Soils manual north Stirling land conservation district

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Recommended Citation
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SOILS
MANUAL

NORTH STIRLING LAND CONSERVATION DISTRICT

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Cover photo:
View to the south-east from the Great Southern Highway, showing land on the basin floor and the Stirling Range foothills.
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January 1993

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INTRODUCTION

The North Stirlings Land Conservation District is located between Katanning and Albany on the northern edge of the Stirling Ranges in south-western Western Australia.

It includes parts of the Shires of Cranbrook and Tambellup, covering approximately 100,000 ha of the catchment of the North Stirlings basin. The basin is a flat area formed on Eocene sediments with poorly defined drainage lines and many salt lakes. It is surrounded by low granite and sandstone hills. The climate is Mediterranean, with cool wet winters and hot dry summers. Average annual rainfall ranges from 375-500 mm per annum. There is very little surface or underground water flow through the basin and the area is subject to waterlogging and salinity owing to the rising water-tables following the clearing of native vegetation (Lewis 1992).

The Land Conservation District was formed in 1985 following concern about the rapid decline in productivity resulting from this salinity and waterlogging. There are about 80 landholders in the district, mostly involved in wool, barley, oat and lupin production.

This manual has been produced to help you identify and map the soils on your farm. The manual has been compiled for the North Stirling Land Conservation District (L.C.D.) and a list of its members is included in Appendix 1. As well as assisting you to identify soil types, the manual encourages everyone within the L.C.D. to use the same terms so that individual soil maps can be compared.

METHODS

The map showing the landscape units was prepared from aerial photograph interpretation (aerial photos 1984/85) and field reconnaissance. The soil descriptions are based on information gathered during field work undertaken in the summer of 1989. Over 100 sites were examined and the soil profiles described, usually from auger holes.

Forty of the sites were located throughout the district while the remainder were on two properties where the soils were mapped in detail to assess the applicability of the soil types to farm scale mapping.

The land qualities and land use recommendations were prepared in consultation with landholders and staff of the Department of Agriculture, Katanning. The manual was tested at the Toolbrunup Sub Catchment Workshop in 1990.
HOW THE MANUAL IS SET OUT

This manual has two sections. The first section (Landscape Units) relates to the landscape map of the North Stirling L.C.D. which accompanies this report. The second section (Soils Manual) describes the common soil types.

Landscape Units

This section of the manual describes the four landscape units which are found in the North Stirling L.C.D. Each unit is described in terms of its occurrence, geology and soil types. The native vegetation and main land degradation hazards of each landscape unit are also listed. Table 1 summarises the range of soils which are found in each landscape unit. Identifying the units that occur on your farm will help you to narrow down the number of soil types likely to be found on your property.

Soils Manual

Sixteen soil types have been identified in the North Stirling L.C.D. The distribution of these soil types is influenced by the landscape. Some soil types are only found in a few landscapes, while others occur in several landscapes.

This section describes the most common soils in the North Stirling L.C.D. It has key diagrams developed for each landscape unit to help you identify your soils. As well as the key diagrams (pages 9–12), this section contains descriptions of each soil type in detail. The soil descriptions are presented in the following format:

• the distinguishing features of each soil type are described in the identification section to help you identify it and differentiate it from similar soils;

• the occurrence of the soil type, which landscape unit it occurs in and its position in the landscape;

• the natural vegetation, with both the dominant and minor species, is also given.

Below this is a profile description and an idealised sketch diagram of the soil type. Each horizon or layer of the soil is described in terms of colour, texture, structure, the presence of stones and pH (whether it is alkaline or acidic using field testing kits). Its colour (e.g. reddish brown) as well as a Munsell colour code (e.g. 7.5YR 4/4) is given. The terms used to describe soils are defined in Appendix 2.

In the profile diagram, the depth of each horizon, its texture, and presence of stones are represented. The sloping lines between the horizons indicate the range of depth of its upper and lower boundaries. For example the A1 horizon of the Red Clay extends to a depth of between 5 and 15 cm in different areas while the B1 horizon below it extends to depths ranging from 30-60 cm. Sandy textured horizons are represented by dots, loamy textures by horizontal lines and clay textures by vertical lines. A sandy loam is represented by dots and horizontal lines and so on.

After the description, the variability of the soil type is described. The profile description is only one example of the soil type and various features will vary from site to site. The range of colours, textures and pH likely to be encountered is given.
Under the heading **Land Qualities**, the various properties of the soil which affect its agricultural use are discussed including aspects relating to soil and water conservation.

Finally, **land use recommendations** are discussed. This section is not intended to be comprehensive but will give you some ideas and suggestions about the management of that soil type.

**HOW TO USE THIS MANUAL WHEN PLANNING YOUR FARM**

The first step when preparing a farm plan or a catchment plan should be to identify and map the soil types. This need not be a complicated process. To start with, draw a quick sketch map of your farm showing areas on which crops and pastures perform differently or where management factors vary. This could include areas of poor yielding "gutless" sands that tend to "blow", boggy heavy "Sunday soils" as well as areas of "good light country" or loamy soils. This sketch map will be the basis for a soils map of your farm.

To help you identify which soil types are likely to occur on your farm, locate your farm on the landscape map. From the landscape map, you can see which landscape units cover your farm. The landscape unit -soil type matrix in Table 1 lists the range of soils for each landscape unit.

To identify your soils use the appropriate key diagrams for the landscape units on your farm. In the key diagrams, we have tried to use features and language which most farmers will recognise easily. These include landforms, natural vegetation and the occurrence of heavy (clayey) and light (sandy) soils. Although most of the natural vegetation has been cleared, small patches often remain and many farmers will know what vegetation the country originally carried. The knowledge gained from many years of farming will be very helpful in doing this.

Once you have a list of the possible soil types for your farm, turn to the Soils Manual section and check and see if the soils match the descriptions. If there is some doubt check the descriptions of similar soil types.

Once you have identified your soil types satisfactorily, it is time to begin drawing your soils map. Boundaries of the soil types should be drawn onto a paddock map or preferably on a plastic overlay on an enlarged air photo. Check the location of these boundaries by visiting the paddock and keeping an eye open for the identifying features, especially if there is some doubt. A legend with suggestions for symbols and colours you might use in preparing your overlay is included in Appendix 3.

Sometimes it may be difficult to distinguish between soil types that appear very similar on the surface without digging many holes, especially where the depth to clay is an important factor. If you do not have the time to do this they may be mapped together as one unit. Sometimes two soil types may occur together in a very complex pattern and may also have to be mapped as one unit. You may find a soil type which does not match any of those described. If this is the case, map it separately as a new soil type.

It is also worthwhile to map any areas of waterlogging, salinity, erosion or any other problem areas you may identify. This may be done on a separate plastic overlay.

When the map is completed it is time to start preparing a farm plan. The information on land qualities, crop and pasture performance and land use recommendations presented with each soil type should assist you in this task.
LANDSCAPE UNITS

This section briefly describes each of the four landscape units identified in the North Stirling Land Conservation District. Information on the occurrence, geology, native vegetation, soils and land degradation hazards of each unit are listed. Table 1 summarises the soil types which occur in each landscape unit.

1. BASIN FLOOR

Description: The Basin Floor is a flat, low lying plain with numerous salt lakes. The Basin Floor is downstream of the Broad Valley Floor unit.

Occurrence: The Basin Floor is located in the centre of the L.C.D. and runs east-west for over 40 km and about 10 km north-south.

Geology: The Basin Floor is underlain by unconsolidated sediments, mainly alluvium\(^1\) and colluvium\(^2\) consisting of sand, silt, clay, pebbles and carbonaceous deposits. These sediments overlie granitic basement rock. Highly saline groundwater is stored within the pore spaces of the sediment.

Native Vegetation: Mallee (Eucalyptus decipiens, E. uncinata) on the duplex soils with flat topped yate (E. occidentalis) in the depressions. Salt-tolerant paperbark (Melaleuca) scrub, sandplain heath, York gum (E. loxophleba) and flooded gum (E. rudis) also occur.

Soils: Sandplain Duplex soils dominate the Basin Floor with Paperbark Swamp soils and Deep Sands being common. Crabhole Clays, Yate Swamp soils and Lunette soils are common around the margins of lakes. White Gum Duplex soils are a minor soil.

Land Degradation: Highly saline groundwater is present within a few metres of the surface of the Basin Floor causing valley floor salting. Waterlogging, flooding and wind erosion are also problems. Localised groundwater recharge occurs from the Deep Sands.

2. BROAD VALLEYS

Description: The Broad Valley Floors are relatively flat and consist of alluvium over granite bedrock at depth.

Occurrence: Broad Valley Floors occur along the major drainage lines in the Granite and Laterite Hills.

Geology: The unit consists of alluvium with sand, silt and clay deposits. Dolerite dykes cross the Broad Valley Floors although they may not always be detected at the surface.

Native Vegetation: Mainly mallee, moort (Eucalyptus platypus), white gum (E. wandoo), flat topped yate (E. occidentalis), heath scrub and paperbarks (Melaleuca spp). Stands of York gum (E. loxophleba) occur on the Red Clay soils.

Soils: Predominantly Grey Clays with White Gum Duplex and Crabhole Clays common. Minor areas of Sandplain Duplex, Yate Swamp soils and Red Clays may occur on the Broad Valleys.

Land Degradation: Rising saline groundwater and associated valley floor salting, decline in soil structure (Grey clays), waterlogging, flooding and erosion (both wind and water). Deterioration of remnant vegetation, particularly flat topped yate.

\(^1\) Alluvium is material deposited by rivers and creeks

\(^2\) Colluvium is material deposited after erosion or movement of material downslope.
3. GRANITE AND LATERITE HILLS

Description: The Granite and Laterite Hills consist of undulating countryside overlying granitic basement rock. In some upland areas, laterite has formed on the hills.

Occurrence: The Granite and Laterite Hills are found in the upland areas in the northern parts.

Geology: The geology consists of granite and gneiss of the Yilgarn Block which is overlain by colluvium and minor deposits of alluvium along drainage lines. Remnant laterite also occurs on this unit. Dolerite dykes occur throughout this landscape.

Native Vegetation: Flat topped yate (Eucalyptus occidentalis), white gum (E. wando), York gum (E. loxophleba), moort (E. platypus), jam (Acacia acuminata) and mallee.

Soils: White Gum Duplex soils dominate with Grey Clays and Sandplain Duplex soils common. Red Clays are common and are associated with dolerite dykes. Rock Outcrop, Deep Sands and Cracking Clays are less common and occupy a small area. Gravelly Duplex soils occur in the south-west corner of the district.

Land Degradation: Rising saline groundwater occurs as saline seeps, upslope of dolerite dykes or where the granite bedrock is shallow. Waterlogging, water and wind erosion are common depending on the soil type and their position in the catchment. Native remnant vegetation is also deteriorating.

4. SANDSTONE HILLS

Description: The Sandstone Hills consist of low to steep slopes formed on fractured sedimentary bedrock.

Occurrence: This unit occurs on the northern footslopes of the Stirling Range, on the southern boundary of the L.C.D.

Geology: Stirling Range Formation sandstone and quartzite and colluvium derived from sandstone. Quartz veins and dolerite dykes occur on this unit. Ironstone ridges also occur.

Native Vegetation: The natural vegetation is similar to the vegetation in the Stirling Range National park. This includes woodland of jarrah (Eucalyptus marginata), white gum (E. wando) and marri (E. calophylla) on lower slopes. Low shrubs, mallee, banksia, hakea, ground covers, orchids and kangaroo paw occur on the steep rocky areas.

Soils: The soils of the Sandstone Hills are mainly Stony Duplex and Rock Outcrop (sandstone and some laterite) with Sandplain and White Gum Duplex soils common. Minor areas of Deep Sands and Red Clays occur in this unit.

Land Degradation: Groundwater recharge is extremely high as a result of the pervious, fractured rock. Wind erosion is a problem during late summer. Non-wetting soils increase the surface run-off. Jarrah dieback due to the Phytophthora fungus is threatening remnant vegetation.
Table 1: Matrix showing range of soil types within each landscape unit in the North Stirling L.C.D

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>CRABHOLE</td>
<td></td>
<td>++</td>
<td>+ (lakes)</td>
<td></td>
</tr>
<tr>
<td>CRACKING CLAY</td>
<td></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DEEP SANDS</td>
<td>+</td>
<td>+</td>
<td></td>
<td>++</td>
</tr>
<tr>
<td>GRAVELLY SANDY</td>
<td></td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DUPLEX</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GREY CLAYS (Light &amp; heavy)</td>
<td>++</td>
<td>+++</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LUNETTE SOILS</td>
<td></td>
<td></td>
<td>+(lakes)</td>
<td></td>
</tr>
<tr>
<td>PAPERBARK</td>
<td></td>
<td></td>
<td>++</td>
<td></td>
</tr>
<tr>
<td>SWAMP SOIL</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RED CLAY (dolerite dykes)</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>ROCK OUTCROP</td>
<td>+++</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SANDPLAIN DUPLEX - shallow and deep phase</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>+++</td>
</tr>
<tr>
<td>STONY DUPLEX</td>
<td>+++</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>WHITE GUM DUPLEX - shallow and deep phase</td>
<td>++</td>
<td>+++</td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>YATE SWAMP SOIL</td>
<td></td>
<td>+</td>
<td>+ (lakes)</td>
<td></td>
</tr>
</tbody>
</table>

**KEY**

Dominant soil: +++
Common soil: ++
Minor soil: +
SOILS MANUAL

The remainder of this manual is devoted to helping you identify the soils on your property. Four key diagrams are included for this purpose. Descriptions of the sixteen soil types that are common in the North Stirling L.C.D. and information on their management is included for your reference.
KEY TO SOILS OF THE BROAD VALLEY FLOORS

Does the soil occur in a swampy depression? → YES → Is the soil clayey with yates growing on it? → YES → YATE SWAMP SOILS
Page 44

NO → Is the soil sandy with paperbarks growing on it? → YES → PAPERBARK SWAMP SOILS
Page 28

NO → Is the soil medium to heavy? → YES → Is the surface soil sandy with white gums growing on it? → YES → WHITE GUM DUPLEX
Pages 40, 42

NO → Is the soil a red-brown colour with white gums and york gums growing on it? → YES → RED CLAYS
Page 30

NO → Does the soil have crabholes and cracks on the surface? → YES → CRABHOLE CLAYS
Page 14

NO → Is the soil boggy and a grey-brown colour with yates growing on it? → YES → GREY CLAYS
Pages 22, 24

NO → Is the soil light? → YES → Is the soil a sand over clay with white gums growing on it? → YES → WHITE GUM DUPLEX
Pages 40, 42

NO → Is the soil a sand over clay with mallee or sandplain vegetation growing on it? → YES → SANDPLAIN DUPLEX
Pages 34, 36
KEY TO SOILS OF THE GRANITE AND LATERITE HILLS

Is the soil too rocky to cultivate?

Is the soil very gravelly with jarrah and white gum growing on it?

Is the soil medium to heavy?

Is the soil light?

Is the soil a red-brown colour with white gums and york gums growing on it?

Is the soil crumbly with cracks on the surface?

Is the soil boggy and a grey-brown colour with yates growing on it?

Is the surface soil sandy with white gums growing on it?

Is the soil a sand over clay with white gums growing on it?

Is the soil a deep gutless sand?

Is the soil a sand over clay with mallees or sandplain vegetation growing on it?

ROCK OUTCROPS
Page 32

GRAVELLY SANDY DUPLEX
Page 20

RED CLAYS
Page 30

CRACKING CLAYS
Page 16

GREY CLAYS
Pages 22, 24

WHITE GUM DUPLEX
Pages 40, 42

WHITE GUM DUPLEX
Pages 40, 42

DEEP SANDS
Page 18

SANDPLAIN DUPLEX
Pages 34, 36
KEY TO SOILS OF THE SANDSTONE HILLS

Is the soil rocky or stony?

NO

Is the soil a sand over clay with white gums growing on it?

NO

Is the soil a deep gultless sand?

NO

Is the soil a sand over clay with mallee or sandplain vegetation growing on it?

YES

YES

STONEY DUPLEX
Page 38

WHITE GUM DUPLEX
Pages 40, 42

DEEP SANDS
Page 18

SANDPLAIN DUPLEX
Pages 34, 36

YES

ROCK OUTCROPS
Page 32

NO
CRABHOLE CLAYS

IDENTIFICATION

Areas of Crabhole Clays can be identified by an uneven (gilgai or crabhole) ground surface and a natural vegetation of mallee. The soil surface is very hard and small cracks appear in summer.

This soil type should not be confused with the Grey Clays or the Cracking Clays. The Grey Clays have a level surface and do not have crabholes (gilgais). The Cracking Clays have a friable, crumbly surface and crack deeply when dry, while the surface of the Crabhole Clays sets hard like concrete. This soil is also known as "cup and saucer" country.

OCCURRENCE

The Crabhole Clays are rare and are found mainly in small patches near lakes on the Basin Floor where they are usually associated with the Yate Swamp soils. They also occur on the Broad Valley Floor.

VEGETATION

The dominant natural vegetation is a dense mallee scrub. Flat topped yate (Eucalyptus occidentalis) is often present.

PROFILE DESCRIPTION

Hardsetting alkaline brownish grey heavy clay with an undulating "crabhole" surface.

A1    Dark brown (10YR 3/3)
      Sandy clay loam
      Hardsetting with surface cracks in summer months
      Stones absent
      Neutral (pH 7.0)

B1    Greyish brown (10YR 5/2)
      Heavy clay
      Strongly structured
      Stones absent
      Alkaline (pH 8.0)

Northcote classification: Dy2.13, Uf6.13

VARIABILITY

The presence of surface cracks varies according to the moisture status of the soil, the drier it is the more cracks that are present. The cracks are never deeper than 20 cm.
LAND QUALITIES

Water availability: In good seasons, this soil will store large amounts of water which is available for plant use. In dry seasons the clay retains water making it difficult for plants to extract.

Nutrient availability: Good.

Rooting conditions: Hardsetting topsoil limits root penetration of seedlings. The subsoil is well structured and provides good rooting conditions once plant is established.

Waterlogging: Very wet in winter, particularly in the crabhole (gilgai) depressions.

Trafficability: Very boggy when wet. Gilgais can be an obstacle to machinery.

Soil workability: Soil can only be worked over a very narrow moisture range as it becomes too boggy when wet and too hard when dry.

SOIL CONSERVATION

Soil structure decline hazard: Highly dispersible soil, often sodic. Hardsetting and surface sealing problems. Naturally poor topsoil structure may be made worse by cultivation.

Salinity risk: These soils often have high salinity levels, especially in the subsoil. Clearing these areas results in salinity owing to rising water tables. Gilgai depressions are also susceptible to surface salinity owing to ponding of water.

Groundwater recharge: As this soil occurs in low lying positions close to groundwater tables, the risk of groundwater recharge is high. Poor infiltration may result in some water being evaporated rather than passing into water tables. Little water is likely to be used by crops and pastures owing to poor growth.

Water erosion hazard: Low.

Wind erosion hazard: Low.

Flood hazard: Subject to flooding in wet years.

WATER CONSERVATION

Water supply: Saline conditions unsuitable for soaks and dams.

CROP AND PASTURE PERFORMANCE

Crops: Poor yields owing to waterlogging and/or high salinity levels.

Annual pastures: Generally poor pasture performance because of waterlogging and/or salinity levels. Some good clover and ryegrass pastures have been observed. Balansa clover is suitable in wetter areas. Medics may also be suitable where the soil is alkaline.

Perennial pastures: May be suitable for tall wheat grass, puccinellia, phalaris and fescue. If ARGT is a problem, drought tolerant ryegrass (e.g. Brumby) may be suitable.

Fodder crops and trees: May be suitable for saltbush and bluebush.

LAND USE RECOMMENDATIONS

These soils should remain uncleared owing to the salinity risk. Where previously cleared these soils can be planted to salt tolerant perennial pastures (tall wheat grass, puccinellia) or shrubs (saltbush).
CRACKING CLAYS

IDENTIFICATION

The Cracking Clays are dark coloured heavy clays with a crumbly (self-mulching) surface and large cracks when dry. In summer months the ground surface becomes very bumpy and deep, wide cracks appear. The soil surface breaks up into small crumbs.

The very distinctive nature of the soil surface means that these soils are easily distinguished from the other heavy soils. The Red Clays have a different colour while both the Grey Clays and Crabhole Clays have a very hard soil surface when dry.

OCCURRENCE

The Cracking Clays occur in small patches on the Granite and Laterite Hills. They usually only cover an area of 2 ha (5 acres) or less. They are often associated with dolerite dykes.

VEGETATION

The natural vegetation of Cracking Clays has not yet been identified. It is possibly York gum (*Eucalyptus loxophleba*) woodland. In cleared paddocks heavy growths of thistles are usually found.

SOIL DESCRIPTION

Dark coloured heavy clay with a crumbly surface and large cracks.

A1  Dark brown (10YR 3/3)
   Heavy clay
   Crumbly granular pedds
   Large cracks when dry
   Dolerite stones sometimes present
   Alkaline (pH 9.0)

B1  Dark brown (10YR 3/3)
   Heavy clay
   Strongly structured with
   large blocky pedds
   Large cracks extend into
   subsoil when dry
   Dolerite stones sometimes present
   Calcium nodules often present
   Alkaline (pH 9.0)

Northcote classification: Ug 6.3

VARIABILITY

The width and depth of the cracks can vary according to the dryness of the soil. Widths of up to 15 cm, and depths of up to 1 metre, have been observed.
LAND QUALITIES

Water availability: In good seasons large amounts of water are held and are available for plant use. In dry seasons the clay holds water which is difficult for plants to obtain.

Nutrient availability: Good, but alkaline nature of the soils may be a problem for some species.

Rooting conditions: Good, soil movement (shrink/swell) may cause problems for some tree species.

Waterlogging: Waterlogging does not appear to be a major problem.

Trafficability: Very slippery when wet. Bumpy ground surface can be a problem for machinery. Cracks can be a hazard for livestock.

Soil workability: Good workability when not too slippery for machinery access.

SOIL CONSERVATION

Soil structure decline hazard: Slight.

Salinity risk: No salinity observed.

Groundwater recharge: Much of the rainfall entering is held by the clay and in subsoil cracks and can be used by plants. Good crop and pasture growth maximises water usage. The cracks may provide pathways for some groundwater recharge.

Water erosion hazard: Low, although water may concentrate and channel down cracks on sloping sites.

Wind erosion hazard: Low.

Flood hazard: Not susceptible.

WATER CONSERVATION

Water supply: Cracking nature of soils makes them unsuitable for dam construction.

CROP AND PASTURE PERFORMANCE

Crops: Very high cereal yields can be achieved in average to good seasons. In dry seasons crops suffer water stress and perform poorly. The alkaline pH means this soil is not suited for lupins.

Annual Pastures: Good performance from most annual pastures, except in dry seasons.

Perennial Pastures: No perennial pastures have been tried on these soils.

Fodder crops and trees: Cracking nature of soil may damage tree roots. This soil is not suitable for tagasaste.

LAND USE RECOMMENDATIONS

These soils usually occur in patches too small to be managed separately from the surrounding soils. However, they should be taken into consideration when determining the management of the paddocks in which they occur.

They are suited to continuous cropping or cereal/pasture rotations.

They need to be worked early in the season before they become too slippery.
DEEP SANDS

IDENTIFICATION

The Deep Sands can be identified by their loose, pale, sandy topsoil, poor pasture and crop growth and a stunted natural vegetation, often a heath. It may be difficult to differentiate Deep Sands from Sandplain Duplex and Lunette soils without first digging a hole to examine the subsoil.

OCURRENCE

The Deep Sands occur throughout the North Stirling L.C.D. They are a common soil type of the Basin Floor, including dunes around the lakes. They are also found as minor soil types on the Sandstone Hills and Granite and Laterite Hills, where they occur as a sandy rise.

VEGETATION

These soils support a sandplain vegetation (mallee - heath or heath). Common species include Christmas tree (*Nyssa floribunda*), banksia, chittick (*Lambertia inermis*) and blue mallee (*Eucalyptus tetragona*). *Eucalyptus decipiens* is found where these sands occur on the Sandstone Hills. Haresfoot clover is often present in pastures.

PROFILE DESCRIPTION

Pale grey "gutless" loose sands over one metre deep.

A1 Dark greyish brown (10YR 4/2)
- Sand
- Loose, single grained
- Stones absent
- Slightly acidic (pH 6.0)

A2 Light grey (10YR 7/2)
- Sand
- Loose, single grained
- Stones absent
- Very slightly acidic (pH 6.5)

B1 Pale yellow (2.5Y 7/4)
- Sand
- Loose, single grained
- Stones usually absent
- Neutral (pH 7.0)
- The B horizon is often absent or may be deeper than 100 cm.

Northcote classification: Uc1.21, Uc2.23

VARIABILITY

A1 COLOUR: Very dark brown to greyish brown
pH: 5.5 - 7.0.

A2 COLOUR: White to pinkish grey, to very pale brown
pH: 6.0 - 7.0.
A2 may be absent with A1 directly overlying B horizon.

B1 COLOUR: Pale yellow, to yellow
pH: 6.5 - 7.5.
Gravel is occasionally present in the B1.
LAND QUALITIES

Water availability: Poor; water passes rapidly through the root zone and moisture conditions are favourable for only a short time after rain. The non-wetting (waxy) nature of these soils adds to the problem of their proneness to drought. Sands with yellow subsoils have slightly better moisture availability.

Nutrient availability: Poor; nutrients are leached rapidly. Trace element deficiencies are common.

Rooting conditions: Good.
Waterlogging: Usually very well drained.
Trafficability: Generally good although loose sand and dune landforms can present problems for machinery.
Soil workability: Easy to work.

SOIL CONSERVATION

Acidification: Soil pH should be tested to check whether liming is required.
Soil structure decline hazard: Compaction pans may result from repeated cultivation.
Salinity risk: Very low except on the flats on the Basin floor.
Groundwater recharge: Very high risk, rainfall infiltrates and moves rapidly through the soil and past the root zone of most species. Little water is used by crops and pastures due to poor growth.

Water erosion hazard: Low.
Wind erosion hazard: High, loose sand grains are susceptible to wind erosion and dunes and rises are exposed to wind. Poor ground cover resulting from poor pasture and crop performance increases the risk of wind erosion.
Flood hazard: Nil.

WATER CONSERVATION

Water supply: Sands have very poor water holding characteristics but limited supplies of good quality water are often available in seeps at the base of dunes.

CROP AND PASTURE PERFORMANCE

Crops: Poor moisture and nutrient availability result in very poor crop growth. In most years cereal and lupin yields are uneconomic.
Annual pastures: Subterranean clovers fail to set seed in most years and do not persist. Grass and broad-leaved weed growth is sparse.
Perennial pastures: Lucerne may perform satisfactorily. Veldt grass may grow well on these sands. Phalaris performs well on the seeps at the base of dunes. Veldt grass/serradella pasture is doing well on the Camel Lake and Hamilla Hill areas.
Fodder crops and trees: Tagasaste grows reasonably well.

LAND USE RECOMMENDATIONS

These soils are unsuitable for conventional crops and pastures as their productivity is so low. The low productivity and therefore low water use of conventional crops and pastures increases groundwater recharge and the risk of wind erosion.

Deep sands should not be cleared. The options for cleared areas include returning them to native vegetation, planting perennial species or tagasaste. If perennial pastures are planted only light grazing should be allowed to ensure persistence of the pastures. Water may be pumped from seeps for stock or other uses.

Soil pH should be measured routinely on this soil to monitor acidification and to determine whether lime is required.

The risk of veldt grass invading natural vegetation should be considered. This is especially a concern in areas adjacent to the National Park.
GRAVELLY SANDY DUPLEX

IDENTIFICATION

The gravelly sandy duplex soils can be identified by their loose gravelly topsoil and the jarrah woodland with scattered white gum growing on them. The topsoil is often high in organic matter and the subsoils are usually gravelly. The gravel proportions may vary throughout the soil. The very gravelly soils support dense stands of jarrah woodland. Layering of sands and then gravels often occurs.

OCURRENCE

The Gravelly Sandy Duplex soils within the North Stirling District only occur on the areas of Granite and Laterite Hills south west of Cranbrook.

VEGETATION

These soils support a woodland vegetation dominated by jarrah (Eucalyptus marginata) and white gum (E. wandoo).

PROFILE DESCRIPTION

A1  Very dark greybrown (10YR 3/2)
    Clayey sand
    Non-wetting
    Neutral (pH 7)
    High organic matter
    40% medium/coarse irregular gravel stones.

A2  Yellow brown (10YR 5/6)
    Fine sandy loam
    Mildly alkaline (pH 7.5)
    60% fine/medium rounded gravel
    Loose structure

B1  Yellow (10YR 7/6)
    Medium clay
    45% red mottles
    Slightly acidic (pH 6.5)
    Good rooting depth
    Weak platy structure

Yellow (10YR 8/6)
    Light clay
    20% red/yellow mottles
    Medium acidic (pH 6)

* Weathered from rock

Northcote classification: Dr5.31

VARIABILITY

The gravel proportions may vary. The very gravelly profiles may have supported dense stands of jarrah woodland. Layering of sands and then gravels often occurs. Often downslope is where more mixing and sorting has occurred. Here jarrah woodland also consists of scattered white gum and marri.
LAND QUALITIES

Water availability: Low, the sandy gravelly topsoil and subsoil holds little moisture.
Nutrient availability: Poor, especially for phosphorus and manganese.
Rooting conditions: Good, unless massive cemented ironstone (laterite) is present at less than 30 cm.
Waterlogging: The sandy gravelly profile allows rapid water entry and free drainage. These soils recharge the groundwater freely.
Trafficability: The loose structure of the topsoil creates little impedence to traffic except where numerous larger lateritic stones cover the soil surface.
Soil workability: Easy to work, unless massive cemented ironstone (laterite) is present at the surface.

SOIL CONSERVATION

Acidification: Soil pH should be tested to check whether liming is required.
Soil structure decline hazard: Traffic compaction pans may develop in sandy topsoil following repeated cultivation.
Salinity risk: Salinity is unlikely to be a problem. Hillside seeps may occur where the clay subsoil is near the surface, for instance where a red clay soil intersects these soil types.
Groundwater recharge: High. If cleared and if crops and pastures are not productive.
Water erosion hazard: Water erosion can occur on the slopes particularly below massive ironstone (laterite) outcrops and breakaways. Often susceptible with summer thunderstorms.
Wind erosion hazard: The loose sandy topsoil is prone to wind erosion, where there is little gravel stone on the surface and if the ground cover is removed (in a cleared state). Their position in the landscape makes them susceptible. Often susceptible during summer thunderstorms.
Flood hazard: Low. Uncontrolled run-off from these areas contributes to the flooding on the basin floor.

CROPS AND PASTURE PERFORMANCE

Crops: Given appropriate fertiliser and rotation practices, cereals can grow satisfactorily. Lupins and peas perform well unless massive ironstone (laterite) occurs at shallow depths. Canola is suitable when there is no shallow ironstone but would require appropriate fertilisers. There could be problems with sub-surface waterlogging if clay or cemented ironstone is too shallow.
Annual pastures: Subterranean clovers are the appropriate pasture legume. These are often grazed preferentially to the lower slopes. Annual pastures may be easier to manage if fenced appropriately.
Perennial pastures: If the soil is unsuitable for crops or if long rotations are used (crop in every five years), lucerne would be suitable on well drained sites. Wetter sites would suit phalaris.
Fodder crops and trees: Tagasaste may be preferred over lucerne if a long-term fodder area on the farm is desired, particularly on the more sandy and deeper profiles (over 60 cm to the clay).

LAND USE RECOMMENDATIONS

This soil type should be fenced separately to improve the grazing management. To complement the cropping (rotation) program on the farm where large areas exist. This will help reduce the water erosion and wind erosion hazard in a severe event, such as a summer storm. These areas often occur on moderate to steep slopes. Here a well planned system of grade banks will help reduce the time of concentration of water on the basin floor. These banks will help reduce the waterlogging and flooding experienced on these lower lying areas.
Soil pH should be monitored to determine whether lime should be incorporated in the soil. The average performance of conventional crops and pastures on this soil type, and the need to use as much water as possible to reduce the risk of groundwater recharge mean that alternatives should be considered.
Where cropping is practised the incidence of wind erosion can be reduced by management practices such as minimum tillage, stubble retention and planting of wind breaks.
IDENTIFICATION

The Grey Clays can be identified by their grey coloured topsoil. They become very wet and boggy in winter and often support growths of toad rush. The Light phase has a shallow sandy topsoil.

Apart from their winter wetness and the common occurrence of toad rush it is often possible to differentiate the Light phase of the Grey Clay from the White Gum Duplex by the dominance of flat topped yate rather than white gum.

OCCURRENCE

The Light phase of the Grey Clay is commonly found on the Granite and Laterite Hills and Broad Valley Floors where it often cover sizeable areas. It often occurs in association with the heavy phase of the Grey Clay.

It is usually found on relatively flat areas (slope gradients less than 2%), often in slight depressions, low lying areas or along drainage lines.

VEGETATION

The dominant natural vegetation is a woodland of flat topped yate (Eucalyptus occidentalis) with scattered white gum (E. wandoo) and York gum (E. loxophleba) present. Toad rush (Juncus bufonius) is commonly found where the native vegetation has been cleared. Moort (E. platypus) may also be present.

PROFILE DESCRIPTION

Shallow grey sandy loam overlying greyish brown sandy clay.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
</table>
| A1    | Dark greyish brown (10YR 4/2)  
Sandy loam  
Hardsetting  
Weakly structured  
Small quartz fragments and ironstone gravel (10%)  
Very slightly acidic (pH 6.5) |
| A2    | Pale brown (10YR 7/3)  
Sandy loam  
Small quartz fragments and ironstone gravel (10%)  
Very slightly acidic (pH 6.5) |
| B1    | Greyish brown (2.5Y 5/2)  
Sandy clay  
Small quartz fragments and ironstone gravel (10%)  
Neutral (pH 7.0) |

Northcote classification: Dy3.82

VARIABILITY RANGE

<table>
<thead>
<tr>
<th>Layer</th>
<th>pH:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>6.0 - 7.5.</td>
</tr>
</tbody>
</table>
| A2    | Horizon may be present or absent.  
COLOUR: Dark greyish brown, very pale brown.  
TEXTURE: Ranges from sand to sandy loam.  
pH: 6.0 - 7.5. |
| B1    | COLOUR: Greyish brown, light grey. |
LAND QUALITIES

Moisture availability: Moderate, soils tend to remain moist underneath a hard dry surface crust.

Nutrient availability: Moderate.

Rooting conditions: Hardsetting topsoils may cause some problems for seedling establishment.

Waterlogging: Very waterlogged during the winter months. In wet seasons, plant growth can be severely limited.

Trafficability: Very boggy during winter months. Wheel ruts and cultivation tracks can set hard when the soil dries out and make the ground surface very rough.

Soil workability: Can only be worked over a narrow moisture range. Too hard when dry and too boggy when wet.

SOIL CONSERVATION

Soil structure decline hazard: The clay is highly dispersible and sodic. The topsoil sets hard in summer when dry and surface sealing occurs. Problems made worse by cultivation.

Salinity risk: Salinity is a problem in some of these soils, especially where they occur along drainage lines.

Groundwater recharge: High run-off occurs on this soil and indirectly contributes to groundwater recharge when it infiltrates further downslope. Little water is likely to be used by crops and pastures owing to poor growth.

Water erosion hazard: High run-off rates (water shedding) occurs on these soils increasing the risk of water erosion.

Wind erosion hazard: Moderate, if ground is left bare.

Flood hazard: Flooding can occur along drainage lines.

WATER CONSERVATION

Water supply: Although soils are suitable for dam construction, high salt levels can occur in the stored water.

CROP AND PASTURE PERFORMANCE

Crops: Crop performance on the Grey Clays is usually poor. This is due to waterlogging and often salinity. When waterlogging is not severe reasonable yields can be achieved. Barley is best adapted to the conditions.

Annual pastures: Waterlogging and salinity reduce pasture performance. Some clover varieties (e.g. balansa, Yarloop, subterranean and white clovers) will perform well in spring when the soil begins to dry out if salinity levels are not too high. Medics are an alternative legume provided appropriate management techniques are used.

Perennial Pastures: Phalaris, fescue, tall wheat grass and puccinellia will all grow well. Phalaris is the least tolerant of salinity while puccinellia is the most tolerant. Strawberry clover and balansa clover are also suitable for planting with perennial grasses.

Fodder Crops and Trees: Saltbush will grow well if establishment problems can be overcome.

LAND USE RECOMMENDATIONS

Careful management is required to produce good yielding crops and annual pastures on this soil. Crops and annual pastures may perform poorly due to waterlogging and salinity and as a result there is low water usage. Perennial pastures and fodder crops such as saltbush and bluebush are the preferred option in these situations.

Testing of soil pH is recommended to determine whether lime is required and to select the best pasture and crop species/varieties.

Drains can be constructed to remove excess water and decrease the salinity risk. However, this often transfers the problem to somewhere lower down in the catchment.
GREY CLAYS - Heavy phase

IDENTIFICATION

The Grey Clays can be identified by their grey topsoil. They become very wet and boggy in winter and often support growths of toad rush. The Heavy phase of the Grey Clay has a clayey topsoil which sets very hard when the soil is dry. This differentiates it from the Grey Clay Light phase which has a sandy topsoil.

The Heavy phase can be distinguished from the Cracking Clays which have a crumbly surface when dry. The Grey Clays do not have the uneven crabbhole (gilgai) surface of the Crabhole Clays. Although yate grow on this soil, it is not found in swamps on the basin floor as are Yate Swamp soils.

OCCURRENCE

The Heavy phases of the Grey Clay are common on the Granite and Laterite Hill and Broad Valley Floors and often cover sizeable areas. They often occur in association with the Light phase of the Grey Clay.

They are usually found on relatively flat areas (slope gradients less than 2%), often in slight depressions, low lying areas or along drainage lines.

VEGETATION

The dominant natural vegetation is a woodland of flat topped yate (Eucalyptus occidentalis) with scattered white gum (E. wandoa) and York gum (E. loxophleba). Toad rush (Juncus bufonius) is commonly found where the native vegetation has been cleared for pastures. Moort (E. platypus) may also be present on this soil.

PROFILE DESCRIPTION

Grey sandy clay loam or sandy clay overlying a sandy clay.

<table>
<thead>
<tr>
<th>A1</th>
<th>Dark greyish brown (10YR 3/2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sandy clay loam</td>
</tr>
<tr>
<td></td>
<td>Very hardsetting when dry</td>
</tr>
<tr>
<td></td>
<td>Small surface cracks may be present</td>
</tr>
<tr>
<td></td>
<td>Small quartz fragments and ironstone gravel (10%)</td>
</tr>
<tr>
<td></td>
<td>Very slightly acidic (pH 6.5)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B1</th>
<th>Brown (10Y 5/3)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sandy clay</td>
</tr>
<tr>
<td></td>
<td>Small quartz fragments and ironstone gravel (10%)</td>
</tr>
<tr>
<td></td>
<td>Slightly alkaline (pH 8.0)</td>
</tr>
</tbody>
</table>

Northcote classification: Dy3.12

VARIABILITY RANGE

<table>
<thead>
<tr>
<th>A1</th>
<th>TEXTURE: Sandy clay loam to sandy clay</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pH: 6.0 - 7.5.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>A2</th>
<th>A2 horizon sometimes absent.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>COLOUR: Dark greyish brown, to very pale brown</td>
</tr>
<tr>
<td></td>
<td>TEXTURE: Sandy loam to sandy clay</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B1</th>
<th>COLOUR: Greyish brown to light grey.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pH: 7.0 - 9.0.</td>
</tr>
</tbody>
</table>
LAND QUALITIES

Water availability: Moderate, soil tends to remain moist underneath a hard dry surface crust.
Nutrient availability: Moderate
Rooting conditions: Hardsetting topsoils may cause some problems for seedling establishment.
Waterlogging: Very waterlogged during the winter months. In wet seasons plant growth can be severely limited.
Trafficability: Very boggy during winter months. Wheel ruts and cultivation tracks can set hard when the soil dries out and make the ground surface very rough.
Soil workability: Can only be worked over a narrow moisture range. Too hard when dry and too boggy when wet.

SOIL CONSERVATION

Soil structure decline hazard: Highly dispersible soils, often sodic. Topsoil tends to set very hard in summer and surface sealing occurs. Cultivation increases the problem.
Salinity risk: Salinity is a problem in some of these soils, especially where they occur along drainage lines.
Groundwater recharge: Run-off indirectly contributes to groundwater recharge by infiltrating lower in the catchment. Little water is likely to be used by crops and pastures due to poor growth.
Water erosion hazard: High run-off rates (water shedding) occurs on these soils increasing the risk of water erosion.
Wind erosion hazard: Low.
Flood hazard: Flooding can occur along drainage lines and where there is a sudden decrease in slope.

WATER CONSERVATION

Water supply: Although soils are suitable for dam construction, high salt levels can occur in the stored water.

CROP AND PASTURE PERFORMANCE

Crops: Crop performance on the Grey Clays is usually poor. This is a result of waterlogging and often salinity. When waterlogging is not severe reasonable yields can be achieved. Barley is best adapted to the conditions.
Annual pastures: Waterlogging and salinity reduce pasture performance. Some clover varieties (e.g. balansa, Yarloop, subterranean and white clover) will perform well in spring when the soil begins to dry out if salinity levels are not too high. Medics may also perform well on alkaline Grey Clays provided the appropriate establishment and management practices are used.
Perennial pastures: Phalaris, fescue, tall wheat grass and puccinellia will all grow well. Phalaris is the least tolerant of salinity while puccinellia is the most tolerant. Strawberry and balansa clover are also suitable for planting with perennial grasses.
Fodder crops and trees: Saltbush will grow well if establishment problems can be overcome.

LAND USE RECOMMENDATIONS

Crops and annual pastures are not the most suitable land use on the Grey Clays. They perform poorly due to waterlogging and salinity and as a result there is low water usage. Perennial pastures and fodder crops are the preferred option.

Regular testing of soil pH is recommended to monitor the rate of acidification and to select the best pastures and crops.

Drains can be constructed to remove excess water and decrease the salinity risk, however this often transfers the problem to somewhere lower down in the catchment.
LUNETTE SOILS

IDENTIFICATION

The Lunette Soils are highly variable. Two main soil materials are usually present: a white sand and an alkaline orange-yellow loam or clay. These materials may occur alone or as alternate layers and their distribution often varies greatly within each dune.

The Lunette soils differ from those Deep Sands which occur on dunes by the presence of heavier loam or clay material. It will often be necessary to dig holes to determine whether it is present. The Lunette soils usually support taller vegetation.

OCCURRENCE

They occur on lunettes (long dunes on the edge of lakes).

The Lunette soils cover small areas with a very limited distribution. The Lunette Soils are often associated with Deep Sands.

VEGETATION

The dominant natural vegetation includes banksia, chittick (Lambertia inermis), redheart (Eucalyptus decipiens) and blue mallee (E. tetragona).

PROFILE DESCRIPTION

Because of the highly variable nature of the Lunette Soils, no typical soil profile was described.
LAND QUALITIES

Water availability: Varies according to soil material.

Nutrient availability: Varies according to soil material.

Rooting conditions: Good.

Waterlogging: Well drained.

Trafficability: Deep sands and steep dunes can provide obstacles for machinery.

Soil workability: Easy to work.

SOIL CONSERVATION

Salinity risk: Low.

Groundwater recharge: Varies depending on amount of sand, clay and loam in the soils. Rainfall will infiltrate rapidly and move past the root zone of most species on most lunettes. Generally the risk of recharge should be considered to be high.

Water erosion hazard: Water erosion can occur if run-off is generated.

Wind erosion hazard: Very high.

Flood hazard: Nil.

WATER CONSERVATION

Water supply: Poor water holding characteristic because of sand seams. Seeps may occur at base of dunes.

CROP AND PASTURE PERFORMANCE

Crops: Highly variable due to patchy nature of soils. Some patches produce good crops.

Annual pastures: Highly variable due to patchy nature of soils with some patches producing good pastures.

Perennial pastures: Veldt grass, serradella and lucerne should all grow well.

Fodder crops and trees: Tagasaste and Acacias such as saligna (golden wreath wattle) are suitable.

LAND USE RECOMMENDATIONS

The Lunette soils generally occur in small narrow strips which are difficult to manage separately. Since they occur with the lakes they could be included in the same paddock.

Perennial pastures or fodder trees should be considered.
PAPERBARK SWAMP SOILS

IDENTIFICATION

The Paperbark Swamps are low lying waterlogged depressions with sandy surfaced soils supporting stands of paperbarks.

The presence of paperbarks is their main distinguishing feature. The Paperbark Swamp soils also differ from the Yate Swamp soils in having a loose sandy surface rather than a hard loamy topsoil. Their darker coloured topsoil, different vegetation and signs of waterlogging differentiate them from the Sandplain Duplex soils.

OCCURRENCE

The Paperbark Swamp soils occur extensively on the Basin Floor usually in depressions or along natural drainage lines. These soils frequently occur near Yate Swamp soils.

VEGETATION

The dominant natural vegetation is a low paperbark (Melaleuca sp.) scrub (1-2 metres tall) with large areas of bare ground often present. Patches of samphire (Halosarcia sp.) and barley grass (Hordeum geniculatum) are occasionally present.

PROFILE DESCRIPTION

Depressions with shallow dark coloured sands overlying grey clay.

A1 Dark greyish brown (10YR 4/2)
   Loamy sand
   Loose, single grained
   Stones absent
   Neutral (pH 7.0)

B1 Greyish brown (2.5Y 5/2)
   Medium clay
   Stones absent
   Very slightly alkaline (pH 7.5)

Northcote classification: Dy 5.52

VARIABILITY RANGE

A1 TEXTURE: Sand to sandy loam.
   pH: 6.0 - 8.0.

B1 COLOUR: Olive brown to light brownish grey. Orange mottles are sometimes present.
   TEXTURE: Light clay to heavy clay.
   Ironstone gravel may be present.
LAND QUALITIES

Water availability: Moderate.
Nutrient availability: Moderate.
Rooting conditions: Sandy topsoil provides good conditions although clayey subsoil may restrict root growth.
Waterlogging: Severely waterlogged in winter with poor drainage in summer.
Trafficability: Too wet and boggy for machinery access for most of the year.
Soil workability: Workability good but machinery access is poor.

SOIL CONSERVATION

Salinity risk: Large areas of this soil are currently saline and other areas are at high risk of becoming saline.
Groundwater recharge: As this soil occurs in low lying areas close to groundwater tables, groundwater recharge is likely to be high, particularly if water use by pasture and crops is low owing to poor growth.
Water erosion hazard: Moderate, can occur as a result of flooding.
Wind erosion hazard: Low.
Flood hazard: Often flooded in winter.

WATER CONSERVATION

Water supply: High salinity levels likely in dams or soaks.

CROP AND PASTURE PERFORMANCE

Crops: Crop growth is very poor owing to salinity and waterlogging.
Annual Pastures: Little annual pasture growth can be expected owing to salinity and waterlogging. Balansa clover is suitable.
Perennial Pastures: Puccinellia may grow where there are patches of barley grass. If waterlogging can be controlled, there may be potential for tall wheat grass, strawberry clover and balansa clover.
Fodder Crops and Trees: Saltbush may grow on areas where salinity and waterlogging is not too severe.

LAND USE RECOMMENDATIONS

The Paperbark Swamp soils are not suited to agricultural production because of waterlogging and salinity problems.

No further clearing should be done on this soil type and cleared areas should be revegetated. Saltbush and puccinellia are options for revegetating salt affected areas of Paperbark Swamp soils.
RED CLAYS

IDENTIFICATION

Areas of Red Clays can be identified by the heavy, reddish brown surface soil and the presence of dolerite rock outcrops. Soils with browner sandy topsoils, dominated by York gum woodland, have been identified in the Lake Toolbrunup area and can be called York gum soils but are not described in this manual because of their limited extent. You may wish to map such soils with the Red Clays.

Patches of Grey Clays and Cracking Clays often occur in association with the Red Clays. However, because of their colour (grey) they are unlikely to be confused with the Red Clays.

OCCURRENCE

The Red Clays are found on the Granite and Laterite Hills. They have formed on top of dolerite dykes and tend to occur as long, narrow strips, usually only a few hundred metres wide. They are often found along ridges with patches of dolerite rock outcrop. Granite and laterite may also be present.

VEGETATION

The native vegetation of the Red Clays is a woodland of York gum (*Eucalyptus loxophleba*), white gum (*E. wandoo*) and jam (*Acacia acuminata*), however, mallee, moort (*E. platypus*) and flat-topped yate (*E. occidentalis*) are also often found.

PROFILE DESCRIPTION

Reddish brown sandy clay loam overlying a yellowish red sandy clay.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Reddish brown (7.5 YR 4/4)</td>
</tr>
<tr>
<td></td>
<td>Sandy clay loam</td>
</tr>
<tr>
<td></td>
<td>Friable, crumb structure</td>
</tr>
<tr>
<td></td>
<td>Dolerite stones often present</td>
</tr>
<tr>
<td></td>
<td>Neutral (pH 7.0)</td>
</tr>
<tr>
<td>B1</td>
<td>Yellowish red (5YR 5/8)</td>
</tr>
<tr>
<td></td>
<td>Sandy clay</td>
</tr>
<tr>
<td></td>
<td>Well structured</td>
</tr>
<tr>
<td></td>
<td>Dolerite stones often present</td>
</tr>
<tr>
<td></td>
<td>Slightly alkaline (pH 8.0)</td>
</tr>
<tr>
<td>B2</td>
<td>Reddish yellow (7.5YR 7/8)</td>
</tr>
<tr>
<td></td>
<td>Sandy clay</td>
</tr>
<tr>
<td></td>
<td>Well structured</td>
</tr>
<tr>
<td></td>
<td>Dolerite stones often present</td>
</tr>
<tr>
<td></td>
<td>May contain lime</td>
</tr>
<tr>
<td></td>
<td>Alkaline (pH 8.5)</td>
</tr>
</tbody>
</table>

Northcote classification: D4r.13, G4n.13

VARIABILITY RANGE

The top 40 cm of these soils may be hardsetting if they have been repeatedly cultivated.

<table>
<thead>
<tr>
<th>Layer</th>
<th>COLOUR:</th>
<th>TEXTURE:</th>
<th>pH:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Dark greyish brown, to reddish brown.</td>
<td>Sandy loam to sandy clay.</td>
<td>6.0 - 8.0.</td>
</tr>
<tr>
<td>B1/B2</td>
<td>Dark yellowish brown, to yellowish red.</td>
<td>5.0-8.5</td>
<td></td>
</tr>
</tbody>
</table>

Stones in profile can be ironstone gravel, quartz, granite or dolerite.
LAND QUALITIES

Water availability: Good, high clay content in topsoil.
Nutrient availability: Good, relatively high natural fertility and added nutrients are retained.
Rooting conditions: Good, naturally friable and well structured subsoil provides good rooting conditions for pastures and crops. Handsetting surface can be a problem in cultivated soils.
Waterlogging: Waterlogging can be a problem in some years although drainage is better than for the Grey Clays.
Trafficability: Bogginess may restrict machine access occasionally. Surface rocks may also be an obstacle.
Soil workability: Rocks on the surface and in the soil can cause problems for cultivation.

SOIL CONSERVATION

Soil structure decline hazard: Repeated cultivation degrades soil structure, making the surface hardsetting and providing poor conditions for plant establishment and growth.
Salinity risk: Where these soils occur they can form barriers to the movement of groundwater. As a result the water may rise to the ground surface and cause salinity problems.
Groundwater recharge: These soils and the associated dolerite dykes can intercept the flow of groundwater and redirect it to discharge areas. High water usage can result from good pasture and crop growth. Recharge may occur along fracture lines in dolerite.
Water erosion hazard: Moderate to high.
Wind erosion hazard: Low.
Flood hazard: Very low except on creek lines.

WATER CONSERVATION

Water supply: Generally too rocky for building dams, susceptible to salting.

CROP AND PASTURE PERFORMANCE

Crops: Cereal crops and lupins perform very well.
Annual pastures: Medic and balansa based pastures perform well. Subterranean clovers experience some problems setting seed when topsoil is hardsetting. Medics may not perform well on slightly acid Red Clays.
Perennial pastures: The performance of most perennial pastures is yet to be assessed. Phalaris, lucerne and tall wheat grass should grow well. Moisture availability may be a limiting factor in the summer months for fescue and strawberry clover.
Fodder crops and trees: Tagasaste, acacias and salt tolerant shrubs grow well. Most tree species are suitable.

LAND USE RECOMMENDATIONS

The soils often occur in patches which are too small and isolated to be managed separately from the surrounding soils.

Where possible the Red Clays should be used to their full potential to maximise production and water usage. Where rockiness restricts cultivation planting of perennial pastures, trees or fodder crops should be considered to maximise water usage. Remnant vegetation should be protected. Where saline seeps are associated with these soils high water using species should be planted upslope.
Test pH to select best pastures and crops or to decide whether to lime.

Gypsum treatment or direct drilling may be necessary to overcome hardsetting topsoils caused by repeated cultivation.
ROCK OUTCROP

IDENTIFICATION

Areas of rock outcrop should be mapped separately. They are easily identified by the large amounts of outcropping bedrock and boulders on the ground surface. Pockets of shallow, stony soil occur between the rock outcrops. These soils can be sands, loams or clays. However, it is not possible to cultivate these soils because of the shallow rock.

Granite is a common rock which usually outcrops as sheets or boulders. It is light coloured and coarse grained with obvious quartz crystals visible.

Dolerite is a dark coloured, fine grained rock which is iron-rich and therefore magnetic. This rock is usually found as clusters of rounded boulders which run in lines (dykes) across the landscape. No quartz is found in dolerite.

Sandstone is a sedimentary rock in which the sand grains are dominant. Areas of the Stony Duplex soils also have rock on the ground which can prevent cultivation.

Quartz usually occurs in veins and outcrops as light coloured rubble in lines across the landscape.

Ironstone (or laterite) occurs as large blocks or gravel. It is common on hill tops and is usually brown or orange-brown. These are often left uncleared because cultivation is not feasible.

OCCURRENCE

Areas of Rock Outcrop occur as small patches, often on hill tops and ridges. Dolerite, (and possibly laterite and granite) are found outcropping on the Granite and Laterite Hills. Sandstone and laterite are found outcropping on the Sandstone Hills.

VEGETATION

The dominant natural vegetation is determined by rock type. White gum (*Eucalyptus wandoo*) and York gum (*E. loxophleba*) grow on areas of dolerite and granite outcrop. Chittick (*Lambertia inermis*), blue mallee (*E. tetragona*), jarrah (*E. marginata*) and banksia grow on sandstone and laterite.
LAND QUALITIES

Water availability: Poor; soils are shallow and dry out rapidly.
Nutrient availability: Varies according to rock type.
Rooting conditions: Very poor, soils are shallow and stony.
Waterlogging: Some temporary waterlogging may occur.
Trafficability: Rock presents a major obstacle to machinery.
Soil workability: Soils too shallow and rocky to cultivate.

SOIL CONSERVATION

Soil structure decline hazard: Not cultivated.
Salinity risk: Usually low.
Groundwater recharge: Very high. Cracks and fracture lines in the bedrock can be direct pathways for groundwater recharge particularly on sandstone outcrops. Native vegetation is well adapted to use this water but crops and pastures will use little or none. Run-off from the surface rocks can move directly into these cracks or move downslope and infiltrate into adjoining soil types.
Water erosion hazard: High; water run-off may cause water erosion of soils downslope.
Wind erosion hazard: Sandy soils can be prone to wind erosion owing to poor pasture growth.
Flood hazard: Nil.

WATER CONSERVATION

Water supply: Too rocky for dam or soak construction but may be useful catchments where run-off is high.

CROP AND PASTURE PERFORMANCE

Crops: Unsuitable for cropping.
Annual Pastures: Poor pasture growth can be expected on pockets of shallow stony soil.
Fodder Crops and Trees: Rooting conditions unsuitable except for native trees adapted to these conditions.

LAND USE RECOMMENDATIONS

These areas are of no agricultural use and are high recharge areas once cleared. No further areas should be cleared and revegetation should be encouraged on cleared areas to maximise water use.
IDENTIFICATION

The Sandplain Duplex soils can be identified by the pale greyish colour of their topsoil and the mallee heath vegetation they support. The shallow phase has a clay subsoil within 30 cm of the surface.

The Sandplain Duplex soils do not support white gum and their topsoil has a lower clay content and is paler than that of the White Gum Duplex soils. It may be necessary to dig a hole to find the depth of the clay subsoil to distinguish between the shallow and deep phases of Sandplain Duplex. The clay layer in the shallow phase Sandplain Duplex is within 30 cm of the soil surface.

OCCURRENCE

The Sandplain Duplex soils occur throughout the North Stirling L.C.D. and are the dominant soil type of the Basin Floor. They are common on the Sandstone Hills and are a minor soil type on the Granite and Laterite Hills and Broad Valley. Sandplain Duplex soils occur on both flats and slopes.

VEGETATION

These soils support a sandplain vegetation (i.e. heath with scattered mallee). Common heath species are chittick (Lambertia inermis), dryandra and hakea. Common mallee species include blue mallee (E. tetragona). Eucalyptus decipiens may be present. Blackboys (Xanthorrhoea sp.) are often present.

PROFILE DESCRIPTION

Pale sandy topsoil 15-30 cm deep over a mottled clay.

A1  Very dark greyish brown
    (10YR 3/2)
    Sand
    Loose, single grained
    Stones usually absent
    Slightly acidic (pH 6.0)

A2  Very pale brown (10YR 7/3)
    Sand
    Loose, single grained
    Ironstone gravel often present especially near
    B horizon boundary
    Very slightly acidic (pH 6.5)

B1  Light yellow brown
    (2.5Y 6/4) with orange,
    red and grey mottles
    Sandy clay
    Neutral (pH 7.0)

Northcote classification: Dy5.82

VARIABILITY RANGE

<table>
<thead>
<tr>
<th></th>
<th>TEXTURE:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>Sand to loamy sand.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pH:</td>
<td>6.0 - 7.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>COLOUR:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>A2</td>
<td>Light grey, pinkish grey to very pale brown.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>TEXTURE:</td>
<td>Loamy sand</td>
</tr>
<tr>
<td></td>
<td>STONE CONTENT:</td>
<td>0-50% ironstone gravel</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>COLOUR:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>Brownish yellow to yellow.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>pH:</td>
<td>7.0-8.5</td>
</tr>
</tbody>
</table>
LAND QUALITIES

Water availability: Low to moderate, sandy topsoil holds little moisture. When gravel is present in the topsoil the moisture availability is better. The non wetting nature of the soil surface is also a problem.

Nutrient availability: Poor, added nutrients are rapidly leached.

Rooting conditions: Good rooting conditions in the topsoil although the clay subsoil may present a barrier to deep rooted species.

Waterlogging: The clay subsoil restricts water movement and soils can become waterlogged in winter, especially when they occur on low lying flats of the Basin Floor.

Trafficability: Soils may be boggy in wet years.

Soil workability: Easy to work.

SOIL CONSERVATION

Soil structure decline hazard: Clayey subsoil may be sodic. Surface sealing and hardsetting problems may result from clay being brought to the surface by cultivation.

Salinity risk: Many areas on the Basin Floor have become saline, and the others are susceptible.

Groundwater recharge: High. Little water is used by crops and pasture owing to poor growth in many seasons.

Water erosion hazard: Water erosion can occur on sloping country.

Wind erosion hazard: The loose sandy topsoil is prone to wind erosion if the ground cover is removed.

Flood hazard: Flooding can occur on the Basin Floor.

WATER CONSERVATION

Water supply: The subsoil is generally suitable for dam construction. Soaks may be saline on the Basin Floor.

CROP AND PASTURE PERFORMANCE

Crops: Moisture stress in spring can limit crop yields in average years. In many locations waterlogging will inhibit crop growth in wet years. Subsoil rooting conditions are not suitable for lupins. Cereal crops such as oats and barley are most suitable.

Annual pastures: Subterranean clovers should persist but their growth may be thin and competition from weeds such as capeweed and erodium may be a problem.

Perennial pastures: Phalaris, fescue, tall wheat grass and balansa clover should do well provided correct establishment techniques are used.

Fodder crops and trees: Rooting conditions are unsuitable for tagasaste.

LAND USE RECOMMENDATIONS

The average performance of conventional crops and pastures on this soil type and the need to use as much water as possible to reduce the risk of salinity mean that alternatives should be considered.

Where soils are well drained perennial pastures such as phalaris can be established. Puccinellia, tall wheat grass, saltbush and bluebush can be grown where salinity is a problem.

Soil pH should be monitored to determine whether lime is required. Where cropping is practised the incidence of wind erosion can be reduced by management practices such as minimum tillage, stubble retention and planting of wind breaks.
IDENTIFICATION

The Sandplain Duplex soils can be identified by the pale greyish colour of their topsoil and the mallee/heath vegetation they support. The deep phase has a clay subsoil within 30 to 80 cm of the surface.

The Sandplain Duplex can be distinguished from White Gum Duplex soils because the soils do not support white gums and their topsoil has a lower clay content and a paler colour. It may be necessary to dig a hole to find the depth of the clay subsoil to distinguish between the shallow and deep phases of Sandplain Duplex and the Deep Sand soils. The clay layer in the deep phase Sandplain Duplex is more than 30 cm below the surface but is shallower than 80 cm.

OCCURRENCE

The Sandplain Duplex soils occur throughout the North Stirling L.C.D. and are the dominant soil type of the Basin Floor. They are common on the Sandstone Hills and are a minor soil type on the Granite and Laterite Hills and Broad Valleys. Sandplain Duplex soils occur on both flats and slopes.

VEGETATION

These soils support a sandplain vegetation (i.e. heath with scattered mallee). Common heath species are chittick (Lamberertia inermis), dryandra and hakea. Common mallee species include blue mallee (E. tetragona). Eucalyptus decipiens may be present. Blackboys (Xanthorrhoea sp.) are often present.

PROFILE DESCRIPTION

Pale sandy topsoil 30-70 cm deep over a mottled clay

A1 Very dark greyish brown (10YR 3/2)
   Sand
   Loose, single grained
   Slightly acidic (pH 6.0)
   Stones usually absent

A2 Very pale brown (10YR 7/3)
   Sand
   Loose, single grained
   Ironstone gravel often present especially near B horizon boundary
   Very slightly acidic (pH 6.5)

B1 Light yellow brown (2.5Y 6/4) with orange, red and grey mottles
   Sandy clay
   Neutral (pH 7.0)

Northcote classification: Dy 5.82

VARIABILITY RANGE

A1 TEXTURE: Sand to loamy sand
   pH: 6.0 - 7.0.
A2 COLOUR: Light grey, pinkish grey to very pale brown
   TEXTURE: Loamy sand
   STONE CONTENT: 0-50% ironstone gravel
B1 COLOUR: Brownish yellow to yellow.
   pH: 7.0-8.5.
LAND QUALITIES

Water availability: Low, sandy topsoil holds little moisture and clayey subsoil is too deep for the roots of many species to reach. When gravel is present in the topsoil the moisture availability is better. The non wetting (waxy) nature of the soil surface is also a problem.

Nutrient availability: Poor, added nutrients are rapidly leached.

Rooting conditions: Good.

Waterlogging: The clay subsoil restricts water movement and soils can become waterlogged in winter, especially when they occur on the low lying flats of the Basin Floor.

Trafficability: Usually good access except where waterlogging is a problem.

Soil workability: Easy to work.

SOIL CONSERVATION

Soil structure decline hazard: Traffic pans can form in the sandy topsoil after repeated cultivation.

Salinity risk: Many areas on the Basin Floor have become saline, and the others are susceptible.

Groundwater recharge: High. Rainfall infiltrates and moves rapidly through topsoil. This water is either not used by the often poorly growing crops and pastures or rapidly moves beyond the root zone of many species. Groundwater recharge occurs via preferred pathways in the clay subsoil such as old root channels. On the Basin Floor water may enter directly into the water table.

Water erosion hazard: Water erosion can occur on sloping country.

Wind erosion hazard: The loose sandy topsoil is prone to wind erosion if the ground cover is removed.

Flood hazard: Flooding can occur on the Basin Floor.

WATER CONSERVATION

Water supply: Subsoil is generally suitable for dam construction. Soaks may be saline on the Basin Floor.

CROP AND PASTURE PERFORMANCE

Crops: Moisture stress in spring can limit crop yields in average years. In many locations waterlogging will inhibit crop growth in wet years. Lupins perform well except where waterlogging occurs.

Annual pastures: Subterranean clovers should persist but growth may be thin and competition from weeds may be a problem.

Perennial pastures: Lucerne should grow well if waterlogging is not a problem. In wetter areas, phalaris, fescue, tall wheat grass and balansa clover should be successful if care is taken in establishment and management. Veldt grass and sarradella also have potential. The risk of veldt grass spreading and invading areas of natural vegetation should be considered before it is introduced. This is especially a concern in areas adjacent to the National Park.

Fodder crops and trees: Tagasaste will perform well, if waterlogging is not a problem.

LAND USE RECOMMENDATIONS

The average performance of conventional crops and pastures on this soil type and the need to use as much water as possible to reduce the groundwater recharge mean that alternatives should be considered. Where soils are well drained, perennial pastures such as lucerne and fodder trees such as tagasaste can be established. Puccinellia, tall wheat grass, saltbush and bluebush can be grown where salinity is a problem.

Deep ripping can break up traffic pans where they occur. Where cropping is practised the incidence of wind erosion can be reduced by management practices such as minimum tillage, stubble retention and planting wind breaks.

Soil pH should be monitored on this soil as acidification may occur, particularly under wheat-lupin rotations.
STONY DUPLEX

IDENTIFICATION

The Stony Duplex can be identified by the large amount of sandstone on the ground surface and throughout its sandy topsoil. These stones usually range in size from 2.5 - 25 cm. In some paddocks these may have been raked into piles.

The presence of these stones makes it easy to differentiate these soils from the Sandplain and White Gum Duplexes which both have a similar sandy topsoil.

OCCURRENCE

The Stony Duplex soils occur only on the Sandstone Hills, where they are a very common soil type. They most commonly occur on sloping country and are especially common on the higher hills, but are also found on flats.

VEGETATION

The natural vegetation is varied. It is often a mallee-heath appearing similar to the sandplain vegetation but with species characteristics of the Stirling Ranges. In other places a woodland of stunted jarrah (Eucalyptus marginata), white gum (E. wandoe) and banksia occurs. Blue mallee (E. tetragona), hakea, dryandra and blackboys (Xanthorrhoea sp.) are often present.

PROFILE DESCRIPTION

Sandy topsoil with numerous stones overlying a yellow brown clay.

A1 Dark greyish brown (10YR 4/2)
   Sand
   Loose, single grained
   Many sandstone fragments
   Some ironstone gravel
   Very slightly acidic (pH 6.5)

A2 Pale brown (10YR 6/3)
   Loamy sand
   Loose, single grained
   Many sandstone fragments
   Some ironstone gravel
   Slightly acidic (pH 6.0)

B1 Yellowish brown (10YR 5/6)
   Sandy clay
   Moderate polyhedral structure
   Sandstone fragments often present
   Slightly acidic (pH 6.0)

Northcote classification: Dy4.21

VARIABILITY RANGE

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<th>STONE CONTENT:</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>Sand to sandy loam.</td>
<td>20 - 60%.</td>
</tr>
<tr>
<td></td>
<td>pH:</td>
<td>5.0 - 7.0.</td>
</tr>
</tbody>
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<thead>
<tr>
<th></th>
<th>COLOUR:</th>
<th>TEXTURE:</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>Light reddish brown to olive yellow.</td>
<td>Sandy clay loam to medium clay with fine sand grains.</td>
</tr>
</tbody>
</table>
LAND QUALITIES

Water availability: Good to moderate, varies according to depth to clayey subsoil.
Nutrient availability: Moderate.
Rooting conditions: Loose sand provides good rooting conditions but stones reduce the amount of soil available for root growth.
Waterlogging: Generally well drained.
Trafficability: Good although rocks can be bumpy to drive over.
Soil workability: Rocks hinder cultivation.

SOIL CONSERVATION

Acidification: Soil pH should be measured routinely on this soil type to monitor acidification and to determine whether lime is required.
Soil structure decline hazard: Low.
Salinity risk: Low.
Groundwater recharge: Very high, water can pass into underlying fractured sandstone and recharge aquifers.
Water erosion hazard: High.
Wind erosion hazard: Moderate, stones on surface lessen wind erosivity.
Flood hazard: Nil, except in drainage lines.

WATER CONSERVATION

Water supply: Rocky subsoils can leak and may not be suitable for holding water.

CROP AND PASTURE PERFORMANCE

Crops: Moderate crop performance, varies depending on fertiliser history.
Annual pastures: Moderate subterranean pastures.
Perennial pastures: Veldt grass with lucerne and serradella are possibilities where there is a deep sandy topsoil. Care should be exercised in planting veldt grass close to National Parks or Nature Reserves. It has the potential to invade areas of natural vegetation and become a major weed problem. Phalaris and strawberry clover are suitable for seepage areas. Lucerne grows well with the deeper sandy topsoils such as at Hamilla Hill.

Fodder Crops and Trees: Tagasaste, saligna, wattle and blue gums can be grown, however the blue gums cannot be expected to perform as well as in higher rainfall areas. Blue gums perform better if fresh underground water is available (e.g. Solomon's Creek).

LAND USE RECOMMENDATIONS

These soil represent a major recharge area and maximum production and water use should be aimed for. Perennial species should be grown where possible. Trees for shelter, timber and fodder should be incorporated into the farm layout on this soil type.
WHITE GUM DUPLEX - Shallow phase

IDENTIFICATION
The White Gum Duplex soils can be identified by their sandy topsoils and the presence of white gums. The only way to differentiate between the deep and shallow phases of the White Gum Duplex is to dig a hole until you locate the clay horizon. If the clay is shallower than 30 cm the soil belongs to the shallow phase.

The Red Clays which also have white gums growing on them have a heavier topsoil which is a reddish brown. The surface of the White Gum and Sandplain Duplex soils appear very similar. The Sandplain Duplex supports heath vegetation with scattered mallee rather than White Gum and the topsoil of the white gum duplex is a bit browner and has a slightly higher clay content.

OCCURRENCE
The shallow phase of the White Gum Duplex soils are found throughout the North Stirling L.C.D. They are the dominant soil type of the Granite and Laterite Hills and also occur on the Sandstone Hills and Broad Valley Floors. On these hills they are usually found on sloping country and are mainly formed on granitic rocks. They are a minor soil type of the Basin Floor.

VEGETATION
The dominant natural vegetation is a woodland of white gum (Eucalyptus wandoo). Flat-topped yate (E. occidentalis), jam (Acacia acuminata) and sheoak (Casuarina fraseriana) are often present. Poison bushes are also often found.

PROFILE DESCRIPTION
Sandy topsoil 10-30 cm deep overlying a sandy clay.
A1  Dark brown (10YR 3/3)
    Sand
    Weakly structured
    Small ironstone and quartz fragments sometimes present
    Very slightly acidic (pH 6.5)

A2  Light yellowish brown (10YR 6/4)
    Sand
    Weakly structured
    Small ironstone and quartz fragments (5%)
    Slightly acidic (pH 6.0)

B1  Yellowish brown (10YR 5/4)
    Sandy clay
    Small ironstone and quartz fragments (10%)
    Neutral (pH 7.0)

Northcote classification: Dy4.22

VARIABILITY RANGE

A  COLOUR: Very dark greyish brown to light yellowish brown.
    TEXTURE: Sand to sandy loam.
    pH: 5.5 to 7.5.

B1  COLOUR: Light brownish grey, to yellowish red, sometimes mottled.
     TEXTURE: Occasionally a sandy clay loam, grading into a sandy clay with depth.
     pH: 6.0 - 7.5.
     Ironstone and quartz fragments may be absent.
LAND QUALITIES

Water availability: Moderate. Although the clay content of the topsoil is usually lower than the deep phase White Gum Duplex, plants can obtain water from the clayey subsoil.

Nutrient availability: Moderate.

Rooting conditions: Good, loose sandy topsoil. Some problems may occur if the clayey subsoil is close to the surface.

Waterlogging: Generally only mild waterlogging occurs, especially in sloping locations.

Trafficability: Generally few problems for machine access, but may be boggy in wet years.

Soil workability: Sandy topsoil is easy to work.

SOIL CONSERVATION

Soil structure decline hazard: Traffic compaction pans may develop in sandy topsoil following repeated cultivations.

Salinity risk: No salinity problems have been observed.

Groundwater recharge: Rainfall infiltrates into the sandy topsoil rapidly. The clay subsoil may present a barrier to movement to the water table although preferred pathways (e.g. root channels) are likely to be present. Water may also move downslope through the topsoil (i.e. throughflow). Some water will be held by the soil and is available for plant use. Good performance of pastures and crops on this soil type can result in high water usage.

Water erosion hazard: Sheet and rill or minor gully erosion can occur on sloping ground.

Wind erosion hazard: Moderate, sandy topsoil is capable of blowing if ground cover is removed.

Flood hazard: Low.

WATER CONSERVATION

Water supply: Subsoil is suitable for dam construction.

CROP AND PASTURE PERFORMANCE

Crops: Cereal crops and lupins yield well in good to average years. Rooting depth for lupins may be restricted by the clayey subsoil.

Annual pastures: Good pastures of subterranean clover can be achieved.

Perennial pastures: Most perennial pasture should grow well.

LAND USE RECOMMENDATIONS

Areas of the White Gum soils are the most productive portions of many farms. They should be used to their full potential to maximise production and water usage. Poor water usage on these soil types will add significantly to groundwater recharge and salinity problems in the North Stirling L.C.D. The option of high water using perennial pastures, fodder crops and trees should be considered.

Soil pH should be monitored regularly to determine whether lime is required.

Ground cover should be maintained in summer and autumn to decrease the risk of wind and water erosion.
IDENTIFICATION

The White Gum Duplex soils can be identified by their sandy topsoils and the presence of white gums. The Red Clays which also have white gums growing on them have a heavier topsoil which is a reddish brown. The surface of the White Gum and Sandplain Duplex soils appear very similar. The Sandplain Duplex supports heath vegetation with scattered mallee rather than White Gum and the topsoil of the White Gum duplex is a bit browner and has a slightly higher clay content. The only way to differentiate between the deep and shallow phases of the White Gum Duplex is to dig a whole until you locate the clay horizon. If it is greater than 30 cm deep the soil belongs to the deep phase.

OCCURRENCE

The deep phase of the White Gum Duplex soils are found throughout the North Stirling L.C.D. They are the dominant soil type of the Granite and Laterite Hills and also occur on the Broad Valley Floor and Sandstone Hills. On these hills they are usually found on sloping country. They are a minor soil type of the Basin Floor.

VEGETATION

The dominant natural vegetation is a woodland of white gum (Eucalyptus wandoo). Flat-topped yate (E. occidentalis), jam (Acacia acuminata) and sheoak (Casuarina fraseriana) are often present. Poison bushes are also often found.

PROFILE DESCRIPTION

Sandy topsoil 30-70 cm deep overlying a sandy clay

A1 Dark brown (10YR 3/3)
Sandy loam
Weakly structured
Small ironstone and quartz fragments (20%)
Slightly acidic (pH 6.0)

A2 Brown (10YR 5/3)
Sandy loam
Weakly structured
Small ironstone and quartz fragments (20%)
Neutral (pH 7.0)

B1 Yellowish brown (10YR 5/4)
Sandy clay
Small ironstone and quartz fragments (20%)
Neutral (pH 7.0)

Northcote classification: Dy4.22

VARIABILITY RANGE

A1/A2 COLOUR: Very dark greyish brown to light yellowish brown
TEXTURE: Sand to light sandy clay loam.
pH: 5.5 to 7.5.

B1 COLOUR: Light brownish grey to yellowish red, sometimes mottled.
TEXTURE: Occasionally a sandy clay loam, grading into a sandy clay with depth.
pH: 6.0 - 7.5.
Ironstone and quartz fragments may be absent, especially in the subsoil.
LAND QUALITIES

Water availability: Moderate, generally better than for the Sandplain Duplex soils owing to higher clay content of the topsoil.

Nutrient availability: Moderate.

Rooting conditions: Good, loose sandy topsoil.

Waterlogging: Generally only mild waterlogging occurs, especially in sloping locations.

Trafficability: Generally few problems for machine access.

Soil workability: Sandy topsoil is easy to work.

SOIL CONSERVATION

Soil structure decline hazard: Traffic compaction pans may develop in sandy topsoil following repeated cultivations.

Salinity risk: No salinity problems have been observed.

Groundwater recharge: Rainfall infiltrates into the sandy topsoil rapidly. The clay subsoil may present a barrier to movement to the water table although recharge may occur through preferred pathways (e.g. root channels). Water may also move laterally through the topsoil. Good performance of pastures and crops on this soil type can result in high water usage and minimise groundwater recharge.

Water erosion hazard: Sheet and rill erosion can occur on sloping ground.

Wind erosion hazard: Moderate, sandy topsoil is capable of blowing if ground cover is removed.

Flood hazard: Low.

WATER CONSERVATION

Water supply: Subsoil is suitable for dam construction.

CROP AND PASTURE PERFORMANCE

Crops: Cereal crops and lupins yield well in good to average years. Wheat/lupin rotations are successful on this soil.

Annual pastures: Good pastures of subterranean clovers can be achieved, although performance is not as good on the deeper sandy topsoils.

Perennial pastures: Most perennial pasture should grow well.

LAND USE RECOMMENDATIONS

Areas of the White Gum soils are the most productive portions of many farms. They should be used to their full potential to maximise production and water usage. Poor water usage on these soil types will add significantly to groundwater recharge and salinity problems in the North Stirling L.C.D.

The options of high water using perennial pastures, fodder crops and trees should be considered. Deep ripping may be necessary to overcome traffic compaction pans in the sandy topsoil. Ground cover should be maintained in summer and autumn to decrease the risk of wind and water erosion. Soil pH should be monitored to see if these soils are acidifying, particularly under wheat/lupin rotations.
YATE SWAMP SOILS

IDENTIFICATION

The Yate Swamps are depressions occurring around the edge of lakes and the soils in these depressions are heavy grey soils supporting flat topped yates. The Yate Swamp soils become very wet in winter and little or no pasture grows on them.

The Yate Swamp soils can be distinguished from the Paperbark Swamp soils because the latter support stands of low, scrubby paperbark and have sandy topsoils. They differ from the Crabhole Clays which support a mallee vegetation and have an uneven ground surface (gilgai). They should not be confused with the Grey Clays.

OCCURRENCE

The Yate Swamps occur mainly near the lakes on the Basin Floor. They also occasionally occur as small isolated pockets on the Basin Floor and Broad Valleys. They are often found as depressions between lakes and dunes or lunettes.

VEGETATION

The dominant natural vegetation is a tall dense growth of flat-topped yate (*Eucalyptus occidentalis*). Paperbark (*Melaleuca sp.*) is often present as an understorey. White gums (*Eucalyptus wandoo*) and York gums (*E. loxophleba*) are occasionally present. Little ground cover is present owing to severe waterlogging.

PROFILE DESCRIPTION

Very hard shallow loams over grey clay in Yate swamps close to lakes.

A1  Dark greyish brown (2.5Y 4/2)
    Sandy clay loam
    Very hard and massive
    Small ironstone fragments
    sometimes present (5%)
    Very slightly alkaline (pH 7.5)

B1  Greyish brown (2.5Y 5/2)
    Medium clay
    Moderate polyhedral structure
    Stones absent
    Alkaline (pH 8.5)

Northcote classification: Dy3.13

VARIABILITY RANGE

A1  TEXTURE:  Sandy loam to clay loam.
    STRUCTURE:  Massive weak structure.
    pH:  6.5 - 8.0.

B1  TEXTURE:  Sandy clay to heavy clay.
    pH:  7.5 - 9.0.
LAND QUALITIES

Water availability: Generally good, although moisture may be difficult to extract from the clays in dry seasons.

Nutrient availability: Good.

Rooting conditions: The hardsetting topsoils may present some problems for seedling establishment but the well structured subsoil allows for root penetration.

Waterlogging: These swamps are severely waterlogged in winter.

Trafficability: These swamps are too wet and boggy for machinery access for much of the year.

Soil workability: Easier to work than Crabbhole Clays.

SOIL CONSERVATION

Soil structure decline hazard: The topsoil is dispersible, often sodic and sets hard when dry after clearing and cultivation.

Salinity risk: Many areas are currently saline. Other areas must be considered to have a high risk of becoming salty.

Groundwater recharge: As this soil occurs in low lying positions close to groundwater tables, the risk of recharge is high. Poor infiltration may result in some water being evaporated rather than percolating into water tables. Little water is likely to be used by crops and pastures owing to poor growth.

Water erosion hazard: Low.

Wind erosion hazard: Low.

Flood hazard: Often flooded in winter.

WATER CONSERVATION

Water supply: High salinity levels could be expected in dams or soaks.

CROP AND PASTURE PERFORMANCE

Crops: Where the soil was not affected by salinity good crop yields have been achieved in the past. However, salinity increases after clearing and long term production is unlikely.

Annual pastures: Salinity and waterlogging reduce yield. Balansa clover and medics may be suitable. Guildford grass tends to dominate.

Perennial pastures: Puccinellia, phalarts, tall wheat grass and strawberry clover should grow on these areas.

Fodder crops and trees: Saltbush can be grown on areas where salinity and waterlogging are not too severe. Saligna (golden wreath) wattle may be suitable where soil is not saline.

LAND USE RECOMMENDATIONS

The Yate Swamps are not suited to long term agricultural production because of waterlogging and salinity problems. Most areas cleared in the past have very low and declining productivity. No further areas should be cleared and areas already cleared should be revegetated with native vegetation. Saltbush and puccinellia may be options for revegetation.
PREVIOUS PUBLICATIONS

The geology of the area was mapped at a scale of 1:250,000 by Muhling and Brakel (1985) while Moncrieff (1977) described the geology and groundwater prospects of the area. Beard (1979) mapped the vegetation of the area at a scale of 1:250,000.

The hydrogeology of the district has been described by Lennard et al. (1991) and Lewis (1992).

The district's soils were mapped at a scale of 1:2,000,000 by Northcote et al. (1967), while Smith (1951) discussed the soils of the area and their pedogenesis. The soils to the east of the North Stirling LCD were mapped and described in detail by Poutsma (1953).

REFERENCES


ACKNOWLEDGEMENTS

We wish to thank many people who provided information and help.

Particular thanks to Bert Hams, Julian Letter, and Ken Groves for allowing us to carry out numerous soil descriptions on most of their farms. Also for spending much of their time showing us over their properties and discussing their experiences in terms of management and capability on the various soil types. Thanks also to many of the other farmers in the North Stirling Land Conservation District.

Thanks also go to Neala Gillespie and Stafford Fairhead, both formerly of the Department of Agriculture in Katanning, for their help in compiling the soil descriptions;

to Fay Lewis formerly Research Officer with the North Stirling Land Conservation District, for her assistance with the hydrology and geology of the district;

to Ian Maling and Carmen Saunders of the Department of Agriculture in Katanning for their assistance with the perennial pastures recommendations;

to the reviewers of the draft, Heather Percy, Department of Agriculture in Katanning, and Jo McFarlane, Department of Agriculture in Albany;

to Ingrid Nelson for the preparation of the Landscape map on the computer (GIS);

and finally, to Rosalee McAuliffe, Department of Agriculture in Katanning, for typing the text.
APPENDICES

APPENDIX 1:

NORTH STIRLING LAND CONSERVATION DISTRICT (1992)

Committee Members

Chairman
Bert Hams (098 258273)
Secretary
Glen and Kathy Oliver (098 258238)
Treasurer
Ian Walsh (098 261034)
Members
Norman White (098 258287)
Ray Squibb (098 258260)
Graham Groves (098 258253)
Prue Littleton (098 261146)
Bill McLevie (098 261024)
Sid Ball (098 261024)
Mike Batchelor (098 251027)
Andy Clapin (098 261776)
Jon Bradshaw (098 258228)

NSCP Project Officer
Justin Hardy (098 213333)

ACTIVITY GROUPS IN THE NORTH STIRLING LAND CONSERVATION DISTRICT

Group 1:
Pinjaling Creek Group (16)
Hugh and Prue Littleton (098)
Andy Clapin 261146
Clem Addis (098)
Peter Climie 261176
Sim Clapin
Malcolm Wornum
John Gillam
Alan Kelly
Bill Toovey
Kevin Watterson
Gordon Wornum
Frank Inglis
Sam Armstrong
Dicksy Betts
Bill Lathwell
Malcolm Parsons

Group 2:
Hamilla Hill (9)
Ian Walsh (098)
Michael Williamson 261034
Ian Lehmann
Bill Williamson
Barry Williamson
Rick Standish
Mick and Graham Jones
David James
John and Gordon Moncrieff
**Group 3:**
**Solomon's Creek Catchment (7)**
- Sid Ball
- Phil Horrocks
- Tom Irving
- Ian Wornum
- Dan Findlay
- Doug Hall
- Ken Mengler

**Group 4:**
**Racecourse Lake Group (8)**
- Bill Mclevie
- Len Peacock
- Don Forward
- Rob Standish
- Graham Miller
- Mr. Cavanagh
- Peter Olden
- Kevin Marshall

**Group 5:**
**Camel Lake Group (8)**
- Glen Oliver
- Norm White
- John Smith
- Charlie Stevenson
- Michael Armstrong
- Gordon and Peter Drage
- Laurie Fiegert
- Ross O'Keefe

**Group 6:**
**Balicup Sub-Group (5)**
- Jon Bradshaw
- Bert Hams
- Peter Jeffries
- Andrew Peters
- Phil Hams

**Group 7:**
**Toolbrunup Catchment (17)**
- Mike Batchelor
- Rod Bowman
- Barry Witham
- Greg Parnell
- Julian Letter
- Mario Cristinelli
- Amelio Manninetti
- Roley and Dawson Patterson
- Murray, Peter and Clive Leach
- Brian Aylmore
- Jack Aylmore
- Norman Herbert
- Brian Veitch
- George Hams
- Ken Groves
- Graham Miller
- Kevin Rumble

**Group 8:**
**Anderson Lake Group (8)**
- Graham and Peter Groves
- Rowland Sprigg
- Rex Herbert
- Murray Groves
- Ken Groves
- Ray Squibb
- Alf Lenane
- Robert Baxter
- Jim Tilbury
- George Hams
- Dawson Patterson
APPENDIX 2
SOIL MAPPING
SOILS OF THE NORTH STIRLING DISTRICT

1. MOST COMMON SOILS

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Colours</th>
<th>Landscape Unit</th>
<th>Vegetation</th>
<th>Page Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deep Sands</td>
<td>Yellow</td>
<td>Sandstone Hills; Granite &amp; Laterite Hills; Basin Floor</td>
<td>mallee, heath, banksia, chittick, christmas tree</td>
<td>18-19</td>
</tr>
<tr>
<td>Sandplain duplex (S/D)</td>
<td>Yellow</td>
<td>Sandstone Hills; Granite &amp; Laterite Hills; Basin Floor</td>
<td>chittick, mallee, <em>E. decipiens</em> (moitch) blackboys</td>
<td>34-37</td>
</tr>
<tr>
<td>Whitegum duplex (S/D)</td>
<td>Yellow</td>
<td>Sandstone Hills; Granite &amp; Laterite Hills; Basin Floor; Broad Valley Floor</td>
<td>white gum, flat-topped yate, jam and sheoak</td>
<td>40-43</td>
</tr>
<tr>
<td>Grey Clay (L/H)</td>
<td>Green</td>
<td>Granite &amp; Laterite Hills; Basin Floor; Broad Valley Floor</td>
<td>flat topped yate, Yorck gum, moort</td>
<td>22-25</td>
</tr>
<tr>
<td>Red Clay</td>
<td>Red</td>
<td>Granite &amp; Laterite Hills; Broad Valley Floor</td>
<td>York gum, white gum, jam, mallee</td>
<td>30-31</td>
</tr>
</tbody>
</table>

2. LESS COMMON SOILS

<table>
<thead>
<tr>
<th>Soil Type</th>
<th>Colours</th>
<th>Landscape Unit</th>
<th>Vegetation</th>
<th>Page Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crabbhole Clay</td>
<td>Green</td>
<td>Broad Valley Floor;</td>
<td>mallee &amp; flat-topped yate</td>
<td>14-15</td>
</tr>
<tr>
<td>Cracking Clays</td>
<td></td>
<td>Granite Laterite Hills</td>
<td>mallee &amp; Yorck gum</td>
<td>16-17</td>
</tr>
<tr>
<td>Lunette Soils</td>
<td>Brown</td>
<td>Basin Floor</td>
<td>banksia, blue mallee, chittick</td>
<td>26-27</td>
</tr>
<tr>
<td>Rock Outcrop</td>
<td>Brown</td>
<td>All</td>
<td>varied</td>
<td>32-33</td>
</tr>
<tr>
<td>Stony Duplex</td>
<td>Brown</td>
<td>Sandstone Hills</td>
<td>jarrah, white gum, blackboy, blue mallee</td>
<td>38-39</td>
</tr>
<tr>
<td>Gravelly Soils</td>
<td>Red</td>
<td>Granite &amp; Laterite Hills</td>
<td>jarrah, white gum blue mallee</td>
<td>20-21</td>
</tr>
<tr>
<td>Swamps</td>
<td>Green</td>
<td>Broad Valley Floor</td>
<td>flat-topped yate, paperbarks</td>
<td>44-45</td>
</tr>
<tr>
<td>Salt affected land</td>
<td>Blue</td>
<td>All</td>
<td>dead timber &amp; scrub &gt; barley grass &gt; bare</td>
<td>28-29</td>
</tr>
</tbody>
</table>

NB:

S = Shallow phase, less than 30 cm depth to clay;
D = Deep phase, more than 30 cm depth to clay;
L = Light Phase (clay)
H = Heavy phase (clay)

These are suggested colours for mapping soils.
Use the BROWN crayon to draw the boundary line around each soil unit.
GLOSSARY OF TERMS

Alluvium  A sediment deposited from transport by stream flow.

ARGT  Annual Ryegrass Toxicity - a cornytoxin poisoning of livestock grazing pastures containing annual ryegrass (Lolium rigidum)

Colluvium  A sediment deposited by natural land erosion process, its movement is due mainly to gravity e.g. landslide, sheet erosion.

Colour  Soil colour is defined in terms of hue, value and chroma using Munsell soil colour charts. Colours are classified by an alphabetical/numerical code

e.g. 10 YR 6/8 - 10 YR: hue (yellowish red)
     6: medium high value
     8: high chroma.

The classification makes it possible to accurately define and compare colours.

Concretion  A circular segregation, includes pisoliths and ooliths.

Dispersible soil  A soil in which the clay becomes unstable in water and breaks down into separate particles. A common property of sodic soils.

Farm plan  An arrangement of physical, conservation and financial assessments into an operational management plan.

Gilgai  Term referring to undulating (depression and mound) microrelief. It is formed by expanding clays.

Gneiss  This term describes granite that has been altered, by a metamorphic event (great heat and pressure), so that crystals and minerals have changed.

Hardsetting  A term indicating a hard, compact condition of the soil surface which is most apparent when the soil is dry. This condition can cause poor subterranean clover seed set.

Igneous rock  Very strong and hard crystalised rock formed from molten minerals e.g. granite, basalt and dolerite.

Land management unit (LMU)  Aggregation of Soil Units into areas of land that:

* require similar land management practices;
* require similar agronomic practices;
* have similar biological potential.

Note: LMU's are equivalent to MIDAS Soil Classes.

Laterite  A porous layer of reddish material which has been strongly leached, leaving iron and aluminium oxides. It becomes extremely hard when exposed to the atmosphere.

Massive  A soil layer that appears as a coherent or solid mass that has no structure.

Mottles  Mottles are spots, blotches or streaks of colour which can be distinguished from the main background soil colour. Mottles usually indicate periodic waterlogging.
Nodules  Small lumps of material in the soil, often formed because of the high concentration of iron, manganese or lime in the soil solution. They vary in size, shape, colour and hardness.

Pan  An indurated and/or cemented soil horizon. The nature of the dominant cementing agent is used to identify different types of pans.

Ped  A natural soil aggregate.

Sodic soil  A soil in which one layer of the top one metre of profile has a high sodium content. This is usually defined as the Exchangeable Sodium Percentage (ESP). A sodic soil has an ESP greater than 6. When surface soils are sodic it means the soil structure is unstable, the clay disperses, leading to surface sealing and crusting. This will adversely affect plant growth.

Soil horizon  A layer of soil that is distinguished by the degree of alteration brought about by soil formation factors. Soil horizons are designated by letters e.g. A, B, C and D.

Soil units  Groupings of soils occurring in the landscape. They should:

* contain soils with similar chemical and physical properties;

* be sufficiently different to justify their separation at the published map scale;

* meet the specified objectives of the soil survey.

Structure  The term relates to the arrangement of soil particles. Structured soils have soil particles orderly arranged in a recognisable shape. The forms are: crumb, granular, polyhedral, blocky, platy, columnar and prismatic.

Texture  Soil texture is determined by the proportion of sand, silt and clay content. The descriptive terms fine, medium and coarse refer to the sand particle size, that is:

<table>
<thead>
<tr>
<th>Texture</th>
<th>Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>coarse sand</td>
<td>2 mm - 0.6 mm</td>
</tr>
<tr>
<td>medium sand</td>
<td>0.6 mm - 0.2 mm; and</td>
</tr>
<tr>
<td>fine sand</td>
<td>0.2 mm - 0.02 mm.</td>
</tr>
</tbody>
</table>

Most of the descriptive terminology is from:

Water shed from the granite, laterite hills north of the Toolbrunup Road

Seed collection in a yate and wandoo woodland on Bert and Betty Ham's property

Inspecting perennial pasture on basin floor. Glen and Kath Oliver’s property. (Tall wheatgrass fescues, phalaris and balansa)

Inspecting perennial grasses on basin floor, sandplain duplex and fodder shrubs on sandy rises in background (Oliver’s)

September rains causing flooding towards Camel Lake from the west

The spill point into Camel Lake from the farmland to the west
Inspecting tagasaste germination on deep sand rises on the basin floor (Ross O'Keefe's property)

Stony duplex soils on sandstone hills are prone to wind erosion and contribute up to 10 per cent of recharge to the basin

Inspecting balansa clover on waterlogged sandplain duplex (The White's property)

Installing a piezometer to monitor groundwater on the Ham's property among perennial pastures

Well planned grade banks control water through a leveed waterway to the creek (Brian Aylmore's property, Lake Toolbrunup)

Water filled crabhole clays on the broad valley floor near Parker Lake