1980

Land capability study of (sandy) soils, north west of the Ivanhoe Plains, Kununurra, W.A

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LAND CAPABILITY STUDY OF (SANDY) SOILS NORTH WEST OF THE IVANHOE PLAINS, KUNUNURRA, W.A.

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CONTENTS


SURVEY AREA
DIVERSION DAM
KUNUNURRA
DUNHAM RIVER
LAKE KUNUNURRA
N.T. BORDER
W.A. BORDER
RIVER
PLAIN
NOMINAL SCALE 1:250 000
PHOTO COPY OF FALSE COLOUR LANDSAT IMAGE

INTRODUCTION AND BACKGROUND TO THE SURVEY:

This survey was conducted at the request of Colonial Sugar Refineries as a co-operative effort involving the West Australian State Government Departments of Agriculture and Lands and Surveys.

C.S.R. are investigating the feasibility of sugar cane production in the Ord River Project Irrigation Area. Part of the project could involve cane production on currently undeveloped sandy soils held under pastoral lease. The object of developing sandy soils is two-fold :-

(i) the sandy soils will require overhead irrigation and it will be possible to mix industrial wastes with the irrigation waters for disposal;

(ii) sandy soils should be trafficable sooner after wet season rains than already developed black clay soils. Consequently, wet season harvesting of sugar cane should be possible on sandy soils; this could extend the period of processing plant operation.

SURVEY OBJECTIVES:

C.S.R. advised (letters from P.F. Byrne 12.6.80) that their company's requirements were for sandy soils having :-

(i) no impermeable layers within the top 120 cm;

(ii) no very gravelly layers causing excess drainage;

(iii) good cultivation characteristics for the top 30 cm.

Representative samples were requested. These were for determination of bulk density, mechanical analysis, organic matters as organic carbon, nitrogen as NO_3,

P (Bicarbonate and BSES methods)

K

Ca

Mg

S as SO_4

Trace Elements Fe, Cu, Mn, Na, Cl

Conductivity

Water pH.

C.S.R. were led to believe that field observations by augering would be on a 100 m grid. (This density was not thought necessary for reasons explained below).

Sufficient area of uniform sandy soils was required for 40 centre pivot irrigators of about 950 m diameter. This area should have been within 20, preferably 15 km of the proposed mill site in Cave Spring Gap (see map).

SURVEY PROCEDURE AND MAP PRODUCTION:

A cleared gridline coinciding with the 470 000 metre-E A.M.G. 1:100,000 mapping grid was discovered on the ground at the commencement of the survey. As it ran through the centre of the area of interest it was adopted as a base line.

A transparent base sheet was prepared by assessing the average scale of the photography (in low level photography relief displacement and other distortions are significant) and drawing a grid to coincide with the 1000 metre grid of the 1:100,000 topographic map series of the area.

This grid was then superimposed onto the 1961 1:15,840 nominal scale black and white aerial photography. These 1 Km grid lines served as traverse lines for ground level investigation by augering and visual vegetation/soil correlations. Along the traverse lines, augerings were made at frequent intervals, five per kilometre of traverse being common and more or less as required by the variability of the terrain. Any photo patterns not intersected by a traverse line were investigated separately.

The land unit boundaries intersected in the field were drawn directly onto the aerial photography and used as a base for interpretation for the intervening areas not visited. Once the boundaries were finalized they were transferred by best fit onto the transparent base sheet by underlaying the photographs and tracing the boundaries.

Once all the information was transferred in this manner the base sheet was digitised using a Gradicon Digitizer which converted the graphical data into a digital form compatible with software developed for the Ashburton Rangeland Study carried out for the Pastoral Appraisement Board of W.A. This allowed the area of each land unit to be calculated and the plan to be reproduced at any desired scale. In this case the scales were 1:25,000 and 1:50,000. Further cartographic enhancement was required due to some limitations by the current system.

The digital data is now being stored on computer tape for future reference.

In the final stages of mapping the soil boundary correlations with Landsat satellite data were investigated as a means of checking the mapping of this area. The correlation was so strong with this and other surveyed areas that an investigation into using Landsat as another tool for soil surveying has been instigated by the Department of Lands and Surveys.

THE SOILS:

The soils encountered, and their pedogenetic position belonged, with only two minor exceptions, to families already described (Dixon and Petheram, 1980, Dixon unpub.). A description of these soils appears as Appendix I. Soil families tended to belong in only one land capability unit, although one capability unit could have two or three soil families.

SOIL/VEGETATION CORRELATIONS:

A previous study (Dixon and Petheram, 1980) in an identical pedological/pedogenetic environment established certain and constant relationships between some woody vegetative species and some soil families. For some of the minor soil families and some of the less frequent tree and shrub species, this relationship has not and cannot, for statistical reasons, be irrefutably established.

For the major soil types and most common Eucalypt species, this relationship has proven invariable. E. tetrodonta and E. miniata, for example, are typically found on the sands of the Cockatoo and Pago Family soils (Land Capability Unit 1).

Traversing areas with this vegetation composition and observing and recording vegetation, with occasional augerings (one per 500 m of traverse) is sufficient to establish with complete confidence the nature of the underlying soil.

Furthermore, the E. tetrodonta and E. miniata produce a very characteristic photopattern on 1:15 840 black and white aerial photography. This is a further aid to accurate mapping of land capability unit 1 for it is this and only this soil/vegetation grouping which is suitable for the cane production enterprise which is contemplated.

THE MAPPING UNIT:

The current study is one of land suitability - the suitability of land for sugar cane production using a given technology. Therefore, the mapping unit adopted was the LAND CAPABILITY UNIT. Areas of more or less similar potential, as limitation FOR CANE PRODUCTION, were grouped together.

If at some later date, other crops or technologies are applied these capability mapping units will apply only in a general sense and should be used with caution.

The soil/land characteristics sought by C.S.R. have already been outlined but to develop a classification, they have been expanded.

C.S.R. is contemplating cane production using centre pivot irrigators. Areas thus irrigated must be capable of receiving diluted effluent discharged through the irrigation waters. They must also be sufficiently free draining internally and externally so that mechanical harvesting in the wet season will be possible.

As a primary requirement, soils accepted for production should be free draining to a depth of at least 120 cm, their texture at 120 cm must be from texture groups 1 or 2 as defined by Northcote (1974) i.e. sands and sandy loams, not heavier in texture than a light sandy clay loam. The land unit accepted

had uniform coarse textured soils and no limitations to production.

All other land units were seen in some way as falling short of this ideal. The limitations encountered were categorised as follows :-

(i) Erosion Limitation

Sandy soils with grades of more than $1\frac{1}{2}^{o}$ were considered to have a high potential for erosion, even with all reasonable erosion control measures such as contours, layouts, header drains and prepared waterways.

(ii) Drainage Limitation

(a) Any soil where there was evidence of surface ponding of water was considered unsuitable since trafficability in the wet season was likely to be difficult. In addition most of these areas suffered from poor internal drainage.

(b) Any area where surface or subsoil textures were loams or heavier, while perhaps suitable for many forms of agriculture, were rejected for the stated cane production enterprise. Their trafficability is likely to be poor for extended periods after wet season rains due to slow internal drainage.

(iii) Stone Limitation

Two forms of stone limitation were encountered, frequently together :-

(a) Large and frequent outcrops of various forms of stone, sandstone, indurated laterites, and Ningbing limestones, will provide physical barriers to clearing, cultivation and movement.

(b) Soils with high gravel content (considered to be greater than 40% at or before 50 cm) were likely to have low soil profile water storage capacity. This is a limitation which can be overcome by modified water management but which it could be better to avoid.

LAND CAPABILITY UNIT 1 (6183 ha.)

(Long slopes with uniform sandy soils)

1. Profile form : uniform coarse textured.

2. Soil types : Cockatoo Sands, Pago Sands, Cajuput Sands.

3. Slope : $< 1\frac{1}{2}^{o}$

4. Surface impediments to agriculture : nil.

5. Sub-surface impediments to agriculture : nil.

General Description of Unit

This unit generally originates near ferruginous sandstone hills which provide the soil parent materials. Soils in the proximity of the hills are Cockatoo sands, usually with sandy surface horizons and loamy sand subsoil horizons. The vegetation is dominated by E. miniata and Grevillia agrifolio with E. tetrodonta over Sorghum australiense being another common vegetation set on Cockatoo family soils).

Further downslope are found Pago family soils, with sandy surface and sub-surface horizons. E. tetrodonta (Stringybark) is a reliable indicator of this soil type; with E. miniata it will indicate members which can be intergrades towards the Cockatoo Sands, with other species it will indicate soils towards the Cajuput family end of the continuum.

E. latifolia, Petalostigma pubescens and Gardenia sp. and Brachychiton tuberculosum are also common.

Further downslope still, representing greater distance of transport, are the coarser sands of the Cajuput family. Vegetation on this soil type is varied but E. tetrodonta may still be found together with Adansonia gregorii, pandanas sp., Lysiphyllum cunninghamii, E. polycarpa, Melaleuca, E. latifolia and Terminalia spp.

LAND CAPABILITY UNIT 1h (305 ha.)

1. Profile form : uniform or gradational profile forms, but always and only loam (i.e. sandy loam to fine sandy clay loam) sub soils.

2. Soil types : Cockatoo heavy phase, Cullen normal phase.

3. Slope : variable, up to 3^{o}.

4. Surface impediments to agriculture : nil.

5. Sub surface impediments to agriculture : nil.

General Description of Unit :-

Vegetation not perceptably different from Unit 1, although may occur in close proximity to parent rock.

Sloping Areas of Unit 1 and 1h

* In some areas, notably close to rock outcrops, Units 1 and 1h have a relatively high slope. Where this slope exceeds $1\frac{1}{2}^{o}$ these areas have been mapped as 1 or 1h and given the suffix 11 In all other respects they are identical to 1 and 1h.

Their problem as far as agriculture is concerned is their high erosion hazard.

LAND CAPABILITY UNIT 2 (2185 ha.)

Areas with impeded drainage and general evidence of surface ponding.

1. Profile form : generally undetermined due to small areas involved, and their high variability, and their lack of suitability for cane production. Gradational and uniform coarse textured profiles were encountered with high percentages of gravels. Rarely there were uniform coarse textured soils with gravels or shallow lateritic soils.

2. Soil types : varied, frequently Cullen and Elliot Family soils, less frequently Holman and Steeple Peak Family soils.

3. Slope : less than one degree where associated with Unit 7, in most other places the slope was imperceptible.

4. Surface impediments to agriculture : evidence of water logging or surface ponding of water for extended periods during the wet season. This 'evidence' usually in the form of a black curled crust on the soil surface.

5. Sub-surface impediments to agriculture : poor drainage within the soil profile of some member soils could provide trafficability problems

during the wet season. Shallow soils or soils with coarse materials could have limited soil volumes available for root exploitation.

6. General Description of Unit : Unit 2 when mapped simply as Unit 2 is usually a complex of the other types of Unit 2 that follow.

LAND CAPABILITY UNIT 2r (1466 ha.)

Large uniform areas of red loamy soils, no perceptible fall and evidence of seasonal inundation.

1. Profile form : uniform medium textured profile form, usually very dense soils.

2. Soil types : the only identified soil type on this capability unit is a red loam, possibly a Packsaddle loam.

3. Slope : imperceptible.

4. Surface impediments to agriculture : black curled crust on soil surface, deep wheel tracks, general vegetation type, overall fall, high bulk density of soil profile, and the position of this unit between one which is well drained and one which is clearly very poorly drained, all serve to indicate that this land capability unit is flooded or waterlogged for considerable periods during the wet season. Surface drainage could control a degree of this ponding, but slow drainage within the soil

profile could still be a problem.

5. Sub-surface impediments to agriculture : slow drainage within the soil profile could easily be a problem during the wet season. The structureless nature of the soil is such that after cultivation, slumping of the soil is likely, however, despite this, this land unit could be suited to perennial crops such as tropical legumes for hay production etc.

6. General description of unit : two vegetation groups have been identified. The most common was E. tectifica and B. tuberculosum over T. australis, the second has the same two species, but in addition, specimens of Terminalia ferdinandiana are also common.

LAND CAPABILITY UNIT 2c (1118 ha.)

Areas of poor surface and internal drainage with clay sub soils.

1. Profile form : uniform fine textured profile form.

2. Soil types : undescribed clay soils.

3. Slope : no perceptible slope.

4. Surface impediments to agriculture : evidence of prolonged inundation during the wet season.

5. Sub-surface impediments to agriculture : very slow internal drainage of the soil could be a problem.

6. General description of unit : highly variable vegetation mix, including E. polycarpa, E. clavigera, E. grandifolia, E. foelscheana, L. cunninghamii, E. tectifica, T. australis, C. fallax, I. fragile and S. australiense.

LAND CAPABILITY UNIT 2g (538 ha.)

Areas showing evidence of seasonal inundation and having a high proportion of gravels in the soil profile.

1. Profile form : uniform coarse textured soils with greater than 40% gravels in the soil profile before 100 cm.

2. Soil types : Holman family soils.

3. Slope : Less than 1^{o}, usually imperceptable.

4. Surface impediments to agriculture : evidence of seasonal inundation, either as throughflow from higher areas or flooding out from creeks and drainage lines.

5. Sub surface impediments to agriculture : Waterlogged soils during the wet season, and limited soil volume during the dry season necessitating frequent irrigation. (Most examples of this soil type had much more

gravel in the profile than the lower limit stated above.)

6. General description of unit : the most common vegetation on this unit is Melaleuca sp over Spinifex sp.

LAND CAPABILITY UNIT 2n (625 ha.)

Areas with poor drainage, heavy textured soils and punctuated by low linear ridges of Ningbing Limestone.

1. Profile form : uniform fine textured soils.

2. Soil types : unclassified

3. Slope : Imperceptible, surface ponding of water in wet season evident.

4. Surface impediments to agriculture : long low linear ridges of limestone or limestone conglomerate are common in this area. In size and importance these outcrops range from a few boulders projecting from the soil surface, to ridges 30 metres across and up to 2 metres high. These ridges are usually less than 200 metres apart. Their influence on mechanised agriculture and channel irrigation is obvious. Between the ridges water is expected to pond for extended periods during the wet season.

5. Sub-surface impediments to agriculture : some small areas of buried stone could be encountered, however the major limitation to agriculture is likely to be poor internal drainage of the soil profile.

6. General description of unit : floristically varied area, with Hakea sp, E. tectifica, E. latifolia, Terminalia ferruginea, I. fragile, T. australis.

LAND CAPABILITY UNIT 3g (1019 ha.)

Well drained shallow gravelly soils.

1. Profile form : uniform coarse textured soils with large percentages of gravel at shallow depth.

2. Soil type : most commonly Holman soils.

3. Slope : less than $1\frac{1}{2}^{o}$ in the broad body of the plain, in association with rock outcrops, the slope could be much higher.

4. Surface impediments to agriculture : high erosion hazard could be a problem in areas with reasonable slope.

5. Sub-surface impediments to agriculture : excessive internal soil drainage and reduced soil volume available to the plant root.

6. General description of unit : the soil materials seem to be the transported remnants of lateritic material, traces of which can still be seen on some rocky hills and outcrops. No constant and reliable indicator plant species has been identified, a task made difficult by large scale burning. A fairly wide range of tree species appears to be represented.

LAND CAPABILITY UNIT 3s (97 ha.)

Shallow sandy soils, and areas punctuated by sandstone ridges.

1. Profile form : uniform coarse textured soils, sometimes shallow soils.

2. Soil type : where there is any depth of soil this has always been Cockatoo sands.

3. Slope : less than $1\frac{1}{2}^{o}$.

4. Surface impediments to agriculture : large sandstone floaters and ridges of sandstone which protrude at frequent intervals. Sometimes the sandstone has indurated ironstone boulders associated with it. The ridges are similar in dimensions to the limestone ridges of Unit 2n that is, less than 2 metres high but perhaps 20 or 30 metres across and approximately 100 metres long.

5. Sub-surface impediments to agriculture : excessive drainage within the soil profile depending on the type of irrigation contemplated, and shallow soils in places.

6. General description of unit : these areas appear to be stratified sandstones which have been uplifted. The cleavages between strata have weathered relatively quickly producing soils, while the harder, less weatherable areas have remained as the ridge. Between the ridges is found the vegetation typical of the soil there, that is vegetation normally indicative and found occurring in association with the Cockatoo Sands. On the ridges themselves, E. ferruginea is reasonably common.

LAND CAPABILITY UNIT 4 (2234 ha.)

Complex pattern comprising units 1 and 2 and mapped as a catena.

1. Profile form : those of units 1 and 2.

2. Soil types : those appropriate to units 1 and 2, Cajuput being the dominant family of the sandy soils.

3. Slope : imperceptible.

4. Surface impediments to agriculture : Waterlogging in some areas. Variability is most obvious. It is impossible to find an area large enough and uniform enough to develop.

5. Subsurface impediments to agriculture : Shallow gravelly soils are possible. Internal drainage of unit 1 members will be excessive in the dry season. All members could be inundated in the wet season.

6. General description of unit : See units 1 and 2.

LAND CAPABILITY UNIT 5a

Black soils surveyed and described by Aldrick and Clarke. (Unpublished)

1. Profile form : Uniform fine textured.

2. Soil types : Aquitaine Family Soils mostly blue phase (heavy cracking clays).

3. Slope : extremely low.

4. Surface impediments to agriculture : Extremely slow drainage makes irrigated agriculture almost impossible. Coarse blocky structure of soils makes good tilth and fine seed bed unattainable.

5. Subsurface impediments to agriculture : Extremely slow internal drainage.

6. General description of unit : Blind drainage region of black soil plains. Vegetation E. tectifica and E. parvifolia and mixed grasses.

LAND CAPABILITY UNIT 7 (2297 ha.)

Streams and eroded stream banks.

1. Profile form : undetermined - varied.

2. Soil types : undetermined - varied.

3. Slope : greater than $1\frac{1}{2}^{o}$.

4. Surface impediments to agriculture : limited area, slope, possible flooding, instability w.r.t. erosion, variability of soil.

5. Sub-surface impediments to agriculture : undetermined.

6. General description of unit : none attempted.

LAND CAPABILITY UNIT 8 (or 8a or 8b) (451 ha.)

Junction complexes described in previous soil surveys (Aldrick and Clarke, Dixon).

1. Profile form : Duplex and gradational are the most common.

2. Soil types : undefined - varied.

3. Slope : low on edges of black soil, could be up to 5^{o} around sandstone hills.

4. Surface impediments to agriculture : High variability and insignificant area.

5. Subsurface impediments to agriculture : none determined.

6. General description of unit : This unit describes the interface between the Cockatoo Land System and the Ivanhoe Land System, and is highly variable and of no practical importance.

SOIL FAMILIES:

Cockatoo Soils Family

This family contains soils thought to be the most recently developed from the ferruginous sandstone parent material. They are the highest in the landscape, being found on crests and upper mid slopes and have the maximum slope, usually between one and two degrees, sometimes slightly higher. They are well drained internally and externally.

The Cockatoo soils have a moderate range of textures and it is not known if this is because of local variation in parent materials or pedogenetic factors.

Typical Cockatoo Soil

0- 10 cm	Loamy sand, reddish brown (5 YR 4/3) pH 6.5 dry slightly hard consistence, earthy fabric massive structure.
10- 35 cm	Sandy loam, dark red (2.5 YR 3/6) pH 6.0, dry slightly hard, earthy, massive.
35-150+ cm	Sandy loam, red (10 R 4/6) pH 6.0, moist friable massive, earthy.

It was necessary to recognise three phases of the Cockatoo soils -

(i) Sandy phase with sandy A and B horizons,

(ii) Normal phase with sandy A horizons and loamy sand B horizons,

(iii) Heavy phase with loamy sand A horizons and clayey sand B horizons.

Surface horizons for all phases should be as red or redder than 7.5 YR (normally 7.5 YR 4/3 or 4/4) and subsoil horizons should be as red or redder than 5 YR usually with intermediate value and high chroma.

Most Cockatoo soils have an earthy fabric and A horizons will be single grained for the light phases and massive for the heavier phases. Light members have moist, very friable consistences and heavier phases are moist and friable. pH of all horizons ranges between 6 and 7, i.e. they have an acid to neutral soil reaction trend.

The soils support almost a monoculture of Eucalyptus miniata, a joint culture of Eucalyptus miniata and Eucalyptus tetrodonta, rarely a monoculture of Eucalyptus tetrodonta. Throughout these associations Erythriphleum chlorostachys is usually present. Other common species are Buchanania obovata, Grevillea agrifolia (in patches) and Persoonia falcata and Owenia

vernicosa (both sparsely).

PAGO FAMILY SOILS

Typical Pago Soil

0- 15 cm	Dark brown sand (10 YR 3/3) pH 6.5, dry loose consistence, sandy/earthy fabric, massive in structure.
15-40 cm	Sand to loamy sand, yellowish brown (10 YR 4/4) pH 6.5, moist, friable, sandy/earthy fabric, massive structure.
40-150+ cm	Sand to loamy sand, strong brown (7.5 YR 5/6) pH 6.5, moist, friable and massive.

The sandier members of the Pago Family could also be described as having single grain structure and loose consistence or alternatively massive with very friable consistence.

In this survey top soil hues of 7.5 YR were accepted and it was felt that the colour of the B horizon was more constant and diagnostic than that of the A horizon. Values tend to be about a unit higher than those of Cockatoo soils. Fabric is less earthy than that of Cockatoo soils and this probably accounts for van Cuylenberg's (unpub.) decision to compromise between earthy and sandy fabrics.

Pago Family soils occur immediately downslope from Cockatoo Family soils with slopes about a half to one degree. They are well drained internally and moderately well drained externally.

Vegetation tends to be similar to that of the Cajuput Family soils, i.e. E. papuana, E. polycarpa, E. foelscheana, Gyrocarpus americanus, Adansonia gregorii, and Melaleuca sp. (Tall).

Other species which form in colonies within the major type are E. tectfica, Melaleuca (Small form), Petalostigma pubescens and Grevillea agrifolia.

CAJUPUT FAMILY SOILS

This is a local name used to describe soils of this type. In the past they have probably been mapped as Pago or Cullen but it is considered that they are quite distinct genetically. They occupy a discreet topographic position and are therefore accorded family status.

Typical Cajuput Soil

0- 10 cm	Coarse sand with a slightly moist, very friable consistence, massive structure (single grain when dry), sandy fabric, pH of 6.5 and highly porous. 10 YR 4/4.5.
10- 40 cm	As above, colour 10 YR 5.5/6.
40-150 + cm	As above, colour 10 YR 6/8.

The main diagnostic feature of this soil is its subsoil colour and the fact that it is almost totally devoid of clay material. It has a discreet position in the landscape, being in places that have been worked and reworked by stream meanderings (resulting in undulating relief) in areas with very little overall slope.

Drainage within the profile tends to be very good to extreme and surface drainage is usually quite good.

Vegetation is similar to that of the Pago Family soils with the addition of Pandanus sp., Grevillea pteridifolia, Ficus opposita and Buchanania obovata.

CULLEN FAMILY SOILS

The name Cullen is used in the literature to describe both a land system (Christian and Stewart 1953) and a soil family (Speck et al 1965. Story et al 1969, Stewart et al 1970 and Story et al 1976).

The Cullen Land System is found only on granite country rock, but the Cullen Family Soils can be found on both granitic and sedimentary land systems. The Cullen Soil Family described in this report is found on lower slopes developed on material transported from adjacent ferruginous sandstone hills. They are often found where there is a flattening of a long slope or in areas

of poor or slow drainage such as drainage lines or in the Junction Complex.

Cullen soils have medium to moderately heavy textured subsoils below a sandy topsoil. Hue of the subsoils must be 7.5 YR.

Typical Cullen Soil

0- 10 cm	Sand to loamy sand, dark greyish brown (10 YR 4/2), dry, slightly hard, pH 6.0, massive and earthy.
10- 30 cm	Light sandy loam, brown to dark brown (7.5 YR 4/4) pH 6.0, dry, slightly hard, massive and earthy.
30-150 + cm	Sandy loam to light sandy clay loam, strong brown (7.5 YR 5/6) dry, slightly hard, pH 5.5, massive and earthy with some red and grey mottling.

Three phases of Cullen soils are recognised:

(i) normal phase as described.

(ii) as described but without mottling in the top 150 cm.

(iii) heavy phase where subsoil textures can rise to a sandy medium clay with or without mottling.

The more extreme members of phase (i) could be undergoing a weak but active laterisation process.

Both surface and internal drainage of these soils is slow and this is reflected in the vegetation which includes Melaleuca (small form), E. polycarpa, E. clavigera, E. tectifica, E. foelscheana and Brachychiton tuberculosum and Lysiphyllum cunninghammii.

ELLIOT FAMILY SOILS

van Cuylenberg describes the typical Elliot Family soil as follows -

0- 8 cm Sandy loam, dark brown (10 YR 4/3) pH 6.0, massive and earthy.

8- 30 cm Light sandy clay loam, dark yellowish brown (10 YR 4/4) pH 6.0 massive and earthy.

30- 80 cm Sandy clay loam, yellowish brown (10 YR 5/6) pH 5.5, massive and earthy, onto an impermeable mottled clay layer.

This has been retained as the central concept but as some members did not have mottling in the top 150 cm the soil has been divided into two phases:

(i) normal phase as described above.

(ii) phase without mottling otherwise the same as that described above.

These soils are found in and around drainage lines. Some members have quite extreme mottling and this is interpreted as being weak but active laterisation. Internal drainage is poor and surface drainage is variable, usually only moderate.

Vegetation found on this soil type includes, E. tectifica, E. papuana, E. clavigera and also small Melaleuca forms. Some of the Elliot soils are better drained and feature E. clavigera and E. ferruginea. The small Melaleuca form is well represented.

HOLMAN FAMILY SOILS

0- 1 cm	Thin layer of organically stained coarse loose sand.
1- 50 cm	Coarse loose sand.
50+ cm	Rounded gravels of either lateritic concretions or polished coated and rounded sandstone fragments, well sorted with respect to size ($\pm$ 1 cm diameter). Gravel is usually close packed with sand filled interstices.

These soils are usually found in areas of very low slope, or are confined to areas of slightly higher slope, but in small occurrences in close proximity to drainage lines.

The rounding, sorting and polishing of the soil materials indicates transportation.

Vegetation is variable, spinifex is a common grass species and a variety of Eucalypts may be present including E. latifolia, E. foelschiana, or in poorer drained areas, E. tectifica and Melaleuca sp. Occasionally E. polycarpa or E. papuana may be present.

RED LOAMY SOILS

0- 10 cm	Massive, dry, firm, earthy organic loam with pH of 6¼ and colour of 10 YR 3/2.
10- 150 + cm	Massive, dry, very firm, earthy clay loam with pH of 6, and colour of 5 YR 4.5/8.

The largest occurrence of this soil is at the foot of a large sloping area of Unit 1 soils; the unit itself is flat and shows evidence of surface ponding of water. This area is in all

probability receiving fine materials from upslope resulting in a relative concentration of clays and loams. Vegetation is usually E. tectifica over T. australis. There are very few other vegetation groups present, except, very rarely T. ferdinandiana and B. tuberculosum.

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APPENDIX 1

BULK DENSITIES OF UNIT 1 SOILS

CO-ORDINATES	BULK DENSITY
90.6/66.5	1.41
82.8/67.2	1.61
80.5/65.5	1.70
87.1/69.0	1.60
81.5/65.5	1.49
87.1/68.15	1.48
90.0/68.0	1.33
87.35/66.45	1.51
85.0/67.0	1.56
84.0/68.0	1.54
84.0/67.2	1.53
82.5/65.5	1.45
88.0/68.0	1.47 (within unit 4)

APPENDIX II

MAP KEY

MAP KEY

UNIT 1 : Cockatoo, Pago, and Cajuput sands suitable for sugar cane production.

UNIT 1h : Cockatoo (Heavy Phase) and Cullen (Normal Phase) soils suitable for sugar cane production but internal drainage slower than for Unit 1.

UNIT 1s II : As above but slope greater than 1½ degrees and possible erosion hazard.

UNIT 2 : Variable soils with poor internal and surface drainage.

UNIT 2r : Large uniform areas of red loamy soils, poor internal and surface drainage.

UNIT 2c : Areas with clay soils, poor internal and surface drainage.

UNIT 2g : Areas with high proportion of gravels in the soil profile.

UNIT 2n : Heavy textured soils punctuated by low linear ridges of Ningbing limestone. Evidence of seasonal inundation.

UNIT 3g : Shallow gravelly soils well drained internally and externally.

UNIT 3s : Shallow sandy soils punctuated by sandstone ridges.

UNIT 4 : Complex pattern of Units 1 and 2, mapped as a catena.

UNIT 5a : Cracking clays (Aquitaine 'blueish' phase. Keep flooded phase) with thick Eucalyptus microtheca/Excoecaria parvifolia woodland: seasonally inundated to moderate depths for long periods.

UNIT 7 : Streams and eroded stream banks.

UNIT 8 : Junction complex.

UNIT 8a : Complex depressed peripheral zones adjoining Unit 8b or sandy land systems: soils very variable but mainly heavy clays: seasonally inundated: Eucalyptus microtheca/Excoecaria parvifolia woodland.

UNIT 8b : Complex zone between Unit 8a and sandy land systems: Soils very variable, mostly duplex soils: variable woodland with Eucalyptus polycarpa and Eucalyptus microtheca.

APPENDIX III

LATIN AND COMMON NAMES OF VEGETATIVE SPECIES ENCOUNTERED DURING THE SURVEY

Adansonia gregorii	Baobab
Brachychiton tuberculosum	
Buchanania obovata	
Eucalyptus clavigera	Cabbage Gum
ferruginea	Rusty Bloodwood
foelscheana	White barked Bloodwood
grandifolia	Large Leaf Cabbage Gum
latifolia	
miniata	Woolibutt
papuana	Ghost Gum
polycarpa	Long fruited Bloodwood
tectifica	Northern Box
tetrodonta	Stringybark
Erythrophleum chlorostachys	Ironwood
Excoecaria parvifolia	Guttapercha
Ficus opposita	Sandpaper fig
Gardenia sp	
Grevillia agrifolia	
Grevillia pteridifolia	
Gyrocarpus americanus	Stinkwood
Hakea sp	
Lysiphyllum cunninghamii	Baukinia
Melaleuca sp	Paperbark
Owenia vernicosa	
Pandanus	
Petalostigma pubescens	Quinine bush
Persoonia falcata	
Terminalia ferdinandiana	Billygoat plum
Terminalia sp	
GRASSES:	
Chrysopogon fallax	Ribbon Grass
Iseilema fragile	Flinders Grass
Sorghum australiense	Cane Grass
Spinifex sp	
Themeda australis	Kangaroo Grass

APPENDIX IV

LAND CAPABILITY UNIT AREA (HECTARES)

UNIT 1	6183
UNIT 1h	305
UNIT 1sii	173
UNIT 2	2185
UNIT 2r	1466
UNIT 2c	1118
UNIT 2r/c	765
UNIT 2g	538
UNIT 2n	625
UNIT 2g/n	56
UNIT 3g	1019
UNIT 3s	97
UNIT 3g/s	221
UNIT 4	2234
UNIT 7	2000 (approx.)
UNIT 8	374
UNIT 8b	77

ADDENDUM

STEEPLE PEAK AREA

The area towards Steeple Peak and Martin's Bluff was investigated briefly, but a detailed investigation was not undertaken. Although in the immediate vicinity of Steeple Peak there is some 2 km^2 of deep sandy soils, this whole area shows signs of being under water during the wet season. Augerings showed moist sandy sub-soils - even in the dry season (July). Examination of aerial photographs show that these sandy areas receive a great deal of run off from the surrounding hills. The vegetation on these sandy soils indicated rather moist conditions.

This area could possibly be used for agriculture if it were provided with flood control levees to control run-on, and sub-soil drainage to control water tables. Economics would determine the feasibility of these engineering works. In the meantime the area should be observed during several wet seasons just to see how bad the flooding is.