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Soils of the Northam Advisory District. Volume 2. The zone of rejuvenated drainage

Neil Clifton Lantzke

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Soils of the
Northam
Advisory District

Volume 2

The Zone of Rejuvenated Drainage

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Figure 1

Physiographic Regions and Rainfall Isohyets in the Department of Agriculture's Northam Advisory District.

LEGEND

- Northam Dept. of Agriculture Advisory District Boundary
- Rainfall Isohyets
- Boundaries of Physiographic Regions
- Zone of Rejuvenated Drainage

Zone of Rejuvenated Drainage
(Volume 2)

Darling Range Zone and West Kokeby 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 manual's primary aims are to:

- assist with the identification of the advisory district’s soils;
- 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 standardised method for describing the soils of 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 Rejuvenated Drainage. Volume 1 deals with the soil types that occur within the Zone of Ancient Drainage and Volume 3 with those soils in the Darling Range and West Kokeby Zones.
Figure 2

IDEALIZED BLOCK DIAGRAM SHOWING THE SOIL LANDSCAPE UNITS THAT OCCUR IN THE ZONE OF REJUVENATED DRAINAGE.

Steep Rocky Hills (R)  Hamersley (H)

WEST  EAST

Rocky, red, sandy
Avon Valley slopes.

Rocky, red, loamy
Avon Valley slopes.

Yellow and
grey sandstones
and gravelly soils.

Shingles with dunes
soils.

Rocky high Plains
with red basalt
and grey loamy
sand soils.

Shingles with dunes
soils.

Rocky high Plains
with red basalt
and grey loamy
sand soils.

Shingles with dunes
soils.

Hamersley River and
Bodallin limestones
remain unconsoldated.

Yellow and
grey sandstones
and gravelly soils.

Shingles with dunes
soils.

Yellow and
grey sandstones
and gravelly soils.

Hamersley River and
Bodallin limestones
remain unconsoldated.

Polished sandstone
with some poorly
weathered areas.

SOIL LANDSCAPE UNIT

York (Y)  Avon (A)  York (Y)  Qualing (Qu)  Ewart (Es)  Marlock (Mo)  Ewart (Es)  Qualing (Qu)  Eaton (E)

MAJOR SOIL TYPES

Rocky Red Brown Loamy Sand/Sandy Loam
Brownish Grey Erosion Loamy Sand
Red Brown Eosollic Clay Loam

Whitebarked Grey Erosion Loamy Sand/Sandy Loam
Rocky Red Brown Loamy Sand/Sandy Loam
Brownish Grey Erosion Loamy Sand

Steep Soils

Red Brown Alluvial Loam
Grey Alluvial Clay
Orange Alluvial Loamy Sand

London Sands/Sandy Valley Duplex
Palo Valley Fine Sand
Grey Alluvial Clay

London Sands/Sandy Valley Duplex
Deep Sands/Sandy Valley Duplex
Shallow Sands/Sandy Valley Duplex
Yellow Erosional Loamy Sand
Sandy Loam Over Clay

Deep Yellow Sands
Deep Organic Sands
Palo Sands Over
Gum/Cotton Sand
Whitebarked Sand

Vegetation

York Gum
Shneck
Salmon Gum
White Gum

York Gum
York Gum
Flowered Gum
Shneck

Selmon Gum
York Gum
York Gum
Flowered Gum
Shneck

White Gum
York Gum
York Gum
Selmon Gum
Shneck

White Gum
Lyn
Yarri
Selmon Gum
Shneck

Gumflats Fir
Barkentine
Yarri
Tea Tree
Pholis Gum
White Gum

Kurrajong
Christmas Tree
White Gum
Yarri
Yeo Tree
Rushes
1.2 The Zone of Rejuvenated Drainage

This zone is bordered to the east by the ‘Meckering Line’ and to the west by the Darling Range Zone. The ‘Meckering Line’ is an imaginary line which is defined by the eastern most extremity of the south-west’s true river systems - beyond which chains of salt lakes occur (Figure 1).

The Zone of Rejuvenated Drainage consists of a dissected, undulating landscape. The valleys are steeper and narrower than those in the Zone of Ancient Drainage and contain rivers and creeklines that flow every winter. This zone contains the Avon Valley and the large areas of rolling country immediately to the east.

The Zone of Rejuvenated 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 eight soil landscape units that occur and lists their major soil types and dominant vegetation (many of these soil landscape units were first described by Mulcahy and Hingston, 1961).

The Qualling unit occurs as an undulating upland plateau containing areas of yellow and pale sandplain. The Ewerts unit, which is often separated from the Qualling unit by a breakaway, occurs on hillslopes over large areas in the east of this zone. Its soils are formed from the dissected lateritic profile and contain predominantly sand or loamy sand over clay soils.

Where rejuvenation of rivers has completely stripped away the lateritic profile areas of soils developed from fresh rock have formed on the York unit. The Avon Valley sideslopes consist almost entirely of the York unit. The Hamersley unit comprises the thin, midslope drainage lines within the York unit.

The Avon unit contains a mixture of well drained alluvial clays, loams and sands. The Mortlock unit, which occurs upstream from the Avon unit, typically contains salinity prone sand or loamy sand over clay soils. The Eaton unit contains the two large areas of pale surfaced sandplain that occur in the North Meckering and the East Bolgart - West Goomalling areas.
Figure 3
Location of the Study Area, Other Survey Areas, Physiographic Regions and the Department of Agriculture's Northam Advisory District.

LEGEND

Study Area
- Lantzko and Fulton (1993)

Other Surveys
- Battenay and Hingston (1961)
- McArthur, unpublished
- King and Wells (1990)
- Grellish, unpublished

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

Zone of Ancient Drainage
Darling Range Zone
West Kokeby Zone

Zone of Rejuvenated Drainage

Swan Coastal Plain

PERTHS

POGDART

STATE FOREST

GOMALLING

NORTHAM

TAMMIN

CUNDERIN

MERREDIN

WEST KOKABY

SWAN COASTAL PLAIN

ZONE OF REJUVENATED DRAINAGE

ZONE OF ANCIENT DRAINAGE

BRUCE ROCK
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 5,100 km² within the Northam Advisory District. This mapping, together with other broadscale 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 by the use of Table 1 on page 106. The major use of this broadscale mapping is regional planning.

1.4 Climate and land use

The average annual rainfall for this zone, within the Northam Advisory District ranges from about 600 mm near Toodyay in the west to about 375 mm in the east. About 70 per cent of the annual rainfall falls during the five to six month growing season (mid May to October). Rainfall is more reliable here than in areas to the north and east, making this some of the best wheatbelt country in the State. Appendix 1 gives the mean monthly rainfall data, mean daily maximum temperature and mean daily pan evaporation of various locations within and around this zone.

Farms generally range from 600 to 1,500 ha. Cropping is more intensive in the east of this zone with about 50 per cent of each farm cropped annually. In the western part, the proportion of the farm in crop decreases to about 30 per cent.

The major crops are wheat, barley, oats, lupins and field peas. The 10 year average yields for these crops within this zone of the Northam Advisory District are wheat (1.4 t/ha), barley (1.4 t/ha), oats (1.2 t/ha), lupins and field peas (1.1 t/ha). Pastures are usually subterranean clover or medic based, with the average carrying capacity being about 5-7 dry sheep equivalents/ha (winter grazed). Sheep are the predominant grazing animal, with cattle only becoming significant in the western part of the zone.

Salinity is a major land degradation problem in the east of this zone. Tree planting, growing crops and pastures with high water use, banks, drains and saltland agronomy are being used to manage or reduce the area affected by salinity. The sandy surfaced soils of this zone are prone to wind erosion if poorly managed. Many of the soils in this zone are subject to water erosion. The soils of the Avon Valley and dispersive clays found beneath the breakaway face are especially prone. Grade and contour banks have been built to control water erosion and flooding. Surface soil structure decline and the development of traffic compaction pans can reduce yields on certain 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.
1.5 The structure of the manual

The 21 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 21 major soil types are described in the following format:

- idealised 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.

One or more Northcote (1984) Principle Profile Form notations are given below the soil title. This classification system is widely recognised throughout Australia by soil and agricultural scientists. The soil series name of each soil type is also included (Purdie, unpublished).

1.5.1 Idealised soil diagrams

The properties of each soil are described by an idealised soil diagram.

The soil diagrams show a slice of soil from the surface down to a depth of one metre. Each 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 characterised by a concentration of clay, a structure and/or consistency unlike the soil above and has 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 soil 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 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, strong brown was abbreviated to orange.

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, blotsches 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 colour photograph of a typical example of the soil profile is shown above the 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 Grey alluvial clay occurs within the Avon 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 on 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 content and porosity.

Nutrient availability (n)

Nutrient availability is the ability of a soil to retain and supply nutrients for plant growth. It depends largely on the 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 amount of soil volume available to plant roots. Siliceous hardpans, hardened mottled zone (called conglomerate by some farmers), ferruginous duricrust (cap rock), 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 below the surface on lighter soils.

Trafficability (t)

Trafficability refers to the ability to use machinery. Boggy, rocky soils and steep sloping land 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, affecting 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 by 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 cosentinii), field peas (Pisum sativum) and tagasaste or tree lucerne (Chamaecytisus palmensis).

Annual pasture generally consists of subterranean clover (Trifolium subterraneum), burr medic (Medicago polymorpha), barrel medic (Medicago truncatula) or murex medic (Medicago murex) 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) because 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 placed 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 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 using 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 fertiliser 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. 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. However, they do give a ‘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 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 the land uses assessed. 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 noted in each table.
The capability ratings quoted relate to 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 seven minor soil types, which, because of their limited occurrence, do not warrant inclusion with the major soil types.

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 5,100 km² within the Zone of Rejuvenated Drainage. Five hundred soil profiles were described.

- Two farms were mapped at a scale of 1:10,000 to test the applicability of mapping the soils described in the manual. Three hundred and fifty soil profiles were described.

- The soils defined in the manual or amalgamations of these were mapped by five different catchment groups. Individual farmers mapped the soils of their farms with assistance from the author of this manual.

- Discussions were held with relevant staff from the Department of Agriculture on the requirements of each crop and pasture type.

- Discussions were held with 15 farmers, located throughout the Zone of Rejuvenated 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 gently undulating sandplain on upland areas. In some cases these soils may ‘spill’ over from the plateau surface onto the hillslopes and extend down towards the valley floor. Slopes generally range from 1 to 5 per cent.

The sandplain soils within the Zone of Rejuvenated Drainage predominantly occur within the Quailing and Eaton soil landscape units. However, the Yellow gradational loamy sand can occur as gravelly ridges on the hillslopes within the Ewerts soil landscape unit. The sandplain soils can be divided into five soil types:

1. Deep pale sand.
2. Deep yellow sand.
3. Pale sand over gravel/loamy sand.
4. Yellow gradational loamy sand.
5. Waterlogged sand.
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  Gray (10YR 5/1) to light gray (10YR 8/1), 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.

<table>
<thead>
<tr>
<th>Yield estimates and capability rating for various land uses</th>
<th>Deep pale sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land use</td>
<td>Achievable average yield</td>
</tr>
<tr>
<td>Pasture (g)</td>
<td>2 DSE/ha</td>
</tr>
<tr>
<td>(winter grazed)</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>0.4-0.8 t/ha</td>
</tr>
<tr>
<td>Lupins</td>
<td>0.6-0.8 t/ha</td>
</tr>
<tr>
<td>Tagasaste</td>
<td>Good growth</td>
</tr>
<tr>
<td>Blue lupins</td>
<td>Average-good growth</td>
</tr>
</tbody>
</table>
2. Deep yellow sand

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 6/6) 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).

Surface

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

The **Deep yellow sand** includes the yellow sandy soils which 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 loamy 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 the landscape

The **Deep yellow sand** is found together with other sandplain soils within the Quailing and Eaton soil landscape units. In some cases this soil occurs as ‘spillway sands’ that spill over from the sandplain plateau surface onto the hillslopes. Slopes are generally 1 to 5 per cent.

Vegetation

The dominant native vegetation is **Banksia** sp. and, in some areas, sandplain pear (**Xylomelum angustifolium**).

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 enables this soil to retain more moisture 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.

The **Deep yellow sand** 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 this soil will develop a traffic compaction pan at about 20 to 30 cm. The presence of a pan can be identified by the increased resistance to digging at about 20 to 30 cm. A steel spike can also be used to identify this pan.
Recharge hazard

The **Deep yellow sand**, drains freely and recharges considerable volumes of water to the groundwater-table. However, the efficiency of water use by plants is higher on this soil than on the **Deep pale sand**.

Wind erosion hazard

Wind erosion and sandblasting of emerging crops are potential problems on these soils if management is poor. Organic particles, which are important for holding nutrients, are easily transported by wind.

Other

These soils are well drained. Access by two wheel drive vehicles can be limited over summer. Rooting conditions are good except when traffic compaction pans form. These soils have a high infiltration rate and rarely 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 practised 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 yield. 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. 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 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 which efficiently extract water.

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 about 10 per cent higher on crops sown after cultivation compared with crops sown using direct drilling. This effect is a response to better seed bed preparation. Seeding equipment that can cultivate deep and sow shallow is being developed. Another option to reduce the risk of wind erosion, but not reduce yield, is to scarify and seed within the same day.
If valley floor or sandplain seepage salinity are problems 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.

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

<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.s)</td>
<td>3-4 DSE/ha</td>
<td>2.0 - 2.2 t/ha</td>
<td>IV</td>
<td>Moisture availability</td>
</tr>
<tr>
<td></td>
<td>(winter grazed)</td>
<td></td>
<td></td>
<td>Nutrient availability</td>
</tr>
<tr>
<td>Wheat</td>
<td>1.5-1.8 t/ha</td>
<td>2.0 - 2.2 t/ha</td>
<td>III</td>
<td>Moisture availability</td>
</tr>
<tr>
<td>Lupins</td>
<td>1.2-1.6 t/ha</td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Tagasaste</td>
<td>Good growth</td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Blue lupins</td>
<td>Good growth</td>
<td></td>
<td>I</td>
<td></td>
</tr>
</tbody>
</table>
3. Pale sand over gravel/loamy sand

P.P.F. Gn 2.75, Uc 2.12, Uc 2.21
Kauering series, Mawson series

Horizon

A1  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

A2  Pale (10YR 7/4), medium to coarse grained sand.
    Single grains.
    May contain ironstone gravel.
    pH = 7.0

A3  Pale (10YR 7/4) medium to coarse grained sand.
    Single grains.
    Large amounts of ironstone gravel.
    pH = 7.0

B2  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

C   Mottled zone.
    Red, orange and yellow mottled sandy clay loam to sandy clay.
    Hardpan.
    pH = 6.5
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 yellowish 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 this soil should be classified as a **Yellow gradational loamy sand**.

Position in the landscape

The **Pale sand over gravel/loamy sand** generally occurs together with other sandplain soils within the Quailing and Eaton soil landscape units. This soil type can also occur on the midslopes within the Ewerts soil landscape, particularly north of the Great Eastern Highway.

Slopes generally range from 1 to 4 per cent.

Vegetation

The native vegetation that grows on this soil varies greatly from area to area. It includes white gum (*Eucalyptus wandoo*), tea tree (*Leptospermum erubescens*), blackboy (*Xanthorrhoea sp.*), tammar (*Allocasuarina campestris*) and in some areas Christmas tree (*Nuytsia floribunda*).

Land qualities

**Moisture availability**

The sandy surface horizon of this soil has a low water holding capacity. Moisture availability is greater in the gravelly and loamy sand subsoil. The depth to these layers is critical in determining how much moisture this soil can supply. These soils may be non-wetting which reduces rainfall infiltration.

**Nutrient availability**

The sandy topsoil has a poor ability to hold nutrients, particularly nitrogen. However, the gravelly subsoil which often has a higher clay content prevents the rapid leaching of nutrients. The ironstone gravel in the subsoil fixes phosphorus, making it unavailable for plant growth (high reactive iron content). 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 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.

**Rooting conditions**

The gravel layer is generally loose and does not restrict root growth.
Soil structure decline

Surface soil structure decline does not occur on this sandy soil. Traffic compaction pans may develop at depths of about 30 cm.

Trafficability

This soil does not become boggy but large ironstone boulders may limit cultivation.

Wind erosion

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

Recharge hazard

Water can move rapidly through this soil to depths beyond the root zone of many agricultural species. In wet years this soil would be capable of adding considerable recharge to the deep ground-water table (but the volume of recharge would not be expected to be as large as that from an area of Deep pale sand).

Other

Water erosion, salinity and waterlogging do not occur.

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. Deep ripping traffic compaction pans may give economic responses in following cereal crops.

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

Field peas perform satisfactorily but should not be grown under current grazing management strategies because of the wind erosion hazard.

Tagasaste generally grows well on this soil, however when the mottled zone occurs within about 1 m of the surface its roots may 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 planting wind breaks. Research on sandy soils has shown that cereal yields are about 10% higher on crops sown after cultivation compared with crops sown using direct drilling. This effect is a result 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.

Application of lime may be necessary 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>Pasture (g,s)</td>
<td>3-5 DSE/ha</td>
<td>1.8-2.5 t/ha</td>
<td>IV</td>
<td>Moisture availability</td>
</tr>
<tr>
<td></td>
<td>(winter grazed)</td>
<td></td>
<td></td>
<td>Nutrient availability</td>
</tr>
<tr>
<td>Wheat</td>
<td>1.2-2.0 t/ha</td>
<td>1.8-2.5 t/ha</td>
<td>III</td>
<td>Moisture availability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Nutrient availability</td>
</tr>
<tr>
<td>Lupins</td>
<td>1.0-1.4 t/ha</td>
<td>1.2-2.0 t/ha</td>
<td>III</td>
<td>Moisture availability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Nutrient availability</td>
</tr>
<tr>
<td>Tagasaste</td>
<td>Good growth</td>
<td></td>
<td>II*-III</td>
<td>Rooting conditions</td>
</tr>
<tr>
<td>Blue lupins</td>
<td>Good growth</td>
<td></td>
<td>I</td>
<td></td>
</tr>
</tbody>
</table>

* For deeper phases of this soil.
4. Yellow gradational loamy sand

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 | Surface
--- | ---
A1 | 10
| 20
| 30
| 40
| 50 Depth (cm)
B1/B2 | 60
| 70
| 80
| 90
C | 100

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.
pH = 6.0

B1/B2 Yellow (10YR 7/6) to yellowish brown (10YR 5/6) 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.
pH = 6.5

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

The **Yellow gradational loamy sand** is a variable soil including 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 idealised 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 depths of about 25 cm; and
- similar to the diagram but with an intermediate, pale grey, gravelly sand layer below the A1 horizon.

This soil can be distinguished from the **Pale sand over gravel/loamy sand** by its heavier textured, often browner topsoil. The **Buckshot gravel** (minor soil type - see Section 2.4) can be distinguished from this soil by its lower clay content, and abundant, round, ‘buckshot’ ironstone gravel. The **Shallow mottled zone** (minor soil type) can be distinguished as it has a hardened mottled zone at a depth of less than about 25 cm.

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

Position in the landscape

This soil covers large areas on the upper to mid slopes and may take the form of ridges or spurs that occur to the sides of breakaways. Here the soil type occurs within the Ewerts soil landscape unit and has slopes from 2 to 10 per cent.

This soil type also commonly occurs within areas of sandplain that occur as a gently undulating plateau at the top of the landscape (Quailing and Eaton soil landscape units).

Vegetation

The dominant indicator vegetation is tammar (** Allocasuarina campestris **) and white gum (** Eucalyptus wandoo **), but sheoak (** Allocasuarina huegeliana **), parrotbush (** Dryandra sp. **) , **Eucalyptus macrocarpa** and blackboy (** Xanthorrhoea sp. **) may also be present.

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. Areas of this soil that occur on ridges tend to dry out a little earlier in spring and hence yield less.
Nutrient availability

The clayey subsoil prevents rapid leaching of nutrients out of the root zone. Phosphorus is fixed by the large percentage of ironstone gravel (high reactive iron levels). Applications of trace elements may be needed to correct deficiencies.

This productive soil is at high risk of surface and subsurface acidification because of its low pH buffering capacity and high potential for leaching (at least from the topsoil).

Waterlogging

These soils generally occur in raised locations and do not become waterlogged.

Rooting conditions

The large percentages of ironstone gravel within the soil profile are rarely cemented and do not greatly hinder root development of crop and pasture species. In phases of this soil where the mottled zone occurs closer to the surface root growth is restricted.

Soil structure decline

Traffic compaction pans can form at a depth of 20 to 30 cm. Pans appear to be more common on less gravelly, deeper phases of this soil. The seasonal effect of raindrop impact and traffic may result in hard surface layers.

Trafficability

This soil is easy to work under a range of moisture conditions, even after heavy rainfall it does not become boggy. The ironstone gravel that can occur on the soil surface is rarely large enough to cause problems during cultivation.

Wind erosion

When exposed or cultivated, these soils are susceptible to wind erosion. However, their higher clay content, gravel content and often hardsetting surface makes them less prone to erosion than the loose surfaced sandplain soils.

Water erosion

Water erosion can occur on sloping land but water usually infiltrates readily.

Other

Loamy to clayey 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 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 extremely well. The favourable rooting conditions allow root development into the loamy subsoil where the moisture availability is high.

Cereals grow well even in drier years. The soil does not become boggy or waterlogged and moisture availability is adequate. Yields may respond to deep ripping of traffic compaction pans, especially on less gravelly, deeper phases.

Lupins grow well but tend to suffer from moisture stress in shallower, very gravelly areas.

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

Tagasaste growth is good, however, if the mottled zone occurs within about 1 m of the surface, its roots may have difficulty exploring enough soil volume to obtain sufficient moisture.

Applications of lime may be necessary to overcome surface soil acidification.

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

**Yellow gradational 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>Pasture(s)</td>
<td>8 -12 DSE/ha (winter grazed)</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>2.5 - 3.0 t/ha</td>
<td>4 t/ha</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Lupins</td>
<td>1.2 - 1.4 t/ha</td>
<td>2.0 - 2.5 t/ha</td>
<td>*1</td>
<td></td>
</tr>
<tr>
<td>Field peas</td>
<td>Good growth</td>
<td></td>
<td>IV</td>
<td>Wind erosion</td>
</tr>
</tbody>
</table>

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

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 (silcrete). This soil usually becomes severely waterlogged over the winter months.

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

Position in the landscape

The Waterlogged sand occurs in the Eaton and Quailing soil landscape units as small areas in low lying depressions, seepage areas and drainage lines.

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 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 fertiliser is rapidly leached from the root zone. Trace element deficiencies may need to be corrected.

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

**Waterlogging**

In most winters this soil becomes waterlogged. Low lying areas within this soil 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 under the valley floor. Water sits on top of the clay layer 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 infrequently 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 water-table. Areas that become severely waterlogged support poor pasture - either being bare or containing reeds and rushes. Areas that occur slightly above these wet areas support good grass and sometimes subterranean clover pastures. The grass often remains green into spring. Couch grass grows 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 available 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. However, in many cases water in these areas is fresh and is required in soaks for stock use.
Yield estimates and capability rating for various land uses

Waterlogged 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,s)</td>
<td>2-4 DSE/ha</td>
<td></td>
<td>IV</td>
<td>Moisture availability</td>
</tr>
<tr>
<td></td>
<td>(winter grazed)</td>
<td></td>
<td></td>
<td>Nutrient availability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Waterlogging</td>
</tr>
<tr>
<td>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>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>Blue lupins</td>
<td>Poor growth</td>
<td></td>
<td>V</td>
<td>Waterlogging</td>
</tr>
<tr>
<td>Tagasaste</td>
<td>Poor in water-logged areas</td>
<td></td>
<td>V</td>
<td>Waterlogging</td>
</tr>
<tr>
<td>Sudax and lucerne</td>
<td>Potential</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saltland agronomy</td>
<td>Good potential</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
2.2 Hillside soils

Hillside soils are found on the sloping country, often below the sandplain soils and above the valley floor soils. They are found in four soil landscape units (the units are illustrated and described in Figure 2).

The Ewerts unit occurs immediately downslope from areas of sandplain and is generally separated by a breakaway. Slope gradients usually range from 2 to 10 per cent except on the breakaway face where slopes of 15 to 30 per cent are common. Its soils are derived from the dissected laterite profile and contain the:

6. **Breakaway face and ironstone cap**

7. **Shallow hardsetting grey sandy loam over clay**

8. **Sandy loam over clay**

9. **Loamy sand surfaced duplex**

10. **Shallow sandy surfaced duplex**; and

11. **Deep sandy surfaced duplex**

The York unit contains soils derived from fresh rock and is commonly found around rock outcrop and adjacent to drainage lines such as in the Avon Valley. Slope gradients generally range from 2 to 10 per cent.

The type of soil formed depends on the nature of the parent rock. Three soil types have been defined, these being:

12. **Rocky red brown loamy sand/sandy loam**;

13. **Brownish grey granitic loamy sand**; and

14. **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.

The Hamersley unit occurs as thin, minor midslope drainage lines within the York unit. Its dominant soil type is the

15. **Waterlogged greyish loamy sand/sandy loam**.

The Steep rocky hills soil landscape unit is comprised of

16. **Stony soils**.
6. Breakaway face and ironstone cap

Identifying characteristics

The surface of the Breakaway face consists of 5 to 30 cm of brownish grey sand to clayey sand. This layer has a dusty appearance and is severely non-wetting. Beneath the topsoil is a pinkish clay which often contains rock fragments. This clay is often exposed by erosion of the topsoil.

The Ironstone cap consists predominantly of large ironstone boulders and sheets of ironstone rock. Small, shallow pockets of yellow, gravelly sands develop between the ironstone boulders.

Position in the landscape

Breakaways are found at the top of the landscape and are the retreating edge of the flat to gently undulating, lateritic plateau. In some cases the old lateritic profile has been almost completely removed to leave only a pointy, cone shaped ‘mallet hill’. The breakaway scarp can vary in height from about 2 to 20 metres and slopes generally range from 15 to 30 per cent.

The Ironstone cap is found on the soil surface at the top of the Breakaway face. This area is generally flat to gently sloping and contains many large ironstone boulders. Moving away from the scarp there is more soil development and the Ironstone cap grades into the Yellow gradational loamy sand, Buckshot gravel or the Pale sand over gravel/loamy sand soil types.

Vegetation

On the Breakaway face the native vegetation commonly contains brown mallet (Eucalyptus astringens), powderbark wandoo (Eucalyptus accedens) and box poison (Oxylobium parviflorum). The Ironstone cap often supports powderbark wandoo and Dryandra sp.

Discussion of capability

The Breakaway face and Ironstone cap are not suitable for agriculture.

If cleared the Breakaway face becomes a major water erosion hazard. The steep slopes, non-wetting topsoil and dispersive clay subsoil make this surface very prone to water erosion. Areas that have been cleared should be fenced off and revegetated. Often a large level bank or contour bank is required at the base of breakaways to cut off water and prevent it from eroding soils downslope.

The Ironstone cap is too rocky and shallow for cropping and produces little pasture. If cleared these areas are believed to add significant volumes of recharge to the deep groundwater-table.
7. Shallow hardsetting grey sandy loam over clay

P.P.F. Dy 2.13, Db 1.43

Meenar series

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Dark greyish (10YR 4/2), medium to coarse grained loamy sand to sandy loam. Hardsetting surface, massive structure. pH = 6.0</td>
</tr>
<tr>
<td>A2/A3</td>
<td>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.)</td>
</tr>
<tr>
<td>B2</td>
<td>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).</td>
</tr>
<tr>
<td>C</td>
<td>Pallid zone or saprolite (decomposing rock).</td>
</tr>
</tbody>
</table>
Identifying characteristics

The Shallow hardsetting grey sandy loam over clay includes all the poorly structured, 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 from the Sandy loam over clay by its shallower, more hardsetting topsoil, often by the presence of large amounts of white decomposing rock, and its poorer yields.

Position in the landscape

The Shallow hardsetting grey sandy loam over clay occurs as small areas on the upper and, in some cases, mid-slope of the landscape. It is most commonly found as sloping ground immediately below breakaways. Slope gradients range from 2 to 10 per cent. This soil occurs within the Ewerts soil landscape unit.

Vegetation

The dominant native vegetation consists of white gum (Eucalyptus wandoo) and, in some areas, mallee species and a few stunted salmon gums (E. salmonophloia).

Land qualities

Moisture availability

Rainfall infiltration into this soil is poor because of the hardsetting, degraded surface. The topsoil is often 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 soil has low potential for acidification.

Soil structure decline

The surface structure of this soil is poor and cultivation leads to further deterioration of soil structure. The clayey subsoil is very shallow and often dispersive. When bought 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.

**Waterlogging**

These soils do not become waterlogged to any great extent. They occur on sloping ground often high up in the landscape.

**Rooting conditions**

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

**Trafficability**

These soils can be extremely slippery when wet. Where large amounts of white decomposing rock occur on the surface this may hinder cultivation and cause excessive wear on tillage equipment.

**Water and wind erosion**

The poor infiltration into the degraded surface of these hillslope soils makes water erosion a major hazard. These hardsetting soils are not susceptible to wind erosion.

**Recharge hazard**

These soils would be expected to add little recharge to the deep groundwater table in most years.

**Salinity**

The *Shallow hardsetting grey sandy loam over clay* is rarely affected by salinity.

**Productivity and capability**

The *Shallow hardsetting grey sandy loam over clay* is a poor agricultural soil. Poor soil structure, adverse rooting conditions, low moisture availability, poor trafficability and the water erosion hazard combine to make this a ‘problem soil’.

Pasture growth is poor. Subterranean clover has difficulty burying its burr resulting in greater availability to the sheep and thus poorer regeneration. Medics perform better than subterranean clover on this soil.

Cereals grow poorly. However, if good weather conditions allow the crop to be seeded and established without the topsoil sealing over then reasonable yields can be obtained. In most years cereal crops experience moisture stress earlier than on other soil types.
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. Lupin seedlings have trouble emerging through the degraded, hardsetting surface of this soil.

Peas are suitable for this soil. Careful management of field pea stubble is essential to control wind erosion.

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

<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.m)</td>
<td>4-5 DSE/ha (winter grazed)</td>
<td></td>
<td>IV</td>
<td>Soil structure decline Moisture availability</td>
</tr>
<tr>
<td>Wheat</td>
<td>0.8-1.5 t/ha</td>
<td>1.0-2.2 t/ha</td>
<td>IV</td>
<td>Soil structure decline Moisture availability Water erosion</td>
</tr>
<tr>
<td>Lupins</td>
<td>0.5-1.0 t/ha</td>
<td>1.0-1.5 t/ha</td>
<td>V</td>
<td>Soil structure decline Moisture availability</td>
</tr>
<tr>
<td>Field peas</td>
<td>0.8-1.0 t/ha</td>
<td>1.4-1.6 t/ha</td>
<td>IV</td>
<td>Soil structure decline Moisture availability Water erosion</td>
</tr>
</tbody>
</table>
8. Sandy loam over clay

P.P.F. Dy 2.13, Dy 2.23
Booraan series

Horizon

A1 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

A3 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

B2 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).
Identifying characteristics

The Sandys loam over clay consists of a grey, and less commonly dull reddish, hardsetting sandy loam to sandy clay loam over clay at 10 to 20 cm.

This soil can be distinguished from the Red brown doleritic clay loam by its poorer structure and duller colour. This soil has a deeper, less hardsetting topsoil and produces higher yields than the Shallow hardsetting grey sandy loam over clay.

This soil is often locally called a ‘grey clay’ despite its thin sandy loam to sandy clay loam topsoil.

Position in the landscape

The Sandys loam over clay is most commonly found on the mid to upper slopes. Slope gradients range from 1 to 6 per cent. This soil occurs within the Ewerts soil landscape unit.

Vegetation

The dominant native vegetation is salmon gum (Eucalyptus salmonophloia), York gum (E. loxophleba) and needle bush (Hakea pretssii).

Land qualities

Moisture availability

The sandy loam to sandy clay loam topsoil has good water holding capacity. The underlying clay 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 subsoil may have an alkaline pH of around 8.5.

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

Waterlogging

This soil is generally well drained.

Trafficability

After heavy rains the Sandys loam over clay becomes boggy, sticky and difficult to manage.

Good seedbed preparation may be difficult to achieve and vehicle access for spraying or fertiliser topdressing may be restricted.
Soil structure decline

Cultivation, and sheep trampling when the soil is above a critical moisture content can degrade the structure of this soil. 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. If the soil surface is degraded this decreases the rate of infiltration thus increasing run-off. Wind erosion is rare on this hardsetting soil.

Other

The rooting conditions are generally good, but the clayey subsoil may limit some species. This soil would not be expected to add large amounts of recharge to the groundwater-table. Salinity is not common on this soil.

Productivity and capability

The Sandy loam over clay is an average to above average producing soil but can be difficult to manage. Surface soil structure decline, trafficability limitations when wet and poor moisture availability in drier years all limit the yield potential.

Medics are well suited to this soil provided the soil pH is not too acid. 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. Poor surface structure may be improved through the application of gypsum and the use of minimum tillage.

Lupins grow poorly. The hardsetting surface restricts lupin emergence, the shallow, clayey subsoil hinders the growth of the lupin tap root and, if the subsoil is calcareous, iron deficiency may occur.

Field peas grow well. The loamy topsoil and shallow clay subsoil are well able to supply field peas with moisture. The grazing of field pea stubbles must be carefully managed in order to control wind erosion.

Contour or grade banks are necessary on sloping ground to control water erosion. The application of gypsum and the use of minimum tillage can improve water infiltration into the soil thus reducing run-off.
Yield estimates and capability rating for various land uses
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>Pasture (m)</td>
<td>6-9 DSE/ha</td>
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<td>II-III</td>
<td>Moisture availability</td>
</tr>
<tr>
<td></td>
<td>(winter grazed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>1.7-2.4 t/ha</td>
<td>3.0-4.0 t/ha</td>
<td>II-III</td>
<td>Moisture availability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soil structure decline</td>
</tr>
<tr>
<td>Lupins</td>
<td>0.8-1.0 t/ha</td>
<td>1.0-1.8 t/ha</td>
<td>IV-V</td>
<td>Moisture availability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soil structure decline</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Nutrient avail (pH)</td>
</tr>
<tr>
<td>Field peas</td>
<td>1.0-1.3 t/ha</td>
<td>1.8-2.0 t/ha</td>
<td>II</td>
<td>Moisture availability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soil structure decline</td>
</tr>
</tbody>
</table>
9. Loamy sand surfaced duplex

P.P.F. Dy 3.42, Dy 5.11
Morbining Series, Mortlock Series

Horizon

A1  Gray (10YR 4/1) to dark brown (10YR 3/3), medium grained sand to clayey sand.
    Loose to hardsetting surface.
    Small quantities of ironstone gravel may be present.
    pH = 6.5

A2/A3 Yellowish (10YR 5/4), very pale brown (10YR 7/4) to yellow (10YR 7/6) loamy sand
    to sandy loam.
    Usually has a massive structure, with an earthy fabric.
    Large quantities of ironstone gravel may be present.
    pH = 6.0

B2  Yellowish brown (10YR 5/6) to yellow (10YR 7/8) sandy clay to medium clay.
    Red and orange mottles are common.
    Moderately structured.
    pH = 6.5
Identifying characteristics

The **Loamy sand surfaced duplex** includes all the good quality, loamy sand surfaced over yellowish clay soils.

The surface horizon is most commonly a loamy sand but can be a clayey sand. The topsoil texture may grade to a sandy loam above the clay layer which is generally found at about 40 cm.

The heavier phases of this soil grade into the **Sandy loam over clay**. Lighter phases can have 50 cm of a weak loamy sand over the clay layer. Small to moderate amounts of ironstone gravel may be present within the profile.

This soil can be distinguished from the **Shallow sandy surfaced duplex** and **Deep sandy surfaced duplex** by the higher percentage of clay in the surface horizons. The **Loamy sand surfaced valley duplex** can be distinguished by its position in the landscape and higher incidence of waterlogging.

The **Loamy sand surfaced duplex** is known locally as a ‘duplex soil’ or ‘white gum soil’.

Position in the landscape

The **Loamy sand surfaced duplex** occupies large areas of land in the area east of the Avon Valley and west of the ‘Meckering Line’. It occurs on the upper to lower slopes (2 to 10 per cent). The **Loamy sand surfaced duplex** occurs in association with other duplex soils within the Ewerts soil landscape unit.

Vegetation

The dominant tree is white gum (*Eucalyptus wandoo*). Sheoak (*Allocasuarina huegeliana*), tammar (*Allocasuarina campestris*), salmon gum (*E. salmonophloia*) and jam (*Acacia acuminata*) occur in association with white gum on different phases of this soil. Sheoak tends to grow on deeper, coarser phases, tammar on gravelly phases, jam on the non-gravelly phases and salmon gum on the heavier phases.

Land qualities

**Moisture availability**

The loamy sand surface horizon is able to retain moderate amounts of moisture within the topsoil for plant growth. Because of this clay content in the topsoil the depth to clay is not as important for crop and pasture growth as in the coarser, sandy surfaced duplex soils. The clay subsoil, which occurs within the root zone of crop and some pasture species has a high water holding capacity.

**Nutrient availability**

The clay subsoil prevents rapid leaching of nutrients out of the root zone. This productive soil has a high risk of surface soil acidification because of its low pH buffering capacity and high potential for leaching from the topsoil.
Waterlogging

The **Loamy sand surfaced duplex**, despite the fact that it occurs on sloping ground, may suffer from transient waterlogging in many years. The clay subsoil is often sodic and disperses and swells when wet. This greatly reduces water movement into and through the clay. However, there appears to be great variation within this soil type with respect to this.

Shallower phases of this soil are more prone to waterlogging than deeper phases as the thinner topsoil and can hold less water. Waterlogging is more common at breaks of slope where laterally flowing subsurface water is forced to the surface.

More waterlogged phases often have a white, sandy layer above the clay, a mottled, greyish clay, and an abrupt boundary between the sandy surface horizons and clay subsoil.

Rooting conditions

The dense clay layer can restrict root growth of cereal and especially lupin crops.

Trafficability

This soil can become boggy if heavy rains fill up the sandy topsoil. However, in most years only small areas, where seepage water is brought to the surface by a break in slope or shallow clay, become boggy.

Water erosion hazard

Water erosion can occur on this soil by two processes - through rainfall excess or saturation excess. Rainfall excess occurs when the rainfall intensity exceeds the infiltration rate of the soil surface. Saturation excess occurs when the soil profile fills up with water and any additional rainfall must therefore run-off.

Salinity

Salinity may develop alongside drainage lines where rock barriers force laterally flowing ground-water to the surface.

Recharge hazard

This soil would not be expected to add large quantities of recharge to the groundwater-table. In wet years, when a perched water table sits on top of the clay layer, recharge through preferred pathways in the clay layer could be significant.

Other

If well managed, wind erosion is unlikely to occur on this firm to hardsetting soil. The **Loamy sand surfaced duplex** does not suffer greatly from soil structure decline, though the seasonal effect of raindrop impact and traffic may result in hard surface layers.
Productivity and capability

The **Loamy sand surfaced duplex** is a good cropping and pasture producing soil. In wet years yields can be reduced, particularly on the lowerslopes, through waterlogging, though the extent of waterlogging is much less than on the **Loamy sand surfaced valley duplex**.

Subterranean clover based pastures grow well because the loamy sand topsoil and shallow clay subsoil are able to supply pasture species with adequate moisture in most years. Burr medic has potential provided the soil pH is not below about 6.0.

Cereals perform well over a wide range of season types and high yields can be obtained.

Lupins can grow quite well, especially if the clay is deeper. In wet years they may be affected by waterlogging.

Field peas grow well, but under current management practices the grazing of field pea stubbles poses a serious wind erosion hazard.

Where the depth to clay is less than 50 cm reverse interceptors banks can be used to remove excess water from the soil, thus reducing waterlogging. These banks or grade banks are required on the longer, steeper slopes to control water erosion.

Applications of lime may be required to overcome soil acidification.

**Note:** Detailed investigations of crop performance on this soil type are being carried out at the East Beverley Annex to Avondale Research Station in a joint program by the Western Australian Department of Agriculture and CSIRO. The study is looking at water use efficiency, waterlogging, nitrogen losses and root penetration.

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

**Loamy sand surfaced duplex**

<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 (s)</td>
<td>8-10 DSE/ha (winter grazed)</td>
<td></td>
<td>I-II</td>
<td>Moisture availability</td>
</tr>
<tr>
<td>Wheat</td>
<td>2.2-2.8 t/ha</td>
<td>3.0-4.0 t/ha</td>
<td>I-II</td>
<td>Moisture availability</td>
</tr>
<tr>
<td>Lupins</td>
<td>1.0-1.5 t/ha</td>
<td>2.0 t/ha</td>
<td>II</td>
<td>Rooting conditions, Moisture availability, Waterlogging</td>
</tr>
<tr>
<td>Field peas</td>
<td>Good growth</td>
<td></td>
<td>IV</td>
<td>Wind erosion</td>
</tr>
</tbody>
</table>

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51. Soils of the Northam Advisory District
10. Shallow sandy surfaced duplex

P.P.F. Dy 5.42, Dy 4.12
Quajabin Series

<table>
<thead>
<tr>
<th>Horizon</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Dark greyish brown (10YR 4/2), medium to coarse grained sand. Single grains, loose surface. pH = 6.0</td>
</tr>
<tr>
<td>A2/A3</td>
<td>Very pale brown (10YR 7/4), medium to coarse grained sand. Single grains. Small amounts of ironstone gravel may be present. pH = 6.5</td>
</tr>
<tr>
<td>B2</td>
<td>Brownish yellow (10YR 5/6) to very pale brown (10YR 7/4) sandy clay to medium clay. Red and orange motiles are common. Well structured. pH = 6.5</td>
</tr>
</tbody>
</table>

Surface

Depth (cm)

10 20 30 40 50 60 70 80 90 100
Identifying characteristics

The **Shallow sandy surfaced duplex** includes all the shallower, sandy surfaced over yellowish clay soils. An arbitrary cut off depth of 45 cm to clay was chosen to divide this soil from the **Deep sandy surfaced duplex**. (This depth is believed to have implications for crop and pasture production).

The **Shallow sandy surfaced duplex** can be distinguished from the **Loamy sand surfaced duplex** by its loose, sandy topsoil. This soil is known locally as a ‘duplex soil’ or a ‘white gum soil’.

Position in the landscape

The **Shallow sandy surfaced duplex** occurs on the upper to lower slopes and has a slope gradient ranging from 2 to 10 per cent. This soil occurs in association with other duplex soils within the Ewerts soil landscape unit.

Vegetation

The dominant tree is white gum (**Eucalyptus wandoo**) with sheoak (**Allocasuarina huegeliana**), jam (**Acacia acuminata**) and tea tree (**Leptospermum erubescens**) in some areas.

Land qualities

**Moisture availability**

The sandy topsoil has a low water holding capacity. However, the clay subsoil is able to hold and supply considerable moisture for plant growth. The depth to clay is critical in determining how much moisture this soil can supply to shallow rooted pasture species.

**Nutrient availability**

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

This productive soil is at high risk of soil acidification because of its low pH buffering capacity and high potential for leaching from the topsoil.

**Waterlogging**

The **Shallow sandy surfaced duplex**, despite the fact that it occurs on sloping ground, may suffer from transient waterlogging in wetter years. The clay subsoil is often sodic and as a result disperses and swells when wet. This greatly reduces water movement into and through the clay. The extent of waterlogging on this soil is patchy, possibly as a result of variation in the infiltration rate of the clayey subsoil. Areas of this soil that occur at a break of slope are more prone to waterlogging.

The **Shallow sandy surfaced duplex** is more prone to waterlogging than the **Deep sandy surfaced duplex** as its thinner topsoil can hold less water.
Rooting conditions

The dense clay subsoil can restrict root growth of cereal and especially lupin crops.

Salinity

Hillside seepage salinity may occur alongside drainage lines where rock barriers or shallow clay layers force laterally flowing ground-water to the surface.

Soil structure decline

Soil structure decline is not a problem on this soil.

Trafficability

Access to this soil is generally good except for boggy areas where seepage water is brought to the surface by a break in slope or shallow clay layer.

Wind erosion

The loose nature of the sandy topsoil makes poorly managed areas of this soil prone to wind erosion.

Water erosion

Water erosion is not common because of the high infiltration rate of the sandy topsoil. However, erosion can occur in winter when the soil profile is saturated with water resulting in additional rainfall becoming run-off.

Recharge hazard

This soil would not be expected to add large quantities of recharge to the groundwater-table. In wet years when a perched water-table sits on top of the clay layer, recharge through preferred pathways in the clay could be significant.

Productivity and capability

The Shallow sandy surfaced duplex is an average to above average pasture and cropping soil. Yields are reduced in wet years by waterlogging and in dry years by the low moisture availability of the topsoil.

Subterranean clover based pastures grow quite well. The clay subsoil, which can store considerable quantities of water, is within reach of the shallow rooted subterranean clover plant.

Cereals produce above average yields. Their adventitious root system is able to penetrate some way into the dense clay subsoil to obtain moisture. In wet years, cereals perform poorly in areas prone to waterlogging. The root pruning caused by waterlogging can add to drought stress at the end of the season if a wet winter is followed by a dry spring.
Lupin growth is average on this soil. The dense clay subsoil prevents the lupin tap root from exploring enough soil volume to obtain sufficient water. As a result lupins often die prematurely in spring. Lupins suffer from waterlogging in seepage areas.

Field peas grow quite well but under current grazing management strategies constitute a major wind erosion hazard.

Dense belts of trees planted above saline seepage areas have been successful in their reclamation or in preventing the spread of salinity.

Reverse seepage interceptors can be built to control waterlogging and water erosion.

Careful management is required to prevent wind erosion of the sandy top soil. Applications of lime may be required to overcome soil acidity.

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

**Shallow sandy surfaced duplex**

<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 (s)</td>
<td>6-8 DSE/ha (winter grazed)</td>
<td></td>
<td>II-III</td>
<td>Moisture availability</td>
</tr>
<tr>
<td>Wheat</td>
<td>1.8-2.2 t/ha</td>
<td>2.4-3.4 t/ha</td>
<td>II-III</td>
<td>Moisture availability</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Waterlogging</td>
</tr>
<tr>
<td>Lupins</td>
<td>0.8-1.3 t/ha</td>
<td>1.3-1.8 t/ha</td>
<td>III</td>
<td>Moisture availability</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td>Waterlogging</td>
</tr>
<tr>
<td>Field peas</td>
<td>Good growth</td>
<td></td>
<td>V</td>
<td>Wind erosion</td>
</tr>
</tbody>
</table>

55 Soils of the Northam Advisory District
11. Deep sandy surfaced duplex

P.P.F. Dy 5.42, Dy 4.12
Dulbelling Series

Horizon

A1  Grey (10YR 5/1) to dark greyish brown (10YR 4/2), medium to coarse grained sand. Loose surface, single grains. pH = 6.0

A2/A3  Light grey (10YR 7/2) to light yellowish brown (10YR 6/4) sand. Single grains. May contain small amounts of ironstone gravel. pH = 6.5

B2  Very pale brown (10YR 7/6) to yellowish brown (10YR 6/4) sandy clay to medium clay. Red and orange mottles are common. Moderately structured. pH = 6.5
Identifying characteristics

The Deep sandy surfaced duplex includes the deeper (greater than 45 cm), often coarse, sand over yellowish clay soils.

In some cases a transitional loamy sand to sandy loam horizon may occur below 50 cm and above the clay layer.

This soil can be distinguished from the Shallow sandy surfaced duplex by its greater depth to clay. The Loamy sand surfaced duplex has a higher clay content in the topsoil and generally has a firm to hardsetting surface.

This soil is known locally as a ‘deep sandy duplex’ or as a ‘white gum soil’.

Position in the landscape

The Deep sandy surfaced duplex occurs on the upper to lower slopes and has a slope gradient ranging from 2 to 10 per cent. This soil occurs in association with other duplex soils within the Everts soil landscape unit.

Vegetation

The dominant tree is white gum (Eucalyptus wandoo) with sheoaks (Allocasuarina huegelianna) being very common, especially on the deeper phases. Some areas support tea tree (Leptospermum erubescens).

Land qualities

**Moisture availability**

The available water content of this soil is greatly dependent on the size of the sand grains in the topsoil. If the topsoil consists of coarse grained sand its water holding capacity is less than if the topsoil is a medium grained sand.

The depth to the clay layer is important in determining the soils ability to supply moisture for crop and pasture growth as it restricts water movement down the profile and can hold large amounts of moisture.

This soil is suited to deeper rooted species which can reach and obtain moisture in or just above the clay layer.

**Nutrient availability**

The sandy topsoil has a poor ability to hold and supply nutrients for plant growth.

This productive soil is at high risk of soil acidification because of its low pH buffering capacity and high potential for leaching from the topsoil.

**Waterlogging**

Areas of the Deep sandy surfaced duplex may suffer from transient waterlogging in wetter years. The clay subsoil is often sodic and therefore disperses and swells when wet. This greatly reduces water movement into and through the clay. The extent of waterlogging on this soil is patchy, possibly as a result of variation in the infiltration rate of the clayey subsoil.
The Deep sandy surfaced duplex does not become waterlogged as often as the shallower duplex soils as its topsoil is thicker and can carry more water. Waterlogging is more common at breaks of slope where laterally flowing subsurface water is forced to the surface.

Rooting conditions
The dense clay layer restricts the root growth of cereal and especially lupin crops. However, the depth to this restricting clay layer is deeper on this soil than on the other duplex soils.

Soil structure decline
This sandy surfaced soil is not affected by surface soil structure decline. Traffic compaction pans may occur.

Trafficability
Access on to this soil is generally good.

Wind erosion
The loose nature of sandy topsoil makes poorly managed areas of this soil prone to wind erosion.

Water erosion
Water erosion is not common because of the high infiltration rate of the sandy topsoil. However, erosion can occur in winter when the soil profile is saturated with water resulting in additional rainfall becoming run-off.

Salinity
Hillside seepage salinity may occur alongside drainage lines where rock barriers force laterally flowing groundwater to the surface.

Recharge hazard
This soil would not be expected to add large quantities of recharge to the groundwater-table. In wet years, when a perched water-table sits on top of the clay layer, recharge through preferred pathways in the clay could be significant.

Productivity and capability
The Deep sandy surfaced duplex is an average cropping and pasture producing soil. Moisture stress caused by the low available water content of the deep, sandy surface horizon is generally the greatest limitation to plant growth.

Subterranean clover and grasses grow fairly well but not as well as they do on the shallower duplex soils. The deep sandy, often coarse grained, surface horizons, have a low water holding capacity and shallow rooted pasture species often have difficulty reaching moisture in the clayey subsoil.

Cereals grow quite well because their root system can reach moisture reserves in the clay subsoil. Deep ripping of traffic compaction pans may produce economic responses.
Lupins in general grow well as their root system is able to explore large volumes of soil. In wet years lupins yield poorly in areas prone to waterlogging.

Field peas grow satisfactorily but under current grazing management practices they constitute a major wind erosion hazard.

Water erosion and waterlogging can be controlled by seepage interceptor banks. In many cases the depth to clay is too great to build reverse bank seepage interceptors with a grader; dozer built banks, placed on a grade, are necessary.

Dense belts of trees planted above saline seepage areas have been successful in reclaiming/preventing the spread of salinity.

These soils need to be carefully managed to prevent wind erosion.

Application of lime may be required to overcome soil acidity.

<table>
<thead>
<tr>
<th>Yield estimates and capability rating for various land uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep sandy surfaced duplex</td>
</tr>
</tbody>
</table>

<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>
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<td>Pasture(s)</td>
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<td>III</td>
<td>Moisture availability</td>
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<tr>
<td></td>
<td>(winter grazed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>1.6-2.0 t/ha</td>
<td>2.0-3.0 t/ha</td>
<td>III</td>
<td>Moisture availability</td>
</tr>
<tr>
<td>Lupins</td>
<td>0.8-1.5 t/ha</td>
<td>1.5-2.0 t/ha</td>
<td>II-III</td>
<td>Moisture availability, Waterlogging</td>
</tr>
<tr>
<td>Field peas</td>
<td>Average growth</td>
<td></td>
<td>V</td>
<td>Wind erosion</td>
</tr>
</tbody>
</table>
12. Rocky red brown loamy sand/sandy loam

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 reddish 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 rock.

There is considerable variability within this soil because of the differences in the parent rock. 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 paler, often 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 the landscape

The **Rocky red brown loamy sand/sandy loam** generally occurs on the mid and lower slopes where areas of fresh rock have been exposed. This soil comprises a large percentage of the Avon Valley. Smaller areas of this soil occur east of the Avon Valley.

On the gently sloping, lower slopes this soil often becomes browner rather then red and the soil depth is deeper due to colluvial movement of soil down the hill. Rock outcrop is less common or rare.

The **Rocky red brown loamy sand/sandy loam** occurs within the York soil landscape unit.

Vegetation

The native vegetation consists of York gum (**Eucalyptus loxophleba**) and jam (**Acacia acuminata**). In some areas white gum (**E. wandoor**) may also grow on this soil.

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 good water holding capacity, while the well structured clay subsoil can supply moisture for plant growth towards the end of the growing season. However, moisture availability is greatly reduced in areas where the bedrock is shallow.
**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 applied 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 moderate 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 of this soil that tend to waterlog are usually greyer. Small patches of salinity may form in areas receiving seepage.

**Water erosion**

This soil is prone to water erosion. Soils on steep, long slopes are most at risk of erosion. Erosion is often initiated by water flowing off rock outcrops.

**Rooting conditions**

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

**Soil structure decline**

This soil is not greatly affected by soil structure decline or 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 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 medic grows well provided the soil pH is not less then about 6.0. The soil retains enough moisture close 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/or rockiness.
Lupins grow well. However, on heavier phases of this soil, yields tend to be lower in dry years because of drought stress in spring.

Peas grow well but under current grazing management strategies some wind erosion is likely.

Canola (*Brassica napus*) grows well on this soil.

On steep and long slopes, grade or contour banks may be required to control water erosion. Minimum tillage is recommended because it leaves the soil bare for shorter periods of time than conventional tillage practices, thus reducing the chance of water erosion. Applications of lime may be necessary in the future to overcome soil acidification.

Yield estimates and capability rating for various land uses

<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>
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<td>Pasture (s)</td>
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<tr>
<td></td>
<td>(winter grazed)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>2.0-3.0 t/ha</td>
<td>3.5-5.0 t/ha</td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Lupins</td>
<td>1.2-1.5 t/ha</td>
<td>1.8-2.5 t/ha</td>
<td>I-II</td>
<td>Moisture availability</td>
</tr>
<tr>
<td>Field peas</td>
<td>1.5-1.8 t/ha</td>
<td>2.5-3.0 t/ha</td>
<td>III</td>
<td>Wind erosion Trafficability (rocks)</td>
</tr>
</tbody>
</table>
13. Brownish grey granitic loamy sand

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 all the brownish grey, sand to clayey sand surfaced soils developed from granitic rock. Beneath the topsoil is a pale brown to brownish yellow sand to clayey sand overlying a yellowish clay and/or bedrock.

This is a variable soil type whose properties depend on the exact nature of the parent rock from which it was formed.

- Heavier phases consist of a clayey sand to 10 cm over a sandy loam overlying clay at about 30 cm.
- Lighter phases consist of about 50 cm of sand grading into a weak clayey sand over decomposing bedrock.

This soil can be distinguished from the Loamy sand surfaced duplex by its better structured clay subsoil, the absence of ironstone gravel and often by the presence of granitic rock.

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

Position in the landscape

The Brownish grey granitic loamy sand occurs on the hillslopes where areas of fresh rock have been exposed. Slopes range from 2 to 10 per cent. Large areas of this soil occur to the east of the Avon Valley where the bedrock is often more granitic than in the Avon Valley (i.e. east of the Jimperding Gneiss Complex).

This soil often occurs together with other soils that have formed from fresh rock (for example, the Rocky red brown loamy sand/sandy loam), with these soils occurring within the York soil landscape unit.

Vegetation

The native vegetation consists of jam (Acacia acuminata) and a scattering of York gum (E. loxophleba). White gum (E. wandoo) and sheoak (Allocasuarina huegeliana) occur in some areas.

Land qualities

**Moisture availability**

The moisture availability of this soil is greatly dependent on the surface texture. In poorer phases, with a coarse, often gritty sand topsoil the water holding capacity is low. However, in heavier phases of this soil, with a loamy sand topsoil, the moisture availability is higher.

The clay subsoil can hold large quantities of moisture and its depth is important in determining how much moisture is available to shallow rooted species.
Nutrient availability

This soil has a good ability to hold and supply nutrients for plant growth. The clay subsoil prevents rapid leaching of applied nitrogen from the root zone.

This productive soil is at high risk of surface and sub-surface acidification because of its low pH buffering capacity and high potential for leaching.

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 but root growth is limited in areas where sheets of granite occur close to the surface. Plants in these areas become moisture stressed during 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

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

Water erosion and wind erosion

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

Productivity and capability

The Brownish grey granitic loamy sand is an above average quality soil suitable for cereal, lupin and pasture growth. 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.

Cereals yields are average or just above average for this zone. Moisture stress in dry periods and, occasionally, waterlogging in wet years reduce cereal yields.
Lupins grow well, especially on phases with a greater depth to clay. Yields are poor in seepage and shallow rock areas because of limited rooting depth.

Field peas grow quite well. The erodible, sandy surface horizon makes the grazing of field pea stubbles a major soil conservation hazard.

Contour or grade banks are required on steep, long slopes to control water erosion. Minimum tillage is recommended because, compared with conventional cultivation, it reduces the period of time when the soil is bare and susceptible to erosion.

Applications of lime may be necessary to overcome soil acidification.

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

*Brownish grey granitic 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>Pasture (s)</td>
<td>7-9 DSE/ha (winter grazed)</td>
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<td>II</td>
<td>Moisture availability</td>
</tr>
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<td>Wheat</td>
<td>2.0-2.6 t/ha</td>
<td>3.0-4.0 t/ha</td>
<td>II</td>
<td>Moisture availability</td>
</tr>
<tr>
<td>Lupins</td>
<td>1.2-1.4 t/ha</td>
<td>1.6-2.0 t/ha</td>
<td>II</td>
<td>Moisture availability Waterlogging Rooting conditions</td>
</tr>
<tr>
<td>Field peas</td>
<td>Average to good growth</td>
<td></td>
<td>IV</td>
<td>Wind erosion</td>
</tr>
</tbody>
</table>
14. Red brown doleritic clay loam

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

Horizon

A1 Reddish brown (5YR 3/3) 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 loam to clay overlying a dark red clay on dolerite. Black dolerite rock is commonly found on the soil surface.

In many places the surface horizon is self-mulching with the soil cracking open and being friable in summer. However, other phases of this soil set hard and contain fewer cracks. Sometimes the topsoil has a high lime content resulting in a surface pH of around 8.5. The soil is occasionally brown to greyish.

The **Red brown doleritic clay loam** can be distinguished from the **Rocky red brown loamy sand/sandy loam** by its heavier, often cracking surface horizon. The **Sandy loam over clay** differs in that it is generally grey, has a hardsetting, poorly structured surface and is poorer yielding.

This soil is locally referred to as a ‘red clay’.

Position in the landscape

The **Red brown doleritic clay loam** is often found as a strip either side of a dolerite dyke (dolerite is a black, fine grained igneous rock that has intruded into the basement bedrock). This soil occurs on slopes of 2 to 12 per cent.

This soil is common within the Avon Valley and occurs within the York soil landscape unit.

Vegetation

The dominant native vegetation is York gum (*Eucalyptus loxophleba*), salmon gum (*E. salmonophloia*) and needle bush (*Hakea pressii*).

Land qualities

**Moisture availability**

This well structured, heavy soil is capable of storing large amounts of moisture following heavy rain. This water can then be used by crops and pastures during dry periods in the growing season. Cracks within the clay subsoil allow good root penetration down to moisture reserves.

**Nutrient availability**

The **Red brown doleritic clay loam** has 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).

The subsoil is often alkaline and in some cases lime can occur on the surface with a resulting pH of around 8.5.

The soil has a low potential for soil acidification because of its fine texture (and therefore low potential for leaching and high pH buffering capacity).
Waterlogging
These soils do not become waterlogged. They generally occur on sloping ground and, because of their good structure, have a high infiltration rate for a clay.

Rooting conditions
The large quantities of doleritic rock that often occur within the soil profile do not greatly affect the root growth of crops and pastures. The depth to bedrock is usually greater than 80 cm.

Soil structure decline
These self-mulching soils crack into aggregates on drying and their structure is not greatly affected by cultivation.

Some phases of the Red brown doleritic clay loam are not self-mulching and are prone to surface structure decline following cultivation.

Trafficability
This soil becomes very boggy and slippery following heavy rainfall. Access back onto the soil after cultivation may be limited for several weeks. Rocky areas may affect cultivation and harvesting.

Water and wind erosion
Water erosion can occur on steep, sloping areas, especially if run-off from adjacent rock outcrop flows onto cultivated land. Wind erosion rarely takes place on this heavy textured soil.

Salinity
Salinity is rare.

Recharge hazard
The Red brown doleritic clay loam would be expected to add little recharge to the deep groundwater-table.

Productivity and capability
The Red brown doleritic clay loam is a good agricultural soil capable of producing excellent crop and pasture yields in good rainfall years. In very wet years, machinery access is limited.

Shallow rooted pasture species, such as subterranean clover and medics, grow well because their roots are able to penetrate into the structured clay and obtain moisture. Subterranean clover plants may have trouble burying their burrs in this hardsetting soil.
Cereal yields can be very high in good rainfall years owing to the soils ability to store water and its natural fertility. However, in some seasons rainfall is either too heavy, causing trafficability problems at seeding, or too dry, resulting in moisture stress. The application of gypsum on hardsetting phases of this soil can improve soil structure, which will increase rainfall infiltration and seedling emergence.

Lupin growth is average on this soil. In dry years lupins grow poorly due to moisture stress. In cases where lime occurs at or near the surface, lupins may suffer from iron deficiency and yield poorly.

Field peas grow well, though harvest difficulties may be experienced because of the soil’s rockiness. Wind erosion following the grazing of field peas stubbles is rare provided good management is practised.

Paddocks that are prone to water erosion should be contour or grade banked.

<table>
<thead>
<tr>
<th>Yield estimates and capability rating for various land uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red brown doleritic clay loam</td>
</tr>
</tbody>
</table>

<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>
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<tbody>
<tr>
<td>Pasture (s, m)</td>
<td>7-9 DSE/ha</td>
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<td>II</td>
<td>Moisture availability</td>
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<td></td>
<td>(winter grazed)</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>2.0-3.0 t/ha</td>
<td></td>
<td>I- II</td>
<td>Trafficability</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.0-1.4 t/ha</td>
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<td></td>
<td></td>
<td>1.6-2.0 t/ha*</td>
<td>III*</td>
<td></td>
</tr>
<tr>
<td>Lupins</td>
<td>1.5-1.8 t/ha</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.0-3.5 t/ha</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Lime absent from surface horizons.
15. Waterlogged greyish loamy sand/sandy loam

P.P.F. Dy 3.22, Dy 2.12
Hamersley Series, Heal series

Horizon

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

A2/A3  Light yellowish brown (10YR 6/4) to brown (7.5YR 5/4), medium to coarse grained sand to sandy clay loam. Single grains to massive structure. pH = 6.0

B2  Brown (10YR 5/3) to very pale brown (10YR 7/3) medium clay. Can contain red, grey and yellow mottles. Well structured. pH = 7.0 to 8.5

C  Decomposing bedrock.
Identifying characteristics

The Waterlogged greyish loamy sand/sandy loam includes the waterlogging prone, greyish brown loamy sand to sandy loam soils that occur in and adjacent to midslope drainage lines. A brownish clay subsoil usually occurs at a depth of 20 to 50 cm.

This soil is often mistaken as a grey clay because of its boggy nature.

Position in the landscape

The Waterlogged greyish loamy sand/sandy loam occurs as thin strips alongside minor creeks and drainage lines in the mid to lower slopes. It is most common in the Avon Valley. It generally occurs downslope from the well drained Rocky red brown loamy sand/sandy loam or Brownish grey granitic loamy sand.

This soil occurs within the Hamersley soil landscape unit. Slope gradients are generally less than 8 per cent.

Vegetation

The native vegetation is york gum (Eucalyptus loxophleba), jam (Acacia acuminata) and in wetter areas flooded gum (E. rudis).

Land qualities

Moisture availability

This soil has a good water holding capacity. Its topsoil is generally a loamy sand but can be a sandy loam. The clayey subsoil, which can hold large volumes of water, is within reach of shallower rooted pasture species.

This soil receives large amounts of additional moisture through seepage and run-on. In most years moisture is available at depth in late spring.

Nutrient availability

The natural fertility of these soils is adequate. This soil is at moderate risk of soil acidification.

Waterlogging

Seepage and run-on result in this soil becoming waterlogged in average and above average rainfall years.

Trafficability

The Waterlogged greyish loamy sand/sandy loam can become very boggy during the winter months. Seeding and access back onto the soil for spraying can be delayed for long periods.
Salinity
Some areas of this soil are saline or are becoming saline. Seepage water is forced to the surface by rock barriers or shallow clay layers. The water evaporates concentrating the salt.

Soil structure decline
Heavier phases of these soils are subject to soil structural decline following cultivation or trampling by stock when wet.

Wind erosion
The Waterlogged greyish loamy sand/sandy loam generally sets hard and is not prone to wind erosion.

Water erosion
These soils are prone to water erosion with gullies often forming down the centre of the drainage line.

Other
Rooting conditions are generally good though shallow bedrock can limit root growth in some areas.

This waterlogged soil has the potential to add considerable amounts of recharge to the groundwater-table.

Productivity and capability
This is a poorer cropping soil prone to waterlogging in average to wetter than average rainfall years.

Subterranean clover based pastures grow well. The excess seepage water and run-on result in additional moisture being available later in the season for pasture growth. However, in severely waterlogged and/or marginally saline areas pasture growth is poor.

Cereal, lupin and field pea crops generally grow poorly due to waterlogging. In most years it is uneconomic to crop this soil.

Densely planted belts of trees can be grown above areas of this soil to cut off seepage water and reduce waterlogging and subsequent salinity. Saline areas can be planted to salt tolerant fodder shrubs.

Erodible areas of this soil are best left as a grassed waterway. In other cases contour or grade banks can be used to control water erosion.
## Yield estimates and capability rating for various land uses

**Waterlogged greyish loamy sand/sandy loam**

<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 (s)</td>
<td>5-8 D.S.E./ha (winter grazed)</td>
<td></td>
<td>II-III</td>
<td>Waterlogging</td>
</tr>
<tr>
<td>Wheat</td>
<td>0.5-1.8 t/ha</td>
<td>1.8-2.2 t/ha</td>
<td>IV</td>
<td>Waterlogging</td>
</tr>
<tr>
<td>Lupins</td>
<td>0.5-1.0 t/ha</td>
<td>1.0-1.4 t/ha</td>
<td>V</td>
<td>Waterlogging</td>
</tr>
<tr>
<td>Field peas</td>
<td>Poor growth</td>
<td></td>
<td>IV</td>
<td>Waterlogging</td>
</tr>
</tbody>
</table>
16. Stony soils

Identifying characteristics

The Stony soils is an association of a number of soil types. These soils are linked together to form one soil because they occur together as one management unit on areas of steep rocky hills.

The soils types in this association are:

- Rocky red brown loamy sand/sandy loam;
- Brownish grey granitic loamy sand;
- Red brown doleritic clay loam;
- Hardsetting gritty quartztic soil (minor soil - see Section 2.4); and
- Coarse granitic sand (minor soil).

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

Stony soils can occur at any position in the landscape where the underlying bedrock has been exposed. These areas most commonly occur on the midslopes or as crests and ridges at the highest point of the landscape, such as in the Avon Valley. Slopes are generally greater than 10 per cent and can be greater than 30 per cent.

Vegetation

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

Productivity and capability

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

Subterranean clover growth is good. The carrying capacity of these areas varies widely depending on the percentage of rock. If well managed, these areas should be able to carry 4-8 DSE/ha (winter grazed - assuming 40 per cent rock outcrop).
Water erosion is common on these steep rocky areas. Large amounts 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. Seepage water is forced to the surface in some areas resulting in waterlogging. Large rock outcrops are useful as water catchments if the run-off can be channelled into a suitable dam site.

2.3 Valley floor soils

The valley floor soils occur at the bottom of the landscape on the floodplains of the major river systems. These soils belong to either the Mortlock or the Avon soil landscape units (see Figure 2).

The Mortlock soil landscape unit occurs adjacent to the Mortlock River and its tributaries. It contains two major soil types:

17. **Pale valley floor sand**, and
18. **Loamy sand surfaced valley duplex**.

The Avon soil landscape unit, which occurs downstream from the Mortlock unit, contains three major soil types:

19. **Grey alluvial clay**, 
20. **Red brown alluvial loam**, and 
21. **Orange alluvial loamy sand**.
17. Pale valley floor sand

P.P.F. Dg 4.42
Calje Series

Horizon

A1  Greyish brown (10YR 4/2), medium to coarse grained sand.
    Loose surface, single grains.
    pH = 6.0

A2/A3  Very pale yellow (10YR 7/4) to white (10YR 8/2), medium to coarse sand.
       Single grains.
       A perched watertable is often present in winter.
       pH = 6.5

B1  Very pale yellow (10YR 7/4) to greyish brown (10YR 5/2) sandy loam.
    Grey, red and orange mottles are often present.
    Massive structure.
    May contain ironstone gravel.
    pH = 6.5

B2  Very pale yellow (10YR 7/4) to greyish brown (10YR 5/2) clay.
    Grey, red and orange mottles are usually present.
    Well structured.
    pH = 7.0
Identifying characteristics

The Pale valley floor sand soil profile consists of the deep, pale sand which often overlies clay at depth.

This variable soil type often contains a complex pattern of the following:

- low lying waterlogged areas;
- sandy rises or low dunes; and
- better producing, rarely waterlogged, deep sand over clay soils.

This soil can be distinguished from the Deep pale sand by its clayey subsoil, position in the landscape, and because of its potential to become waterlogged.

This soil is often called a ‘river sand’.

Position in the landscape

The Pale valley floor sand occurs on alluvial terraces, immediately adjacent to the Mortlock and other similar rivers. Some areas of this soil occur on low dunes on the valley floor. The Pale valley floor sand occurs within the Mortlock soil landscape unit.

Vegetation

The dominant native vegetation on these sandy river flats is sheoak (Allocasuarina obesa), jam (Acacia acuminata) and some York gum (Eucalyptus loxophleba) and white gum (E. wandoor). Flooded gum (E. rudis) occurs in some areas on more poorly drained sites.

Land qualities

Moisture availability

The deep, medium to coarse grained sandy topsoil has a low water holding capacity. However, moisture is often available at depth as a perched watertable develops on top of the clay layer. These soils can be non-wetting, causing rainfall to sit on the soil surface and evaporate rather than infiltrate.

Nutrient availability

This soil has a low inherent fertility and nitrogen fertiliser is rapidly leached from the root zone.

Under current agricultural systems the Pale valley floor sand has a low potential for acidification due to its poor productivity. However, when under a productive legume based system (e.g. serradellas) this soil is at considerable risk of becoming acid. The 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 many years, parts of this soil become waterlogged. The clay subsoil acts as a barrier to water movement holding up the large amounts of water that seep in from surrounding areas. The more dunal areas do not experience waterlogging.

Heavy rainfall can cause the river to flood onto low lying areas of this soil.

Trafficability

The Pale valley floor sand can become very boggy during the winter months. Elevated areas of this soil, that do not become waterlogged, provide a good base for traffic.

Salinity

Large areas of this soil are saline or are at risk of becoming saline. A saline watertable often occurs at 1 to 2 m below the soil surface.

Wind and water erosion

The loose, sandy topsoil and average to poor pasture growth combine to make this soil prone to wind erosion. It is, however, less erodible then the Deep pale sand because of its better pasture growth and more sheltered position in the landscape.

Water erosion is unlikely to occur because of the high infiltration rate of the topsoil.

Recharge hazard

The Pale valley floor sand would be expected to add considerable volumes of recharge to the groundwater-table. The low water holding capacity and rapid infiltration rate result in excess water draining past the root zone until it forms a perched water-table on top of the clay layer. This water slowly seeps through the clay layer or moves through preferred pathways more rapidly until it reaches the deep groundwater-table.

Other

Rooting conditions are good. These soils are rarely cropped and are unlikely to develop a traffic compaction pan.

Productivity and capability

The Pale valley floor sand is a poor soil type that suffers from waterlogging in low lying areas and poor moisture availability on the deeper, dunal areas. Cropping is rarely economic.

The pasture production is below average to poor. Subterranean clover growth is sparse with grasses and broad-leaved weeds dominating.

There is potential for alternative pasture species such as yellow serradella, blue lupins or tagasaste on the deep sands, and lucerne where subsoil moisture is available. Salt tolerant species should be planted on the saline areas.
Cereals and lupins grow poorly in waterlogged areas and suffer from drought stress on the deeper sands in drier periods. In better drained areas, which have a clay subsoil, reasonable cereal and lupin yields can be obtained.

Access onto some areas of this soil for seeding, chemical spraying and application of fertiliser can be limited in wet years.

Field peas grow poorly and are a major wind erosion hazard.

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

**Pale valley floor 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>2-3 D.S.E./ha (winter grazed)</td>
<td></td>
<td>IV-V</td>
<td>Moisture availability, Waterlogging</td>
</tr>
<tr>
<td>Wheat</td>
<td>0.6-1.0 t/ha</td>
<td>1.4-1.8 t/ha</td>
<td>III-V</td>
<td>Waterlogging, Moisture availability</td>
</tr>
<tr>
<td>Lupins</td>
<td>0.4-1.0 t/ha</td>
<td>1.0-1.8 t/ha</td>
<td>IV-V</td>
<td>Waterlogging, Moisture availability</td>
</tr>
<tr>
<td>Field peas</td>
<td>Poor growth</td>
<td></td>
<td>V</td>
<td>Waterlogging, Wind erosion</td>
</tr>
</tbody>
</table>

* Non-saline examples.
18. Loamy sand surfaced valley duplex

P.P.F. Dy 5.42
Mortlock Series

Horizon

A1  Greyish brown (10YR 4/2), fine to medium grained sand to clayey sand. Loose to hardsetting surface. Small quantities of ironstone gravel may be present. pH = 6.5

A2/A3  Very pale brown (10YR 7/3) to yellowish brown (10YR 5/4) loamy sand to sandy loam. Single grains or massive structure. Some ironstone gravel may be present. pH = 6.5

B2  Very pale brown (10YR 7/3), yellowish brown (10YR 5/8) to grey (10YR 5/1) sandy clay to medium clay. Red, orange and grey mottles are often present. Well structured. pH = 6.5 to 8.5
Identifying characteristics

The **Loamy sand surfaced valley duplex** contains all the loamy sand surfaced, over yellowish clay soils that occur on the valley floor or lower slopes and have the potential to become waterlogged in wet years.

The surface texture is generally a loamy sand but can be a sand to clayey sand. The depth to the clay varies from 20 to 60 cm but is most commonly around 30 to 40 cm.

This soil looks similar to the **Loamy sand surfaced duplex** but can be distinguished by its position in the landscape and extent of waterlogging. In addition the **Loamy sand surfaced valley duplex** often has a greyer, mottled subsoil. The **Pale valley floor sand**, which is common on the valley flats, can be distinguished from this soil type by its deep, loose, sandy topsoil and poorer crop and pasture growth.

These soils are known in some areas as ‘wandoo flats’.

Position in the landscape

This soil occurs on the lower slopes and flat valley floor, but it can occur further upslope in depressions and adjacent to water courses. Slope gradients are usually less than 2 per cent. This soil occurs in the Mortlock soil landscape unit which occurs adjacent to the Mortlock River and its tributaries.

Vegetation

The dominant native vegetation is white gum (**Eucalyptus wandoo**) with some jam (**Acacia acuminata**), salmon gum (**E. salmonophloia**), sheoak (**Allocasuarina huegeliana**) and York gum (**E. loxophleba**) occurring in areas.

Land qualities

**Moisture availability**

This soil is well suited to supplying moisture for plant growth. The loamy sand surface horizon is able to retain moderate amounts of moisture, while the clay subsoil can supply moisture for plant growth towards the end of the growing season. Because of their position in the landscape, these soils often receive subsurface seepage flow from further upslope. This effectively lengthens the growing season. However, if waterlogging is severe, crop roots can be pruned and in spring, when most of the moisture occurs at depth, plants may experience moisture stress.

**Nutrient availability**

This soil has a good ability to hold and supply nutrients for plant growth. Nitrogen may become deficient in waterlogged areas owing to denitrification, and because the slower rate of mineralisation of organic nitrogen.

The topsoil of this productive soil has a high acidification potential because of its high potential for leaching and low pH buffering capacity.
Waterlogging

In wet years these soils become waterlogged for long periods (one week to two months). The clay subsoil is often sodic and as a result disperses and swells when wet. This greatly reduces water movement into and through the clay.

In addition these soils often receive large volumes of water from subsurface seepage flow.

If this soil occurs adjacent to a creek or river it can be affected by flooding.

Rooting conditions

Rooting conditions are generally good but the dense clay subsoil can restrict root growth of some species.

Soil structure decline

The surface structure of this sandy surfaced soil is rarely degraded by cultivation. However, the seasonal effect of raindrop impact and traffic may result in hard surface layers.

Trafficability

Access onto some areas of this soil is limited during wet winters as the soil becomes very boggy.

Wind erosion

If poorly managed the sandy topsoil is prone to wind erosion.

Water erosion

Water erosion is rare as this soil occurs on flat to very gently sloping ground. Waterways, which carry water from the hillslopes above, should be left uncultivated.

Salinity

Large areas of this soil are affected by valley floor salinity.

Recharge hazard

Waterlogged areas of this soil could be expected to add significant amounts of recharge.

Productivity and capability

This soil can produce well in below average to average rainfall years, however, in wet years waterlogging is a major limitation for cropping. Salinity affects large areas of this soil.

Subterranean clover based pastures grow very well. They are not greatly affected by the degree of waterlogging and thrive on the excess soil moisture. Pastures often remain green longer into spring on this soil than on other soil types. Burr medics have potential provided the soil pH is above about 6.0.

Cereals grow well in below average rainfall years but become severely affected by waterlogging in wet years.
Lupins may grow satisfactorily in some years but there is a high risk that they will be affected by waterlogging.

Field peas grow well in non-waterlogged years. Under current management strategies, the grazing of field pea stubbles is a major wind erosion hazard.

Saline areas of this soil should be planted to salt tolerant fodder species.

Seepage interceptor banks can be built on the lower slopes to intercept subsurface seepage flow before it reaches the valley floor and contributes to waterlogging. Rows of trees can be used to the same effect.

Application of lime may be necessary to overcome soil acidity.

<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 (s)</td>
<td>8-10 D.S.E./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>Wheat</td>
<td>1.4-2.0 t/ha</td>
<td>3.0-3.5 t/ha</td>
<td>III</td>
<td>Waterlogging</td>
</tr>
<tr>
<td>Lupins</td>
<td>0.7-1.0 t/ha</td>
<td>2.0 t/ha</td>
<td>IV</td>
<td>Waterlogging</td>
</tr>
<tr>
<td>Field peas</td>
<td>Average to good growth</td>
<td></td>
<td>IV</td>
<td>Wind erosion</td>
</tr>
</tbody>
</table>

* For non-saline areas.
19. Grey alluvial clay

P.P.F. Db 1.13, Dy 2.13
Beverley Series

Horizon

A1  Dark greyish brown (10YR 4/2) sandy loam to light clay.
    Hardsetting, often degraded surface.
    pH = 6.0

(Note - A thin, brownish sandy clay loam A3 horizon may occur at 10-20 cm.)

B2  Greyish brown (10YR 5/2) to dark yellowish brown (10YR 4/6)
    medium clay.
    Pale mottles may occur.
    Strongly structured.
    Calcareous (lime) segregations may be present at depth.
    pH = 7.0 to 8.5
Identifying characteristics

The Grey alluvial clay includes the fine textured, grey alluvial soils. The surface texture is most commonly a sandy loam or sandy clay loam but can be a clay loam or clay. The grey clay subsoil is shallow, occurring at 10 to 20 cm.

This soil can be distinguished from the Grey alluvial self-mulching clay (see minor soil types - section 2.4) by its hardsetting surface.

Position in the landscape

The Grey alluvial clay occurs on the alluvial floodplain of the Avon, Mortlock, Dale and Mackie Rivers. Slope gradients are usually less than 1 per cent.

This soil occurs in association with other alluvial soils, within the Avon soil landscape unit. Smaller areas of this soil are also mapped within the Mortlock soil landscape unit. This soil is more common in the south of the Advisory District with the redder, alluvial soils being more common in the York-Toodyay area.

Vegetation

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

Land qualities

Moisture availability

The shallow loamy topsoil has a good water holding capacity. The underlying clay layer is capable of storing large amounts of moisture. However, in dry years and during dry periods within the season plants have more difficulty in extracting water from this clayey soil than from some of the lighter soils.

Nutrient availability

This soil has a relatively high natural fertility. The subsoil may have an alkaline pH of 8.5.

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

Waterlogging

Large areas of this soil can become severely waterlogged in wet years. Flooding may occur leaving the soil under water for some time. However, many other areas of this soil further from the river and on higher ground do not become waterlogged to the same extent.

Trafficability

After heavy rains this soil becomes very boggly and sticky. Good seedbed preparation is difficult to achieve with the soil often being too wet or too dry for cultivation. Heavy rains after seeding may limit vehicle access for spraying and
topdressing fertiliser.

**Soil structure decline**

Cultivation and trampling by sheep when the soil is above a critical moisture content can degrade the structure of this soil. The hardsetting surface limits rainfall infiltration and hinders seedling emergence.

**Salinity**

Considerable areas of this soil have become affected by salinity (especially east of the Avon Valley).

**Other**

Rooting conditions are generally good, although the clayey subsoil may limit some species. Wind erosion and water erosion are rare. These soils would not be expected to add large volumes of recharge to the groundwater-table.

**Productivity and capability**

The *Grey alluvial clay* is an above average producing soil in better rainfall years, but in very wet years waterlogging and poor trafficability can be major limitations. Areas of this soil suffer from soil structure decline and salinity.

The *Grey alluvial clay* produces good pasture growth. Medic plants are well suited to obtaining moisture in this heavier textured soil. Subterranean clover growth is average as the hardsetting surface restricts burr burial, thus reducing plant numbers.

Cereals yields are average to just above average for this zone. However, in wet years large areas of this soil become waterlogged and boggy and yields are very poor. The soil surface may seal over reducing plant emergence. The poor structure can be improved by application of gypsum and the use of minimum tillage.

Lupins grow poorly. The hardsetting surface hinders lupin emergence, the shallow clayey subsoil restricts the lupin tap root’s growth and, if the subsoil is calcareous, iron deficiency may occur.

Field peas grow well on this soil except in very wet years. The shallow loamy topsoil and clay subsoil are well able to supply field peas with moisture. Wind erosion following the grazing of field pea stubbles is less likely on this hardsetting soil than on most other soils.

Contour or grade banks placed above areas of these valley floor soils can help alleviate waterlogging. Surface drainage works can be used to remove excess water. Salt tolerant fodder shrubs should be grown on saline areas.
# Yield estimates and capability rating for various land uses

**Grey alluvial 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>Pasture (m)</td>
<td>7-8 DSE/ha</td>
<td>II</td>
<td>Moisture availability</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(winter grazed)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>1.5-2.5 t/ha</td>
<td>2.5-3.5 t/ha</td>
<td>II-III</td>
<td>Waterlogging</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Trafficability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Moisture availability</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Soil structure decline</td>
</tr>
<tr>
<td>Lupins</td>
<td>0.8-1.0 t/ha</td>
<td>1.0-2.0 t/ha</td>
<td>IV</td>
<td>Waterlogging</td>
</tr>
<tr>
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<td>Soil structure decline</td>
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<td>Nutrient avail. (pH)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Moisture availability</td>
</tr>
<tr>
<td>Field peas</td>
<td>1.2-1.5 t/ha</td>
<td>1.8-2.0 t/ha</td>
<td>II</td>
<td>Waterlogging</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Trafficability</td>
</tr>
</tbody>
</table>
20. Red brown alluvial loam

P.P.F. Dr 2.13
Avon Series

Horizon

A1  Dark reddish brown (5YR 4/6) to dark brown (7.5YR 3/4), fine to medium grained clayey sand to sandy clay loam.
Firm to hardsetting surface.
$\text{pH} = 6.0$

A3/B1 Reddish brown (5YR 4/4) to strong brown (7.5YR 4/6), fine to medium grained sandy loam to clay loam.
Massive to moderately structured.
$\text{pH} = 6.5$

B2  Red (2.5YR 4/6) to brown (10YR 5/4) medium clay.
Strongly structured.
Calcereous (lime) segregations may be present at depth.
$\text{pH} = 7.0$ to $8.5$
Identifying characteristics

The **Red brown alluvial loam** includes all the red to brown, loam and clay loam over clay, alluvial soils.

The topsoil is most commonly a sandy loam but can be a clayey sand through to, on rare occasions, a clay. The clay subsoil occurs most commonly at about 30 cm but can occur as deep as about 45 cm.

Position in the landscape

The **Red brown alluvial loam** occurs on the flood plains of the Avon, lower Mortlock, lower Dale and lower Mackie Rivers and Toodyay Brook. It occurs in association with the **Orange alluvial loamy sand** and **Grey alluvial clay** with these soils occurring within the Avon soil landscape unit. Slope gradients are less than 2 per cent.

Vegetation

The dominant native vegetation is york gum (**Eucalyptus loxophleba**), salmon gum (**E. salmonophloia**) and jam (**Acacia acuminata**).

Land qualities

*Moisture availability*

This soil has a good ability to supply moisture for plant growth. The sandy loam topsoil has a high water holding capacity and the shallow clayey subsoil can store large quantities of moisture following heavy rainfall.

*Nutrient availability*

The **Red brown alluvial loam** has a high natural fertility and is well able to retain and supply nutrients for plant growth. Some of these soils have an alkaline subsoil, with a pH of around 8.5.

This soil is at some risk of surface acidification because of its moderate pH buffering capacity and moderate potential for leaching from the topsoil.

*Waterlogging*

The **Red brown alluvial loam** is generally well drained, but areas of low lying ground do become waterlogged in wet winters.

*Soil structure decline*

On heavier phases of this soil the surface structure has become degraded following cultivation and trampling by sheep. As a result the soil surface seals over, affecting crop emergence and reducing rainfall infiltration.

*Trafficability*

The **Red brown alluvial loam** can become very boggy following heavy rain. Access back onto the soil following cultivation may be limited for extensive periods.
Other

The rooting conditions are good. Salinity, wind erosion and water erosion rarely occur. This soil would not be expected to add large amounts of recharge to the groundwater-table.

Productivity and capability

The **Red brown alluvial loam** is a good cereal cropping and pasture producing soil.

Medics grow well with their root system being well suited to extracting moisture from the loamy topsoil and shallow clayey subsoil. Subterranean clovers also grow well but the hardsetting surface may restrict burr burial, thus reducing plant numbers.

Cereals grow very well and excellent yields can be obtained. However, in wet years trafficability problems and waterlogging in low lying areas can limit crop growth. The application of gypsum may improve soil structure, increasing infiltration and therefore trafficability.

Lupins growth is average. The hardsetting surface hinders seedling emergence. If the subsoil is alkaline, iron deficiency may be induced. The shallow clay layer limits the growth of the lupin tap root.

Field peas grow well. Their root system is well able to exploit moisture reserves in the loamy topsoil and clayey subsoil. Careful grazing management is required to prevent wind erosion.
**Yield estimates and capability rating for various land uses**

*Red brown alluvial loam*

<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 (s,m)</td>
<td>9-10 DSE/ha (winter grazed)</td>
<td></td>
<td>I</td>
<td></td>
</tr>
<tr>
<td>Wheat</td>
<td>2.0-2.8 t/ha</td>
<td>3.0-5.0 t/ha</td>
<td>I-II</td>
<td>Trafficability</td>
</tr>
<tr>
<td>Lupins</td>
<td>1.0-1.4 t/ha</td>
<td>1.6-2.5 t/ha</td>
<td>III</td>
<td>Waterlogging</td>
</tr>
<tr>
<td>Field peas</td>
<td>1.5-2.8 t/ha</td>
<td>3.0-3.5 t/ha</td>
<td>II</td>
<td>Wind erosion</td>
</tr>
</tbody>
</table>
21. Orange alluvial loamy sand

P.P.F. Uc 5.22, Dr 4.12, Dy 5.22
Katrine Series

Horizon

**A1** Brown (7.5YR 4/4), fine grained sand to clayey sand.
Loose to firm surface.
P$H = 6.0$

**A3** Orange (7.5YR 5/6) to reddish (5YR 4/6), fine grained sand to clayey sand.
Single grained to massive structure, earthy fabric.
P$H = 6.5$

**B2** Reddish (5YR 4/6) to light yellowish brown (10YR 6/4), fine grained sandy clay to light clay.
Yellowish brown versions may contain red and grey mottles.
Moderately structured.
P$H = 7.0$
Identifying characteristics

The **Orange alluvial loamy sand** includes the fine grained, alluvial sands found on the floodplains of the Avon and Mortlock Rivers. These loamy sands are generally orange but can be reddish brown or yellowish brown. A clay subsoil may occur below about 45 cm but is often not present in the top metre. These soils may have a high percentage of silt within them.

The **Orange alluvial loamy sand** can be distinguished from the **Red brown alluvial loam** by its deep, sandy surface horizon and the absence of clay within the top 45 cm.

This soil type is known locally as a ‘riverbank silty loam’ or ‘river sand’.

Position in the landscape

The **Orange alluvial loamy sand** occurs as thin strips on the floodplain immediately adjacent to the Avon River, lower Mortlock river and similar watercourses. It often has a slightly raised position, almost dunal in some cases, above the rest of the floodplain.

This soil occurs with other alluvial soils within the Avon and, less commonly, the Mortlock soil landscape units.

Slope gradients are usually less than 3 per cent.

Vegetation

The dominant indicator vegetation is flooded gum (*Eucalyptus rudis*), sheoak (*Allocasuarina obesa*), york gum (*E. loxophleba*) and jam (*Acacia acuminata*).

Land qualities

**Moisture availability**

This deep, fine grained, sand to loamy sand is capable of storing reasonable amounts of moisture for plant growth. However, crops and pasture species do experience moisture stress earlier in spring on this soil than on the more loamy Avon Valley soils.

**Nutrient availability**

This soil has a fair ability to hold and supply nutrients for plant growth. It has a high risk of surface acidification because of its low pH buffering capacity and high potential for leaching.

**Waterlogging**

These soils are well drained and do not become waterlogged. They often occur in slightly raised positions on the floodplain. Paler phases of this soil with a yellowish brown clay subsoil may experience some subsurface waterlogging in wet years.
Trafficability

These soils do not become boggy.

Salinity

Small areas of this soil are affected by regional groundwater salinity.

Other

Wind erosion can occur on poorly managed areas of this loose, sandy surfaced soil. Rooting conditions are good and soil structural decline is rare. Water erosion does not occur. This soil would not be expected to add large amounts of recharge to the groundwater-table.

Productivity and capability

This is an average crop and pasture producing soil that experiences few limitations other than moisture stress in drier periods.

Subterranean clover pasture growth is average with carrying capacities being lower on this soil than on the loamy Avon Valley soils.

Cereal and lupin crops grow quite well but yields are lower on this soil type than the more loamy Avon Valley soils owing to lower moisture availability.

Field peas grow satisfactorily but under current management strategies they constitute a major wind erosion hazard.

Yield estimates and capability rating for various land uses

<table>
<thead>
<tr>
<th>Orange alluvial loamy sand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land use</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>Pasture (s)</td>
</tr>
<tr>
<td>Wheat</td>
</tr>
<tr>
<td>Lupins</td>
</tr>
<tr>
<td>Field peas</td>
</tr>
</tbody>
</table>
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 proportion of some farms.

Minor soils that occur within the Zone of Rejuvenated Drainage are:

22. Buckshot gravel
23. Shallow mottled zone
24. Sandy loam over pinkish clay below breakaways
25. Coarse granitic sand
26. Hardsetting gritty quartzitic soil
27. Yellow alluvial sand
28. Grey alluvial self-mulching clay
22. Buckshot gravel

The Buckshot gravel contains the yellow sandy gravels that often occur above breakaways at the top of the landscape. This soil is commonly referred to as ‘buckshot gravel’ or ‘pea gravel’.

Soil Description

A brownish, fine to medium grained sand to loamy sand topsoil with large amounts of ironstone gravel overlying a yellowish brown sand to clayey sand with large amounts of ironstone gravel often over lateritic duricrust (cap rock) at depth. The ironstone gravel is round and has a diameter of 5 to 10 mm. It often makes up 70 to 80 per cent of the soil volume. The texture of the subsoil may increase to a sandy clay loam above the lateritic duricrust. The pH throughout the profile is about 6.0. These soils are often non-wetting.

This soil can be distinguished from the Yellow gradational loamy sand by its deeper, sandier topsoil, the presence of large amounts of ‘buckshot gravel’.

Northcote PPF KS - Uc 5.22, Dy 5.52.
Yalanbee series.

Position in the landscape

This soil is found on the flat to gently undulating plateau surface that occurs above breakaways at the top of the landscape (Quailing soil landscape unit). The Buckshot gravel is more common in the Darling Range zone.

Vegetation

The dominant native vegetation is parrot bush (Dryandra sp.), Eucalyptus macrocarpa and blackboy (Xanthorrhoea sp.). White gum (E. wandoo) may occur in some areas.

Discussion of capability

The Buckshot gravel is an average cropping and pasture producing soil that is limited by moisture availability in average to below average rainfall seasons.

The high reactive iron levels of the soil result in large amounts of applied phosphate being fixed and therefore unavailable for plant growth. Cereals are susceptible to manganese deficiency on these soils.

Subterranean clover growth is average with pastures dying off early in spring in many years. The loamy sand phases of this soil are better able to retain moisture within the root zone of shallow rooted pasture species.

Cereals can grow well in better seasons with good finishing rains, but in many years they are limited by moisture availability.

Lupins produce good yields as their root systems are well suited to exploring and gathering moisture from this deep, sandy soil. However, lupin growth is poorer on areas where the duricrust occurs within the top metre.
The **Buckshot gravel** is capable of adding large amounts of recharge to the groundwater-table. Rainfall moves quickly through the free draining soil and out of the root zone.

Tagasaste, a perennial fodder shrub which is capable of using large amounts of water, grows well and may warrant consideration as an alternative landuse if salinity occurs within the catchment.

Poorly managed areas of this soil are susceptible to wind erosion. Water erosion can occur, especially where tracks or firebreaks concentrate run-off.
23. Shallow mottled zone

The Shallow mottled zone contains the poor quality agricultural soils which have a shallow, gravelly topsoil overlying mottled zone. The mottled zone hardens when it is exposed to the atmosphere and is called ‘conglomerate’ by some farmers.

Soil description

The Shallow mottled zone consists of 5-15 cm of greyish brown loamy sand over a thin, yellowish clayey sand overlying mottled zone. The surface is hardsetting and large amounts of ironstone gravel often occur within the topsoil. The pH throughout the profile is usually between 5.5 and 6.0 but can be more acidic at depth.

If the depth to the mottled zone is greater than about 25 cm, this soil should be placed into the Yellow gradational loamy sand.

Northcote PPF Uc 5.13.
Wyalkatchem series.

Position in the Landscape

The Shallow mottled zone is a minor soil type occupying small areas within the Quailing soil landscape unit. It is more common in the far east and north east of the advisory district in the Zone of Ancient Drainage. This soil often occurs on ridge crests and upper slopes and is usually associated with the Yellow gradational loamy sand.

Vegetation

Tammar (Allocasuarina campestris) and black tammar (Allocasuarina acutivalvis) are the dominant native vegetation species of this soil.

Discussion of Capability

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

This soil supports poor pasture growth. Subterranean clover generally grows poorly because of the moisture stress. However, in deeper phases of this soil (20-25 cm of topsoil) satisfactory growth can be obtained.

Stock should be carefully managed to prevent overgrazing. Wind erosion of the thin topsoil exposes the hostile subsoil in which little or nothing will grow.

Cereal crops grow poorly because of the shallow depth of soil. 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 areas with a shallow topsoil. Tagasaste grows very poorly.

Recharge to the deep groundwater-table is high under agricultural species.
24. Sandy loam over pinkish clay below breakaways

This soil includes the brownish to reddish brown sandy loam over pinkish clay soils that occur immediately below the breakaway face.

Soil description

A thin, hardsetting dark reddish brown to grey clayey sand to sandy clay loam topsoil over a pinkish to white clay at 5 to 20 cm.

The thin topsoil is often non-wetting and can have a powdery feel about it. Angular ironstone gravel which is usually dark red to purple may be present on the soil surface.

In many cases the topsoil has been eroded exposing the dispersive (erodible) pink to white clay subsoil.

The pH of the topsoil is about 6 while the subsoil is commonly around 7.

Northcote PPF Dr 2.12.

Balkuling series.

Position in the landscape

This soil occurs as small areas immediately below breakaways or mallet hills. Slopes are often 5 to 10 per cent but can be steeper at around 20 per cent. These soils are formed from the pallid and transitional zones of the lateritic profile. This soil often grades into the Sandy loam over clay soil type as you move further downslope from the breakaway face.

These soils occur within the Ewers soil landscape unit.

(Note: The Sandy loam over pinkish clay below breakaways is more common further to the west in the Darling Range Zone.)

Vegetation

The dominant indicator trees are salmon gum (Eucalyptus salmonophloia), white gum (E. wandoo) and, in some areas, morrel (E. longicornis).

Discussion of capability

The Sandy loam over pinkish clay below breakaways is an average pasture and crop producing soil. However, where the topsoil is very thin or has been eroded away, plant growth is very poor due to the harsh rooting conditions and consequent low moisture availability.

Cropping this soil often constitutes a major water erosion hazard. The non-wetting topsoil, dispersive clay subsoil and steep slopes on which the soil occurs result in this soil being highly prone to water erosion. Run-off from the breakaway face can initiate erosion on these soils. However, some better quality areas of this soil can be cropped without erosion if they are carefully managed.

Other steeper areas of this soil type and the associated areas of breakaways, laterite cap rock and steep, very rocky ironstone areas should not be cleared.
25. Coarse granitic sand

This soil includes the poor quality, coarse to very coarse, pale sand that has formed from decomposed granitic rock.

Soil description

A loose, grey, coarse to very coarse sand overlying a loose, pale, coarse to very coarse sand which often becomes yellower at depth. Bedrock commonly 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. A clay layer may occur above the bedrock. The pH throughout the profile is 6.0 to 6.5.

Northcote PPF 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 or quartzitic rock.

It is often found in association with, and grades into, the Brownish grey granitic loamy sand. This soil occurs within the York or Steep rocky hills soil landscape units.

Vegetation

The dominant native vegetation is rock sheoak (Allocasuarina huegeliana) and various Acacia species including jam (A. acuminata). Scattered white gum (E. wandoo) may also occur.

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 rock outcrops contributing to the recharge. Poor ground cover results in a high wind erosion hazard.

Most areas of this soil do not warrant clearing.
26. Hardsetting gritty quartzitic soil

This soil includes all the grey to brownish, gritty, hardsetting soils formed from quartzite.

Soil description

The topsoil is a shallow, grey to brownish, hardsetting clayey sand to sandy clay loam containing much quartz grit. A greyish brown clay subsoil occurs at about 10 cm. Red and yellow mottles often occur within the clay subsoil. The surface pH is most commonly 6 while the subsoil pH varies from 6 to 8.5. Large amounts of quartz or quartzite rock commonly occur on the soil surface.

Northcote PPF Db 1.12, Db 1.23.
Bakewell series.

Position in the landscape

The Hardsetting gritty quartzitic soil often occurs as a strip either side of a quartzite ridge. Large amounts of quartz rock are commonly seen on the soil surface. These soils occur within the York soil landscape unit.

Vegetation

The dominant native vegetation consists of rock sheoak (Allocasuarina huegeliana), white gum (Eucalyptus wandoo), York gum (E. loxophleba), jam (Acacia acuminata) and in some areas salmon gum (E. salmonophloia).

Discussion of capability

This is a below average agricultural soil with a poor soil structure. The tough rooting conditions greatly limit the availability of moisture for plant growth.

Cereal and field pea growth is below average and lupins perform poorly. Medic and subterranean clover pastures perform poorly.

The low infiltration rate on these soils causes water to run-off often resulting in water erosion.

Many areas of this soil do not warrant clearing.
27. Yellow alluvial sand

This soil includes the small areas of yellow sand that occur immediately adjacent to the Mortlock and Avon Rivers.

Soil description

A loose, brownish, medium grained sand over a loose, yellow sand. The pH throughout the profile is about 6.0 to 6.5.

Northcote PPF Uc 5.11.

Pingelly series.

Position in the landscape

The Yellow alluvial sand often occurs as small areas on the inside bend of the Mortlock and Avon Rivers, where slower moving water has deposited the sand. In some cases wind has blown the sand into dunes. This soil occurs within both the Mortlock and Avon soil landscape units.

Discussion of capability

This soil has a very similar capability to the Deep yellow sand (soil type 2). Some areas of this soil, because of their low lying position, can experience subsoil waterlogging. This may affect the growth of tagasaste and other trees.
28. Grey alluvial self-mulching clay

This soil includes the grey, self-mulching clays that occur on the alluvial terrace of the Avon River.

Soil description

This soil consists of a grey, self-mulching clay (self-mulching refers to a crumbling soil which cracks open upon drying). The surface pH is about 7 while the subsoil has a pH of 8 to 8.5.

Northcote PPF Ug 5.25, Ug 5.16.

Gwambygine series.

Position in the landscape

The Grey alluvial self-mulching clay occurs on the broad, alluvial floodplain of the Avon River. It is more common south of York. Slope gradients are less than 1 per cent. This soil type usually occurs in association with the Grey alluvial clay with these soils occurring within the Avon soil landscape unit.

These soils often have many crabholes or gilgai on the soil surface.

Vegetation

The dominant native species are salmon gum (Eucalyptus salmonophloia), York gum (E. loxophleba) and needle bush (Hakea preissii).

Discussion of capability

This is a high yielding soil capable of excellent yields in good rainfall years.

The self-mulching clay is capable of storing large volumes of moisture. Its natural fertility is high. Yields can be depressed in very wet years because of waterlogging and trafficability limitations.

Medics, cereals and field peas grow well. Lupins perform satisfactorily. Cereal yields are on average probably 30 per cent higher on this soil than on the Grey alluvial clay.

Water erosion, wind erosion and salinity do not or very rarely occur.
2.5 Table 1. Soil types in each soil landscape unit

The following table divides 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>Soil landscape 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>Quailing</td>
<td>Deeply weathered laterite</td>
<td>Undulating yellow and pale sandplain often above a breakaway</td>
<td>Banksia sp., Christmas tree, sheoak and low scrub</td>
<td>Loose, grey sand to depth of 10-15 cm</td>
<td>Loose, white or pale yellow sand to a depth of 80 cm or greater. Occasionally overlying ironstone gravel</td>
<td>1. Deep pale sand (15%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Banksia sp. and sandplain pear</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 (15%)</td>
</tr>
<tr>
<td></td>
<td>Tammar, sandplain mallee, white gum and Eucalyptus macrocarpa</td>
<td>Tammar sandplain mallee, white gum and Eucalyptus macrocarpa</td>
<td>Loosely 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. Pale sand over gravel/loamy sand (35%)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Tea tree scrub and white gum</td>
<td>Tea tree scrub and white gum</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>Coherent, yellowish brown sand to clayey sand with large amounts of ironstone gravel over laterite cap rock at depth</td>
<td>22. Buckshot gravel (3%)</td>
</tr>
<tr>
<td></td>
<td>Parrot bush, blackboy, white gum and Eucalyptus macrocarpa</td>
<td>Parrot bush, blackboy, white gum and Eucalyptus macrocarpa</td>
<td>Firm, brownish sand to loamy sand to a depth of 10-15 cm. Large amounts of ironstone gravel</td>
<td>Loose, pale sand to a depth of 70 cm or greater</td>
<td>Loose, pale sand to a depth of greater than 70 cm over sandy clay</td>
<td>5. Waterlogged sand (2%)</td>
</tr>
<tr>
<td></td>
<td>Poorly drained seepage areas</td>
<td>Poorly drained seepage areas</td>
<td>Loose, grey sand to a depth of 10-15 cm</td>
<td>Loose, pale sand to a depth of 10-15 cm</td>
<td>Loose, pale sand to a depth of 10-15 cm</td>
<td>1. Deep pale sand (15%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Loose, yellow sand to a depth of 70 cm or greater. Sometimes overlying yellow loamy sand</td>
<td>2. Deep yellow sand (15%)</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Soil landscape 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>Ewerts</td>
<td>Colluvium derived from lateritic profile</td>
<td>Upper, mid and lower slopes</td>
<td>White gum with some jam. Tammar may occur on gravelly phases</td>
<td>Loose to hardsetting, greyish brown loamy sand to a depth of 10-15 cm</td>
<td>Coherent, pale to yellowish brown clayey sand overlying a yellowish brown, mottled clay about 40 cm. Ironstone gravel commonly occurs above the clay</td>
<td>9. Loamy sand surfaced duplex (45%<em>) (20%</em>)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>White gum with some sheoak, jam and tea tree</td>
<td>Loose, greyish brown sand to a depth of 10-15 cm</td>
<td>Loose, pale sand overlying a yellowish brown, mottled clay at depths less than 45 cm. Ironstone gravel commonly occurs above the clay</td>
<td>10. Shallow sandy surfaced duplex (15%<em>) (10%</em>)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>White gum, sheoak and tea tree</td>
<td>Loose, greyish brown sand to a depth of 10-15 cm</td>
<td>Loose, pale sand overlying a yellowish brown, mottled clay at depths greater than 45 cm. Ironstone gravel commonly occurs above the clay</td>
<td>11. Deep sandy surfaced duplex (15%<em>) (10%</em>)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tammar and white gum</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>4. Yellow gradational loamy sand (15%<em>) (30%</em>)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Salmon gum, white gum and some mallee 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>8. Sandy loam over clay (5%<em>) (5%</em>)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>White gum and tea tree</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>3. Pale sand over gravel/loamy sand (1%<em>) (20%</em>)</td>
</tr>
</tbody>
</table>

+ Percentage occurrence south of the Great Eastern Highway.

x Percentage occurrence north of the Great Eastern Highway.

Other soil types including:
7. Shallow hardsetting grey sandy loam over clay
24. Sandy loam over pinkish clay below breakaways
1. Deep pale sand
6. Breakaway face and ironstone cap
18. Loamy sand surfaced valley duplex
<table>
<thead>
<tr>
<th>Soil landscape 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>York</td>
<td>Predominantly granite, gneiss and migmatite</td>
<td>Upper, mid and lower slopes adjacent to dolerite dykes</td>
<td>York gum and jam</td>
<td>Firm 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>12. Rocky red brown loamy sand/sandy loam (65%) (40%)&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Dolerite and other fine grained, basic rocks</td>
<td>Upper, mid and lower slopes immediately adjacent to dolerite dykes</td>
<td>York gum, salmon gum and needle bush</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 bedrock</td>
<td>13. Brownish grey granitic loamy sand (15%) (55%)&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Red brown clay loam to a depth of 15 cm, often self-mulching</td>
<td>Well structured, dark red clay overlying decomposing dolerite rock. May contain lime at depth</td>
<td>14. Red brown doleritic clay loam (15%) (1%)&lt;sup&gt;x&lt;/sup&gt; Rock outcrop (3%)&lt;sup&gt;x&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

+ Percentage occurrence in the Avon Valley.

x Percentage occurrence east of the Avon Valley.

Other soil types including:

26. Hardsetting gritty quartzitic soil
15. Waterlogged greyish loamy sand/sandy loam
25. Coarse granitic sand

<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>Hamersley</td>
<td>Predominantly granite, gneiss and migmatite</td>
<td>Narrow, 1st and 2nd order, mid-slope drainage lines which occur within the York unit</td>
<td>Flooded gum, york gum and jam</td>
<td>Dark greyish brown sand to sandy loam to a depth of 10-15 cm</td>
<td>Light yellowish brown sand to sandy loam overlying a brownish clay at 15 to 50 cm</td>
<td>15. Waterlogged greyish loamy sand/sandy loam (80%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>York gum and jam</td>
<td>Firm 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>12. Rocky red brown loamy sand/sandy loam (15%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></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 bedrock</td>
<td>13. Brownish grey granitic loamy sand (15%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Rock outcrop (10%)</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Soil landscape 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>Avon</td>
<td>Alluvium</td>
<td>Floodplains of the major waterways within the Avon Valley</td>
<td>York gum, salmon gum and jam</td>
<td>Hardsetting, dark reddish brown clayey sand to sandy clay loam to a depth of 10-15 cm</td>
<td>Structured, reddish brown sandy loam to clay loam to a depth of 10 to 50 cm overlying a structured, red to brown clay. Lime may occur at depth</td>
<td>20. Red brown alluvial loam (40%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Salmon gum, york gum, and needle bush</td>
<td>Hardsetting, dark greyish brown sandy loam to clay to a depth of 10-15 cm</td>
<td>Structured, greyish brown clay. Lime may occur at depth</td>
<td>19. Grey alluvial clay (30%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Flooded gum, sheoak, york gum and jam</td>
<td>Firm, brown, fine grained sand to clayey sand to a depth of 10-15 cm</td>
<td>Coherent, orange, fine grained sand to clayey sand to a depth of at least 40 cm. A reddish to light yellowish clay may occur at depth</td>
<td>21. Orange alluvial loamy sand (20%)</td>
</tr>
</tbody>
</table>

Other soil types including:
28. Grey alluvial self-mulching clay
27. Yellow alluvial sand
17. Pale valley floor sand
18. Loamy sand surfaced valley duplex
12. Rocky red brown loamy sand/sandy loam
<table>
<thead>
<tr>
<th>Soil landscape 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>Mortlock</td>
<td>Alluvium</td>
<td>Alluvial flats and low lying areas adjacent to the Mortlock River and similar water courses</td>
<td>White gum, jam, york gum, sheoak and the occasional salmon gum in some areas</td>
<td>Loose to hardsetting, greyish brown sand to clayey sand to a depth of 10-15 cm</td>
<td>Coherent, pale to yellowish brown loamy sand to about 40 cm overlying a structured, yellowish brown, mottled clay</td>
<td>18. <strong>Loamy sand surfaced valley duplex</strong> (65%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sheoak, jam and some york gum and white gum. Flooded gum on poorly drained areas</td>
<td>Loose, greyish brown sand to a depth of 10-15 cm</td>
<td>Loose, pale sand overlying a pale yellow, mottled, structured clay at depths of 50 cm to greater than 100 cm</td>
<td>17. <strong>Pale valley floor sand</strong> (25%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Salmon gum, york gum and needle bush</td>
<td>Hardsetting, dark greyish brown sandy loam to clay to a depth of 10-15 cm</td>
<td>Structured, greyish brown clay. Lime may occur at depth</td>
<td>19. <strong>Grey alluvial clay</strong> (5%)</td>
</tr>
</tbody>
</table>

Other soil types including: 21. Orange alluvial loamy sand 27. Yellow alluvial sand

<table>
<thead>
<tr>
<th>Soil landscape 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>Eaton</td>
<td>Deeply weathered laterite</td>
<td>Undulating pale and yellow sandplain</td>
<td>Tea tree scrub and white gum</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 a mottled zone</td>
<td>3. <strong>Pale sand over gravel/loamy sand</strong> (40%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Christmas tree, banksia, tea tree and low scrub</td>
<td>Loose, grey sand to depth of 10-15 cm</td>
<td>Loose, white or pale yellow sand to a depth of 80 cm or greater. Occasionally overlying ironstone gravel</td>
<td>1. <strong>Deep pale sand</strong> (30%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Tammar and white gum</td>
<td>Loose to firm, grey brown loamy sand to a depth of 10-15 cm. Ironstone gravel present</td>
<td>Coherent, yellow clayey sand grading to a sandy loam often with large amounts of ironstone gravel overlying mottled zone</td>
<td>4. <strong>Yellow gradational loamy sand</strong> (15%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Banksia and sandplain pear</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. <strong>Deep yellow sand</strong> (10%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Poorly drained depressions within pale and yellow 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. <strong>Water logged sand</strong> (5%)</td>
</tr>
</tbody>
</table>

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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 familiarise all members of the group with the soils of the catchment and their capability. Dealing with catchments allows land degradation problems that go beyond farm boundaries, such as salinity, 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 finalised. 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 for catchment mapping in the Zone of Rejuvenated 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.

(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 digitising 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 Simon Peters for his 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 those farmers who spent time providing yield and capability information to me.
5. References


Munsell soil colour charts. Munsell Colour Co. Inc. Baltimore 18, Maryland, U.S.A.


6.1 Appendix 1. Climatic Data

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

<table>
<thead>
<tr>
<th>STATION</th>
<th>JAN</th>
<th>FEB</th>
<th>MARCH</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>
</tr>
</thead>
<tbody>
<tr>
<td>Beverley (1886-1988)</td>
<td>9</td>
<td>13</td>
<td>17</td>
<td>23</td>
<td>56</td>
<td>82</td>
<td>79</td>
<td>60</td>
<td>36</td>
<td>23</td>
<td>14</td>
<td>9</td>
<td>421</td>
</tr>
<tr>
<td>Northam (1965-1986)</td>
<td>8.7</td>
<td>18.3</td>
<td>21.9</td>
<td>27.5</td>
<td>52.2</td>
<td>83.5</td>
<td>75.7</td>
<td>54.9</td>
<td>40.3</td>
<td>27.3</td>
<td>14.9</td>
<td>8.3</td>
<td>433.5</td>
</tr>
<tr>
<td>Bakers Hill (1965-1985)</td>
<td>6.9</td>
<td>14.8</td>
<td>15.6</td>
<td>37.5</td>
<td>79.3</td>
<td>117.4</td>
<td>108.9</td>
<td>83.1</td>
<td>59.9</td>
<td>34.6</td>
<td>18.9</td>
<td>9.5</td>
<td>586.4</td>
</tr>
<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>
</tr>
<tr>
<td>Wongan Hills (1966-1987)</td>
<td>11.1</td>
<td>23.0</td>
<td>18.7</td>
<td>27.0</td>
<td>46.9</td>
<td>68.8</td>
<td>60.1</td>
<td>47.3</td>
<td>30.8</td>
<td>21.1</td>
<td>14.6</td>
<td>5.8</td>
<td>375.2</td>
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</table>

Mean daily maximum temperature (°C)

<table>
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<tr>
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<th>FEB</th>
<th>MARCH</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>
</tr>
</thead>
<tbody>
<tr>
<td>Northam</td>
<td>34.0</td>
<td>33.6</td>
<td>30.6</td>
<td>25.9</td>
<td>20.8</td>
<td>17.7</td>
<td>16.7</td>
<td>17.8</td>
<td>20.4</td>
<td>23.7</td>
<td>28.3</td>
<td>32.1</td>
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</tbody>
</table>

Mean daily pan evaporation (mm)

<table>
<thead>
<tr>
<th>STATION</th>
<th>JAN</th>
<th>FEB</th>
<th>MARCH</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>
</tr>
</thead>
<tbody>
<tr>
<td>Bakers Hill</td>
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<td>8.2</td>
<td>4.9</td>
<td>2.9</td>
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<td>2.3</td>
<td>3.2</td>
<td>5.0</td>
<td>7.7</td>
<td>9.9</td>
</tr>
<tr>
<td>Wongan Hills</td>
<td>12.7</td>
<td>11.7</td>
<td>9.2</td>
<td>5.4</td>
<td>3.4</td>
<td>2.1</td>
<td>2.1</td>
<td>2.5</td>
<td>3.9</td>
<td>6.1</td>
<td>8.5</td>
<td>11.3</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 characterises 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.

![Figure A.3.1. Size of sand fraction](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 and has a feel similar to raw sugar.

This distinction into particle size helps to evaluate the water retention characteristics of the sand because of the dependence of water movement and retention on the pore size distribution in a soil.
<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.

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

* 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.

** Incoherent 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 recognisable 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 characterised 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.
6.5 Appendix 5 Land quality definitions and land use requirements

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 pasture, cereals, lupins, blue lupins, field peas, and tagasaste.

<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>

**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).

![Figure A.5.1. Typical water-holding capacities of different textured soils (adapted from Millar 1965).](image-url)
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 which 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.

The available water content of a soil is also affected by the proportion of fine, medium and coarse sand. This is because grain size has a big influence on 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.

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 yield.

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.

<table>
<thead>
<tr>
<th>Year</th>
<th>Sand 1</th>
<th>Wongan Hills Sand 2</th>
<th>Loamy sand 3</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.
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 on these soils.

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**

Because of their varying root morphology, species differ in their ability to obtain moisture from different soil types.

Subterranean clover, because of its shallow root system (maximum depth of 40 to 50 cm under favourable conditions), has difficulty obtaining sufficient moisture for growth and reproduction on deep sands. For good growth on sandy surfaced soils subterranean clover generally requires 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 either subterranean clover or medic to deep, sandy soils because its roots can reach down to depths 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 to depths of about 2 m in deep sands. The adventitious root system 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 to depths of 100 cm. However, in heavier textured soils about 95% 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 to 10 m in deep sands. The clay layers in many duplex soils severely restrict tagasaste root growth and cause leaf drop in summer.
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 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’; and
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 so as to preserve electrical neutrality, they attract and loosely hold positively charged ions. The nutrient elements held in this way are nitrogen in ammonium (NH₄⁺), potassium (K⁺), calcium (Ca²⁺), magnesium (Mg²⁺), iron (Fe²⁺ or Fe³⁺), manganese (Mn²⁺), copper (Cu²⁺) and zinc (Zn²⁺). 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 (NO$_3^-$), sulphur in sulphate (SO$_4^{2-}$), phosphorus in phosphate (H$_3$PO$_4$), molybdenum in molybdate (MoO$_4^{2-}$), boron in various borate anions (B$_4$O$_7^{2-}$, HBO$_4^{2-}$, 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 from 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 fertilisers. 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.

**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 owing to iron deficiency.

<table>
<thead>
<tr>
<th>Table A.5.3. Critical pH levels for various species and varieties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Species/variety</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Truncaula medics (e.g. Cyprus)</td>
</tr>
<tr>
<td>Polymorpha medics</td>
</tr>
<tr>
<td>Murex medics</td>
</tr>
<tr>
<td>Subterranean clover, field peas</td>
</tr>
<tr>
<td>Serradella, lupins</td>
</tr>
<tr>
<td>Barley, sensitive wheats</td>
</tr>
<tr>
<td>Tolerant wheats</td>
</tr>
<tr>
<td>Oats, triticale</td>
</tr>
<tr>
<td>Tagataaste</td>
</tr>
<tr>
<td>Cereal rye</td>
</tr>
</tbody>
</table>

**Waterlogging (i)**

Waterlogging occurs when a soil is saturated with water and most, or all, of the soil air is displaced. 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 outcrop 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, causing isolated patches of waterlogging.

The pruning of roots during winter 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 is a list of 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 in summer at depth.

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, though burr medics are tolerant of transient periods 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 soil volume available for plant roots to develop in and the mechanical impedance to root development.

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

These impeding layers effectively limit root exploration thus reducing the plants ability to find moisture and nutrients. Different species have different abilities 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 dry off earlier due to the lack of moisture and yield poorly.

Cereals are generally less affected than lupins on soils with a silicious hardpan, hardened mottled zone or fractured rock layer.

**Soil structure decline (s)**

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

Cultivation and trampling by stock on heavy soils, especially under adverse moisture conditions, can cause aggregate breakdown 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 through the use of minimum/zero tillage and the application of gypsum. Pasture helps to increase the organic matter levels in the soil and this may improve structure 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.

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 prior to the adoption of minimum tillage 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 yield very poorly on hardsetting, degraded soils. The emerging lupin seed leaf or cotyledon has trouble 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 cotyledon stays 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. However, degraded soils do reduce seedling emergence which can have a large affect 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 crop and pasture types*

The management of pastures is rarely affected by trafficability problems. Aerial seeding and fertilisation may be needed on steep, rocky areas.

Rocky soils can cause problems when harvesting field peas owing 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 clearing 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 water-table. ‘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 pale sand 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. The following table outlines these.

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)*

<table>
<thead>
<tr>
<th></th>
<th>Light</th>
<th>0% reduction</th>
<th>Light</th>
<th>50% reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>33</td>
<td>53</td>
<td>72</td>
<td>115</td>
</tr>
<tr>
<td>Barley</td>
<td>44</td>
<td>71</td>
<td>99</td>
<td>159</td>
</tr>
<tr>
<td>Subterranean clover</td>
<td>8</td>
<td>13</td>
<td>19</td>
<td>50</td>
</tr>
<tr>
<td>Medic (barrel)</td>
<td>-</td>
<td>-</td>
<td>54</td>
<td>68</td>
</tr>
<tr>
<td>Couch</td>
<td>38</td>
<td>61</td>
<td>86</td>
<td>130</td>
</tr>
<tr>
<td>Ryegrass</td>
<td>31</td>
<td>49</td>
<td>70</td>
<td>108</td>
</tr>
</tbody>
</table>

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.
Wind erosion hazard (w)

Wind erosion hazard is the potential of a piece of land to erode by 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 (the smaller the more erodible) 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 (m) and nutrient availability (n) 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 ground water table. Water runs off the outcrops and is able to reach the water-table through zones of fractured rock.

Seepage areas, which remain wet for most of the year, can also contribute substantial recharge through preferred pathways within the clay or rock confining layers.

Deep, gravelly sands such as ‘buckshot gravels’ are also believed to contribute considerable recharge.

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.

In order to reduce salinity, areas identified as contributing recharge should be placed under a higher water using land use. Large areas of higher water using species may need to be planted to cause any significant alteration of a catchment water balance.

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 use less soil water than the deeper rooted species, such as serradella, 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 (early sown, healthy, 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 the 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 A.6.1. Land capability classes

<table>
<thead>
<tr>
<th>Class</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class I:</td>
<td>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.</td>
</tr>
<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 five stages in deriving the land capability classification.

1. Identifying and describing the soils.

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. Holding discussions with Department of Agriculture staff and farmers to define how capable each soil is of supporting common agricultural landuses. The limiting factors (qualities) of each soil were identified.

5. Developing the overall land capability classification for the soil types for each land use type (see Table A.6.2 on page 136). The overall capability is determined by the most limiting quality or qualities. In Table A.6.2 those land qualities which are most 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>
### Table A.6.2. Land capability assessment tables

<table>
<thead>
<tr>
<th></th>
<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>
<td>I-II m,n</td>
</tr>
<tr>
<td>2. Deep yellow sand</td>
<td>IV m,n</td>
<td>III m</td>
<td>I</td>
<td>V w</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>3. Pale sand over gravel/loamy sand</td>
<td>IV m</td>
<td>III m</td>
<td>II m</td>
<td>V w</td>
<td>I</td>
<td>II-III d</td>
</tr>
<tr>
<td>4. Yellow gradational loamy sand</td>
<td>I</td>
<td>I</td>
<td>I</td>
<td>IV w</td>
<td>I</td>
<td>II d</td>
</tr>
<tr>
<td>5. Waterlogged sand</td>
<td>IV i,m,n</td>
<td>IV i</td>
<td>V i</td>
<td>V i</td>
<td>V i</td>
<td>V i</td>
</tr>
<tr>
<td>6. Breakaway face and ironstone cap</td>
<td>V m,d,e</td>
<td>V m,d,e,t</td>
<td>V m,d,e,t</td>
<td>V m,d,e,t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Shallow hardsetting grey sandy loam over clay</td>
<td>IV s,m</td>
<td>IV s,m,e</td>
<td>V s,m</td>
<td>IV s,m,e</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Sandy loam over clay</td>
<td>II m</td>
<td>II m,s</td>
<td>IV m,s,n</td>
<td>II w,s</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Loamy sand surfaced duplex</td>
<td>I-II m</td>
<td>I-II m</td>
<td>II d,m,i</td>
<td>IV w</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Shallow sandy surfaced duplex</td>
<td>II-III m</td>
<td>III m,i</td>
<td>V w</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Deep sandy surfaced duplex</td>
<td>III m</td>
<td>III m</td>
<td>II-III m,i</td>
<td>V w</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Rocky red brown loamy sand/ sandy loam</td>
<td>I</td>
<td>I</td>
<td>I-II m</td>
<td>II-III w,t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Brownish grey granitic loamy sand</td>
<td>II m</td>
<td>II m</td>
<td>II m,i,d</td>
<td>IV w</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Red brown doleritic clay loam</td>
<td>II m</td>
<td>I-II t,m</td>
<td>III m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Stony soils</td>
<td>III e,t,d</td>
<td>V t</td>
<td>V t</td>
<td>V t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Waterlogged greyish loamy sand/ sandy loam</td>
<td>III-III i</td>
<td>IV i</td>
<td>V i</td>
<td>IV i</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Pale valley floor sand</td>
<td>IV-V m,i</td>
<td>III-V i,m</td>
<td>IV-V i</td>
<td>V w,i</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Loamy sandy surfaced valley duplex</td>
<td>I</td>
<td>I</td>
<td>IV i</td>
<td>IV i</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. Grey alluvial clay</td>
<td>II m</td>
<td>II-III i,t,m,s</td>
<td>IV i,s,n,m</td>
<td>II i,t</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. Red brown alluvial loam</td>
<td>I m</td>
<td>I-II t</td>
<td>III i</td>
<td>II w</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Orange alluvial loamy sand</td>
<td>III m</td>
<td>II-III m</td>
<td>II m,i</td>
<td>V w</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This classification was derived with assistance from various farmers and of the Western Australian Department of Agriculture.
## 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>Monkopen 1</td>
<td>5. Deep sand hollows</td>
</tr>
<tr>
<td>2. Deep yellow sand</td>
<td>Qualing Depositional 1</td>
<td>5. Deep sand hollows</td>
</tr>
<tr>
<td>3. Pale sand over gravel/loamy sand</td>
<td>Kauring 1</td>
<td>-</td>
</tr>
<tr>
<td>4. Yellow gradational loamy sand</td>
<td>Qualing Erosional 1, Belmunging 1, 2</td>
<td>4. Gravelly slopes and ridges</td>
</tr>
<tr>
<td>5. Waterlogged sand</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>6. Breakaway face and ironstone cap</td>
<td>-</td>
<td>1. Ironstone cap. 2 Breakaway faces and mallet hills</td>
</tr>
<tr>
<td>7. Shallow hardsetting grey sandy loam over clay</td>
<td>Balkuling 1,4</td>
<td>-</td>
</tr>
<tr>
<td>8. Sandy loam over clay</td>
<td>Balkuling 1,4</td>
<td>10. Lower slopes (wandoo flats)</td>
</tr>
<tr>
<td>10. Shallow sandy surfaced duplex</td>
<td>Malebelling 2?</td>
<td>10. Lower slopes (wandoo flats)</td>
</tr>
<tr>
<td>12. Rocky red brown loamy sand/sandy loam</td>
<td>York 1, 2</td>
<td>6. Grey sandy slopes with scattered granite outcrops</td>
</tr>
<tr>
<td>13. Brownish grey granitic loamy sand</td>
<td>Malebelling 1</td>
<td>7. Red-brown loamy slopes with scattered dolerite outcrops</td>
</tr>
<tr>
<td>14. Red brown doleritic clay loam</td>
<td>York 3</td>
<td>-</td>
</tr>
<tr>
<td>15. Waterlogged greyish loamy sand/sandy loam</td>
<td>York 4</td>
<td>8. Steep rocky hills, Granite bosses</td>
</tr>
<tr>
<td>16. Stony soils</td>
<td>York and Malebelling soils</td>
<td>-</td>
</tr>
<tr>
<td>17. Pale valley floor sand</td>
<td>Calje 1</td>
<td>10. Lower slopes (wandoo flats)</td>
</tr>
<tr>
<td>18. Loamy sand surfaced valley duplex</td>
<td>Calje 2, Mortlock 1</td>
<td>11. Valley flats (salmon gums/york gum flats)</td>
</tr>
<tr>
<td>20. Red brown alluvial loam</td>
<td>Avon 1</td>
<td>-</td>
</tr>
<tr>
<td>21. Orange alluvial loamy sand</td>
<td>-</td>
<td>11. Valley flats (salmon gum/ york gum flats)</td>
</tr>
</tbody>
</table>

**Minor soils**

<table>
<thead>
<tr>
<th></th>
<th>Quailing Erosional 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>22. Buckshot gravel</td>
<td></td>
</tr>
<tr>
<td>23. Shallow mottled zone</td>
<td>-</td>
</tr>
<tr>
<td>24. Sandy loam over pinkish clay below breakaways</td>
<td>Balkuling 1</td>
</tr>
<tr>
<td>25. Coarse granitic sand</td>
<td>-</td>
</tr>
<tr>
<td>26. Hardsetting gritty quartzitic soil</td>
<td>-</td>
</tr>
<tr>
<td>27. Yellow alluvial sand</td>
<td>-</td>
</tr>
<tr>
<td>28. Grey alluvial self-mulching clay</td>
<td>Avon 2</td>
</tr>
</tbody>
</table>
6.8 Appendix 8. Possible amalgamations of soil types for catchment mapping

The soil types to be mapped by a catchment group will differ from one area to another depending on the soil types that occur in the catchment. For example, in catchments which are predominantly sandplain, all the sandplain soils should be mapped and the small areas of valley floor soils can be amalgamated into one or two map units.

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 Rejuvenated Drainage.

1. Deep pale sand.
2. Deep yellow sand and Pale sand over gravel/loamy sand.
3. Yellow gradational loamy sand.
4. Sandy loam over clay.
5. Sand to loamy sand surfaced duplex soils (combination of the Loamy sand surfaced duplex, Shallow sandy duplex and the Deep sandy surfaced duplex).
6. Rocky red brown loamy sand/sandy loam.
7. Brownish grey granitic loamy sand.
8. Stony soils.
9. Loamy sand surfaced valley duplex.

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 occurs within the Avon Valley then the Red brown doleritic clay loam and Waterlogged greyish loamy sand/sandy loam soils should be included for mapping.

- If the catchment includes the floodplain of the Avon River, lower Mortlock or lower Dale Rivers then the Red brown alluvial loam and Orange alluvial loamy sand should be mapped out.

- In catchments with large areas of sand and loamy sand surfaced duplex soils the Loamy sand surfaced duplex, Shallow sandy surfaced duplex and the Deep sandy surfaced duplex should be mapped separately.

- If breakaways or mallet hills occur within the mapping area then the Breakaway face and ironstone cap should be included for mapping.

- The Waterlogged sand should be mapped out in catchments which contain large areas of the Eaton soil landscape unit.