  A horizon: a moderately self mulching, moderately cracking surface, weak to strongly brown mottled dark (10YR 2/1, 3/1, 3/2) to grey (10YR-2.5Y 4/2) to grey brown (7.5YR 4/1, 4/2); light medium to medium clay; moderate fine to medium angular blocky; very hard (dry); trace to small amount of manganiferous concretions. B21 horizon: commonly weakly brown mottled dark (10YR 3/1) or grey (10YR-2.5Y 4/1-2); medium to medium heavy clay; moderate medium to coarse angular blocky or lenticular; very hard to extremely hard (dry); trace to small amounts of manganiferous and ferruginous concretions; *subhorizons of mottling, concretions common.* B22ca horizon: as above but with small amounts of carbonate concretions. Variants: (i) sporadic bleach occasionally found at the base of the A horizon in uncultivated situations (Ug3.1). (ii) carbonate may not occur in top 150 cm of the profile. This variant is more common in gilgai depressions.	Alluvial plain Low lying positions, back swamp depressions and broad drainage lines.	Open forest of bluegum Moderately to strongly developed ground layer of bluegrasses and sedges.

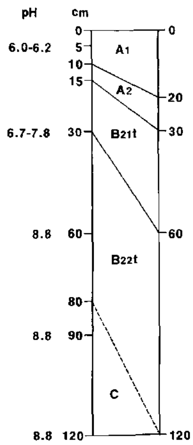
Soil Profile Class	P.P.F.(S)		Soil Profile Class Description	Physiography	Natural Vegetation
Pennell	Ug5.37 Ug5.32 Ug5.13 Ug5.23	Brown Clay - Black Earth:  	A horizon: weakly to moderately self-mulching, cracking surface. Dark (7.5YR-10YR 3/1-2) to brown (7.5YR 3/3); light to medium clay; strong medium granular grading to moderate medium blocky in deeper A horizons; hard to very hard (dry). B horizon: brown (7.5YR-10YR 4/3, 4/4, 7.5YR 5/4-6) to red brown (5YR 4/3-6); medium to medium heavy clay; moderate medium prismatic or angular blocky grading to coarse lenticular at depth; extremely hard (dry); trace to small amounts of manganiferous concretions or soft segregations. Subhorizons due to colour, structure or concretions common. Commonly contains carbonate at transition to C horizon. C horizon: yellow brown (10YR 5/4 7.5YR 6/6) or yellow (10YR 5-6/6, 7/6, 8/6); coarse sand to sandy clay loam; massive; hard (dry); commonly contains small to trace amounts of carbonate. Consists of weathered lithic or calcareous sandstone. Subhorizons due to colour and concretions common. Variants: (i) A horizon - grey (10YR 4/2). (ii) B horizon - yellow brown (10YR 5/4), clay over brown clay, small amounts of gravel (Ug5.23). (iii) C horizon - sandy clay (iv) non-cracking surface (Uf6.31).	Knolls, upper slopes and mid slopes of undulating low hills 1-5% slopes.	Mostly cleared. Bluegums, Moreton Bay Ash and silver-leaved ironbark occasionally present. Moderately to strongly developed ground layer of bluegrasses.
Warumkarie	Ug5.14	Black Earth:  	A1 horizon: moderately to strongly self mulching cracking surface; dark (10YR 3/1-7.5YR 3/2); medium clay; strong medium granular; very hard (dry). B1 horizon: dark (10YR 3/1, 3/2); medium clay; strong coarse angular blocky or lenticular; very hard (dry). Trace to small amounts of concretionary manganese. B2 horizon: grey (10YR 4/2, 5/2); medium clay; strong coarse angular blocky or lenticular; very hard (dry). Trace to small amounts of concretionary manganese. C horizon: light grey (5YR 8/1) to yellow (10YR 5/6), occasional yellow or grey mottle; clayey mudstone with ghost rock structure; hard (dry); may contain gravel. Trace to small amounts of concretionary carbonate or manganese. Variants: (i) dark (10YR 3/1, 4/1) medium clay layer containing trace amounts of concretionary carbonate and manganese between B1 horizon and C horizon. (ii) grey-brown (7.5YR 4/2) A1 horizon over grey B1 horizon (10YR 4/2) over brown B2 horizon (Ug5.22).	Mid to lower slopes of undulating lowhills 4-5% slopes.	Mostly cleared or cultivated - some Moreton Bay Ash.

Soil Profile Class	P.P.F.(S)	Soil Profile Class Description	Physiography	Natural Vegetation
Kulgun	Ug5.24 Ug5.14 Ug5.22 Ug5.16	Grey Clay - Black Earth: Weak to moderate linear alpha gilgai occasionally evident in uncultivated situations.  A horizon: moderately self-mulching, moderately cracking surface; dark (7.5YR-10YR 2/2, 3/1-2) to grey brown (7.5YR 4/2); light medium to medium heavy clay; moderate fine granular to coarse angular blocky; very hard (dry). B1 &/or B21 horizon: dark (10YR 2/2, 3/1-2) to grey (10YR-2.5Y 4/1-2) to grey brown (7.5YR 4/2); medium to medium heavy clay; moderate medium to coarse angular blocky, prismatic or lenticular; extremely hard (dry); trace to small amounts of manganiferous concretions. Subhorizons due to concretions or colour common. B22ca horizon: grey (10YR-2.5Y 4/1-2, 5/1-2), yellow brown (10YR 5/3) to yellow grey (2.5Y 5/3); medium heavy clay; medium coarse lenticular; extremely hard (dry); trace to small amounts of carbonate concretions and manganiferous concretions. Sub-horizons due to concretions or colour common. C horizon: mottled yellow grey (2.5Y 5/3, 7/4) or yellow (2.5Y 7/6, 8/6) or grey (2.5Y 5/1, 10YR 5/6-1) clayey soft mudstone or shale, commonly containing carbonate. Subhorizons due to colour common. Variants: B22ca - dark mottles along fissures. B21 - brown (7.5YR 4/3) colour (Ug5.33) (integrading to McGrath Soil Profile Class).	Saddle between knolls, of foot-slopes or alluvial-colluvial fans of undulating low hills. 1-4% slopes.	Most cleared. Bluegums, narrow leaved ironbark, Moreton Bay ash, silver leaved ironbark occasionally present. Moderately to strongly developed ground layer of bluegrasses.

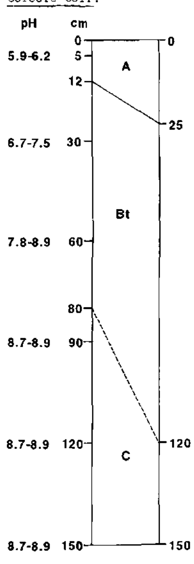
Soil Profile Class	P.P.F.(S)	Soil Profile Class Description	Physiography	Natural Vegetation
McGrath	Ug5.33 Ug5.13 Ug5.37 Ug5.32	Brown Clay - Black Earth: Weak to strong lattice and nuram alpha gilgai on knolls, linear alpha gilgai on slopes, common in uncultivated situations.  A horizon: hardsetting to moderately self-mulching, cracking surface. Dark (7.5YR-10YR, 2/1, 3/1-2) to brown (7.5YR 3/3), light to medium clay; moderate to strong fine to coarse granular; hard to very hard (dry). B_1 horizon: dark (7.5YR-10YR 3/1-2) to brown (7.5YR 3/3); medium clay; moderate medium to coarse angular blocky; very hard (dry). B_{21} horizon: brown (7.5YR-10YR 4/3-4) to red brown (5YR 4/3-4) occasionally mottled; medium to medium heavy clay; moderate medium to coarse lenticular or angular blocky; extremely hard (dry); trace to small amounts of manganiferous concretions. Sub-horizons due to colour, structure or concretions common. B_{22} or B_{22ca} horizon: dark (7.5YR-10YR 2/1, 3/1-2) grey (10YR-2.5Y 4/1-2) or brown (7.5YR-10YR 4/3-4) or yellow brown (10YR 5/3-4, 6/4); medium to medium heavy clay; moderate medium to coarse lenticular; extremely hard (dry). Trace to small amounts of manganiferous concretions; commonly trace to small amounts of soft or concretionary carbonate. Subhorizons due to colour or concretions common. C or C_{ca} horizon: yellow brown (10YR 5/4, 6/4-6, 7/6) or red brown (5YR 5/6) becoming grey mottled at depth; clayey soft mudstone or occasionally sandy, calcareous sandstone; trace to small amounts of soft or concretionary lime common. Sub-horizons due to colour, mottling and concretions common. Variants: (i) carbonate found at 25 cm (ii) transitional B_{23}-horizon with yellow brown (10YR 5/4) clay 10-15 cm thick occurs. (iii) trace to small amounts of gravel can occur throughout profile but more commonly at depth. (iv) non cracking surface (Uf 6.31) with deeper profile. (v) deep profile (>150 cm) (Ug5.34, Ug5.15).	On knolls, mid lower slopes and alluvial-colluvial fans of undulating low hills.	Mostly cleared. Moreton Bay ash most common, but also narrow-leaved ironbark and silver-leaved ironbark. Moderately to strongly developed ground layer of bluegrasses.
Churchbank	Gn3.23 Uf6.31	Prairie Soil:  A horizon: moderate to strongly hard setting surface; dark (10YR 3/2); clay loam (sandy) to light clay; moderate fine granular; hard (dry). B horizon: brown (10YR 4/3); medium to heavy clay; moderate medium angular blocky; very hard (dry). B_3 horizon: grey (2.5Y 4/2) clay and angular volcanic gravel. C horizon: yellow (10YR 5/6) and brown (10YR 4/3) mottled weathered microsyenite or calcareous sandstone. Occasional brown mottle.	Mid to upper slopes of knolls of undulating low hills.	Mostly cleared. Some narrow-leaved ironbark moderate development of native grasses.

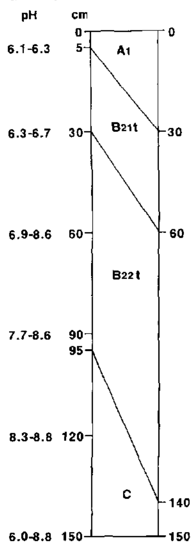
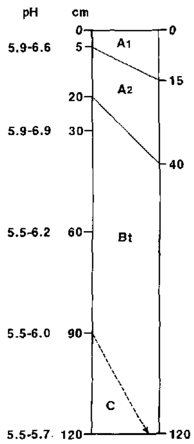
Soil Profile Class	P.P.F.(S)	Soil Profile Class Description	Physiography	Natural Vegetation
Weber	Dy2.43	Solodic Soil: (see profile diagram 1) A1 horizon: hardsetting surface; grey brown (7.5YR 4/2); sandy loam to sandy clay loam, weak granular to massive; very hard (dry). A2 horizon: grey brown (5YR 5/2) to brown (7.5YR 5/3), commonly with a faint yellow mottle, conspicuously bleached when dry; loamy sand; massive; very hard (dry). B21t horizon: grey brown (7.5YR 5/2) to brown (7.5YR 5/3), commonly with a faint yellow mottle; light medium to medium clay (sandy); moderate coarse angular blocky or prismatic; extremely hard (dry); commonly trace to small amounts of concretionary manganese and iron. B22t horizon: yellow brown (10YR 5-6/4); medium clay (sandy) to heavy clay; moderate coarse angular blocky or lenticular; extremely hard (dry); commonly trace amounts of concretionary manganese and soft or concretionary carbonate. Lower subhorizons may become yellow (10YR 6/6) to red brown (5YR 6/6). C horizon: mottled grey (2.5Y 7-8/1) medium clay or yellow brown (10YR 6/4); sandy clay; commonly contain traces of manganese or carbonate.	Mid to lower slopes of undulating low hills. 3-7% slopes.	Mostly cleared. Moreton Bay ash, narrow-leaved ironbark, bluegum and quinine berry occasionally present
Furnivall	Db1.13 Dy2.33 Db1.33 Dy2.13	Solodic Soil: (see profile diagram 2) A horizon: moderate to strong hardsetting surface; dark (7.5YR 3/2) to grey brown (7.5YR 4/2); commonly sporadically bleached at base; sandy loam to sandy clay loam; massive; hard (dry). Bt horizon: grey (10YR 4/2) to brown (10YR 4/4, 7.5YR 3/3) becoming paler with depth (2.5Y 5/3, 7.5YR-10YR 5/3-4, 6/4); medium clay (sandy) to heavy clay; moderate medium angular blocky; extremely hard (dry); trace to small amounts of soft and concretionary manganese. Trace amounts of siliceous gravel and ferruginous segregations. Subhorizons due to colour and accumulations common. Carbonate may be present at transition to C horizon. C horizon: brown (7.5YR 5/4) to yellow brown (10YR 6/4-6) commonly strong grey mottle; fine sandy clay to medium clay; moderate medium angular blocky; slightly hard to very hard (dry). Trace to small amounts soft and concretionary line and manganese. Subhorizons common. Consists of weathered mudstones to fine grained sandstone (7.5-10YR 6/6). Variants: (i) shallow profile (55 cm) with yellow subsoil. (ii) deep profile (145 cm) (Dy2.13). (iii) acid soil reaction trend with colour A2 horizon (Dy2.21).	Mid to lower slopes of undulating low hills. 3-7% slopes.	Narrow-leaved ironbark, bluegum, Moreton Bay ash.

Weber — Solodic Soil:



Furnivall — Solodic Soil:



Soil Profile Class	P.P.F.(S)		Soil Profile Class Description	Physiography	Natural Vegetation
Yellunga	Db1.32 Db1.33 var. Dy2.33 Dy2.12	Solodic Soil: 	A_1 horizon: strongly hardsetting surface: grey brown (7.5YR 4/1-2); clay loam; weak medium blocky to massive; very hard (dry). sporadic bleach common. B_{21t} horizon: brown to yellow brown 7.5YR 4/3. 10YR 5/3); light medium to medium heavy clay; moderate angular blocky or prismatic: trace to small amounts of soft and concretionary manganese. B_{22t} horizon: brown (7.5YR-10YR 4/3-4). grey (10YR 5/2) or yellow brown (10YR 5/3-4); medium to medium heavy clay; moderate medium angular blocky; trace to small of soft and concretionary manganese. Carbonate occasionally present. Subhorizons due to colour and concretions common. C horizon: yellow brown to light grey (10YR 6/3 - 2.5Y 8/2); medium clay; occasional grey or yellow mottle: medium blocky. Variants: (i) some surface erosion of A horizon; clay loam weak crumb to massive. (ii) occasional rounded quartz. (iii) acid soil reaction throughout profile. (iv) shallow depth (70-80 cm) to C horizon. This is equivalent to Ortels SPC at Kalbar (Powell 1979). (v) eroded phase appears as a Uf6.31.	Mid slopes of undulating low hills 2-4% slope.	Mostly cleared. Well developed ground layer of blue grasses.
Evans	Dy5.41 Dy3.41 Dy4.41 Dy2.21	Yellow Podzolic Soil: 	A_1 horizon: hardsetting or loose surface; grey brown (7.5YR 4/2); loamy sand to sandy loam; massive slightly hard (dry). A_2 horizon: brown (7.5YR 4-5/3. 6/4) or grey brown (7.5YR 5/1-2) usually bleached when dry: sand to sandy loam; loose to slightly hard (dry): massive small to large amounts of siliceous gravel and trace amounts of concretionary manganese common. B_t horizon: strongly mottled yellow-brown (10YR 5-6/4). yellow (10YR 6/6) and grey (10YR 6/1) or yellow brown (7.5YR 5/6); red mottling common at depth; sandy clay to medium clay: moderate. medium to coarse angular blocky: very hard to extremely hard (dry); traces of concretionary manganese common. siliceous gravel occasionally present. Subhorizons due to colour. manganese and gravel common. C horizon: weathered sandstone. Variants: (i) loam A horizons (ii) upper slope profiles have shallow A horizons while lower slope profiles have deeper A horizons.	Upper to lower slopes of undulating low hills. 2-5% slopes.	Mostly cleared. Narrow-leaved ironbark. and Moreton Bay ash occasionally present. Moderately developed ground layer.

APPENDIX 2

MORPHOLOGY AND ANALYSIS OF REPRESENTATIVE PROFILES

Notes:

Soil Profile Morphology : As per notes (iii) to (vii) in Appendix 1.

Chemical Data : Apart from pH, E.C. and fertility data, chemical data are presented on an oven dry (O.D.) basis.

Soil Profile Class:	CYRUS	Map Unit:	Cy	Site No:	R1
Great Soil Group:	Black Earth	Soil Taxonomy:	Udorthentic Pellustert	P.P.F.:	Ug 5.16
Parent Material:	Quaternary alluvium	A.M.G. Ref:	469105 mE, 6926500 mN		
Topography:	Nearly flat (< 0.5%) alluvial plain	Air Photo Ref:			
		Location:	Mutdapilly Research Station		

Vegetation: None

Profile Morphology: Surface : cultivated, strongly self mulching, seasonal cracking.

Ap 0 - 20 cm Dark (10YR 3/1); medium clay; strong fine granular; slightly hard (slightly moist). Clear to -

B_{21} 20 - 70 cm Grey (10YR 4/1); medium clay; strong medium lenticular; soft (moist); trace amounts of concretionary manganese. Clear to -

B_{22} 70 - 130 cm Grey (10YR 4/1) with 10% faint grey mottle; medium clay; strong coarse lenticular; soft (moist); small amounts of concretionary carbonate and concretionary manganese. Gradual to -

B_{23} 130 - 150 cm Grey (2.5Y 5/1); medium clay; strong coarse lenticular; soft (moist); small amounts of concretionary carbonate and concretionary manganese.

Laboratory Data:

Lab.No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio (R_1)	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	Na^+	K^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m. equiv/100 g O.D.					% O.D.					
4381	0-10	6.2	0.14	0.006	0.59	2	4	17	73	-	-	-	-	-	0.049	0.19	0.041	7.2	54	-
4383	20-30	7.2	0.07	0.004	0.71	2	3	8	87	75	34	29	2.8	0.14	0.026	0.11	0.018	8.3	67	36
4386	50-60	8.1	0.13	0.016	0.81	2	3	9	84	70	33	29	4.4	0.12	0.020	0.10	0.015	8.3	65	36
4389	80-90	8.6	0.34	0.052	0.61	2	4	12	84	68	31	33	5.6	0.11	0.016	0.12	0.009	7.4	63	34
4392	110-120	8.7	0.65	0.102		5	5	10	78	66	28	34	6.0	0.12	0.018	0.13	0.007	7.1		
4395	140-150	8.6	0.80	0.141	0.71	3	4	12	77	66	26	33	6.5	0.15	0.021	0.19	0.007	7.6	60	32

Lab.No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb Extr. P ppm	Repl. K m.equiv/100g	Fe	Mn	Cu	Zn	B ppm
							D.T.P.A. Extr. ppm				
4381	0-10	2.5	0.21	48	43	0.34	91	31	2.6	1.0	
4382	10-20	2.1	0.19	10	11	0.21					

Soil Profile Class:	CYRUS - Gilgaied phase	Map Unit:	(Cy - G)	Site No:	R2
Great Soil Group:	Grey Clay	Soil Taxonomy:	Udorthentic Pellustert	P.P.F.:	Ug 5.2
Parent Material:	Quaternary alluvium	A.M.G. Ref:	468375 mE, 6926220 mN		
Topography:	Nearly flat (< 0.5%) alluvial plain Mound of nuram alpha gilgai microrelief	Air Photo Ref:			
		Location:	Mutdapilly Research Station		

Vegetation: Cleared, previously bluegum open forest. Dense ground cover dominated by scented top, with sedges and nardoo.

Profile Morphology: Surface : moderately self mulching, seasonal cracking.

A_1 0 - 10 Dark (10YR 3/1); medium clay; moderate fine blocky; hard (slightly moist); trace amounts of concretionary manganese. Gradual to -

B_{21} 10 - 30 Grey (10YR 4/1); medium clay; moderate medium blocky; soft (moist); small amounts of concretionary manganese and soft ferruginous nodules. Gradual to -

B_{22} 30 - 80 Grey (10YR 4/1) with 10% faint grey mottle gradually becoming paler grey (2.5Y 5/1); medium clay; moderate coarse lenticular; soft (moist); small amounts of concretionary manganese and soft ferruginous nodules. Gradual to -

B_{23} 80 - 140 Dark (10YR 3/1); medium clay; moderate coarse lenticular; soft (moist); small amounts of concretionary manganese and concretionary carbonate. Gradual to -

B_{24} 140 - 150 Brown (7.5YR 4/3) with 10% faint grey mottle; medium clay; moderate medium lenticular; hard (slightly moist); small amounts of soft manganese and concretionary carbonate.

Laboratory Data:

Lab.No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio (R_1)	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	Na^+	K^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m. equiv/100 g O.D.					% O.D.					
4397	0-10	6.4	0.06	0.005	0.51	6	5	14	75	72	16	29	2.1	0.63	0.051	0.38	0.031	7.9	64	34
4399	20-30	7.2	0.02	0.011	0.65	3	6	10	83	72	24	41	3.8	0.40	0.027	0.30	0.015	8.6	67	36
4402	50-60	7.8	0.31	0.054	0.75	2	6	14	79	69	26	40	5.3	0.28	0.026	0.31	0.011	8.2	63	35
4405	80-90	8.3	0.38	0.065	0.73	2	7	14	79	70	24	42	6.0	0.38	0.024		0.039	7.6	63	34
4408	110-120	8.7	0.41	0.066		1	7	14	75	67	21	39	5.7	0.30	0.027	0.37	0.009	7.8		
4411	140-150	9.0	0.37	0.051	0.77	1	29	30	45	47	15	30	4.4	0.24	0.112	1.02	0.006	5.3	45	24

Lab.No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb Extr. P ppm	Repl. K m.equiv/100g	Fe	Mn	Cu	Zn	B ppm
							D.T.P.A. Extr. ppm				
4397	0-10	2.6	0.21	21	23	0.66	268	68	3.2	1.2	
4398	10-20	1.2	0.10	4	4	0.38					

Soil Profile Class: CYRUS
Great Soil Group: Black Earth
Parent Material: Quaternary alluvium
Topography: Nearly flat (< 0.5%) alluvial plain; incipient gilgai
Map Unit: Cy
Soil Taxonomy: Udic Pellustert
A.M.G. Ref: 467885 mE, 6927190 mN
Air Photo Ref:
Location: Mutdapilly Research Station
Site No: R3
P.P.F.: Ug 5.16

Vegetation: Open forest of bluegums. Dense ground cover dominated by scented top and paspalum.

Profile Morphology: Surface : moderately cracking.

A_1 0 - 10 cm Dark (10YR 3/1); medium heavy clay; moderate fine blocky; very hard (slightly moist). Gradual to -

B_{21} 10 - 100 cm Dark (10YR 2/1); medium heavy clay; moderate medium blocky; hard (slightly moist); trace amounts of concretionary manganese and soft ferruginous nodules. Diffuse to -

B_{22ca} 100 - 130 cm Dark (10YR 3/1); medium clay; moderate medium blocky; slightly hard (moist); trace amounts of concretionary carbonate and soft ferruginous nodules. Diffuse to -

B_{23} 130 - 150 cm Grey (10YR 4/1); medium clay; moderate coarse lenticular; slightly hard (moist); trace amounts of concretionary manganese and soft ferruginous nodules.

Laboratory Data:

Lab.No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio (R_1)	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	Na^+	K^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m. equiv/100 g O.D.					% O.D.					
4413	0-10	6.4	0.12	0.013	0.71	6	5	26	59	59	16	20	2.3	1.2	0.148	1.05	0.041	6.5	54	29
4415	20-30	6.6	0.20	0.032	0.78	2	4	23	66	60	20	25	4.9	0.65	0.117	1.00	0.020	6.8	56	29
4418	50-60	7.1	0.32	0.055	0.94	2	6	23	68	61	25	27	8.3	0.41	0.109	0.92	0.015	6.6	62	31
4421	80-90	8.2	0.31	0.046	0.99	2	4	23	68	63	26	29	9.9	0.31	0.106	0.97	0.010	6.6	60	31
4424	110-120	8.7	0.22	0.034		3	3	20	71	64	24	30	12	0.35	0.083	0.86	0.008	6.9		
4427	140-150	8.9	0.30	0.039	0.99	2	4	17	75	64	21	31	13	0.35	0.035	0.047	0.006	7.0	67	35

Lab.No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb Extr. P ppm	Repl. K m.equiv/100g	Fe D.T.P.A. Extr. ppm	Mn	Cu	Zn	B ppm
4413	0-10	3.8	0.29	96	217	1.3	282	51	3.2	2.2	
4414	10-20	1.7	0.14	115	127	0.71					

Soil Profile Class: FASSIFERN
Great Soil Group: Wiesenboden
Parent Material: Quaternary alluvium
Topography: Nearly flat (< 0.5%) alluvial plain; lowlying area
Map Unit: Fa
Soil Taxonomy: Typic Pelludert
A.M.G. Ref: 467195 mE, 6927385 mN
Air Photo Ref:
Location: Mutdapilly Research Station
Site No: R4
P.P.F.: Ug 5.16

Vegetation: Cleared grassland with dense ground cover of scented top, sedges and nardoo.

Profile Morphology: Surface : moderately self mulching, seasonal cracking.

A_1 0 - 10 cm Dark (10YR 3/1) with 5% distinct brown mottle; medium clay; moderate fine blocky; soft (moist). Gradual to -

B_1 10 - 30 cm Dark (10YR 3/1); medium clay; moderate blocky; soft (moist). Diffuse to -

B_{21} 30 - 110 cm Dark (10YR 3/1) with 5% faint brown mottle; medium clay; moderate blocky; soft (moist); trace amounts of concretionary manganese and soft ferruginous nodules. Gradual to -

B_{22} 110 - 150 cm Grey (10YR 4/1) with 15% faint brown mottle; medium clay; moderate blocky; slightly hard (slightly moist); small amounts of soft manganese patches and soft ferruginous nodules.

Laboratory Data:

Lab.No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio (R_1)	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	Na^+	K^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m. equiv/100 g O.D.					% O.D.					
4429	0-10	6.1	0.04	0.004	0.56	5	6	27	57	-	-	-	-	-	0.128	1.20	0.027	6.5	57	-
4431	20-30	6.7	0.03	0.004	0.68	3	5	24	68	60	29	21	0.76	1.2	0.105	1.08	0.012	7.2	56	31
4434	50-60	7.3	0.03	0.003	0.51	2	4	27	66	58	29	20	1.2	0.34	0.084	1.06	0.008	6.9	58	31
4437	80-90	7.2	0.05	0.008	0.71	2	5	26	66	62	32	24	1.5	0.38	0.105	1.00	0.008	7.3	60	32
4440	110-120	7.4	0.05	0.008		2	6	34	57	58	32	22	1.2	0.28	0.109	1.08	0.006	6.8		
4443	140-150	7.4	0.04	0.006	0.76	2	5	34	57	57	32	23	1.2	0.32		1.07	0.006	7.1	54	30

Lab.No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb Extr. P ppm	Repl. K m.equiv/100g	Fe D.T.P.A. Extr. ppm	Mn	Cu	Zn	B ppm
4429	0-10	2.9	0.26	103	306	1.6	290	18	3.1	2.3	
4430	10-20	1.3	0.14	166	192	1.4					

Soil Profile Class: PENNELL
Map Unit: Pe
Site No: R6
Great Soil Group: Brown Clay
Soil Taxonomy: Udorthentic Chromustert
P.P.F.: Ug 5.37
Parent Material: Feldspathic sandstone of the Walloon Coal Measures
A.M.G. Ref: 465500 mE, 6928120 mN
Topography: 3% upper slope of undulating low hills
Air Photo Ref:
Location: Mutdapilly Research Station

Vegetation: Cleared bluegum open forest. Dense ground cover dominated by pitted blue, windmill grass and cobbler's peg.

Profile Morphology: Surface : moderately self mulching, seasonal cracking.

A_1	0 - 20 cm	Dark (10YR 3/1); medium clay; strong medium granular; hard (dry). Clear to -
B_2	20 - 50 cm	Red brown (5YR 4/6); medium heavy clay; moderate medium prismatic; very hard (slightly moist); trace amounts of concretionary manganese. Clear to -
B_3	50 - 65 cm	Brown (10YR 4/4); medium clay; moderate coarse lenticular; very hard (slightly moist); trace amounts of soft manganese nodules. Clear to -
C	65 - 70 cm	Yellow brown (10YR 5/4); clayey sand; structureless; hard (slightly moist).

Laboratory Data:

Lab.No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio (R_1)	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	Na^+	K^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m. equiv/100 g O.D.					% O.D.					
4462	0-10	6.6	0.10	0.004	0.33	11	13	21	52	47	18	14	0.21	2.4	0.116	0.35	0.066	5.3	51	27
4464	20-30	6.8	0.03	0.001	0.40	5	10	11	70	54	26	22	0.43	1.2	0.047	0.02	0.028	6.2	55	29
4467	50-60	7.6	0.04	0.002	0.50	11	13	13	60	55	28	26	0.96	0.28	0.028	0.09	0.013	6.9	54	28

Lab.No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb Extr. P ppm	Repl. K m.equiv/100g	Fe	Mn	Cu	Zn	B ppm
							D.T.P.A. Extr. ppm				
4462	0-10	5.6	0.42	158	126	2.1	184	70	2.7	9.6	
4463	10-20	2.4	0.23	20	27	1.6					

Soil Profile Class: KULGUN
Map Unit: Ku
Site No: R8
Great Soil Group: Black Earth
Soil Taxonomy: Udic Chromustert
P.P.F.: Ug 5.17
Parent Material: Mudstone of the Walloon Coal Measures
A.M.G. Ref:
Topography: 2% footslope of undulating low hills
Air Photo Ref:
Location: Mutdapilly Research Station

Vegetation: Cleared. Dense ground cover of Rhodes grass.

Profile Morphology: Surface : moderately self mulching, seasonal cracking.

A_1	0-10 cm	Dark (10YR 2/2); medium heavy clay; moderate coarse blocky; very hard (dry). Gradual to -
B_1	10-40 cm	Dark (10YR 2/2); medium heavy clay; moderate coarse blocky; extremely hard (dry). Gradual to -
B_2	40-70 cm	Dark (2.5Y 3/2); medium heavy clay; moderate medium blocky; very hard (slightly moist); trace amounts of concretionary manganese. Clear to -
2_uA_1	70-90 cm	Dark (10YR 3/1); medium heavy clay; moderate medium blocky; very hard (slightly moist); trace amounts of concretionary manganese. Clear to -
2_uB_2	90-100 cm	Grey (2.5Y 4/2) with 10% faint dark mottle; medium heavy clay; moderate coarse lenticular; very hard (slightly moist); small amounts of concretionary manganese and concretionary carbonate. Gradual to -
2_uB_3	100-120 cm	Grey (2.5Y 4/1) with 50% distinct dark mottle; medium heavy clay; moderate coarse lenticular; very hard (slightly moist); Clear to -
C	120-150 cm	Yellow grey (2.5Y 5/3) with 30% distinct grey mottle; medium clay; moderate fine blocky; slightly hard (slightly moist); moderate amounts of soft carbonate.

Laboratory Data:

Lab.No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio (R_1)	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	Na^+	K^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m. equiv/100 g O.D.					% O.D.					
4486	0-10	6.6	0.08	0.009	0.74	10	33	20	34	34	7.3	9.1	2.2	0.44	0.102	0.56	0.027	3.1	34	15
4488	20-30	7.5	0.28	0.045	0.92	9	26	20	45	38	10	15	6.8	0.19	0.048	0.50	0.021	3.8	46	21
4491	50-60	8.5	0.68	0.122	0.99	7	22	16	53	45	10	22	13	0.25	0.032	0.43	0.015	4.4	56	26
4494	80-90	8.9	0.86	0.141	0.98	6	19	19	57	53	10	23	15	0.29	0.038	0.49	0.009	4.9	57	28
4497	110-120	9.7	0.72	0.094		5	13	27	53	62	12	31	21	0.40	0.034	0.85	0.011	5.7		
4500	140-150	9.9	0.78	0.098	0.89	6	38	23	27	60	9.3	32	21	0.47	0.021	0.28	0.004	5.2	53	26

Lab.No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb Extr. P ppm	Repl. K m.equiv/100g	Fe	Mn	Cu	Zn	B ppm
							D.T.P.A. Extr. ppm				
4486	0-10	2.0	0.14	68	54	0.45	161	59	1.4	1.6	
4487	10-20	1.6	0.11	30	19	0.21					

Soil Profile Class: McGRATH | **Map Unit:** McG | **Site No:** R5

Great Soil Group: Brown Clay | **Soil Taxonomy:** Udorthentic Chromustert | **P.P.F.:** Ug 5.37

Parent Material: Mudstone of the Walloon Coal Measures | **A.M.G. Ref:** 466460 mE, 6928000 mN

Topography: 2% upper slope of undulating low hills | **Air Photo Ref:**

Location: Mutdapilly Research Station

Vegetation: Mostly cleared of trees; some Moreton Bay ash; dense ground layer of scented top and kangaroo grass.

Profile Morphology: Surface : moderately self mulching, seasonal cracking.

A_1	0 - 10	Dark (7.5YR 3/2); light medium clay; strong coarse granular; slightly hard (dry); trace amounts of charcoal. Clear to -
B_{21}	10 - 30	Red brown (5YR 4/3) with faint brown mottle; medium heavy clay; moderate coarse blocky; hard (slightly moist); trace amounts of charcoal. Gradual to -
B_{22}	30 - 65	Brown (10YR 4/4) with 2% distinct red mottle; medium heavy clay; moderate coarse lenticular; hard (slightly moist); small amounts of concretionary manganese. Clear to -
B_{23}	65 - 85	Dark (10YR 2/1); medium heavy clay; moderate medium lenticular; hard (slightly moist); trace amounts of concretionary carbonate and soft manganese nodules. Clear to -
C_1	85 - 110	Yellow brown (10YR 6/4) with 5% prominent dark mottle; medium clay; moderate fine blocky; hard (slightly moist); small amounts of concretionary carbonate. Gradual to -
C_2	110 - 140	Yellow (10YR 7/6) with 5% faint grey mottle; medium heavy clay; moderate coarse lenticular; hard (slightly moist); small amounts of concretionary carbonate. Gradual to -
C_3	140 - 160	Yellow (10YR 7/8) with 15% prominent grey mottle; medium clay; moderate medium blocky; slightly hard (slightly moist); small amounts of soft carbonate.

Laboratory Data:

Lab.No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio (R_1)	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	Na^+	K^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m. equiv/100 g O.D.					% O.D.					
4445	0-10	6.3	0.04	0.004	0.38	14	20	20	42	42	11	13	0.54	0.84	0.059	0.27	0.039	4.7	41	23
4447	20-30	7.3	0.08	0.011	0.62	6	12	13	68	53	19	26	3.0	0.30	0.031	0.22	0.019	6.8	55	29
4450	50-60	8.2	0.35	0.067	0.70	7	12	15	65	52	19	30	5.5	0.23	0.016	0.18	0.016	6.0	55	28
4453	80-90	8.7	0.38	0.064	0.77	14	12	24	49	46	17	28	5.6	0.16	0.164	0.38	0.017	5.3	45	23
4456	110-120	9.3	0.38	0.069		2	4	27	67	49	17	33	6.1	0.16	0.025	0.78	0.013	5.2		
4459	140-150	9.0	0.42	0.067	0.75	2	2	17	76	65	19	41	8.9	0.19	0.014	0.52	0.010	6.9	54	28

Lab.No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb Extr. P ppm	Repl. K m.equiv/100g	Fe	Mn	Cu	Zn	B ppm
							D.T.P.A. Extr. ppm				
4445	0-10	3.0	0.25	19	18	0.73	115	106	2.4	1.4	
4446	10-20	1.5	0.11	3	5	0.35					

Soil Profile Class: FURNIVALL | **Map Unit:** Fu | **Site No:** R7

Great Soil Group: Solodic soil | **Soil Taxonomy:** Mollic Natrustalf | **P.P.F.:** Db 1.13

Parent Material: Mudstone | **A.M.G. Ref:** 469680 mE, 6929100 mN

Topography: 4% mid lower slope of undulating low hills | **Air Photo Ref:**

Location: Mutdapilly Research Station

Vegetation: Open forest of narrow leaved ironbark. Patchy ground cover of blue couch and pitted bluegrass.

Profile Morphology: Surface : strongly hardsetting (2-15% rounded siliceous gravel).

A_1	0-20 cm	Dark (7.5YR 3/2); sandy clay loam; small amounts of rounded siliceous gravel; massive becoming moderate coarse granular; hard (dry). Clear to -
B_{21t}	20-45 cm	Brown (10YR 4/3); medium heavy clay; moderate coarse prismatic; very hard (slightly moist); trace amounts of soft manganese nodules. Gradual to -
B_{22t}	45-65 cm	Yellow grey (2.5Y 5/3); medium heavy clay; moderate medium blocky; hard (slightly moist); trace amounts of soft manganese nodules. Gradual to -
B_3	65-80 cm	Yellow brown (10YR 6/4) with yellow and grey mottle; medium clay; moderate medium blocky; hard (slightly moist); trace amounts of soft manganese nodules and soft carbonate. Gradual to -
C_1	80-125 cm	Pale yellow (5Y 8/2) with 20% prominent yellow mottle; medium clay; moderate fine blocky; hard (slightly moist); small amounts of soft manganese nodules and concretionary carbonate. Gradual to -
C_2	125-150 cm	Yellow (10YR 6/6) with 25% prominent grey mottle; light clay; moderate medium blocky; slightly hard (slightly moist); small amounts of soft manganese nodules and concretionary carbonate.

Laboratory Data:

Lab.No.	Depth cm	pH 1:5	E.C.(1:5) $mScm^{-1}$	Cl %	Dispersion Ratio (R_1)	C.S.	F.S.	Si	C	C.E.C.	Ca^{++}	Mg^{++}	Na^+	K^+	P	K	S	Moisture % A.D.	1/3 bar	15 bar
						Particle Size % O.D.				Exch. Cations m. equiv/100 g O.D.					% O.D.					
4470	0-10	5.6	0.05	0.005	0.56	26	45	9	17	21	3.7	5.8	0.15	0.69	0.061	0.37	0.028	1.9	22	8
4472	20-30	6.4	0.14	0.023	0.66	18	30	8	43	37	9.0	20	2.5	0.19	0.028	0.26	0.017	3.6	33	16
4475	50-60	8.7	1.10	0.192	0.53	7	20	11	62	56	17	36	8.0	0.11	0.024	0.36	0.019	5.8	48	25
4478	80-90	8.8	1.00	0.197	0.56	1	21	16	60	65	17	40	9.9	0.25	0.013	0.80	0.007	6.4	49	26
4481	110-120	9.0	0.96	0.176		1	25	24	50	60	15	37	8.8	0.30	0.021	0.99	0.004	6.5		
4484	140-150	8.3	0.74	0.138	0.45	3	30	23	39	57	14	36	9.0	0.35	0.027	1.17	0.003	5.4	43	23

Lab.No.	Depth cm	Org. C %	Tot. N %	Acid Extr. P ppm	Bicarb Extr. P ppm	Repl. K m.equiv/100g	Fe	Mn	Cu	Zn	B ppm
							D.T.P.A. Extr. ppm				
4470	0-10	1.8	0.13	46	36	0.73	281	30	1.2	2.8	
4471	10-20	1.1	0.07	15	18	0.31					

APPENDIX 3

VEGETATION - COMMON AND SCIENTIFIC NAMES

Common Name	Scientific Name
<u>Trees</u>	
Blue Gum	*Eucalyptus tereticornis*
Narrow-leaved ironbark	*E. crebra*
Moreton Bay ash *or* carbeen	*E. tessellaris*
Quinine berry	*Petalostigma pubescens*
River she-oak	*Casuarina cunninghamiana*
River tea tree / black tea tree	*Melaleuca bracteata*
Silver-leaved ironbark	*Eucalyptus melanophloia*
Weeping bottlebrush	*Callistemon viminalis*
<u>Ground Cover</u>	
Barnyard grass	*Echinochloa crus-galli*
Blady grass	*Imperata cylindrica*
Blue grass	*Dichanthium sericeum and Bothriochloa* spp.
Blue verbena	*Verbena* sp. *Helistropium amplexicaule*
Clustered love grass	*Eragrostis elongata*
Cobbler's peg	*Bidens pilosa*
Couch grasses	*Cynodon dactylon* and *Digitaria didactyla*
Columbus grass	*Sorghum almum*
Green panic	*Panicum maximum* var. *trichoglume*
Groundsel bush	*Baccharis halimifolia*
Johnson grass	*Sorghum halepense*
Kangaroo grass	*Themeda australis*
Native glycine	*Glycine* spp.

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Common Name	Scientific Name
Noogoora burr	*Xanthium pungens*
Paspalum	*Paspalum longifolium*
	Paspalum dilatatum
Pennyweed	*Centella asiatica*
Phasey bean	*Macroptilium lathyroides*
Pidgeon grass	*Setaria* spp.
Rat's tail grass	*Sporobolus* spp.
Rhodes grass	*Chloris gayana*
Rushes	*Juncus continuus*
Scented top	*Capillipedium spicigerum*
Spear thistle or Scotch thistle	*Cirsium vulgare*
Sedges	*Eleocharis dietrichiane*
Setaria	*Setaria anceps*
Sour grass	*Paspalum conjugatum*
White clover	*Trifolium repens*
White root	*Lobelia purpurascens*
Wild aster or bushy stawort	*Aster subulatus*
Windmill grass	*Chloris truncata / Chloris divaricata*
Sweet Alys	*Alysicarpus bupleurifolius*
	Cyperus procerus
Angleton grass	*Dichanthium aristatum*
Slender canegrass	*Leptochloa decipens*
Nardoo	*Marsilea augustifolia*

<u>Understorey</u>

Brisbane wattle / fringed wattle	*Acacia fimbriata*

APPENDIX 4

GENERAL RATINGS USED FOR INTERPRETATION OF SOIL CHEMICAL ANALYSES (BRUCE AND RAYMENT 1982)

		Very low	Low	Medium	High	Very high
EC	(mS cm^{-1})	<0.15	0.15-0.45	0.45-0.90	0.90-2.0	>2.0
Cl	(%)	<0.01	0.01-0.03	0.03-0.06	0.06-0.20	>0.20
P_A	(µg g^{-1})	<10	10-20	20-40	40-100	>100
P_B	(µg g^{-1})	<10	10-20	20-40	40-100	>100
Exch. K	(m. equiv. 100 g^{-1})	<0.1	0.1-0.2	0.2-0.5	0.5-1.0	>1.0
Extr. K	(m. equiv. 100 g^{-1})	<0.1	0.1-0.2	0.2-0.5	0.5-1.0	>1.0
Cu	(µg g^{-1})	<0.1	0.1-0.3	0.3-5	5-15	>15
Zn pH >7:	(µg g^{-1})	<0.3	0.3-0.8	0.8-5	5-15	>15
pH <7:	(µg g^{-1})	<0.2	0.2-0.5	0.5-5	5-15	>15
Mn	(µg g^{-1})	<1	1-2	2-50	50-500	>500
B	(µg g^{-1})	<0.5	0.5-1	1-2	2-5	>5
Total N	(%)	<0.05	0.05-0.15	0.15-0.25	0.25-0.50	>0.50
Org. C	(%)	<0.5	0.5-1.5	1.5-2.5	2.5-5.0	>5.0
SO_4-S	(µg g^{-1})	<5	5-10	10-20	20-100	>100
Total S	(%)	<0.005	0.005-0.02	0.02-0.05	0.05-0.10	>0.10
Total P	(%)	<0.005	0.005-0.02	0.02-0.05	0.05-0.10	>0.10
Total K	(%)	<0.1	0.1-0.5	0.5-1	1-3	>3