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Jerdacuttup Land Resource and Capability Study

GA Moore, ST Gee and D Vincent

Resource Management Technical Report 101

Disclaimer

The contents of this report were based on the best available information at the time of publication. It is based in part on various assumptions and predictions. Conditions may change over time and conclusions should be interpreted in the light of the latest information available.

Summary

The Jerdacuttup catchment on the south coast of Western Australia has a number of significant land degradation problems. This study was carried out following a request from the Ravensthorpe Soil Conservation District for resource information for farm and catchment planning. A soil-landform map of the catchment, covering approximately 31,000 ha, was produced at a scale of 1:50,000.

The map units are a combination of landform and soil type. Eleven landforms and ten soil groups were identified and mapped. A land capability assessment was undertaken for five land uses; improved annual pastures, perennial pastures, Lucerne, cereal cropping and lupins, using a five class classification. The catchment is dominated by shallow to moderately deep, gravelly duplex soils, although there is also a significant amount of deep sand. The major landforms are a level to gently undulating sandplain with extensive areas subject to waterlogging.

There is considerable secondary salinity in the catchment considering the relatively short time since the land was cleared. The potential for salinisation to spread is high because of the low relief in many areas. The implications of landform on the likelihood of salinity developing are discussed. The areas with mound/depression microrelief are thought to have a higher probability of becoming saline. Expansion of the area under perennial pasture and lucerne, with the resultant increase in water use, may limit the future spread of salinity.

The map should prove a useful aid to farm planning with minor modifications to account for the scale.

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1. Introduction

1.1 Background

A catchment in the Jerdacuttup region of the south coast was identified as having a number of significant land degradation problems which could only be overcome by group action. The two main drainage lines within the catchment were poorly defined, resulting in periodic flooding after heavy rains. In the relatively short time since the catchment was cleared (approx. 20 years), a substantial area of formerly good land has become saline. During winter large tracts of land are waterlogged for periods of one week to several months. The sandy surfaced soils which are dominant throughout the catchment are highly susceptible to wind erosion. The main land uses within the catchment are, sheep grazing improved or volunteer annual pastures and cereal cropping.

A plan was initiated by the Ravensthorpe Land Conservation District Committee to tackle the above problems on a catchment basis. Firstly, the drainage system would be up-graded to reduce flooding. Then farm plans would be developed on individual properties to help rectify the other problems which require management and cultural changes. The role of the Western Australian Department of Agriculture (WADA) was to provide technical support for the project.

1.2 Objectives

The objective of the overall plan was to rectify or reduce the flooding and land degradation problems in the catchment and thus improve the long-term viability of the farms involved. A soil/landform map defines the areas at risk, while the soils influence the type and scope of management solutions. As part of the overall plan, the specific objectives of this study were;

i) To map the soils and landforms of the catchment at a scale suitable for farm planning.

ii) To provide an overview of the catchment's resources including soils, landforms, degradation hazards and surface water flow.

iii) Identify the land uses that are technically most suited to the catchment.

To meet the above requirements a land resource map (1:50,000) of the catchment was produced, showing the soil types, landform, salinity, waterlogging, landscape features and surface water flow. A land capability assessment was undertaken for five land uses.

1.3 Study area

The catchment is located on the south coast of Western Australia, immediately south-west of the Jerdacuttup townsite (Figure 1). The nearest sizeable town is Esperance, approximately 150 km to the east, while other small towns in the region are Hopetoun, Munglinup and Ravensthorpe.

The catchment of about 25,000 ha, plus those blocks which extended into the catchment were mapped, giving a total area of about 31,000 ha.

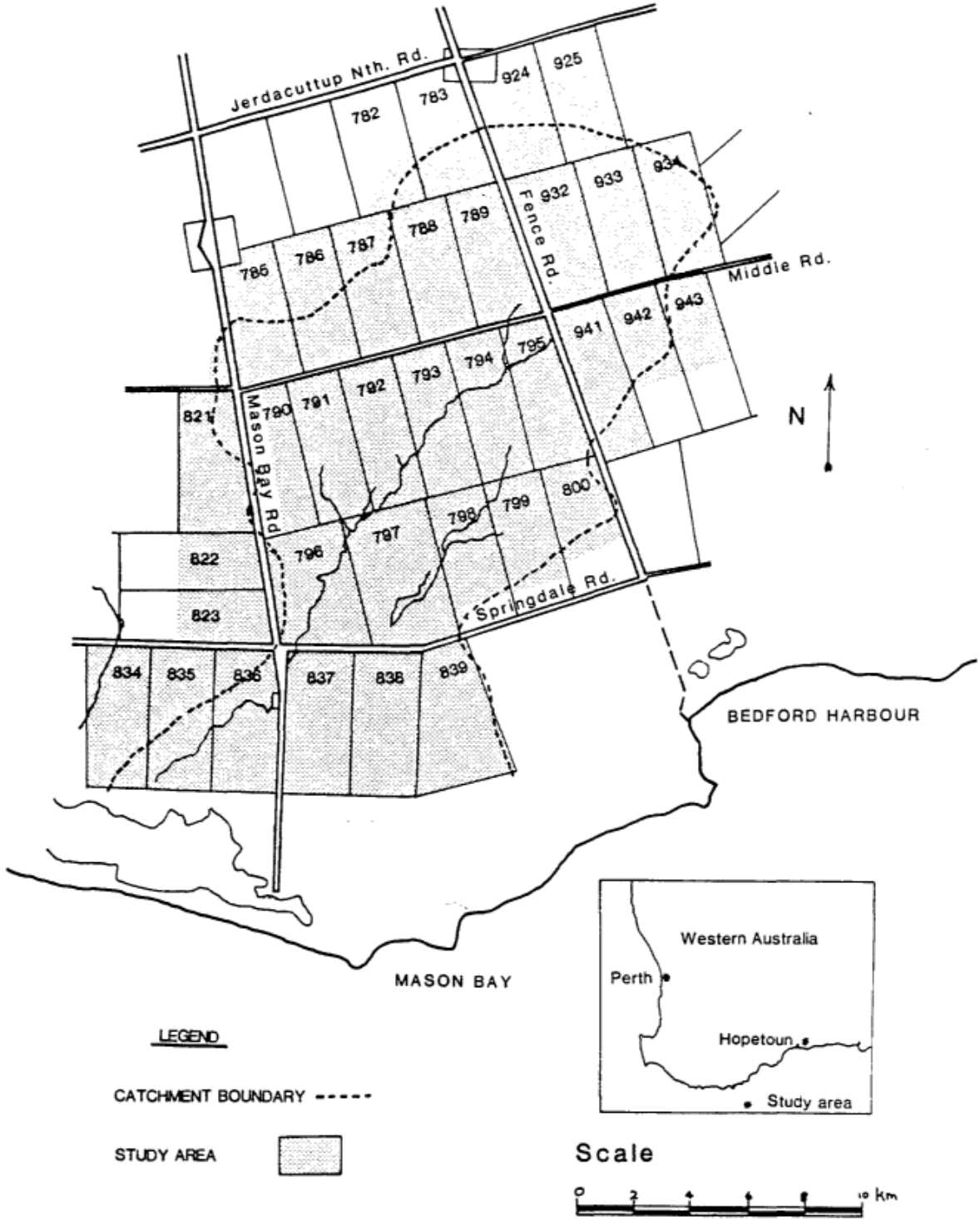

Figure 1. Location of study area

1.4 Climate

The study area experiences a Mediterranean - type climate with hot dry summers and cool wet winters. There is a strong marine influence on the climate due to the proximity to the coast.

There is a paucity of climatic data for the area, with no meteorological stations and only a small number of rainfall recording stations on various properties. The meteorological station at Esperance, 150 km to the east is the nearest station with a similar geographical location. A continuous recording station has been installed on a WADA trial site at Bedford Harbour Station immediately east of the study area, although the length of record (approx. 5 years) is inadequate for analysis. At Hopetoun there are rainfall records for about 80 years.

The catchment has a winter dominant rainfall pattern, with about 70% of the average annual total falling in the months May to October (Table 1). Winter rainfall is quite reliable, while summer rainfall is far more variable. False breaks to the season are relatively common.

Table 1 Average monthly and annual rainfall (mm)

Station	**Month**													
	LR*	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Hopetoun (Jerdacuttup)	17	18	25	30	44	80	78	82	78	59	49	49	19	611
Hopetoun P.O.	80	18	22	29	41	60	65	61	60	54	46	30	21	507
Munglinup (Myola)	9	15	30	18	36	68	69	64	63	50	49	31	15	508
Hopetoun (Tallangatta)	15	15	20	24	34	65	73	73	69	54	41	33	17	518

**LR - length of recording (years)*

(Source - Bureau of Meteorology microfiche)

Summer temperatures are mild to warm and are moderated by the sea breeze. The area is characterised by windy conditions similar to the whole south coast of Western Australia. During summer, winds are generally from the north-east in the morning and swing around to the south-east in the afternoon as a sea breeze develops along the coast. Strong winds from the north-west which precede cold fronts early in the season are particularly important from a wind erosion perspective.

2. Methods

2.1 Land resource survey

The methodology for the resource survey can be broken down into six stages. The fieldwork was undertaken from May to July 1987.

i) Preliminary reconnaissance trips to determine the major soil types within the catchment. The only soil map available for the catchment was the Atlas of Australian Soils, Sheet 5 (Northcote et al., 1967), which is a very broad scale map and not suitable for the intended use of this study.

ii) Initial aerial photo interpretation (API) to delineate the soil landform units (Section 2.2) according to photo pattern, tone and relief, utilising colour aerial photography (1:20,000) taken in January 1987. Most of the catchment was covered by the colour photography, while the remaining area was mapped using black/white aerial photography (1:40,000) taken in 1969 with reference to the 1980 photography (1:86,000).

iii) Field work to check the boundary reliability and internal variability of the units mapped during the initial API. The procedure involved irregular traverses through paddocks with observations at a maximum of 200 m intervals. On the sandplain soil types, the depth of sand was measured with a metre long probe.

iv) Final mapping of units utilising API and the field observations from (iii).

v) Detailed site descriptions were made in representative areas, using the definitions in the “Australian Soil and Land Survey, Field Handbook” (McDonald et al., 1984).

vi) The 1:50,000 map was produced on the Western Australian Department of Agriculture’s Geographic Information System (G.I.S.).

Map reliability: McDonald (1975) recommends a minimum purity of 70% with respect to the homogeneity of mapping units. This was the level aimed for in the study, thus the field checking was fairly intensive with an average of one field observation every five to ten hectares. The amount of field checking and consequently the reliability and homogeneity was reduced in some paddocks due to the extensive regrowth present. This was the case for approximately 1/3rd of location 791 (refer Figure 1), the southern 1/4 of location 838, the southern 2/3rd of location 839 and a significant portion of the northern half of location 785. Extensive reed growth hindered movement in many low lying and waterlogged parts of the catchment. The major portions of locations 941, 942 and 943 on the eastern side of the catchment (Figure 1) are uncleared and the absence of tracks resulted in this area being mapped solely on API. Consequently, it has a relatively low reliability. Taking the above concessions into consideration the map should provide a suitable basis for farm planning, with only minor modifications to account for the scale.

2.2 Map Units

The map units are a combination of landform and soil type. The landform was derived by following a hierarchial key, with subdivisions for the landform pattern, slope, drainage and microrelief (Figure 2). Three types of landform patterns were identified, these being plains, dunes and valley sideslopes. A second subdivision more precisely defined landform in terms of slope categories.

For example, the 'plain" type of landform was divided into four categories according to slope and drainage;

- level plains *(L,* slope 0-12)
- level plains with poor drainage (P. slope 0-1%)
- gently undulating plains (G, slope 1-3%)
- undulating plains to rises (U, slope 3-10%)

The level plains with poor drainage were identified from a combination of aerial photo pattern and tone, landscape position, plant species present and site observations. The field work was undertaken after a period of sustained heavy rain, and the areas of poor drainage were mainly identified by the presence of a shallow perched watertable.

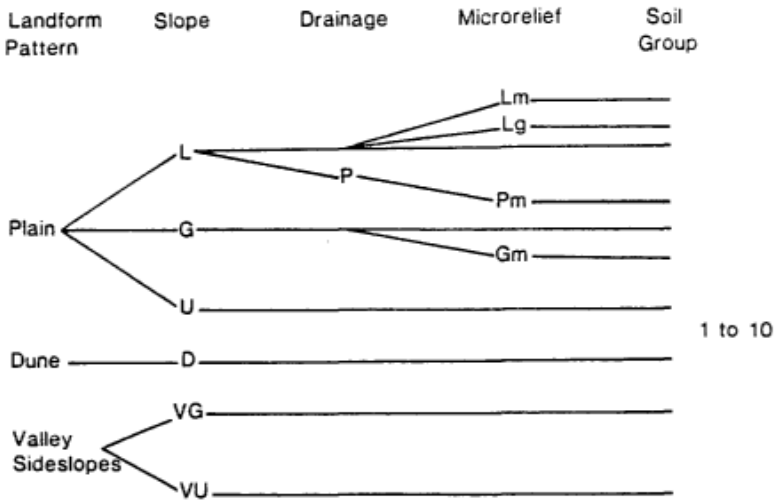

Figure 2 Hierarchial system of map units.
(The letters denote the map symbol).

For the plain landform there was a third sub-division according to the presence or absence of microrelief. Two types of microrelief were identified, gilgai microrelief (g) and mound/depression microrelief (m).

The landform types are summarized in Table 2.

Overall eleven landform types and ten soil groups were identified in the survey, although not all the soils occur on all the landforms. The relationship between landforms and soils is summarized in Figure 3.

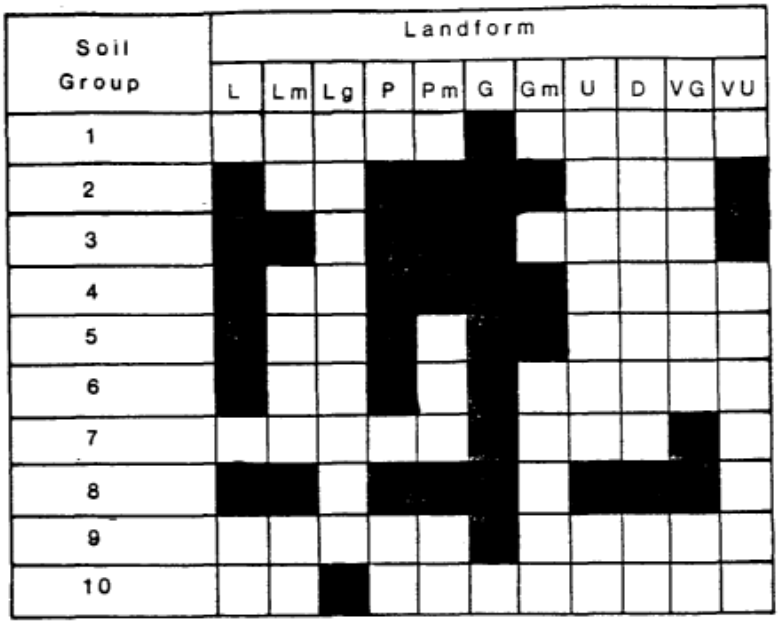

Figure 3 Relationship of landform to soil type.

Map unit symbols

The map unit symbols are alphanumeric, with the letters denoting the landform and the numbers the soil group.

For example, an “L2” map unit is a level plain with slopes < 1% with soil type 2, a gravelly duplex soil with shallow fine sand to loamy sand (0-30 cm) over ferruginous gravel with a mottled clay subsoil.

Complexes: Areas with intricate patterns of two or more units were mapped as a complex (i.e. unit X/unit Y). The dominant soil type which occupies greater than 50% of the map unit is listed first.

For example, “L6/Lg10” is a complex of L6 (A level plain with alkaline duplex soils) and Lg10 (A level plain with gulag micro relief and uniform clay soils). Soil type 6 would be the dominant soil type.

Table 2 Summary of landform categories.

Landform	Map	Description Symbol	Slope %
Plain	L	Level plain	0-11
	Lm	Level plain with mound/depression microrelief, some waterlogging in the depressions.	0-11
	Lg	Level plain with gilgai microrelief.	0-1
	P	Level plain with poor drainage	0-1
	Pm	Level plain with poor drainage and mound/depression microrelief.	0-1
	G	Gently undulating plain	1-3
	Gm	Gently undulating plain with mound/depression mircorelief.	1-3
	U	Undulating plain to rises.	3-10
Dune	D	Moderately inclined linear dunes.	3-6
Valley Side/slopes	VG	Gently sloping valley sideslopes.	1-3
	VU	Moderately sloping valley sideslopes.	3-10

Secondary Salinity:	Secondary salinity is denoted by the following suffixes:
Ps	Partially saline – areas with a complex pattern of saline and non-saline areas.
S	Saline
e.g. 1	“P2s” is a level plain with poor drainage, with soil type 2, which is saline.
e.g. 2	“P2ps” is a level plain with poor drainage, with soil type 2, which has a complex of saline and non-saline areas
Small Areas:	Areas on map units less than 3ha are indicated by the unit name in brackets.
e.g.	‘(P2) is a small seasonally water logged area with soil type 2.

[N.B. Small areas of secondary salinity are denoted by (s)]

2.3 Land capability assessment

This section details the procedure used for deriving capability ratings for the five types of land use considered.

Land capability is the ability of the land to sustain a specific use without undesirable on-site or off-site land degradation.

The capability classes

A five class system is employed by the Western Australian Department of Agriculture to express land capability. Land capability classes indicate the degree of severity of physical limitations to a particular land use, together with levels of management needed to contain any subsequent land degradation (Table 3). It ranges from Class 1 which signifies a very high capability with few limitations for the proposed land use, to Class V which is regarded as prohibitive for the specified use. The quality, or qualities which are the limiting factors for a land use are shown as subscripts (Table 4). No subscript is shown for units rated as Class I, because there are no significant limiting factors.

Table 3 Land capability classes

Class I Areas with a very high capability for the proposed activity or use. Very few physical limitations to the specified use are present, or else they are easily overcome. Risk of land degradation under the proposed use is negligible.

Class II Areas with a high capability for the proposed activity or use. Some physical limitations to the use do occur, affecting either its productive use, or the hazard of land degradation. These limitations can be overcome through careful planning.

Class III Areas with a fair capability for the proposed activity or use. Moderate physical limitations to the land use do occur which will significantly affect its productive use or result in moderate risk of land degradation unless careful planning and conservation measures are applied.

Class IV Areas with a low capability for the proposed activity or use. There is a high degree of physical limitation which is not easily overcome without extensive application of conservation measures.

Class V Areas with a very poor capability for the proposed activity or use. The severity of its physical limitation usually prohibits its use because of the high risk of degradation or high development costs.

Table 4 The land qualities assessed for each map unit and their subscripts.

Land Quality	Subscript
Site drainage	i
Moisture availability	m
Nutrient availability	n
Rooting conditions	R
Salinity hazard	Y
Potential for mechanization	Q
Soil workability	K
Soil structural decline hazard	S
Water erosion hazard	E
Wind erosion hazard	W

Deriving the classification

The land capability methodology was broadly based upon the land evaluation guidelines developed by the Food and Agriculture Organization of the United Nations (FAO, 1976, 1983). The procedure is outlined in Figure 4.

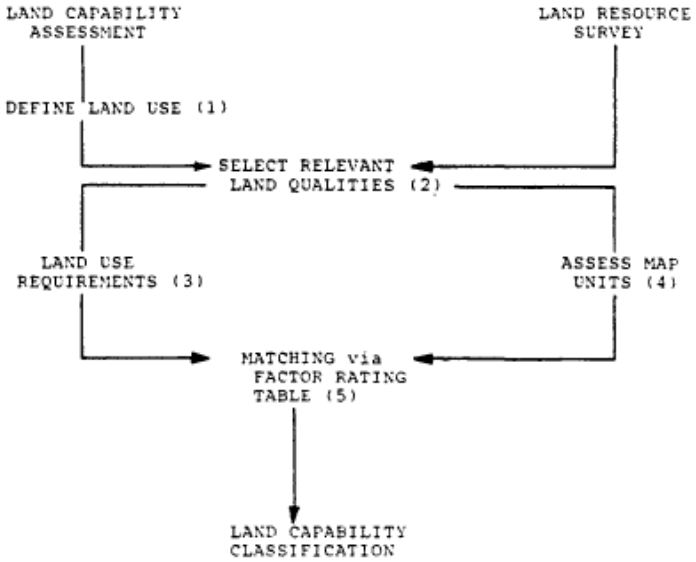

Figure 4. Flow diagram illustrating land capability assessment procedure.

The steps involved are:

- Define the land use(s)
- A land capability classification inherently relies on specification of the land use type. For instance, land may be too waterlogged for cereals, although it is ideal grazing country. In this study the main existing and potential land uses for the Jerdacuttup catchment were considered to be; improved annual pastures, perennial pastures, lucerne, cereal cropping and lupin cropping.
- Select the relevant land qualities, considering the land use(s) to be assessed.
- Land qualities are those attributes of land which influence its capability for a specified use. The land qualities selected are listed in Table 4. Descriptions of each land quality, plus value descriptions are provided in Appendix 3.
- Formulate the ‘land use requirements’ in terms of land quality values (i.e. factor rating tables).
- Land use requirements and descriptions are provided in Appendix 4.
- Assess each map unit for each land quality.
- In Appendix 1 there is a summary of the assessed land quality values for each map unit.
- Matching of requirements via factor rating tables.
- Land capability classification, determined by ‘most limiting factor method.
- The capability ratings for each map unit are summarised in Appendix 2, with the limiting land qualities shown as a subscript(s). For example, an area designated as IIIir for lucerne has only a fair capability for growing lucerne, because of the waterlogging hazard and rooting conditions.

3. Results

3.1 Landform

The landform pattern of the catchment is predominantly a level to gently undulating sandplain. There are gently undulating rises at the top of the catchment on the watershed, giving way to a level plain with extensive areas of poor drainage in the middle of the catchment. In the lower reaches of the catchment, the land is generally low lying and swampy, with a few subdued linear dunes. In the south-west corner of the catchment, near the coast, the drainage lines become more incised. These valley sideslopes and a rise on the southern boundary are the only places where the general slope exceeds 3%

In addition to the landform patterns and their subdivision according to slope, two types of microrelief were recorded. The most common of these was the mound/depression microrelief, which can be described as irregularly distributed mounds and depressions set in a planar surface (McDonald et.al., 1984). There would normally be about 30-40 cm relief from the top of the mounds to the bottom of the depressions. This type of microrelief was most common on the low lying flats in the middle of the catchment. There were also a few small areas with gilgai microrelief in the north-west corner. The gilgais were generally shallow and fairly widely spaced.

There are two small defined drainage lines (un-named) flowing in a southwest direction across the catchment. The eastern drainage line which is the smaller, disappears near Springdale Road. The western drainage line is responsible for most of the flooding problems in the catchment and it flows through to the Jerdacuttup salt lake system.

3.2 Soils and Land Capability

Ten main soil groups were identified within the catchment and these are summarized in Table 5

Table 5 Summary of soil groups.

Soil Group	Description
Gravelly soils	
1	Shallow (<25 cm) gravelly sand over sheet laterite with common areas of exposed laterite (Ks-Uc 1.21).
2	Duplex soil, shallow (0-30 cm) fine sand to loamy sand over ferruginous gravel over mottled clay (Dy 5.82, Dg 4.83).
3	Duplex soil, moderately deep (30-80 cm) fine sand with a conspicuously bleached A2 horizon overlying ferruginous gravel over a clay B horizon (Dy 5.82).
3a	Shallow phase of soil type 3 with the depth to gravel 30-40 cm
3b	Deep phase of soil type 3 with the depth to gravel 60-80 cm. Duplex soils:
Duplex soils:	
4	Duplex soil, with shallow (10-30 cm) fine sand to loamy fine sand over a columnar structured medium clay B horizon (Dy 5.42).
5	Duplex soil, moderately deep (30-80 cm) fine sand with a conspicuously bleached A2 horizon over a brownish-yellow medium clay B horizon (Dy 4.42, Dy 5.43).
6	Duplex soil, with a shallow (10-30 cm) loamy fine sand to sandy loam A horizon overlying brownish-yellow medium clay with an alkaline soil reaction trend (Dy 4.13).
7	Duplex soil, with dark grey loamy sand over brown-yellow coarse clayey sand with a mottled brown-yellow medium clay B horizon at about 30 cm (Dy 5.22).
Uniform sands	
8	Deep, uniform fine sand, with light grey fine sand overlying an olive-yellow fine sand to loamy fine sand subsoil (Uc 2.21).
9	Deep, uniform, brownish-yellow loamy to clayey sand (Uc 5.11).
Uniform Clays	
10	Medium to heavy textured uniform soils, commonly with a light clay to medium clay texture with an alkaline soil reaction trend (Uf 6.33).

The catchment is dominated by duplex sandplain soils. The dominant soils are the gravelly duplex group 2 and 3 soils, although there is also a significant amount of deep sand (group 8). Over most of the catchment the surface soil is a uniform sheet of fine sand to loamy fine sand, with an accumulation of organic matter in the top 10 to 20 cm. On shallow soils there may also be considerable amounts of ferruginous gravel present on the surface. In the northern section of the catchment, minor areas of alkaline soils which originally supported a “mallee” vegetation occur (soil types 6 and 10). The drainage lines become more incised in the south-west corner of the catchment and associated with this landscape are soil types 7 and 9.

The soils are not uniformly distributed across the catchment, with various soils tending to be more prevalent in certain sections of the catchment. In the north the shallow gravelly duplex (group 2) soils are dominant on the gently sloping watershed of the catchment. Immediately south there is a band of moderately deep duplex soils (group 3) and uniform sands going in a general east-west direction. On the low lying flats between Middle Road and Springdale Road the gravelly duplex soils are dominant. The largest area of deep sand (group 8) is just to the north of Springdale Road, there is also a small area of dune sands in this area. Most of the duplex soils without a gravel layer occur in the south of the catchment below Springdale Road.

The following section describes each soil group with a profile description, relationship to landform, occurrence, soil properties, degradation hazard and land capability.

Gravelly soils

3.2.1. Soils (Group 1)

Soil Description: This group consists of shallow gravelly soils with a sandy matrix overlying sheet laterite. The ferruginous gravel occupies more than 60% of the soil volume and there are common areas of exposed laterite. This unit contains areas of group 2 soils.

ppF:	KS-Uc 1.21, Dy 5.82
Landform:	Low gravel rises
Occurrence:	A minor soil type (< 1%) predominantly confined to the western and south-western sections of the catchment.
Soil Properties:	
Surface condition:	Loose, gravelly.
Rooting depth:	Generally less than 25 cm.
Soil reaction trend:	Neutral
Site drainage:	Moderately well to well drained.
Degradation hazard:	
Wind erosion:	Moderate hazard (gravel on the surface increases the surface roughness factor).

Water erosion: Low hazard due to high infiltration rate and gentle slopes.

Salinity: Not subject to salinisation due to landscape position.

Existing Land Use: Sheep grazing on annual pastures, while cropping is restricted by the exposed laterite. Some areas are only partially cleared.

Land capability:

	Land Use Type				
Map Unit	Improved annual pastures	Perennial pastures	Lucerne	Cereal cropping*	Lupins*
G1	IVr	IVr	Vr	IVr	Vr

* Cropping is marginal because of the climate.

Management: These shallow soils are best suited to annual pastures, or left under natural vegetation.

3.2.2 Soils (Group 2)

Soil Description: This group is gravelly duplex soils where the depth to the gravel layer is < 30 cm. The typical soil profile has a shallow sandy A horizon over a layer of dense ferruginous gravel in a sandy matrix. With many of the group 2 soils cultivation has brought gravel to the surface. The A horizon has a fine sand texture with a low clay content (< 4%) and a single grain structure. There is a dark staining in the top 10 to 15 cm because of the accumulation of organic matter. The gravel layer normally consists of loose ferruginous gravel which occupies more than 50% of the soil volume, although it is frequently partially cemented forming ironstone boulders or a sheet laterite pan. The mottled yellow B horizon underlies the gravel layer and is either massive or has a weakly pedal structure. The subsoil has a much lower hydraulic conductivity than the A horizon, resulting in the formation of a saturated zone above the clay during the winter.

ppF's: Dy 5.82, Dg 4.83 (waterlogged areas).

Landform: This soil type is found on many of the landforms within the catchment, level plain (L), level plain with poor drainage (F), level plain with poor drainage and mound/depression microrelief (Pm), gently undulating plain (G), gently undulating plain with mound/depression microrelief (Gm) and moderately inclined valley sideslopes (VU). The dominant landforms are L, G and P.

Occurrence: The most common soil type in the catchment occupying about 40% of the total area. This soil type is particularly dominant on the gently undulating rises on the northern edge of the catchment.

Soil properties:	
Surface condition:	Loose
Rooting depth:	0.3 to 0.7 m. During winter the rooting depth is likely to be limited by the presence of a perched watertable on top of the clay layer. The massive structure of the clay layer also inhibits root growth. In some areas the presence of a sheet laterite pan restricts rooting depth.
Soil reaction trend:	Generally a neutral soil reaction trend with a slightly acidic surface soil, although waterlogged areas may have an alkaline soil reaction trend.
Site Drainage:	Depends on the landform and proximity to the coast. Will also vary according to the depth of the clay layer.
L2:	Imperfectly drained
P2:	Poorly drained
Pm2:	Poorly drained with the mounds less waterlogged.
G2:	Imperfectly to moderately well drained
Gm2:	Generally imperfectly drained to moderately well drained with waterlogging in the depressions.
VU2:	Moderately well drained. Degradation Hazard:
Wind erosion:	Highly susceptible to wind erosion if an adequate surface cover is not maintained.
Water erosion:	The areas with a level plain landform type (L,P,Pm) have a very low water erosion hazard. The gently undulating units have a moderately low water erosion hazard and may require contour banks if cropped, depending on the slope and slope length.
Salinity:	Units with mound/depression microrelief (i.e. Pm2, Gm2) are likely to be more susceptible to salinity They should be managed conservatively to maintain plant cover and maximise water use. Not suitable for cropping.
Existing Land Use:	Sheep grazing annual pastures and cereal cropping.

Land Capability:

	Land Use Type				
Map Unit	Improved annual pastures	Perennial pastures	Lucerne	Cereal cropping*	Lupins*
L2	IIw	IIrw	IVr	IIIi	IVi
P2	IIIirw	IIIri	Vi	IVi	IVir
Pm2	IIIirwy	IIIri	Vi	IVi	IVir
G2	IIw	IIrw	IIIir	II-IIIi	III-IVi
Gm2	IIIy	IIrwy	IIIir	IVy	III-IVi
VU2	IIw	IIrw	IIIr	IIiew	IIIir

* Cropping is marginal because of the climate.

Management: The poorly drained units (P2, Pm2) are best suited to waterlogging tolerant pasture species, unless drainage is feasible. Lucerne and lupins are highly marginal on all of the group 2 soils because of the shallow depth of porous soil and the waterlogging hazard. Cereal cropping is best confined to those units with reasonable drainage in the northern portion of the catchment. Pastures, either annual or perennial are the best option on these soils.

3.2.3 Soils (Group 3)

Soil Description: The group 3 soils are gravelly duplex soils with a medium depth of sand (30 - 80 cm) overlying a layer of dense ferruginous gravel in a sandy matrix. The typical profile has a fine sand A horizon with dark staining in the top 10 cm from the accumulation of organic matter and a conspicuously bleached A2 horizon. In the lower portion of the A2 horizon there may be some distinct red mottles (10 - 20%). The gravel layer may be quite thick (e.g. 50 - 80 cm) and is frequently either partially or wholly cemented to form ironstone boulders or a sheet laterite pan. There is a sharp change in texture to the clayey B horizon which has a sandy clay to light medium clay texture. The subsoil is mottled and varies from a yellow-brown to a grey colour and is either massive or has a weak blocky structure. The group 3 soils grade into the uniform deep sands (group 8).

3a: The shallow phase of soil type 3 with the depth to gravel 30 — 40 cm.

3b: The deep phase of soil type 3 with the depth to gravel 60 — 80 cm.

ppF: Dy 5.82

Landform: This soil type is found on many of the landforms within the catchment; level plain (L), level plain with mound/depression microrelief

(Lm), level plain with poor drainage (P), level plain with poor drainage and mound/depression microrelief (Pm), gently undulating plain (G) and moderately sloping valley sideslopes (VU). The dominant landforms are 'L' and 'G'.

Occurrence: The second most common soil type in the catchment (approx. 35%). Widespread throughout the catchment, particularly on the level plain south of Middle Road.

Soil Properties:

Surface condition: Loose

Rooting depth: 0.5 to 1.5 m. The rooting depth may be restricted by sheet laterite, a perched watertable during winter and the massive clay subsoil.

Soil reaction trend: Neutral

Site Drainage: Will vary according to the landform, depth of the sandy A horizon and the depth to the clay layer.

L3: imperfectly drained

Lm3: imperfectly drained with water occasionally ponding in the depressions.

P3: poorly drained

Pm3: poorly drained with the mounds less waterlogged.

G3: moderately well drained

VU3: moderately well to well drained

Degradation hazard:

Wind erosion: Highly susceptible to wind erosion if an adequate plant cover is not maintained. The waterlogged units (P,Pm) are more susceptible, because they are likely to sustain only poor plant growth over the growing season, leaving the ground exposed during summer.

Water erosion: The high infiltration rates, the depth to clay and the lower slopes (< 3%) result in a low water erosion hazard. The moderately sloping valley sideslopes would require contour banks if cropped, although the proximity to the coast really precludes this activity.

Salinity: There are a number of map units with soil type 3 which are partially saline. If these areas are not managed separately (i.e.

fenced off) to maintain a good plant cover at all times, then the salinity is likely to spread rapidly. They are not suitable for cropping. The areas with mound/depression microrelief which are presently non-saline should be managed carefully, because they have a higher likelihood of salinity developing. They are also not suitable for cropping because of the associated risk.

Existing Land Use: The main land uses are sheep grazing annual pastures, cereal cropping, cattle on annual and perennial pastures and a small amount of lupin cropping.

Land capability:

	Land Use Type				
Map Unit	Improved annual pastures	Perennial pastures	Lucerne	Cereal cropping*	Lupins*
L3	IImw	IImw	IIIi	IIIi	IVi
Lm3	IIIy	IIImwy	IIIi	Ivy	IVi
P3	IIIiyw	IIIi	Vi	IVi	Ivi
Pm3	IIIiyw	IIIi	Vi	IViy	IVi
G3	Iimw	Iimw	IIIiwr	IIisw	IIIi
VU3	IImw	IImw	IIrw	IIews	IIiws

* Cropping is marginal because of the climate.

Management: The group 3 soils are reasonably flexible in that they are suitable for a range of land uses. Lupins would be most suited to the deep phase of this soil type (i.e. 3b), on the gently undulating to undulating country. Perennial pastures are well suited to these soils, while improved annual pastures should do well on the shallow phase (i.e. 3a). Lucerne may be favoured as the pasture alternative on the deep phase group 3 soils, and would also perform reasonably well on the shallow phase. In the northern half of the catchment cereal cropping should be successful, especially on the gently undulating land. The poorly drained units (P3, Pm3) are best suited to waterlogging tolerant varieties of subterranean clover. The areas with mound/depression microrelief (Pm3, Lm3) tend to be more prone to salinity, thus cropping is a risky alternative. In a wet year the crop would perform poorly on these areas, which could increase the likelihood of salinity developing.

Duplex Soils

3.2.4 Soils (Group 4)

Soil Description: This group consists of duplex soils with a sandy A horizon overlying a columnar clay subsoil. The loamy fine sand topsoil has dark staining from the organic matter, and there is usually a conspicuously bleached A2 horizon of fine sand. The A horizon is normally in the range from 10 to 30 cm deep, although the sand seams in between the columns can extend a further 50 cm. There is a sharp textural change to the medium clay B horizon which has a strong columnar structure. The columns are approximately 15-20 cm in diameter and the bleached A2 horizon

extends down between them. Within the columns the soil has only weak pedological development. In some instances cultivation has brought the top of the domes to the surface.

ppF's: Dy 5.42, Dy 4.43, Dy 5.43

Landform: This soil type is found on the level plain (L), level plain with poor drainage (P), level plain with poor drainage and mound/depression microrelief (Pm), gently undulating plain (G) and gently undulating plain with mound/depression microrelief (Gm). The main landform type is the level plain (L).

Occurrence: A minor soil group (approx.2Z), which often occurs in small isolated patches. The group 4 soils more commonly occur in the lower parts of the landscape (e.g. Near drainage lines).

Soil Properties:

Surface condition:	loose
Rooting depth:	0.3 to 0.8 m. Root growth will be restricted within the columns, because of the massive structure and high bulk density. The roots will grow down the sand seams between the columns.
Soil reaction trend:	Normally a neutral soil reaction trend, although the group 4 soils may have an alkaline pH in the deep subsoil.
Site drainage:	The drainage will vary depending on the landform and the depth of the A horizon.
	L4: imperfectly drained
	P4: poorly drained
	Pm4: poorly drained
	G4: imperfectly to moderately well drained
	Gm4: imperfectly drained

Degradation Hazard:

Wind erosion: The sandy surface soil is highly susceptible to wind erosion. It is very important that the columnar subsoil is not exposed, because if this were to occur then subsequent production is negligible.

Water erosion: Generally occurs on level areas, consequently runoff would be minimal. On gently sloping land, working on the contour would be necessary and contour banks may also be required depending on the slope and slope length.

Salinity: At present there is no secondary salinity on the group 4 soils, although it could develop in the future.

Existing Land Use: Mainly sheep grazing annual pastures.

Land Capability:

Map Unit	Improved annual pastures	Perennial pastures	Lucerne	Cereal cropping*	Lupins*
L4	IIw	Iirw	IIIir	IIIi	IVi
P4	IIIiw	IIIir	Vi	IVi	IVir
Pm4	IIIiwy	IIIir	Vi	IViy	IVir
G4	IIw	Iirw	IIIir	II-IIIi	III-IVi
Gm4	IIwy	Iirw	IIIir	IIIiy	IVi

* Cropping is marginal because of the climate.

Management: The poorly drained units (P4, Pm4) are best suited to pasture species tolerant of waterlogging. The group 4 soils are marginal for cropping because of the waterlogging hazard. The waterlogging hazard and the shallow rooting depth result in lucerne being a marginal option. These soils are best suited to pasture.

3.2.5 Soils (Group 5)

Soil Description: The group 5 soils are yellow duplex soils with a medium depth (30-80 cm) sandy A horizon. A typical profile has a dark organic stained loamy fine sand topsoil overlying a conspicuously bleached fine sand A2 horizon. There may be a layer of olive yellow sand present below the bleached A2 horizon. In the subsoil, there is a sharp textural change to a brownish yellow medium clay with moderate angular blocky structure. The deep subsoil is likely to have distinct grey mottles and have only weak pedological developments. There may be a thin (<10 cm) layer of ferruginous gravel present between the A and B horizons.

ppF's: Dy 4.42, Dy 5.43

Landform: These soils are predominantly found on the level plain (L), although also on the level plain with poor drainage (P), gently undulating plain (G) and gently undulating plain with mound/depression microrelief (Gm).

Occurrence: A minor soil type (approx. 7% of catchment) which is mainly confined to the southern section of the catchment below Springdale Road.

Soil Properties:

Surface condition: loose

Rooting depth: 0.6 to 1.0 m. Root growth will be restricted by a seasonal perched watertable and the structure of the subsoil.

Soil reaction trend: Normally a neutral soil reaction trend, although the group 5 soils may have an alkaline soil reaction trend in waterlogged areas.

Site drainage: The drainage will vary depending on the landform and the depth of the sandy A horizon.

L5: imperfectly to moderately well drained.

P5: poorly drained

G5: moderately well drained

Gm5: moderately well drained with waterlogging in the depressions

Degradation Hazard:

Wind erosion: The fine sandy surface soil is highly susceptible to wind erosion if an adequate plant cover is not maintained.

Water erosion: These soils generally occur on the level plain and combined with the high infiltration rate result in minimal runoff.

Salinity: At present there is no secondary salinity on the group 5 soils, although it could develop in the future.

Existing Land Use: Sheep grazing annual pastures with a small amount of perennial pastures and occasional cropping.

Land capability:

Map Unit	Improved annual pastures	Perennial pastures	Lucerne	Cereal cropping*	Lupins*
L5	IIwm	Iimw	IIIi	II-IIIi	III-IVi
P5	IIIwi	IIIi	Vi	IVi	IVi
G5	IIwm	IImw	IIiwr	IIwis	IIIi
Gm5	IIIwmy	IImw	Iiriw	IIIy	IIIiyq

* Cropping is marginal because of the climate.

Management: The group 5 soils predominantly occur south of Springdale Road, consequently cropping is a marginal activity. These soils are best suited to either improved annual pastures or perennial pastures. Lucerne should do well on the gently undulating country which is less prone to waterlogging in winter.

3.2.6 Soils (Group 6)

Soil Description: This group consists of light textured duplex soils with an alkaline soil reaction trend. The typical soil profile has a shallow (5 to 30 cm) A horizon with a sand to sandy loamy texture. In the subsoil there is a sharp texture change to a brown to brownish yellow, light clay to medium clay. There are frequently nodules of limestone on the surface and carbonate nodules in the subsoil. In some areas there may be ferruginous gravel present in the A horizon.

ppF: Dy 4.13

Landform: This soil type is found on the level plain (L), level plain with poor drainage (P) and gently undulating plain (G).

Occurrence: A very minor soil type (< 1%), mainly confined, to the northwestern part of the catchment. Frequently occurs in a complex association with soil type 10.

Soil Properties:

Surface condition:	Loose to firm
Rooting depth:	0.3 to 0.6 m. The rooting depth will be restricted by the structure of the subsoil.
Soil reaction trend:	Alkaline
Site drainage:	Will vary with the landform and the depth of the A horizon.
	L6: imperfectly drained
	P6: poorly drained
	G6: imperfectly to moderately well drained
Degradation Hazard:	
Wind erosion:	Highly susceptible to wind erosion if an adequate ground cover is not maintained.
Water erosion:	On gently sloping land, soil conservation works may be required depending on the slope and slope length.
Salinity:	Presently not subject to secondary salinisation, although could develop in the future.
Existing Land Use:	Sheep grazing annual pastures and cereal cropping.

Land Capability:

Map Unit	Improved annual pastures	Perennial pastures	Lucerne	Cereal cropping*	Lupins*
L6	Iiw	IIrw	IIIir	IIIi	IVi
P6	IIIi	IIIi	Vi	IVi	IVi
G6	IIw	IIrw	IIIir	II-IIIi	III-IVi

* Cropping is marginal because of the climate.

Management: The group 6 soils are best suited to either improved annual pastures or perennial pastures, although cereal cropping could be an option as these soils mainly occur in the northern part of the catchment. The waterlogging hazard and effective soil depth restrict lucerne and lupins.

3.2.7 Soils (Group 7)

Soil Description: This soil group comprises yellow mottled duplex soils with a brownish yellow sandy A horizon. A typical profile has a dark organic stained loamy sand topsoil with a brownish yellow clayey coarse sand A2 horizon. The A2 horizon is massive with a few quartz fragments and normally extends to a depth of 25 to 50 cm. The subsoil is a brownish yellow medium clay with distinct red mottles.

ppF: Dy 5.22

Landform: These soils are found on the gently undulating plain (G) and on gently sloping valley sideslopes (VG).

Occurrence: A very minor soil type (< 1%), confined to the south-western corner of the catchment.

Soil Properties:

Surface condition:	Loose
Rooting depth:	0.6 to 1.0 m
Soil reaction trend:	Neutral
Site drainage:	G7: moderately well drained
	VG7: moderately well drained Degradation hazard:
Wind erosion:	The loamy sand surface soil is highly wind erodible if an adequate plant cover is not maintained.
Water erosion:	If cropped then soil conservation earthworks may be required depending on the slope and slope length.

Salinity: Landscape position and soil type result in these areas having a low salinity hazard.

Existing Land Use: Sheep grazing annual pastures.

Land Capability:

Map Unit	Improved annual pastures	Perennial pastures	Lucerne	Cereal cropping*	Lupins*
G7	Iiw	IIw	IIirw	IIwi	IIIi
VG7	Iiw	IIw	IIirw	IIwi	IIIi

* Cropping is marginal because of the climate.

Management: These soils only occur in the south-west corner of the catchment close to the coast, thus cropping is a highly marginal land use. These soils are suitable for all of the pasture types.

Uniform Sands:

3.2.8 Soils (Group 8)

Soil Description: The group 8 soils comprise the uniform deep sands (>80 cm). A typical profile has a grey, organic stained fine sand (0-15 cm) overlying a conspicuously bleached A2 horizon of light grey fine sand with a single grain structure. Below this pale layer (0.4 to 1.0 m) there is frequently an olive yellow fine sand to loamy fine sand colour B horizon. Underlying the sand there is an abrupt change in texture to a sandy clay. In some profiles the sand extends to a depth of 2 m, although generally within the Jerdacuttup catchment the clay layer is within 1.2 m of the surface, with the exception of the dune sands. A thin layer of ferruginous gravel may be present above the clay layer. The deep phase of the group 3 soils (i.e. 3b) and the group 5 soils grade into the group 8 soils.

ppF: Uc 2.21

Landform: The group 8 soils are found on many of the landforms within the catchment; level plain (L), level plain with mound/depression microrelief (Lm), level plain with poor drainage (P), level plain with poor drainage and mound/depression microrelief (Pm), gently undulating plain (G), undulating plain (U), moderately inclined linear dunes (D) and gently sloping valley sideslopes (VG),

Occurrence: The third most common soil type in the catchment (approx.13%), with a fairly even distribution through the catchment. The area of dune sands (D8) is minor and they only occur in the south of the catchment.

Soil Properties:

Surface condition:	Loose
Rooting depth:	1.0 to 2.0 m +.
Soil reaction trend:	Neutral (although occasionally the pH is acidic at depth, Acid soil reaction trend).
Site drainage:	Generally well to rapidly drained, although perched watertables on top of the clay layer are not uncommon. In a few small areas the landscape position results in considerable run-on and a waterlogged profile despite the sand depth.
	L8: well drained
	Lm8: well drained, although the depressions may be waterlogged for short periods.
	P8: imperfectly to poorly drained
	Pm8: imperfectly to poorly drained
	G8: rapidly drained
	U8: rapidly drained
	D8: rapidly drained
	VG8: rapidly drained

Degradation Hazards:

Wind erosion:	The deep sands are extremely susceptible to wind erosion because of their low soil moisture holding capacity and subsequent poor plant growth. The dune sands are extremely susceptible and should be managed conservatively to maintain a good plant cover.
Water erosion hazard:	The high infiltration rates result in a low water erosion hazard.
Salinity:	On the level plain (L,P,Lm, Pm) a few areas of this soil type have become saline, although there is generally a lower probability than with other soil types. There is a negligible salinity hazard with the other landform types (i.e.G, U, D, VU).
Existing Land Use:	The group 8 soils are mainly used for grazing. The pastures are dominated by broadleaf weeds such as capeweed.

Management: In general the deep rooted species are favoured on the deep sands. Lucerne has proved an extremely productive pasture alternative in other areas with similar soils and comparable climatic conditions. Improved annual pastures are marginal as the subclover may fail to persist, because of the moisture holding and nutrient retention characteristics of these deep sands. The poorly drained units (P8,Prn8) which tend to occur in depressions could be sown to a perennial pasture. Cropping with cereals and, in particular, lupins is a reasonable alternative in the northern half of the

catchment, provided the wind erosion hazard is adequately managed. The dune sands (D8) should be fenced off so that grazing can be carefully controlled. Lucerne may be best pasture alternative, while they are not suitable for cropping.

Land Capability:

	Land Use Type				
Map Unit	Improved annual pastures	Perennial pastures	Lucerne	Cereal cropping*	Lupins*
L8	IIIwm	IIIm	IIwm	II-IIIw	II-IIIw
Lm8	IIIwm	IIIm	IIwm	IIIwq	IIIwq
P8	IIIw	iimiw	IVi	III-IVi	IVi
Pm8	IIIw	iimiw	IVi	III-IVyi	IVi
G8	IIImw	Ivm	IIwm	IIIw	IIIw
U8	IIImw	Ivm	IIwm	IIIw	IIIw
D8	IVw	Vm	IIIwn	IVwmn	IVw
VG8	IIImw	Ivm	IIwm	IIIw	IIIw

* Cropping is marginal because of the climate.

3.2.9 Soils (Group 9)

Soil Description: This group consists of uniform, brownish-yellow loamy to clayey sand. A typical profile has a dark organic stained layer (0-10 cm) of loamy sand overlying brownish yellow loamy sand to clayey sand with a massive structure, which continues to more than one metre.

ppF: Uc 5.11

Landform: These soils are found on the gently undulating plain (G).

Occurrence: A very minor (< 1%) soil type confined to the south-west corner of the catchment.

Soil Properties:

Surface condition: Loose

Rooting depth: 1 m +

Soil reaction trend: Neutral

Site drainage: Well drained

Degradation hazard:

Wind erosion: These deep sands are highly susceptible to wind erosion if adequate ground cover is not maintained.

Water erosion: Low hazard due to the high infiltration rate.

Salinity: Negligible hazard.

Existing Land Use: Sheep grazing annual pastures.

Land Capability:

MAP UNIT	Improved annual pastures	Perennial pastures	Lucerne	Cereal cropping*	Lupins*
G9	IIImw	IIIm	IIw	II-IIIw	II-IIIw

* Cropping is marginal because of the climate.

Management: These deep sands are well suited to a deep rooted species like lucerne. The group 9 soils only occur in the south-west corner of the catchment close to the coast, thus cropping is not a viable option.

Uniform clays

3.2.10 Soils (Group 10)

Soil Description: Medium to heavy textured uniform soils. A typical profile has an olive brown light medium clay topsoil overlying a light medium clay at depth. The soils often have moderate pedality, are slightly to highly calcareous and carbonate nodules may be present in the B horizon.

ppF. Uf 6.33

Landform: This soil type is only found on the level plain with gilgai microrelief (Lg). Within the catchment, the gilgais tend to be fairly shallow and ill-defined.

Occurrence: A very minor soil type (< 1%) confined to the north-western corner of the catchment. The group 10 soils are often associated in a complex with the group 7 soils.

Soil Properties:

Surface condition: Hardsetting

Rooting depth: 0.3 to 0.5 m

Soil reaction trend: Alkaline

Site drainage: Imperfectly drained

Degradation hazard:

Wind erosion: Low hazard unless recently cultivated.

Water erosion: Low hazard due to the topography.

Salinity: Presently non-saline, but may develop secondary salinity in the future.

Existing Land Use: Sheep grazing annual pastures.

Land Capability:

MAP UNIT	Improved annual pastures	Perennial pastures	Lucerne	Cereal cropping*	Lupins*
Lg10	I	IIr	IVi	IIIiq	IVi

* Cropping is marginal because of the climate.

Management: Best suited to improved annual pastures.

4. Discussion

The Jerdacuttup catchment has a number of significant land degradation problems. Salinity is likely to become the overwhelming problem in the future if steps are not taken to rectify the situation. Considerable improvement should be possible through altering the land use and management to match the capability of the land. There is a growing recognition amongst the farmers in the catchment of the requirement to manage certain soils separately. This is reflected by the fact that at the time of going to press, eight farm plans had been produced utilising the base information gathered for this survey. Prior to this happening, there had been minimal farming and fencing according to soil types. Most farms have simply been sub-divided on a grid basis, resulting in many paddocks containing a mixture of soil types with variable production levels.

There is considerable secondary salinity in the catchment, particularly considering the relatively short period that has elapsed since the land was cleared. There is also the potential for substantial spread due to the low relief. In the middle of the catchment there is an extensive level plain with minimal relief, thus the potential for large tracts of land to become saline. At present a number of significant areas are partially saline (e.g. P3ps) and without remedial measures these entire units could rapidly become saline. On the partially saline land remedial measures would include additional fencing so that these areas could be managed separately. They should not be cropped because this tends to exacerbate the salinity, because of the poor plant cover. A good ground cover of annual or perennial pasture should be maintained to maximise water use.

Within the catchment there are both recharge and discharge sites. The discharge sites which are presently saline are readily observable, although this is not the case for sites presently non-saline which will become saline in the future. It is only possible to speculate on where salinity will develop, although some areas may have a higher probability if there is a relationship between soil type or landform and salinity. Salinity occurs on a number of different soil types within the catchment, even on areas with about one metre of sand overlying clay. There was not a close association between the soil type and the likelihood of salinity developing. Most of the salinity occurs on the group 2 and 3 soils, which only reflects that these are the dominant soils in the catchment. The pH at depth is usually alkaline to highly alkaline (pH 8.5-9.5). On the other hand, there was a reasonably good correlation between the landform and the likelihood of secondary salinity. Many of the saline areas are on a level plain with a mound/depression microrelief. The microrelief was present prior to clearing, although in some cases it has been accentuated by wind erosion removing soil from the waterlogged depressions. In the natural state there were clumps of mallees on the mounds, while the depressions may have been caused by surface water flow, wind action or both. With this type of microrelief the subsoil is normally fairly level, while the depth of sandy A horizon fluctuates between the mounds and depressions. The sequence of events appears to be as follows. After the land was cleared the depressions are waterlogged during the winter months, while the mounds produce pasture. Over time the depressions gradually become saline and eventually the whole area is affected. This is not to say that only areas with mound/depression microrelief

have become saline or will become saline in the future, but they appear to have a higher probability of becoming affected.

The land with mound/depression microrelief which is presently non-saline should be managed conservatively. Ideally it should be fenced out so that stock numbers can be carefully controlled. In general it should not be cropped and a good ground cover of annual or perennial pasture should be maintained. It may also be feasible in some areas to install a surface drainage system to drain the depressions if water ponding is a problem. Saline land should be fenced off and saltbush or other salt tolerant pasture species established.

It is difficult to identify future discharge areas and equally difficult to identify recharge sites in a sandplain environment. The entire catchment may be contributing some recharge, particularly in high rainfall years. Withstanding this general recharge, there are probably a few areas which contribute a proportionally greater amount of recharge. To the north of Middle Road an extensive area of moderate to deep sandy soils (e.g. L3, G3, L8, G8) is probably a major recharge area for the catchment. The very low moisture holding capacity of the deep sands and the resultant poor pasture and crop growth are a particular problem. The water quickly passes below the root zone of the annual species into the groundwater. The amount of recharge could be significantly reduced if the volunteer annual pasture was replaced with a deep rooted species like lucerne. Perennial pastures are climatically well suited to the catchment, particularly the southern half, where they have been successfully grown for a long time on two properties. On one property this has resulted in noticeably less salinity developing. The grazing of perennial pastures is a more stable land use than annual pastures; the strong root growth binds the topsoil together decreasing wind erosion, there is an increase in organic matter and a decrease in salinity. The drawbacks of perennial pastures are that the cropping option is no longer available and the real or perceived problems with grazing sheep on perennial pastures. The catchment is climatically marginal for cropping, especially the southern half. It is easier to manage cattle on perennial pastures rather than sheep because of their different grazing habits, although rotationally grazing sheep on perennial pastures should be successful.

There are extensive areas of land affected by waterlogging in the catchment. This includes not only all the units with a ‘P’ landform type, but all the duplex soils would have perched watertables for certain periods during the winter months. Thus after heavy or prolonged rainfall up to 70-80% of the catchment may be waterlogged. Most of the waterlogging would be fairly transitory, although other areas are waterlogged for several months. Ameliorative measures through drainage or the use of tolerant species or cultivars should reduce production losses and also help to reduce recharge of the deep groundwater.

The majority of the soils in the catchment are water repellent to some extent. They have a fine sand surface soil with a low clay content (<5%). The severity depends on the amount and type of organic matter present, with clover dominant pastures more susceptible. Water repellency results in uneven germination of crops and pastures and

increases run-off from the watershed. Research is currently underway to develop solutions which are economically viable.

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Appendix 1. Land Qualities For All Map Units – Gravelly Duplex Soils

Map Unit	Site drainage (i)	Moisture availability (m)	Nutrient availability (n)	Rooting conditions (r)	Salinity hazard (y)	Soil workability (k)	Potential for mechanization (q)	Soil structural decline hazard (s)	Water erosion hazard (e)	Wind erosion hazard (w)
Gravelly Duplex Soils:										
G1	moderately well to well drained	very low	Low	Poor	nil	high	low to moderate	nil to low	low	Moderate to high
L2	imperfectly drained	Moderate	Low	Fair	low to moderate	moderate to high	high	low	very low	high
P2	poorly drained	Moderate	Low	poor to fair	moderate	moderate	high	low	very low	high to very high
Pm2	poorly drained	Moderate	Low	poor to fair	high	moderate	low to moderate	low	very low	high to very high
G2	imperfectly to moderately well drained	Moderate	Low	Fair	low	high	high	low	low	high
Gm2	imperfectly to moderately well drained	Moderate	Low	Fair	high	high	low to moderate	low	low	high
VU2	moderately well drained	moderate	Low	Fair	low	high	high	low	moderate	high
13	imperfectly drained	low	Low to very low	Good	low	moderate to high	high	moderate	very low	high
Lm3	imperfectly drained	low	low to very low	Good	high	moderate to high	low to moderate	moderate	very low	high

Appendix 1. Land Qualities For All Map Units – Gravelly Duplex Soils (cont)

Map Unit	Site drainage (i)	Moisture availability (m)	Nutrient availability (n)	Rooting conditions (r)	Salinity hazard (y)	Soil workability (k)	Potential for mechanization (q)	Soil structural decline hazard (s)	Water erosion hazard (e)	Wind erosion hazard (w)
Gravelly Duplex Soils:										
P3	poorly drained	moderate	low to very low	fair	moderate	moderate	high	moderate	very low	high to very high
Pm3	poorly drained	moderate	low to very low	fair	high	moderate	low to moderate	moderate	very low	high to very high
G3	moderately well drained	low	low to very low	good	low	high	high	moderate	low	high
VU3	moderately well to well drained	low	low to very low	good	low	high	high	moderate	moderate	high

Appendix 1. Land qualities for all map units – Duplex Soils

Map Unit	Site drainage (1)	Moisture availability (m)	Nutrient availability (n)	Rooting conditions (Cr)	Salinity hazard (y)	Soil workability (k)	Potential for mechanization (q)	Soil structural decline hazard (s)	Water erosion hazard (e)	Wind erosion hazard (w)
Duplex Soils:										
L4	imperfectly drained	moderate	low	fair	low to moderate	moderate to high	high	low	very low	high
P4	poorly drained	moderate	low	poor to fair	moderate	low to moderate	high	low	very low	high to very high
Pm4	poorly drained	moderate	low	poor to fair	high	low to moderate	low to moderate	low	very low	high to very high
G4	imperfectly to moderately well drained	moderate	low	fair	low	high	high	low	low	high
Gm4	imperfectly drained	moderate	low	fair	moderate high	moderate to high	low to moderate	low	low	high
L5	imperfectly to moderately well drained	low	low to very low	good	low to moderate	moderate to high	high	moderate	very low	high
PS	poorly drained	moderate	low to very low	fair	moderate	moderate	high	moderate	very low	high to very high
G5	moderately well drained	low	low to very low	good	low	high	high	moderate	low	high
Gm5	moderately well drained	low	low to very low	good	moderate high	high	low to moderate	moderate	low	high

Appendix 1. Land Qualities For All Map Units – Duplex Soils (cont)

Map Unit	Site drainage (1)	Moisture availability (m)	Nutrient availability (n)	Rooting conditions (Cr)	Salinity hazard (y)	Soil workability (k)	Potential for mechanization (q)	Soil structural decline hazard (s)	Water erosion hazard (e)	Wind erosion hazard (w)
Duplex Soils:										
L6	imperfectly drained	moderate	moderate	fair	low to moderate	moderate to high	high	low	very low	moderate high
P6	poorly drained	moderate	moderate	fair	moderate	moderate	high	low	very low	moderate high
G6	imperfectly to moderately well drained	moderate	moderate	fair	low	moderate to high	high	low	low	moderate high
G7	moderately well drained	moderate	low	good	low	high	high	low	low	high
VG7	moderately well drained	moderate	low	good	low	high	high	low	low	high

Appendix 1. Land Qualities For All Map Units – Uniform Sands

Map Unit	Site drainage (i)	Moisture availability (m)	Nutrient availability (n)	Rooting conditions (r)	Salinity hazard (y)	Soil workability (k)	Potential for mechanization (q)	Soil structural decline hazard (s)	Water erosion hazard (e)	Wind erosion hazard (w)
Uniform Sands:										
L8	well drained	low to very low	very low	very good	low	high	high	moderate	very low	high to very high
Lm8	well drained	low to very low	very low	very good	moderate to high	high	low to moderate	moderate	very low	very high
P8	imperfectly to poorly drained	low	very low	good	moderate	moderate high to high		moderate	very low	very high
Pm8	imperfectly to poorly drained	low	very low	good	moderate to high	moderate to high	low to moderate	moderate	very low	very high
GB	rapidly drained	very low	very low	very good	nil	high	high	moderate	low	very high
U8	rapidly drained	very low	very low	very good	nil	high	high	moderate	low	very high
D8	rapidly drained	extremely low	extremely low	very good	nil	high	high	moderate	low	very high to extremely
VG8	rapidly drained	very low	very low	very good	nil	high	high	moderate	low	very high
G9	well drained	very low	low to very low	very good	nil	high	high	moderate	low	high to very high
Uniform Clays:										
LglO	Imperfectly drained	moderate	moderate	fair	moderate	moderate	low to moderate	moderate	very low	moderate low

Appendix 2. Land capability ratings for all map units – Gravelly Duplex Soils

	Land Use Type				
Map Unit	Improved annual pastures	Perennial pastures	Lucerne	Cereal Cropping*	Lupins*
Gravelly Duplex Soils					
G1	IVr	IVr	V	IVr	Vr
L2	IIw	IIrw	IVr	IIIi	IVi
P2	IIIirw	IIIri	Vi	IVi	IVir
Pm2	IIIirwy	IIIri	Vi	IVi	IVir
G2	IIw	IIwr	IIIir	II-IIIi	III-IVi
Gm2	IIIy	IIrwy	IIIir	IVy	III-IVi
VU2	IIw	IIrw	IIIr	IIIew	IIIir
L3	IImw	IImw	IIIi	IIIi	IVi
Lm3	IIIy	IImwy	IIIi	IVy	IVi
P3	IIIiyw	IIIi	Vi	IVi	IVi
P2	IIIirw	IIIri	Vi	IVi	IVir
Pm3	IIIiyw	IIIi	Vi	IViy	IVi
G3	IImw	IImw	IIiwr	IIisw	IIIi
VU3	IImw	IImw	IIrw	IIews	IIiews

* Cropping is marginal because of the climate.

Appendix 2. Land capability ratings for all map units –Duplex Soils

	Land Use Type				
Map Unit	Improved annual pastures	Perennial pastures	Lucerne	Cereal Cropping*	Lupins*
Duplex Soils					
L4	IIw	Iirw	IIIir	IIIi	IVi
P4	IIIiw	IIIir	Vi	IVi	IVir
Pm4	IIIiwy	IIIir	Vi	IViy	IVir
C4	IIw	Iirw	IIIir	II-IIIi	III-IVi
Gm4	IIwy	Iirw	IIIir	IIIiy	IVi
L5	IIwm	Iimw	IIIi	II-IIIi	III-IVi
P5	IIIwi	IIIi	Vi	IVi	IVi
G5	IIwm	Iimw	IIiwr	IIwis	IIIi
Gm5	IIwmy	Iimw	IIriw	IIIy	IIIiyq
L6	IIw	Iirw	IIIir	IIIi	IVi
P6	IIIi	IIIi	V	IVi	IVi
G6	IIw	Iirw	IIIir	II-IIIi	III-IVi
G7	IIw	Iiw	IIirw	IIwi	IIIi
VG7	IIw	Iiw	IIirw	IIwi	IIIi

* Cropping is marginal because of the climate.

Appendix 2. Land capability ratings for all map units – Uniform Sands/Clays

	Land Use Type				
Map Unit	Improved annual pastures	Perennial pastures	Lucerne	Cereal Cropping*	Lupins*
Uniform Sands					
L8	IIIwm	IIIm	IIwm	II-IIIw	II-IIIw
Lm8	IIIwm	IIIm	IIwn	IIIwy	IIIwq
P8	IIIw	Iimiw	IVi	III-IVi	IVi
Pm8	IIIw	Iimiw	IVi	III-IViy	IVi
G8	IIImw	Ivm	IIwn	IIIw	IIIw
U8	IIImw	Ivm	IIwn	IIIw	IIIw
D8	Ivw	Vm	IIIwn	Ivwmn	Ivw
VG8	IIImw	Ivm	IIwn	IIIw	IIIw
G9	IIImw	IIIm	IIw	II-IIIw	II-IIIw
Uniform Clays					
Lg10	I	Iir	IVi	IIIiq	IVi

* Cropping is marginal because of the climate

Appendix 3

Land qualities

The following sections briefly describe each land quality. The accompanying tables describe the values for each land quality. The number of values for each land quality varies from three to six. The lower numbered values being generally more favourable for plant growth.

The land quality value descriptions were obtained from the following reports; site drainage (McDonald et al., 1984); moisture availability, nutrient availability, potential for mechanization, soil structural decline hazard and water erosion hazard (Muller et al., In Prep); rooting conditions, soil workability and wind erosion hazard (Moore, 1990); while salinity hazard was adapted from Moore (1990).

Appendix	Land Quality (symbol)
3.1	Site drainage (i)
3.2	Moisture availability (m)
3.3	Nutrient availability (n)
3.4	Rooting conditions (r)
3.5	Salinity hazard (y)
3.6	Potential for mechanization (q)
3.7	Soil workability (k)
3.8	Soil structural decline hazard (s)
3.9	Water erosion hazard (e)
3.10	Wind erosion hazard (w)

3.1 Site drainage (i)

The land quality, site drainage (waterlogging), refers to the overall site and internal soil drainage. Drainage is influenced by internal factors including soil texture, structure, water holding capacity, the presence of an impermeable layer, the depth to this layer if present and external factors including the slope and the amount of run-on. The definitions are from the 'Australian Soil and Land Survey Field Handbook' (McDonald et al., 1984).

Site drainage (i)

Value	Numerical Rating	Description
Very poorly drained	6	Water is removed from the soil so slowly that the water-table remains at or near the surface for most of the year.
Poorly drained	5	Water is removed very slowly in relation to supply. All horizons remain waterlogged for periods of several months.
Imperfectly drained	4	Water is removed only slowly in relation to supply. Some horizons may be mottled and/or have orange or rusty linings of root channels, and are waterlogged for periods of several weeks.
Moderately well drained	3	Water is removed from the soil somewhat slowly in relation to supply, due to low permeability, shallow water-table, lack of gradient, or some combination of these. Some horizons may remain waterlogged for as long as one week after addition of water.
Well drained	2	Water is removed from the soil readily, but not rapidly. Some horizons may remain waterlogged for several days after addition of water.
Rapidly drained	1	Water is removed from the soil rapidly in relation to supply. No horizon is normally waterlogged/wet for more than several hours after addition of water.

3.2 Moisture Availability (m)

Moisture availability refers to the water-holding capacity of soil profile, that is the amount of water held within the root zone between field capacity and wilting point for plants. On certain soil types deep-rooted plants have an advantage over shallow-rooted plants and are able to extract more water from the profile. This has been taken into account in the respective factor-rating tables for the different land use types.

Moisture availability (m)

Value	Numerical Rating	Description
Extremely low	5	Extremely poor water-holding capacity. Deep, leached sands with a low clay content (less than 3%) with the subsoil well beyond the root zone.
Very low	4	Very poor water-holding capacity. Generally deep sands with a reasonable clay content (more than 5%) or leached deep sands with the subsoil within the root zone (less than 1.4 m).
Low	3	Poor water-holding capacity. Generally duplex soils with a sandy A horizon (30-80 cm) overlying gravel or clay.
Moderate	2	Average water-holding capacity. Generally duplex soils, with clay within about 30 cm of the surface.
High	1	Good water-holding capacity. Generally medium to heavy textures throughout the profile.

3.3. Nutrient availability (n)

The nutrient availability of soils depends upon soil characteristics including texture, cation exchange capacity, the organic matter content and the pH. Soils with a low exchange capacity which are readily leached and soils with high fixing capacities are naturally low in available nutrients.

Nutrient availability (n)

Value	Numerical Rating	Description
Extremely low	5	Soils with a low exchange capacity in the A horizon and the subsoil is beyond the root zone of agricultural plants. Consequently applied fertilizers are rapidly leached below the root zone.
Very low	4	Soils with a low exchange capacity in the A horizon and the subsoil is just within reach of the deeper-rooted plants. Consequently, applied fertilizers are leached below the root zone of shallow-rooted plants.
Low	3	Soils with a low exchange capacity in the surface soil, although the subsoil is well within the root zone of all pasture and crop species. Consequently, applied fertilizers may be leached out of the topsoil, although not beyond the root zone.
Moderate	2	Soils may have a deficiency in one or more nutrients before clearing, but deficiency is easily corrected withy appropriate fertilizers. Thereafter, phosphate is normally the only fertilizer applied.
High	1	High intrinsic fertility. Only infrequent applications of fertilizer are required.

3.4 Rooting conditions (r)

Rooting conditions refers specifically to root room and mechanical impedance. Root room is the soil volume available for root growth and is predominantly a function of the effective soil depth and content of coarse fragments. Gravels and stone in the soil profile reduce the soil volume in proportion to their abundance. The effective soil depth is the depth to an impenetrable barrier such as rock, a cemented ironstone pan or a dense, massive clay subsoil. A perched or permanent watertable can also act as a barrier to root development. For this study an impenetrable layer is deemed to be any layer which impedes the development of the majority of the roots.

Rooting conditions (r)

Value	Numerical Rating	Description
Poor	4	Shallow soils with an effective soil depth less than 0.2 m. Alternatively the soils are moderately shallow (0.2-0.5 m) with a high (> 50%) gravel/stone content. Soil types include skeletal soils over bedrock and some very poorly drained soils.
Fair	3	Moderately shallow soils with an effective soil depth from 0.2 to 0.5 in. Alternatively the soils are moderately deep (0.5-1.0 in) with a high (> 50%) gravel stone content. Soil types include duplex soils with a massive, impermeable B horizon.
Good	2	Moderately deep soils with an effective soil depth from 0.5 to 1.0 m. Alternatively the soils are deep C> 1.0 m) with a high (> 50%) gravel/stone content. Soil types include gravelly duplex soils and duplex soils with well structured subsoils. Also transitional soil types between deep, sandy duplex soils and uniform sands.
Very good	1	Deep soils with an effective soil depth greater than one metre. Soil types include uniform sands and gradational earths.

3.5 Salinity hazard (y)

Salinity is the build-up of salts, especially sodium chloride within the top two metres of the soil profile. Existing salinity can be detected through a soil test or inferred from the vegetation type, while in severe cases crystalline salt may be visible on the soil surface. Salinity is caused by high watertables with the capillary rise of groundwater into the root zone and the subsequent concentration of salt through evapotranspiration.

In areas which are presently non-saline, the salinity hazard is fairly difficult to determine and any predictions are going to have a low reliability. In the Jerdacuttup catchment the likelihood of salinity developing seems to be related to the landscape position and microrelief rather than the soil type (see Discussion).

Salinity hazard (y)

Value	Numerical Rating	Description
Highly saline	5	Areas which are presently highly saline, with a surface (0-0.2 in) soil salinity level greater than 1200 uS/cm. Ground cover is likely to be absent or a sparse cover of highly salt tolerant species. There is likely to be a saline watertable within one metre of the surface.
Saline	4	Areas which are presently saline, with a surface (0-0.2 in) soil salinity level 600-1200 uS/cm. Pastures would be dominated by sea barley grass (Hordeum marinum) with an absence of clovers. The watertable is likely to be within two metres of the surface.
Non-saline (High salinity hazard)	3	Areas which are presently non-saline, although there is a high risk of salinity developing, due to the landscape position, landform and soil type. The surface (0—0.2 in) soil salinity level is less than 600 uS/cm, although the watertable may be within one to two metres of the surface.

Salinity hazard (y) (cont)

Value	Numerical Rating	Description
Non-saline (Moderate salinity hazard)	2	Areas which are presently non-saline, although there is a moderate risk of salinity developing, due to the landscape position, landform and soil type. The watertable may be about two metres below the surface.
Non-saline (Nil to low salinity hazard)	1	Areas which are presently non-saline and the likelihood of salinity developing is slight due to the landscape position and soil type.

3.6 Potential for mechanization (g)

The land quality potential for mechanization refers to features of the land which directly help or hinder mechanized agricultural operations. Hindrances include surface rocks, rock outcrop, gilgai microrelief and excessive slope. The land quality is distinct from 'soil workability' which refers to the ease of cultivation.

Value	Numerical Rating	Description
Nil	4	Surface rocks, gilgai microrelief or slopes > 15% prevent cultivation.
Low	3	Surface rocks, gilgai microrelief or slope (10-15%) severely hinder cultivation.
Moderate	2	Surface rocks, gilgai microrelief or slope are a moderate hindrance to cultivation.
High	1	Flat to gently sloping land (0-5%), rock outcrop and gilgai microrelief are absent.

3.7 Soil workability (k)

Soil workability is the ease with which a soil can be tilled. The workability of a soil depends on a number of interrelated soil characteristics including texture, structure, organic matter content, hardsetting nature and the amount of gravel or stone in the surface layer.

Soil workability (k)

Value	Numerical Rating	Description
Low	3	Soil factors greatly restrict cultivation and these soils can only be cultivated satisfactorily over a narrow moisture range. When dry the soil is too hard to work and they tend to get excessively boggy for long periods in winter. These soils may be poorly or very poorly drained and/or the heavy textured surface soils are massive and hardsetting.
Moderate	2	Soil factors restrict cultivation in most years to some extent and there will be periods in winter when the soil is boggy. Surface soils are usually medium textured with a firm surface soil condition. Site drainage is poorly drained to moderately well drained.
High	1	Under normal conditions soil factors rarely restrict cultivation. The soil can be worked over a wide moisture range and can normally be worked within 72 hours of a significant rainfall event. Surface soils are usually light textured (Texture groups 1 and 2) with a single grain structure or massive with a soft surface soil condition. Soils would normally be moderately well drained to rapidly drained.

3.8 Soil structural decline hazard (s)

A decline in soil structure compared with the pristine state could take the form of surface slaking, development of a hard-setting surface, decrease in pedality or the development of a traffic pan. The majority of soils within the Jerdacuttup catchment have a loose, single grain surface, consequently the development of a traffic pan in moderately deep to deep sandy soils is the main type of structural decline.

Soil structural decline hazard Cs)

Value	Numerical Rating	Description
High	3	Soil structure adversely affected under continued cultivation, resulting in substantial yield penalties. This situation is not easily reversed.
Moderate	2	Soil structure adversely affected under continued cultivation, resulting in some yield loss. This situation can be economically reversed. (For example, development of a traffic pan on sandplain soils).
Nil to low	1	Soil structure suffering nil to minor degradation under continued cultivation. Any yield losses are small and would not offset costs of treatment. Surface soils are usually single grained or highly pedal (self-mulching).

3.9 Water erosion hazard (e)

Water erosion is a process in which soil is detached and transported from the land by action of rainfall, runoff and seepage. Common types of water erosion include sheet, rill, gully, streambank and tunnel erosion (Houghton and Charman, 1986).

Water erosion is generally not a major problem in the area because of the low rainfall intensity, low slopes and high infiltration rates on the sandy soils. A simple classification based predominantly on slope has been used to assess the water erosion hazard.

Water erosion hazard (e)

Value	Numerical Rating	Description
Very high	5	Moderate to highly erodible soils with a low rainfall acceptance (medium to heavy surface textures) on slopes >30% (Does not occur in study area).
High	4	Sandy duplex soils on slopes > 10%. Medium and heavy textured soils on slopes of 10-30%
Moderate	3	Sandy duplex soils with slopes of 3-10%. Medium and heavy textured soils with a low rainfall acceptance on slopes of 3-10%.
Low	2	All soils (except for highly erodible soils with a low rainfall acceptance) on slopes of 1-3% and uniform sands on slopes of 3-10%.
Very low	1	All soils on slopes < 1% and uniform sands on slopes < 3%.

3.10 Wind erosion hazard (w)

Wind erosion hazard refers to the ease with which soil particles are detached and transported from land surfaces by the action of the wind. Transport of wind-blown particles can occur through saltation, suspension or surface creep (Bagnold, 1941). Wind erosion hazard is a combination of climatic, landform and soil factors. Climatic factors include the frequency, strength and direction of erosive winds (wind speed > 30 km/h).

Landform, including aspect is a major determinant of exposure. Soil factors include the surface condition, surface structure and the texture, particularly the fine sand component.

Wind erosion hazard (w)

Value	Numerical Rating	Description
Extremely high	6	Highly erodible soils with a low stability, subject to frequent strong winds because of their very highly exposed position. The soils are uniform sands with a single grain structure and a loose surface condition. The sand fraction is medium to fine. Landforms include coastal dunes, foredunes and blowouts.
Very high	5	Highly erodible soils in moderate to highly exposed positions. The soils are uniform sands with a single grain structure and a loose surface condition. The sand fraction is medium to fine. Soil types include dune sands and deep sands on a plain.
High	4	Moderately to highly erodible soils. Surface soils have a single grain structure and may be loose with a coarse sand fraction, or have a surface crust and a predominantly fine sand fraction. Surface soil textures are generally light; sands to loamy sands. Soil types include uniform deep sands and duplex soils.

Wind erosion hazard (w) (cont)

Value	Numerical Rating	Description
Moderate	3	Soil types with a moderate erodibility. There is a wide range of soils in this category including light textured soils (sands to loamy sands) with a massive to weakly pedal surface structure and a soft to firm surface condition when dry. Also, sandy soils with a significant surface gravel component and self-mulching clays with a loose surface condition and with an average ped size < 1mm.
Moderately low	2	Soils with a moderately low erodibility. Soil types include medium to heavy textured soils, except for those with a hardsetting surface condition. Also, hardsetting light textured soils.
Low	1	Soils with a low erodibility. Soil types include hardsetting medium to heavy textured soils. Also, all soil types which are very poorly drained (i.e. the surface remains moist to wet for the whole year).

Appendix 4 Land Use Types

Five land use types have been used in this project to cover both the major existing and potential land uses within the study area. This section describes the requirements for each land use type, along with the assumptions made in the land capability assessment. With all the land use types assessed, the main assumption is an average level of management. This is an important concept and it is worth noting that this does not necessarily coincide with the average level of management prevailing in the district. In particular lucerne, perennial pastures and lupins are land uses with considerable potential for the area, although as yet relatively small areas of them are grown. The skills for growing them successfully are therefore not widespread and the average level of knowledge/management in the district may be less than that assumed in this capability assessment. The factor rating tables used to derive the capability ratings have also been included.

Appendix	Land Use Type
4.1	Improved annual pastures
4.2	Perennial pastures
4.3	Lucerne
4.4	Cereal cropping
4.5	Lupins

4.1 Improved annual pastures

Improved annual pastures are those in which subterranean clover (Trifolium subterraneum) is dominant and which may or may not have a significant component of annual grasses, especially annual ryegrass (Lolium rigidum). An average level of management includes using the most suitable varieties: for example, using the subterranean clover cultivar Trikkala on wet areas and annual medics on the alkaline soils.

Annual pastures occupy a large proportion of the catchment, although many have a small legume component and a high proportion of the volunteer species, capeweed and erodium. These volunteer species have a rapid root penetration after germination (Asher and Ozanne, 1966) and deep tap-roots enabling them to survive false breaks to the season and to persist on deep sands where subterranean clover may not (Bolland, 1983). Consequently, pastures dominated by volunteer species do not fit this category, as the assumptions about moisture availability, nutrient requirements and waterlogging tolerance for subterranean clover may not apply.

4.2 Perennial pastures

Perennial pastures have been successfully grown in tbe catchment over an extended period on a small number of properties. This shows that the climate is suitable, although near the coast where there are frequent light showers would be preferable to further inland. The existing areas are predominantly used for grazing cattle, although sheep could be used on a rotational grazing programme. The main pasture species would include phalaris, cocksfoot, perennial ryegrass, veldt grass and strawberry clover.

4.3 Lucerne

The rating of lucerne (Medicago sativa) for grazing relates to established stands. Management of a new stand is a separate consideration as the wind erosion hazard is considerably greater during the establishment phase. Management includes fencing off the lucerne so that it can be managed separately. The grazing strategy is important to ensure the long-term viability of the stand. Lucerne can be grazed by set stocking with cattle. With sheep it is necessary to rotate the grazing. The pasture should be spelled for approximately four weeks between grazing and the plants must be allowed to flower at least once during the season.

4.4 Cereal cropping

This land use type refers to the broadacre cropping of wheat, barley and oats. Management includes an annual basal application of superphosphate and adequate grass control the year prior to cropping to reduce the carryover of root disease.

The Jerdacuttup catchment is marginal for cereals because of the proximity to the coast. In many years there are frequent coastal showers during the grain ripening and harvesting phases, resulting in harvesting problems, while fungal diseases can reduce grain quality. The incidence of these showers diminishes quickly with distance from coast, thus the northern section of the catchment is more suitable for cropping than the south. In general, the area south of Springdale Road is not suitable for cropping, between Springdale and Middle Roads is marginal, while the risk is lower north of Middle Road.

4.5 Lupins

For cropping lupins (Lupinus angustifolius), an average level of management is assumed, including selection of a well-drained site, adequate manganese nutrition and attention to disease control. Growing lupins on a medium to deep sand is the safest way to minimise the likelihood of waterlogging and their root morphology is well adapted to exploit this soil type. Lupins have a higher manganese requirement than cereals. If the supply of manganese is inadequate there will be problems with split seeds and the plants will not mature evenly.

The Jerdacuttup catchment is marginal for lupin cropping because of the frequent coastal showers during November and December. Lupins tend to be an indeterminate crop and the showers exacerbate this problem by prolonging vegetative growth at the

expense of grain yield. In Spring a heatwave or moisture stress conditions can result in the cessation of growth with only poor pod set. The northern part of the catchment with a lower frequency of coastal showers is more suitable for the lupins than the southern section. When grazing lupin stubbles, lupinosis can be a major problem with the summer rains, which account for about 25% of the average annual rainfall.

Land capability rating table for improved annual pastures.

	Capability Class				
Land quality	**I**	**II**	**III**	**IV**	**V**
Site drainage (i)	rapidly, well, moderately well, imperfectly drained	-	poorly drained	-	very poorly drained
Moisture availability (m)	high, moderate	low	-	very low	extremely low
Nutrient availability (n)	high, moderate, low	very low	-	extremely low	-
Rooting conditions (r)	very good, good, fair	-	-	poor	-
Salinity hazard (y)	low, moderate	high	-	-	presently saline, presently highly saline
Potential for mechanization (q)	high, moderate, low	-	-	nil	-
Soil workability (k)	high, moderate, low	-	-	-	-
Soil structural decline hazard (s)	low, moderate, high	-	-	-	-
Water erosion hazard (e)	very low, low, moderate	high	very high	-	-
Wind erosion hazard (w)	low, moderate	high, very high	extremely high	-	-

Land capability rating table for perennial pastures.

	Capability Class				
Land quality	**I**	**II**	**III**	**IV**	**V**
Site drainage (i)	rapidly, well, moderately well, imperfectly drained	-	poorly drained	-	very poorly drained
Moisture availability (m)	high, moderate	low	-	very low	extremely low
Nutrient availability (n)	high, moderate, low	very low	-	extremely low	-
Rooting conditions (r)	very good, good	fair	-	poor	-
Salinity hazard (y)	low, moderate	high	-	-	presently saline, presently highly saline
Potential for mechanization (q)	high, moderate, low	-	-	nil	-
Soil workability (k)	high, moderate, low	-	-	-	-
Soil structural decline hazard (s)	low, moderate, high	-	-	-	-
Water erosion hazard (e)	very low, low, moderate	high	very high	-	-
Wind erosion hazard (w)	low, moderate	high, very high	extremely high	-	-

Land capability rating table for lucerne.

	Capability Class				
Land quality	**I**	**II**	**III**	**IV**	**V**
Site drainage (i)	rapidly, well drained	moderately well drained	imperfectly drained	-	poorly, very poorly drained
Moisture availability (m)	high, moderate, low, very low	extremely low	-	-	-
Nutrient availability (n)	high, moderate, low	very low	extremely low	-	-
Rooting conditions (r)	very good	good	fair	-	poor
Salinity hazard (y)	low, moderate, high	-	-	-	presently saline, presently highly saline
Potential for mechanization (q)	high, moderate, low	-	-	nil	-
Soil workability (k)	high, moderate, low	-	-	-	-
Soil structural decline hazard (s)	low, moderate, high	-	-	-	-
Water erosion hazard (e)	very low, low, moderate	high	very high	-	-
Wind erosion hazard (w)	low, moderate	high, very high	-	extremely high	-

Land capability rating table for cereal cropping

	Capability Class				
Land quality	**I**	**II**	**III**	**IV**	**V**
Site drainage (i)	rapidly, well drained	moderately well drained	imperfectly drained	poorly drained	very poorly drained
Moisture availability (m)	high, moderate, low	very low	-	extremely low	-
Nutrient availability (n)	high, moderate, low	very low	-	extremely low	-
Rooting conditions (r)	very good, good, fair	-	-	poor	-
Salinity hazard (y)	Low	moderate	-	high	presently saline, presently highly saline
Potential for mechanization (q)	High	moderate	Low	-	-
Soil workability (k)	High	moderate	low	-	-
Soil structural decline hazard (s)	Low	moderate	high	-	-
Water erosion hazard (e)	very low, low	moderate	-	high	very high
Wind erosion hazard (w)	Low	moderate, high	very high	-	extremely high

Land capability rating table for lupin cropping.

	Capability Class				
Land quality	**I**	**II**	**III**	**IV**	**V**
Site drainage (i)	rapidly, well drained	-	moderately well drained	imperfectly drained, poorly drained	very poorly drained
Moisture availability (m)	high, moderate, low	very low	extremely low	-	-
Nutrient availability (n)	high, moderate, low	very low	extremely low	-	-
Rooting conditions (r)	very good	good	fair	-	poor
Salinity hazard (y)	low	moderate	high	-	presently saline, presently highly saline
Potential for mechanization (q)	high	moderate	Low	-	nil
Soil workability (k)	high	moderate	low	-	-
Soil structural decline hazard (s)	Low, moderate	high	-	-	-
Water erosion hazard (e)	very low, low	moderate	-	high	very high
Wind erosion hazard (w)	low	moderate, high	very high	-	extremely high

Appendix 5

Typical Soil Profiles

5.1 Soil group 2

5.2 Soil group 3

5.3 Soil group 4

5.4 Soil group 5

5.5 Soil group 6

5.6 Soil group 7

5.7 Soil group 8

5.8 Soil group 9

5.9 Soil group 10

5.1 Soil group 2; L2, P2, Pm2, G2, Gm2, VU2 - Typical soil profile: Dy 5.82

Depth (m)	Horizon	Description
O - 0.10	A1	Greyish brown (1OYR 5/2 M) loamy fine sand, single grain structure, 10 - 20% ironstone gravel, 5 - 25 mm, subrounded, pH 6.0, abrupt boundary to,
0.10 - 0.53	A2cb	Very pale brown (1OYR 7/3 M, 1OYR 8/3 D,), fine sand, conspicuously bleached, single grain structure, 70 - 80% ironstone gravel, 10 - 30 mm, subrounded, pH - 6.5, abrupt boundary to,
0.53 - 1.10	B2	Olive yellow (2.5 Y 6/6 M) light medium clay, 30 - 40% distinct grey mottles, massive to weakly pedal structure, 0 - 2% ironstone gravel, pH 6.5 - 7.0, orange mottles present at depth.

Variations:

The group 2 soils may have an alkaline soil reaction trend (e.g. pH 8.5 - 9.0 at 1.0 in), especially in waterlogged areas.

5.2 Soil group 3; L3, Lm3, P3, Pm3, G3, VU3 - Typical soil profile: Dy 5.82

Depth (m)	Horizon	Description
0 - 0.10	A1	Dark grey (1OYR 4/1 M) loamy fine sand, single grain structure, pH — 6.5, abrupt boundary to,
0.10 - 0.36	A21cb	Very pale brown (1OYR 7/3M), 1OYR 8/3 D) fine sand, single grain structure, pH - 6.5, gradual boundary to,
0.36 - 0.58	A22cb	Very pale brown (1OYR 7/4 M, 1OYR 8/4 D) fine sand, 10 - 20% distinct red mottles, single grain structure, pH 7.0, abrupt boundary to,
0.58 - 1.05	A3	Very pale brown (1OYR 7/4 M) fine sand, single grain structure, > 70% ironstone gravel, rounded, size 10 – 25mm, pH 7.0, clear boundary to,
1.05 - 1.20	B1	White (7.5YR 8/0 H) clayey sand,10 – 20% ironstone gravel.

5.3 Soil group 4; L4, P4, Pin4, G4, Gm4 - Typical soil profile: Dy 5.42

Depth (m)	Horizon	Description
0 - 0.14	A1	Dark greyish brown (1OYR 4/2 H) loamy fine sand, single grain structure, pH - 6.0, abrupt boundary to,
0.14 - 0.26	A2cb	Pale yellow (2.5Y 7/4 M, 1OYR 7/2 D) fine sand, single grain structure, 2 - 10% ironstone gravel, pH - 6.5, sharp boundary to,
0.26 - 0.74	B21	Brownish yellow (1OYR 6/8 H) medium clay, 10 - 20% faint red and grey mottles, moderate - strong columnar structure with weak pedality within the domes. pH - 6.0, gradual boundary to,
0.74 - 1.00 +	B22	Olive yellow (2.5Y 6/6 M) sandy medium clay, 30 - 40% distinct red and grey mottles, massive to weakly pedal structure, pH 7.5 - 8.0.

5.4 Soil group 5; L5, P5, G5, Gm5 - Typical soil profile: Dy 4.42

Depth (m)	Horizon	Description
0 - 0.11	Al	Dark greyish brown (1OYR 4/2 H) loamy fine sand, single grain structure, pH - 6.0, abrupt boundary to,
0.11 - 0.26	A2cb	Very pale brown (1OYR 7/4 H, 1OYR 8/3 D) fine sand, single grain structure, pH - 6.5, abrupt boundary to,
0.26 - 0.30	A3	Olive yellow (2.5Y 6/6 H) fine sand to loamy fine sand, single grain structure, pH - 6.5, sharp boundary to,
0.30 - 0.60	B22.	Brownish yellow (1OYR 6/8 H) medium clay, whole coloured, moderate angular blocky structure, pH — 6.5, gradual boundary to,
0.60 - 1.0+	B22	Olive yellow (2.5Y 6/6 H) sandy medium clay, 30 — 50% distinct grey mottles, weakly structured, pH - 8.0.

Variations:

The top of the B horizon may have a columnar structure.

5.5 Soil group 6; L6, P6, G6 - Typical soil profile: Dy 4.13

Depth (m)	Horizon	Description
O - 0.11	A1	Dark greyish brown (1OYR 4/2 H) loamy fine sand, single grain structure, pH - 6.5, sharp boundary to,
0.11 - 0.26	B21	Strong brown (7.5YR 5/6 M) light clay, whole coloured, moderate subangular blocky structure, pH — 7.0, clear boundary to,
0.26 - 0.65	B22	Brownish yellow (1OYR 6/6 H) light medium clay, 2 - 10% faint red mottles, moderate subangular blocky structure, 10 - 20% rounded carbonate nodules, pH 8.5, gradual boundary to,
0.65 - 1.00+	B23	Olive yellow (2.5Y 6/6 H) light medium clay, whole coloured, moderate subangular blocky structure, 2 - 10% rounded carbonate nodules, pH - 9.0.

5.6 Soil group 7; G7, VG7 - Typical soil profile: Dy 5.22

Depth (m)	Horizon	Description
0 - 0.08	A1	Very dark greyish-brown (1OYR 3/2 H) loamy sand, single grain structure, pH - 6.5, abrupt boundary to,
0.08 - 0.35	A2	Brown yellow (1OYR 6/6 M) clayey coarse sand, massive structure, 2 - 10% quartz fragments, subangular, pH - 6.5, sharp boundary to,
0.35 - 0.55	B21	Brownish yellow (1OYR 6/8 H) medium clay, 10 - 20% distinct red mottles, moderate polyhedral structure, small amount of mica, pH — 7.0, clear boundary to,
0.55 - 0.82+	B22	Light yellowish brown (1OYR 6/4 M) medium heavy clay, 30 - 40% distinct red mottles, moderate polyhedral structure, small amount of mica, pH - 7.5.

5.7 Soil group 8; L8, Lm8, P8, Pm8, G8, U8, D8, VG8. Typical soil profile: Uc2.21

Depth (m)	Horizon	Description
0 - 0.14	A1	Grey (1OYR 5/1 H) fine sand, single grain structure, pH - 6.0, clear boundary to,
0.14 - 0.49	A2cb	Light grey (1OYR 7/2 M, 1OYR 8/2 D) fine sand, single grain structure, pH - 6.5, clear to gradual boundary to,
0.49 - 0.96	B2	Olive yellow (2.5Y 6/6 H) fine sand to loamy fine sand, single grain structure, pH 6.0, gradual boundary to,
0.96 - 1.10+	B3	Very pale brown (1OYR 7/3 N) fine sand, single grain structure, - 50% ferruginous gravel, rounded, size 5 - 20 mm, pH - 7.0.

Variations:

The deep sands may have an acidic pH at depth (e.g. Acid soil reaction trend). The ferruginous gravel layer above the clay is often absent.

5.8 Soil group 9; G9 - Typical soil profile: Uc 5.11

Depth (m)	Horizon	Description
0 - 0.06	A11	Light yellowish brown (1OYR 6/5 N), loamy sand, single grain structure, pH - 6.5, clear boundary to,
0.06 - 0.30	A12	Brownish yellow (1OYR 6/8 H) loamy sand, massive structure, pH 6.5, diffuse boundary to,
0.30 - 1.10+	A13	Yellowish brown (1OYR 5/8 N) clayey sand, massive structure, pH 7.5.

5.9 Soil group 10; Lg1O - Typical soil profile: Uf 6.33

Depth (m)	Horizon	Description
0 - 0.10	A1	Olive brown (2.5Y 4/4 N) light medium clay, whole coloured, moderate pedality, moderately calcareous, pH - 8.5, sharp boundary to,
0.10 - 0.30	B21	Light yellowish brown (2.5Y 6/4 M) light medium clay, 2 - 10% faint yellow mottles, moderate platy structure, small amount of ferruginous gravel plus carbonate nodules present, highly calcareous, pH - 9.0, diffuse boundary to,
0.30 - 1.00+	B22	Yellow (2.5Y 7/6 N) light medium clay, 2 -10% faint grey mottles, moderate platy structure, small amount of ferruginous gravel, highly calcareous, pH 9.0.

Appendix 6

List Of Map Units

Map Symbol	Description
Gravelly Soils:	
G1	Gently undulating plain (l-3%)and low gravel rises with shallow (<25 cm) gravelly soils and common areas of exposed laterite.
L2	Level plain (0-1%), with gravelly duplex soils, shallow (0-30cm) fine sand to loamy sand over ferruginous gravel over a mottled clay B horizon.
P2	Level plain with poor drainage (0-1%), with gravelly duplex soils (group 2, as above).
Pm2	Level plain with poor drainage (0-1%) and mound/depression microrelief, with gravelly duplex soils (group 2, as above).
G2	Gently undulating plain (1-3%) with gravelly duplex soils (group 2, as above).
Gm2	Gently undulating plain (1-3%) with mound/depression microrelief, with gravelly duplex soils (group 2, as above).
VU2	Moderately sloping valley sideslopes (3-10%), with gravelly duplex soils (group 2, as above).
L3	Level plain (0-1%), with gravelly duplex soil, moderately deep (30-80 cm) fine sand with a conspicuously bleached A2 horizon overlying ferruginous gravel over a clay B horizon.
Lm3	Level plain (0-1%) with mound/depression microrelief, with medium depth gravelly duplex soils (group 3, as above).
P3	Level plain with poor drainage (0-1%), with medium depth gravelly duplex soils (group 3, as above).
Pm3	Level plain with poor drainage (0-1%) and mound/depression microrelief, with medium depth gravelly duplex soils (group 3, as above).
G3	Gently undulating plain (1-3%), with medium depth gravelly duplex soils (group 3, as above).
VU3	Moderately sloping valley sideslopes (3-10%), with medium depth gravelly duplex soils (group 3, as above).

Map Symbol	Description
Duplex Soils:	
L4	Level plain (0-1%), with shallow (10-30 cm), fine sand to loamy fine sand over a columnar structured medium clay B horizon (solonetzic soils).
P4	Level plain with poor drainage (0-1%), with solonetzic soils (group 4, as above).
Pm4	Level plain with poor drainage (0-1%) and mound/depression microrelief, with solonetzic soils (group 4, as above).
G4	Gently undulating plain (1-3%), with solonetzic soils (group 4, as above).
Gm4	Gently undulating plain (1-3%) with mound/depression microrelief, with solonetzic soils (group 4, as above).
L5	Level plain (0-1%), with duplex soils consisting of moderately deep (30-80 cm) fine sand with a conspicuously bleached A2 horizon over a brownish yellow medium clay B horizon.
P5	Level plain with poor drainage (0-1%), with medium depth sandy duplex soils (group 5, as above).
G5	Gently undulating plain (1-3%), with medium depth sandy duplex soils (group 5, as above).
Gm5	Gently undulating plain (1-3%) with mound/depression microrelief, with medium depth sandy duplex soils (group 5, as above).
L6	Level plain (0-1%), with alkaline duplex soils with a shallow (10-30 cm) loamy fine sand to sandy loam topsoil overlying brownish-yellow medium clay B horizon.
P6	Level plain with poor drainage (0-1%), with alkaline duplex soils (group 6, as above).
G6	Gently undulating plain (1-3%), with alkaline duplex soils (group 6, as above).
G7	Gently undulating plain (1-3%), with duplex soils consisting of dark grey loamy sand over brown-yellow coarse clayey sand with a mottled brown-yellow medium clay B horizon at about 30 cm.
VG7	Gently sloping valley sideslopes (1-3%), with brown-yellow sandy duplex soils (group 7, as above).

Map Symbol	Description
Uniform Sands:	
L8	Level plain (0-1%), with deep uniform fine sand consisting of light grey fine sand overlying an olive-yellow fine sand to loamy fine sand subsoil.
Lm8	Level plain (0-1%) with mound/depression microrelief, with deep uniform sands (group 8, as above).
P8	Level plain with poor drainage (0-1%), with deep uniform sands (group 8, as above).
Pm8	Level plain with poor drainage (0-1%) and mound/depression microrelief, with deep uniform sands (group 8, as above).
G8	Gently undulating plain (1-3%), with deep uniform sands (group 8, as above).
U8	Undulating plain to rises (3-10%), with deep uniform sands (group 8, as above).
D8	Moderately inclined linear dunes (3-6%), with deep uniform sands (group 8, as above).
VG8	Gently sloping valley sideslopes (1-3%), with deep uniform sands (group 8, as above).
G9	Gently undulating plain (1-3%), with deep uniform, brownish yellow loamy to clayey sand.
Uniform Clays:	
Lg10	Level plain (0-1%) with gilgai microrelief, with medium to heavy textured uniform soils, commonly with a light clay to medium clay texture and an alkaline soil reaction trend.