1992

**Soils of the Northam Advisory District. Volume 1. The zone of ancient drainage**

Neil Clifton Lantzke

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Soils of the Northam Advisory District
The Zone of Ancient Drainage

Compiled by Neil Lantzke
Volume 1

The Zone of Ancient Drainage

Compiled by Neil Lantzke
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Figure 1
Physiographic Regions and Rainfall Isohyets In the Department of Agriculture's Northam Advisory District.

Legend
- Yellow: Zone of Ancient Drainage
- Black: Dept. of Agriculture's Northam Advisory District Boundary
- Brown: Boundaries of Physiographic Regions
- Red: Rainfall Isohyets

Zone of Ancient Drainage (Volume 1)
Darling Range Zone and West Kokeybo Zone (Volume 3)
1. Introduction

1.1 Aims of the manual

This manual describes the soils of the Department of Agriculture’s Northam advisory district. Information is provided on the characteristics of each soil, its capability is discussed and yield estimates are given for the major land uses.

Designed for use by farmers and Department of Agriculture staff, the manuals primary aims are to:

- assist with identification of the major soil types in the advisory district;
- match land use with land capability;
- improve farm productivity and efficiency; and
- reduce the incidence of land degradation.

The manual provides a framework for the description and classification of the advisory districts soils. The soil types described provide a basis for farm and catchment soil mapping from which land management plans can be developed.

General use of this manual will promote consistency and avoid confusion when referring to soil types. This will allow more accurate extension of farm management information and research results. Other applications include an introduction to the soils of the district for people new to the area and provision of a standardized method for describing the soils at trial sites within the Northam advisory district.

The manual is divided into three volumes according to the broad physiographic regions within the advisory district (Figure 1). This volume deals with the soil types that occur within the Zone of Ancient Drainage. Volume 2 deals with the soil types that occur within the Zone of Rejuvenated Drainage and Volume 3 with those soils in the Darling Range and West Kokeby Zones.
IDEALIZED BLOCK DIAGRAM SHOWING THE SOIL LANDSCAPE UNITS THAT OCCUR IN THE ZONE OF ANCIENT DRAINAGE.

- **Danneberrin (D)**: Rocky hilltops containing red brown loams and grey loamy sands.
- **Steep Rocky Hills (R)**: Long hilltops containing hardcrusting grey to brown sandy loams.

### SOIL LANDSCAPE UNIT
- **Merredin (M)**
  - Major Soil Types: Red Brown Sandy Loam Over Clay Valley Soils, Red Clay Valley Soil, Grey Clay Valley Soil, Grey to Brown Cracking Clay
  - Vegetation: Salmon Gum, Gimlet
- **Baandee (Ba)**
  - Major Soil Types: Salt Lake and Channels; Soils Fringing the Salt Lakes
  - Vegetation: Barley Grass, Bluebush, Saltbush, Samphire, Bare Ground
- **Nangeenan (N)**
  - Major Soil Types: Powdery Surfaced Calcarenite Soil
  - Vegetation: Salmon Gum, York Gum, White Gum, Gimlet
- **Belka (Be)**
  - Major Soil Types: Deep Sandy Surfaced Valley Soil, Shallow Sandy Surfaced Valley Soil
  - Vegetation: Mallee Species, York Gum, York Gum, Sheoak, White Gum, Salmon Gum
- **Collgar (C)**
  - Vegetation: York Gum, York Gum, Sheoak, White Gum, Salmon Gum, Mallee Gimlet
- **Booraan (B)**
  - Major Soil Types: Sandy Loam Over Clay, Shallow Hardsetting Grey Sandy Loam Over Clay, Loamy Sand Over Clay
  - Vegetation: Salmon Gum, White Gum, Mallee Gimlet
- **Ulva (U)**
  - Major Soil Types: Yellow Gradational Loamy Sand, Deep Yellow Sand, Pale Sand Over Gravel/Loamy Sand, Deep Pale Sand, Shallow Mottled Zone, Deep Yellow Acid Sand
  - Vegetation: Barley Grass, Bluebush, Saltbush, Samphire, Bare Ground, Barley Grass, Bluebush, Saltbush, Samphire, Bare Ground
The Zone of Ancient Drainage is a landscape characterized by broad, flat valleys of low gradient with salt lake chains at their lowest point, gently sloping valley sides, some rock outcrop and large areas of yellow sandplain. This physiographic region occupies 6630 km² in the eastern third of the Northam Advisory District. To the west, roughly on the other side of the Meckering Fault Line is the Zone of Rejuvenated Drainage. Here the lateritic profile has been more dissected leaving more breakaways, exposing large areas of fresh country rock and giving steeper, narrower valleys in which water flows every winter in creeklines and rivers.

The Zone of Ancient Drainage can be divided into soil landscape units that occur in specific parts of the landscape and have a particular set of soils associated with them. Figure 2 is a block diagram of this landscape showing the nine soil landscape units that occur and lists their soil types and dominant vegetation. (These soil landscape units were first described in the Merredin area by Bettenay and Hingston (1961).)

The Ulva unit contains large areas of yellow sandplain and gravelly soils that occur as long, regular slopes often high up in the landscape. This unit is all that remains of the old lateritic profile that once covered the entire landscape. The Booraan unit occurs on the hillslopes and contains hard-setting sandy loam over clay soils formed from the dissection of the lateritic profile. The Collgar unit occurs on the lower slopes and contains sandy surfaced duplex soils derived from colluvial material. The Danberrin unit occurs adjacent to rock outcrop and contains soils formed from the weathering of exposed bedrock.

Two types of non-saline valley floor soils occur within the Zone of Ancient Drainage. The Belka unit contains pale, sandy surfaced valleys while the Merredin unit contains heavy red and grey valley soils.

The Nangeenan unit contains areas of calcareous, 'morel soils' that often occur adjacent to salt lakes. The Baandee unit contains the salt-lake system and its associated dunes.
Figure 3
Location of the Study Area, Other Survey Areas, Physiographic Regions and the Department of Agriculture’s Northam Advisory District.

LEGEND

Study Area
- Lantzke and Fulton (1993)

Other Surveys
- McArthur, unpublished.
- King and Wells (1990)
- Greathish, unpublished

Dept. of Agriculture’s Northam Advisory District Boundary.
Boundaries of Physiographic Regions.

Zone of Ancient Drainage
Darling Range Zone and West Kokeby Zone
Zone of Rejuvenated Drainage
1.3 Broadscale soil landform mapping

The soil landscape units shown in Figure 2 have been mapped at a scale of 1:100,000 over about 2600 km² within the Northam Advisory District. This mapping, together with other mapping in the district, is published in a report titled ‘The land resources of the Northam region’ (Lantzke and Fulton, 1993). The location of this and other surveys around the advisory district is shown in Figure 3.

Mapping at this scale is of limited use to the farmer and farm planner. However, the maps can be used to identify a soil landscape unit at a particular site, and from this a soil type can be keyed out using Table 1 on page 108. The major use of this broadscale mapping is regional planning.
The average annual rainfall of this zone, within the Northam Advisory District, ranges from 320 to 375 mm. About 70% of the annual rainfall falls during the five month growing season. Rainfall is more reliable here than in areas to the east and north, making this some of the better wheatbelt country in the State. Appendix 1 gives the mean monthly rainfall data, mean maximum daily temperature and the mean monthly dam evaporation for various locations within and around the zone.

Farms are generally 2,000 to 3,000 ha. On average about 50% of the farm is cropped annually. The major crops are wheat, barley, oats, lupins and field peas. The ten year average yields for these crops within this zone of the Northam Advisory District are wheat (1.21 t/ha), barley (1.09 t/ha), oats (0.90 t/ha), lupins (0.90 t/ha) and field peas (0.95 t/ha). Pastures are usually subterranean clover or medic based, with the average carrying capacity being about 3 to 4 DSE/ha (winter grazed). Sheep are the dominant grazing animal, with small numbers of cattle, goats and horses.

Salinity is a major soil conservation problem with 3 to 4% of this zone affected. Tree planting, growing crops and pastures with high water use, banks, drains and saltland agronomy are being used to manage or reduce the area of salt. The sandy surfaced soils of this zone are prone to wind erosion if they are poorly managed. Water erosion is also a problem, especially on long or steep slopes. Grade and contour banks have been built to control water erosion and flooding. Surface soil structure decline and the development of traffic compaction pans reduce yields on certain soil types. The use of gypsum and minimum tillage to improve soil structure is widespread. Deep ripping of traffic compaction pans has resulted in large yield increases on some soils. Soil acidification is now becoming a problem on higher producing, sandy surfaced soils which have a low buffering capacity. Liming will be necessary on many soils in the future.

The 20 major soil types described in this manual are placed into three groups according to where they occur in the landscape. These three groups are:

- Sandplain soils (2.1)
- Hillside soils (2.2)
- Valley floor soils (2.3).

Each of the 20 soil types is described in the following format:

- idealized soil diagram;
- identifying characteristics;
- position in the landscape;
- vegetation;
- land qualities;
- productivity and capability; and
- yield estimates and capability ratings table.
Where possible the soils have been given commonly used local names such as **Deep yellow sand**. In other cases it was considered more appropriate to title the soils more fully in order to avoid confusion (for example in some areas ‘Wodjil country’ refers to the **Shallow mottled zone** soil type while in other areas it refers to the **Deep yellow acid sand**).

One or more Northcote (1984) Principle Profile Form notations are listed below the brief soil description at the top of the page. This classification system is widely recognized throughout Australia by soil and agricultural scientists. The soil series name of each soil type is also included (Purdie, unpublished).

### 1.5.1 Idealized soil diagrams

The properties of each soil are described by an idealized soil diagram. The soil diagrams show a slice of soil from the surface down to a depth of one metre. The profile can be broken up into layers or horizons, with each horizon given a different notation.

The A1 horizon is the darker topsoil layer where humified organic matter has accumulated. An A2 horizon may be present in some soils, occurring immediately below the A1 horizon. It is a paler, often bleached layer with less clay than the horizons above or below. A B2 horizon is the subsoil layer characterized by a concentration of clay, a structure and/or consistency unlike the soil above and stronger colours. C horizons refer to the decomposing parent material or rock which occurs beneath the soil.

(Note - A transitional A3 horizon may occur with characteristics of both the A and B horizons but closer in properties to the A horizons. A B1 horizon is a transitional horizon with characteristics between those of the A and B horizons but closer in properties to the B2 horizon.)

For more information on describing soil horizons refer to McDonald *et al.* (1984).

The different horizons within the diagram are coloured in the most commonly occurring colour. The sloping line boundaries between horizons indicate the range of depths at which the boundary can occur. For example the top of the A2 horizon in the **Deep pale sand** may occur from 10 to 15 cm, with this layer reaching to a depth of greater than 80 cm. A dashed boundary line indicates a diffuse boundary between the two soil horizons.

The colours of each soil horizon are described and a Munsell colour code, such as 10YR 3/2, given in parenthesis. In some cases the Munsell colour was abbreviated for the sake of simplicity. For example, light brownish yellow was abbreviated to yellow.

The texture of each horizon is given at the side of each soil diagram. Many farmers in Western Australia tend to over-estimate clay content. For example, the ‘Avon valley loam’ is in fact generally a loamy sand but can be a sandy loam. Many soils locally referred to as ‘clays’ have a thin sandy loam or sandy clay loam topsoil. The standard definitions of each texture class are given in Appendix 2. Appendix 3 defines the three different sand grain sizes.
The condition of the surface soil, structure and fabric are described. Appendix 4 defines each of these characteristics.

The presence or absence of rocks, calcareous (lime) segregations and mottles is also noted. Mottles are spots, blotches or streaks of subdominant colours different from the general soil colour.

A typical pH (in water) of each horizon is listed. In some cases a range of pH values is given.

A photograph of a typical example of each soil profile is included above the idealized soil diagram.

1.5.2 Identifying characteristics

This section contains a brief description of the soil type. Possible variations from the soil diagram are given (soils never all fit neatly into specific soil types). Distinguishing features which separate the soil from other similar but different soils are provided. This information can help the user decide into which soil type a particular soil fits. Any locally used names for the soil are given.

1.5.3 Position in the landscape

The ‘Position in the landscape’ section describes where that particular soil occurs in the landscape. This can be helpful in identifying a particular soil type. For example, the Red brown doleritic clay loam occurs immediately adjacent to dykes of dolerite rock. The soil landscape unit(s) in which the soil occurs is given. For example the Deep yellow sand occurs within the Ulva soil landscape unit.

1.5.4 Vegetation

The dominant, indicator vegetation species on each soil are included. However, care must be taken as the vegetation growing in a particular soil may vary from area to area.

1.5.5 Land qualities

The characteristics of each soil type are discussed by the use of land qualities such as moisture availability, waterlogging and wind erosion hazard. In effect this section analyses the merits and limiting factors of each soil type.

The land qualities considered appropriate in this study were:

*Moisture availability (m)*

Moisture availability is the ability of a soil to retain moisture for plant growth. It is dependent on soil texture, structure, organic matter and porosity.

*Nutrient availability (n)*

Nutrient availability is the ability of a soil to retain nutrients for plant growth. It depends largely on the soils clay content, clay type, organic matter content and pH.
**Waterlogging** (i)

Waterlogging occurs when a soil is saturated with water. Oxygen supply to the roots becomes limited affecting plant growth and vigour.

**Rooting conditions** (d)

Rooting conditions refer to the physical impedance to root development and the soil volume available to plant roots. Siliceous hardpans, mottled zone (called conglomerate by some farmers), shallow bedrock and dense clay layers all affect root growth.

**Soil structure decline** (s)

Soil structure decline can be divided into two categories:

- surface soil structure decline on heavy soils and
- the development of traffic compaction pans on lighter soils.

**Trafficability** (t)

Trafficability refers to the ability to use machinery on a particular soil type. Boggy and rocky soils and steep sloping areas all limit vehicle access.

**Salinity** (y)

Salinity is the build up of soluble salts, especially sodium chloride, within the soil profile. High salt levels in the soil water increase the osmotic pressure and affect the plant’s ability to take up moisture.

**Wind erosion hazard** (w)

Wind erosion hazard is the potential for a piece of land to erode because of the action of wind. It is dependent on the soil’s erodibility, the wind exposure, the type and amount of ground cover and land management practices.

**Water erosion hazard** (e)

Water erosion hazard is the potential for sheet, rill or gully erosion to occur on a piece of land. It is dependent upon soil erodibility, slope gradient, rainfall intensity, run-on received, ground cover and land management.

**Recharge hazard** (g)

Recharge hazard is the potential for a piece of land to recharge the deep groundwater-table and thus contribute to salinity.

Detailed discussion on each land quality and its effect on land use is contained in Appendix 5.
1.5.6  Productivity and capability

This section describes how productive the soil is and discusses its capability for six land uses. The six land uses assessed are annual pasture, cereals, sweet lupins (*Lupinus angustifolius*), blue lupins (*Lupinus cosentini*), field peas (*Pisum sativum*) and tagasaste (*Chamaecytisus palmensis*). These land uses were chosen because they are commonly practiced or because they have future potential.

Annual pasture generally consists of subterranean clover (*Trifolium subterraneum*), burr medic (*Medicago polymorpha*), murex medic (*Medicago murex*) or barrel medic (*Medicago truncatula*) based pastures or grassy and broad leaved pastures.

The most common types of cereals grown are wheat (*Triticum aestivum*), barley (*Hordeum vulgare*), oats (*Avena sativa*) or triticale (*Triticosecale*).

For each soil type, estimates of achievable yields for relevant crop and pasture species are given in a table form. Included in the table is a capability rating for the soil to support each land use.

The yield estimates were obtained from discussions with farmers and Department of Agriculture staff. Pasture production is expressed as carrying capacity in dry sheep equivalents (DSE) per hectare (winter grazed) as estimates of pasture growth could not be obtained. A dry ewe or wether equals 1 DSE, a ram about 2 DSE and a ewe with a lamb 1.2-1.5 DSE (April/May lambing 1.5 DSE, July lambing 1.2 DSE). The type of pasture can be put into three categories: subterranean clover based, medic based and grass and broad-leaved weeds based. The type of pasture on which the carrying capacities are based is indicated in each table by the parenthetical notation - s, m and g respectively. Crop yield estimates are given in tonnes per hectare (t/ha).

The ‘achievable average yield’ figures quoted are the average yields that the best farmers in the zone are obtaining now (1990) on that soil with good management and up-to-date technology. For crop production this refers to factors such as, early seeding, herbicide use, current recommended variety and optimum economic fertilizer use. For pasture production this refers to grass control, insect control, correct stocking rate and adequate nutrient supply.

Note Because of the marked increase in potential yield over the last few years from the above developments, farmers were asked to estimate their ‘average yield’ over a ten year period, five years either side of the present day. The ‘achievable average yield’ is a figure many farmers should strive to average.

The ‘achievable yield (excellent season)’ figures quoted are the yields that can be obtained on that soil in an excellent season with good management (in many cases figures were quoted from 1988). This figure is an estimate of the potential of that particular soil under ideal conditions.

These yield figures are estimates and will not be agreed to by every farmer in the district. They do, however, give a general ‘ball park figure’ for yields on that soil and highlight the relative performances between soil types.
There is considerable variation in the properties of some soil types. This variation has been accounted for in the discussion of each soil type, and in some cases, by giving a range of yields in the yield table.

Different farmer practices and ability should be taken into account when using the yield figures. The type and length of rotation will also affect yield.

The yield figures will become dated with further advances in agriculture. They should be revised periodically.

The three volumes of this manual covering the broad physiographic regions of the Northam advisory district (the Zone of Ancient Drainage, the Zone of Rejuvenated Drainage and the Darling Range and West Kokeby Zones) divide the district's soils up into three climatic zones. However within each zone there is some variation in rainfall, with the annual average decreasing to the east. The location of any farm within the zone and therefore its rainfall should also be taken into account when using the yield figures.

Land capability, the ability of land to sustain a specific land use without undesirable on-site or off-site effects, has been assessed by comparing the requirements of the six land uses with the physical attributes of the soil types described.

The 'Yield estimates and capability ratings table' at the end of each soil type gives a capability rating from I to V for various land uses. Where Class I land has the highest potential with the fewest limitations, for a specified use and Class V land is regarded as prohibitive for the proposed land use (see Appendix 6 for details on the Department of Agriculture's five class land capability rating system). The land quality, such as moisture availability or wind erosion, which is the greatest limitation to that particular land use on that soil type, is given in each table.

The capability ratings quoted relate the capabilities of soils within the Department of Agriculture’s Northam Advisory District only. Consequently pasture production on Class I land in the Northam Advisory District will be less than that on, say, Class I land at Margaret River.

Section 2.4 defines four minor soil types whose limited occurrence does not warrant their inclusion with the major soil types.

Section 2.5 provides a system for the classification of saline land.

Chapter 3 discusses the application of the manual to mapping soils for farm planning.
1.6 Methodology

The following procedures helped in the development of this soil manual.

- Broadscale soil landform mapping at a scale of 1:100,000 over 2700 km$^2$ within the Zone of Ancient Drainage. Three hundred soil profiles were described.
- Two ‘window farms’ were mapped to test the applicability of mapping the soils described in the manual at farm scale (1:10,000). Two hundred soil profiles were described.
- The soils defined in the manual or amalgamations of these were mapped by four catchment groups. Individual farmers mapped the soils of their farms with assistance from the author of this manual.
- Discussions were held with the relevant Department of Agriculture staff on the requirements of each crop and pasture type.
- Discussions were held with ten farmers situated throughout the Zone of Ancient Drainage in order to obtain comments and yield data for each soil type.
- Yield estimates were obtained for each soil type from Department of Agriculture advisory and technical staff.
2. Soil types

2.1 Sandplain soils

These sandy surfaced soils generally occur as a gently undulating sandplain on upland areas. However, areas of sandplain soils may spill downslope from upland areas and in some cases border salt lakes on the valley floor. Slopes generally range from 1 to 5%.

The sandplain soils in the Zone of Ancient Drainage occur within the Ulva soil landscape unit.

The sandplain soils can be divided into seven soil types:

1. Deep pale sand;
2. Deep yellow sand;
3. Yellow gradational loamy sand;
4. Pale sand over gravel/loamy sand;
5. Waterlogged sand;
6. Deep yellow acid sand;
7. Shallow mottled zone.
1. Deep pale sand

P.P.F. Uc 1.21, Uc 2.12, Uc 1.22, Uc 5.11, Uc 2.21
Phillips series, Eaton series

Horizon

A1 Grey (10YR 5/1) to light grey (10YR 6/1), medium to coarse grained sand.
Single grains, loose surface.
pH = 6.0

A2 White (10YR 8/2) to pale yellow (10YR 8/6), medium to coarse grained sand.
Single grains.
pH = 6.5

B1 White (10YR 8/2) to pale yellow (10YR 8/6), medium to coarse grained sand.
Single grains
Large ironstone gravel.
pH = 6.5
(Note – this layer is sometimes present)
Identifying characteristics

The Deep pale sand includes the loose, white and pale yellow sands which are commonly over 2 m deep and have a grey topsoil.

The Deep pale sand can be distinguished from the Pale sand over gravel/loamy sand by the absence of ironstone gravel and/or a layer with a higher clay content (e.g. loamy sand) within the top 80 cm. The Deep pale sand can be distinguished from the Waterlogged sand as it is well drained and does not occur in seepage areas.

These sands are commonly called ‘Christmas tree sands’ or ‘gutless sands’.

Position in the landscape

The Deep pale sand is most commonly found as ‘spillway sands’ or deep sand hollows within areas of sandplain. These ‘spillway sands’ occur on the backslopes of breakaways and run down towards the valley floor (Quailing soil landscape unit).

Extensive areas of this soil also occur in the Eaton soil landscape unit which occurs north of Meckering and in the West Bolgart area.

Vegetation

The dominant native vegetation is Christmas tree (Nuytsia floribunda), sheoak (Allocasuarina huegeliana), Banksia sp. and tea-tree (Leptospermum erubescens). In some areas this soil supports a low scrub.

Land qualities

Moisture availability

The very low clay content (often less than 2%) and medium to coarse sand grain size result in a very low available water content. Moisture conditions are only favourable for traditional crops and pastures for a short time after rainfall. In addition, these soils are often non-wetting, causing rainfall to sit on the surface and evaporate rather than infiltrate. The phases of this soil with a pale yellow subsoil have a slightly higher clay content and therefore slightly better water-holding capacity than the deep white sands.

Nutrient availability

These soils have a very low natural fertility. Added nutrients, in particular nitrogen, are rapidly leached out of the root zone. Trace element deficiencies need to be corrected.

The very low buffering capacity of this soil (low clay and organic matter content) indicates that any acid inputs into this soil will result in large pH changes. A productive system, especially based on legumes (e.g. blue lupins) would probably result in rapid sub surface acidification. An unproductive system (e.g. wheat/subterranean clover rotation) would result in little nitrogen accumulation and hence a low rate of acidification.
Wind erosion

The **Deep pale sand** is highly susceptible to wind erosion as it consists of loose, single grains. The organic particles which are important for holding nutrients are the first to blow away. Poor crop and pasture growth predisposes this soil to wind erosion.

Recharge hazard

The free draining nature of the soil, and low water use by poorly growing annual species, results in a high percentage of rainfall passing through the root zone. This soil can add large amounts of recharge to the regional groundwater-table.

Other

Rooting conditions in these deep, loose sands are very good. Waterlogging and salinity do not occur. Traffic compaction pans may result from repeated cultivation. Vehicles getting bogged in deep sand is the only trafficability consideration. Water erosion rarely occurs on these soils. The non-wetting characteristic is patchy. Hence run-off from non-wetting areas readily soaks into the surrounding sand.

Productivity and capability

The poor moisture and nutrient availability of these soils results in poor crop and pasture growth.

Subterranean clover fails to set seed in most years and does not persist. Grass and broad-leaved weeds are noticeably sparse.

The poor yields make cereal and lupin cropping uneconomic in almost all years. Deep ripping to remove traffic compaction pans is not economic.

The poor performance of pastures and crops is likely to leave much of the soil bare and exposed, increasing the risk of wind erosion. Areas of ‘gutless’ sand within a paddock limit the grazing capacity of that paddock as they are the first to blow and dictate when stock should be moved. Sandblasting of crops in adjacent areas may occur.

Alternative land uses should be sought on this soil. Blue lupins are capable of good production provided a gravel layer occurs within the top 2 m. Tagasaste generally grows well because its deep root system is well suited to extracting moisture. Both blue lupins and tagasaste provide valuable grazing and protect the soil from wind erosion. They are high water users and decrease the amount of water recharging the groundwater system (see Western Australian Department of Agriculture Farmnote No. 45/88 for more information on tagasaste).

Acacia species such as *A. saligna* and *A. salicina*, which can be used for sheep fodder, have shown potential on this soil.
Yellow serradella (*Ornithopus compressus*) may be a pasture legume option for this soil but the cost of establishment is currently prohibitive. French serradella (*Ornithopus sativus*) may be a cheaper option but information is not available on its long term persistence.

Combinations of perennial and annual species such as tagasaste with blue lupins or serradella between the rows have grown well on this soil.

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### Yield estimates and capability rating for various land uses

**Deep pale sand**

<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pasture (g)</td>
<td>2 DSE/ha (winter grazed)</td>
<td>V</td>
<td></td>
<td>Moisture availability, nutrient availability, recharge hazard</td>
</tr>
<tr>
<td>Wheat</td>
<td>0.4-0.8 t/ha</td>
<td>1.0-1.5 t/ha</td>
<td>V</td>
<td>Moisture availability, nutrient availability</td>
</tr>
<tr>
<td>Lupins</td>
<td>0.6-0.8 t/ha</td>
<td>1.0-1.5 t/ha</td>
<td>V</td>
<td>Moisture availability, nutrient availability</td>
</tr>
<tr>
<td>Tagasaste</td>
<td>Good growth</td>
<td>I-II</td>
<td></td>
<td>Moisture availability, nutrient availability</td>
</tr>
<tr>
<td>Blue lupins</td>
<td>Average-good growth</td>
<td>I-III</td>
<td></td>
<td>Moisture availability, nutrient availability</td>
</tr>
</tbody>
</table>
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<td>1. Pasture (g)</td>
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<td>moisture availability, nutrient availability, recharge hazard</td>
</tr>
<tr>
<td></td>
<td>(winter grazed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Wheat</td>
<td>0.4-0.8 t/ha</td>
<td>1.2-1.4 t/ha</td>
<td>V</td>
<td>moisture availability, nutrient availability</td>
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<tr>
<td>3. Lupins</td>
<td>0.6-0.8 t/ha</td>
<td>1.2-1.4 t/ha</td>
<td>V</td>
<td>moisture availability, nutrient availability</td>
</tr>
<tr>
<td>4. Blue lupins</td>
<td>average-good growth</td>
<td>I-III</td>
<td></td>
<td>moisture availability, nutrient availability</td>
</tr>
<tr>
<td>5. Tagasaste</td>
<td>good growth</td>
<td>I-II</td>
<td></td>
<td>moisture availability, nutrient availability</td>
</tr>
</tbody>
</table>
2. Deep yellow sand

Average quality yellow sand –
'Sandplain pear and banksia country'.

P.P.F. Uc 5.11

Cunderdin series.

Horizon

A1  Brown (10YR 4/3), medium grained sand.
    Single grains, loose surface.
    $pH = 6.5$

B1  Yellow (10YR 6/8) medium grained sand.
    Single grains.
    $pH = 7.0$

B2  Yellow (10YR 6/8) loamy sand.
    Single grains or massive structure.
    Earthy fabric.
    $pH = 7.0$
    (Note – this layer is sometimes present).
Identifying characteristics

The **Deep yellow sand** includes the yellow sandy soils that are commonly over 2 m deep. They have a brown topsoil.

The **Deep yellow sand** varies little from the soil diagram given. The texture is a sand but may increase to a clayey sand below 80 cm. The darker yellow subsoil distinguishes this soil from the poorer **Deep pale sand**. The **Yellow gradational loamy sand** can be distinguished from the **Deep yellow sand** by its higher clay content and often by the presence of ironstone gravel. This soil is commonly referred to as 'sandplain pear and banksia country'.

Position in landscape

The **Deep yellow sand** occupies a large area throughout the gently undulating Ulva sandplain. It is especially common in the Cunderdin and Meckering areas. In many cases the **Deep yellow sand** occurs in sand filled hollows below the **Yellow gradational loamy sand**. However, the **Deep yellow sand** can occur as rises with a slight dunal appearance. Slope gradients usually range from 1 to 5%.

Vegetation

The dominant native vegetation is sandplain pear (**Xylomelum angustifolium**), and banksia (**Banksia** sp.) with the odd tussock grass (**Lepidosperma orgustatti**). North of the Nungarin-Wyalkatchem road flame grevilleas (**Grevillea pterosperma** and **Grevillea eriostachya**) are common.

Land qualities

**Moisture availability**

This soil has a poor ability to retain moisture for plant growth. The large pores of this sandy soil drain easily and the clay content is low (around 3%). However, the yellow colouring of this soil indicates a possibly higher clay and hydrous iron content than the **Deep pale sand**. This results in this soil being able to retain more water than the poorer sands. Seasons in which there are many rainfall events spread out over the growing season suit crop and pasture growth on this soil type.

**Nutrient availability**

This soil has a low natural fertility. Trace element deficiencies need to be corrected. Nutrients, in particular nitrogen, are rapidly leached out of the root zone. This soil has a low pH buffering capacity because of its low clay and organic matter content. The potential for acidification is high under a productive wheat-lupin system.
Soil structure decline

After repeated cultivation a traffic compaction pan will develop at about 20-30 cm. The presence of a pan can be identified by the increased resistance to digging at about 20-30 cm. A steel spike can also be used to identify this pan.

Recharge hazard

The Deep yellow sand can, because of its free draining nature, add considerable amounts of recharge to the groundwater table. However, water use efficiency is higher on this soil than on the Deep pale sand.

Wind erosion hazard

Wind erosion and sandblasting of emerging crops are potential problems if management is poor. The fine organic particles, which are important for holding nutrients and moisture are easily transported by wind.

Other

These soils are very well drained and are not subject to waterlogging or salinity. Access to two wheel drive vehicles can be limited over summer. Rooting conditions are good except when traffic compaction pans form. These soils have a very high infiltration rate and do not water erode.

Productivity and capability

The Deep yellow sand is an average quality cropping soil and below average quality pasture producing soil.

The two most common rotations practiced on this soil type are a wheat/lupin rotation and a wheat/subterranean clover based pasture rotation.

Subterranean clover grows poorly on this soil and pasture is generally sparse. Shallow rooted pasture species have trouble exploring enough soil volume to obtain sufficient moisture.

Cereal yields are average for the zone, and are mainly limited by poor moisture and nutrient availability. Traffic compaction pans can reduce cereal yields. Trials on this soil type have shown an average increase in wheat yield of almost 500 kg/ha in the first year following deep ripping of traffic compaction pans. The benefit of deep ripping lasts a number of years. Results indicate that the residual benefit of deep ripping in the second cereal year is about half the initial response. Direct drilling in years following ripping reduces the rate of pan development. Lupins seldom respond to deep ripping. See Western Australian Department of Agriculture Farmnote 61/85 for more details.

Lupins grow well on this soil and are able to develop deep root systems to extract moisture.
The incidence of wind erosion can be reduced by management practices such as stubble retention, direct drilling and the planting of wind breaks. However, research on sandy soils has shown that cereal yields are around 10% higher on cultivated crops than they are on crops sown using direct drilling because of better seed bed preparation. Seeding equipment that can cultivate deep and sow shallow is being developed. Another option to reduce the possibility of wind erosion, but not reduce yield, is to scarify and seed within the same day.

If valley floor or sandplain seepage salinity is a problem within the catchment, then high water using crops and trees should be encouraged on these sandplain intake areas. Deep rooted species such as lupins, barley, wheat or trees are capable of using much more water than pasture species (see Nulsen and Baxter 1984).

Tagasaste and blue lupins grow well. Serradellas may have a role on this soil. Applications of lime may be necessary in the future to overcome soil acidification.

<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (g,s)</td>
<td>3-4 DSE/ha (winter grazed)</td>
<td></td>
<td>IV</td>
<td>moisture availability</td>
</tr>
<tr>
<td>2. Wheat</td>
<td>1.4-1.7 t/ha</td>
<td>2.0-2.2 t/ha</td>
<td>II-III</td>
<td>moisture availability</td>
</tr>
<tr>
<td>3. Lupins</td>
<td>1.2-1.5 t/ha</td>
<td>1.4-1.8 t/ha</td>
<td>I</td>
<td>soil structure decline</td>
</tr>
<tr>
<td>4. Blue lupins</td>
<td>very good growth</td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>5. Tagasaste</td>
<td>very good growth</td>
<td></td>
<td>I</td>
<td></td>
</tr>
</tbody>
</table>
3. Yellow gradational loamy sand

Good quality, yellow, gravelly sandplain — 'Tammar country' and other non-gravelly, good quality, yellow sandplain

P.P.F. Dy 5.52, Dy 3.62, Gn 2.61, KS-Uc 4.12

Tammin series, Ejanding series, Wyola series, Ucarty series.

Horizon

A1  Greyish brown (10YR 4/2) to yellowish brown (10YR 5/8), medium grained sand to clayey sand.  
Loose to hardsetting surface.  
Single grains to massive structure.  
Usually contains small to moderate amounts of ironstone gravel.  
\text{pH} = 6.0

B1/B2  Yellow (10YR 7/6) to yellowish brown (10YR 5/8) clayey sand grading to a sandy loam or sandy clay loam at depth.  
Massive structure, earthy fabric.  
May contain red and orange mottles.  
Large amounts of ironstone gravel often present.  
\text{pH} = 6.5

C  Mottled zone.  
Red, orange and yellow mottled sandy clay loam to sandy clay.  
Hardpan.  
Little or no ironstone gravel.  
\text{pH} = 6.5
Identifying characteristics

The Yellow gradational loamy sand is a variable soil type containing all the good quality sandplain which often contains large percentages of ironstone gravel. The topsoil is a brownish sand or loamy sand and generally overlies a yellowish clayey sand grading into a sandy clay loam. Variations from the idealized soil diagram include:

- a yellowish brown hardsetting surface with a high gravel content;
- a deeper phase with no gravel in the top metre;
- a shallower phase with the mottled zone occurring at about 25 cm or greater; and
- similar to the diagram but with an intermediate, pale grey, gravelly sand layer below the A1 horizon.

The Shallow mottled zone soil type may look similar to this soil from the surface but it can be distinguished by its hardened mottled zone at about 10 to 25 cm.

Most of these soils contain ironstone gravel and are locally referred to as 'tammar country'.

Position in the landscape

This soil occupies large areas throughout the gently undulating Ulva sandplain. Slope gradients are often uniform at around 2 to 3% but this soil can occur on steeper, gravelly ridges.

Vegetation

Tammar (Allocasuarina campestris) scrub occurs on the gravelly phases of this soil. Pear fruited mallee or Dowerin rose (Eucalyptus pyriformis) and some tussock grass (Lepidosperma orgustatum), Acacia sp. and quandong (Santalum sp.) occur on the less gravelly or non-gravelly phases.

Land qualities

Moisture availability

The loamy sand to loamy textures of this soil enable it to hold and supply large amounts of moisture for plant growth.

Nutrient availability

Applied nutrients are not rapidly leached from the root zone as in some of the lighter sands. Trace element applications may be required to overcome deficiencies. Phosphate fertilizer is fixed by the large percentages of ironstone gravel found in some of these soils (high reactive iron content). This productive soil is at high risk of surface and sub surface acidification because of its low pH.
Trafficability
This soil is easy to work under a range of moisture conditions, even after heavy rain it does not become boggy. The ironstone gravel that sometimes occurs on the soil surface is rarely large enough to cause problems during cultivation.

Soil structure decline
Traffic compaction pans often develop at a depth of about 20 to 30 cm. Pans appear to be more common on the less gravelly, deeper phases.

The seasonal effect of raindrop impact and traffic may result in hard surface layers.

Rooting conditions
The large percentages of gravel that often occur within the profile are rarely cemented and do not greatly restrict root growth of crop and pasture species. In phases of this soil where the mottled zone occurs closer to the surface, root growth is restricted.

Wind erosion
When exposed or cultivated these soils are susceptible to wind erosion. However, their higher clay content, gravel content and subsequent better plant growth makes wind erosion and sandblasting of emerging crops less of a risk than on the other sandplain soils.

Water erosion
Water erosion can occur on sloping areas of this soil. Generally, however, rainfall infiltrates quite readily.

Other
These soils are freely drained. Heavier subsoil textures and good crop and pasture performance suggest that these soils are unlikely to be a major source of groundwater recharge. Salinity rarely occurs.
Productivity and capability

The Yellow gradational loamy sand is a favoured soil type that produces high to very high cereal, lupin and pasture yields in most years. This soil does not become waterlogged in wet years and is able to supply more moisture than most other soils in drier years. It has few problems associated with it and is easy to manage.

Subterranean clover grows very well. The favourable rooting conditions allow root development into the loamy subsoil where moisture availability is high.

The cereal yields obtained are, on average, close to, if not the best in the zone. Traffic compaction pans can reduce cereal yields. Deep ripping responses are well documented on the non-gravelly phases of this soil. The gravelly phases, provided they are not too shallow, may also be responsive.

Lupin yields are very good in the deeper phases of this soil, but in some of the shallow, very gravelly areas lupins experience moisture stress earlier in spring and tend to die off (premature senescence).

Field peas should not be grown under current grazing and stubble management strategies because of the wind erosion hazard.

Tagasaste growth is good but if the mottled zone is present in the top metre or so it will restrict root growth.

Applications of lime may be necessary in the future to overcome soil acidification.

<p>| Yield estimates and capability rating for various land uses |
|-----------------------------|-----------------------------|-----------------------------|-------------------------------|-----------------------------|</p>
<table>
<thead>
<tr>
<th><strong>Yellow gradational loamy sand</strong></th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (s)</td>
<td>7-9 DSE/ha</td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(winter grazed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Wheat</td>
<td>2.0-2.2 t/ha</td>
<td>3.0 t/ha</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>3. Lupins</td>
<td>1.2-1.6 t/ha</td>
<td>1.8-2.4 t/ha</td>
<td>I*</td>
<td></td>
</tr>
<tr>
<td>4. Blue lupins</td>
<td>very good growth</td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>5. Tagasaste</td>
<td>average to poor growth</td>
<td></td>
<td>II* - IV</td>
<td>rooting conditions</td>
</tr>
</tbody>
</table>

* For deeper phases of this soil.
4. Pale sand over gravel/loamy sand

Pale, sandy surfaced sandplain over gravel and/or loamy sand at about 40 cm.

P.P.F. Gn 2.75, Uc 2.12, Uc 2.21

Kauring series, Mawson series

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Greyish brown (10YR 5/2) to light grey (10YR 6/1), medium to coarse grained sand. May contain ironstone gravel. Single grains, loose surface. pH = 6.5</td>
</tr>
<tr>
<td>A2</td>
<td>Pale (10YR 7/4), medium to coarse grained sand. Single grains. May contain ironstone gravel. pH = 7.0</td>
</tr>
<tr>
<td>A3</td>
<td>Pale (10YR 7/4) medium to coarse grained sand. Single grains. Large amounts of ironstone gravel. pH = 7.0</td>
</tr>
<tr>
<td>B2</td>
<td>Yellow (10YR 6/8), loamy sand to sandy loam. Massive structure, earthy fabric. Large amounts of red and pale mottles. May contain ironstone gravel. pH = 7.0</td>
</tr>
<tr>
<td>C</td>
<td>Mottled zone. Red, orange and yellow mottled sandy clay loam to sandy clay. Hardpan. pH = 6.5</td>
</tr>
</tbody>
</table>
Identifying characteristics

The **Pale sand over gravel/loamy sand** is a loose, pale sand with a greyish surface overlying an ironstone gravel layer and/or loamy sand subsoil usually between 40 and 70 cm. In some cases ironstone gravel, often of large diameter (10-20 mm), may occur close to or at the surface.

Deeper phases of the **Pale sand over gravel/loamy sand** grade into the **Deep pale sand**. If the gravel or loamy sand subsoil occurs below 80 cm then this soil should be classified as a **Deep pale sand**. If the loamy sand subsoil occurs above 40 cm then this soil should be classified as a **Yellow gradational loamy sand**.

Position in landscape

This soil type occurs in areas of the gently undulating Ulva sandplain. It is especially common in the west of the Zone of Ancient Drainage around the Meckering area. Seepage areas (**Waterlogged sand**) may occur in association with or further downslope from this soil type.

Vegetation

Low tea tree (**Leptospermum erubescens**) scrub is the dominant native vegetation on this soil.

Land qualities

**Moisture availability**

The pale, sandy topsoil has a low water holding capacity. Moisture availability is greater in the loamy sand subsoil. The depth to this layer is critical in determining how much moisture this soil can supply. These soils may be non-wetting which reduces rainfall infiltration.

**Nutrient availability**

Nutrients are leached rapidly from the topsoil. Trace element deficiencies may need to be corrected. When under a productive legume based system (e.g. lupins) this soil is at considerable risk of acidification. The very low pH buffering capacity of this soil (low clay and organic matter content) indicates that any acid inputs into the soil will result in large pH changes.

**Wind erosion**

If poorly managed, the loose, sandy surface of these soils is prone to wind erosion. Sandblasting of emerging crops can occur.

**Soil structure decline**

A traffic compaction pan may develop after cultivation. The depth of this pan is usually greater than 30 cm, which is deeper than on the **Yellow gradational loamy sand** (this is due to the lower clay content in the surface horizon of the **Pale sand over gravel/sandy loam**).
Recharge hazard

This soil is capable of adding recharge but is likely to add less recharge to the groundwater than the deep sands. This is because the subsoil can hold more water within the root zone for crops and pastures to use.

Other

The rooting conditions in the topsoil are good. The mottled zone (if present) will impede deeper rooted species. Salinity, waterlogging, trafficability and water erosion are not or are rarely problems on this soil.

Productivity and capability

This is an average to below average soil for cereal and lupin cropping and subterranean clover based pastures.

Subterranean clover will persist on this soil but is generally sparse. The deep sandy, surface horizons can retain little moisture for use by shallow rooted pasture species. Pastures are often dominated by grasses and capeweed.

Cereal growth varies from below average to average depending on the depth to the subsoil and the percentage of clay in the surface horizons. The deep ripping of traffic compaction pans may give economic responses in following cereal crops.

Lupins grow quite well, being suited to this deeper, sandier soil.

Field peas should not be grown under current grazing and stubble management strategies because of the wind erosion hazard.

Tagasaste generally grows well on this soil, but where the mottled zone is present in the subsoil, its roots have trouble exploring enough soil volume to obtain sufficient moisture. Serradella may have a role on this soil. Blue lupins grow well.

The incidence of wind erosion can be reduced by management practices such as not overgrazing, minimum tillage, stubble retention and the planting of wind breaks.

Research on sandy soils has shown that cereal yields are around 10% higher on cultivated crops than they are on crops sown using direct drilling because of better seedbed preparation. Seeding equipment that can cultivate deep and sow shallow is being developed. Another option to reduce the possibility of wind erosion but not reduce yield is to scarify and seed within the same day.

Applications of lime may be necessary in the future to overcome soil acidity.
# Yield estimates and capability rating for various land uses

## Pale sand over gravel/loamy sand

<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (g, s)</td>
<td>4 DSE/ha (winter grazed)</td>
<td></td>
<td>IV</td>
<td>moisture availability</td>
</tr>
<tr>
<td>2. Wheat</td>
<td>1.0-1.5 t/ha</td>
<td>1.8 t/ha</td>
<td>III</td>
<td>moisture availability</td>
</tr>
<tr>
<td>3. Lupins</td>
<td>1.0-1.2 t/ha</td>
<td>1.6 t/ha</td>
<td>II-III</td>
<td>moisture availability</td>
</tr>
<tr>
<td>4. Blue lupins</td>
<td>good growth</td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>5. Tagasaste</td>
<td>good growth</td>
<td></td>
<td>II*-III</td>
<td>rooting conditions</td>
</tr>
</tbody>
</table>

* For deeper phases of this soil.
5. Waterlogged sand

Winter waterlogged, pale sand. Found in poorly drained depressions within areas of sandplain.

P.P.F. Dy 5.82, Uc 1.21

Cularing series

Horizon

A1  Grey (10YR 4/1), medium to coarse grained sand.
Single grains, loose surface.
pH = 6.0

A2  Pale (10YR 7/3), medium to coarse grained sand.
Single grains.
pH = 7.0

B2  Mottled pale (10YR 7/2), yellow (5Y 7/6) and grey (5Y 5/1)
sandy clay.
pH = 7.0

(Note — Silcrete often occurs below this soil.
— The watertable may reach the surface in winter and generally remains within 150 cm all year round).
Identifying characteristics

The **Waterlogged sand** consists of a pale, loose sand with a grey surface. A mottled sandy clay is generally found at depths in excess of 70 cm. The clay layer is often underlain by a siliceous hardpan. This pan is often exposed in soaks dug in this soil. This soil becomes very waterlogged over the winter months.

The **Waterlogged sand** may be distinguished from the **Deep pale sand** by its low lying position in the landscape and its poor drainage. The **Pale sand over gravel/sandy loam** differs in that it contains large amounts of ironstone gravel at depth and does not become severely waterlogged.

Position in landscape

The **Waterlogged sand** occurs as small areas in low lying depressions, seepage areas and drainage lines within the Ulva sandplain unit.

Vegetation

Rushes (*Juncus* sp.) and tea tree (*Leptospermum* sp.) scrub are often present on this soil.

Land qualities

**Moisture availability**

This soil occurs in seepage areas and moisture is often still available at depth during summer. The soil type itself is a deep sand capable of holding small amounts of moisture.

**Nutrient availability**

This sandy soil has a poor ability to retain nutrients and added nitrogen fertilizer is rapidly leached from the root zone. Trace element deficiencies may need to be corrected.

Under current farming systems this soil has a low soil acidification potential. When under a productive legume based system (e.g. alternative subterranean clover species) this soil is at considerable risk of acidification. The very low pH buffering capacity of this soil (low clay and organic matter content) indicate that any acid inputs into the soil will result in large pH changes.

**Waterlogging**

In most winters this soil becomes waterlogged. Low lying areas suffer more severe waterlogging than higher areas.

Water often moves downslope from these areas on top of the clay layer causing waterlogging and sometimes salinity on areas of shallower duplex soils.
Rooting conditions

Rooting conditions are not limiting for annual crops and pastures. If a siliceous hardpan occurs below the clay layer it may limit the root growth of tree species.

Trafficability

The Waterlogged sand may become very boggy over the winter months and may remain so until late spring.

Salinity

Some sandplain seepage areas are saline. Other areas have the potential to become saline.

Wind erosion

This sandy soil is highly erodible, but wind erosion is rare as the soil surface is often protected by rushes and thick grassy pastures.

Recharge hazard

The Waterlogged sand is a discharge area for the surrounding sandplain. However, areas of Waterlogged sand often also act as recharge areas for the water-table in the valley floor. Water sits on top of the clay layer of this soil type for much of the year. The clay layer is permeable and water slowly percolates down to the deep groundwater system.

Other

Traffic compaction pans rarely develop because this soil is generally not cultivated. Run-off and consequently water erosion do not occur because of the high infiltration rate.

Productivity and capability

The Waterlogged sand is a poor quality soil for cereal and lupin cropping and subterranean clover based pasture.

Pasture growth is variable depending on the depth to the watertable. Areas that become severely waterlogged support poor pasture - either being bare or containing reeds and rushes. Areas that occur slightly above these very wet areas support good grass and sometimes subterranean clover pastures. The grass often remains green into spring. Couch grass grows very well. Perennial grasses such as phalaris and alternative clover species such as balansa (Trifolium balansae) and strawberry clover (Trifolium fragiferum) may have potential.

In wet years, cereal and especially lupin crops, are greatly affected by waterlogging.
Tagasaste grows poorly on wetter areas of this soil as it is unable to tolerate the winter waterlogging. Tagasaste and other tree species grow well on the margins of these areas where large amounts of moisture are obtainable at depth.

Sudax and lucerne may have potential on these sites as summer crops.

Areas of Waterlogged sand that are saline or have the potential to become saline can be dried up by planting trees at close spacings around the margins of such areas. In many cases, however, water in these areas is fresh and is required in soakages for stock use.

<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (g,s)</td>
<td>2-4 DSE/ha</td>
<td></td>
<td>IV</td>
<td>moisture availability, nutrient availability, waterlogging</td>
</tr>
<tr>
<td></td>
<td>(winter grazed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Wheat</td>
<td>0.7-1.0 t/ha</td>
<td>2.0-2.4 t/ha</td>
<td>IV</td>
<td>waterlogging</td>
</tr>
<tr>
<td>3. Lupins</td>
<td>0.4-0.8 t/ha</td>
<td>1.0-1.6 t/ha</td>
<td>V</td>
<td>waterlogging</td>
</tr>
<tr>
<td>4. Blue lupins</td>
<td>poor growth</td>
<td></td>
<td>V</td>
<td>waterlogging</td>
</tr>
<tr>
<td>5. Tagasaste</td>
<td>poor in waterlogged areas</td>
<td></td>
<td>V</td>
<td>waterlogging</td>
</tr>
<tr>
<td>6. Sudax and lucerne</td>
<td>potential</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Saltland agronomy</td>
<td>good potential</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
6. Deep yellow acid sand

Poor quality, deep, yellow, acid sandplain. Found in the east of the Advisory District — ‘Wodjil country’

P.P.F. Dy 2.51, Dy 4.51, Gn 2.21, Uc 5.22

Holleton series

Horizon

A1  Brown (10YR 4/3), sand to loamy sand. Loose to hardsetting surface. 
   pH = 5.0 (water)  
   pH = 4.3 (CaCl₂)

B1  Yellow (10YR 6/8), sand to sandy loam. Single grains to massive structure, often with an earthy fabric. 
   pH = 4.5 (water)  
   pH = 3.9 (CaCl₂)

   pH = 4.0 (water)  
   pH = 3.7 (CaCl₂)
Identifying characteristics

The Deep yellow acid sand includes all non-productive, deep yellow sandplain with an acid subsoil. The profile is generally a deep, earthy, yellow sand, and may contain small amounts of ironstone gravel at depth. The subsoil pH is quite variable though it is generally less than 4.3 (CaCl₂).

This soil can be distinguished from the Deep yellow sand by its pH, often heavier texture and poor crop and pasture growth. In some areas this soil type is referred to as ‘wodjil country’, but in other areas ‘wodjil’ refers to the Shallow mottled zone soil type.

Position in landscape

The Deep yellow acid sand is a minor soil occupying small pockets at no set position within the Ulva sandplain unit. It is found in the north east and far east of the Northam Advisory District.

Vegetation

The native vegetation is commonly called ‘wodjil scrub’. The term wodjil refers to the number of species of acacia which grow on these acid soils. Examples include Acacia resinomarginea, Acacia assimilis, Acacia neurophylla and Acacia signata. Tammin mallee (Eucalyptus leptopoda) can also be found on this soil.

Land qualities

Nutrient availability

The Deep yellow acid sand has an inherently low subsoil pH. This acidity can cause aluminium to reach toxic levels and phosphorus, calcium, molybdenum or magnesium to be less available and possibly deficient.

Aluminium toxicity is probably the main cause of poor yields on the Deep yellow acid sand. It reduces root growth and therefore reduces the ability of the plant to take up water and nutrients. Molybdenum deficiency can also be a growth limiting factor on these soils as it is converted to forms that are unavailable to plants. Molybdenum deficiency can be corrected by applying molybdenum fertilizer or by seed dressing with sodium molybdate.

Soil acidity reduces the ability of rhizobia to form nodules and fix nitrogen. However, rhizobia vary widely in their tolerance to acid soils. Table A.5.3 on page 127 shows the critical pH at which productivity is reduced for different species and varieties.

This soil is unlikely to become more acid under current farming practices because of its low productivity.
**Moisture availability**

The poor subsoil root growth caused by aluminium toxicity results in plants becoming drought stressed early in spring (the soil type itself usually has a reasonable available water capacity). In years when good spring rains occur there is sufficient moisture in the surface horizons to obtain average yields.

**Soil structure decline**

These soils will develop a traffic compaction pan following repeated cultivations.

**Wind and water erosion**

The poor pasture and crop growth predisposes the soil surface to wind and water erosion.

**Recharge hazard**

Poor plant growth and hence poor water usage on these soils results in a high percentage of rainfall moving through the profile and into the deep groundwater table. Once cleared these soils can add significant amounts of recharge.

**Other**

These soils do not become waterlogged or saline and are capable of being worked after heavy rainfall.

---

**Productivity and capability**

The **Deep yellow acid sand** is a poor agricultural soil that produces low yields for conventional crops and pastures because of its subsoil acidity.

The subsoil acidity limits root growth of subterranean clover. This results in drought stress during dry periods of the season, with the plant failing to set seed in many years. Pastures are dominated by annual ryegrass and capeweed with wild radish and turnip often being present. Yellow serradella (*Ornithopus compressus*) is tolerant to these levels of acidity and has performed well in trials. The cost of establishment is currently prohibitive for widespread use.

Cereals generally grow poorly but can produce average yields in higher rainfall seasons. The application of lime has rarely resulted in improved wheat production. This is because lime is very insoluble and only small percentages are leached into the acid subsoil. Deep ripping to overcome traffic pans is not recommended as it can bring the hostile, acid subsoil closer to the surface.

Cereal rye, triticale and oats are more tolerant of acidity and are better suited to this soil than wheat.

Lupins grow, in relative terms, quite well as they are more tolerant of acidity than most varieties of wheat.

Perennial fodder shrubs and trees grow quite well and can be placed strategically to reduce wind erosion and recharge. Species that have performed well in trials include: *Acacia brumalis*, *A. saligna*, *A. salicina* and tagasaste (*Chamaecytisus palmensis*).
## Yield estimates and capability rating for various land uses

### Deep yellow acid sand

<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (g)</td>
<td>2.3 DSE/ha (winter grazed)</td>
<td></td>
<td>IV-V*</td>
<td>nutrient availability (pH) moisture availability recharge hazard</td>
</tr>
<tr>
<td>2. Wheat</td>
<td>0.8-1.0 t/ha</td>
<td>1.4-1.8 t/ha</td>
<td>IV-V*</td>
<td>nutrient availability (pH) moisture availability</td>
</tr>
<tr>
<td>3. Lupins</td>
<td>0.8-1.1 t/ha</td>
<td>1.7 t/ha</td>
<td>III-IV*</td>
<td>nutrient availability (pH) moisture availability</td>
</tr>
<tr>
<td>4. Triticale</td>
<td>0.9-1.4 t/ha</td>
<td>1.6-2.0 t/ha</td>
<td>III-IV*</td>
<td>nutrient availability (pH) moisture availability</td>
</tr>
<tr>
<td>5. Blue lupins</td>
<td>average growth</td>
<td></td>
<td>III-IV*</td>
<td>nutrient availability (pH) moisture availability</td>
</tr>
<tr>
<td>6. Tagasaste</td>
<td>good growth</td>
<td></td>
<td>I-III*</td>
<td>nutrient availability (pH) moisture availability</td>
</tr>
</tbody>
</table>

* Dependent on acidity of sub soil.
7. Shallow mottled zone

Poor quality, gravelly soils.
Yellow, gravelly soils overlying mottled zone at about 15 cm.
— 'Shallow conglomerate or wodjil country'

P.P.F. Uc 5.13

Wyalkatchem series

Horizon

A1  Greyish brown (10YR 4/2) loamy sand.
Massive structure.
Firm to hardsetting surface.
May contain ironstone gravel.
\( pH = 6.0 \)

A3  Yellow (10YR 7/6) to yellowish brown (10YR 5/8) clayey sand.
Massive structure.
Often contains loose, ironstone gravel.
\( pH = 5.5 \)

C  Mottled zone.
Yellow, red and orange mottled sandy loam to sandy clay loam.
Hardpan.
Little or no ironstone gravel.
\( pH = 5.5 \)
Identifying characteristics

The Shallow mottled zone soil type consists of 5-15 cm of greyish brown loamy sand over a thin yellowish clayey sand overlying mottled zone. Deeper phases of this soil type grade into the Yellow gradational loamy sand. If the depth to the mottled zone is greater than about 25 cm, this soil should be placed into the Yellow gradational loamy sand. In some areas this soil type is referred to as ‘wodjil country’ or ‘shallow conglomerate’. The Deep yellow acid sand is also referred to as ‘wodjil country’.

Position in landscape

The Shallow mottled zone is a minor soil type occupying small pockets within the Ulva sandplain. It is most common in the far east and north-east of the Northam advisory district. It often occurs on ridge crests and upper slopes and is usually associated with the Yellow gradational loamy sand.

Vegetation

Wodjil (Acacia sp.), tammar (Allocasuarina campestris) and black tammar (Allocasuarina acutivalvis) are the dominant native vegetation species.

Land qualities

Moisture availability and rooting conditions

The mottled zone greatly restricts root growth. As a consequence plants become moisture stressed during periods of drought within and at the end of the growing season.

Nutrient availability

These soils tend to be prone to trace element deficiencies. Phosphorus is fixed because of the high reactive iron content.

The pH of the subsoil may be acidic enough to effect plant growth. This is inherent acidity rather than as a result of farming practices.

Waterlogging and trafficability

These soils rarely become waterlogged. They can become slippery, which may limit machinery access for a day or so after heavy rains.

Wind and water erosion

The poor plant growth on these soils predisposes the surface to wind erosion. Water erosion can occur, especially during heavy summer thunderstorms.
Recharge hazard

Because of the poor growth of agricultural species these soils are capable of adding considerable amounts of recharge to the deep groundwater-table. The amount of recharge would probably be less than on the Deep yellow acid sand because of higher run-off and slower water movement through the mottled zone.

Other

Soil structure decline and salinity rarely occur on this soil.

Productivity and capability

The Shallow mottled zone is a very poor producing soil which, in many cases, does not warrant clearing.

This soil is capable of supporting some grasses and capeweed. Subterranean clover often will not persist because of moisture stress caused by the harsh rooting conditions and in some cases the low subsoil pH. However, in deeper phases of this soil (20-25 cm of topsoil) satisfactory subterranean clover growth can be obtained. Careful management of stock is required to prevent the thin topsoil from blowing away and exposing the hostile subsoil in which little or nothing will grow.

Cereal crops grow poorly because the mottled zone restricts root growth and consequently access to moisture. In seasons with many rainfall events, which keep the topsoil moist, cereals may produce satisfactorily. Lupins grow very poorly and may die out completely in very shallow areas. Lupins because they are stressed, tend to be prone to the disease brown leaf spot (*Pleiochaeta setosa*).

Recharge to the deep groundwater-table is high under agricultural species. Tagasaste grows very poorly on this soil.

<table>
<thead>
<tr>
<th>Yield estimates and capability rating for various land uses</th>
<th>Shallow mottled zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land use</td>
<td>Achievable average yield</td>
</tr>
<tr>
<td>1. Pasture (g)</td>
<td>3-4 DSE/ha (winter grazed)</td>
</tr>
<tr>
<td>2. Wheat</td>
<td>0.6-1.0 t/ha</td>
</tr>
<tr>
<td>3. Lupins</td>
<td>0.5-0.8 t/ha</td>
</tr>
<tr>
<td>4. Tagasaste</td>
<td>very poor growth</td>
</tr>
</tbody>
</table>

* Depending on depth of topsoil.
2.2 Hillside soils

Hillside soils are found on the sloping country generally below the sandplain soils and above the Valley floor soils. They are found in three soil landscape units, the Booraan, Collgar and Danberrin (these three units are illustrated and described in Figure 2).

In most situations the Booraan unit occurs downslope from the Ulva sandplain and extends towards to the valley floor. It contains the **Shallow hardsetting grey sandy loam over clay**, **Sandy loam over clay** and patches of **Loamy sand over clay** soil types. Slopes are in the order of 2 to 8%.

The Collgar unit occurs on the gentle, lower slopes (1 to 3%) and contains **Loamy sand over clay** soils.

The Danberrin unit contains soils derived from fresh rock and is commonly found around rock outcrops and in minor drainage lines. Slope gradients generally vary from 2 to 8%. The type of soil formed depends on the nature of the parent rock. Three soil types have been defined, these being the **Rocky red brown loamy sand/sandy loam**, the **Brownish grey granitic loamy sand** and the **Red brown doleritic clay loam**. The **Brownish grey granitic loamy sand** is formed from granitic rocks such as granite, migmatite and gneiss. The **Red brown doleritic clay loam** is formed from fine grained, basic rocks such as dolerite. While the **Rocky red brown loamy sand/sandy loam** is probably formed from granitic rocks which have a higher percentage of iron within them, or, in areas where greater mixing of soils developed from both basic rocks and granitic rocks has occurred.

There are six soil types that occur on the hillslopes:

8. **Shallow hardsetting grey sandy loam over clay**
9. **Sandy loam over clay**
10. **Loamy sand over clay**
11. **Rocky red brown loamy sand/sandy loam**
12. **Brownish grey granitic loamy sand**
13. **Red brown doleritic clay loam**.
8. Shallow hardsetting grey sandy loam over clay

Hardsetting, hard to manage, grey sandy loam. Found on the upper slopes, often immediately below a breakaway or low scarp. White, decomposing granitic rock or pallid zone often occurs on the surface.

P.P.F. Dy 2.13, Db 1.43

Meenaar series

Horizon

A1  Dark greyish (10YR 4/2), medium to coarse grained loamy sand to sandy loam. Hardsetting surface, massive structure. pH = 6.0

A2/A3  Light brownish grey (10YR 6/2) to yellowish brown (10YR 5/6) clayey sand to sandy clay loam. Massive structure. pH = 6.5
(Note — this layer is often absent.)

B2  Pale brown (10YR 6/4) to light brownish grey (10YR 6/2), sandy clay to medium clay. Moderately structured. May contain calcareous (lime) segregations. pH = 6.5 (but can become alkaline at depth).

C  Pallid zone or saprolite (decomposing rock).
Identifying characteristics

The **Shallow hardsetting grey sandy loam over clay** includes all the poorly structured, very hardsetting, gritty, grey soils formed from the pallid zone of the lateritic profile. This soil consists of a hardsetting, greyish loamy sand to sandy loam topsoil to about 10 to 20 cm over a brownish clay subsoil often overlying pallid zone or saprolite. White decomposing rock is commonly seen on the soil surface.

Deeper phases of this soil grade into the **Sandy loam over clay**. The **Shallow hardsetting grey sandy loam over clay** can be distinguished by its shallower, more hardsetting topsoil and its poorer yields.

Position in the landscape

This soil usually occurs only as small areas and is often found immediately below a breakaway, dip in the landscape or gravel ridge that forms the edge of the Ulva sandplain. In some cases this soil can occur on the midslopes as small ridges. Slopes are usually in the order of 4 to 7%. This soil occurs within the Booraan soil landscape unit.

Vegetation

White gum (*Eucalyptus wandoo*) is the dominant native vegetation with some mallee species and salmon gum (*E. salmonophloia*).

Land qualities

**Soil structure decline**

The surface structure of this soil is poor and cultivation leads to further deterioration of the soil structure. The clayey subsoil is very shallow and is often dispersive. When brought to the surface during cultivation the dispersive clay will adversely affect the stability of the surface soil layers. Soil compaction through sheep trampling may also result in surface structural deterioration. Soil structural decline can decrease rainfall infiltration thereby reducing soil available water, increase soil density and the degree of hardsetting, restrict crop emergence and root growth and result in a narrow time range in which machinery can be used on the land.

**Moisture availability**

The topsoil is often very thin and because of its poor structure it has fewer pores and cracks in which to store moisture. The clay subsoil is capable of storing large quantities of moisture.
Nutrient availability

This soil has a good ability to hold and supply nutrients for plant growth. The confining clay layer prevents nutrients from being rapidly leached out of the root zone. The subsoil is sometimes alkaline (pH up to 8.5).

The topsoil has a low potential for acidification.

Waterlogging and trafficability

Waterlogging rarely occurs on these soils because of their slope and position in the landscape. However, if heavy rains follow seeding, vehicle access may be limited. Where large amounts of white decomposing rock occur on the surface this may hinder cultivation and cause excessive wear on tillage equipment.

Rooting conditions

This dense, poorly structured soil greatly restricts the root growth of crop and pasture species. This is one of the major limitations to production.

Water erosion

Water erosion is very common on these sloping soils. The degraded soil structure limits rainfall penetration, causing run-off and erosion.

Salinity

The pallid zone underneath these soils often contains large amounts of salt. In some cases the topsoil is saline, which affects plant growth.

Other

Wind erosion is rare on this hardsetting soil. Recharge to the groundwater table would be expected to be low on this clayey soil.

Productivity and capability

The Shallow hardsetting grey sandy loam over clay is a poor producing soil. Adverse rooting conditions, low moisture availability, soil structural deterioration, poor trafficability and the water erosion hazard combine to make this a problem soil.

Subterranean clover grows poorly as it has difficulty burying its burr under the hardsetting surface. With good management, burr medic growth is average, though the hardsetting surface of this soil reduces medic emergence and plant numbers.

Cereal yields are below average because of problems associated with poor structure and moisture availability. However, in seasons when surface sealing is less of a problem and rain continues into spring, good yields can be achieved. The application of gypsum and reduced tillage has been shown to improve soil structure, making these soils more manageable and increasing yield. Deep ripping does not improve the soil condition.
Lupins grow poorly because of the shallow depth to the dense, often calcareous clay. The calcareous subsoil with its alkaline pH reduces the availability of iron to the lupin plant and may cause iron deficiency. Lupin seedlings have trouble emerging through the degraded, hardsetting surface of this soil.

Field peas are suitable for this soil type. Careful management of field pea stubbles is essential to control wind erosion.

Contour or grade banks are often required in order to control water erosion. These banks provide an efficient method of collecting water for farm dams. Harsher, steeper areas of this soil should not be cleared because of the water erosion hazard.

### Yield estimates and capability rating for various land uses

**Shallow hardsetting grey sandy loam over clay**

<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (g, m)</td>
<td>4-5 DSE/ha (winter grazed)</td>
<td></td>
<td>III-IV</td>
<td>moisture availability, soil structure decline</td>
</tr>
<tr>
<td>2. Wheat</td>
<td>0.8-1.5 t/ha</td>
<td>1.0-2.2 t/ha</td>
<td>III-IV</td>
<td>moisture availability, soil structure decline, water erosion</td>
</tr>
<tr>
<td>3. Lupins</td>
<td>poor growth</td>
<td></td>
<td>V</td>
<td>moisture availability, soil structure decline</td>
</tr>
<tr>
<td>4. Field peas</td>
<td>0.5-1.0 t/ha</td>
<td>1.2 t/ha</td>
<td>IV</td>
<td>moisture availability, soil structure decline, water erosion</td>
</tr>
</tbody>
</table>
9. Sandy loam over clay

Grey, brown or dull reddish loamy sand to sandy loam over clay supporting salmon gum and found on the upper and mid slopes.

P.P.F. Dy 2.13, Dy 2.23

Booraan series

Horizon

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Dark greyish brown (10YR 4/2) to reddish brown (7.5YR 3/4) loamy sand to sandy loam. Hardsetting surface, massive structure. pH = 6.5</td>
</tr>
<tr>
<td>A3</td>
<td>Dark greyish brown (10YR 4/2), dark reddish brown (5YR 3/3) to light yellowish brown (10YR 6/4) sandy loam to sandy clay loam. Massive structure. pH = 6.5 to 8.0</td>
</tr>
<tr>
<td>B2</td>
<td>Light yellowish brown (10YR 6/4), brown (7.5YR 5/4) to dark reddish brown (5YR 3/3) medium clay. Moderately structured. May contain calcareous (lime) segregations. The pH is generally about 7.0 but can become alkaline at depth (8.5).</td>
</tr>
</tbody>
</table>
Identifying characteristics

The **Sandy loam over clay** includes the large areas of hardsetting, heavier, grey to brownish soils that occur on hillsides. The loamy sand to sandy loam topsoil is about 10 cm deep and is often underlain by a thin layer of dark yellowish brown loamy sand to sandy clay loam. The clay subsoil occurs at 10 to 30 cm. Variations of this soil that may be encountered include: a thin, pale A2 horizon above the clay layer and heavier phases where a sandy clay loam occurs at the surface.

This soil has a deeper, less hardsetting topsoil and produces higher yields than the **Shallow hardsetting grey sandy loam over clay**.

Position in the landscape

The **Sandy loam over clay** occurs on the upper and mid slopes (2 to 6%). It often occurs downslope from the **Shallow hardsetting grey sandy loam over clay** and extends towards the valley floor. This soil comprises a large percentage of the Booraan soil landscape unit.

Vegetation

Salmon gum (*Eucalyptus salmonophloia*) is the dominant native vegetation. Gimlet (*E. salubris*), white gum (*E. wandoo*) and some mallee species can also occur.

Land qualities

**Moisture availability**

This soil has a good ability to supply moisture for plant growth. The loamy sand to sandy loam topsoil, which can be up to 30 cm deep, has a good water holding capacity. The clay subsoil, which is capable of storing large amounts of moisture, is within the root zone of crop and pasture species.

**Nutrient availability**

This soil has a good ability to hold and supply nutrients for plant growth. The clay subsoil prevents nutrients from being rapidly leached out of the root zone. The subsoil is sometimes alkaline (the pH can be 8.5).

This productive soil is at some risk of topsoil acidification because of this layer's low to moderate pH buffering capacity. The high clay content of the subsoil reduces the risk of subsurface acidification (high pH buffering capacity and low leaching potential).

**Waterlogging and trafficability**

These soils can become waterlogged but generally they occur on slopes steep enough for water to drain away. They become boggy following heavy rain and vehicle access may be limited.
Soil structure decline
Cultivation, and sheep trampling when the soil is above a critical moisture content can degrade the structure of this soil. As a result the soil slakes and sets hard resulting in poor rainfall infiltration, poor seedling emergence and increased run-off.

Water and wind erosion
These hillside soils are prone to water erosion. Runoff from areas of Shallow hardsetting grey sandy loam over clay soils upslope can initiate erosion. Wind erosion is rare on this hardsetting soil.

Recharge hazard
This soil would be expected to add little recharge to the deep groundwater-table in most years.

Other
Rooting conditions are generally good though the clay subsoil may present a barrier to the roots of some species. Salinity is not common on this soil.

Productivity and capability
The Sandy loam over clay is a good producing, heavier soil with good moisture and nutrient availability. Problems with soil structural decline and water erosion may be encountered.

Burr and barrel medic pasture grow well provided the soil pH is not too acid. The loamy topsoil and shallow clay subsoil are well suited to supplying moisture to these plants. Subterranean clover growth is variable with the plant having trouble burying its burr under the hardsetting surface of the heavier phases of this soil.

Cereals grow well and good yields can be obtained in wetter years. However, in more degraded examples the soil surface may seal over reducing plant emergence.

Lupin growth is generally poor. If the subsoil is alkaline then lupin growth can be affected owing to iron deficiency. The hardsetting soil surface hinders lupin seedling emergence.

This soil is well suited for growing field peas. Careful management of field pea stubbles is essential to control wind erosion.

The application of gypsum and/or the use of minimum tillage has been shown to improve the structure of these soils. Improving soil structure increases infiltration, decreasing some of the risk of water erosion. On longer slopes, contour or grade banks may be required to control surface waterflow. Contour cultivation can reduce run-off.
<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (m)</td>
<td>6-8 DSE/ha (winter grazed)</td>
<td></td>
<td>II</td>
<td>moisture availability</td>
</tr>
<tr>
<td>2. Wheat</td>
<td>1.6-1.8 t/ha</td>
<td>2.5-3.3 t/ha</td>
<td>I-II</td>
<td>moisture availability, water erosion, soil structure decline</td>
</tr>
<tr>
<td>3. Lupins</td>
<td>0.7-1.0 t/ha</td>
<td>1.6 t/ha</td>
<td>IV</td>
<td>moisture availability, nutrient availability (pH), soil structure decline</td>
</tr>
<tr>
<td>4. Field peas</td>
<td>1.0-1.2 t/ha</td>
<td>1.8-2.0 t/ha</td>
<td>II</td>
<td>wind erosion, soil structure decline</td>
</tr>
</tbody>
</table>
10. Loamy sand over clay

Good quality, greyish loamy sand over a pale sand to clayey sand overlying yellowish clay at about 40 cm — 'Mallee soils'

P.P.F. Dy 3.42, Dy 2.12, Dy 5.42

Morbinning series, Quajabin series, Mortlock series.

Horizon

A1     Grey brown (10YR 4/2), medium to coarse grained sand to loamy sand.
       Usually has a loose to firm surface, but can be hardsetting.
       pH = 6.5

A2/A3 Pale (10YR 7/4) to yellowish brown (10YR 5/4) sand to clayey sand.
       Single grained to massive structure.
       pH = 6.5

(Note — an ironstone gravel layer or silicious hardpan may occur above the clay subsoil.)

B2     Light yellowish brown (10YR 6/4) medium clay.
       Red and pale mottles commonly occur.
       Moderately structured.
       pH = 6.5
Identifying Characteristics

The **Loamy sand over clay** consists of a greyish sand to loamy sand topsoil over a pale to yellowish brown sand to loamy sand layer over a yellowish brown clay subsoil. This clay subsoil is usually encountered at depths between 20 and 60 cm. Variations that may occur in this soil type include where:

- the depth to clay is up to 80 cm
- the texture of the surface horizon below 10cm is a sandy loam or
- where a white bleached A2 horizon occurs above the clay.

A siliceous hardpan may develop above the clay subsoil when this soil occurs on the lower slopes of the landscape. In this case the clay is usually mottled or greyer.

This soil is commonly referred to as a ‘mallee soil’.

Position in the landscape

The **Loamy sand over clay** occurs on the mid and lower slopes. It occurs within the Collgar and Booraan soil landscape units, where the Collgar unit occurs on lower slopes and is more prone to waterlogging.

This soil type is common in the Wyalkatchem, Dowerin and East Quairading areas.

Vegetation

Various species of mallee (*Eucalyptus transcontinentalis*, *E. cylindrilflora*, *E. erythronema*, and *E. foecunda*) are the dominant native vegetation. White gum (*E. wandoo*) and tammar (*Allocasuarina campestris*) also occur with some stunted salmon gums (*E. salmonophloia*) on heavier phases.

Land qualities

**Moisture availability**

This soil is able to hold and supply sufficient amounts of water for good plant growth. The surface horizon is often a loamy sand and therefore has a reasonable water holding capacity. The clayey subsoil can store large quantities of moisture for plant growth.

Phases of this soil with shallower depths to clay and with a higher percentage of clay in the surface horizons are usually better able to supply moisture for plant growth than deeper, sandier phases.

**Nutrient availability**

This soil has a fair to good ability to hold and supply nutrients for plant growth. The clay subsoil prevents the rapid leaching of nutrients from the root zone. This productive soil is at high risk of surface soil acidification because of its low pH buffering capacity and high potential for leaching from the topsoil.
Waterlogging and salinity

In heavier rainfall years a perched water table may develop on top of the clay layer. Waterlogging of crops can occur, especially at a break of slope or within depressions where run-on or seepage flow accumulates.

This soil may also suffer from salinity.

Rooting conditions

Rooting conditions are generally good although the clay subsoil may present a barrier to some species. If a siliceous hardpan has developed above the clay it will restrict root growth.

Trafficability

This soil is quite easy to work because of its sandy surface and lack of rocks. It is also capable of being worked over a wider range of moisture conditions than the heavier soils. Some waterlogging prone areas that occur on the lower slopes become boggy following heavy rain.

Soil structure decline

A traffic compaction pan may develop following cultivation, especially on soils with a deeper, sandy topsoil.

Wind erosion and water erosion

Wind erosion can occur on phases of this soil with a loose, sandy topsoil. Water erosion can be a problem on these sloping soils.

Recharge hazard

Little is known about how much recharge these soils add to the groundwater. However, if these soils are waterlogged they would be expected to add significant recharge.

Productivity and capability

The Loamy sand over clay is generally a productive soil with good moisture and nutrient availability. Waterlogging problems can occur in some years in areas of this soil on lower slopes. Traffic compaction pans, water and wind erosion may present some problems.

Subterranean clover and other pasture species grow well, particularly when the clayey subsoil is closer to the surface and the sandy topsoil has a higher clay content. Murex medic and burr medic have potential on this soil provided the topsoil is not too acidic (see Appendix 5, p. 127).

Cereals grow well on this soil as their adventitious root system is able to reach, penetrate and extract water from the clay subsoil. Deep ripping can be used to break up traffic compaction pans.

Lupins generally grow well but can suffer from waterlogging in wetter areas and moisture stress in areas where the topsoil is shallow or where a siliceous hardpan limits root growth.
Field peas grow well, however, under current management practices the grazing of stubbles poses a serious wind erosion hazard.

Careful management of stock, minimum tillage and stubble retention practices should be used to reduce the risk of wind erosion.

Grade banks, reverse bank seepage interceptors or level banks are required to control runoff on steeper, longer slopes.

Applications of lime may be necessary in the future to overcome soil acidity.

### Yield estimates and capability rating for various land uses

**Loamy sand over clay**

<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (s,m)</td>
<td>7-8 DSE/ha (winter grazed)</td>
<td>I-II</td>
<td>moisture availability</td>
<td></td>
</tr>
<tr>
<td>2. Wheat</td>
<td>1.6-2.2 t/ha</td>
<td>2.2-3.0 t/ha</td>
<td>I-II</td>
<td>moisture availability waterlogging</td>
</tr>
<tr>
<td>3. Lupins</td>
<td>1.0-1.4 t/ha</td>
<td>2.0 t/ha</td>
<td>II</td>
<td>moisture availability waterlogging</td>
</tr>
<tr>
<td>4. Field peas</td>
<td>1.0-1.2 t/ha</td>
<td>1.8-2.0 t/ha</td>
<td>IV</td>
<td>wind erosion</td>
</tr>
</tbody>
</table>
11. Rocky red brown loamy sand/sandy loam

Rocky, red brown to brown loamy sand to sandy loam over clay and/or bedrock - 'York gum/jam soils'

P.P.F. Dr 2.12, Db 3.12, Uc 6.13

York series, Mulukine series, Seabrook series.

Horizon

A1  Brown (10YR 4/3) to dark reddish brown (5YR 3/3) medium to coarse grained loamy sand to sandy loam. Loose to hardsetting surface. Weakly structured to massive. pH = 6.0

A3/B1 Reddish brown (5YR 4/4) to yellowish brown (10YR 5/4) clayey sand to sandy loam. Weakly structured to massive. pH = 7.0

B2  Reddish brown (5YR 5/6) to brown (7.5YR 4/4) medium clay. Moderately structured. pH = 7.0

C  Decomposing bedrock.
Identifying characteristics

The **Rocky red brown loamy sand/sandy loam** includes all the red brown, loamy textured soils formed from the breakdown of fresh rock.

This soil consists of a red to brown loamy sand to sandy loam overlying a reddish to yellowish brown clayey sand to sandy loam which overlies a reddish to yellowish brown clay and/or decomposing bedrock. The soil profile generally becomes deeper further downslope from rock outcrops due to colluvial movement.

There is considerable variability within this soil because of the differences in the parent rock from which the soil is formed. If the parent rock is more basic then the soils are generally redder and heavier. If the parent rock is more granitic, then the soils are paler and sandier. The more extreme cases of this variation are described as separate soil types: the **Red brown doleritic clay loam** is a heavy soil formed from dolerite rock while the **Brownish grey granitic loamy sand** is a grey, sandier soil over clay or granite.

The **Rocky red brown loamy sand/sandy loam** is commonly referred to as a ‘York gum-jam soil’.

Position in landscape

This soil occupies no set topographical position but occurs where fresh rock has been exposed. This is commonly around rock outcrops and usually on hillslopes. It is also found in minor drainage lines. This soil occurs in association with the **Brownish grey granitic loamy sand** and the **Red brown doleritic clay loam**. These three soils occur together in the Danberrin soil landscape unit.

Vegetation

York gum (**Eucalyptus loxophleba**) and jam (**Acacia acuminata**) are the dominant native vegetation. **E. foecunda** occurs in some areas.

Land qualities

**Moisture availability**

These soils are good at storing and supplying moisture for crop and pasture growth. Their loamy sand to sandy loam topsoil has a good water holding capacity, while the well structured clay subsoil can supply moisture for plant growth towards the end of the growing season. However, where the bedrock is shallow, the moisture availability is greatly reduced.

**Nutrient availability**

The natural fertility of these soils is often high. This is because the soil is relatively young, being formed from fresh rock.

The clay subsoil prevents the rapid leaching of fertiliser nutrients from the root zone.

This productive soil is at high risk of surface acidification because of its low to moderate pH buffering capacity and high potential for leaching from the topsoil.
**Waterlogging and salinity**

Generally these soils are well drained. Waterlogging may occur in small areas where water seeps off rock outcrop or is forced to the surface by shallow bedrock. Areas that tend to waterlog are usually greyer in colour. Small patches of salinity may form in areas receiving seepage.

**Water erosion**

This soil is prone to water erosion with steeper, longer slopes being most at risk. Erosion is often initiated by water flowing off rock outcrop.

**Rooting conditions**

Rooting conditions are generally good despite the large amounts of rock within the profile. However, where sheets of bedrock occur close to the surface the soil volume is greatly reduced.

**Soil structure decline**

This soil is not greatly affected by surface soil structure decline or by the development of traffic compaction pans.

**Trafficability**

The large amounts of surface rock may limit cultivation and harvesting, especially of peas. Rocks may need to be collected and removed. Tractor access after heavy rain is usually possible within a few days.

**Other**

Wind erosion is rare if the soil is well managed. This soil would not be expected to be a major contributor to groundwater recharge.

---

**Productivity and capability**

Pastures and crops perform consistently well on the *Rocky red brown loamy sand/sandy loam*. This soil is relatively free of the nutrient and moisture availability, waterlogging and salinity problems which beset many of the other soil types.

This is one of the best pasture growing soil types within the zone. Subterranean clover, broad-leaved weeds, and grasses all grow well. Burr medics grow well provided the soil pH is not less than about 6.0. The soil retains enough moisture close to the surface to be accessible to these shallower rooted species. Some areas need to be left in continuous pasture because of their steep slope and rockiness.

Cereal yields are some of the highest in the zone and are responsive to high applications of nitrogen.

Lupins can grow well but yields tend to be variable with lower yields produced in dry years because of drought stress in spring.

Field peas produce good yields, but under current grazing management strategies, some wind erosion is likely to occur.
Canola grows well on this soil.

On the steeper and longer slopes, grade or contour banks may be required to control water erosion. Minimum tillage practices are recommended as they leave the soil surface bare for shorter periods than conventional cultivation thus reducing the chance of water erosion.

Applications of lime may be necessary in the future to overcome soil acidification.

<table>
<thead>
<tr>
<th>Yield estimates and capability rating for various land uses</th>
<th>Rocky red brown loamy sand/sandy loam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land use</td>
<td>Achievable average yield</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------------</td>
</tr>
<tr>
<td>1. Pasture (s)</td>
<td>7.9 DSE/ha (winter grazed)</td>
</tr>
<tr>
<td>2. Wheat</td>
<td>1.8-2.0 t/ha</td>
</tr>
<tr>
<td>3. Lupins</td>
<td>1.0-1.2 t/ha</td>
</tr>
<tr>
<td>4. Field peas</td>
<td>1.0-1.2 t/ha</td>
</tr>
</tbody>
</table>
12. Brownish grey granitic loamy sand

Greyish sand to loamy sand over a pale, clayey sand overlying yellowish clay and/or rock. Often found adjacent to granite outcrops.

P.P.F. Dy 5.22, Dy 5.12, Dy 5.42, Uc 5.22

Malebelling series, Boyadine series.

Horizon

A1 Greyish brown (10YR 4/2), medium to coarse sand to loamy sand. Loose to hardsetting surface. Single grains or massive structure. pH = 6.0

A2/A3 Pale (10YR 7/3) to yellowish brown (10YR 6/4) sand to clayey sand. Single grained to massive structure. pH = 6.5

B2 Yellowish brown (10YR 6/6) to pale brown (10YR 7/4) sandy clay to clay. Often contains red, pale and yellow mottles. Moderately structured. pH = 6.5

C Decomposing granite.
Identifying characteristics

The **Brownish grey granitic loamy sand** includes the brownish grey, sand to clayey sand surfaced soils that have developed from granitic rock. Beneath the topsoil is a pale to yellowish brown sand to clayey sand, which in turn overlies a mottled clay and/or bedrock.

The **Brownish grey granitic loamy sand** can be distinguished from the **Loamy sand over clay** by its better structured clay subsoil, absence of ironstone gravel and often by the presence of rock outcrop.

This soil can be distinguished from the **Rocky red brown loamy sand/sandy loam** by its greyer colour and generally lighter texture. The **Brownish grey granitic loamy sand** is commonly called a ‘jam soil’.

Position in the landscape

This soil is found adjacent to granitic rock outcrop. Slopes range from 2 to greater than 10%. It usually occurs in association with the **Rocky red brown loamy sand/sandy loam** and sometimes the **Red brown doleritic clay loam**. These three soil types occur together in the Danberrin soil landscape unit.

Vegetation

Jam (**Acacia acuminata**) is the dominant native vegetation. The occasional York gum (**Eucalyptus loxophleba**), sheoak (**Allocasuarina heugeliana**) and, in some areas, white gum (**E. wandoo**) also occur.

Land qualities

**Moisture availability**

The more productive phases of this soil have a loamy sand topsoil which has a good water holding capacity. However, in poorer phases, the topsoil is often a coarse or even gritty sand which has a low moisture availability. As a result, crops and pasture can experience premature moisture stress during dry periods within or at the end of the growing season.

The clayey subsoil can hold larger quantities of water. The depth of this clay layer and percentage of clay in the topsoil are very important in determining how much moisture this soil can supply.

**Nutrient availability**

This soil has a good ability to hold and supply nutrients for plant growth. The clay subsoil prevents rapid leaching of nitrogen fertiliser from the root zone.
This productive soil is at high risk of surface and subsurface acidification because of its low pH buffering capacity and high potential for leaching from the topsoil.

**Waterlogging and salinity**

In wet years waterlogging of crops can occur in small patches where water seeps out of rocky areas. Salinity may form in seepage areas.

**Rooting conditions**

The rooting conditions are generally good however sheets of granite may occur close to the surface limiting root growth. Plants in these areas become moisture stressed in drier periods.

**Recharge hazard**

The Brownish grey granitic loamy sand generally has a clayey subsoil and would not be expected to add appreciable amounts of recharge. However, recharge can occur through preferred pathways such as weathered quartz veins.

**Soil structure decline**

This soil is not greatly affected by surface soil structure decline. A traffic compaction pan may develop at about 20 cm on sandier phases of this soil.

**Trafficability**

Small seepage areas, that often occur adjacent to rock outcrop, become boggy. Surface rock can limit cultivation and rocks may need to be collected and placed in piles.

**Water erosion and wind erosion**

Water erosion is common, especially where run-off from rock outcrops flows onto this soil. Wind erosion is a potential problem following cultivation and/or overgrazing on this sandy surfaced soil.

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**Productivity and capability**

The Brownish grey granitic loamy sand is an average to above average quality soil suitable for cereals, lupins and pasture. Limited moisture availability in dry periods, waterlogging in seepage areas and shallow rock areas which limit root growth result in reduced yields. The soil must be managed carefully to control water and wind erosion.

Pasture growth is generally quite good but subterranean clover tends to be affected by moisture stress earlier in spring than on the Rocky red brown loamy sand/sandy loam. Burr medic has potential provided the soil pH is not below about 6.0.

Cereal yields are about average or just above that for this zone. Moisture stress in dry periods and, occasionally, waterlogging in wet years, reduce cereal yields.
Lupins grow well, especially where the soil is deeper. However, yields are poor in seepage areas because of waterlogging and poor in shallow rock areas because of limited rooting depth.

Field peas can grow quite well on this soil type. Surface rock is often a hindrance to harvesting. Field pea stubbles should not be grazed or if grazed should be managed carefully to avoid wind erosion.

On the steeper, longer slopes, grade or contour banks may be required to control water erosion. Minimum tillage practices are recommended as they leave the soil bare for shorter periods than conventional cultivation, thus reducing the chance of water erosion.

Applications of lime may be necessary in the future to overcome soil acidification.

<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (s)</td>
<td>6-7 DSE/ha (winter grazed)</td>
<td>II</td>
<td>moisture availability</td>
<td></td>
</tr>
<tr>
<td>2. Wheat</td>
<td>1.5-1.8 t/ha</td>
<td>2.2-2.6 t/ha</td>
<td>II</td>
<td>moisture availability waterlogging</td>
</tr>
<tr>
<td>3. Lupins</td>
<td>1.0-1.4 t/ha</td>
<td>1.6-1.8 t/ha</td>
<td>II</td>
<td>moisture availability waterlogging rooting depth</td>
</tr>
<tr>
<td>4. Field peas</td>
<td>0.8-1.0 t/ha</td>
<td>1.8-2.0 t/ha</td>
<td>IV</td>
<td>wind erosion</td>
</tr>
</tbody>
</table>
13. Red brown doleritic clay loam

Red brown loam or clay over a red clay found in strips alongside dolerite dykes. Black dolerite rock often occurs on the soil surface.

P.P.F. Dr 2.12, Gn 3.13, Ug 5.36

Northam series

Horizon

A1 Reddish brown (5YR 3/3) sandy clay loam to medium clay. Often self-mulching with surface cracks, but can be hardsetting. pH = 6.5

(Note — A transitional A3 sandy clay loam or clay loam horizon may occur.)

B2 Reddish brown (5YR 4/4) medium clay. Strongly structured. Often contains dolerite rock. May contain lime at depth. pH = 6.5 to 8.5

C Decomposing dolerite rock.
Identifying characteristics

The **Red brown doleritic clay loam** includes the red to brown, heavy textured soils formed from dolerite or similar fine grained, basic rocks.

The soil consists of a reddish brown sandy clay loam to clay loam overlying a dark red clay on dolerite. The soil surface often has crabholes (gilgais). Black dolerite rock is commonly found on the surface. Variation can occur in the surface texture which may range from a sandy loam to a medium clay. The soil is occasionally greyish.

This soil type can be distinguished from the **Rocky red brown loamy sand/sandy loam** by its heavier topsoil and generally by the presence of surface cracks.

Position in the landscape

The **Red brown doleritic clay loam** occurs immediately adjacent to the dolerite dykes from which it was formed (dolerite is a fine grained, black basic rock which when in a molten state intruded through the granitic basement rock). As a result this soil often forms as a thin strip or small area, within areas of **Rocky red brown loamy sand/sandy loam** or **Brownish grey granitic loamy sand**. This soil occurs together with these other two soil types within the Danberrin soil landscape unit.

The **Red brown doleritic clay loam** is far more common in the Avon Valley where the landscape has been more dissected and where the incidence of dolerite dykes is more common (Jimperding Gneiss Complex).

Vegetation

York gum (*Eucalyptus toxophleba*), salmon gum (*E. salmonophloia*) and needle bush (*Hakea preissii*) are the dominant native vegetation.

Land qualities

*Moisture availability and rooting conditions*

The good structure of this heavy soil with its many cracks and pores allows large amounts of water to be stored following heavy rain. This water can then be utilized by crops and pastures in dry periods during the growing season. The cracks within the clay subsoil allow good root penetration down to moisture reserves.
**Nutrient availability**

These soils have a high natural fertility. This is because the soil has formed from fresh dolerite rock and has not been weathered for long periods of time (high percentage of primary, weatherable minerals).

This soil has a low potential for acidification because of its fine texture (therefore low potential for leaching and high pH buffering capacity). The subsoil is often alkaline.

**Waterlogging**

These structured soils are well drained.

**Water erosion**

Water erosion can occur on steeper, sloping areas especially if run-off from adjacent rock outcrops flows onto cultivated land.

**Soil structure decline**

This soil does not suffer from soil structure decline following cultivation and can often have a self-mulching surface.

**Trafficability**

Rocky areas may limit cultivation. Heavy rain will cause this soil to become very boggy, especially after it has been cultivated. Access back onto this soil after cultivation may be limited for several weeks.

**Other**

Salinity and wind erosion are rare. The amount of recharge to the groundwater would be expected to be small. Rooting conditions are good.

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**Productivity and capability**

The **Red brown doleritic clay loam** is a good agricultural soil that can produce exceptional yields in good rainfall years.

Shallow rooted pasture species such as subterranean clover and medics grow well as their roots are able to penetrate into the structured clay and obtain moisture. Subterranean clover may have trouble burying its burrs in this hardsetting soil.

Cereal yields can be exceptional in good rainfall years because of this soil's ability to store water and its natural fertility. In dry years yields can be poor. This soil is capable of producing excellent hay crops. Cereal yields are very responsive to high rates of applied nitrogen.
Lupin yields are variable, with very poor yields in dry years and average yields in better years. If the pH is alkaline at depth, lupins may suffer from iron deficiency and yield poorly.

Field peas grow well, although the rocky surface may result in harvest difficulties. Wind erosion following grazing of field pea stubbles is rare provided good management is practised.

Grade or contour banks may need to be constructed to control water erosion. Minimum tillage is recommended as it leaves the soil exposed for a shorter period than conventional cultivation.

<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (s,m)</td>
<td>6-7 DSE/ha</td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(winter grazed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Wheat</td>
<td>1.8-2.5 t/ha</td>
<td>3.0-5.0 t/ha</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>3. Lupins</td>
<td>0.8-1.0 t/ha</td>
<td>1.5 t/ha</td>
<td>IV</td>
<td>moisture availability, nutrient availability (pH)</td>
</tr>
<tr>
<td>4. Field peas</td>
<td>1.2-1.5 t/ha</td>
<td>2.0-2.2 t/ha</td>
<td>I</td>
<td></td>
</tr>
</tbody>
</table>
2.3 Valley floor soils

The valley floor soils occur on the broad, flat valley floors of the Zone of Ancient Drainage. Three soil landscape units occur, the Merredin, Belka and Nangeenan units.

The Merredin unit contains the heavy red and grey soils which characteristically support salmon gum (*Eucalyptus salmonophloia*) and gimlet (*E. salubris*). Four soil types occur within this unit. These are: the **Red brown sandy loam over clay valley soil**, the **Red clay valley soil**, the **Grey clay valley soil** and the **Grey to brown cracking clay**.

The other major valley type is the pale, sandy surfaced Belka unit, which supports salmon gum (*E. salmonophloia*), york gum (*E. loxophleba*), white gum (*E. wandoo*) and some types of mallee. The depth of the sandy topsoil in these valleys ranges from about 10 cm to over 100 cm. The soils on the Belka unit have been divided into two soil types based on the depth to clay. The cut-off point was taken at 40 cm, as it was believed to have significance for cropping and pasture growth.

The Nangeenan unit occupies small areas and is usually found around salt lakes. The dominant tree is morrel (*E. longicornis*). One soil type - the **Powdery surfaced calcareous soil** occurs within this soil landscape unit.

The following soil types occur on the valley floors within the Zone of Ancient Drainage:

14. **Deep sandy surfaced valley soil**
15. **Shallow sandy surfaced valley soil**
16. **Red brown sandy loam over clay valley soil**
17. **Red clay valley soil**
18. **Grey clay valley soil**
19. **Grey to brown cracking clay**
20. **Powdery surfaced calcareous soil**.
14. Deep sandy surfaced valley soil

Grey, sandy surfaced valleys. Clay occurs at about 60 cm.

P.P.F. Dy 4.43, Dy 5.13

Bungulla series

Horizon

A1 Grey brown (10YR 3/3) sand to loamy sand. Loose to firm surface. Single grains. pH = 6.5

A2/A3 Light yellowish brown (10YR 6/4) sand to clayey sand. Single grains. pH = 7.0

B2 Pale brown (10YR 6/3) to brownish yellow (10YR 6/6) medium clay. Faint, pale mottles may be present. Strongly structured. Calcareous (lime) segregations are often present. pH = 7.0 to 8.5
Identifying characteristics

The topsoil consists of a loose, grey brown sand overlying a light yellowish brown sand to clayey sand. A pale brown to brownish yellow sandy clay occurs at depths between 40 and 80 cm. In some phases, a transitional sandy loam horizon is found above the clay layer. Small percentages of ironstone gravel may occur within the profile.

This soil can be differentiated from the Shallow sandy surfaced valley soil by the depth of the sandy topsoil.

Position in the landscape

This soil occurs on the broad, flat, pale sandy surfaced valleys of the central and eastern wheatbelt. It occurs together with the Shallow sandy surfaced valley soil within the Belka unit. Gradients on the Belka unit are very low often having a slope of around 1:1500.

Vegetation

The dominant native vegetation is salmon gum (Eucalyptus salmonophloia), York gum (E. loxophleba), white gum (E. wandoo) and some types of mallee.

Land qualities

Moisture availability

The deep, sandy topsoil has a low to moderate water holding capacity (depending on the percentage of clay). The clayey subsoil is capable of storing large amounts of moisture. The depth to this clay layer is important in determining how well crops and especially pastures perform. This soil, because it occurs on the valley floor, tends to receive some seepage from areas above.

Nutrient availability

This soil has a good ability to hold and supply nutrients for plant growth. The confining clay layer prevents nutrients from being rapidly leached out of the root zone. The subsoil is often alkaline with a pH of around 8.5.

The topsoil has a moderate to high risk of acidification because of its low pH buffering capacity and the potential for leaching from this layer.

Waterlogging

As these soils occur on the valley floor there is little external drainage. The clay subsoil impedes water movement and as a result a perched water-table can develop in wet years. The depth to the clay layer on the Deep sandy surfaced valley soil generally makes waterlogging less common than on the Shallow sandy surfaced valley soil.
Salinity
Large areas of this soil are saline. Many other areas have the potential to become saline.

Soil structure decline
This soil does not suffer surface structure decline following cultivation. A traffic compaction pan may develop at around 25 cm.

Trafficability
Cultivation is easy because of the sandy nature of the topsoil. In wet years, areas may become boggy limiting machinery access.

Wind erosion
The sandy topsoil makes these soils prone to wind erosion if poorly managed. However, erosion is less likely than on the poorer sandplain areas because of the higher clay content in the surface horizons and much better pasture growth.

Recharge hazard
In most years this soil would not be expected to contribute large amounts of recharge. However, areas that remain waterlogged over winter are likely to contribute recharge through preferred pathways in the clay subsoil.

Other
The rooting conditions are good. Water erosion rarely occurs.

Productivity and capability
The Deep sandy surfaced valley soil is an average to good quality soil suitable for cereals, pastures and lupins. Problems with salinity, waterlogging and wind erosion may be encountered.

This soil is suited to both subterranean clover and burr medics, but because of the depth to clay, pasture growth is not as good as on the Shallow sandy surfaced valley soil.

Cereal yields are generally high as their root system is able to exploit moisture reserves found at depth. Economic responses to deep ripping may be possible where traffic pans have developed.

Lupin yields are variable, in wet years waterlogging can affect growth, especially where the clay is closer to the surface. The calcareous subsoil, with its high pH, can cause iron deficiency in lupins.

Field peas produce satisfactory yields. Under current management strategies, grazing of field pea stubbles constitutes a major wind erosion hazard.

Considerable areas of this soil have been affected by salinity. See Section 2.5 for a classification of saline areas and suggested salt-tolerant species.

Applications of lime may be necessary in the future to overcome soil acidification.
Yield estimates and capability rating for various land uses

Deep sandy surfaced valley soil

<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (s,m)</td>
<td>6-7 DSE/ha (winter grazed)</td>
<td></td>
<td>II</td>
<td>moisture availability</td>
</tr>
<tr>
<td>2. Wheat</td>
<td>1.5-1.7 t/ha</td>
<td>2.8 t/ha</td>
<td>II</td>
<td>moisture availability waterlogging</td>
</tr>
<tr>
<td>3. Lupins</td>
<td>0.8-1.2 t/ha</td>
<td>1.8 t/ha</td>
<td>III</td>
<td>moisture availability waterlogging</td>
</tr>
<tr>
<td>4. Field peas</td>
<td>0.8-1.0 t/ha</td>
<td>1.4-1.6 t/ha</td>
<td>IV</td>
<td>wind erosion</td>
</tr>
</tbody>
</table>
15. Shallow sandy surfaced valley soil

Grey sandy surfaced valleys.
Clay occurs at about 10 - 30 cm.

P.P.F. Dy 4.12, Dy 2.13

Belka series

Horizon

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Grey brown (10YR 3/3) sand to loamy sand. Generally loose but may be hardsetting. Single grained or massive. pH = 6.5</td>
</tr>
<tr>
<td>A2/A3</td>
<td>Light yellowish brown (10YR 6/4) sand to clayey sand. Single grained or massive. pH = 7.0. (Note — this layer may be very thin or absent.)</td>
</tr>
<tr>
<td>B2</td>
<td>Light yellowish brown (10YR 6/4) medium clay. Faint, pale mottles may be present. Moderately structured. Calcareous (lime) segregations are often present. pH = 8.5</td>
</tr>
</tbody>
</table>
Identifying characteristics

The soil consists of a grey brown sand to loamy sand topsoil overlying a light yellowish brown sand to clayey sand. A light yellowish brown clay occurs at depths of less than 40 cm.

This soil can be differentiated from the **Deep sandy surfaced valley soil** by the depth of the sandy topsoil.

Position in the landscape

This soil occurs on the broad, flat, pale, sandy surfaced valleys of the central and eastern wheatbelt. It occurs together with the **Deep sandy surfaced valley soil** within the Belka soil landscape unit. Gradients on the Belka unit are very low, often having a slope of around 1:1500.

Vegetation

Dominant indicator vegetation consists of salmon gum (Eucalyptus salmonophloia), York gum (E. loxophleba), white gum (E. wandoo), gimlet (E. salubris) and some types of mallee.

Land qualities

**Moisture availability**

This shallow duplex soil is able to supply enough moisture in most years to both shallow rooted pasture species and deeper rooted crops to enable good growth. The topsoil is often a clayey sand and therefore has a reasonable water holding capacity. Large reserves of water can be held in the clayey subsoil.

**Nutrient availability**

This soil has a good ability to hold and retain nutrients for plant growth. The confining clay layer prevents nutrients from being rapidly leached out of the root zone. The subsoil is alkaline with a pH of around 8.5.

The soil is at some risk of surface acidification because of the low pH buffering capacity and high potential for leaching from the topsoil. The lime content of the subsoil results in a very high pH buffering capacity.

**Waterlogging**

As these soils occur on valley floors there is little external drainage. The clay subsoil impedes water movement and, as a result, a perched water table can develop in wet years. The depth to the clay layer on the **Shallow sandy surfaced valley soil** generally makes waterlogging more common than on the **Deep grey sandy surfaced valley soil**.

**Salinity**

Large areas of this soil are saline. Many other areas are at risk of becoming saline.
Soil structure decline
These soils do not suffer surface structure decline following cultivation. A traffic compaction pan may develop.

Trafficability
Cultivation is easy because of the sandy surface. In wet years, some areas of this soil become boggy and vehicle access is limited.

Wind erosion
The clay content in the surface horizons and good ground cover makes wind erosion unlikely. However, if managed poorly, wind erosion can occur.

Recharge hazard
In most years this soil would not be expected to contribute large amounts of recharge. However, areas that remain waterlogged over winter are likely to contribute recharge through preferred pathways in the clay subsoil.

Other
Rooting conditions are good although the clay subsoil may present a barrier to some species. Water erosion rarely occurs.

Production and capability

The **Shallow sandy surfaced valley soil** is a good quality soil suitable for cereal and pasture production. However, problems with salinity and waterlogging may be encountered.

This soil is suited to both subterranean clover and burr medics. Subterranean clover grows well and in an average rainfall year this soil will support equal to or more stock than the heavier clay soils. Pasture growth is poor if this soil becomes saline.

Cereal yields are good, although waterlogging can reduce yields in very wet years.

Lupins generally grow poorly. The shallow depth to clay may limit growth of the lupin tap root. In wetter years lupins become affected by waterlogging. The calcareous subsoil with its high pH can cause iron deficiency in lupins.

Good field pea yields can be obtained but under current management strategies the grazing of field pea stubbles constitutes a major wind erosion hazard.

Applications of lime may be necessary in the future to overcome soil acidification.

Section 2.5 outlines salt tolerant fodder shrubs suitable for growing on saline areas of this soil.
Yield estimates and capability rating for various land uses

Shallow sandy surfaced valley soil

<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (s,m)</td>
<td>7.9 DSE/ha (winter grazed)</td>
<td>3.3 t/ha</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>2. Wheat</td>
<td>1.5-1.9 t/ha</td>
<td>3.3 t/ha</td>
<td>I-II</td>
<td>waterlogging</td>
</tr>
<tr>
<td>3. Lupins</td>
<td>0.8-1.0 t/ha</td>
<td>1.4 t/ha</td>
<td>IV</td>
<td>moisture availability, waterlogging, nutrient availability (pH)</td>
</tr>
<tr>
<td>4. Field peas</td>
<td>1.0-1.2 t/ha</td>
<td>1.6-1.8 t/ha</td>
<td>IV</td>
<td>wind erosion</td>
</tr>
</tbody>
</table>
16. Red brown sandy loam over clay valley soil

Red brown sandy loam over clay soils found on the broad valley floors of the central and eastern Wheatbelt — 'Merredin sandy loam'
P.P.F. Db 1.13, Dr 2.13.
Merredin series, Kellerberrin series.

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Dark brown (7.5YR 3/4) sandy loam to sandy clay loam. Hardsetting, often degraded. Weakly structured. pH = 7.0</td>
</tr>
<tr>
<td>B21</td>
<td>Reddish brown (7.5YR 4/6) sandy clay loam to medium clay. Strongly structured. pH = 7.5</td>
</tr>
<tr>
<td>B22</td>
<td>Reddish brown (7.5YR 4/6) medium clay. Strongly structured. Calcareous (lime) segregations. pH = 8.5</td>
</tr>
</tbody>
</table>

Surface | Depth (cm) |
---------|------------|
10       | 20         |
30       | 40         |
50       | 60         |
70       | 80         |
90       | 100        |
Identifying characteristics

The **Red brown sandy loam over clay valley soil** includes the red brown loamy surfaced valley soils of the Zone of Ancient Drainage.

The soil consists of a dark brown sandy loam over a reddish brown clay at about 15 to 40 cm. An intermediate sandy clay loam layer may occur above the clay. This soil can be distinguished from the **Red clay valley soil** by its sandy loam topsoil. This soil is sometimes referred to as a ‘Merredin sandy loam’.

Position in the landscape

This soil occurs on the broad, flat, heavy textured valleys of the central and eastern wheatbelt. It occurs in association with the **Red and grey clay valley soils** and the **Grey to brown cracking clay** with these soils occurring on the Merredin soil landscape unit. Gradients in the Merredin unit are very low often having a slope of around 1:500.

Vegetation

The dominant indicator vegetation is salmon gum (*Eucalyptus salmonophloia*) and gimlet (*E. salubris*).

Land qualities

**Moisture availability**

This soil is well suited to supplying moisture for plant growth. The sandy loam topsoil has good water holding capacity. The clay subsoil is close to the surface and can retain large volumes of moisture from heavy rainfall. Crops and pastures growing on this soil do not suffer moisture stress during dry periods to the same extent as those growing on the **Red and grey clay valley soils**.

**Nutrient availability**

These soils are naturally some of the most fertile in the wheatbelt. The subsoil is alkaline with a pH of around 8.5.

The topsoil of this productive soil is at some risk of acidification because of its moderate pH buffering capacity. The subsoil has a low risk of soil acidification because of its high lime and clay content.

**Waterlogging**

These soils are quite well drained and waterlogging of crops only occurs in very wet years. Very heavy rainfall events can result in flash flooding, which may cause damage to fences and roads.

**Trafficability**

After heavy rainfall, access can be limited for periods of several days but these soils do not become as boggy and difficult to manage as the **Red and grey clay valley soils**.
Soil structure decline

Cultivation and trampling by sheep when the soil is above a critical moisture content can degrade the structure of this soil. Many of these soils have been cropped continuously, often under adverse moisture conditions. In degraded areas the soil slakes and sets hard, resulting in poor rainfall infiltration, poor seedling emergence and increased run-off.

Salinity

Areas of the Merredin unit have become saline. The saline groundwater-table need only come within 1 to 2 m of the surface before capillary action draws salty water to the surface. Other areas have the potential to become saline.

Water and wind erosion

Water erosion is not common because of the low gradient. Wind erosion is rare on this hardsetting soil.

Other

The rooting conditions are good, although the clay subsoil may limit root growth of some species. This soil type would not be expected to add large amounts of recharge to the groundwater-table.

Productivity and capability

The Red brown sandy loam over clay valley soil produces good cereal and field pea crops and good medic based pastures. Production may be reduced in some areas due to salinity and soil structure decline.

This soil is well suited to growing both burr and barrel medic pastures. The sandy loam topsoil and shallow clay subsoil are capable of providing the shallow rooted medic plant with adequate moisture in most years. Subterranean clovers have difficulty burying their burr in this hardsetting soil and plant establishment is reduced. Ryegrass grows well but in some areas it must be killed because of ryegrass toxicity.

This soil can produce excellent cereal yields, especially in wetter seasons.

Lupins are not well suited as the hardsetting surface limits seedling emergence and the calcareous, alkaline subsoil causes iron deficiency. The clay subsoil may also limit growth of the lupin tap root. In good rainfall years average lupin yields can be obtained but in average to dry years yields will be low.

Field peas grow well. Wind erosion of field pea stubbles may occur if overgrazed.

The application of gypsum and/or the use of minimum tillage has been shown to improve the structure of these soils. With careful management this soil can be quite friable and easy to handle.

Section 2.5 outlines salt tolerant fodder shrubs suitable for growing on saline areas of this soil.
Yield estimates and capability rating for various land uses

Red brown sandy loam over clay valley soil

<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (m)</td>
<td>7-9 DSE/ha</td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(winter grazed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Wheat</td>
<td>1.6-2.0 t/ha</td>
<td>3.3 t/ha</td>
<td>I</td>
<td>nutrient availability (pH), soil structure decline, moisture availability</td>
</tr>
<tr>
<td>3. Lupins</td>
<td>0.8-1.0 t/ha</td>
<td>1.6 t/ha</td>
<td>IV</td>
<td>wind erosion, moisture availability</td>
</tr>
<tr>
<td>4. Field peas</td>
<td>1.0-1.2 t/ha</td>
<td>1.8-2.0 t/ha</td>
<td>II</td>
<td></td>
</tr>
</tbody>
</table>
17. Red clay valley soil

Red brown clay soils found on the broad valley floors of the central and eastern Wheatbelt.

P.P.F. Gc 2.21, Uf 6.31, Db 1.13

Trayning series

Horizon

A1  Dark brown (7.5YR 3/4) clay loam to light clay. Hardsetting, often degraded. Often cracks on the surface. pH = 7.5

B2  Reddish brown (7.5YR 4/4) medium clay. Strongly structured. Calcareous (lime) segregations at depth. pH = 8.5

May have crabholes (gilgai) on the surface
Identifying characteristics

The soil consists of a thin, dark brown clayey topsoil over a reddish brown clay subsoil occurring at about 10 cm.

The Red clay valley soil can be distinguished from the Red brown sandy loam over clay valley soil by its clay topsoil. The Grey to brown cracking clay is generally darker and has a more friable surface structure than the Red clay valley soil.

Position in the landscape

This soil occurs on the broad, flat, heavy textured valleys of the central and eastern wheatbelt. It occurs in association with the Red brown sandy loam over clay valley soil, the Grey clay valley soil and the Grey to brown cracking clay, with these soils occurring on the Merredin soil landscape unit. Gradients on the Merredin unit are low, often having a slope of around 1:500.

Vegetation

The dominant indicator vegetation is salmon gum (Eucalyptus salmonophloia) and gimlet (E. salubris).

Land qualities

Moisture availability

The clay texture enables this soil to hold large volumes of moisture. However, under dry conditions the small pores of the clay hold onto water tightly resulting in poor moisture availability to the plant. In drought years these soils yield poorly.

Nutrient availability

These soils are naturally some of the most fertile in the wheatbelt. The subsoil is alkaline with a pH of around 8.5.

This soil has a low acidification potential because of its heavy texture (therefore low potential of leaching and high pH buffering capacity).

Waterlogging

The infiltration rate of these clayey, often degraded soils is low. Waterlogging of crops can occur in wet years. Very heavy rainfall can result in flash flooding which may cause damage to fences and roads.

Trafficability

This soil is difficult to manage. After heavy rainfall, access can be limited for periods of up to a week. However, these soils do not generally become as boggy as the Grey clay valley soil.
Soil structure decline

Cultivation and trampling by sheep when the soil is above a critical moisture content can degrade the structure of this soil. Many of these soils have been cropped continuously over many years, often under adverse moisture conditions. As a result the soil slakes and sets hard causing poor rainfall infiltration, poor seedling emergence and increased runoff. Heavy rainfall immediately after sowing may result in the surface crusting.

Salinity

Areas of this soil have become saline. The saline groundwater table need only come within 1 to 2 m of the surface before capillary action draws salty water to the surface. Other areas have the potential to become saline.

Water and wind erosion

Water erosion is rare on these soils as they occur on flat ground. This hardsetting soil is not prone to wind erosion.

Other

The rooting conditions are good, although the clay subsoil may limit root growth of some species. This soil would not be expected to add large amounts of recharge to the groundwater table.

Productivity and capability

The Red clay valley soil can produce good cereal and field pea crops and good burr and barrel medic pastures in higher rainfall years. However problems with moisture availability in dry years, soil structure decline and salinity may reduce yields.

The Red clay valley soil produces similar or slightly lower yields than the Red brown sandy loam over clay valley soil but its management constraints are more inflexible and its yields less reliable.

This soil is well suited to growing medic pastures. The clay texture is capable of providing the shallow rooted medic plant with moisture, especially in wetter years. Subterranean clovers have difficulty burying their burr in the hardsetting topsoil. Ryegrass grows well but in some areas it must be killed because of ryegrass toxicity.

This soil can produce excellent cereal yields, especially in wetter seasons. In seasons with drier finishes, cereal crops die off earlier than on some of the lighter textured soils. The use of gypsum and minimum tillage can improve soil structure and thus cereal yield.
Lupins are not suited to this soil. The hardsetting surface limits seedling emergence and the calcareous, alkaline subsoil causes iron deficiency. The clay subsoil may also limit growth of the lupin tap root.

Field peas grow well on this clay soil type. Wind erosion may occur if field pea stubbles are overgrazed.

Section 2.5 outlines salt tolerant fodder shrubs suitable for growing on saline areas of this soil type.

<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable yield (excellent season)</th>
<th>Achievable yield (winter grazed)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (m)</td>
<td>7-8 DSE/ha</td>
<td>1.5-1.7 t/ha</td>
<td>I-II</td>
<td>moisture availability</td>
</tr>
<tr>
<td>2. Wheat</td>
<td>1.5-1.7 t/ha</td>
<td>3.3 t/ha</td>
<td>II</td>
<td>moisture availability soil structure decline trafficability</td>
</tr>
<tr>
<td>3. Lupins</td>
<td>0.6-0.8 t/ha</td>
<td>1.6 t/ha</td>
<td>IV-V</td>
<td>nutrient availability (pH) soil structure decline moisture availability</td>
</tr>
<tr>
<td>4. Field peas</td>
<td>1.0-1.2 t/ha</td>
<td>2.0 t/ha</td>
<td>I</td>
<td></td>
</tr>
</tbody>
</table>
18. Grey clay valley soil

Grey clay soils found on the broad valley floors of the central and eastern wheatbelt.

P.P.F. Uf 6.33, Dy 2.13

Corigin series

Horizon

A1  Grey (10YR 3/2) sandy clay loam to medium clay.
    Hardsetting, often degraded.
    Surface cracks may be present.
    pH = 7.5

B2  Grey brown (10YR 5/3) medium clay.
    Strongly structured.
    Calcareous (lime) segregations at depth.
    pH = 8.5

May have crabholes (gilgai) on the surface
Identifying characteristics

The soil consists of a thin, grey clayey topsoil over a grey brown clay at about 10 cm.

The Grey clay valley soil can be distinguished from the Grey to brown cracking clay by its very hardsetting soil surface. This soil type is sometimes known as a ‘blue clay’ or ‘gimlet clay’.

Position in the landscape

This soil occurs on the broad, flat, heavy textured valleys of the central and eastern wheatbelt. It occurs in association with the Red brown sandy loam over clay valley soil, the Red clay valley soil and the Grey to brown cracking clay, with these soils occurring on the Merredin soil landscape unit. Gradients on the Merredin unit are low, often having a slope of around 1:500.

Vegetation

Indicator vegetation include salmon gum (*Eucalyptus salmonophloia*) and gimlet (*E. salubris*), with gimlet often being more dominant.

Land qualities

**Moisture availability**

The clay texture of this soil enables it to hold large volume of moisture. However, under dry conditions the small pores of the clay hold onto water tightly, resulting in poor moisture availability to the plant. In drought years these soils yield poorly.

**Nutrient availability**

These soils are naturally some of the most fertile soils in the wheatbelt. The subsoil is alkaline with a pH of around 8.5.

This soil has a low potential for soil acidification because of its heavy texture (therefore low potential for leaching and high buffering capacity).

**Waterlogging**

These soils can become waterlogged, resulting in poor crop growth. Very heavy rainfall can result in flash flooding which may damage fences and roads.

**Trafficability**

This soil is difficult to manage. After heavy rainfall these soils become very slippery and boggy with access possibly limited for periods of up to a week or more. These soils are commonly known as ‘Sunday soils’ - too wet to work on Saturday and too dry on Monday. They are more difficult to handle and stickier than the Red clay valley soil.
Soil structure decline

Cultivation and trampling by sheep when the soil is above a critical moisture content can degrade the structure of this soil. Many of these soils have been cropped continuously over many years, often under adverse moisture conditions. As a result the soil slakes and sets hard, resulting in poor rainfall infiltration, poor seedling emergence and increased run-off. Heavy rainfall immediately after sowing may result in the surface crusting.

Salinity

Areas of this soil have become saline. The saline groundwater table need to only come within 1 to 2 m of the surface before capillary action draws salty water to the surface. Other areas have the potential to become saline.

Water and wind erosion

Water erosion is rare as these soils occur on flat ground. This hardsetting soil is not prone to wind erosion.

Other

The rooting conditions are good, although the clay subsoil may limit root growth of some species. This soil would not be expected to add large amounts of recharge to the groundwater table.

Productivity and capability

The Grey clay valley soil can produce good cereal and field pea crops and burr and barrel medic pastures in better rainfall years. However, in many years, conditions for plant growth are less than optimal owing to low moisture availability, waterlogging or trafficability problems. Salinity and soil structure decline can also reduce yields.

This soil is well suited to growing medic pastures. The clayey texture is capable of providing the shallow rooted medic plant with moisture, especially in wetter years. Subterranean clovers grow poorly as they have trouble burying their burr in the hardsetting topsoil. Ryegrass grows well, but in some areas it must be killed because of ryegrass toxicity. Barley grass, wild oats and other poorer, pasture species grow well.

High cereal yields can be obtained in good seasons but in many years the season is either too dry, resulting in moisture stress, or less commonly too wet, resulting in delayed seeding and waterlogging. If the structure is degraded it should be improved through the use of gypsum and/or minimum tillage.
Lupins are not suited to this soil. The hardsetting surface limits seedling emergence and the calcareous subsoil with its alkaline pH can cause iron deficiency. The shallow clay may also limit growth of the lupin tap root.

Field peas grow well. This is one of the safest soils on which to grow field peas and graze their stubbles without wind erosion occurring.

Section 2.5 outlines salt-tolerant fodder shrubs suitable for growing on saline areas of this soil type.

### Yield estimates and capability rating for various land uses

**Grey clay valley soil**

<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (m)</td>
<td>7-8 DSE/ha</td>
<td>I-II</td>
<td></td>
<td>moisture availability</td>
</tr>
<tr>
<td></td>
<td>(winter grazed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Wheat</td>
<td>1.4-1.6 t/ha</td>
<td>3.0 t/ha</td>
<td>III</td>
<td>soil structure decline trafficability</td>
</tr>
<tr>
<td>3. Lupins</td>
<td>0.6-0.8 t/ha</td>
<td>1.0 t/ha</td>
<td>IV-V</td>
<td>nutrient availability (pH) soil structure decline</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>moisture availability</td>
</tr>
<tr>
<td>4. Field peas</td>
<td>0.9-1.1 t/ha</td>
<td>2.0 t/ha</td>
<td>I</td>
<td></td>
</tr>
</tbody>
</table>
Grey to brown cracking clay

Grey to brown, friable clay found on the valley floors of the central and eastern wheatbelt. Has a better inherent structure than the other clay valley soils.

P.P.F. Uf 6.33, Uf 6.31, Dy 2.13

Minnivale series.

Horizon

A1 Grey (10YR 3/1) to dark brown (10YR 3/3) sandy clay loam to medium clay. More friable structure than other clay soils through hardsetting. Surface cracks common. pH = 7.5

B2 Grey (10YR 4/1) to brown (10YR 4/3) medium clay. Strongly structured. Calcareous (lime) segregations at depth. pH = 8.5

May have crabholes (gilgai) on the surface
Identifying characteristics

This soil consists of a thin, grey to dark brown topsoil over a greyish brown clay at about 15cm.

The Grey to brown cracking clay includes all the better quality grey to brownish clay valley soils that tend to crack open more and do not set as hard as the Grey clay valley soil.

Position in landscape

The Grey to brown cracking clay occurs on the broad, flat, heavy textured valleys of the central and eastern wheatbelt. It occurs in association with the Red brown sandy loam over clay valley soil and the Red and grey clay valley soils, with these soils occurring in the Merredin soil landscape unit. Gradients on the Merredin unit are low often having a slope of around 1:500.

Vegetation

The dominant native vegetation is salmon gum (Eucalyptus salmonophloia), gimlet (E. salubris) and needle bush (Hakea preissii).

Land qualities

Moisture availability

The clay texture and good structure of this soil enables it to hold large volumes of moisture. However, under dry conditions the small pores of this clay soil hold onto water tightly resulting in poor moisture availability to the plant. In drought years these soils yield poorly.

Nutrient availability

These soils are naturally some of the most fertile in the wheatbelt. The subsoil is alkaline with a pH of around 8.5.

This soil has a low potential for soil acidification because of its heavy texture (therefore low potential for leaching and high pH buffering capacity).

Soil structure decline

This soil has a more friable nature and is easier to work than the other clay soils. It does not suffer soil structure decline to the same extent as the Grey clay valley soil.

Trafficability

After heavy rain access can be limited for periods of up to a week.
Salinity

Many areas of the Merredin unit have become saline. The saline groundwater-table need only come within 1 to 2 m of the surface before capillary action draws salty water to the surface. Other areas of this soil type have the potential to become saline.

Water and wind erosion

Water erosion is rare as these soils occur on flat ground. This soil is not prone to wind erosion.

Other

Waterlogging can occur for short periods after heavy rainfall. Rooting conditions are good. This soil would not be expected to add large amounts of recharge to the groundwater table.

Productivity and capability

The Grey to brown cracking clay can produce good cereal and field pea crops and burr and barrel medic pastures. Problems may be encountered with moisture availability in dry years, trafficability in wet years and salinity in some areas.

This soil is well suited to growing medic pastures. The well structured clay is able to provide the shallow rooted medic plant with adequate moisture. Subterranean clovers have difficulty burying their burr, and plant establishment in subsequent years is reduced. Ryegrass grows well but in some areas it must be killed because of ryegrass toxicity.

This soil can produce excellent cereal yields especially in wetter seasons. In seasons with drier finishes cereal crops die off earlier than on some of the lighter soils. Gypsum and/or minimum tillage can improve the structure of degraded areas and increase yield.

Lupins are not well suited as seedling emergence is hampered by the hardsetting surface and the clay may limit lupin tap root growth. The calcareous, alkaline subsoil can cause iron deficiency in lupins.

Field peas grow well. This is one of the safest soils on which to graze pea stubbles without wind erosion occurring.

Section 2.5 outlines salt-tolerant fodder shrubs which are suitable for growing on saline areas of this soil type.
## Yield estimates and capability rating for various land uses

Grey to brown cracking clay

<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (m)</td>
<td>7-8 DSE/ha</td>
<td></td>
<td>I-II</td>
<td>moisture availability</td>
</tr>
<tr>
<td></td>
<td>(winter grazed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Wheat</td>
<td>1.6-1.8 t/ha</td>
<td>3.0 t/ha</td>
<td>I-II</td>
<td>moisture availability trafficability</td>
</tr>
<tr>
<td>3. Lupins</td>
<td>0.8-1.0 t/ha</td>
<td>1.6 t/ha</td>
<td>IV</td>
<td>nutrient availability (pH) soil structure decline</td>
</tr>
<tr>
<td>4. Field peas</td>
<td>1.0-1.2 t/ha</td>
<td>2.0 t/ha</td>
<td>I</td>
<td></td>
</tr>
</tbody>
</table>
20. **Powdery surfaced calcareous soil**

Red, powdery surfaced soils often found adjacent to salt lakes. Contains lime as a fine powder or as rocks—‘Morrel soil’

P.P.F. Dr 4.13

**Nangeenah series**

**Horizon**

A1  Dark reddish brown (5YR 3/3) fine, sandy loam to clay loam. Has a ‘fluffy’ surface due to the high lime content. Massive structure. Large amounts of soft lime and limestone segregations. pH = 8.5

B21 Yellowish red (5YR 5/8) clay. Moderately structured. Large amounts of soft lime and segregations. pH = 8.5

May have crabholes (gilgai) on the surface
Identifying characteristics

The **Powdery surfaced calcareous soil** includes the ‘morrel soils’ that often contain lime rocks.

The soil consists of a reddish brown, powdery surfaced, calcareous, loamy topsoil over a reddish, calcareous subsoil. Often this soil grades into areas of **Red brown sandy loam over clay valley soil**. The **Powdery surfaced calcareous soil** can be distinguished from the **Red brown sandy loam over clay valley soil** by its ‘fluffy’ surface, high topsoil pH and often by the presence of lime rocks.

Position in the landscape

These soils are formed from material that has blown from salt lakes onto adjacent areas. They are generally found on the valley floor but may occur on the lower slopes. They occupy a small percentage of the Northam Advisory District and are far more common in the eastern wheatbelt. A large area of this soil occurs adjacent to the Cowcowing lakes, north of Wyalkatchem.

This soil occurs within the Nangeenan soil landscape unit.

Vegetation

Morrel (*Eucalyptus longicornis*) is the dominant indicator species on the soil.

Land qualities

**Moisture availability**

Rainfall infiltrates poorly into these non-wetting soils resulting in poor moisture availability for plant growth in average to dry seasons. However, if good soaking rains occur at the break of the season and the soil profile becomes moist then good yields can be obtained. Good finishing rains are also important.

**Nutrient availability**

The high pH of around 8.5 throughout the profile can cause deficiencies in elements such as manganese, zinc and iron. Other trace elements such as boron may become toxic.

This soil has a low potential for soil acidification.

**Waterlogging**

The **Powdery surfaced calcareous soil** is well drained but may become flooded in low lying areas.
Trafficability
This soil is quite easy to work because of its loose nature. It can become slippery following heavy rain.

Soil structure decline
The high lime content results in a loose surface that does not suffer soil structure decline.

Salinity
The Powdery surfaced calcareous soil is inherently saline. These soils are derived from material that has blown off the salt lakes. There is considerable variation in the level of salinity within this soil. Many areas of this soil have the potential to become saline if regional groundwater-tables rise.

Wind and water erosion
The loose surface of this soil makes it very prone to wind erosion. Wind erosion can be severe if salinity prevents pasture or crop growth.

Water erosion can occur on sloping areas, and may be severe if the soil is non-wetting.

Other
Rooting conditions are good. This soil would not be expected to add large amounts of recharge to the groundwater-table.

Productivity and capability
This is an above average to poor soil depending on the level of salinity. Careful management of these soils is required to prevent wind erosion.

Medic pastures can grow well in non-saline areas. However, pasture growth is most commonly average to poor depending on the salinity.

High cereal yields can be obtained in wetter years with a good finish. However, in many drier years, cereals perform poorly. Barley, because of its tolerance to salinity often out yields wheat. On the most saline examples of this soil even barley performs badly.

Lupins grow very poorly because the lime and associated high pH are hostile for lupin growth. Iron deficiency is common.

Field peas will grow on this soil type, but under current grazing management strategies they are a major wind erosion hazard, and for this reason should not be grown.

On the more saline areas blue bush can out-perform traditional crops and pastures.

Section 2.5 outlines salt-tolerant fodder shrubs which are suitable for growing on saline areas of this soil type.
# Yield estimates and capability rating for various land uses

**Powdery surfaced calcareous soil**

<table>
<thead>
<tr>
<th>Land use</th>
<th>Achievable average yield</th>
<th>Achievable yield (excellent season)</th>
<th>Capability rating</th>
<th>Limiting factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pasture (m)</td>
<td>3-7 DSE/ha</td>
<td>I</td>
<td>II</td>
<td>moisture availability, wind erosion</td>
</tr>
<tr>
<td></td>
<td>(winter grazed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Wheat</td>
<td>1.0-1.7 t/ha</td>
<td>3.0 t/ha</td>
<td>II</td>
<td>moisture availability</td>
</tr>
<tr>
<td>3. Barley</td>
<td></td>
<td>I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Lupins</td>
<td>very poor growth</td>
<td>V</td>
<td>V</td>
<td>nutrient availability (pH)</td>
</tr>
<tr>
<td>5. Field peas</td>
<td>1.0-1.2 t/ha</td>
<td>1.8-2.0 t/ha</td>
<td>IV</td>
<td>wind erosion</td>
</tr>
<tr>
<td>6. Bluebush</td>
<td></td>
<td>I</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* For non saline areas.
2.4. Minor Soil Types

This section describes minor soil types whose limited occurrence does not warrant a detailed description. It should be noted that these soils may occupy a significant percentage of some individual farms.
21. Soils fringing the salt lakes

Soil description

Dunes and flats of sand, silt, clay or gypsum.
Stirling Association

Position in the landscape

This association of soils is found on the fringe of the main salt lake channel. They can occur as flats but often are low dunes with slopes of around 10 to 20%. The Soils fringing the salt lakes occur within the Baandee soil landscape unit.

Vegetation

These soils support dense thickets of *Melaleuca* sp., *Hakeapreissii*, *Allocasuarina lepidophloia* and *Callitris* sp.

Discussion of capability

This soil association should not be cleared. Most of the soils are of low agricultural potential. The sand dunes are highly prone to wind erosion when the vegetation is removed. Many areas are saline or have the potential to become saline. The gypsum dunes provide a source of gypsum, but in some cases it may be too saline for agricultural use.
22. Steep rocky hill soils

Soil description

The Steep rocky hills soils soil type is an association of a number of different soil types.

These soils are linked together to form one soil type because they occur together as a management unit on areas of steep rocky hills.

The soil types in the association are:

- Rocky red brown loamy sand/sandy loam;
- Brownish grey granitic loamy sand;
- Red brown doleritic clay loam;
- Coarse granitic sand.

These soil profiles are described elsewhere in the manual, however, when they occur on areas of steep rocky hills they are much rockier and the depth to bedrock is usually shallower. Areas of rock outcrop are very common.

Position in the landscape

Steep rocky hills soils can occur at any position in the landscape where the underlying bedrock has been exposed. These areas are most common on the midslopes or as crests and ridges at the highest part of the landscape. This soil type occurs within the steep rocky hills soil landscape unit (see figure 2, page 6). Slopes are generally greater than 10% and can be greater than 30%.

Vegetation

The native vegetation on these areas consists of jam (Acacia acuminata), York gum (Eucalyptus loxophleba), sheoak (Allocasuarina heugeliana) and in some areas white gum (E. wandoo).

Discussion of capability

This land is too steep and rocky for cropping but does provide some grazing value. Very rocky and steep areas do not warrant clearing because of the small amount of pasture that can be grown and the high water erosion hazard.

Water erosion is common on these steep, rocky areas. Large volumes of run-off are produced by the many rock outcrops while sheep and wheel tracks can concentrate water flow. Contour or grade banks may need to be built to control erosion. Large rock outcrops are useful as water catchments if water can be channelled into a suitable dam site. The Steep rocky hills are capable of adding large amounts of recharge to the groundwater-table.
23. Coarse granitic sand

Soil description

A loose, grey, coarse to very coarse grained sand overlying a loose, pale, coarse to very coarse grained sand which often becomes yellower at depth. Granitic bedrock often occurs within the top 150 cm. The texture may increase to a weak clayey sand and ironstone gravel and/or quartz grit may occur in the subsoil. The pH throughout the profile is 6.0 to 6.5.

Northcote P.P.F. Uc 2.12.

Bobakine series, Needling series

Position in the landscape

The Coarse granitic sand is usually found immediately adjacent to and overlying large sheets of granitic rock.

It is often found in association with the Brownish grey granitic loamy sand and occurs within the Danberrin soil landscape unit.

Vegetation

The dominant native vegetation is rock sheoak (Allocasuarina heugeliana) and various Acacia species including jam (A. acuminata).

Discussion of capability

The Coarse granitic sand has a very low water holding capacity. Added nutrients are rapidly leached out of this infertile soil.

Cereal and lupin crops grow very poorly and subterranean clover usually fails to persist.

These free draining soils are capable of adding large amounts of recharge to the groundwater-table. Large volumes of water can run off adjacent rock outcrop contributing to recharge. Poor ground cover results in a high wind erosion hazard.
24. Pale valley floor sand

Soil description

A loose, grey sand over a loose, pale sand often overlying clay at depths of greater than 60 cm.

Northcote P.P.F. Dg 4.42 Calje Series.

Position in the landscape

The Pale valley floor sand is often found as thin seams of sand on the valley floor. This soil is especially common on the Belka soil landscape unit. These sand seams, which are often only 20 m wide are believed to be infilled, ancient drainage lines.

Vegetation

Unknown. May have contained sheoak (Allocasuarina sp.), jam (Acacia acuminata) and some York gum (E. loxophleba).

Discussion of capability

Crops and pastures can become waterlogged in wet years. Nutrients, in particular nitrogen, are rapidly leached from this soil.

Crops often remain greener, longer into spring because of the availability of subsoil moisture. However, yields are generally lower than on the surrounding valley soils.

Yellow serradella may have potential on this soil.

These seams often act as sub surface drainage lines within the valley floor. Waterlogged sand seams are probably a major source of recharge to the groundwater-table. Some areas of this soil have become saline.

These sand seams usually occur as thin strips which makes farming them separately a difficult proposition.
2.5. Saline soils

Saline land can be divided according to the severity of salinization and the degree of waterlogging or frequency of flooding. This section defines the different levels of salinity and suggests possible salt tolerant forage plants to grow on each of these areas.

Large areas of saline soils occur within the salt lake system (Baandee soil landscape unit). Smaller areas of saline soils occur within other soil landscape units, in particular the Belka and Merredin valley units.

(The following text is taken from Western Australian Department of Agriculture Farmnote No. 32/86 “Saltland, management-selecting forage plants for saltland”, by C.V. Malcolm).

Site severity

On most saltland the severity of ‘salting’ is assessed by observing the species of ‘volunteer’ plants present and the proportion of the area these plants cover. This plant cover may also be affected by seasonal conditions, cultivation and stock grazing intensity. It is convenient to divide saltland into three categories: mild, moderate and severe.

- On mildly affected saltland the usual plant is Mediterranean barley grass (*Hordeum geniculatum*), often called sea barley grass in Western Australia. Plant species sensitive to salt such as subterranean clover, barrel medic and capeweed are usually absent but annual ryegrass and woolly clover can be present. There may be some plants of sand spurry (*Spergularia rubra*), curly ryegrass (*Pholiurus incurvus*), ice plant (*Mesembryanthemum nodiflorum*), *Plantago* spp. and *Cotula* spp. On mildly salt affected soils, plants usually cover the whole area.
- On moderately affected saltland the plants are usually Mediterranean barley grass, annual ryegrass and woolly clover amongst areas of bare ground.
- On severely affected saltland the only plants present are sand spurry, curly ryegrass, iceplant, samphire, *Plantago* spp. and *Cotula* spp. After grazing by stock these areas are usually completely bare.

If site severity cannot be assessed from the volunteer plant cover, the salt affected areas can be sown to an ‘indicator’ crop like barley or oats.

- Mild areas may give a profitable return only if seasonal conditions are favourable, that is, a good opening rain for germination, no winter waterlogging and good finishing rains.
- Moderate areas will not give a profitable crop even in favourable seasons.
- Severe areas will not mature a crop at all.
The site severity is usually related to the depth below the soil surface of saline groundwater (water-table). In a sandy soil the groundwater must be much closer to the surface than in a loamy soil to cause the same severity of 'salting'. Typical depths to groundwater for the three classes of saltland severity are:

<table>
<thead>
<tr>
<th>Severity of saltland</th>
<th>Depth to saline groundwater*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>more than 1.6 m</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.8 to 1.8 m</td>
</tr>
<tr>
<td>Severe</td>
<td>0 to 1.1 m</td>
</tr>
</tbody>
</table>

* This is only a guide as it varies with season and soil type.

There is some overlap in the depth to saline groundwater between the classes of saltland severity. The depth to saline groundwater can vary between the seasons within the year. On some soil types, for example the **Powdery surfaced calcareous soil** (Morrel soils), severe salting may occur without any water-table.

The following table gives measurements of the salt content for various types of salinity.

<table>
<thead>
<tr>
<th>Salinity level</th>
<th>% Chloride</th>
<th>Electrical conductivity* at 25°C (milliSiemens per metre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-saline (subterranean clover/grass)</td>
<td>Less than 0.03</td>
<td>0 to 20</td>
</tr>
<tr>
<td>Mildly saline (thick barley grass)</td>
<td>0.03 to 0.15</td>
<td>20 to 100</td>
</tr>
<tr>
<td>Moderately saline (patchy barley grass)</td>
<td>0.15 to 0.44</td>
<td>100 to 300</td>
</tr>
<tr>
<td>Severely saline (bare soil)</td>
<td>0.44 to 3.00</td>
<td>300 to 2,000</td>
</tr>
</tbody>
</table>

* Electrical conductivity of a 1:5, soil:water suspension (EC_{1:5}).

**Waterlogging and flooding**

Saltland sites may be permanently waterlogged due to seepage or seasonally waterlogged (usually in winter) due to shallow groundwater and excess water on the soil surface. Before planting species on saltland, minimize waterlogging by installing surface drains and contouring the catchment above the area.

The severity of waterlogging is best assessed by its duration. Salt tolerant forage plants are rarely killed by 'flash' floods, but when the soil surface is waterlogged for several weeks some species die. Few species survive when waterlogged for several months.

The following table presents a guide to selecting salt tolerant forage plants for saltland types in the agricultural areas of Western Australia.
<table>
<thead>
<tr>
<th>Saltland type and conditions</th>
<th>Mild</th>
<th>Site severity*</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hillside seepage</td>
<td>Soil surface dry in summer</td>
<td>Puccinellia, barley</td>
<td>Puccinellia</td>
<td>Puccinellia</td>
</tr>
<tr>
<td></td>
<td>Commonly flooded</td>
<td>Saltbushes, Puccinellia, barley</td>
<td>Saltbushes, Puccinellia</td>
<td>Samphire</td>
</tr>
<tr>
<td>Saline valley floors</td>
<td>less than 375 mm annual rainfall</td>
<td>Seldom flooded</td>
<td>Barley, bluebush, Puccinellia, saltbushes</td>
<td>Saltbushes, bluebush, Puccinellia, saltbushes</td>
</tr>
<tr>
<td>Dryland salinity (Powdery Surfaced Calcareous Soil)</td>
<td>less than 375 mm annual rainfall</td>
<td>Never flooded</td>
<td>Barley, bluebush, saltbushes</td>
<td>Bluebush, saltbushes</td>
</tr>
</tbody>
</table>

* The recommended plants are underlined, others listed are also capable of reasonable growth.

**Description of some salt tolerant species**

- Barley (six-row) will tolerate mild salinity.
- Puccinellia (*Puccinellia ciliata*) is a winter growing perennial, tussock-forming grass highly tolerant of salt and waterlogging. It will grow on all salt-affected soils in areas receiving more than 375 mm of annual rainfall. In drier areas its growth is less reliable.
- Bluebush (*Maireana brevifolia*) is a highly salt tolerant perennial shrub. It is sensitive to waterlogging and should not be planted if there is danger of being flooded for more than two to three days.
- Wavy leaf saltbush (*Atriplex undulata*) is a highly salt tolerant perennial shrub. It is moderately tolerant to waterlogging. It will survive several weeks on a flooded site in winter. The branches can form roots where they rest on the ground thus aiding recovery from grazing and control of soil erosion.
- River saltbush (*Atriplex amnicola*) is a highly salt-tolerant perennial shrub. It is slightly more waterlogging tolerant than wavy leaf saltbush. The branches form roots readily and recovery from severe grazing is excellent.
- Samphire (*Halosarcia* spp.) is represented by several species. All are highly tolerant of salt and waterlogging and will grow to the edges of salt lakes. The plant material has a high salt content but may be grazed by sheep provided other feed such as stubble or dry annual pasture is available.
### 2.6. Table 1. Soil types in each soil landscape unit

The following table breaks down each soil landscape unit into its respective soil types. The table can be used as a key to aid in the identification of a particular soil type. An estimate of the percentage area that each soil type occupies within the soil landscape unit is given.

<table>
<thead>
<tr>
<th>Map Unit</th>
<th>Parent material</th>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil material</th>
<th>Subsurface soil material</th>
<th>Soil type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ulva</td>
<td>Deeply weathered laterite</td>
<td>Undulating yellow and pale sandplain</td>
<td>Christmas tree, banksia, tea tree and low scrub</td>
<td>Loose, grey sand to a depth of 10-15 cm</td>
<td>Loose, white or pale yellow sand to a depth of 60 cm or greater. Occasionally overlying ironstone gravel.</td>
<td>1. Deep pale sand (3%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Banksia and sandplain pear. Flame grevillea in some areas</td>
<td>Loose, brown sand to a depth of 10-15 cm</td>
<td>Loose, yellow sand to a depth of 70 cm or greater. Sometimes overlying yellow loamy sand.</td>
<td>2. Deep yellow sand (25%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tammar or sandplain mallee</td>
<td>Loose to firm, grey brown loamy sand to a depth of 10-15 cm. Often contains ironstone gravel.</td>
<td>Coherent, yellow clayey sand grading to a sandy loam often with large amounts of ironstone gravel overlying mottled zone</td>
<td>3. Yellow gradational loamy sand (50%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tea tree (Lepidospermum erubescens) scrub</td>
<td>Loose, pale greyish brown sand to a depth of 10-15 cm.</td>
<td>Loose, pale sand to a depth of about 40-60 cm overlying a gravel layer and/or mottled zone</td>
<td>4. Pale sand over gravel/loamy sand (15%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wodjil scrub</td>
<td>Firm, brown loamy sand to a depth of 10-15 cm</td>
<td>Coherent, yellow loamy sand to sandy loam grading to a sandy clay loam. Very acidic at depth.</td>
<td>6. Deep yellow acid sand (2%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Wodjil and tammar scrub</td>
<td>Hardsetting, brownish to yellowish loamy sand to a depth of 5-15 cm. Often contains ironstone gravel.</td>
<td>Coherent, yellow clayey sand often containing ironstone gravel to 10-25 cm over mottled zone</td>
<td>7. Shallow mottled zone (4%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Poorly drained depressions within undulating yellow and pale sandplain</td>
<td>Loose, grey sand to a depth of 10-15 cm.</td>
<td>Loose, pale sand to a depth of greater than 70 cm over sandy clay.</td>
<td>5. Waterlogged sand (&lt; 1%)</td>
<td></td>
</tr>
<tr>
<td>Map Unit</td>
<td>Parent material</td>
<td>Landform</td>
<td>Dominant vegetation</td>
<td>Surface soil material</td>
<td>Subsurface soil material</td>
<td>Soil type</td>
</tr>
<tr>
<td>-----------</td>
<td>--------------------------------------</td>
<td>-------------------------------</td>
<td>---------------------------------------------</td>
<td>--------------------------------------------</td>
<td>----------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Booraan</td>
<td>Colluvium derived from lateritic profile</td>
<td>Upper and mid slopes</td>
<td>White gum, some mallee species and salmon gum</td>
<td>Hardsetting, structureless, dark grey brown sandy loam to a depth of 5-10 cm</td>
<td>Massive, grey brown sandy loam to sandy clay loam to 10-15 cm overlying a structured pale brown clay and/or pallid zone.</td>
<td>6. Shallow hardsetting grey sandy loam over clay (15%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upper, mid and lower slopes</td>
<td>Salmon gum, gimlet, white gum and some mallees species</td>
<td>Hardsetting, dark greyish-brown to reddish brown sandy loam to a depth of 5-15 cm</td>
<td>Massive, dark yellowish brown sandy loam to sandy clay loam overlying a structured, light yellowish brown clay at about 20 cm. Lime may be present in the clay.</td>
<td>9. Sandy loam over clay (70%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mid and lower slopes</td>
<td>Mallee, some stunted salmon gums on heavier versions</td>
<td>Loose to firm grey brown sand to loamy sand to a depth of 5-15 cm.</td>
<td>Coherent, pale yellowish brown sand to clayey sand overlying a yellowish brown clay at about 40 cm.</td>
<td>10. Loamy sand over clay (15%)</td>
</tr>
<tr>
<td></td>
<td>Colluvium derived from lateritic profile</td>
<td>Footslopes</td>
<td>Mallee sp.</td>
<td>Loose to firm grey brown sand to loamy sand to a depth of 5-15 cm.</td>
<td>Coherent, pale yellowish brown sand to clayey sand overlying a yellowish brown mottled clay at about 40 cm.</td>
<td>10. Loamy sand over clay (100%)</td>
</tr>
<tr>
<td>Denberin</td>
<td>Granitic and basic bedrock</td>
<td>Upper, mid and lower slopes</td>
<td>York gum and jam</td>
<td>Loose to hardsetting, brown loamy sand to sandy loam to a depth of 15 cm.</td>
<td>Reddish brown to brown clayey sand to sandy loam to a depth of 20-60 cm over a reddish to yellowish brown, structured clay and/or decomposing bedrock.</td>
<td>11. Rocky red brown loamy sand/sandy loam (45%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upper, mid and lower slopes</td>
<td>Jam, occasional York gum, sheoak and in some areas white gum</td>
<td>Loose to hardsetting, grey brown sand to loamy sand to a depth of 15 cm.</td>
<td>Pale to yellowish brown sand to clayey sand over a structured, yellowish clay at about 50 cm overlying decomposing granitic rock.</td>
<td>12. Brownish grey granitic loamy sand (50%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Upper, mid and lower slopes</td>
<td>York gum, salmon gum and needle bush</td>
<td>Red brown clay loam to a depth of 15 cm, often self-mulching.</td>
<td>Well structured, dark red clay overlying decomposing colerite rock. May contain lime at depth.</td>
<td>13. Red brown coleritic clay loam (5%)</td>
</tr>
</tbody>
</table>

Hillside soils

Soils of the Northam Advisory District
## Valley floor soils

<table>
<thead>
<tr>
<th>Map Unit</th>
<th>Parent material</th>
<th>Landform</th>
<th>Dominant vegetation</th>
<th>Surface soil material</th>
<th>Subsurface soil material</th>
<th>Soil type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belka</td>
<td>Alluvium</td>
<td>Sandy surfaced, broad valley</td>
<td>Salmon gum, York gum, white gum and some types of mallee</td>
<td>Loose, grey brown sand to a depth of 10-20 cm</td>
<td>Coherent, light yellow brown sand to a depth of 40-60 cm overlying a brownish yellow, calcareous, structured clay.</td>
<td>14. Deep sandy surfaced valley soil (40%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>floors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Salmon gum, gimlet, York gum, white gum and some types of mallee</td>
<td>Loose to firm, grey brown sand to loamy sand to a depth of 10 cm.</td>
<td>Coherent, light yellow brown sand to clayey sand, to a depth of 15-40 cm, overlying a light yellowish brown, calcareous, structured clay.</td>
<td>15. Shallow sandy surfaced valley soil (60%)</td>
</tr>
</tbody>
</table>

| Marredin       | Coluvium and Alluvium | Loamy or clayey surfaced broad valley floors (sometimes contains crabholes) | Salmon gum and gimlet | Hardsetting, dark reddish brown sandy loam to a depth of 10-15 cm. | Structured, reddish brown sandy clay loam to about 30 cm overlying a structured, reddish brown clay with lime nodules at depth. | 16. Red brown sandy loam over clay valley soil (75%) |
|                |                 |                               | Salmon gum and gimlet | Hardsetting, reddish brown clay loam to light clay to a depth of 10-15 cm. | Structured, reddish brown clay with lime nodules. |                                               |
|                |                 |                               | Gimlet and salmon gum | Hardsetting, grey clay loam to clay to a depth of 10-15 cm. | Structured, grey brown clay with lime nodules. |                                               |

| Nan-geenon     | Aeolian material derived from salt lakes | Valley floor (occasionally on lower slopes) | Morrel | Powdery, dark reddish brown to grey sandy clay loam to a depth of 20-40 cm. | Structured, reddish to dark yellow brown clay loam to clay. Abundant lime present. | 20. Powdery surfaced calcareous soil (100%)     |
3. Application of the manual to mapping soils

3.1. Introduction

A major use of this manual will be to provide a framework for mapping soils at a scale suitable for farm and catchment planning. The soils defined or, if appropriate, associations of two or more soil types can be mapped at a scale of 1:10,000 over individual farms. These soil maps can then be used to develop a land management plan. They can help identify various target areas for specific action and familiarize all members of the group with the soils of the catchment and their capability. Dealing with catchments allows problems such as salinity that go beyond farm boundaries to be tackled effectively.

3.2. Mapping the soils of a catchment

The following outlines a suggested method for mapping the soils of a catchment.

Step 1. Establish the ‘catchment group’. Catchment groups normally comprise of 5 to 20 landholders who farm in the same drainage catchment. The number of landholders should be limited to less than 20 to enable effective interaction amongst group members. Successful catchment groups are autonomous, that is, they are ‘farmer driven’ with Department of Agriculture back up support. This gives greater involvement and ownership to the farmer groups.

Step 2. The Department of Agriculture staff member assisting in the soil mapping should arrange a preliminary visit to the catchment to identify the major soil types. This will involve driving around the catchment with one or more of the landholders to identify sites for backhoe pits (to be used on the soil mapping field day). It is preferable to locate the backhoe pits of each soil type as close to each other as possible.

The soil types defined in the manual provide a basis for the selection of soil types.

To avoid confusion not more than about 12 soil types should be selected. It may be considered appropriate to amalgamate two or more soil types from the manual as they have similar capabilities and/or occur together in too complex an association to map out separately. (It is necessary to draw up a preliminary list of soil types to be mapped in order to present them for discussion at the soil mapping field day).

Step 3. The farmers arrange for the backhoe pits to be dug. Each pit should be dug to a depth of at least 1.5 m (if possible), 1 m wide and 2 m long. Fencing off the pits is recommended if they are to be left open for future reference.
The soil mapping field day

Step 4. Hold a preliminary discussion with the group members to:

- introduce the aims of the day;
- outline the proceedings of the day;
- provide a copy of the soil manual or photocopies of relevant sections to members.

The importance of the soil map as the basis for developing a catchment land management plan should be highlighted.

Step 5. The catchment group members tour the soil pits in a bus, truck or convoy of utilities. The following attributes and characteristics are discussed at each pit:

- describe the soil type and point out its important and distinguishing characteristics;
- discuss the land use options, possible yields and conservation aspects;
- the dominant, indicator vegetation and position in the landscape should be highlighted;

The pits provide an avenue to promote discussion on each soil type (it is beneficial to have a general adviser present to assist with any other farming issues that may arise). Before leaving each pit the group members must feel confident that they can identify that soil type.

Step 6. After inspecting the soil pits the group reconvenes in a shed or house which has plenty of table space.

Step 7. A list of soil types to be mapped is finalized. Members of the catchment group need to consider if they:

- agree with the list of soil types;
- can think of any important soils that should be included; or
- believe some of the suggested soil types should be omitted.

As suggested previously, about 12 soil types is the maximum number that should be mapped. Commonly used local names may be used in preference to the soil type names defined in this manual. (See appendix 8 for a suggested list of soil types to be mapped in the Zone of Ancient Drainage.)

Step 8. Before the soil mapping field day each farmer should have ordered an enlarged aerial photograph of their property to use as a base map for the soil mapping. A scale of 1:10,000 is usually the most suitable.

(NOTE - Aerial photographs can be ordered directly from the Department of Land Administration or via the Department of Agriculture. It may take as long as two months for the photographs to arrive.)

Step 9. Each member should obtain, or be provided with, a permanent marker pen and a sheet of clear plastic overlay. The overlay should be taped to the aerial photograph and the soil boundaries drawn in by the landholder with the marker pen. Farmer knowledge of his soils, the time available, and the
distribution of soils on the farm will affect the accuracy of each soil map. Many farmers know their soils well and can map their farm, to their satisfaction, with little or no field work. Others may need to dig holes with a spade and/or hand auger in areas of uncertainty.

Department of Agriculture staff members should be available to answer any queries. Areas of soil types of less than about 2 ha should not be mapped unless they require a significantly different land use.

Soil peels of the major soil types found in the Department of Agriculture’s Northam Advisory District are stored at the Northam Office. The peels can be taken to such workshops to help clarify a soil type.

Step 10. When group members have finished their soil mapping, they should check their soil boundaries with their neighbours to make sure they coincide.

Step 11. Department of Agriculture staff collect the finished soil maps for digitizing and production of the catchment soil map. Many farmers will need to take their soil maps home and conduct some field checking before completion. These maps will need to be collected at a later date.

Step 12. Members of the catchment group who could not attend the soil mapping field day should be shown around the soil pits and helped with the soil mapping by catchment group members who have completed their mapping.

3.3 Developing a land management plan

In addition to soil types, other information such as natural features, areas of degradation and man made structures need to be taken into account when producing a land management plan. This information can be mapped on additional clear plastic overlays.

Natural features include ridges, drainage lines, rock outcrops, breakaways and remnant vegetation. Forms of degradation such as salinity (mild, moderate and severe), wind and water erosion and waterlogging should also be mapped. As should man-made structures such as fences, watering points, banks, dams or any other features that the group feels are important.

A series of workshops need to be held to discuss degradation types and processes, land capability and the concept of a land management unit. (A land management unit is a single soil type or group of soil types that are linked together by factors influencing productivity, land use and degradation hazards).

Land management units for the individual farms within the catchment can then be defined by combining these different layers of information. It should be noted that land management units may differ from one farm to another depending on factors such as preference to cropping, rotations practiced, farming equipment and the occurrence of soil types.
The land management plan may suggest the implementation of options such as:

- refencing;
- different rotations;
- earthworks and drainage;
- tree planting; and
- salt-land agronomy.

Economic analysis of various land uses on each land management unit can now be evaluated using farm management models developed by the Department of Agriculture.

For more detailed information on farm planning refer to Hawkins, Findlay and Findlay (1991).
4. Acknowledgements

I wish to thank Jim Broun and David (Blue) Greep for their assistance in the field. Many thanks to Peter Tille and Bill McArthur for sharing their experience and useful ideas.

I also wish to thank the Department of Agriculture staff who provided expertise in their specialist fields. Lastly I would like to thank all those farmers who spent time providing yield and capability information.

5. References

6.0 APPENDICES

6.1 Appendix 1. Climatic data

Mean monthly rainfall at six locations in and around the zone (mm)

<table>
<thead>
<tr>
<th>STATION</th>
<th>JAN</th>
<th>FEB</th>
<th>MAR</th>
<th>APRIL</th>
<th>MAY</th>
<th>JUNE</th>
<th>JULY</th>
<th>AUG</th>
<th>SEPT</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
<th>YEAR</th>
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<tbody>
<tr>
<td>Cunderdin (1957-1988)</td>
<td>10.7</td>
<td>19.4</td>
<td>18.1</td>
<td>24.6</td>
<td>47.7</td>
<td>68.2</td>
<td>60.8</td>
<td>46.3</td>
<td>29.8</td>
<td>18.2</td>
<td>13.4</td>
<td>6.7</td>
<td>363.9</td>
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<td>Bencubbin (1957-1988)</td>
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<td>20.7</td>
<td>21.5</td>
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<td>40.0</td>
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<td>37.4</td>
<td>22.4</td>
<td>15.1</td>
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<td>75.7</td>
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<td>27.0</td>
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<td>47.3</td>
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<td>21.1</td>
<td>14.6</td>
<td>5.8</td>
<td>375.2</td>
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<tr>
<td>Wyalkatchem (1965-1975)</td>
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<td>15.5</td>
<td>28.3</td>
<td>35.3</td>
<td>35.9</td>
<td>65.5</td>
<td>51.1</td>
<td>32.5</td>
<td>28.1</td>
<td>21.5</td>
<td>13.7</td>
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Mean daily maximum temperature (°C)

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<th>APRIL</th>
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<th>SEPT</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
</tr>
</thead>
<tbody>
<tr>
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<td>25.2</td>
<td>20.8</td>
<td>17.6</td>
<td>16.5</td>
<td>17.5</td>
<td>20.3</td>
<td>24.1</td>
<td>28.2</td>
<td>31.9</td>
</tr>
</tbody>
</table>

Dam evaporation (mm/month)

<table>
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<tr>
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<th>MAR</th>
<th>APRIL</th>
<th>MAY</th>
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<th>JULY</th>
<th>AUG</th>
<th>SEPT</th>
<th>OCT</th>
<th>NOV</th>
<th>DEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cunderdin (1950-1966)</td>
<td>285</td>
<td>242</td>
<td>205</td>
<td>117</td>
<td>70</td>
<td>43</td>
<td>44</td>
<td>53</td>
<td>85</td>
<td>130</td>
<td>184</td>
<td>256</td>
</tr>
</tbody>
</table>
6.2 Appendix 2. Descriptions of texture grades

(McDonald et al. 1984)

Field texture is a measure of the behaviour of a small handful of soil when moistened and kneaded into a ball and then pressed out between thumb and forefinger.

Take a sample of soil sufficient to fit comfortably into the palm of the hand. Moisten the soil with water, a little at a time, and knead until the ball of soil, so formed, just fails to stick to the fingers. Add more soil or water to attain this condition, known as the sticky point, which approximates field moisture capacity for that soil. Continue kneading and moistening until there is no apparent change in the soil ball, usually a working time of 1 to 2 minutes. The soil ball, or bolus, is now ready for shearing manipulation, but the behaviour of the soil during bolus formation is also indicative of its field texture. The behaviour of the bolus and of the ribbon produced by shearing (pressing out) between thumb and forefinger characterizes the field texture. Field texture grades may be defined by the behaviour of the moist bolus as set out in Table A.2.1. The approximate percentage content of clay (particles less than 0.002 mm in diameter) is given as a guide.

6.3 Appendix 3. Size of sand fraction

(from Hamblin 1985)

The following diagram can be used as an aid to determine the size of the sand fraction within a soil.

![Diagram of sand size categories](Image)

Fine sand grains can just be seen individually with the naked eye and have a feel similar to coarse-flour or table salt.

Medium sand can easily be seen as individual grains and feels similar to white sugar.

Coarse sand is very distinctive; many medium sands may seem “coarse”. Similar to raw sugar.

This distinction into particle sizes helps to evaluate the water behaviour of the sand, because of the close dependence of water retention and movement properties on the pore size distribution of the soil.
Table A.2.1. Descriptions of texture grades

<table>
<thead>
<tr>
<th>Field texture grade*</th>
<th>Behaviour of moist bolus</th>
<th>Approximate clay content (percentage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>Coherence nil to very slight, cannot be moulded; single sand grains adhere to fingers.</td>
<td>Always less than 10% and commonly less than 5%</td>
</tr>
<tr>
<td>Loamy sand</td>
<td>Slight coherence; can be sheared between thumb and forefinger to give minimal ribbon of about 5 mm.</td>
<td>5% to 10%</td>
</tr>
<tr>
<td>Clayey sand</td>
<td>Slight coherence; sticky when wet, many sand grains stick to fingers; will form minimal ribbon of 5-15 mm; discolours fingers with clay stain.</td>
<td>5% to 10%</td>
</tr>
<tr>
<td>Sandy loam</td>
<td>Bolus just coherent but very sandy to touch; will form ribbon of 15-25 mm; dominant sand grains are of medium size and are readily visible.</td>
<td>10% to 15%</td>
</tr>
<tr>
<td>Loam</td>
<td>Bolus coherent and rather spongy; smooth feel when manipulated but with no obvious sandiness; may be somewhat greasy to the touch if much organic matter present; will form ribbon of about 25 mm.</td>
<td>about 25%</td>
</tr>
<tr>
<td>Sandy clay loam</td>
<td>Strongly coherent bolus, sandy to touch; medium size sand grains visible in finer matrix; will form ribbon of 25-40 mm.</td>
<td>20% to 30%</td>
</tr>
<tr>
<td>Clay loam</td>
<td>Coherent plastic bolus, smooth to manipulate; will form ribbon of 40-50 mm.</td>
<td>30% to 35%</td>
</tr>
<tr>
<td>Light clay</td>
<td>Plastic bolus; smooth to touch; slight resistance to shearing between thumb and forefinger; will form ribbon of 50-75 mm.</td>
<td>35% to 40%</td>
</tr>
<tr>
<td>Light medium clay</td>
<td>Plastic bolus; smooth to touch; slightly greater resistance to ribboning shear than light clay; will form ribbon of about 75 mm.</td>
<td>40% to 45%</td>
</tr>
<tr>
<td>Medium clay</td>
<td>Smooth plastic bolus; handles like plasticine and can be moulded into rods without fracture; has some resistance to ribboning shear; will form ribbon of 75 mm or more.</td>
<td>45% to 55%</td>
</tr>
<tr>
<td>Heavy clay</td>
<td>Smooth plastic bolus; handles like stiff plasticine; can be moulded into rods without fracture; has firm resistance to ribboning shear; will form ribbon of 75 mm or more.</td>
<td>50% or more</td>
</tr>
</tbody>
</table>

* Field texture grades may be qualified according to the size of the sand fraction.
6.4 Appendix 4. Condition of surface soil, structure and fabric

(from McDonald et al. 1984).

Condition of surface soil when dry

Many surface soils have a characteristic appearance when dry. Surface conditions are often relevant to the use of the soil and indicative of particular kinds of soil. The following conditions are not necessarily mutually exclusive:

Self-mulching  Highly pedal, loose surface mulch forms on drying.

Loose  Incoherent* mass of individual particles or aggregates. Surface easily disturbed by pressure of forefinger.

Soft  Coherent** mass of individual particles or aggregates. Surface easily disturbed by pressure of forefinger.

Firm  Coherent** mass of individual particles or aggregates. Surface disturbed or indented by moderate pressure of forefinger.

Hard-setting  Compact, hard, apparently apedal condition forms on drying. Surface not disturbed or indented by pressure of forefinger. Surface seal is not necessarily associated with hard setting.

* Incoherent means that less than two-thirds of the soil material, whether composed of peds or not, will remain united at the given moisture state without significant force.

** Coherent means that two-thirds of the soil material, whether composed of peds or not, will remain united at the given moisture state unless force is applied.

Structure

Soil structure refers to the distinctness, size and shape of peds. A ped is an individual natural soil aggregate consisting of a cluster of primary particles, and separated from adjoining peds by surfaces of weakness which are recognizable as natural voids or by the occurrence of cutans (Brewer 1960).

Soil structure can only be described reliably in a relatively fresh vertical exposure or relatively undisturbed soil core, not from an auger boring.

Grade of pedality is the degree, development and distinctness of peds. In pedal soils it expresses the relative difference between the strength of cohesion within peds and the strength of adhesion between adjacent peds.

Apedal soils have no observable peds and are divided into:

Single grain  Loose incoherent mass of individual particles.

Massive  Coherent. When disturbed, soil separates into fragments which may be crushed to ultimate particles.
Pedal soils have observable peds and are divided into:

**Weak** Peds indistinct and barely observable in undisplaced soil. When displaced, up to one-third of the soil material consists of peds.

**Moderate** Peds well formed and evident but not distinct in undisplaced soil. Adhesion between peds is moderate to strong. When displaced, more than one-third of the soil material consists of peds.

**Strong** Peds quite distinct in undisplaced soil. Adhesion between peds is moderate to weak. When displaced, more than two-thirds of the soil material consists of peds.

**Fabric**

Fabric describes the appearance of the soil material (under x10 hand lens). Differences in fabric are associated with the presence or absence of peds, the lustre or lack of lustre of the ped surfaces, and the presence, size and arrangement of pores (voids) in the soil mass. The descriptions given below apply primarily to B horizons.

**Earthy (or porous) fabric.** The soil material is coherent and characterized by the presence of pores (voids), few, if any, peds, and a general floc condition throughout. Ultimate soil particles (sand grains, for example) are coated with oxides and/or clays and are arranged (clumped) around the pores.

**Sandy fabric.** The soil material is coherent with few, if any, peds. The closely packed sand grains provide the characteristic appearance of the soil mass.
This appendix defines each land quality and discusses the factors which affect it. The effect of that land quality on the six land uses is discussed. The six land uses being assessed are annual pastures, cereals, lupins, blue lupins, field peas and tagasaste.

<table>
<thead>
<tr>
<th>Table A.5.1. List of land qualities assessed for each soil type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land quality</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Plant requirements:</td>
</tr>
<tr>
<td>Moisture availability</td>
</tr>
<tr>
<td>Nutrient availability</td>
</tr>
<tr>
<td>Waterlogging</td>
</tr>
<tr>
<td>Rooting conditions</td>
</tr>
<tr>
<td>Salinity</td>
</tr>
<tr>
<td>Management requirements:</td>
</tr>
<tr>
<td>Trafficability</td>
</tr>
<tr>
<td>Conservation requirements:</td>
</tr>
<tr>
<td>Soil structural decline hazard</td>
</tr>
<tr>
<td>Water erosion hazard</td>
</tr>
<tr>
<td>Wind erosion hazard</td>
</tr>
<tr>
<td>Recharge hazard</td>
</tr>
</tbody>
</table>
Moisture availability (m)

The availability of moisture is generally the greatest yield determining factor on most soils in the Western Australian wheatbelt.

The available water content (AWC) is a measurement of a soil’s ability to supply moisture for plant growth (where the AWC is the difference between the soil’s field capacity and the wilting point - see Figure A.5.1. below).

Field capacity occurs when a soil’s large pore spaces (>30 microns) have drained but when all the small pores and capillary channels are still filled with water. Wilting point occurs when the soil is so dry that plant roots can obtain no more water. That is the soil pores hold on to the remaining soil water tighter than the absorptive power of the roots. Unless water is added to the soil at wilting point, plants eventually die.

It can be seen from Figure A.5.1. that the texture of a soil has a major influence on the available water content. A sand is able to hold only a small amount of water when completely full i.e. it has a low water content at field capacity. This is because sandy soils have big pore spaces that drain freely.

Clay soils can store larger quantities of water. However, because of their large percentage of very small pores, they hold onto much of this water tightly (i.e. high water content at wilting point). This fact explains why crops grown on clay soils feel the 'pinch' and run out of moisture during a dry spring.

It is the loamy soils which are able to supply the maximum amount of available water to plants.

Perry (1985) used a water balance model to examine the effect of available water content on grain yield for three soil types over five years at Wongan Hills.

The results from the model displayed in Table A.5.2. show that small increases in texture and available water content can greatly affect productivity.
Table A.5.2. Grain yield (kg/ha) on three soil types at Wongan Hills (Perry 1985)

<table>
<thead>
<tr>
<th>Year</th>
<th>Sand1</th>
<th>Wongan Hills Sand2</th>
<th>Loamy sand3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1978</td>
<td>178</td>
<td>728</td>
<td>942</td>
</tr>
<tr>
<td>1979</td>
<td>527</td>
<td>1,206</td>
<td>1,699</td>
</tr>
<tr>
<td>1980</td>
<td>677</td>
<td>1,368</td>
<td>1,704</td>
</tr>
<tr>
<td>1981</td>
<td>801</td>
<td>1,668</td>
<td>2,187</td>
</tr>
<tr>
<td>1982</td>
<td>1,018</td>
<td>2,172</td>
<td>2,825</td>
</tr>
<tr>
<td>Potential</td>
<td>(4,799)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Soils 1, 2 and 3 have available water contents of 5, 6 and 7% respectively and possibly equate to the Deep yellow sand and two phases of the Yellow gradational loamy sand respectively.

The available water content of a soil is also affected by the proportion of fine, medium and coarse sand. This is because grain size affects pore size. Appendix 3 defines the differences between fine, medium and coarse sand. Even a small percentage of coarse sand within a medium or fine sand will greatly reduce the water holding capacity.

Water holding capacity is affected by the structure of the soil. Well structured soils have many cracks and large pores between the soil aggregates which are able to store considerable quantities of moisture.

Water may run off non-wetting sandy soils or hardsetting soils which have a low infiltration rate thus resulting in less moisture for plant growth.

The available water content of the sandy topsoils of many duplex and sandplain soils in Western Australia is low. The depth to a clay or confining layer such as ironstone gravel is very important in determining moisture availability.

The ability of a soil to supply moisture is also affected by seepage flow that often benefits lower positions in the landscape.

The occurrence of large amounts of rock or gravel within the soil profile reduces the available water content as the soil volume is effectively reduced.

Comparison of crop and pasture types

Different crop and pasture species, because of their different root morphology, are able to better obtain moisture from different soil types.

Because of their shallow root system (maximum depth of 40 to 50 cm under favourable conditions) subterranean clover species have difficulty obtaining sufficient moisture for growth and reproduction on deep sands. For good growth on sandy surfaced soils subterranean clovers generally require a heavier textured layer within 40 cm.
Medic species can root to greater depths (maximum depth of about 75 cm under favourable soil conditions) than subterranean clover. However, the bulk of the root system occurs within the top 20 to 30 cm and these plants are better suited to shallower, heavier textured soils.

Serradella is better suited than subterranean clovers and medics to deep sandy soils as its roots can reach a depth of about 100 cm.

The cereal root system is suited to obtaining moisture from a wide range of soil types. Under ideal conditions cereal roots can reach depths of about 2 m in deep sands. The cereal root system, because of its adventitious nature, is well adapted to penetrate and extract moisture in clay layers.

Lupin roots have been measured to depths of about 3 m in deep, sandy soils. However, their tap root has difficulty penetrating very far into many clay layers. Lupins appear to be less drought tolerant than cereals and, on most soils, yield reductions in dry years are more pronounced.

The fibrous field pea root system can, under favourable soil conditions, reach depths of 100 cm. However, in heavier textured soils the bulk of the root mass occurs within the top 30 cm. Compared with lupins, field peas are less tolerant of dry periods and grow better in years with small and regular rainfall.

Tagasaste, and to a lesser extent blue lupins are deep rooted species well adapted to obtaining moisture from deep sands. Tagasaste roots may reach depths of 8-10 m in deep sands. The clay layers in many duplex soils severely restrict tagasaste root growth and cause leaf drop in summer as a result of moisture stress.
The nutrient availability is the ability of a soil to retain and supply nutrients for plant growth. Nutrient availability depends on the clay content, type of clay, organic matter content and pH.

The elements nitrogen, phosphorus, potassium, calcium, magnesium and sulphur are termed macro-elements and are required in considerable amounts by all plants. Manganese, boron, iron, copper, zinc, molybdenum, sodium, chlorine and cobalt are termed trace elements and are all needed only in small quantities.

These nutrient elements occur in soils in several forms:

1. combined with other elements in minerals;
2. combined with other elements in organic residues (humus);
3. on the surfaces of mineral and organic particles as electrically charged ‘ions’;
4. dissolved in the water in the soil (the soil solution) as ions.

It is as ions or charged particles that plants take up most of the nutrient elements they require. The ions come either from water in the soil (the soil solution) or from the surfaces of minerals and organic matter.

These surfaces are usually negatively charged, and to preserve electrical neutrality, they attract and loosely hold positively charged ions. The nutrient elements held in this way are nitrogen in ammonium ($\text{NH}_4^+$), potassium ($\text{K}^+$), calcium ($\text{Ca}^{2+}$), magnesium ($\text{Mg}^{2+}$), iron ($\text{Fe}^{2+}$ or $\text{Fe}^{3+}$), manganese ($\text{Mn}^{2+}$), copper ($\text{Cu}^{2+}$) and zinc ($\text{Zn}^{2+}$). Other non-nutrient elements are held there too.
Some particles or parts of particles are positively charged and so can hold negatively charged ions. The nutrient elements that can be held in this way are nitrogen in nitrate (NO₃⁻), sulphur in sulphate (SO₄²⁻), phosphorus in phosphate (H₂PO₄⁻), molybdenum in molybdate (MoO₄²⁻), boron in various borate anions (B₄O₇²⁻, HBO₄²⁻, etc.) and chlorine as chloride (Cl⁻).

There are fewer sites for holding negatively charged ions in soils and most are held only lightly. Elements such as nitrate and chloride remain in the soil solution. They are therefore relatively easily leached out of the surface layers of a soil by heavy rainfall. Phosphate is more firmly held, but the holding is due more to fixing by ironstone gravels, than adsorption of ions.

Ions are constantly being released from soil mineral particles as they ‘weather’ or break down, and form organic matter as it is decomposed by microbes. These then become available for adsorption onto particle surfaces.

**Soil pH**

Soil pH is a measure of the acidity or alkalinity of a soil. A pH of 7.0 denotes neutrality, higher values indicate alkalinity and lower values indicate acidity. Soils in the agricultural zone of Western Australia are becoming more acid due to farming practices. Acids accumulate when nitrogen is leached from a soil or when plant produce (especially legume hay or, to a lesser extent seed) is removed from an area of soil. Nitrogen is added to the soil either by legumes or nitrogen fertilizers. The rate of acidification is higher on sandy surfaced soils as they have a lower buffering capacity than clayey soils. The rate of acidification is also faster on higher producing soils than poorer soils such as the Deep pale sand.

Lime can be used to improve the pH of these acid soils. Less lime is required to improve the pH of sandy soils than clayey soils.

Some yellow sandplain soils commonly found in the eastern and north eastern wheatbelt (but do occur in small areas in the east of the Northam Advisory District) have a naturally acidic subsoil. These soils are often called ‘Wodjil soils’, or in this manual the Deep yellow acid sand.

**Comparison of crop and pasture types**

The nutrient requirements of different crop and pasture species is too complex to be discussed in any detail here.

Deeper rooted species are generally better able to obtain nutrients in deep, sandy profiles where leaching is common.

Legumes such as subterranean clover, medics, field peas, lupins, tagasaste and acacias are capable of producing their own nitrogen through fixing nitrogen from the atmosphere.

Broad-leaved plants require higher levels of soil potassium than cereals (60 ppm is marginal for legumes whereas 40 ppm is marginal for cereals).

Trace element deficiencies are more common in sandplain soils.

For more detailed information on plant nutrition requirements and common
nutrient deficiencies in the Western Australian wheatbelt, refer to Western Australian Department of Agriculture Farmnotes.

Table A.5.3 gives the critical pH levels at which productivity is reduced for different species and varieties.

It should be noted that in the case of legumes it is often rhizobial nodulation rather than the host plant which is limited by the low soil pH. Alkaline soils with high lime content which have a pH around 8.5 can greatly affect lupin growth due to iron deficiency.

<table>
<thead>
<tr>
<th>Species/variety</th>
<th>Critical pH level (CaCl₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truncatula medics (e.g. Cyprus)</td>
<td>5.5-5.8</td>
</tr>
<tr>
<td>Polymorpha medics</td>
<td>4.8-5.2</td>
</tr>
<tr>
<td>Murex medics</td>
<td>4.5-4.8</td>
</tr>
<tr>
<td>Subterranean clover, field peas</td>
<td>4.2-4.5</td>
</tr>
<tr>
<td>Serradella, lupins</td>
<td>4.0-4.3</td>
</tr>
<tr>
<td>Barley, sensitive wheats</td>
<td>4.2-4.5</td>
</tr>
<tr>
<td>Tolerant wheats</td>
<td>4.1-4.4</td>
</tr>
<tr>
<td>Oats, triticale</td>
<td>4.0-4.3</td>
</tr>
<tr>
<td>Tagasaste</td>
<td>4.0-4.5</td>
</tr>
<tr>
<td>Cereal rye</td>
<td>3.9-4.2</td>
</tr>
</tbody>
</table>
Waterlogging occurs when a soil is saturated with water, thereby replacing most or all of the soil air. The oxygen supply to the plant roots, which are the main area of oxygen uptake, is greatly limited. This inhibits the plants’ energy generating systems and results in root cell death which in turn causes a rapid reduction in the water absorbing capacity of roots.

Factors which combine to cause waterlogging can include low relief (poor external drainage), run-on, low soil permeability and seepage.

Soils occurring on gentle, lower slopes or valley flats are prone to waterlogging because of poor external drainage. Run-on from low infiltration areas such as non-wetting soils below breakaways or rock outcrops can contribute to waterlogging. Low subsoil permeability is a major cause of waterlogging on many of the duplex soils within the advisory district. The clay subsoil of these soils is often sodic (has a high ratio of sodium to calcium and magnesium) and disperses when wet, blocking soil cracks and thus water movement down the profile. Rock barriers or a break in slope can cause subsurface seepage flow to come to the surface, which results in isolated patches of waterlogging.

Root pruning during winter months by waterlogging often decreases the drought tolerance of crops and pastures in spring. In some situations this may be compensated for by seepage flow later into the season.

Plant root diseases, such as take-all and rhizoctonia, are more common on waterlogged affected sites.

Waterlogging can also cause certain plant nutrients to become more or less available for plant growth. For example, nitrogen becomes less available because of reduced organic matter breakdown. Furthermore, any nitrate present in the soil will be reduced under the oxygen deficient conditions and is lost as nitrogen or oxides of nitrogen.

Established plants are better able to handle waterlogging than seedlings. Consequently early seeded crops generally suffer less from waterlogging.

Comparison of crop and pasture types

Different crop and pasture species are able to tolerate waterlogging to varying degrees.

The following paragraph lists relevant crop and pasture species starting from the least tolerant to waterlogging through to the most tolerant. It must be remembered, however, that there is considerable variation in tolerance to waterlogging within some crop and pasture species.

Tagasaste is very susceptible to waterlogging, though it will thrive if subsoil moisture is available at depth into summer. Lupins and field peas are more susceptible to waterlogging than cereals, and poor growth or death is common in wet years. Oats are more tolerant of waterlogging than wheat and barley and outyield these crops in wetter years. Medics are believed to be more susceptible to waterlogging than subterranean clover, although burr medics are tolerant of
transient periods of waterlogging. Waterlogged subterranean clover pastures often experience compensatory growth during the spring flush. However, the amount of pasture during the spring does not limit carrying capacity to the same extent as does winter growth.

Rooting conditions (d)

Rooting conditions refer to the amount of space available for plant roots to develop in and the mechanical impedence to root development.

Siliceous hardpans, hardened mottled zone (known in some areas as conglomerate), shallow bedrock and dense clay layers all affect root growth.

These impeding layers effectively limit root exploration thus reducing the plants ability to find moisture and nutrients. Different species have different abilities to penetrate such impeding layers.

Comparison of crop and pasture types

Shallow rooted pasture and field pea crops are not affected by subsoil hardpans or rock to the same extent as deeper rooted crop and tree species. In most soil types a large percentage of the root system of subterranean clovers, medic and field peas occurs within 30 cm of the soil surface and would not be greatly affected by pans located below this depth.

Lupins grow poorly in areas with a shallow, confining layer. They die off earlier due to the lack of moisture, and yield poorly.

Cereals are generally less affected than lupins on soils with a siliceous hardpan, hardened mottled zone layer or fractured rock layer.
Soil structure decline (s)

Soil structure decline can be divided into two categories: (1) surface structural decline on heavy, fine textured soils and (2) the development of traffic compaction pans below the surface on lighter textured soils.

Cultivation and trampling by stock of heavy soils, especially under adverse moisture conditions, can cause aggregate break-down and soil compaction. This results in reduced rainfall infiltration, poor soil aeration, reduced seedling emergence and root growth and increased run-off. Soil structure may be improved in cropping years through the use of minimum and zero tillage and the application of gypsum. Pasture helps to increase the organic matter levels in the soil and structure may improve provided sensible grazing management practices are adopted.

A simple dispersion test should be conducted to see if the soil will respond to gypsum (Western Australian Department of Agriculture Farmnote No. 32/85). If the soil is gypsum responsive and crop yield is being depressed by the unstable structure of the soil, then test strips are warranted to assess whether gypsum application will be beneficial. Additional nitrogen may also be required in order to get a yield response from gypsum application (see Western Australian Department of Agriculture Farmnote No. 57/90).

Crop yields on degraded soils often decrease in the first couple of years following the introduction of minimum/zero tillage. This is because of problems associated with creating a suitable seedbed without two or more cultivations. However, after a couple of years of cropping using minimum/zero tillage, soil structure generally improves and crop yields often outyield those obtained by district tillage practices. Gypsum applied before the adoption of minimum/zero tillage practices can prevent the initial yield penalty provided nitrogen is not limiting.

 Cultivation of sandy soils can lead to the formation of a traffic compaction pan at about 10 to 30 cm. This pan forms because of the soil’s inability to support vehicles and cultivation implements. Traffic compaction pans affect crop root growth, effectively limiting the plants ability to find moisture and nutrients. Deep ripping can remove these pans and increase yield. Direct drilling following ripping reduces the rate of pan development.

Comparison of crop and pasture types

Cereal yields can be reduced by as much as 50% on heavy soils with a degraded surface structure. This is partly a result of reduced rainfall infiltration effectively reducing the amount of water available at seeding, and increased soil density and strength affecting seedling emergence and root growth.

Lupins often grow very poorly on hardsetting, degraded soils. The emerging lupin seed leaf or cotyledon has difficulty in pushing through any hard surface layers. Consequently, the percentage of lupins emerging on these soils is often low.
Field peas are not affected by surface structural decline to the same extent as lupins. Their cotyledons stay below the surface and the emerging shoot can more easily penetrate the surface.

Hardsetting soils greatly limit the ability of subterranean clover plants to bury their burr. This limits seed production and a greater percentage of the seed is available to animals. Subterranean clover plants may have trouble persisting in soils with poor surface structure.

Medics are not greatly affected by hardsetting soils as they do not bury their seed. Degraded soils do, however, reduce seedling emergence which can have a large effect on early pasture production.

Traffic compaction pans can greatly limit cereal yields. The average yield increase to ripping on responsive soils is 500 kg/ha (Department of Agriculture trials). This response is approximately halved every subsequent year. Lupin, field pea, subterranean clover and medic growth is not or is only slightly affected by traffic compaction pans.

**Trafficability (t)**

Trafficability refers to the ability to use machinery. Soils which become boggy can greatly restrict access at seeding and during chemical spraying. Areas prone to becoming boggy include heavy textured soils, saturated duplex soils and seepage areas.

Steep slopes and very rocky soils affect the ease and safety of vehicle use.

**Comparison of crops and pasture types**

The management of pastures is rarely affected by trafficability problems. On steep, rocky areas, aerial seeding and fertilization of pastures may be needed.

Mechanical access for seeding cereals, lupins and field peas is equally affected by boggy soils. Rocky soils can cause problems when harvesting field peas due to the field peas low growth habit.
Salinity (y)

Salinity is the build up of soluble salts, especially sodium chloride within the soil profile. High salt levels in the soil water affect the plants ability to take up moisture.

Salinity occurs as a result of the clearing of native vegetation and replacement with lower water using crops and pastures. The hydrological balance is affected with increased recharge to the groundwater table. The groundwater, which is often saline, rises to a height where it begins to affect crop growth.

There are four types of salinity; valley floor salinity, sandplain seepages, hillside seepages and dryland salinity.

Valley floor salinity is the most widespread and occurs as described above. Sandplain seepages are located where areas of sandplain meet heavier soils. Water, which is often relatively fresh, is forced to the surface, where it evaporates causing the salt to concentrate. Hillside seeps are formed when a rock barrier such as a dolerite dyke forces laterally flowing water to the surface. Evaporation concentrates the salt. Dryland salinity occurs where the soil is inherently salty and it does not involve a rising watertable. The Powdery surfaced calcareous soil or ‘Morrel soils’ often fit into this category.

Various options are available to combat salinity and often a range of approaches is needed. The recharge areas, such as the Deep palesand can be planted to high water using species (agronomic manipulation). Contour banks can be used to divert water away from seepages. Deep drains can be dug in order to lower the water table. Saline areas can be planted to salt tolerant species (saltland agronomy).

Comparison of crop and pasture types

Different crops and pastures have different tolerances to salinity. Table A.5.4 outlines these.

Oats have a salinity tolerance roughly equivalent to that of wheat. Lupins and field peas have a poor tolerance to salinity. Tagasaste also has a poor tolerance to salinity.

If the soil is poorly drained as well as saline, plant growth is more severely affected.

| Table A.5.4. Yield decrease of crops at conductivity levels (mSm⁻¹) of 1:5 soil:water extracts for three different textural ranges (Western Australian Department of Agriculture Technote No. 6/85) |
|---------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|
|                                 | Light | 0% reduction | Medium | Heavy | Light | 50% reduction | Medium | Heavy |
| Wheat                           | 33    | 53            | 75     |       | 72    | 115           | 161    |
| Barley                         | 44    | 71            | 99     |       | 99    | 159           | 224    |
| Subterranean clover            | 8     | 13            | 19     |       | 31    | 50            | 71     |
| Medic (barrel)                 | -     | -             | -      |       | 54    | 68            | 96     |
| Couch                          | 38    | 61            | 86     |       | 81    | 130           | 183    |
| Ryegrass                       | 31    | 49            | 70     |       | 67    | 108           | 152    |
Wind erosion hazard (w)

Wind erosion hazard is the potential of a piece of land to erode due to the action of wind. It is dependent on the soil erodibility, the wind exposure, the ground cover and land management practices.

Soil erodibility is primarily determined by particle size and soil structure (the more a soil is aggregated the less erodible it is). As a result, soils with a good surface structure or that hard-set are less prone to erosion. Loose, sandy soils that do not form clods or peds are prone to erosion.

Indirectly, other land qualities such as moisture availability and nutrient availability which affect pasture growth and ground cover also affect the wind erosion hazard.

Wind erosion predominantly occurs at two times of the year: in the period following cultivation before the emerging crop has established a reasonable ground cover, and following overgrazing of stubbles and pastures in summer and autumn.

Good management practices such as avoiding overgrazing, the planting of windbreaks, direct drilling and stubble retention can reduce or prevent wind erosion.

Comparison of crop and pasture types

Lupin stubbles do not offer the same level of protection as cereal stubbles and greater amounts should be left on the soil surface following grazing.

Field pea stubbles offer little protection to the soil surface especially when grazed. Wind erosion is a major limitation to growing field peas on all but hardsetting soils.

Pastures are prone to wind erosion if overgrazed. Medics are generally grown on heavy textured soils that are not prone to wind erosion. However, they tend to break up more easily than subterranean clovers and when grown on lighter soils offer the soil less protection from the wind.

Pastures with a high grass content are less likely to erode than legume dominant pastures when grazed over summer.
Water erosion hazard (e)

Water erosion hazard is the potential for sheet, rill or gully erosion to occur on a piece of land. It is dependent upon a number of characteristics including soil erodibility, slope gradient, rainfall, run-on received, ground cover and land management.

Good land management can prevent erosion in all but the most severe of rainfall events. Practices used include earthworks, contour working, stubble retention and minimum tillage.

Comparison of crop and pasture types

All crops have roughly the same water erosion hazard with the critical period being from when the soil is first cultivated until reasonable ground cover is established. Soils under pasture are less likely to erode than those under crops.

Recharge hazard (g)

Recharge hazard is the potential for a piece of land to recharge the deep groundwater table and thus contribute to salinity. Under natural vegetation (uncleared state) the amount of recharge is low and is roughly equal to losses from the catchment. Following clearing and the introduction of lower water using pasture and crop species this equilibrium has been altered.

The greatest amount of recharge occurs in deep permeable soils such as the Deep pale sand where the soil water quickly drains out of the root zone. The bulk of recharge is contributed in early winter when rainfall is high but moisture use by plants low. Areas of deep, infertile sands generally support poor pasture growth which uses a low percentage of the rainfall, with the rest either evaporating or becoming recharge.

Soils immediately adjacent to rock outcrops can often add large quantities of recharge to the groundwater table. Water runs off the outcrops and is able to reach the water table through zones of fractured rock.

Seepage areas, where large amounts of water sit for most of the year, can also contribute substantial recharge through preferred pathways within the clay or confining rock layers.

Soils with a clay subsoil that is within reach of plant roots generally contribute little recharge. Large volumes of rainfall can be stored here (not lost from root zone) and subsequently used by plants. However, in waterlogged duplex soils it is believed that significant recharge may occur through preferred pathways in the clay layer.
Comparison of crop and pasture types

Pasture species use considerably less soil moisture than crop or tree species thus allowing more recharge. There appears to be little variation in water use from one pasture species to another. However, subterranean clover and medics would use less soil water than deeper rooted serradella species, especially on deep sands.

The recharge contributed through a field pea crop is probably similar to that of pasture species.

On the better soil types cereal and lupin crops are able to use most or all of the soil water in many seasons if management is good (healthy, early sown, fast growing crops use more soil water than poor crops). Lupins use more soil water than cereals. Among the cereals, barley and oats use more water than wheat. On the light soil types where recharge hazard is greatest, cereals and lupins in most years are unable to use all the soil moisture before it is lost from the root zone.

Fodder trees are capable of using large amounts of soil water.
6.6 Appendix 6. The land capability classification

The capability classes

The classification used in this study is the standard five class system adopted by the Western Australian Department of Agriculture for land capability assessment. Class I land has the highest potential and fewest limitations for a specified use, while class V land is regarded as prohibitive for the proposed land use (see Table A.6.1.).

<table>
<thead>
<tr>
<th>Class I:</th>
<th>Land with a very high capability for the proposed use. Either there are no physical limitations to the specified land use, or the limitations are easily overcome. Risk of land degradation is low.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class II:</td>
<td>Land with a high capability for the proposed use. Some physical limitations do occur, affecting either its use, or land degradation risk. These limitations can be overcome through careful planning or moderate application of conservation measures.</td>
</tr>
<tr>
<td>Class III:</td>
<td>Land with a fair capability for the proposed use. Physical limitations do occur which will significantly affect land use or result in moderate risk of land degradation. Careful planning and/or extensive conservation measures are required.</td>
</tr>
<tr>
<td>Class IV:</td>
<td>Land with a low capability for the proposed use. There is a high degree of physical limitation or a high risk of degradation which can only be overcome with expensive conservation measures or development costs. Future technology or economic circumstances may change this classification.</td>
</tr>
<tr>
<td>Class V:</td>
<td>Land with a very poor capability for the proposed activity or use. The severity of its physical limitation prohibits its use.</td>
</tr>
</tbody>
</table>

Deriving the classification

There were six stages in deriving the land capability classification.

1. Identifying and describing the soil types.

2. Selecting the land use types relevant to the region. These were annual pastures, cereal crops, sweet lupins, blue lupins, field peas and tagasaste.

3. Identifying relevant land qualities of importance for plant growth, for farm management and for conservation requirements.
Land qualities are those attributes of, or affecting, land which influence the suitability of land for a specific use. They render land either suitable for a specific use or, conversely, they become limiting factors for such use. The land qualities considered relevant for this study are listed below.

4. Formulating the requirements of each land use type in terms compatible with the land qualities.

5. (a) Ranking each land quality into an appropriate capability class, for each of the land use types.

   (b) Matching the plant requirements, from the factor-rating tables with the physical characteristics of the soil types.

6. Deriving the overall land capability classification for the soil types for each land use type (see Table A.6.2. in this Appendix). The overall capability is determined by the most limiting quality or qualities. In Table A.6.2. those land qualities which are limiting are shown as letter suffixes. There may be more than one limiting land quality. No subscript is shown for units rated as class I because there are no significant limiting factors.

<table>
<thead>
<tr>
<th>Land quality</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plant requirements:</strong></td>
<td></td>
</tr>
<tr>
<td>Moisture availability</td>
<td>m</td>
</tr>
<tr>
<td>Nutrient availability</td>
<td>n</td>
</tr>
<tr>
<td>Waterlogging</td>
<td>i</td>
</tr>
<tr>
<td>Rooting conditions</td>
<td>d</td>
</tr>
<tr>
<td>Salinity</td>
<td>y</td>
</tr>
<tr>
<td><strong>Management requirements:</strong></td>
<td></td>
</tr>
<tr>
<td>Trafficability</td>
<td>t</td>
</tr>
<tr>
<td><strong>Conservation requirements:</strong></td>
<td></td>
</tr>
<tr>
<td>Soil structural decline hazard</td>
<td>s</td>
</tr>
<tr>
<td>Water erosion hazard</td>
<td>e</td>
</tr>
<tr>
<td>Wind erosion hazard</td>
<td>w</td>
</tr>
<tr>
<td>Recharge hazard</td>
<td>g</td>
</tr>
</tbody>
</table>
The following classification and assessments were derived with assistance from various farmers and the advisory, technical and research staff of the Western Australian Department of Agriculture.

<p>| Table A.6.2. Land capability assessment tables |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| Pasture | Wheat | Lupins | Field peas | Blue lupins | Tagasaste |</p>
<table>
<thead>
<tr>
<th>Pasture</th>
<th>Wheat</th>
<th>Lupins</th>
<th>Field peas</th>
<th>Blue lupins</th>
<th>Tagasaste</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Deep pale sand</td>
<td>V m,n,g</td>
<td>V m,n</td>
<td>V m,n</td>
<td>V w,m,n</td>
<td>I-III m,n</td>
</tr>
<tr>
<td>2. Deep yellow sand</td>
<td>IV m</td>
<td>II-III m,s</td>
<td>I</td>
<td>V w</td>
<td>I</td>
</tr>
<tr>
<td>3. Yellow gradational loamy sand</td>
<td>I</td>
<td>I</td>
<td>IV w</td>
<td>I</td>
<td>II-IV d</td>
</tr>
<tr>
<td>4. Pale sand over gravel/loamy sand</td>
<td>IV m</td>
<td>III m</td>
<td>II-III m</td>
<td>V w</td>
<td>I</td>
</tr>
<tr>
<td>5. Waterlogged sand</td>
<td>IV m,i,n</td>
<td>IV i</td>
<td>V i</td>
<td>V w</td>
<td>V i</td>
</tr>
<tr>
<td>6. Deep yellow acid sand</td>
<td>IV-V** n,m,g</td>
<td>IV-V** n,m</td>
<td>III-IV** n,m</td>
<td>V w</td>
<td>III-IV** n,m</td>
</tr>
<tr>
<td>7. Shallow mottled zone</td>
<td>IV d,m,n</td>
<td>IV-V d,m,n</td>
<td>V d,m,n</td>
<td>IV w,d,m,n</td>
<td>V d,m</td>
</tr>
<tr>
<td>8. Shallow hardsetting grey sandy loam over clay</td>
<td>III-IV m,s</td>
<td>III-IV m,s,e</td>
<td>V m,s</td>
<td>IV m,s,e</td>
<td>V m,s</td>
</tr>
<tr>
<td>9. Sandy loam over clay</td>
<td>II m</td>
<td>I-II m,e,s</td>
<td>IV m,n</td>
<td>II w,s</td>
<td>IV m,n</td>
</tr>
<tr>
<td>10. Loamy sand over clay</td>
<td>I-II m</td>
<td>I-II m,i</td>
<td>II m,i</td>
<td>IV w</td>
<td>II m,i</td>
</tr>
<tr>
<td>11. Rocky red brown loamy sand/sandy loam</td>
<td>I</td>
<td>I</td>
<td>II-III m</td>
<td>II-III w</td>
<td>II-III m,i</td>
</tr>
<tr>
<td>12. Brownish grey granitic loamy sand</td>
<td>II m</td>
<td>II m,i</td>
<td>II m,i,d</td>
<td>IV w</td>
<td>II m,i,d</td>
</tr>
<tr>
<td>13. Red brown doleritic clay loam</td>
<td>I</td>
<td>I</td>
<td>IV m,n</td>
<td>I</td>
<td>II-III m,n</td>
</tr>
<tr>
<td>14. Deep sandy surfaced valley soil</td>
<td>II m</td>
<td>II m,i</td>
<td>III m,i,n</td>
<td>IV w</td>
<td>II m,i</td>
</tr>
<tr>
<td>15. Shallow sandy surfaced valley soil</td>
<td>I</td>
<td>I-II i</td>
<td>IV m,i,n</td>
<td>IV w</td>
<td>II-III m,i,n</td>
</tr>
<tr>
<td>16. Red brown sandy loam over clay valley soil</td>
<td>I</td>
<td>I</td>
<td>IV n,m,s</td>
<td>II w,m</td>
<td>III n,m,s</td>
</tr>
<tr>
<td>17. Red clay valley soil</td>
<td>I-II m</td>
<td>II m,s,t</td>
<td>IV-V n,m,s</td>
<td>I</td>
<td>IV n,m,s</td>
</tr>
<tr>
<td>18. Grey clay valley soil</td>
<td>I-II m</td>
<td>III s,t</td>
<td>IV-V n,m,s</td>
<td>I</td>
<td>IV n,m,s</td>
</tr>
<tr>
<td>19. Grey to brown cracking clay</td>
<td>I-II m</td>
<td>I-II m,t</td>
<td>IV n,s</td>
<td>I</td>
<td>IV n,m,s</td>
</tr>
<tr>
<td>20. Powdery surfaced calcareous soil</td>
<td>II m,w</td>
<td>II m</td>
<td>V n</td>
<td>IV w</td>
<td>V n</td>
</tr>
</tbody>
</table>

** Dependent on the subsoil pH.
+ Non saline areas
## 6.7. Appendix 7. A correlation of the soil types with other studies in the area

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Deep pale sand</td>
<td></td>
<td>Deep uncemented gravelly soils - non acid</td>
</tr>
<tr>
<td>2. Deep yellow sand</td>
<td></td>
<td>Deep earthy sands - non acid</td>
</tr>
<tr>
<td>3. Gradational yellow loamy sand</td>
<td>Ulva sandy loam</td>
<td>Deep earthy sands and gravelly soils - acid</td>
</tr>
<tr>
<td>4. Pale sand over gravel/loamy sand</td>
<td></td>
<td>Shallow cemented laterite</td>
</tr>
<tr>
<td>5. Waterlogged sand</td>
<td></td>
<td>White gum soils or erosional soils</td>
</tr>
<tr>
<td>6. Deep yellow acid sand</td>
<td>Norpa clayey sand</td>
<td>Salmon gum soils or medium textured soils or depositional soils</td>
</tr>
<tr>
<td>7. Shallow mottled zone</td>
<td>Ulva sandy loam</td>
<td>Mallee or duplex soils</td>
</tr>
<tr>
<td>8. Shallow hardsetting grey sandy loam over clay</td>
<td>Booraan sandy loam</td>
<td>York gum, jam soils</td>
</tr>
<tr>
<td>9. Sandy loam over clay</td>
<td></td>
<td>York gum, jam soils</td>
</tr>
<tr>
<td>10. Loamy sand over clay</td>
<td>Colgar sandy loam, Elabbin sandy loam</td>
<td>York gum, jam soils</td>
</tr>
<tr>
<td>11. Rocky red brown loamy sand/sandy loam</td>
<td>Jura clayey sand</td>
<td>York gum, jam soils</td>
</tr>
<tr>
<td>12. Brownish grey granitic loamy sand</td>
<td></td>
<td>York gum, jam soils</td>
</tr>
<tr>
<td>13. Red brown doleritic clay loam</td>
<td></td>
<td>York gum, jam soils</td>
</tr>
<tr>
<td>14. Deep sandy surfaced valley soil</td>
<td></td>
<td>York gum, jam soils</td>
</tr>
<tr>
<td>15. Shallow sandy surfaced valley soil</td>
<td></td>
<td>York gum, jam soils</td>
</tr>
<tr>
<td>16. Red brown sandy loam over clay valve soil</td>
<td>Merredin sandy loam, Merredin sandy clay loam</td>
<td>Salmon gum gimlet soils</td>
</tr>
<tr>
<td>17. Red clay valley soil</td>
<td>Neening loam</td>
<td>Morrel soils</td>
</tr>
<tr>
<td>18. Grey clay valley soil</td>
<td></td>
<td>Morrel soils</td>
</tr>
<tr>
<td>19. Grey to brown cracking clay</td>
<td></td>
<td>Morrel soils</td>
</tr>
<tr>
<td>20. Powdery surfaced calcareous soil</td>
<td>Hines Hills loam, Nangeenan loam, Belluguttin clay loam, Belluguttin sandy clay loam</td>
<td>Morrel soils</td>
</tr>
</tbody>
</table>
The soil types to be mapped by a catchment group will differ from one area to another depending on the soil types that occur within the catchment. For example, in catchments which occur predominantly on sandplain, all the sandplain soil types should be mapped while the small areas of valley soil types can be amalgamated into one mapping unit.

Experience has shown that, in order to prevent confusion no more than about 12 soil types should be mapped within a given catchment. This appendix gives a list of major soil types and amalgamations of soil types suggested for presentation to catchment groups in the Zone of Ancient Drainage.

1. Deep pale sand
2. Deep yellow sand
3. Yellow gradational loamy sand.
4. Pale sand over gravel/loamy sand.
5. Shallow hardsetting grey sandy loam over clay,
6. Sandy loam over clay.
7. Loamy sand over clay.
8. Soils formed from fresh rock (combination of Rocky red brown loamy sand/sandy loam with the Brownish grey granitic loamy sand and possibly the Red brown doleritic clay loam).

The following notes give examples of how the list can be modified to account for the variation in soil type from area to area.

- If the catchment contains large areas of soils developed from fresh rock then it is preferable that all three soil types; the Rocky red brown loamy sand/sandy loam, the Brownish grey granitic loamy sand and the Red brown doleritic clay loam be mapped. The Coarse granitic sand (minor soil types - see Section 2.4) may also be relevant.
- If the catchment occurs in the far east or north-east of the Northam advisory district, the Deep yellow acid sand and Shallow mottled zone soil types may need to be included.
- If large areas of sandplain occur within the catchment and salinity and waterlogging are problems then areas of Waterlogged sand should be mapped out.
- If the catchment includes large areas of valley floors then all the valley soils in the manual may need to be mapped out. The Pale valley floor sand may also be relevant (minor soil type - see section 2.4).
- If the catchment contains areas of ‘Morrel soils’ then the Powdery surfaced calcareous soil should be highlighted for mapping.