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Yarra Yarra Catchment
Rapid Catchment Appraisal Report 2001

Compiled by Mike Clarke
for the Northern Agricultural Region
Rapid Catchment Appraisal Team

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1. Executive Summary

The Department of Agriculture has obligations under the State Salinity Strategy to provide all landholders in agricultural areas with:

- an assessment of current salinity;
- risk of further spread;
- options for managing those risks and their likely impacts; and
- help in accessing further assistance.

This process is known as Rapid Catchment Appraisal and will ensure that all farmers, not just those in active catchment groups, receive technical information to ensure informed decisions are made in managing salinity.

In the Northern Agricultural Region during 2001, this process was carried out in the Yarra Yarra Catchment. This catchment is internally draining and has its headwaters in the Koorda and Wongan-Ballidu Shires before draining northwards towards Morawa and then heading west and south through Three Springs and finally Carnamah Shire into the Yarra Yarra Lakes.

The area within the clearing line is about a million hectares of which around 86,000 hectares or 8.6 per cent is affected by salinity. Analysis of digital elevation models suggests that long-term, up to 280,000 hectares or 28 per cent is at risk of developing a shallow watertable. Results for the seven individual shires in the catchment are summarised in the table below.

<table>
<thead>
<tr>
<th>Shire by shire statistics</th>
<th>Shire of Koorda (31,033 ha in the Yarra)</th>
<th>Shire of Wongan-Ballidu (32,420 ha in the Yarra)</th>
<th>Shire of Dalwallinu (247,833 ha in the Yarra)</th>
<th>Shire of Perenjori (248,034 ha in the Yarra)</th>
<th>Shire of Morawa (213,797 ha in the Yarra)</th>
<th>Shire of Three Springs (91,197 ha in the Yarra)</th>
<th>Shire of Carnamah (71,388 ha in the Yarra)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current area of salinity in the valleys</td>
<td>360 ha</td>
<td>770 ha</td>
<td>24,000 ha</td>
<td>16,800 ha</td>
<td>20,985 ha</td>
<td>12,500 ha</td>
<td>9,800 ha</td>
</tr>
<tr>
<td>Potential for shallow watertables</td>
<td>9,000 ha</td>
<td>9,000 ha</td>
<td>97,000 ha</td>
<td>55,000 ha</td>
<td>42,000 ha</td>
<td>33,000 ha</td>
<td>32,000 ha**</td>
</tr>
<tr>
<td>Remnant vegetation currently affected</td>
<td>20 ha</td>
<td>11 ha</td>
<td>3,747 ha</td>
<td>2,090 ha</td>
<td>12,076 ha*</td>
<td>8,245 ha</td>
<td>3,371 ha</td>
</tr>
<tr>
<td>Remnant vegetation at risk of shallow watertables</td>
<td>300 ha</td>
<td>342 ha</td>
<td>8,635 ha</td>
<td>4,962 ha</td>
<td>14,680 ha*</td>
<td>11,797 ha</td>
<td>3,644 ha</td>
</tr>
<tr>
<td>Roads currently affected</td>
<td>10 km</td>
<td>5 km</td>
<td>50 km</td>
<td>70 km</td>
<td>80 km</td>
<td>70 km</td>
<td>80 km</td>
</tr>
<tr>
<td>Roads at risk of shallow watertables</td>
<td>40 km</td>
<td>50 km</td>
<td>350 km</td>
<td>250 km</td>
<td>190 km</td>
<td>170 km</td>
<td>110 km</td>
</tr>
</tbody>
</table>

* Includes samphire flats of salt lake chain.
** Includes area of Yarra Yarra lakes of 11,500 ha.
Many options to manage dryland salinity are already being implemented by individual farmers. The main recurring message is not to delay in changing management. Farmers should not ignore early warning signs such as crops staying greener for longer in spring or an increase barley grass cover. By acting early and changing management, they will have far more options than waiting and allowing salts to accumulate in the topsoil through the evaporation of shallow watertables.

Priority actions that should be adopted to minimise the impacts of shallow watertables include:

1. Watch for early warning signs.
2. Control stock on susceptible areas.
3. Improve surface water control.
4. Change farming systems to reduce recharge to groundwater.

Better monitoring will be an essential component of good management. The most useful long-term groundwater monitoring sites are generally located in mid to upper landscape positions. They consist of a deep piezometer paired with a shallow observation bore if a perched groundwater system is present.

It is recommended that not only should the bore network be expanded, but a feedback mechanism be established to inform landholders and catchment groups, of the results annually.

The Department of Agriculture aims to support landholders and the wider rural community in the search for information about how to manage salinity on farms or within towns. It is also researching the impacts of salinity on the way of life of rural communities.

The Department can assist landholders requiring further information and follow-up after the Rapid Catchment Appraisal.
2. Introduction

Mike Clarke, Revegetation Officer, Geraldton District Office

Following the review of the 1996 Salinity Action Plan and the subsequent release of the State Salinity Strategy, the Department of Agriculture has developed a new direction for salinity extension methodology.

Under the State Salinity Strategy the agency has obligations to provide all farmers in the agricultural areas with the following information by 2005:

- An assessment of current salinity.
- Risk of further spread.
- Options for managing those risks and likely impacts of those options; and
- Help in accessing further assistance.

This process is known as Rapid Catchment Appraisal (RCA) and will ensure that all farmers, not just those in active catchment groups, will receive technical information to ensure that informed decisions are being made in regard to managing salinity.

The Department of Agriculture team responsible for this report includes:

Mike Clarke  Team Leader and revegetation
Marcus Deshon  Groundwater hydrology
Frank Rickwood  Surface water hydrology
David Rogers  Farming systems
Kari Lee Falconer  Farming systems
Jason Batory  GIS mapping support and data interrogation
Ross Upchurch  GIS mapping support
John Bonnardeaux  Soils and climate
Emma Scotney  Social impacts of salinity
Jessica Johns  Social impacts of salinity
Amelia McLarty  Social impacts of salinity
Jason Kelly  Economic impacts of salinity
Nancye Gannaway  Editing

The land use options for these areas are likely to increase significantly over the next decade as funding resources are directed to initiatives such as the CRC for Plant-based Management of Salinity, The Saltland Pastures Association and the Department of Agriculture’s projects focussing on salinity. Follow up support for catchment groups after the Rapid Catchment Appraisal process will be brokered through the Department of Agriculture’s district offices.

In the Northern Agricultural Region, during 2001, this RCA process was carried out in the Yarra Yarra Catchment. This catchment is internally draining and has its headwaters in the Koorda and Wongan-Ballidu Shires before draining northwards towards Morawa and then heading west and south through Three Springs and finally Carnamah Shire in the Yarra Yarra Lakes (see Figure 1).
Figure 1. The Yarra Yarra Catchment.
3. Catchment Resource Base

3.1 Geology

*Marcus Deshon, Groundwater Hydrologist, Moora District Office*

The Yarra Yarra Catchment is found predominantly on the Yilgarn Block, a nucleus of Archaean (3600 million years old) igneous and metamorphic rocks. The block has been described as the Great Plateau of SW Australia and is considered to have developed its present form in response to many millions of years weathering and erosion. The alteration of the Yilgarn Block extends to the Mesozoic (225 million years old) when Australia was a component of Gondwanaland, with India attached to the west and Antarctica to the south. The separation of India in the Cretaceous (136 million years) caused extensive linear fracturing of the crystalline granites that were later intruded by molten lava and quartz, resulting in dykes that are typically aligned in a north-west to south-east direction in the Yarra Yarra. Minor uplift of the block has occurred, leading to renewed erosion and rejuvenated drainage and erosion of the weathered materials. In the late Tertiary (60 million years) the rainfall was intense and sufficient for the development of a land surface with low relief.

It was during the Tertiary that the Yilgarn Block probably formed its laterite profile, a deeply weathered soil profile, consisting of a gravelly and laterised surface, underlain by clays weathered *in situ* which overlay a saprolite grit immediately above the basement rock. Much of the landscape was formed in late Tertiary times. Some of the major valleys had formed prior to laterisation with evidence of the remnant profile extending from the uplands to the valley floors. The remnants of the laterite within the region slopes towards the ancient drainage lines.

![Conceptual geological cross-section across a typical catchment](adapted-from-Bettenay-and-Hingston-1964)

3.2 Major soil groups within the Yarra Yarra Catchment

*John Bonnardeaux, Horticulturist, Geraldton District Office*

Soil landscape surveys undertaken by the Department of Agriculture over the past decade indicate that 87% of the Yarra Yarra Catchment has soils that fall into five main groups. These are:

- calcareous loamy earths
- red-brown hardpan shallow loams
- red loamy earths
- yellow sandy earths
- yellow deep sands.
## Soil group

**Calcareous loamy earth**

Calcareous loam, may grade to calcareous clay. It commonly occurs on lower slopes and valley flats.

### Characteristics
- Loam throughout, or may grade to clay
- Calcereous throughout, although may be non-calcareous in top 30 cm
- Usually red or brown topsoil but may be grey
- May have limestone or calcrite at depth
- Calcareous gravel often present in profile
- Hardsetting or fluffy surface
- Sometimes saline
- Hard or soft carbonate segregations commonly occur in profile

### Typical Australian Soil Classification (ASC)
- **Calcic Calcargosol**
- **Calcic Red Sodosol**

### Vegetation:
Salmon gum-gimlet, wandoo and York gum woodland.

## Soil attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water repellence</td>
<td>Variable</td>
</tr>
<tr>
<td>Soil structure decline</td>
<td>Low</td>
</tr>
<tr>
<td>Subsurface acidification</td>
<td>Low</td>
</tr>
<tr>
<td>Surface condition</td>
<td>Variable</td>
</tr>
<tr>
<td>Unrestricted rooting depth</td>
<td>Moderate</td>
</tr>
<tr>
<td>Available water storage</td>
<td>Moderate</td>
</tr>
<tr>
<td>Subsurface compaction</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>pH 0-10 cm</td>
<td>Alkaline</td>
</tr>
<tr>
<td>pH 50-80 cm</td>
<td>Alkaline</td>
</tr>
<tr>
<td>Soil permeability</td>
<td>Moderately slow</td>
</tr>
<tr>
<td>Soil workability</td>
<td>Fair</td>
</tr>
<tr>
<td>Wind erodibility</td>
<td>Low to high</td>
</tr>
</tbody>
</table>

### Land use considerations
- High lime content may inhibit some agricultural crops
- May have high salt content in subsoil

## Management options

### Cropping options
- Cereals (wheat, barley, oats), field peas suited to this soil type
- Canola an option if the soil is well drained
- Faba beans can tolerate transient waterlogging conditions
- Lentils, but not in waterlogging areas

Because of the position in the landscape this type of soil is susceptible to salinity. Because they are often prone to waterlogging they are not recommended for lucerne. Perennials like Saltbush, Bluebush, Puccinellia and Tall Wheat Grass are all possible options particularly if the area is becoming saline. Annuals like Balansa (pH 4.4–7.75) may also do well and options like forage Millet's and Sorghum's may be worth looking at.
### Soil group

**Red-brown hardpan shallow loam**

Red loam over red-brown hardpan at < 50 cm. Occurs in narrow drainage lines to broad level salt plains in broad mature valleys.

#### Characteristics
- Red within top 30 cm
- Red-brown hardpan by 50 cm
- Often with stony surface mantle

#### Typical Australian Soil Classification (ASC)
(dominant ASC in italics)
- *Duric Red Kandosol*

**Vegetation:** York gum woodland and halophytic vegetation.

### Soil attributes

<table>
<thead>
<tr>
<th>Attribute</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water repellence</td>
<td>Low</td>
</tr>
<tr>
<td>Soil structure decline</td>
<td>Moderate</td>
</tr>
<tr>
<td>Subsurface acidification</td>
<td>Low</td>
</tr>
<tr>
<td>Surface condition</td>
<td>Hardsetting</td>
</tr>
<tr>
<td>Unrestricted rooting depth</td>
<td>Shallow to moderate</td>
</tr>
<tr>
<td>Available water storage</td>
<td>Low</td>
</tr>
<tr>
<td>Subsurface compaction</td>
<td>Moderate</td>
</tr>
<tr>
<td>pH 0-10 cm</td>
<td>Neutral to acid</td>
</tr>
<tr>
<td>pH 50-80 cm</td>
<td>Neutral</td>
</tr>
<tr>
<td>Soil permeability</td>
<td>Moderate</td>
</tr>
<tr>
<td>Soil workability</td>
<td>Fair</td>
</tr>
<tr>
<td>Wind erodibility</td>
<td>Low</td>
</tr>
</tbody>
</table>

### Land use considerations
- Shallow soil depth limits rooting depth and waterholding capacity

### Management options

#### Cropping options
- Cereals and canola are suitable on this soil type. Avoid waterlogging areas for canola
- Lupins possible on well drained areas
- Chickpeas possible when soil surface is only slightly acidic
- Field peas grow best when pH > 5, need an even surface for harvest

This type of soil is not as well suited for lucerne as are some of the deeper soils. If the hardpan layer is impermeable to lucerne roots, it will stop the lucerne accessing moisture from soil deeper in the profile causing the stand to be less productive and persistent than it would be elsewhere. Annual options are likely to be more profitable.
### Soil group

**Red loamy earth**
Red loam, may grade to clay, may have a red-brown hardpan below 50 cm.

### Characteristics
- Red top 30 cm
- Usually massive or poorly structured
- Usually porous (sometimes called earthy fabric)
- Neutral to acid pH, or sometimes calcareous at depth
- Hardsetting or crusting
- Sometimes with red-brown hardpan at > 50 cm
- Gravels (usually non-ironstone) may be present

### Typical Australian Soil Classification (ASC) (dominant ASC in italics)
- Red Kandosol
- Red Dermosol

### Soil attributes

<table>
<thead>
<tr>
<th>Soil attributes</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water repellence</td>
<td>Low</td>
</tr>
<tr>
<td>Soil structure decline</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>Subsurface acidification</td>
<td>Low</td>
</tr>
<tr>
<td>Surface condition</td>
<td>Hardsetting</td>
</tr>
<tr>
<td>Unrestricted rooting depth</td>
<td>Moderate</td>
</tr>
<tr>
<td>Available water storage</td>
<td>Moderate</td>
</tr>
<tr>
<td>Subsurface compaction</td>
<td>Moderate</td>
</tr>
<tr>
<td>pH 0-10 cm</td>
<td>Neutral to acid</td>
</tr>
<tr>
<td>pH 50-80 cm</td>
<td>Neutral to alkaline</td>
</tr>
<tr>
<td>Soil permeability</td>
<td>Moderate</td>
</tr>
<tr>
<td>Soil workability</td>
<td>Fair to good</td>
</tr>
<tr>
<td>Wind erodibility</td>
<td>Low</td>
</tr>
</tbody>
</table>

### Land use considerations
- Potentially highly productive soil with good physical properties.

### Management options

#### Cropping options
- Cereals and lupins suitable on this soil type
- Canola is possible although soil depth may be limiting for canola. Hardsetting soils can prevent good emergence
- Lentils are an option but avoid waterlogging areas
- Field peas suited to soils with pH > 5

This soil type is probably the one most suited to lucerne in the Yarra Yarra however work still needs to be done testing the production and persistence of lucerne in these areas before it is widely recommended. Casbah Biserrula is a deeper rooted annual pasture that could also be a productive option on these types of soil.
**Soil group**

**Yellow sandy earth**
Yellow sand grading to loam by 80 cm. Occurs in level to gently undulating sandplain.

<table>
<thead>
<tr>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow to within 30 cm</td>
</tr>
<tr>
<td>Neutral to acid pH</td>
</tr>
<tr>
<td>Gravels (mainly ironstone) may be present</td>
</tr>
<tr>
<td>May be clayey at depth</td>
</tr>
<tr>
<td>Usually massive or poorly structured</td>
</tr>
<tr>
<td>Usually porous (sometimes called earthy fabric)</td>
</tr>
</tbody>
</table>

**Typical Australian Soil Classification (ASC)** (dominant ASC in italics)
- Yellow Kandosol
- Orthic Tenosol

**Vegetation:** Mixed Kwongan associations. Black Tamma/Melaleuca cordata.

**Soil attributes**

<table>
<thead>
<tr>
<th>Water repellence</th>
<th>Low to Moderate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil structure decline</td>
<td>Low</td>
</tr>
<tr>
<td>Subsurface acidification</td>
<td>Moderate to high or presently acid</td>
</tr>
<tr>
<td>Surface condition</td>
<td>Loose to firm</td>
</tr>
<tr>
<td>Unrestricted rooting depth</td>
<td>Deep to very deep</td>
</tr>
<tr>
<td>Available water storage</td>
<td>Moderate</td>
</tr>
<tr>
<td>Subsurface compaction</td>
<td>High</td>
</tr>
<tr>
<td>pH 0-10 cm</td>
<td>Neutral to acid</td>
</tr>
<tr>
<td>pH 50-80 cm</td>
<td>Neutral to acid</td>
</tr>
<tr>
<td>Soil permeability</td>
<td>Moderate to moderately rapid</td>
</tr>
<tr>
<td>Soil workability</td>
<td>Good</td>
</tr>
<tr>
<td>Wind erodibility</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

**Land use considerations**
- Good physical characteristics for plant growth.
- May be prone to subsurface acidification.

**Management options**

**Cropping options**
- Cereals (wheat, barley, oats), lupins and canola are suited to this soil type

In the Yarra Yarra these soils are often too acidic for lucerne. Annual pasture options like serradellas could be a good option.
Soil group

Yellow deep sand
Yellow sands greater than 80 cm deep. Occurs on upper and mid-slopes.

Characteristics
- Yellow within top 30 cm
- Neutral to acid pH
- Ironstone gravel may be present throughout, sometimes common (> 20%) below 15 cm
- Limestone or duricrust may be present at > 80 cm

Typical Australian Soil Classification (ASC)
(dominant ASC in italics)
- Orthic Tenosol

Vegetation: Acacia thickets.

Soil attributes

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Soil attribute</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water repellence</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>Soil structure decline</td>
<td>Low</td>
</tr>
<tr>
<td>Subsurface acidification</td>
<td>Variable</td>
</tr>
<tr>
<td>Surface condition</td>
<td>Soft to loose</td>
</tr>
<tr>
<td>Unrestricted rooting depth</td>
<td>Deep to very deep</td>
</tr>
<tr>
<td>Available water storage</td>
<td>Low to moderate</td>
</tr>
<tr>
<td>Subsurface compaction</td>
<td>Moderate to high</td>
</tr>
<tr>
<td>pH 0-10 cm</td>
<td>Neutral to acid</td>
</tr>
<tr>
<td>pH 50-80 cm</td>
<td>Neutral to acid</td>
</tr>
<tr>
<td>Soil permeability</td>
<td>Rapid to very</td>
</tr>
<tr>
<td>Soil workability</td>
<td>rapid</td>
</tr>
</tbody>
</table>

Land use considerations
- Prone to wind erosion in exposed positions
- Some have poor fertility and waterholding characteristics
- Moderate recharge hazard under annual agriculture

Management options

Cropping options
- Cereals (wheat, barley, oats), lupins and canola suited to this soil type

In the Yarra Yarra these soils are often too acidic for lucerne. Annual pasture options like serradellas could be a good option.
3.3 Climate

*John Bonnardeaux, Department of Agriculture, Geraldton*

The Yarra Yarra Catchment has a dry-summer Mediterranean climate with three strongly expressed characteristics:

- A concentration of the rainfall in the winter season, however summer thunderstorm activity can cause localised heavy down pours.
- Warm to hot summers and mild winter; and
- High solar radiation, especially in summer.

Climatic data from three centres (Carnamah, Dalwallinu and Morawa) are shown in Tables 1 to 6. Carnamah receives the greatest amount of rainfall and Morawa is the driest centre. However Morawa has 20% more summer rainfall than Carnamah. Summer rainfall can be particularly valuable in providing the soil moisture for subsequent vegetative growth.

Regarding temperatures, Carnamah is the warmest centre while Morawa has the lowest minimum temperatures. When the temperature drops to below 2.2°C the ground temperature can drop to 0°C and frosts may occur. The occurrence of frost is dependent on not only cold temperatures but also low wind speeds, humidity and landscape position. Temperatures of 2°C at flowering and podding causes heavy flower and seed losses of pulses and oil seeds.
### Table 1. Morawa

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean monthly rainfall (mm)</td>
<td>15</td>
<td>18.1</td>
<td>23.2</td>
<td>22.5</td>
<td>46.8</td>
<td>61</td>
<td>55.2</td>
<td>39.5</td>
<td>21.7</td>
<td>15.3</td>
<td>10.9</td>
<td>8.7</td>
<td>337.8</td>
</tr>
<tr>
<td>Median (5th decile) monthly rainfall</td>
<td>8.4</td>
<td>6.6</td>
<td>8.4</td>
<td>14.2</td>
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3.4 Hydrology

*Marcus Deshon, Groundwater Hydrologist, Moora District Office*

The low relief and permeability of soils limit the rate of groundwater movement in the Yarra Yarra Catchment. The permeability of a soil is determined mainly from the parent material and weathering processes. The granite block underlying the area has formed a weathered mantle typified by quartz grains suspended in pallid zone clays. The permeability of these clays increases towards bedrock, though is generally poor. Immediately overlying the parent material is a zone of saprolite characterised as the transitional weathering layer immediately overlying the parent material. The texture of the saprolite zone is typically a coarse gritty-textured material. The permeability of this zone is relatively high compared to the overlying pallid zone.

Molten lava that has infilled fractures on the Yilgarn Block is predominantly doleritic. These lineaments of dolerite are often referred to as a 'dyke' which range in width from a few centimetres to hundreds of metres wide and can extend for kilometres in length. The dolerite weathers to an almost impermeable clay that can serve as a barrier or carrier of groundwater. Groundwater movement can be promoted with preferential flow along these dykes or could inhibit flow by being dammed behind the dyke. The ability of the dykes to act as barriers or carriers makes the ability to predict groundwater movement within the Yarra Yarra Catchment exceedingly difficult.

**Groundwater systems**

Groundwater systems in the Yarra Yarra can be generalised as either *intermediate* or *localised*.

The *intermediate groundwater system* extends across the entire catchment and is affected by all land-use within the catchment. The intermediate groundwater system includes the water resources within the pallid zone and saprolite aquifers. Groundwater is relatively easily drawn from the saprolite aquifer due to the coarse nature of sediments. Aquifer yields can be as high as 250 kL/day. The salinity of the aquifer increases towards the valley floor as do the flow rates through a concentration of groundwater from within the catchment. Groundwater yields within the pallid zone are remarkably lower due to the higher composition of clays restricting groundwater flow.

Groundwater yields are also located within *localised groundwater systems* such as sediments and fractured rocks. Sediments such as the aeolian (wind blown) deposits within the Yarra Yarra Catchment are commonly sands with a high permeability. They are normally fresh below the surface and often expressed as soaks. The yields and sustainability of the sediment aquifer are dependent upon the extent of these overlying sediments. Fractured rock aquifers are another localised groundwater flow system. They are difficult to locate, requiring an exhaustive drilling program to assure success. Lineaments such as dolerite and quartz dykes, with associated fractures can facilitate large movements of groundwater flow. Major fracture systems often produce large flows following drilling, but regularly slow up as the fractures are drained at a rate quicker than the aquifer is recharged.
3.5 Native vegetation

Mike Clarke, Revegetation Officer, Geraldton District Office

The Yarra Yarra Catchment occupies an area of roughly 1 million hectares and has three main vegetation systems as described by Beard (1976, 1979 and 1980). These include the:

1. **Guangan System.** This accounts for the headwaters of the Yarra Yarra from Kirwin northwards to Pithara.
2. **Jibberding System.** This includes the eastern half of the catchment from Dalwallinu to the Koolanooka hills.
3. **Perenjori System.** This is the remaining western half of the catchment from Wubin to the Koolanooka hills and includes the towns of Perenjori, Morawa, Three Springs and Carnamah.

1. **The Guangan System**

The word Guangan (pronounced gwong-gan) is an Aboriginal word meaning sandy country with an open scrubby vegetation.

The vegetation communities of the Guangan System can be divided into four broad categories according to soil type.

**Sandplain associations**
- Deep Yellow Sand. *Acacia resinomarginea* (old man wodgil) thickets.
- Deep Yellow Sandy Loams. Mixed Kwongan association. *Allocasuarina acutivalvis* (Black Tamma)/*Melaleuca cordata*.
- Sand over Gravel. *Allocasuarina campestris* (tamma) thickets.

**Duplex soils**
- Winter wet places. Melaleuca thickets.

**Loams and clays**
- Eucalypt woodlands. *Eucalyptus loxophleba* (York gum) on loams, *Eucalyptus salmonophloia* (salmon gum), and *Eucalyptus salubris* (gimlet) and *Eucalyptus longicornis* (morrel) on clays.

**Saline soils**
- Melaleuca thickets with halophyte (saltbush) understorey.

2. **The Jibberding and Perenjori Systems**

These systems are described as having a simple sequence of soils ranging from yellow sandy soils over gravel on the higher ground, to red loams on the lower ground with saline grey soils along the drainage lines. As the Jibberding System is further east than the Perenjori System, floristic differences occur due to lower rainfall. The most obvious of these is that *Acacia* species dominate in the more eastern Jibberding sandplains as opposed to casuarinas (tamma) in the Perenjori sandplains.
Sandplain associations
- Yellow sandplain soils. Acacia (wattle) thickets in the Jibberding System and Casuarina (Tamma) thickets in the Perenjori System.

Loams and clays
- Eucalypt woodlands. *Eucalyptus loxophleba* (York gum) with jam (*Acacia acuminata*) on loams, *Eucalyptus salmonophloia* (Salmon gum), and *Eucalyptus salubris* (gimlet) on clays.

Saline soils
- Melaleuca thickets with halophyte (saltbush/samphire) understorey.

Information derived from the National Land and Water Resources Audit (using 1995/96 Landsat TM imagery) indicates the agricultural areas of the Yarra Yarra Catchment have a little over 100,000 hectares of remnant vegetation remaining. The following table summarises the percentage of remnant vegetation remaining according to Beard’s vegetation associations.

Table 7.

<table>
<thead>
<tr>
<th>Vegetation association</th>
<th>% Remnant remaining</th>
</tr>
</thead>
<tbody>
<tr>
<td>Succulent steppe (samphire/saltbush) with woodland or thicket</td>
<td>27</td>
</tr>
<tr>
<td>Medium woodland (York/salmon gum)</td>
<td>27</td>
</tr>
<tr>
<td>Acacia shrubland</td>
<td>19</td>
</tr>
<tr>
<td>Thicket (casuarina, melaleuca, mallee)</td>
<td>14</td>
</tr>
<tr>
<td>Shrublands with scattered York gum</td>
<td>4</td>
</tr>
<tr>
<td>Other</td>
<td>9</td>
</tr>
</tbody>
</table>
4. Catchment Condition and Future Risk

Marcus Deshon, Groundwater Hydrologist, Moora District Office

4.1 Salinity and groundwater introduction

Dryland salinity will continue to be one of Australia’s most critical environmental problems with social and economical implications. The salt in the Yarra Yarra soil profiles has always been there, as a consequence of deposition from rainfall. Land clearing has been responsible for these salts accumulating at the surface providing an unfavourable environment for plant growth.

The clearing of native vegetation occurred with European settlement in Western Australia beginning during the nineteenth century. The introduction of western-style agricultural practices by Europeans contributed to the development of widespread secondary salinisation. In 1997, 9.4% of cleared farmland in Western Australia was affected by secondary salinisation, with the salt-affected area predicted to double in size over the next 25 years, and double again before reaching a new equilibrium in 100 to 200 years time (George et al. 1997).

The clearing of deep-rooted native perennials and their replacement with shallow-rooted, annual crops results in a higher percentage of rainfall available to recharge the groundwater. An increase in recharge is responsible for a rise in the groundwater table (Ruprecht and Schofield 1991). The rise in the watertable brings salts to the surface where they concentrate by evaporation making the land unproductive for conventional agriculture.

![Figure 3. Severe dryland salinity within the wheatbelt. Note the high level of erosion and mortality of trees along the creek lines.](image)

Without salt in a waterlogged environment, production may be only slightly reduced. The introduction of salt into a waterlogged environment drastically reduces the capacity of plants to uptake water and essential elements. Salt within the soil profile of the Yarra Yarra Catchment has accumulated from the dissolved salts in rain. The concentration of salts from frontal systems range from very low 1-2 mg/L to more than 15 mg/L. An average concentration would be 5 mg/L. Salt storage would be greatest in the valley floors through accumulation from the continual flow and evaporation of groundwater.
The landscape position enables a prediction to be made concerning the development of a shallow watertable and the potential to go saline. The first areas expected to develop a shallow watertable in the Yarra Yarra Catchment are along the valley floors where the groundwater discharges at the surface and concentrates the salts. The shallow watertable in the valley floor is caused by the intermediate groundwater system which gains recharge from the entire catchment. The areas that are expected to develop a shallow watertable in the valley floors have been mapped from the Land Monitor Project using computer data and technical advice from Department of Agriculture hydrogeologists.

The Land Monitor Project utilised satellite data to determine relationships between current and historical land conditions, landform and salinity. Automated computer processes were used to establish rules for the ground data. Once the rules are established they are applied to generate broad scale maps showing areas predicted to develop a shallow watertable. The data used included Digital Elevation Models to pick out the valley floors and flow lines and combined this with data showing areas of high light reflectance interpreted as areas of low production. Further information about this project can be found at the website www.landmonitor.wa.gov.au.

4.2 Current extent of salinity and potential for shallow watertables

Land Monitor forecasts that a shallow watertable will develop on 280,000 ha (28%) of the catchment area. The area currently affected by salinity in the valleys is 8.6%.

Table 8. Current area (hectares) of salinity in the valleys and potential area for shallow watertables within the clearing line of shires found in the Yarra Yarra

(Please note that the areas expressed as having ‘potential for shallow watertables’ are cumulative, and include the areas already affected by salinity.)

<table>
<thead>
<tr>
<th>Shire</th>
<th>Area in Yarra Yarra (ha)</th>
<th>Current area of salinity in the valley (ha)</th>
<th>Potential for shallow watertables (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Koorda</td>
<td>31,033</td>
<td>360</td>
<td>9,000</td>
</tr>
<tr>
<td>Wongan-Ballidu</td>
<td>32,420</td>
<td>770</td>
<td>9,000</td>
</tr>
<tr>
<td>Dalwallinu</td>
<td>247,833</td>
<td>24,000</td>
<td>97,000</td>
</tr>
<tr>
<td>Perenjori</td>
<td>248,094</td>
<td>16,800</td>
<td>55,000</td>
</tr>
<tr>
<td>Morawa</td>
<td>213,757</td>
<td>21,000</td>
<td>42,000</td>
</tr>
<tr>
<td>Three Springs</td>
<td>91,975</td>
<td>12,500</td>
<td>33,000</td>
</tr>
<tr>
<td>Carnamah</td>
<td>71,398</td>
<td>9,800</td>
<td>32,000*</td>
</tr>
</tbody>
</table>

* Includes area of the Yarra Yarra Lakes.

It should be noted that the figures relating to the current area of salinity are an underestimate. This is because the Land Monitor project only looked at areas of consistently low production in the valleys and therefore salinity occurring on hillsides and upper slopes were screened out. Also the satellite data was unable to differentiate between saline areas with a cover of barley grass (Hordeum geniculatum) and adjacent stubble areas covered with cereal stubble. Therefore these areas were not mapped as existing salinity.
4.3 Groundwater trends

Only limited data exists on the rates of rise of the intermediate groundwater levels within the Yarra Yarra region. A field of monitoring bores located midslope of the Burakin-Bunketch catchment within the Dalwallinu Shire indicates a rise of 36 to 80 cm/yr (Figure 7). The rate of rise is considerably higher than documented trends in agricultural areas that rarely exceeded 30 cm/yr (Nulsen 1998).

![Graph showing groundwater trends](image)

Figure 4. Hydrographs of monitoring bores located midslope in the Dalwallinu Shire.

The existence of an ephemeral perched watertable is responsible for winter waterlogging. The ephemeral system is developed over an impermeable substrate and highlights the importance of hydrogeological investigations as a tool to accurately identify the source from a discharging system.

Groundwater discharge from seeps and scalds associated with dolerite dykes, bedrock highs, perched systems, fractures and faults on the development of a shallow watertable fell outside the scope of the Land Monitor Project. The monitoring bore sites at Dalwallinu indicate the contribution of perched systems to seasonal waterlogging. At the site an ephemeral system developed over an impermeable substrate and highlights the importance of hydrogeological investigations to accurately identify the cause of a discharge.

Localized discharge systems occurring mid to upper slope tend to have a very localised catchment enabling a more direct management practice. The nature of the seep will depend upon the appropriate management action to take. The most abundant of the seeps is the sandplain seep, which develops near the base of sand...
deposits, caused by a perched aquifer developing in deep sand. Rainfall that
infiltrates into the permeable sands is prevented from further vertical movement by
the impermeable nature of the underlying sediments. The groundwater accumulated
at the soil interface moves laterally down gradient and discharges at the surface
through a reduction in the sand aquifer thickness.

Other types of seeps include those caused by a break of slope and geological
structures including dolerite dykes, structural fractures or bedrock highs. A break of
slope seepage is caused by a reduction in the slope, where the hydraulic conductivity
of the soil is too low to transmit the water moving from upslope. Groundwater seeps
from bedrock highs and lineaments are caused by impeding the groundwater
movement by a reduced hydraulic conductivity.

Figure 5. Four major types of seeps from localised groundwater systems.
5. Management Options and Impacts

*Marcus Deshon, Groundwater Hydrologist, Moora District Office*

5.1 Groundwater hydrology

5.1.1 Introduction

An understanding on the nature of discharge is required to optimally manage the groundwater system. The feasibility of a management option is certainly dependent upon whether the groundwater is a localised or an intermediate groundwater system. Localised flow systems occur where the recharge and discharge points are in close proximity. The system has a relatively smaller more defined catchment area with complete amelioration of the discharge area possible. In contrast, management to reduce the rate of salinity encroachment from the intermediate aquifer requires an integrated catchment management approach. The approach will require the addressing of surface water problems, combined with improved agronomic practices and strategic planting.

The type of management options available for treatment of discharge areas from a localised system is more diverse due to the concentration of the salinity from the aquifer. Realistically, no localised discharge areas should exist with the ability and choice of planting, pumping and drains to reclaim the land.

5.1.2 Management options for localised groundwater system

The options available to farmers managing groundwater discharge from a localised system are more direct with land reclaimed over a relatively short time frame. The smaller and more defined catchment area contributing to recharge enables a more effective and faster response to the implementation of a management option.

Trees and perennial grasses

The strategic planting of trees and high water use grasses at the discharge areas of localised flow systems have been successful in the reclamation of groundwater problem. Although the successes of tree planting in the catchment is proven, a number of localised discharge areas remain in the catchment.

See the revegetation chapter for details.

Pumping and well liners

Although sparsely employed over the wheatbelt, sandplain seeps have the potential to provide a water resource to farmers in the catchment. The mapping of lineaments and seeps in the catchment provides a basis to develop sandplain seeps. Seeps with a good water quality could be used as an alternative to importing scheme water.

The development of further water resources requires additional investigation into methods for locating high water yielding sites from aerial geophysical interpretation, appropriate methods of resource development, sustainable yield and methods of management. Further research into the role of lineaments as carriers of groundwater and their influence on seeps is also required.
Mid-slope interceptor drains

Drains intercepting the localised groundwater system before it seeps to the surface provide an additional alternative for reclaiming land. Interceptor drains rely on the subsoil having a significantly lower hydraulic conductivity than the overlying soil horizon. The intercepted localised groundwater is channelled safely downslope on a grade into a natural watercourse. In addition to being able to manage the localised groundwater systems the drains can have the additional benefit of surface water management.

5.1.3 Management options for intermediate groundwater systems

No single tool exists to halt or reclaim land that has become saline from the rise of an intermediate groundwater system. To reduce the rate of salinity spread in the catchment the water balance needs to be returned nearer to pre clearing conditions. As much as 70 to 80% of a catchment may need to be replanted to perennials to have a significant impact on intermediate groundwater systems (George et al. 1999). It is unlikely in the short to medium term that these targets will be achieved, therefore the amount of land with a shallow watertable in the Yarra Yarra is likely to increase.

There are six recognised options for managing dryland salinity. These are discussed in more detail in the relevant chapters of this report (except for drainage and pumping which is discussed below). They include:

- increase water use of annual crops and pastures;
- increase water use by introducing perennial species;
- improve protection and management of native remnant vegetation;
- collect and re-use or dispose of surface water;
- productive use and rehabilitation of saline land;
- drain and pump and re-use or dispose of groundwater.

Drainage and pumping systems have an important role to play in salinity management as they can increase groundwater discharge rates and relieve the hydraulic pressure of the groundwater system.

Recharge management practices alone are unlikely to sufficiently reduce the rates of watertable rise within the catchment to prevent the further development of secondary salinity. To protect priority resources, such as prime agricultural land, infrastructure and high value conservation areas, groundwater drainage and/or pumping may need to be considered in some situations to complement recharge management practices. It is unrealistic to expect recharge management practices to prevent the further spread of salinity and similarly the development of salinity cannot be reversed purely through the use of drains and pumps.

The success of any groundwater drainage or pumping system is dependent upon whether it takes into account the size and characteristics of the contributing groundwater flow system. Investing in ‘on-ground works' for which there is an expectation of some benefits (production and/or environmental) requires soundly-based planning and assessment before implementation.
Groundwater drainage (deep open or closed drains and tube drains)

These drainage designs are used to lower watertables to prevent the additional accumulation of soil salts, while allowing rainfall (or irrigation water) to leach salt from the soil profile. They tend to be deep (> 1 m depth) and either open or closed to surface water flow or completely back filled with coarse aggregate after some form of tubing has been installed (tube drains).

Deep open and closed drains are also relatively expensive to construct and their effectiveness is variable. The effectiveness of any drain designed to lower watertables is dependent on the drainage site having:

- suitable soils (highly permeable and stable) and underlying aquifer materials with an adequate ability to transmit groundwater; and
- an aquifer with adequate hydraulic gradient on the watertable to ‘push’ groundwater into the drainage system.

Design of these drains need to consider surface and flood flows, as these can cause erosion of drain batters and floors if not managed appropriately.

Groundwater pumping (pumps, vegetation and relief wells)

Using mechanical pumps (production wells) is a costly method of removing groundwater to lower watertables, however they can be effective and economic in protecting high value assets. In many situations a single pump will have a minimal radial effect on groundwater levels and therefore most pumping systems require a number of bores and pumps to be installed. The hydrological effectiveness of a pumping system relies on the underlying aquifer having high permeability and a good hydraulic connection to the soil surface.

Most species of trees, shrubs and perennial pastures do not directly access groundwater stored in aquifers. In shallow watertable situations some plants access water from above the capillary fringe of the watertable and this is then replaced by water drawn up from the aquifer. In these situations trees can lower watertables by one to two metres, but they are less effective where the groundwater is saline (> 1,000 mS/m). There is generally only minimal drawdown of watertables 10-30 m away from planted areas. Perennials are most effective on localised groundwater flow systems particularly in reducing seepage from perched aquifers.

Relief wells are artesian wells driven by the hydraulic pressure in the aquifer. Groundwater is pushed into and out of a bore by this hydraulic pressure. Relief wells are cheaper to establish and maintain, as they do not have the costs associated with purchasing, running and maintaining a mechanical pump. However, they are only suitable in situations where there is an aquifer with a hydraulic pressure head (piezometric head) above the land surface.

5.1.4 Responsibilities (legal and community)

Current legislation (Soil and Land Conservation Act) requires landholders that are proposing:

“to drain or pump water from under the land surface because of salinity and to discharge that water onto other land, into other water or into a watercourse”,

26
to notify the Commissioner of Soils and Land Conservation in writing at least 90 days before the works commence (Notice of Intent to Drain or Pump).

Disposing of excess water from salinity management systems in a responsible manner is essential. It is currently not acceptable for a landholder to increase the volume of water or salt leaving their property if it significantly contributes to waterlogging, salinity or flooding on neighbouring private or public land. In situations where there is a high risk of this occurring, evaporation basins or storage ponds may need to be considered to evaporate or store the excess water. Basins and ponds need to be carefully designed, located and constructed to ensure that they have adequate capacity, are not at risk from flooding and do not leak. Landholders need to be conscious of their duty of care to ensure their management practices do not lead to further land degradation.

5.1.5 Monitoring

Monitoring the change in the health of the land can be used to assess the stability of the groundwater, the impact of alternative land management practices and severity of the problem. Clearly simple observations on the land may reduce the necessity to spend large amounts of money if the problem is stable rather than increasing. Loss of yields may be as high a 30% before there is any visible sign of salinity. Vegetation can also be used as a tool for locating saline land. Through observing the presence, proportion and type of indicator species, such as barley grass, an assessment can be made about the degree of salinisation of the land.

The observation and comparison of historic with current aerial photographs are a good means by which land managers can assess the encroachment of a shallow watertable on the land. Ideally, the aerials should be flown at the same time of the season to avoid complexities within the analysis. Mapping of the saline areas based on low production and indicator species could be used a benchmark to evaluate the effectiveness of the implementation of various management activities and the expected expansion before reaching a hydraulic equilibrium. The scale is suggested to be at 1:5,000 for properties less than 1,000 ha and 1:10,000 for properties larger. Changes in the area affected by salinity within a paddock can also be simply monitored by driving in steel posts along the boundary and detecting any change over time with the use of photographs, etc.

A way to measure the groundwater within the soil profile is to insert a monitoring bore, either a piezometer or an observation bore. Piezometers measure the generally upward groundwater pressure whereas observation bores are shallower measuring the levels of the free groundwater surface.

Observation bores are installed where the groundwater is suspected to be caused from a perched system. In these circumstances the observation bores should be installed onto the perching layer that comprises an impervious clay or precipitated media. The hydrograph from water levels in observation bores are generally episodic, characterised by large water level peaks immediately following intense to moderate rainfall events.

Piezometers consist of 1 to 2 m slots to allow water to enter at the depth. The space between the column and drill hole above the slots is sealed off with bentonite to
measure the pressure within the aquifer. Principally the piezometers installed within the wheatbelt should be drilled to composite bedrock and slotted into the saprolitic grit. The bentonite plug should be at the margin where the saprolite grits underlie the pallid zone. The height to which the water rises towards the surface is a measure of the hydraulic head or potentiometric head of the saprolite grits. Valuable information on the lithology of the catchment is gained from the drilling of piezometers to basement.

A drilling program should be aimed at addressing the particular interests of the land manager. The purpose of drilling may range from providing an understanding of the hydrogeology to determining the rate of groundwater rise in the catchment. The use of electromagnetic surveys can aid in the identification of piezometer monitoring sites. However the cost of an electromagnetic survey is expensive and it is generally more efficient to install the piezometers based on a desktop study of the area.

Further information

Department web page

Salinity /environment/land/salinity/index.htm
Provides information concerning the causes, extent, management options, monitoring methodologies and research completed in salinity.

Drainwise /environment/land/drainwise/index.htm
Provides information for effective decisions in water management. Included in drainwise is the identification of water management issues, management options, and integrated water management plans.

Farm revegetation /progserv/natural/trees/index.htm
Information on revegetation for landcare, watercare, nature conservation, productivity gains and diversification.

Farmnotes relevant to salinity agency/Pubns/farmnote/

<table>
<thead>
<tr>
<th>Farmnote</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>20/2001</td>
<td>George. R. Groundwater Pumping for Salinity Control</td>
</tr>
<tr>
<td>18/2001</td>
<td>George. R. Airborne Geophysics - Tool for Salinity Control</td>
</tr>
<tr>
<td>08/2000</td>
<td>Nulsen, B., McConnell, C. Salinity at a Glance</td>
</tr>
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<td>47/1993</td>
<td>Notification of Draining or Pumping Saline Land</td>
</tr>
<tr>
<td>79/1986</td>
<td>Legal Aspects of Land Drainage</td>
</tr>
<tr>
<td>36/1991</td>
<td>Negus, T. Planning to Combat Salinity - Checklist</td>
</tr>
<tr>
<td>116/1988</td>
<td>George, G., Frampton, P. Reclaiming Sandplain Seeps with Small Blocks of Trees</td>
</tr>
<tr>
<td>19/1983</td>
<td>Negus, T. Reverse-Bank Seepage Interceptor Drains</td>
</tr>
</tbody>
</table>
5.2 Farming systems

Dave Rogers Farming Systems Development Officer, Geraldton District Office

5.2.1 AgET - Model estimating the water use of different rotations

AgET is a program that compares water use and leakage (recharge) under different rotations on different soil types. It is a bucket model and does not take into account any flow from neighbouring areas, only direct rainfall. Water simply moves straight through the soil profile ignoring influences other than plant water use, evaporation and run-off. AgET also does not consider interactions with waterlogging and preferred pathway recharge as a result recharge amounts on some soil types may be higher than the model suggests.

The information generated from the model is based on 40 years of rainfall data from 1953 to 1993. Leaf area index, rooting depth and soil waterholding capacities are tied together in the model to produce the results.

Water use is based on leaf area index of the different crops and this closely ties to rooting depth. Soil calculations are made on permeability and waterholding capabilities of the different soils. AgET takes no account of watertables and all calculations are carried out as if watertables are too deep to impact on the plant.

These results should not be seen as exact, rather as a guide. AgET is a model and while it does provide some comparisons that are beneficial to stimulate thinking it does make many assumptions that may not be completely accurate in many cases.

Several rotations for each soil type were investigated. It should be acknowledged that this is only an estimate of recharge and the figures presented should not be taken as exact figures but only as a guide.

<table>
<thead>
<tr>
<th>Shire</th>
<th>Average annual rainfall (1953-1993)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three Springs</td>
<td>378 mm</td>
</tr>
<tr>
<td>Carnamah</td>
<td>378 mm</td>
</tr>
<tr>
<td>Dalwallinu</td>
<td>362 mm</td>
</tr>
<tr>
<td>Morawa</td>
<td>332 mm</td>
</tr>
<tr>
<td>Perenjori</td>
<td>288 mm</td>
</tr>
</tbody>
</table>

The figures in the following tables show AgET’s estimate of the percentage of average annual rainfall that recharges the watertable under different rotations for each shire.

Table 9. Deep sands and sandy earths

<table>
<thead>
<tr>
<th>Rotation</th>
<th>Wheat/Wheat/Pasture</th>
<th>Wheat/Wheat/Serradella/Serradella</th>
<th>Wheat/Lupin/Wheat/3 yrs</th>
<th>Remnant vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shire</td>
<td>Pasture/</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three Springs</td>
<td>20.63%</td>
<td>8.73%</td>
<td>9.79%</td>
<td>6.88%</td>
</tr>
<tr>
<td>Carnamah</td>
<td>20.11%</td>
<td>8.47%</td>
<td>9.26%</td>
<td>6.08%</td>
</tr>
<tr>
<td>Dalwallinu</td>
<td>19.06%</td>
<td>7.46%</td>
<td>8.29%</td>
<td>5.52%</td>
</tr>
<tr>
<td>Morawa</td>
<td>14.76%</td>
<td>4.52%</td>
<td>5.42%</td>
<td>3.61%</td>
</tr>
<tr>
<td>Perenjori</td>
<td>13.19%</td>
<td>2.78%</td>
<td>3.47%</td>
<td>2.08%</td>
</tr>
</tbody>
</table>
Deep sands and sandy earths are the most ‘leaky’ soils types in the Yarra Yarra. This is because they have a lower waterholding capacity and as a result have the highest recharge percentages. Because of this high recharge they are also a soil where you can make the biggest reduction to recharge with the smallest amount of change to the system.

Options for reducing recharge on these soils included phase pastures, deep-rooted perennials and improved varieties of deeper rooted annual pastures (e.g. serradellas). Poor performing and unimproved pastures can significantly add to recharge. For this model we tested phase farming with lucerne.

A rotation with three years of crop followed three years of lucerne. When this rotation was simulated in AgET it had a lower leakage value but it was not significantly lower than improved pastures and cropping. Currently the only phase farming option with a perennial that we have is lucerne. Much of the deep sands in the Yarra Yarra are unsuitable for lucerne as they are too acidic. Lucerne is also an unknown in the Yarra Yarra for production, persistence, density and its proneness to erosion. These parameters for lucerne in the Yarra Yarra would have to be well known and accepted before it is recommended for these areas.

Table 10. Red loamy earth

<table>
<thead>
<tr>
<th>Rotation</th>
<th>Wheat/ Pasture</th>
<th>Wheat/ Grain/ Legume/ Wheat/ Pasture</th>
<th>Wheat/ Wheat/ 3 yrs Perennial</th>
<th>Remnant vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shire</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three Springs</td>
<td>8.20%</td>
<td>7.15%</td>
<td>5.29%</td>
<td>1.50%</td>
</tr>
<tr>
<td>Carnamah</td>
<td>7.94%</td>
<td>6.88%</td>
<td>5.03%</td>
<td>1.32%</td>
</tr>
<tr>
<td>Dalwallinu</td>
<td>6.08%</td>
<td>5.25%</td>
<td>3.59%</td>
<td>0.55%</td>
</tr>
<tr>
<td>Morawa</td>
<td>3.92%</td>
<td>3.61%</td>
<td>1.81%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Perenjori</td>
<td>2.78%</td>
<td>2.78%</td>
<td>1.39%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

These soils are quite deep and have high waterholding capabilities however they are still high contributors to recharge. Phase farming with a perennial does offer the best recharge control as long as there is a productive option available. Lucerne may be an option here and it is likely to perform better and be more productive on these soils than on the deep sands and sandy earths. Improving the annual pastures on these soils may offer some benefit to recharge control. Using deeper-rooted pasture varieties may increase production and water use.

Table 11. Red-brown hardpan, shallow loam

<table>
<thead>
<tr>
<th>Rotation</th>
<th>Wheat/ Pasture</th>
<th>Wheat/ Wheat/ Pasture</th>
<th>Wheat/ Grain/ Legume/ Wheat/ Pasture</th>
<th>Wheat/ Wheat/ 3 yrs Perennial</th>
<th>Remnant vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shire</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three Springs</td>
<td>7.41%</td>
<td>6.08%</td>
<td>5.82%</td>
<td>2.65%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Carnamah</td>
<td>7.41%</td>
<td>6.35%</td>
<td>6.08%</td>
<td>2.65%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Dalwallinu</td>
<td>5.80%</td>
<td>4.97%</td>
<td>4.42%</td>
<td>1.66%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Morawa</td>
<td>3.31%</td>
<td>3.31%</td>
<td>2.41%</td>
<td>0.60%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Perenjori</td>
<td>2.08%</td>
<td>2.43%</td>
<td>1.74%</td>
<td>0.35%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>
This soil type had very similar results to the red loamy earth. The slight differences between these soil types are due to the hardpan slowing the movement of water through the soil profile. As a result the watertable recharge figures are not as high. Phase farming did not control recharge as well on these soils.

Table 12. Calcareous loamy earths

<table>
<thead>
<tr>
<th>Rotation Shire</th>
<th>Wheat/ Wheat/ Pasture/ Pasture</th>
<th>Wheat/ Wheat/ Grain/ Legume</th>
<th>Wheat/ Wheat/ Wheat/ Wheat/ 3 yrs Perennial</th>
<th>Remnant vegetation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three Springs</td>
<td>1.59%</td>
<td>1.06%</td>
<td>0.79%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Carnamah</td>
<td>1.85%</td>
<td>1.32%</td>
<td>1.06%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Dalwallinu</td>
<td>1.38%</td>
<td>0.55%</td>
<td>0.28%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Morawa</td>
<td>0.90%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
<tr>
<td>Perenjori</td>
<td>0.69%</td>
<td>0.00%</td>
<td>0.00%</td>
<td>0.00%</td>
</tr>
</tbody>
</table>

All the rotations on this soil type had very low percentages of recharge. The simulation suggests that switching rotations on these soils will have little impact on recharge throughout the catchment however this assumption may not be correct. AgET does not take surface water movement into account and as these soil types are situated lower in the landscape there is the potential that surface water may pond in these areas and add significantly to recharge. As these soils are generally located in valley floors they are prone to rising watertables and can quite often become saline. On these sites perennial systems should be considered when a groundwater source is approaching the root zone.

Summary

The deep sand and sandy earths have the largest percentage of rainfall contributing to recharge with the rainfall on many of these rotations recharging the watertable from 5 to 20%. The lowest recharge soil type was on the calcareous loamy earths with all rotations contributing very little to recharge. Both of the red loams were somewhere in between the sands and the clays. The difference between shires is due to the difference in rainfall amount and the rainfall distribution throughout the year.

The deep sands and sandy earths are the most important soil types to improve water use on, as these are the areas where the model suggested most of the leakage or recharge occurs.

Although phase farming with perennials gave the lowest amount of recharge it was only marginally better than improved crops and pastures. The profitability of phase farming with lucerne is unproven in the Yarra Yarra. Lucerne production and how well it fits into farming systems needs further assessment, therefore improving annual crops and pastures is currently a better option. Perennial systems should be investigated for niche areas where they can be extremely profitable with increased water availability and use.

In conclusion we now recognise that salinity is something that we will have to learn to live with. We do not currently have viable farming systems that will reduce recharge enough across the landscape to halt and reduce the spread of salinity. If a perennial
or deeper-rooted annual can play a part in your farming system as profitably as the current system you are using then they should be used, as they maintain or improve your production and their increased water use may slow down the rate that salinity is spreading. In potential saline areas be aware of indicators of the area turning saline. As soon as saline indicators are noticed management on these areas should be changed accordingly. The sooner these changes are made the more options there are available to use on these areas.

5.2.2 Improving crop and pasture water use

*Kari-Lee Falconer, Development Officer, Three Springs District Office*

Annual crops and pastures in our agricultural system do not have the ability to use all the rain that falls throughout the year. Nearly one third of the annual rainfall occurs outside their growing season limiting their role in recharge reduction. However, annual crops and pastures occupy a large component of the current cropping system and will continue to occupy a significant area in future cropping systems.

Maximising the water use of annual crops and pastures throughout the growing season is still a tool for minimising recharge. The added focus will be maximising the yield and profitability of these annual crops and pastures by increasing their water use efficiency. Increased profitability will enable farmers to invest more money into more effective recharge reduction tools such as establishing perennial pastures, perennial vegetation and surface water control.

**Maximising water use**

To increase water use the amount of green material produced by the plant needs to be maximised.

**Annual pastures**

For annual pastures this involves:

- growing varieties/mixes that cater for long growing seasons;
- adequate soil fertility to promote rapid and early growth;
- effective pest and disease control programs to maximise leaf area;
- correct grazing pressure to maximise growth (leaf area).

**Annual crops**

For crops, research into water use has found that in environments where there are no limitations to healthy root and plant growth there is a difference between the amount of water different crops use. They have found that water use decreases as follows:

- oilseeds/lupins > cereals > other pulses > unimproved annual pastures > fallow

Productive crops can use more water than annual pastures and the principles for increasing water use are similar to pastures:

- Controlling pests, diseases and weeds to maximise leaf area.
- Sowing appropriate species/varieties for soil type and local conditions.
- Sowing crops at the optimum time, using higher seeding rates.
- Optimising fertiliser use: P, N and trace elements to promote rapid early growth.
It is also important to remove problems to root growth such as hardpans, acidic soil, non-wetting sands, herbicide residues and eroded soils. Hardpans can restrict the amount of root growth reducing the plants ability to take up and use more water. They also limit the depth in the soil from where the water is taken. Removing hardpans will ensure that a longer rooting depth for some crops is still a water use advantage. Hardpans do limit water use in some soils in the Yarra Yarra.

**Overcoming land degradation problems**

There is a wealth of information in Farmnotes that have been written for these topics.

### Soil acidity

<table>
<thead>
<tr>
<th>Farmnote</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>80/2000</td>
<td>Management of soil acidity in agricultural land</td>
</tr>
<tr>
<td>78/2000</td>
<td>Looking at liming: The importance of soil pH</td>
</tr>
<tr>
<td>68/2000</td>
<td>Looking at liming: Test strips</td>
</tr>
<tr>
<td>70/2000</td>
<td>Looking at liming: Consider the rate</td>
</tr>
<tr>
<td>67/2000</td>
<td>Looking at liming: Quality</td>
</tr>
<tr>
<td>69/2000</td>
<td>Looking at liming: Comparing lime sources</td>
</tr>
<tr>
<td>79/2000</td>
<td>Soil acidity and barley production</td>
</tr>
</tbody>
</table>

### Soil degradation

<table>
<thead>
<tr>
<th>Farmnote</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>65/1996</td>
<td>Soil management options to control land degradation</td>
</tr>
<tr>
<td>66/1996</td>
<td>Stubble management to control land degradation</td>
</tr>
<tr>
<td>9/1995</td>
<td>No tillage sowing minimises water erosion</td>
</tr>
</tbody>
</table>

### Non-wetting sands

<table>
<thead>
<tr>
<th>Farmnote</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>106/1996</td>
<td>Managing water repellent soils</td>
</tr>
<tr>
<td>110/1996</td>
<td>Assessing water repellence</td>
</tr>
<tr>
<td>111/1996</td>
<td>Furrow sowing for improved crops and pastures on water repellent</td>
</tr>
<tr>
<td>14/1997</td>
<td>Claying water repellent soils</td>
</tr>
</tbody>
</table>

### Deep ripping

<table>
<thead>
<tr>
<th>Farmnote</th>
<th>Title</th>
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<tbody>
<tr>
<td>88/1994</td>
<td>Deep ripping</td>
</tr>
<tr>
<td>2000 Crop Updates</td>
<td>Improving wheat yield, soil physical and chemical fertidity by a package of deep ripping, gypsum and complete nutrients</td>
</tr>
</tbody>
</table>

Research has also recently started in the Northern Region into raised bed farming.

### Raised beds

<table>
<thead>
<tr>
<th>Farmnote</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Raised Bed Farming Newsletters</td>
</tr>
<tr>
<td></td>
<td>For back issues and mailing list registration contact Greg Hamilton,</td>
</tr>
<tr>
<td></td>
<td>Department of Agriculture, South Perth.</td>
</tr>
<tr>
<td>2000 Crop Updates</td>
<td>Raised bed farming for improved cropping of waterlogged soils</td>
</tr>
</tbody>
</table>
Maximising agronomy

High production agronomic packages, called the Crop Essentials, for each crop are found in the Crop Variety Sowing Guide released each year by the Department of Agriculture. The Crop Essentials cover fertiliser, weed and insect control, seeding methods and variety selection recommendations.

The correct time of sowing for crop varieties is also located in the Crop Variety Sowing Guide. An aim in maximising crop or pasture water use is to grow them for as long as possible to maximise the amount of time that the crop is actively taking up water. The longer the plant is growing the more water the plant can use so it is not recharging the groundwater.

Pest, weed and disease management is important not only for preventing significant yield loss but also for protecting the vigour of the crop and preventing leaf area loss.

Increasing water use efficiency of the crop

While the total amount of water that annual crops and pastures can use is important the productivity of the crop is also important.

The water use efficiency (WUE) of a crop describes its ability to convert millimetres (mm) of rainfall into grain (kg/ha). Maximising the water use efficiency of a crop will help the crop achieve its yield potential. Calculating the yield potential of a crop provides a benchmark to assess its performance against.

\[
Yield Potential = (Available Water – Evaporation) \times Water\ Use\ Efficiency
\]

Table 13. The potential yield of selected crops in the Yarra Yarra (t/ha)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Carnamah</th>
<th>Dalwallinu</th>
<th>Perenjori</th>
<th>Three Springs</th>
<th>Morawa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>4.7</td>
<td>3.9</td>
<td>3.5</td>
<td>4.6</td>
<td>3.4</td>
</tr>
<tr>
<td>Canola</td>
<td>3.0</td>
<td>2.5</td>
<td>2.2</td>
<td>3.0</td>
<td>2.2</td>
</tr>
<tr>
<td>Lupins</td>
<td>3.5</td>
<td>2.8</td>
<td>2.5</td>
<td>3.4</td>
<td>2.5</td>
</tr>
<tr>
<td>Barley</td>
<td>5.6</td>
<td>4.6</td>
<td>4.2</td>
<td>5.5</td>
<td>4.1</td>
</tr>
<tr>
<td>Chickpeas</td>
<td>3.6</td>
<td>2.9</td>
<td>2.6</td>
<td>3.5</td>
<td>2.6</td>
</tr>
</tbody>
</table>

In practice crop yields will not always match the yield potential of the crop, which indicates that some property or management practice is constraining yields (e.g. extremes of temperature, agronomic deficiencies, pests, physical soil conditions).

It is therefore easier to set target yields and strive to attain those. A target yield, which aims for 75% of the potential yield, is a more practical yield to target and benchmark crop performance against.
Table 14. Target yields of selected crops in the Yarra Yarra (t/ha)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Carnamah</th>
<th>Dalwallinu</th>
<th>Perenjori</th>
<th>Three Springs</th>
<th>Morawa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>3.5</td>
<td>2.9</td>
<td>2.6</td>
<td>3.4</td>
<td>2.6</td>
</tr>
<tr>
<td>Canola</td>
<td>2.3</td>
<td>1.9</td>
<td>1.7</td>
<td>2.2</td>
<td>1.6</td>
</tr>
<tr>
<td>Lupins</td>
<td>2.6</td>
<td>2.1</td>
<td>2.1</td>
<td>2.6</td>
<td>1.9</td>
</tr>
<tr>
<td>Barley</td>
<td>4.2</td>
<td>3.5</td>
<td>3.1</td>
<td>4.1</td>
<td>3.1</td>
</tr>
<tr>
<td>Chickpeas</td>
<td>2.7</td>
<td>2.2</td>
<td>2.0</td>
<td>2.6</td>
<td>1.9</td>
</tr>
</tbody>
</table>

Maximising the water use efficiency of a crop is about fine tuning production packages to achieve the best possible yields. The TOPCROP program provides more information on calculating yield potential and monitoring for limiting yield practices.

5.2.3 Pasture based options for increasing water use

Dave Rogers Farming Systems Development Officer, Geraldton District Office

This report contains a series of possible options for niche and broad-acre areas. The niche areas considered are those with elevated moisture levels (rising groundwater or hillside seeps). The access to excess moisture in these areas is ‘artificially’ elevating plant access to water above that obtained from rainfall. This provides opportunities, to grow varieties of productive plants usually not suitable in low rainfall areas. Of the following options most are for areas where groundwater is approaching the surface and while not a bare scald the area is subjected to waterlogging and varying saline conditions.

It is critical to get the correct timing in establishing some of these options. The longer an area with shallow watertables is left without a change of management the more saline it becomes and the less options we have available to use on it.

Some indicators of rising groundwater are:
- increased yields and extension of the growing season in certain areas;
- presence of barley grass and other salt tolerant indicator species;
- absence of clover, cape weed and other salt sensitive pasture species;
- evidence of shallow watertables and visible salt on the surface;
- vegetation health (leaf chlorosis, necrosis);
- crop failure due to waterlogging.

If you are starting to notice these symptoms in areas it is time to be thinking about what other options there may be available for that area.

Lucerne

Lucerne is a perennial, deep-rooted legume well adapted to the southern Australian environment. Once established it will persist on as little as 300 mm annual rain. Lucerne will grow in a wide range of soil types which meet the following criteria: surface and subsurface soil pH > 4.8, a site that is well drained and one with a low weed burden.
Results collected from experiments in medium and low rainfall zones of south Western Australia show that lucerne has a greater capacity to use soil moisture while producing similar levels of biomass compared to annual pastures.

There are many different varieties of lucerne currently available. In a dryland situation the best varieties to choose are winter active or highly winter active varieties. All lucerne varieties are as productive as each other through summer but to take advantage of winter rainfall it pays to use winter active varieties. In phase farming situations use highly winter active varieties. In long term stands for greater persistence chose a moderately winter active variety as these varieties persist longer than the highly winter active varieties.

Establishing lucerne can be difficult due to low seedling vigour. The main points to keep in mind when establishing lucerne are:

- Seeds need to be sown no deeper than 1 cm.
- Excellent weed control is necessary prior to establishment. The establishing seeding is extremely uncompetitive and weed competition in many cases leads to seedling death.
- Pest control during establishment is a priority, as the seedling will be destroyed quickly by a range of pests.
- Soil pH is also critical. The pH of the soil needs to be above 4.8. If it is from 4.8-5.5 you may still establish lucerne but an application of lime will be necessary prior to establishment. This may change in the future as more acid tolerant rhizobia are developed.
- Soil depth. Lucerne will persist as a stand more productively on deeper soil types.

Areas not sub-irrigated and not prone to waterlogging should be planted as early as possible in the season without compromising weed control. Areas with mild winter waterlogging are marginal for lucerne and as a rule general advice is to plant further up the slope. If seeding mildly waterlogged areas, plant later in the season to reduce the likelihood of seedlings being destroyed by waterlogging.

Figure 6. An established lucerne pasture on a shallow watertable east of Three Springs.
In areas that are very prone to waterlogging look at options other than lucerne. Current information indicates the risk of failure as quite high. A general guideline is that if there are wheat stubbles then lucerne will establish if the wheat has failed from waterlogging. If there are no stubbles present then chances are that the lucerne will also fail to establish.

For lucerne to persist, stands need to be rotationally grazed. The size of the paddock and the duration of grazing and rest periods will determine the productivity and persistence of a stand.

Many of the deep sands in the Yarra Yarra are unsuitable for lucerne as they are too acidic. Lucerne is also an unknown in the Yarra Yarra for production, persistence, density and proneness to erosion. These parameters for lucerne in the Yarra Yarra would have to be well known and accepted before it is widely recommended.

<table>
<thead>
<tr>
<th>Farmnote</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>135/2000</td>
<td>Lucerne in Pasture-crop Rotations - Establishment and Management</td>
</tr>
</tbody>
</table>

**Summer fodder crops**

**Sorghums**

Sorghums are a summer growing grass that can be very productive through summer in areas where there is access to suitable subsoil moisture. The plant is classified as a semi-perennial as most stands only last two or three years. However where there is sufficient moisture and the correct management is applied, some stands may persist and be productive for many years. These plants may produce some toxins (prussic acid) in new growth and under conditions of stress such as frost, nutrient stress, water stress, waterlogging, etc. There have been many productive sites in this area on hillside seeps and on the margins of saltland areas.

Figure 7. Maurice Bryant, a farmer near Latham, with his 9 year old stand of sorghum on a seepage site.
Millet

Millet like sorghum is a summer active forage crop. It is a semi-perennial but does not seem to persist as well as sorghum with very few stands persisting into and past the second year. The varieties being widely used do not recover as well or as quickly from grazing as sorghum, however there is a range of millet varieties available all with varying growth habits and performance under grazing. Millets contain no toxins so poisoning is not an issue.

These summer grasses are temperature sensitive and will need to be planted in August/September or later in summer if a suitable opportunity through summer rainfall occurs. They will be productive through the summer as long as there is moisture available. They will then become dormant through the winter resprouting (ratooning) again in spring.

These crops can be very productive on suitable sites and have potential for filling feed gaps in a pasture grazing system. They can also be harvested for fodder conservation producing good quality silage or hay.

<table>
<thead>
<tr>
<th>Farmnote</th>
<th>Title</th>
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<tbody>
<tr>
<td>93/2001</td>
<td>Forage millet growing in Western Australia</td>
</tr>
<tr>
<td>94/2001</td>
<td>Grain sorghum growing in Western Australia</td>
</tr>
<tr>
<td>82/1985</td>
<td>Summer fodder crops for the South West irrigation areas</td>
</tr>
</tbody>
</table>

Tall wheat grass

Tall wheat grass is a temperate perennial grass. It is summer active and with sufficient moisture it will grow well in spring, summer and autumn. It is waterlogging tolerant, mildly salt tolerant and also has good drought tolerance.

The main variety of tall wheat grass in Australia is Tyrell however there is a new cultivar available named Dundas which has increased leaf production and greater forage quality.

Tall wheat grass has potential in mildly saline conditions (barley grass areas) particularly in combination with Frontier balansa. The combination of a summer active perennial and an annual pasture can be very productive through extending the length of time that green feed is available to stock. It also allows the establishment of the annual component of the pasture to extend into areas not normally suitable. Tall wheat grass can create a localised lowering of the watertable. Salts then leach deeper into the profile allowing the annuals to establish in areas that would usually be too saline, resulting in an increased production capability of that area.

Points to consider when establishing tall wheat grass are:
- tall wheat grass is slow to establish so thorough weed control is essential;
- seed should be sown no more than 5 mm deep;
- it is important that the seed is fresh as the germination percentage rapidly declines if the seed is more than two years old;
- initial grazing of the stand needs to be carefully timed when the plant is firmly anchored to the ground (usually 6-8 months). The initial grazing should only be light.
Once established, tall wheat grass can be grazed quite heavily. Tall wheat grass is most palatable in January when there are fleshy green shoots and a moist seed head. It is best grazed hard over summer down to a uniform stubble of three to five centimetres in height by the end of summer. This prevents the grass from going clumpy and rank. Like any grass responds well to applications of nitrogen fertiliser or nitrogen fixed from legumes.

<table>
<thead>
<tr>
<th>Farmnote</th>
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</tr>
</thead>
<tbody>
<tr>
<td>44/2000</td>
<td>Tall wheat grass and balansa clover: A beneficial partnership for waterlogged, mildly saline soils</td>
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<tr>
<td>47/2000</td>
<td>Saltland pastures: Changing attitudes toward saline land</td>
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<tr>
<td>11/1998</td>
<td>Well-adapted perennial grasses for the Esperance sandplain</td>
</tr>
<tr>
<td>59/1996</td>
<td>Green Feed in Summer</td>
</tr>
<tr>
<td>4321</td>
<td>Saltland Pastures in Australia, A Practical Guide</td>
</tr>
</tbody>
</table>

**Balansa clover**

Balansa clover is a small-seeded annual clover. The plant is quite waterlogging tolerant and also tolerates mild to moderate salinity levels (less than 80 mSm). It is very susceptible as a seedling to redlegged earth mite. Balansa can be grown on acidic soils with pH greater than 4.5.

Frontier is a new earlier maturing variety and will enable the species to be used in lower rainfall areas.

Balansa makes an excellent companion annual legume to saltbush, tall wheat and puccinellia plantings particularly the shorter seasoned variety frontier. This partnership of perennial and annual plants allows the balansa to establish further into the salt scald. The perennial draws down the watertable allowing the salt to leach out of the soil surface. This area can then be colonised by balansa plants.

![Figure 8. A very productive balansa/bluebush stand on a saline site.](image)

Growth of first year stands is often prolific. Seed can be easily harvested with conventional cereal harvesters.
Hard summer grazing is necessary for good regeneration and seeds can survive ingestion by sheep.

<table>
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<tr>
<td>47/2000</td>
<td>Saltland pastures: Changing attitudes toward saline land</td>
</tr>
<tr>
<td>26/1999</td>
<td>Establishing balansa and persian clovers on waterlogged mildly saline soils</td>
</tr>
<tr>
<td>4321</td>
<td>Saltland pastures in Australia, A Practical Guide</td>
</tr>
</tbody>
</table>

**Puccinellia**

This species is tolerant of saline and waterlogged conditions. Puccinellia is a grass that forms tussocks up to 40 cm high and 40 cm wide. The plant grows during winter and is dormant over summer. May be grown on salt-affected soils that are to wet for saltbush during winter however sites should be dry at the surface in summer. Can be grown as a companion with tall wheat grass and balansa clover.

<table>
<thead>
<tr>
<th>Farmnote</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1/1999</td>
<td>Puccinellia - for productive saltland pastures</td>
</tr>
<tr>
<td>47/2000</td>
<td>Saltland pastures: Changing attitudes toward saline land</td>
</tr>
<tr>
<td>4321</td>
<td>Saltland pastures in Australia, A Practical Guide</td>
</tr>
</tbody>
</table>

**Saltbush and bluebush**

Saltbush and bluebush are two of the better adapted shrubs for saltland areas.

Saltbush will tolerate some waterlogging and is quite salt and drought tolerant. Saltbush is usually quite palatable and has excellent recovery from grazing. These types of plants are again useful in saline areas in partnership with other perennial and annual plant species. They can be grown successfully in alley type plantings with a more productive annual plant between the rows.

![Saltbush alleys with establishing balansa clover in the inter row.](image-url)

**Figure 9.** Saltbush alleys with establishing balansa clover in the inter row.
Bluebush is a native of Australia and it will usually colonise rapidly from roadsides and other stands into areas where it is suited. Grazing should be managed in a way to assist its establishment. Bluebush is less tolerant of waterlogging than saltbush (only able to tolerate waterlogging or flooding for a few days) and can usually be seen in areas with well drained marginal to moderately saline soils. Bluebush provides good grazing and recovers well. It has a better nutritional value than saltbush. It should however be grazed in conjunction with other pastures or stubbles as it does contain oxalates and stock could be poisoned if they are hungry and feed exclusively on a bluebush stand. If you intend to establish from seed, only recently collected seed should be used, as the seed loses its viability within a year of being collected.

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td>47/2000</td>
<td>Saltland pastures: Changing attitudes toward saline land</td>
</tr>
<tr>
<td>4321</td>
<td>Saltland pastures in Australia, A Practical Guide</td>
</tr>
<tr>
<td>4153</td>
<td>Forage shrubs and grasses for revegetating saltland</td>
</tr>
<tr>
<td>4473</td>
<td>The good food guide for sheep (may be worth including)</td>
</tr>
</tbody>
</table>

**Subtropical perennial grasses**

These type of perennials have not been tested in the Yarra Yarra as yet but may have potential in some areas. At present they are only recommended for use on areas unsuitable for cropping as once they are established they may be difficult to eradicate and then crop over.

**Rhodes grass** is a subtropical perennial grass. It is a tufted perennial with runners. It has moderate frost tolerance and will combine well with legumes. The fast growing runners allow the plant under the right condition to rapidly cover the ground surface.

**Bambatsi** is a very drought resistant and cold tolerant subtropical grass. Bambatsi has bluish coloured leaves with a prominent white midrib. This species can remain greener during winter than many other subtropical grasses, as it is able to produce basal shoots in response to winter rain.

**Green panic** has fine soft leaves and slender stems growing to 1.5 m, it is very palatable. It also has a richly branched root system that facilitates rapid growth after light showers. Despite having a concentration of roots close to the soil surface it still has good drought resistance.

The **Setarias** are amongst the most cold tolerant of the subtropical grasses. Setarias are a tufted grass that can grow to a height of over 2 m and are tolerant of temporary waterlogging. Setarias have a spike-like flower head. **Nandi Setaria** has vigorous summer growth and reasonable cold tolerance. **Solander Setaria** has a more even seasonal production, producing less in summer, but having better cool season performance.
Key tips

In general, most establishing perennials are small and uncompetitive and as a result you need excellent pest and weed control prior to and during establishment.

Choose the right perennial for the right site. You need to make sure that the perennial you have chosen is suited to the site you are trying to establish it in as many of the species available have specific requirements for them to establish and be productive.

Many perennials, especially the ones with smaller seeds, need to be sown precisely as if they are sown to deep they will fail to emerge and establish.

To get the most out of a perennial it needs to be in an area where it has a good chance of accessing out of season moisture of a quality it can use.

Grazing must be managed appropriately to maintain the density and productivity of the stand. Set stocking is usually not the best option for perennials.

In many cases a perennial annual mixed stand suited to the environment you are using it in will be more productive and sustainable than either the perennial or annual on their own.

Lucerne is currently the only working perennial model we have for phase farming though other perennials are being trialed in this type of system.

Establishment of perennials is in general very expensive when compared to other pastures so it is important that you source the best advice and information available so that you make the best decisions possible and minimise the risk of failure.
Broad-acre options
At present there are not many profitable perennial options for low rainfall, broad-acre areas. Although several possibilities are currently being investigated at present phase farming with lucerne is the only one that looks like it may have some potential. However this type of system has not been tested in this area and it may not be productive or sustainable. Lucerne is also unsuitable for large areas of the Yarra Yarra as several soil types are to acidic. In the areas where lucerne is more suited to the soils the question becomes if the lucerne will establish and persist in high enough densities to be productive and profitable enough to warrant its establishment in these areas. Lucerne should be tried on small areas on heavier ground initially so that its establishment, persistence and production capabilities can be assessed without a large outlay.

Another option is to look at the types of annuals that are currently used in the system and if they could be substituted for annuals with increased production, rooting depth and water use. Serradellas offer increased water use to other pastures on the more acid sands and earths and can also increase production.

Serradella recommendations

Low rainfall areas
Serradellas are well suited to the highly acidic, light textured soils in the low rainfall zones (more common in L1-L4 than in L5). In the western parts of the L zones yellow serradellas Santorini, Paros and Charano are all suitable to be sown alone or in mixtures. Charano and Paros are the earliest maturing varieties and should be favoured in the eastern areas. Cadiz French serradella can be included in mixtures with yellow serradellas however its regeneration could be unreliable in these areas.

Medium rainfall areas
Santorini yellow serradella is the variety of choice for all medium rainfall zones where crop pasture rotations are planned. Madeira can be used alone or in mixtures with Santorini on less acidic sites (pH > 5.5). The early maturing varieties Charano and Paros could be included in a mix if regular spray topping is expected.

Cadiz French serradella is well suited to all the medium rainfall zones and can be used on a wide range of light textured soils either sown alone for short pasture phases or in mixtures with yellow serradellas where self regenerating systems are being put in place. Cadiz will not regenerate following a crop and will need to be resown at the start of each pasture phase.

<table>
<thead>
<tr>
<th>Farmnote</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>4238</td>
<td>New developments in serradella</td>
</tr>
<tr>
<td>12/1997</td>
<td>Cadiz French serradella - a new pasture variety for deep acid soils</td>
</tr>
<tr>
<td>30/1998</td>
<td>Santorini a new yellow serradella for medium rainfall areas</td>
</tr>
<tr>
<td>29/1998</td>
<td>Charano - a new serradella for low rainfall areas</td>
</tr>
</tbody>
</table>

Another option for the heavier ground with higher pH less suited to serradellas is a deep-rooted annual called casbah biserrula. **Biserrula** is one of the newer species to be commercialised in Australia. This species is expected to be used in mixtures with serradella on sandy soils and on the better class of soils where subterranean
clover is grown. Data is limited, but early indications are that biserrula will also perform well in a mixture with medics, particularly on the sandier medic soils. Biserrula will not tolerate waterlogging, particularly at germination.

The variety casbah should be suited to regions with 325-700 mm annual rainfall. It is deep-rooted and has the capacity to remain green after other pasture species have dried off. It is very hard seeded, has small seeds which can survive ingestion by sheep and seed is easier to thresh from the pod than serradella. Casbah is sensitive to blue-green aphids and to many herbicides used to control broadleaved weeds.

<table>
<thead>
<tr>
<th>Farmnote</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>28/1998</td>
<td>Casbah - a new and promising pasture legume for low to medium rainfall environments</td>
</tr>
</tbody>
</table>

Development of viable pasture options for both broad-acre and niche areas is continuing with research and development in these areas becoming a high profile objective in recent years. This will hopefully lead to us having many more options available to us in the near future.

5.3 Surface water management

Frank Rickwood, Land Conservation Officer, Moora District Office

5.3.1 Surface water control - overview

Structural soil conservation works are used in the landscape to control run-off, rehabilitate areas that are affected by erosion, reduce waterlogging by removing subsurface water and to safely divert water to appropriate disposal sites. The structures are used to reduce existing erosion but are also a means of preventing future erosion.

Specific earthworks such as grade banks, apart from reducing soil erosion, lengthen the time of concentration and reduce peak flows. This reduces flooding further down catchments.

It is important that all earthworks are correctly planned, designed, surveyed and constructed since incorrect practices can result in increased damage on farms than was there in the first place. To design various earthworks, rainfall, catchment size and characteristics are required. The Average Recurrence Interval (ARI) is also necessary for reliable design. This is the expected frequency structures will fill or fail safely. A minimum 10 year ARI is used when designing surface water control structures such as grade banks and drains, although a 20 year ARI may be required at some sites. Larger earthworks such as absorption banks, waterways and dams are designed for a minimum 20 year ARI.

Conservation earthworks are:
- Banks surveyed across slopes to control surface water flow. These are located mainly in upper slopes to mid-slopes, i.e. grade banks, level banks.
- Drainage channels that intercept and remove surface and subsurface water and surveyed on a grade. They are mainly located in a lower landscape position, e.g. interceptor drains.
- Dams which are earth tanks used as erosion mitigation structures or for water storage.
Management of water erosion in the Yarra Yarra Catchment - General comments

There are a number of management practices to avoid water erosion:

- **Do not cultivate grass waterways**, either natural or constructed, and ensure they have a **safe width** to cater for overland flows. The design width is based on a 20 year ARI. (Waterway design width will depend on a number of factors such as catchment size, annual rainfall, calculated peak flows, soil type, vegetative cover, slope and maximum permissible velocity allowed for a particular waterway.)

- Increase vegetative cover to prevent soil erosion and decrease run-off.

- Leave a good grass cover on paddocks during the summer/autumn period.

- Work on the contour to hold rainfall in the furrows, thereby increasing infiltration and decreasing run-off.

- Use minimum cultivation techniques such as no-till or direct drill to minimise water erosion and increase infiltration so that water is held in the root area of the soil to be utilised by plants.

- Survey earthworks at the correct grades to avoid erosion of channels.

- Ensure grade banks discharge safely into stable waterways or into dams to avoid serious erosion.

- Allow for suitable bank spacings to reduce run-off velocity down slopes. Spacing is determined by annual rainfall, soil type and slope.

- Don’t work up and down headlands on slopes where they will washout.

- Locate farm tracks and firebreaks in safe positions such as on ridge tops or downslope of grade banks.

- Firebreaks - chemicals are the first option. Divert run-off at regular intervals with spur drains or spreader banks.

- Reclaim gullies by filling and protect the loose fill with grade banks and spreader banks.

- Avoid overstocking.

5.3.2 Selection of soil conservation earthworks

Absorption and level banks - upper slope

These banks are surveyed and built on the contour on upper slopes generally below rocky outcrops and breakaways to control run-off where suitable water disposal areas are not available. Level banks have one end or both ends open to allow for overflow. Larger absorption banks have both ends turned up so that more water is stored above ground.

It is always better to use grade banks in preference to level banks unless there are no established waterways to discharge into or there is no scope for artificial waterway construction. This is because the level banks store water in the channel and add to recharge (water that is absorbed and added to the watertable) of saline and waterlogged sites further down. There is also a danger that in flood events the banks will breach leading to erosion and gully formation immediately downslope. Where
these earthworks are required, it would be a good practice to plant rows of trees below to utilise any added recharge.

**Grade banks and broad based banks - upper to mid-slope**

Grade banks and broad based banks are used across slopes in upper to mid-slope positions, to prevent soil erosion by intercepting and diverting run-off into stable waterways or dams. By controlling the run-off, peak flows are also reduced, thereby reducing flooding further down catchments.

Bank spacings for grade banks are between 50 and 250 metres with the grade along the channel being 0.2-0.5%.

Spacings for broad based banks are generally from 100 to 250 metres with the grade being 0.15-0.3%. The profile allows cropping on the bank to occur.

**Seepage interceptor drains - mid to lower slope**

These are drains constructed across the slope to divert surface water flows as well as intercept subsurface seepage on duplex soils (sand over clay) in the mid to lower slopes. They can be constructed as seepage interceptor drains or reverse bank seepage interceptor drains. Both have a ‘V’ shaped channel cut 20-30 cm into clay to intercept subsurface seepage. Generally built with a grader up to a depth of 75 cm. These drains can control waterlogging by surveying them above the waterlogged area and ensuring that they are built into clay. Spacings range from 50 to 100 metres.

**Seepage interceptors** have the channel into clay upslope collecting seepage as well as surface flows. Spoil from the channel is placed downhill. Channel grades are up to 0.5%. Since the front batter is steep, there is a risk of erosion and soil slumping.

**Reverse bank seepage interceptors** have the channel into the subsoil clay downslope and the spoil placed upslope. The advantage with this particular earthwork is that surface flows and seepage are separated so that batter erosion is minimised. It is important that a small pastured waterway is left above the uphill spoil to allow for the surface flows. Channel grades can be up to 0.75%.

**Level sill outlets**

It is recommended that **level sill outlets** are added to the end of all the above banks and drains where there is a risk of erosion at the discharge point. Level sills are 12-15 metres long and surveyed level as a continuation of the earthworks’ channel. They spread the discharged water and allow it to move more slowly towards a stable waterway.

**W-drains, Spoon drains, V-drains - valley floors**

On flat, low lying country where flooding and waterlogging on heavy textured soils occurs and vegetation is dying, consider draining with W-drains or spoon drains.

**W-drains** have flat-bottomed channels on either side of a central bank built by a grader. Low spots where water ponds can be linked up to the drains to enable the area to be more productive. The drain will overflow when peak flows are exceeded but will continue removing water until the floodwaters recede. Water will be
discharged into waterways and drainage lines. W-drains are constructed with grades up to 0.3%.

A good way of marking out the path of the drain is to place pegs where ponding is evident in winter or where there is a clear flowline.

**Spoon drains/V-drains** have a similar function to W-drains in that they move surface water and can alleviate waterlogging. However, there is only one channel and the spoil must be spread out on either side or used to fill hollows, so that water is not prevented from entering the drain. W-drains would be the preferred option.

**Levee banks and levied waterways - most parts of the landscape**

These are used to confine surface water flows and prevent flooding on adjacent land. Levied waterways are also used where no natural waterways exist. They are a safe discharge point for bank systems and can be constructed in most parts of the landscape provided careful planning, design and management is carried out.

**Open deep drains - broad valley floors**

These are drains constructed to remove subsurface water mainly in the broad flat valley systems of the Yarra Yarra where salinity has claimed large areas. The spoil from the deep drains is used to form levees on either side so that surface water flows are excluded and erosion of the channel does not occur. The drains can be up to 2 metres deep.

Careful planning and design are required. Deep drains in permeable soils with high hydraulic conductivity will have the most success.

An important consideration when planning the drains is to ensure that there are no likely harmful downstream impacts. Increased salinity and increased flow rates can cause severe land degradation and damage to vegetation, ecosystems, roads, culverts and other infrastructure.

For further information on surface water control and drainage visit:


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**Figure 11. A mix of typical earthworks.**
5.3.3 Maintenance of earthworks

It is important that all constructed earthworks are regularly maintained so that they are capable of carrying out the job that they were intended to do. Channels that are silted up will hold back water and overtop leading to erosion further downslope so these need to be cleaned out. Breaches can occur at low points where stock have crossed and release diverted or stored run-off. Therefore, low points must be built up as soon as possible.

Notification of draining or pumping saline land

When a new drainage or pumping scheme is proposed to control salinity, there is a requirement for landholders to notify the Commissioner of Soil and Land Conservation at least 90 days before the commencement of the works. It is also important that written consent is obtained from two downstream neighbours (Refer to Farmnote 47/93).

Landholders carrying out drainage activities should keep in mind that they have a duty of care to those affected by their actions, and take all reasonable steps to consult with and avoid causing damage to those people affected.

Contact the Department of Agriculture Offices when intending to undertake drainage works to control salinity. Application forms and further information can be obtained from the Department of Agriculture site at:


Dams

Dams can be used for water supplies on farms and towns or for surface water control to prevent erosion down slopes or both. In the Yarra Yarra Catchment great care should be taken in selecting dam sites as a suitable waterholding clay is required. Good planning and design are factors necessary for dam success. Some points to note are:

- Ensure there is a suitable catchment above. Thorough investigation is required for the best selection.
- Keep dams out of waterways. Instead, divert water across slopes to dams using grade banks. Although grade banks are useful, correctly planned roaded catchments are the most efficient water harvesters.
- Sites must be test drilled to establish the depth to a saline watertable and to test for soil suitability.
- Dams need to be a suitable size (preferably 3000 m$^3$ +) and deeper rather than shallower to ensure they provide a reliable water supply all year round.
- Make provision for an adequate freeboard. This should be at least 1 metre.
- Plan for a spillway so that overflow water cannot cause erosion of the dam wall. The spillway conveys water away from the dam in a safe manner and discharges into a stable waterway. Considerable erosion and crop loss can result from inadequate overflows from dams. Planned grade banks can also be used to remove excess water from the dam to a defined drainage line or creekline.
- Consider a 4-walled dam with piped inlets to reduce pollution from outside the dam. There will also be some reduction in evaporation.
Further information on dams can be obtained at:


Your local Community Landcare Technician can assist with planning and design of earthworks on your farm. A list of names is available from Department of Agriculture Offices.

Table 15. Soil conservation earthworks design criteria

<table>
<thead>
<tr>
<th>Type of earthwork</th>
<th>Location in landscape</th>
<th>Land slope</th>
<th>Grade along channel, drain or waterway</th>
<th>Channel depth</th>
<th>Channel width</th>
<th>Bank height settled</th>
<th>Bank length/drain length (maximum)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade bank</td>
<td>Upper to mid-slope. To control run-off and erosion.</td>
<td>Up to 10%</td>
<td>0.2%-0.5% (1:500-1:200)</td>
<td>30 cm</td>
<td>3-4 m</td>
<td>60 cm</td>
<td>1000 metres</td>
</tr>
<tr>
<td>Broad based bank</td>
<td>Upper to mid-slope. To control run-off and erosion.</td>
<td>2-6%</td>
<td>0.15-0.3% (1:660-1:330)</td>
<td>30-35 cm</td>
<td>5 m+</td>
<td>50-60 cm</td>
<td>1000 metres</td>
</tr>
<tr>
<td>Level and absorption banks</td>
<td>Upper slope below rocky outcrops or breakaways.</td>
<td>Up to 10%</td>
<td>Nil (surveyed on the contour)</td>
<td>30 cm for level bank. Can be greater for absorption.</td>
<td>Variable</td>
<td>Variable</td>
<td>Site specific</td>
</tr>
<tr>
<td>Seepage interceptor drains</td>
<td>Mid to lower slope to control surface flow and subsurface seepage on duplex soils.</td>
<td>Up to 6%</td>
<td>0.5% for Seepage Interceptor Drain. 0.5-0.8% (1:200-1:125) for Reverse Bank Seepage Interceptor Drain.</td>
<td>Up to 75 cm. (Depends on depth to clay. To extend 20 cm into clay subsoil.)</td>
<td>2.5 m</td>
<td>60 cm</td>
<td>Up to 500 m</td>
</tr>
<tr>
<td>W-drains</td>
<td>Valley flats. Lowest part of landscape.</td>
<td>Flat land</td>
<td>Up to 0.3% (up to 1:330)</td>
<td>30 cm</td>
<td>3-5 m generally</td>
<td>Variable</td>
<td>Site specific</td>
</tr>
<tr>
<td>Spoon drains, V-drains or flat bottomed drains</td>
<td>Valley flats. Lowest part of landscape.</td>
<td>Flat land</td>
<td>Up to 0.3% (up to 1:330)</td>
<td>30 cm</td>
<td>3-4 m generally</td>
<td>Soil spread out on each side of drain</td>
<td>Site specific</td>
</tr>
<tr>
<td>Open deep drain (levied)</td>
<td>Broad valleys. Lower landscape.</td>
<td>Flat land</td>
<td>Up to 0.2% (up to 1:500). Can be greater.</td>
<td>Up to 2 m</td>
<td>Variable</td>
<td>Variable</td>
<td>Site specific</td>
</tr>
<tr>
<td>Levee banks and leved waterway</td>
<td>Flood risk areas, below dams, most positions in landscape.</td>
<td>Flat land and up to 10% slopes.</td>
<td>Variable</td>
<td>Variable</td>
<td>Variable</td>
<td>Site specific</td>
<td></td>
</tr>
<tr>
<td>Dams</td>
<td>All locations, but generally in a mid-slope position. Careful investigation required.</td>
<td>Site specific</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>Variable</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Variable: Design and placement of the structure depends on rainfall, catchment size and its characteristics.
5.3.4 Primary soil groups of the Yarra Yarra Catchment and related drainage earthworks

Five major soil groups have been identified in the Yarra Yarra Catchment and the suitability of these for specific earthworks is listed below. Together these soils cover up to 87% of the Catchment.

Table 16.

<table>
<thead>
<tr>
<th>Soil type</th>
<th>Suitable earthwork/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow deep sand</td>
<td>Generally not suitable for surface water control earthworks due to slumping of the structures. Wind erosion of the sands may be a problem. Preferable to protect soil with management practices such as working to the contour and maintaining a healthy pasture cover.</td>
</tr>
<tr>
<td>Yellow sandy earth</td>
<td>As above.</td>
</tr>
<tr>
<td>Red-brown hardpan shallow loam</td>
<td>Suitable for earthworks to control surface water erosion and to reduce waterlogging, e.g. grade banks, seepage interceptor drains. For dams check depth to clay and soil suitability.</td>
</tr>
<tr>
<td>Calcareous loamy earth</td>
<td>Earthworks to control erosion and waterlogging are generally suitable. This soil is sometimes saline. Check depth to clay and salt content before transporting water across slopes or for water storage.</td>
</tr>
<tr>
<td>Red loamy earth</td>
<td>Earthworks to control surface erosion and waterlogging are suitable but check depth to clay for seepage interceptors. For dams check clay depth and soil suitability.</td>
</tr>
</tbody>
</table>

Further information:

- Resource Management Technical Report 185, Common Conservation Works used in Western Australia, which is available on request from Department of Agriculture Offices.
- Bulletin 4343, Soil Guide, A handbook for understanding and Managing Agricultural Soils. For those interested, this book is available at Department of Agriculture Offices for $44.00.
- Farmnotes:

<table>
<thead>
<tr>
<th>Farmnote</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>78/93</td>
<td>Waterlogging and inundation: Why they could be costing you money</td>
</tr>
<tr>
<td>79/93</td>
<td>Managing waterlogging and inundation in pastures</td>
</tr>
<tr>
<td>80/93</td>
<td>Managing waterlogging and inundation in crops</td>
</tr>
<tr>
<td>79/86</td>
<td>Legal Aspects of land drainage</td>
</tr>
</tbody>
</table>

Further useful information can be found at the Department of Agriculture sites:
http://www.agric.wa.gov.au/agency/Pubns/farmnote

For the soil improvement options, gypsum and claying, visit the sites:
5.4 Remnant vegetation management and revegetation

Mike Clarke, Revegetation Officer, Geraldton District Office

5.4.1 Remnant vegetation management

The remnant vegetation is important for its:

- nature conservation value in conserving the remaining biological diversity of a region;
- ability to supply seed for future revegetation programs;
- role in protecting soils on unarable land such as shallow rocky or gravelly soil types, gutless deep sands and areas prone to watertable rise;
- water use capabilities. This is well documented with watertables under vegetated catchments, such as Canna reserve (in the hydrograph below), remaining stable.

![Canna Reserve hydrograph showing the relatively stable watertable beneath a totally vegetated catchment.](image)

Fencing is seen as the first step in ensuring the future survival of remnants, in that it prevents stock eating any regenerating plants during their first summer. This is particularly true following a fire when the bush is easier for stock to penetrate and fresh seedlings are plentiful. Stock are also responsible for compacting the soil around trees and shrubs, introducing weed seeds and increasing nutrients in the form of dung. This nutrient increase benefits grasses and weeds more than the native plants which have adaptations to nutrient poor soils.

Undoubtedly these remnants are also under threat from salt encroachment, disease, rabbits, insect attack, chemical damage from herbicides, and stubble fires.
**Buffer plantings**

Apart from fencing the remnants out, they can be enhanced further by planting buffer strips around them. In doing so it is a good idea to plant a minimum of five or six rows of trees and shrubs around the perimeter of the remnant to act as a buffer for weed invasion, chemical drift, etc. These plantings will also enhance water use, particularly if the soils are shallow and gritty surrounding rocky outcrops. These are well documented as high recharge soils.

When deciding which remnant to fence out first on your farm, start with the largest patch in reasonable condition and work from there. Where possible remnants should be linked to other patches of bush with revegetated strips otherwise known as **wildlife corridors**. Drainage lines make good sites for such corridors as they link the top of the catchment to the bottom (see section on drainage lines). When designing wildlife corridors the minimum width should be 40 metres and the species planted should reflect the original vegetation that would of grown on each of the soil types it crosses.

It’s important to make the planting as structurally diverse as possible with trees, shrubs and herbaceous cover. This gives protection to the smaller, shyer species of birds and animals. Low, prickly acacias such as *Acacia andrewsii*, *A. erinacea*, *A. colletioides* and *A. nyssophylla* give excellent protection for such wildlife.

### 5.4.2 Revegetation for salinity control

Latest research into revegetation for salinity control is suggesting that between 70 and 80% of catchment areas may need to be revegetated with perennial plants to have significant effects on groundwater. It also suggests that the greatest effects on groundwater are from revegetation sited in recharge areas (George et al. 1999). For this to be feasible the revegetation needs to be economic in its own right such as a commercial timber crop, perennial pasture or fodder shrub. At this point in time the only potential broad-acre, commercial tree option readily available for this area are oil mallees. Other perennial options may include pastures such as perennial grasses, lucerne and fodder shrubs such as *Acacia saligna* and tagasaste.

It is highly unlikely that the farming systems are going to give way to agroforestry in the short to medium term so tree and shrub plantings need to be located in areas where they can maximise their water using ability. The following areas in the Yarra Yarra Catchment are suggested for strategic plantings:

- At the break of slope, above the valley floor.
- Above seepage areas.
- Below rocky outcrops.
- At the change of soil type texture, particularly from a sand to loam or clay.
- Flanking drainage lines.
- On salt-affected areas with melaleucas, saltbushes, samphires, bluebush and balansa clovers, etc.
5.4.3 Planting layouts

Seepage plantings

One of the commonly observed forms of salinity in the catchment is sandplain seeps. These develop on the gentle slopes usually downhill from extensive areas of yellow sandplain soil. The extra groundwater recharge occurring since clearing, drains deep into the subsoil until it hits a relatively impermeable clay or hardpan. This gradually accumulates and flows downslope until the impermeable layer becomes less than two metres from the surface. This then allows the now shallow groundwater to evaporate from the soil surface by capillary rise resulting in a initial wet seepage area, which if allowed to continue gradually becomes more salty (see Figure 13).

![Simplified cross-section of a sandplain seep](image)

Figure 13. Simplified cross-section of a sandplain seep

Seepages such as these have been successfully reclaimed throughout the wheatbelt of Western Australia by planting trees to dry the seeps out. Many successful examples of this in the catchment can be found.

![Block planting of trees](image)

Figure 14. This block planting of trees above a seepage at Goodlands turned a salt scald back to a productive wheat crop in 5 years.
When planting trees to control sandplain seeps, plantings should extend the entire width of the seep on the upslope side and contain 8 to 10 rows of trees and shrubs on a 5 by 5 metre spacing.

(If planting melaleucas or acacias you could reduce their spacings to 3 metres.)

The following table gives a good indication as to the approximate numbers of trees required for sandplain seepages of varying sizes.

Table 17.

<table>
<thead>
<tr>
<th>Approximate size of seep (ha)</th>
<th>Annual volume to be used Approx. (kL)</th>
<th>Minimum number of trees at less than 30 L/day/tree</th>
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<tbody>
<tr>
<td>1</td>
<td>1,000</td>
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</tr>
<tr>
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<td>4,000</td>
<td>400</td>
</tr>
<tr>
<td>9</td>
<td>5,000</td>
<td>500</td>
</tr>
</tbody>
</table>

Farmnote No. 116/88 R. George and P. Frampton.

Suitable local species to include in planting above seepages in these eastern wheatbelt areas include swamp sheoak (*Casuarina obesa*), broombush (*Melaleuca uncinata*), *Melaleuca acuminata*, *M. eleuterostachya*, *M. adnata*, and *M. lateriflora* directly above the wet seepage, with York gums (*Eucalyptus loxophleba*), river redgums (*E. camaldulensis*), *Acacia hemetelas*, *A. obtecta*, *A. eremaea* and *A. bromalis* scattered further upslope.

**Seepages associated with dolerite dykes**

Simply planting out areas upslope from seepages that area fed by dolerite dykes, may not be enough to intercept water feeding such seeps. Where dolerite dykes are acting as a carrier of groundwater across a slope and into a seepage area, tree planting should also take place along the upslope side of the dyke for at least 50 metres.

Species selection should reflect the soil type that the dyke is traversing, however the above list should suffice in most instances.

**Plantings below rocky outcrops**

The soils surrounding exposed rock outcrops are composed largely of quartz and can be quite porous. They are recognised as being sites of high recharge as the water that is shed off the exposed rock surface, infiltrates the porous soil and contributes to groundwater. If the rock extends just below the soil surface for some distance into cleared paddocks, the areas can also be prone to waterlogging resulting in machinery becoming bogged during seeding or spraying operations (so called Sunday soils: one day rock hard and dry, the next too wet).
These areas also have a high nature conservation value as the rock pools that form after rains provide breeding grounds and a supply of fresh water for many species of wildlife including frogs, dragonflies, etc.

**Break of slope plantings**

Areas in the catchment where the gentle slopes meet the flat valley floor, provide an opportunity for trees and shrubs to use excess groundwater. Subsurface water flowing above a hardpan or clay layer tends to bank up with the change in hydraulic gradient as it arrives at the valley floor. Often these areas also correspond to a change in soil texture, going from a lighter sandier texture to a heavier loam or clay. This changes the hydraulic conductivity resulting in a slowing of groundwater flow. For management purposes such as grazing efficiency, these boundaries also make logical sites for fences.

A belt of trees and shrubs sited just above the valley floor should be able to intercept the groundwater before it reaches the more saline ‘regional groundwater’ of the valley floor. Eight to ten rows of tree and shrubs planted around these areas would occupy land approximately 50 metres wide. Some of the oil mallee plantings in the district are sited on these areas for the same reason.

**Commercial options:**

**Oil mallees**

The revegetation option with the most promise from a commercial point of view are oil mallees. The Oil Mallee Association and CALM have been working together on developing the industry and several million have been planted in the Kalannie Goodlands area. Results so far indicate that plantings midslope and at the break of slope out of the salt-affected valleys, are showing better establishment and recovery after cutting (Pat Ryan, pers. comm.).

Oil Mallee Association contacts for the Yarra Yarra are Robyn Stephens (Canna) 9972 3001 or Max and Angela Waters (Kalannie) on 9666 2131.

**Sandalwood**

Western Australian sandalwood (*Santalum spicatum*) is a native, parasitic tree that requires a host to help it take up nutrients and water. The most common host is jam (*Acacia acuminata*), although on acidic sandplain such as that occurring in the Yarra Yarra it can be found hosting *Acacia resinomarginea* (old man wodgil).

Further information can be found in the Department of Agriculture, Revegetation on Farms information kits entitled Oil Mallees 1/01 and Southern Sandalwood for Western Australia. Many of WA’s native trees have commercial potential and a Farmnote entitled ‘Specialty Timbers for the Western Australian Wheatbelt’ (No. 90/89) introduces some of these options.

**Vegetating drainage lines**

Drainage lines in the catchment are generally ill defined because of little vertical relief. It is likely that prior to clearing, many of the drainage lines would of only been a moisture gaining site with a corresponding woodland or melaleuca vegetation.
system. Since clearing however, and the associated increase in water run-off, the drainage lines now run water. Areas bordering drainage line channels are moisture gaining sites and as such can make good sites for revegetation from not only a salinity point of view but also from a nature conservation and drainage line stability aspect.

Drainage lines are important areas as they carry excess surface water from the catchment to neighbouring saltlakes. These areas are also at greatest risk from salinity.

**Because of the fragility of these areas, all major drainage lines should be fenced out to exclude stock and allow natural regeneration and replanting to take place.**

When revegetating areas flanking drainage lines we are trying to construct a similar community of plants that would of grown there originally or if conditions have deteriorated, try to construct the healthy saline plant communities that exists on naturally saline drainage lines.

What follows is a typical cross-section through a saline drainage line indicating appropriate species starting with the most salt tolerant closest to the drainage channel.

A minimum vegetated width of 50 metres either side would be suitable for the major drainage lines in the catchment.

![Recommended planting layout for saline drainage lines.](image)

Figure 15. Recommended planting layout for saline drainage lines.

Much of the main drainage channel in the catchment has remnants of vegetation flanking its margins which, if protected from grazing, should regenerate in time.

Generally natural regeneration events occur after episodic events such as flooding.

When considering revegetating drainage lines make sure that excess surface water is controlled, particularly if the area to be planted is showing early signs of salinity. While some plants can tolerate a bit of waterlogging or some salinity, combining the two can have disastrous results.
Saltland revegetation

The value in revegetating your saltland with salt tolerant perennial shrubs include:

- They use groundwater and may improve conditions to enable other more valuable fodder to establish.
- They are able to colonise degraded saltland sites.
- They provide shelter for stock and wildlife.
- They can provide a valuable autumn forage reserve when hand feeding is usually the only other option.

The first step in managing saline areas is to control grazing, so these areas should be fenced out. This alone is usually sufficient to enable salt tolerant plants to establish naturally. Many of the fenced salt-affected areas found in the eastern wheatbelt of this region have had the small-leaved bluebush (*Maireana brevifolia*) colonise naturally. Even in paddocks high on the catchment divide bluebush has established itself naturally. This species, which is native to the wheatbelt of Western Australia, is high in protein, highly palatable, recovers amazingly well from heavy grazing and if given a chance spreads well from the seed of established plants.

However it will only tolerate around two to three days of waterlogging and stock should be fed in combination with stubble or pasture to avoid oxalate poisoning. Most farmers graze their bluebush stands during late summer/early autumn, allowing access to adjacent stubble paddocks and a good water supply. If for some reason bluebush does not initially colonise your saltland, ripe seed can easily be collected in summer and autumn by shaking the bushes over a bin or bag. The seed should then be air dried and used in the year it is collected for best germination.

In saltland areas which may be waterlogged for periods up to two weeks, saltbush pastures are recommended. Suggested species include:

- river saltbush (*Atriplex amnicola*);
- wavy leaf saltbush (*Atriplex undulata*);
- quail brush (*Atriplex lentiformis*).

These plants also have the ability to lower watertables enough to allow other, less salt tolerant, plants such as balansa clover to establish.

The Department of Agriculture has some very good Farmnotes and Bulletins for establishment and management techniques including Farmnotes 44/86, 56/88, 43/83, 26/99 and Bulletin 4153.
5.4.4 Species list by soil type

Appendix 1. Recommended trees and shrubs for replanting in the Yarra Yarra Catchment.

(*) Indicates species with some salt tolerance.)

**Calcareaous loamy earth**

*Eucalyptus yilgarnensis* (yorrel)
*Eucalyptus brachycorys* (Cowcowing mallee)
*Eucalyptus salmonophloia* (salmon gum)
*Eucalyptus loxophleba* (York gum)
*Eucalyptus transcontinentalis* (Redwood)
*Eucalyptus erythronema* (Red-flowered mallee)
*Eucalyptus salubris* (gimlet)
*Eucalyptus torquata* (coral gum)
*Melaleuca acuminata*
*Melaleuca leuteoretachya*
*Melaleuca sheathiana* (booree)
*Melaleuca lateriflora* (gorada)
*Melaleuca uncinata* (broombush)
*Melaleuca adnata*
*Senna nemophila* (desert cassia)
*Maireana brevifolia* (bluebush)
*Olearia drummondii*
*Olearia muelleri* (Goldfields daisy)
*Acacia acusaria*
*Acacia obtecta*
*Acacia microbotra* (manna gum)
*Acacia eremaea*
*Acacia acuminata* (jam)
*Acacia anthochaera*
*Acacia prainii* (Prain’s wattle)
*Acacia hemeteleos* (tan wattle)
*Acacia tetragonophylla* (kurara)
*Acacia colletioides* (Wait a while)
*Acacia ramulosa* (horse mulga)
*Hakea recurva* (needlebush)
*Hakea priessii* (standback)
*Grevillea pterosperma*
*Grevillea huegeli*
*Rhagodia drummondii* (lake fringing rhagodia)*

**Yellow sandy earth**

*Eucalyptus burracoppinensis* (Burra Coppin mallee)
*Eucalyptus ceratocorys*
*Eucalyptus subangusta*
*Eucalyptus leptopoda* (Tammin mallee)
*Eucalyptus stowardii* (fluted-horn mallee)
*Eucalyptus oldfieldii* (Oldfield’s mallee)
Eucalyptus hypochlamydea ssp. hypochlamydea
Eucalyptus kochii sub. plenissima (oil mallee)
Acacia resinomarginea (old man wodgil)
Acacia assimilis (fine-leafed wodgil)
Acacia stereophylla (wodgil)
Acacia neurophylia (wodgil)
Acacia anchochaera
Acacia coolgardiensis (sugarbrother)
Grevillea apiciloba var. apiciloba (black toothbrushes)
Grevillea excelsior (flame grevillea)
Grevillea obliquistigma
Grevillea candelabroides
Grevillea eriostachya
Grevillea paradoxa (bottlebrush grevillea)
Grevillea juncifolia (honeysuckle grevillea)
Grevillea petrophiloides (pink pokers)
Hakea invaginata
Hakea francisiana (pink spike hakea)
Calothamnus aridus
Calothamnus gilesii
Melaleuca cordata
Melaleuca conothamnoides
Melaleuca filifolia (wiry honeymyrtle)
Melaleuca radula (graceful honeymyrtle)
Banksia benthamiana
Allocasuarina acutivalvis (black tamma)
Allocasuarina campestris (tamma)
Allocasuarina corniculata
Santalum acuminatum (quandong)
Santalum spicatum (sandalwood)

Red loamy earth and red-brown hardpan-shallow loam

Eucalyptus yilgarnensis (yorrell)
Eucalyptus brachycorys (Cowcowing mallee)
Eucalyptus salmonophloia (salmon gum)
Eucalyptus loxophleba* (York gum)
Eucalyptus transcontinentalis (redwood)
Eucalyptus salubris (gimlet)
Eucalyptus torquata (coral gum)
Eucalyptus sheathiana
Eucalyptus celastroides ssp. virella (snap and rattle)
Eucalyptus brockwayii (Dundas mahogany)
Eucalyptus kochii ssp. plenissima (oil mallee)
Eucalyptus calycogona (Square-fruited mallee)
Melaleuca eleuterostachya*
Melaleuca uncinata* (broombush)
Melaleuca lateriflora*
Melaleuca pauperiflora ssp. fastigata
Melaleuca adnata* (boree)
Melaleuca acuminata*
Acacia acuminata (jam)
Acacia hemeteles* (tan wattle)
Acacia eremaea*
Acacia microbotrya* (manna gum)
Acacia tetragonophylla (kurara)
Acacia colletioides
Acacia prainii
Acacia obtecta*
Acacia ramulosa (horse mulga)
Hakea recurva (needle bush)
Hakea preissii* (standback)

Shallow soil over granite
Eucalyptus petrea (granite rock box)
Eucalyptus stowardii (fluted-horn mallee)
Eucalyptus capillosa (inland wandoor)
Eucalyptus subangusta (Mallee wandoor)
Eucalyptus loxophleba (York gum)
Eucalyptus kochii ssp. plenissima (oil mallee)
Melaleuca radula (graceful honeymyrtle)
Melaleuca filifolia (wiry honeymyrtle)
Melaleuca fulgens (scarlet honeymyrtle)
Calothamnus gilesii
Acacia graniticola
Acacia assimilis
Acacia neurophylla (wodgil)
Acacia acuminata (jam)
Allocasuarina acutivalvis (black tamma)
Allocasuarina campestris (tamma)
Kunzea pulchella (granite kunzea)
Calicopeplus ephedroides (broom spurge)
Grevillea rosieri
Grevillea tenuloba
Grevillea nana (dwarf grevillea)
Grevillea levis (kerosene bush)
Grevillea extorris
Santalum acuminatum (quandong)
Santalum spicatum (sandalwood)

Gravels
Eucalyptus leptopoda (Tammin mallee)
Eucalyptus stowardii (fluted-horn mallee)
Eucalyptus subangusta
Calothamnus gilesii
Calothamnus aridus
Acacia stereophylla (wodgil)
Acacia neurophylla (wodgil)
Acacia coolgardiensis (sugarbrother)
Melaleuca cordata
Melaleuca filifolia (wiry honeymyrtle)
Melaleuca radula (graceful honeymyrtle)
Melaleuca uncinata (broombush)
Melaleuca conothamnoides
Allocasuarina acutivalvis (black tamma)
Allocasuarina campestris (tamma)
Allocasuarina corniculata
Grevillea paradoxa (bottlebrush grevillea)
Grevillea petrophyioides (pink pokers)
Petrophile incurvata
Petrophile shuttleworthiana
Hakea invaginata

Yellow deep sand

Eucalyptus leptopodia (Tammin mallee)
Eucalyptus burracoppinis (Burrawoppin mallee)
Eucalyptus kochii ssp. plenissima (oil mallee)
Eucalyptus subangusta
Eucalyptus hypochlramydea
Eucalyptus camaldulensis (river redgum)
Eucalyptus oldfieldii (Oldfields mallee)
Banksia benthamiana
Acacia assimilis
Acacia resinomarginea (old man wodgil)
Grevillea excelsior (flame grevillea)
Grevillea eriostachya
Grevillea pterosperma
Grevillea apiciloba ssp. apiciloba
Hakea francisiana (pink spike hakea)
Hakea invaginata
Hakea scoparia
Hakea minyma
Calothamnus aridus
Santalum acuminatum (quandong)

Further information

The following publications are available from the Department of Agriculture:

Bankias for cut flowers Fact sheet series 1
Broombush Fact sheet series 1
Brown Mallett Fact sheet series 1
Flat topped Yate Fact sheet series 1
Jojoba Fact sheet series 1
Maritime Pine Fact sheet series 1
Oil Mallees Fact sheet series 1
Olives Fact sheet series 1
Paulownia Fact sheet series 1
River Red Gum Fact sheet series 1
Rock Sheoak Fact sheet series 1
Sandalwood Fact sheet series 1
Sugar Gum Fact sheet series 1
Wandoo Fact sheet series 1
Rate Relief for Privately Owned Bush Farmnote - farnbush series
Low Rainfall Farm Forestry for the Wheatbelt Farmnote - general
Conserving Farmbush through Subdivision Farmnote - general
Direct Seeding Native Trees and Shrubs 40/98 Farmnote - landcare case study
Direct Seeding of Native Plants for Revegetation 34/98 Farmnote - revegetation series
Site Assessment for Successful Revegetation 367/98 Farmnote - revegetation series
Site Preparation for Successful Revegetation 37/98 Farmnote - revegetation series
Weed Control for Successful Revegetation 47/98 Farmnote - revegetation series
Vegetation Buffer Zones Farmnote - revegetation series
Pioneer Plants in Revegetation Farmnote - revegetation series
Puccinellia - For Productive Saltland Pastures 1/99 Farmnote - salinity series
Eucalypts Oil Mallee 48/98 Farmnote - tree crop series
Tagasaste Farmnote - tree crop series
Southern Sandalwood: An Introduction 27/98 Farmnote - tree crop series
Specialty Timbers for the Western Australian Wheatbelt Farmnote - tree crop series
Direct Seeding Kit 3/98 Information kit
Managing Granite Outcrops 2/99 Information kit
Maritime pine 1/99 Information kit
Sandalwood 4/98 Information kit
Olive 3/99 Information kit
Managing Wheatbelt Woodlands Information kit
Jojoba 1/00 Information kit
Native Grasses 2/00 Information kit
The Value and Benefits of Healthy Farmbush Information kit
Oil Mallee 1/01 Information kit
Direct Seeding Presenters Pack Presenter kit
Rex 3/96 Revegetation Software

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2. Preparing sites for tree planting
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4. Pruning trees for sawlogs
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7. Timber Advisory Notes
8. Preserving round posts on the farm
9. Paulownia
10. Farm forestry definitions and designs
11. Benefits of farm forestry
12. Farmer experiences in farm forestry: D. and D. Jenkins, Bridgetown
13. Farmer experiences in farm forestry: J. and M. Frith, Bridgetown
15. Farmer experiences in farm forestry: N. and M. Klopper, Mayanup
16. Farmer experiences in farm forestry: G. and M. Rowan-Robinson, Bridgetown
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24. Farmer experiences in farm forestry: K. and J. Ritson, Boyup Brook
25. Farmer experiences in farm forestry: P. and J. Coffey, Kojonup
26. Parrot damage in agroforestry
27. Growing Tasmanian blue gum - overview
28. Growing Tasmanian blue gum for pulpwood - the profit potential
29. Rectifying parrot damage in eucalypts
30. Farmer experiences in farm forestry: E. and T. Hawter, Balingup
31. Farmer experiences in farm forestry: D. and L. Campbell, Scaddan, Esperance
32. Farmer experiences in farm forestry: R. and M. Johnstone, Neridup, Esperance
33. Farmer experiences in farm forestry: G. and J. English, Gibson, Esperance
34. Control of the Australian ringneck parrot by trapping in south-west Western Australia

Enquiries to Treenote Editor, Peter Watt on (08) 9368 3390
5.5 Economic impacts of salinity

Jason Kelly, Regional Economist, Geraldton District Office

Production trends

In response to depressed wool prices following the collapse of the reserve price scheme the cropped area of farms in this region has increased significantly to on average 71%. Farms now derive more than 80% of income from cropping.

Wheat is the dominant crop. Other crops include barley, canola and pulses. Sheep are a small but significant contributor to farm income (12%). Broadacre agriculture dominates the catchment, the enterprise mix varying between farms.

The number of properties and families residing in the Yarra Yarra has and continues to fall as farms increase size to compensate for escalating input costs and a declining resource base to maintain living standards. Farms in this region are the largest in the State.

Advances in low rainfall farming technology including tillage methods, fertilisers and herbicides has enabled farms to sustain productivity improvement, doubling average yields per hectare in the last two decades. High input farming is increasingly industry practise with producers chasing potential yields.

Herbicide resistance and land degradation are limiting further productivity gains in this region. Phase farming incorporating perennial pastures and livestock are progressively being adopted into farm system rotations; improved wool and meat prices are aiding this transition.

Catchment performance

The Yarra Yarra Catchment excluding Koorda and Wongan-Ballidu shires had a gross value of agricultural production (GVAP) of approximately $114m in 1996/97. Of this $97m was contributed by broadacre crops. Significant increases in GVAP over the period 1990/91 to 1996/97 followed the increase in cropping area.

Farm performance

Farms in the region according to survey data\(^1\) have the lowest debt and second lowest asset levels of all regions in WA at $118/ha and $902/ha respectively and highest equity levels at 87%.

Poor seasons have contributed to low yields and reduced returns to capital in recent years, recording an average return of -2.5% in the 2000/01 season.

There is significant variation in farm performance within the region with the top 25% when compared to the bottom 25% recording returns on capital of 5.3% (-11%), maintaining equity levels at 90% (82%) and reducing debt to $102/ha ($163/ha) per effective hectare. For this season the better performing farms tended to crop less land and run more sheep.

\(^1\) Bankwest Benchmarks 2000/01.
Table 18. Comparative analysis of < 350 mm district performance 2000/01. Source: Bankwest Benchmarks 2000/01

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<td>Operating cost/farm income (%)</td>
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<td>Grain % of farm income</td>
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<table>
<thead>
<tr>
<th>Cropping analysis</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total crop area (ha)</td>
<td>2494</td>
<td>2452</td>
<td>2692</td>
<td>2006</td>
</tr>
<tr>
<td>Crop % of effective area (%)</td>
<td>71%</td>
<td>72%</td>
<td>74%</td>
<td>70%</td>
</tr>
<tr>
<td>Machinery value ($/crop ha)</td>
<td>260</td>
<td>275</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crop yields</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat (t/ha)</td>
<td>1.31</td>
<td>1.72</td>
<td>1.38</td>
<td>1.33</td>
</tr>
<tr>
<td>Barley (t/ha)</td>
<td>1.42</td>
<td>1.56</td>
<td>1.40</td>
<td>1.55</td>
</tr>
<tr>
<td>Lupins (t/ha)</td>
<td>0.64</td>
<td>1.07</td>
<td>0.69</td>
<td>0.64</td>
</tr>
<tr>
<td>Chickpeas (t/ha)</td>
<td>0.32</td>
<td>0.81</td>
<td>0.37</td>
<td>0.22</td>
</tr>
<tr>
<td>Canola (t/ha)</td>
<td>0.49</td>
<td>0.79</td>
<td>0.50</td>
<td>0.57</td>
</tr>
</tbody>
</table>

Farms at risk

Production risk from salinity threatens farm and catchment viability and poses a major challenge in terms of management and amelioration. Land monitor data provides estimates for the extent of salinity encroachment before hydrological equilibrium is reached. An attempt at evaluating the cost of salinity has the following assumptions. That the 4-year average operating profit for the catchment ($37/ha) represents the cost once an area becomes saline and is taken out of production, that the spread of salinity in the valley floors is linear over a fifty year period and that this area is immediately unproductive. With this in mind calculations show that the current cost of saline areas to farmers in the catchment is around $3m. The increase in saline areas could be costing the catchment over $10m dollars in lost production annually 50 years from now. Accounting for the time value of money gives a net
present value of over $60m, the cost of salinity to the catchment in today’s dollars over the period analysed. This however only looks at the on farm costs. The cost to the communities and towns will inflate this figure many times.

**Infrastructure at risk**

Shallow watertables have a significant impact on the life of roads, railways and infrastructure within towns. Dames and Moore (2001) identified the likely increase in construction and maintenance costs associated with the effects of shallow watertables. These costs vary depending on the type of road and are listed in the table below.

**Table 19. Road construction and maintenance costs, Dames and Moore (2001)**

<table>
<thead>
<tr>
<th>Construction costs (per km) 000s</th>
<th>Additional costs (per km) 000s</th>
<th>Annual maintenance cost (km/yr)</th>
<th>Additional maintenance cost (km/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major State highway</td>
<td>$390-400</td>
<td>$71-115</td>
<td></td>
</tr>
<tr>
<td>Standard sealed country road</td>
<td>$100</td>
<td>$25-35</td>
<td>$2,500</td>
</tr>
<tr>
<td>Minor sealed country road</td>
<td>$100</td>
<td>$25-35</td>
<td>$1,500</td>
</tr>
<tr>
<td>Gravelled road</td>
<td>$7</td>
<td>$3</td>
<td>$800</td>
</tr>
</tbody>
</table>

**Table 20. Annual cost of shallow watertables affecting roads in the Yarra Yarra**

<table>
<thead>
<tr>
<th>Description</th>
<th>km</th>
<th>Additional construction cost* 000s</th>
<th>Annuity** 000s</th>
<th>Additional maintenance cost* 000s</th>
<th>Total due to shallow watertables 000s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roads currently affected</td>
<td>385</td>
<td>9,125</td>
<td>861</td>
<td>146</td>
<td>1,007</td>
</tr>
<tr>
<td>Roads at risk (includes affected)</td>
<td>1,120</td>
<td>28,000</td>
<td>2,643</td>
<td>448</td>
<td>3,091</td>
</tr>
</tbody>
</table>

* Assumes standard sealed country road with life expectancy halved. All roads at risk affected within 20 years.
** Discount rate 7% over 20 years.

The above table illustrates the potentially sizeable costs associated with shallow watertables if roads need to be resurfaced. While this is effective in demonstrating the impact of shallow watertables it is more likely that additional maintenance costs would be representative of the burden to local and State governments from rising watertables. There will also be substantial costs to those towns situated in valley floors within the catchment, this has not been included here. Dames and Moore (2001) contains a detailed evaluation on the cost to regional towns of shallow watertables.

**Economics of options**

There are a number of options for managing shallow watertables presented throughout this document encompassing water use, water surface management, engineering methods, revegetation, soil treatment, etc. No attempt is made here to evaluate each of the options suggested, as the relevance of each will depend on the situation being analysed, the farm, its capital structure and the preferences of the individual. The process is what's important and should involve a comparison of the
various options. As many of these will take time to implement, a cash flow budget that incorporates the following is recommended:

- Identify the establishment costs.
- Identify ongoing maintenance costs.
- Determine the benefits.
- Incorporate into a cash flow.
- Discount to account for the time value of money.
- Compare the options on a net present value basis.

For further information contact a farm management economist in your regional office of the Department of Agriculture.
5.6 Social impacts of salinity

*Emma Scotney, Project Manager, Moora District Office*

The Department of Agriculture aims to support landholders and the wider rural community in their search for information about how to manage salinity on their farm or within their town. It is also researching what the impacts of salinity may be on the way of life of rural communities.

The Department can assist landholders requiring further information and follow up after the Rapid Catchment Appraisal by acting as a sign post. We can put you in touch with the right person within the Department of Agriculture or other relevant government organisations in the region. We can also provide information about relevant funding opportunities and support in writing applications or making a sponsorship proposal to local businesses keen to support sustainable land management.

Out team conducted a survey investigating some of the concerns and consequences of salinity as perceived by landholders attending the Rapid Catchment Appraisal in your area. Some of the key issues were:

- reduced productivity;
- increased costs;
- visual aspect of towns and surrounding areas;
- loss of people from towns;
- decreased value of farm land;
- loss of productive agricultural land;
- damage to roads, assets and infrastructure;
- loss of farmer income;
- loss of biodiversity and fauna;
- increased farm size pushing smaller landholders out - especially those with salt-affected land;
- cost of carrying out landcare is increasing;
- change in lifestyle;
- decrease in export potential.

If you require any information or support in relation to follow up after the Rapid Catchment Appraisal, please contact Jessica Johns at Three Springs (9954 3333) or Amelia McLarty at Wongan Hills on 9671 1664.
6. References


