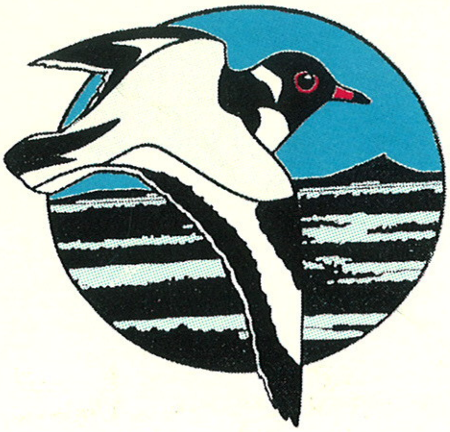
BATIN!

Lake Warden



Recovery Farm Kit

Prepared by

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As part of the Lake Warden Recovery Project

For the Department of Conservation and Land Management
January 2000

The front cover and headers of this document display a symbol for the Lake Warden Catchment. The Hooded Plover is a water bird that relies on the Lake Warden Wetlands for food and nesting sites. The view in the background of the symbol is from 6 Mile Hill looking east over the Lake Warden Wetland System towards Cape Le Grand. The symbol was designed by CALM's Esperance District Interpretation Officer.

Acknowledgements

The Lake Warden Recovery Project is the result of the catchment community and government agencies working together for the benefit of the Lake Warden Wetlands and community prosperity.

The Project has been funded by the Department of Conservation and Land Management's (CALM) Nature Conservation Division through the State Salinity Action Plan.

CALM would like to thank all farmers who participated in the Farm Survey, sharing invaluable local expertise about their properties across the catchment. The hospitality towards CALM staff during the farm survey is very much appreciated.

The Stakeholder Steering Committee provided valuable direction for the development of the Recovery Farm Kit in accordance with the Recovery Catchment Plan. CALM would like to thank the Neridup Creek Soil Conservation Group, Wittenoom Hills Landcare Group, Coramup Creek Catchment Group and Esperance Land Conservation District Committee for their support.

The technical support from the Esperance Catchment Support Team has been instrumental in the development of this document. CALM thanks the interagency support from Agriculture Western Australia, (Ag West) Esperance and the Water and Rivers Commission, Albany. Thankyou to all those involved in this project.

Executive Summary

The Lake Warden Catchment is classified a Recovery Catchment under the State Salinity Action Plan. The Lake Warden Wetland System has conservation values of international significance and is under threat from salinity, waterlogging, and eutrophication. These threats result from surrounding catchment landuses and must be addressed at a catchment scale to conserve the wetland's conservation values for future generations.

83% of the catchment is farmland and farmers are the most widespread stakeholders across the catchment. The Lake Warden Catchment recovery project involves applying catchment scale strategies as outlined in the Lake Warden Catchment Recovery Plan, at a farm scale using Recovery Farm Kits as a tool for implementation.

The Recovery Farm Kits are targeted at about 120 farmers and cover over 200 property locations. The farm-specific maps and the Farm Kit information are designed to be used by farmers as a mechanism to help support their decision-making through a farm planning process.

Farmers can use the Farm Kit information to:

- plan on-farm nature conservation programs,
- diversify farming production with high water use farming systems,
- increase their understanding of landscape processes; and
- apply for financial assistance from various funding bodies.

Contents

Introduction

The Lake Warden Catchment Recovery Project aims to provide for the maintenance and enhancement of natural diversity and prosperity of the community for the Lake Warden Catchment.

The objective of the Recovery Project is to protect and enhance the Lake Warden Wetland System through sustainable catchment management implemented at a farm level.

The Recovery process is an integrated approach involving:
- Maintaining and enhancing natural systems; and
- Increasing water-use throughout the landscape.

What is a Recovery Catchment?

The State Salinity Action Plan aims to address the threat of salinity to agricultural land, water resources, natural biodiversity, infrastructure, recreation, tourism, families and communities throughout the state of Western Australia (State Salinity Council 1998).

The State Salinity Action Plan addresses the threat of salinity at a catchment scale by the means of two main mechanisms:
- Focus Catchments; and
- Recovery Catchments.

Focus catchments are those catchments where productive agricultural land is the main asset at risk from salinity and where it is largely within the means of the landholders to implement the changes required to protect or restore the land (SSC 1998). The Esperance Catchment Support Team supplies technical expertise and resources to help focus catchment groups address issues that are relevant and important to their catchment.

Recovery catchments are those where major and high priority public resources are at risk (SSC 1998). The Lake Warden Wetland System is a high priority public resource currently at risk from salinity, waterlogging, eutrophication and disease.

The Lake Warden Wetlands are linked to the rest of the catchment. The Esperance Lakes Nature Reserve Management Plan also states the need for integrated catchment planning outside of the CALM managed reserves for the future well being of the wetlands.

The impacts of salinity do not discriminate between agricultural land and natural biodiversity. During the initial stage of planning, the Lake Warden Catchment will receive the technical support of that given to focus catchments to address agricultural production issues, which are linked to the health of the Lake Warden Wetlands.

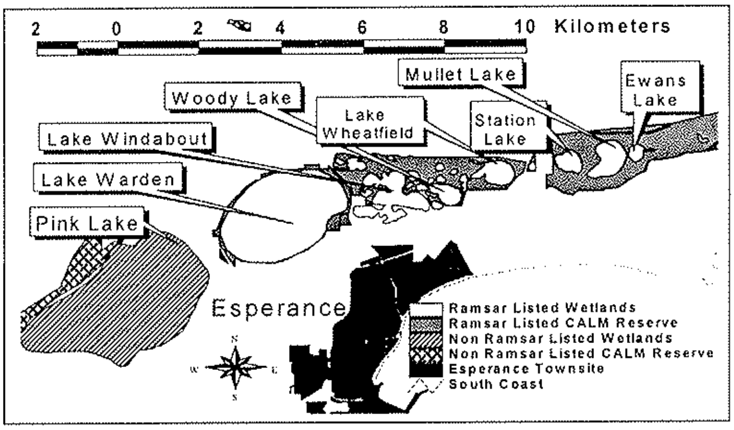
Why are the Lake Warden Wetlands Internationally Significant?

The Lake Warden Wetland System is one of nine wetland areas in Western Australia recognised as wetlands of international importance under the Ramsar convention. The Ramsar convention is an intergovernmental treaty, which provides for the international cooperation for the conservation of wetland habitats (Haberley 1999).

The Ramsar wetland system comprises Lake Warden, Woody Lake and a portion of Mullet Lake Nature Reserves. Shark Lake, Pink Lake and the remainder of the Mullet Lake Nature Reserves are not part of the Ramsar wetland system (Haberley 1999).

The Lake Warden System gained Ramsar listing because of its habitat importance to migratory water birds and for being an excellent example of a south coast wetland. Under this convention CALM has special obligations to the conserve these wetlands.

Figure 1. The Lake Warden Wetland System



Source: CALM, 1999, Tilo Massenbauer, Recovery Catchment Officer

Why is CALM the Coordinating Agency?

The Lake Warden Catchment, being designated a Recovery Catchment as a result of its natural diversity, means that CALM is the coordinating Government Agency. CALM has a statutory responsibility for all native flora and fauna throughout the state. CALM managed estate, such as the Esperance Lakes Nature Reserves, and other remnant vegetation located outside CALM managed estate are important for nature conservation throughout the catchment.

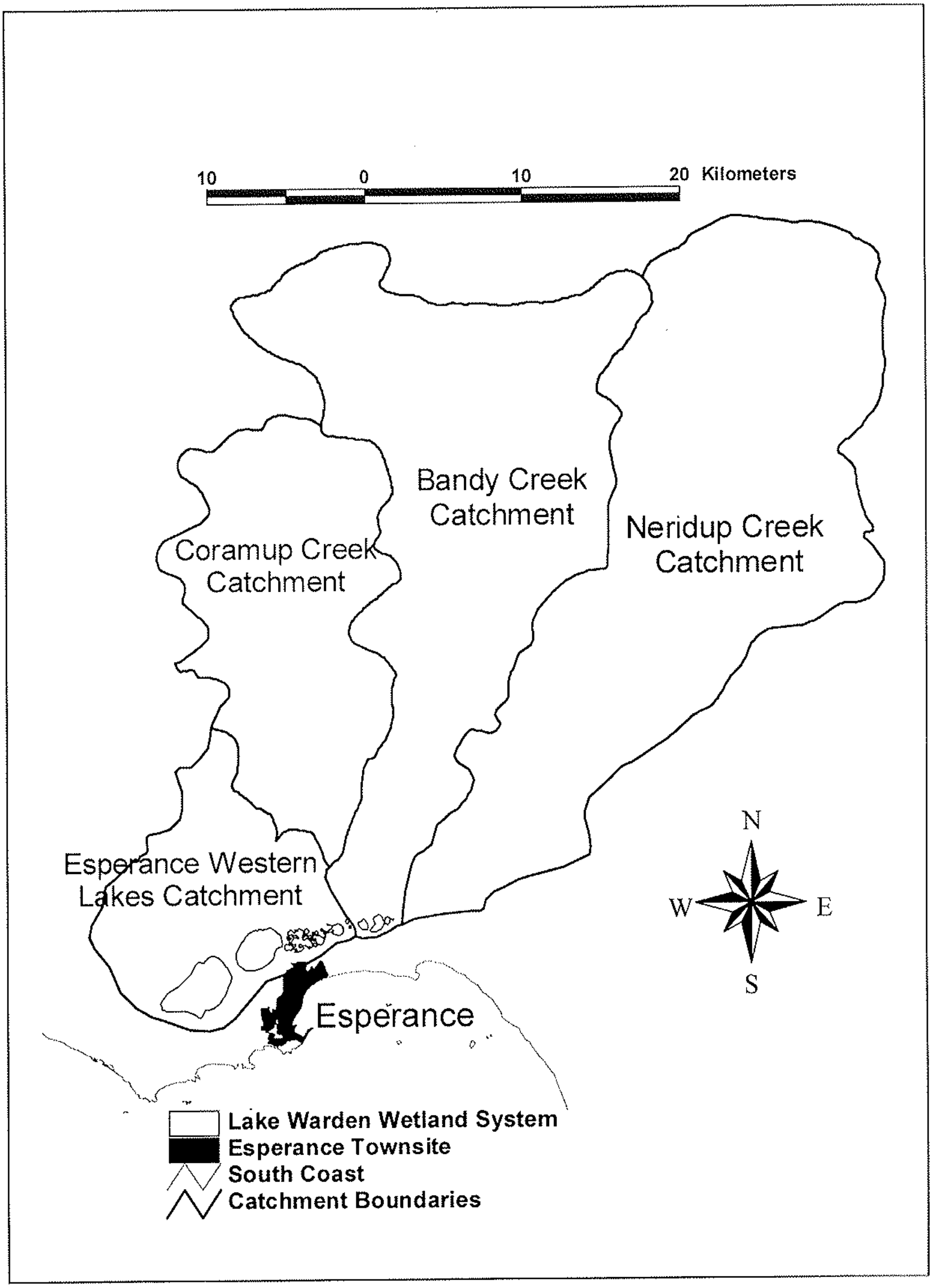
The long-term future of the reserves, other remnants, and their plants and animals depends on how the surrounding agricultural lands are managed.

Table 1: Coordinating Agencies for Recovery Catchments

Public assets to be protected -type of recovery catchment-	Co-ordinating Agency
1. Natural Diversity	CALM
2. Water Resource	Water & Rivers Commission
3. Rural Infrastructure	
• Towns	Ag West
• Main Roads	Main Roads WA
• Other	Asset owner/manager

Source: Western Australian Salinity Action Plan Draft Update, 1998.

Figure 2: The Lake Warden Catchment



Source: Data supplied by CALM, Information Management Branch.
Figure produced by Tilo Massenbauer, CALM Recovery Catchment Officer.

Lake Warden Catchment Facts

Table 2. Facts about the Lake Warden Catchment

Facts about the Lake Warden Catchment:

- There are approximately 120 farmers in the Recovery Catchment.
- The total area of the catchment is 171000ha.
- Farmland area totals 142 500ha (83% of the Catchment is zoned farmland).
- Less than 5% of its original native vegetation is remaining on farmland.
- Farmers have revegetated 1900ha with native species and 2400 ha with farm trees.
- A total of about 2.5% of the catchment has been revegetated with natives and farm trees.
- Currently about 3000 ha of remnant vegetation has been fenced off from stock. This equates to about 40% of on-farm remnant vegetation.
- The catchment is susceptible to waterlogging and secondary salinity.
- There are four main sub-catchments:
  - Esperance Western Lakes Catchment 13500ha
  - Coramup Creek Catchment 31000ha
  - Bandy Creek Catchment 50500ha
  - Neridup Creek Catchment 62600ha
- 13000 ha (7.6%) of the catchment is CALM managed estate.
- The catchment drains into the Ramsar listed 'Wetlands of International Importance' Lake Warden Wetland System.
- The Lake Warden Wetlands are listed on the National Estate Register.
- The Catchment contains 'Conservation Category Wetlands' (Benje Benjenup Lake).
- Mt Burdett Nature Reserve and the Esperance Lakes Nature Reserves are used for tourism and recreation.
- The Wetland habitat protects 17 waterbird species cited in the:
  - Japan - Australian Migratory Birds Agreement (JAMBA) &
  - China - Australia Migratory Birds Agreement (CAMBA).
- The wetlands contain key bird breeding sites, especially for the Hooded Plover and Banded Stilt.
- The catchment contains two species of declared rare flora and thirty-four priority flora species.
- Shark Lake is an important fresh water wetland.

Information Sources:

- Gee S and Simons J, 1997, '*Catchments of the Esperance Region, Western Australia*', Resource Management Technical Report 165, Ag West.
- CALM (1999) Esperance Lakes Nature Reserves Management Plan.
- CALM (1999) Tilo Massenbauer, Recovery Catchment Officer.

Five Strategies for Reducing Recharge

There are five strategic steps we can take to slow or even reverse rising watertables across the Lake Warden Catchment to protect the Lake Warden Wetlands and farmland:

1. Increase water use by conventional annual crops and pastures.
2. Increase water use by introducing perennial species.
3. Improve protection, management and enhancement of remnant native vegetation.
4. Collect and re-use or dispose of surface water.
5. Drain or pump and re-use or dispose of groundwater.

(George et al 1997)

The Farm Kit focuses on implementing strategies 2 and 3 at a farm scale. These are priority strategies in the Lake Warden Catchment Recovery Plan because they are long-term strategies that we as a catchment community need to start implementing today.

Strategy 1 is a water use strategy, which can be easily implemented into your existing farm practices. Even though this may be potentially the easiest of strategies to implement, its limitation is that the reduction required in groundwater recharge across the catchment will not be met. We need to change and diversify our landuse practices with an integration of all five strategies taking into account our social, economic and environmental values.

It is still important to recognise the role that annual pastures and crops can play in increasing water use. Even though the increased water use may be small it will apply over a large part of the landscape. Any strategy used to improve the growth of annual plants should maximise water use of these plants. By farming to land management units, improving agronomy, removing impediments to root growth and improving grazing management, water use can be maximised (Bowyer pers.com 1999).

An example is using serradella as an annual pasture species. Serradella is deeper rooted and has a longer growing season. This will allow it to dry a greater depth of the soil profile. Less moisture in the soil will result in less recharge (Bowyer per.com 1999).

Remnant vegetation protection and management and using perennials across more of the landscape will be the further focus of the Recovery Farm Kit.

What is a Recovery Farm Kit?

The Recovery Plan for the Lake Warden Catchment addresses catchment issues at a catchment scale (CALM, forthcoming 2000). The Recovery Farm Kit is a mechanism for implementing catchment strategies at a farm scale.

The Recovery Farm Kit is a tool to assist you in making decisions relating to on-farm:
Natural diversity enhancement:

- Prioritising remnant vegetation for protection and enhancement; and
- Revegetation Planning (Corridor linkages, buffering remnants); and

High Water Use Farming Systems:

- Identify high recharge/discharge areas, and associated soil types; and
- Detailed land use options for differing soil types, drainage, and rainfall conditions.

The Recovery Farm Kit comprises of farm scale maps, which are supplied to individual farmers. You will receive maps for properties under your management. The information supplied contains natural resource overlays and farm recovery actions developed with the farmer during CALM's natural resource survey process.

The farm map information can be used to help determine high water use options and natural diversity enhancement options specific for that property location. It is your decision to implement the recovery options available for your property.

Using Your Farm Maps for Planning

The A3 maps of your farm locations provided in this kit is the information base on which you can make decisions about where you would like to revegetate or where to implement high water use farming systems.

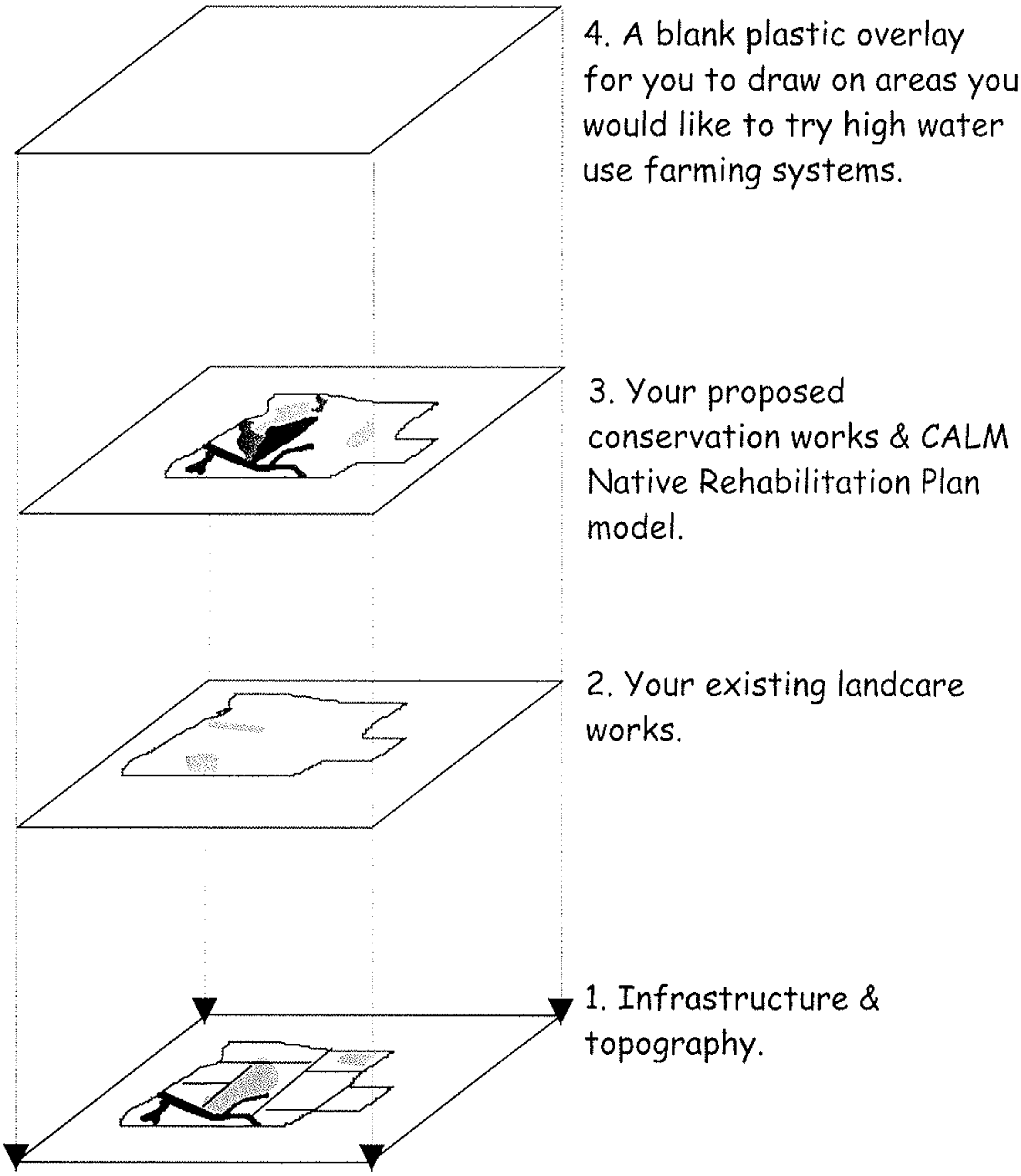
The maps provided for each property location under your management contains three layers of information relating to landuse, conservation, landscape and infrastructure.

Table 3: Layers of information supplied on your farm maps.

Natural Resource Management Information	Data Source
Paper Base Map 1:	
• Catchment Boundary	Ag West
• Location Boundary	Ag West
• Paddock Fence lines.	CALM Farmer Survey
• Road	Ag West
• Drainage	Ag West
• Lake	Ag West & CALM
• Swamp	Ag West & CALM
• Winter Wet Area	Ag West
• Soils;	Ag West
• Salinity;	CALM Farmer Survey
• Waterlogging;	CALM Farmer Survey
• Both Salinity and waterlogging;	CALM Farmer Survey
Transparency Overlay Map 2	
• Unfenced Remnant Vegetation;	CALM Farmer Survey
• Native Revegetation;	CALM Farmer Survey
• Farm Trees;	CALM Farmer Survey
• Fenced Remnant Vegetation	CALM Farmer Survey
• Woody Vegetation	CALM
Transparency Overlay Map 3	
• Native Rehabilitation Plan;	CALM
• Farmer Proposed Revegetation;	CALM Farmer Survey
• Farmer Proposed Remnant Fencing;	CALM Farmer Survey

A fourth clear plastic overlay is supplied with your farm maps so that you can manually draw in areas that can support high water use farming systems. These options are determined by using the High Water Use Tables. This overlay is a basic farm plan map.

Figure 3: Concept diagram of Recovery farm maps



To use the Farm Kit for planning you are required to have a basic understanding of the information supplied on your farm maps. The Appendices of the Farm Kit is designed to provide resource information to help you develop the basic understanding required to effectively use your farm maps and kit to make landuse decisions.

A basis to understanding soils, hydrology, nature conservation, water quality, salinity and high water use farm systems is supplied in the appendices of your Farm Kit. This information is specific to the Lake Warden Catchment.

Ag West and CALM will provide workshops on how to use the Recovery Farm Kit to help make land management decisions specific to your property and for the benefit of your neighbours and the Catchment.

The two main components of the farm kit rely on the information supplied on your farm maps and the way you interpret the information. To help with the interpretation is:

- A Native Rehabilitation Plan layer of information coloured in yellow on your farm map that helps identify initial conservation potential for proposed revegetation; and
- High water use production tables that offer landuse options in different parts of the landscape.

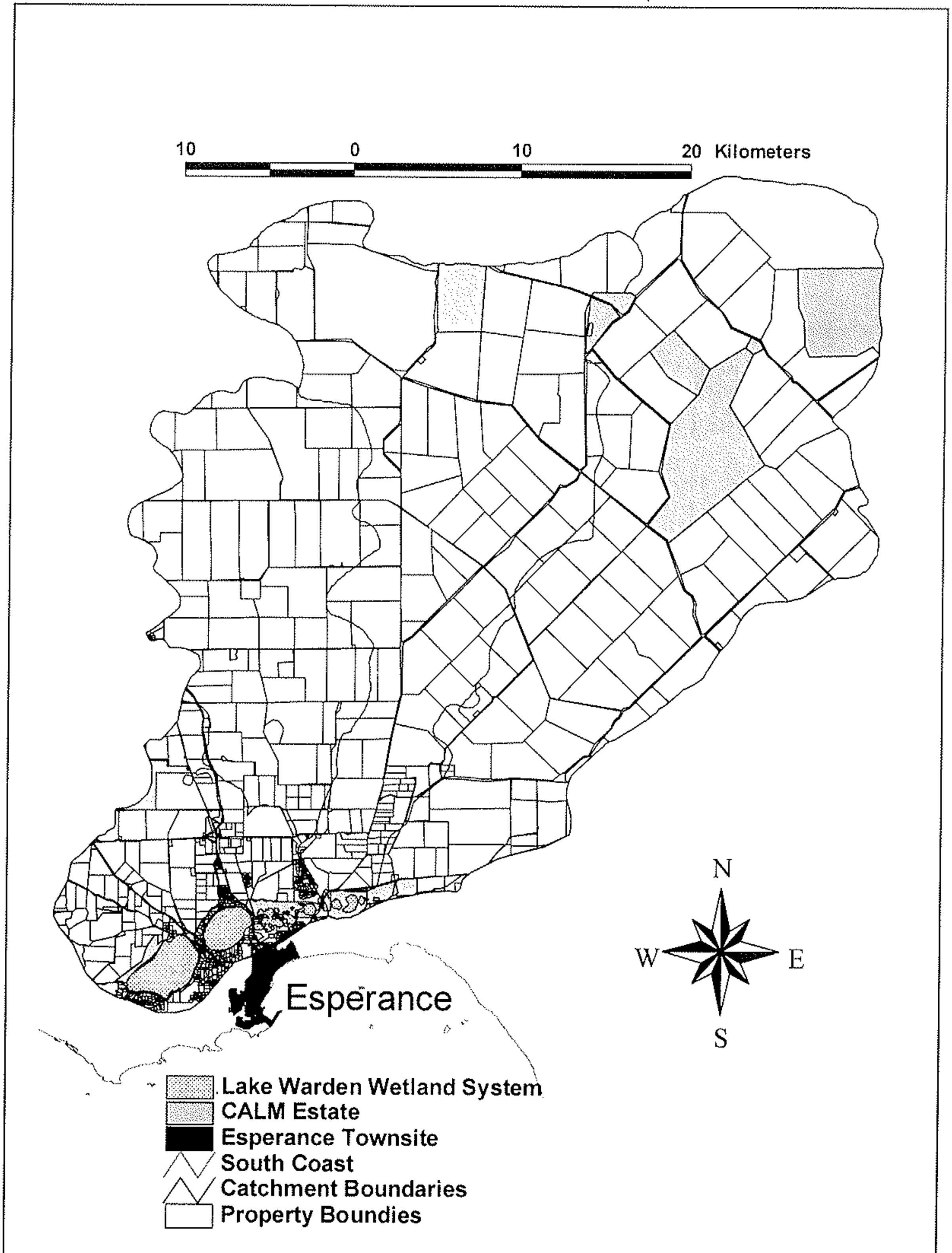
These two components are described in further detail.

Firstly, it is important that you understand how to use your farm maps to plan on ground works for your property. To do so you will need to know how to measure distances and areas from your farm maps.

Figure 4: Where does your farm fit into the catchment picture?

You should attempt to highlight the location of properties that you manage on this map to identify where you fit into the catchment landscape (Upper, middle or lower Catchment).

Source: Data supplied by CALM, Information Management Branch.
Figure produced by Tilo Massenbauer, CALM Recovery Catchment Officer.



How to Measure Distances and Areas on Your Farm Maps.

Measuring Distances

When planning nature conservation, farm forestry or fodder shrub revegetation works, you will need to measure distances to determine fencing materials required to keep out stock.

At the bottom of your property base map there is a scale. This scale is the ratio of one unit of length on the map to the corresponding length on the ground. For example, for a scale of 1:10 000, one millimetre on the map represents 10 metres, on the ground.

The formula that you should use to find how many metres for each 1 millimetre you measure is:

$$\text{For every 1 mm measured} = \frac{\text{Scale}}{1000\text{ m}}$$

For example: a scale of 1:20 000

$$\text{For every 1 mm measured} = \frac{20\,000}{1000\text{ m}}$$

$$= \mathbf{20\ m}$$

From the example above, if you measure **25 mm** on the map that you wish to fence, the corresponding length of fence required on the on the ground should be 500m. This comes about by calculating the following:

$$25 \times 20\text{ m} = 500\text{ m}$$

As a quick reference, which may save you having to do the above formula, the following table has been developed.

Scale	mm	cm
1:5 000	5 m	50 m
1:10 000	10 m	100 m
1:15 000	15 m	150 m
1:20 000	20 m	200 m
1:25 000	25 m	250 m

Measuring Areas

In the A3 plastic sleeve attached to this kit is a transparent dot grid. The dot grid is a relatively accurate method of measuring areas.

Area is calculated using the dot grid by:

1. counting how many dots are located within the area to be measured;
2. then multiply the number of dots by the appropriate hectares/dot figure; and
3. the result being the area in hectares.

This hectares/dot figure is located within the table at the top of the dot grid and varies for each of the different scales. The number located under your map scale in the table is the hectare/dot figure that you should be using.

For example: a scale of 1:20 000, 74 dots are counted in a waterlogged area that you would like revegetate.

Area = 74 x hectares/dot
= 74 x 1
= 74 hectares

The table at the top of the dot grid indicated that at a scale of 1:20 000 there was 1 hectare for each dot. Hence 1 became the multiplying factor. The above process applies to different farm map scales. Scales on your farm maps will range between 1:5000 to 1:25 000.

Handy Tips For Measuring Areas

1. Drop the grid randomly over the area to be measured. The theory of the system is that the number of squares along the border that are counted as in will balance those counted as out. The average will be very close to the real area.

2. Lining the grid up with a straight border of the area will cause large errors in the answer.

3. Use grids back to front to extend the life of the dot grid, that is, dots are less likely to rub off.

4. For each area repeat the measurement a few times. If any large variations occur, take an average.

5. Count dots on the line as in. Areas should not be greatly affected if they are counted as out. It is important to be consistent.

6. Write your scale and the area per square on a separate sheet of paper.

7. HAVE A GO AND START USING YOUR MAP

On Farm Nature Conservation Planning

How will work I do benefit me rather than just my downstream neighbour?

Nearly all revegetation work has on farm benefits. Most salinity benefits will be local, waterlogging is local, wind erosion is local, livestock and crop shelter is local. The sum of these local benefits across the landscape provides extra, community benefit.

Native Rehabilitation Plan

The Native Rehabilitation Plan (NRP) zone has been modelled for the Catchment to provide a preliminary guide for you to prioritise native revegetation works.

Step 1: Preliminary Revegetation Planning using the Native Rehabilitation Plan.

The NRP zone is the yellow shaded area on the third transparent overlay map for your property. Where your proposed native revegetation (Transparency Map 2) intersects with this zone, the proposal then has initial conservation and strategic hydrological benefits for the catchment that need to be further explored.

You can identify revegetation projects for your properties by simply looking at the farm maps to see if your proposed works intersect (overlap) with the Native Rehabilitation Plan.

Step 2: Applying the Nature Conservation Strategy Guidelines

The next planning step is for the Recovery Catchment Officer and you to apply more specific conservation guidelines set out in the Conservation Strategy of the Recovery Catchment Plan. This allows both you and CALM to maximise the nature conservation and water use benefits from the proposed works.

Species selection, fauna habitat requirements, size and shape of remnant vegetation to be linked or buffered need to be assessed in greater detail at this stage of the planning process using the Conservation Strategy guidelines.

Step 3: Negotiation and Consultation

The final process is for you to decide whether you want to implement the on ground works for your proposal and what resources are available. This process involves negotiating what assistance CALM can supply to meet your needs and what assistance is available through other funding sources, such as the Natural Heritage Trust. The negotiation with CALM takes place between you and the Recovery Catchment Officer.

If you have implemented high water use production options on the upper recharge areas of a revegetation proposal, then greater subsidy of the conservation works can be negotiated. This is important for successfully revegetating discharge sites with local native species and determining your commitment to increasing water use on your property.

Appendix 7.0 is a summary of the Nature Conservation works proposed for the Lake Warden Catchment by farmers. Figure 5 is the step-by-step decision-making process for determining the prioritising of your proposed revegetation projects.

Figure 5: Native Revegetation Decision Making Process

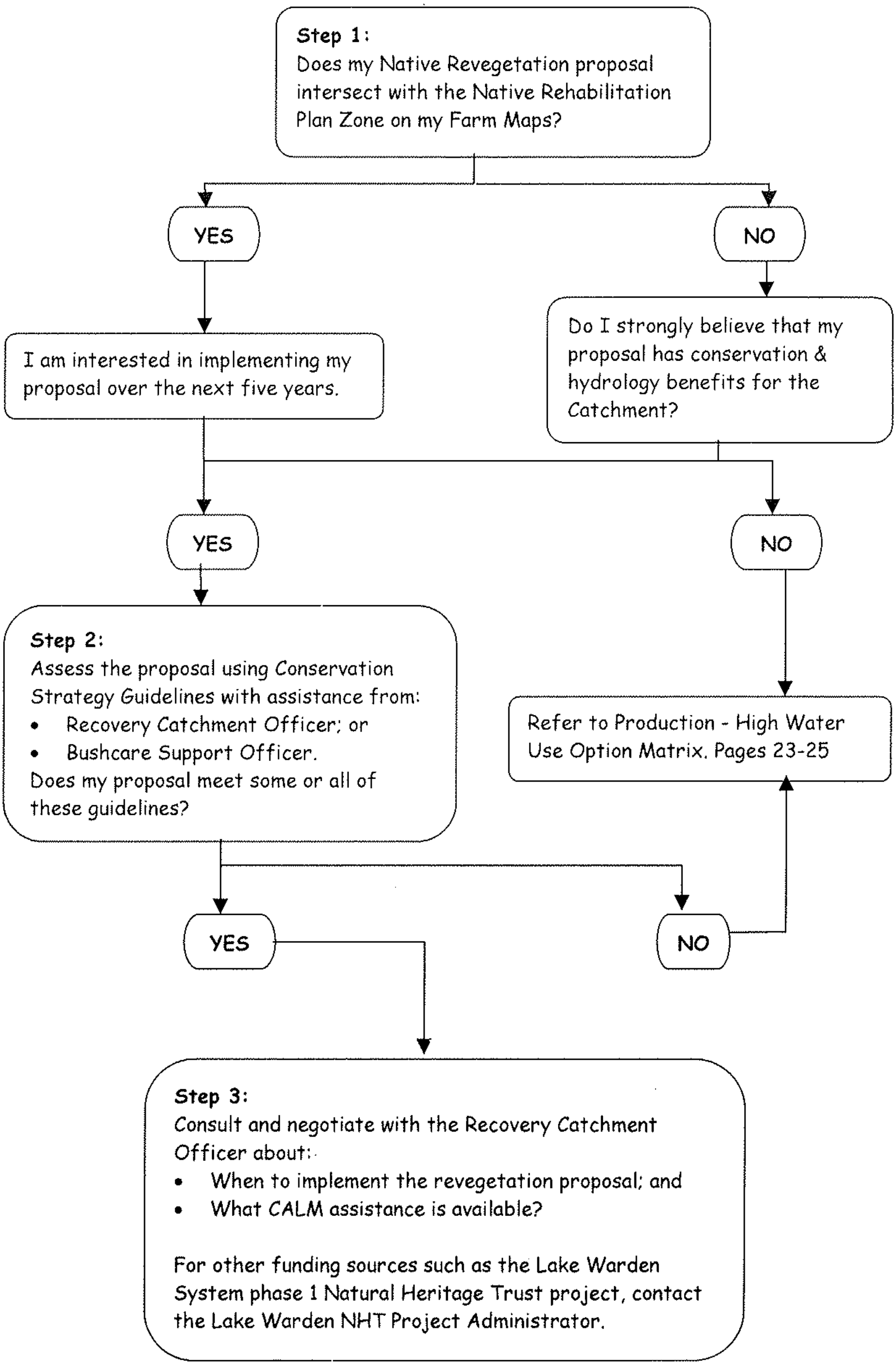
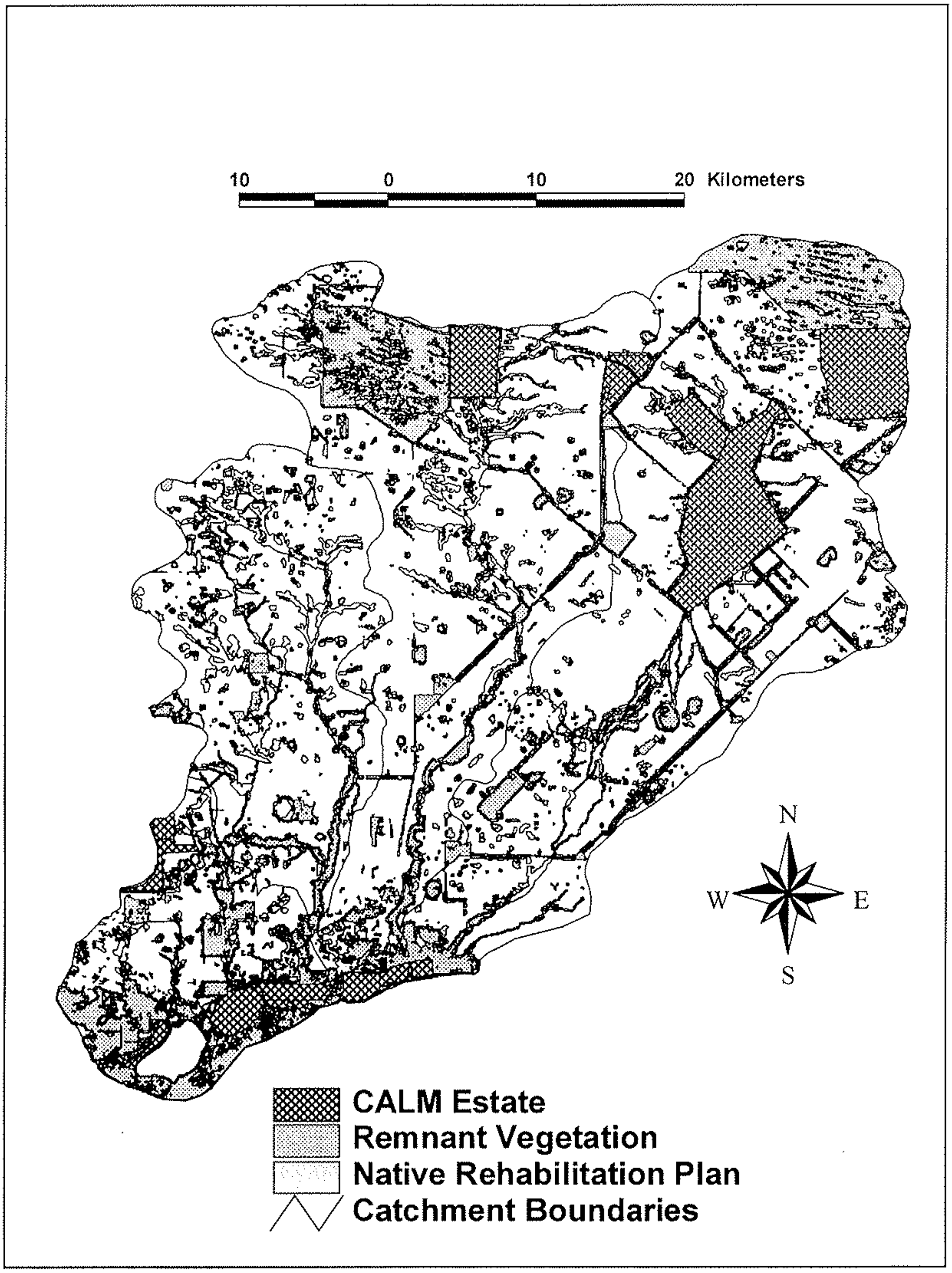


Figure 6: Lake Warden Catchment Native Rehabilitation Plan and Remnant Vegetation Cover.

Source: base data supplied by CALM information services branch and CALM Esperance. Map and Native Rehabilitation Plan developed by Tilo Massenbauer, CALM Recovery Catchment Officer.



On farm High Water Use Production

Increasing water use across the landscape is a very important component of the Recovery Project. Native revegetation will only cover a small area of the catchment targeting marginal agricultural land.

About 83% of the catchment is zoned rural land and over 95% of this area has been cleared for agricultural production. By clearing the deep-rooted perennial native vegetation and replacing it with shallow rooted annual crops and pastures, an imbalance in the amount of water that seeps into the ground has occurred. This has resulted in water tables rising, bringing stored salts to the soil surface. (For further information about hydrology and salinity processes, refer to appendix 5.0, page 42.)

Farm diversification targeting economically viable high water use farming systems across landscapes is important for the future well being of farm land and remnant vegetation. This part of your farm kit offers the options currently available for increasing water use on your farm.

These options are presented in three tables and relate directly to the information on your farm maps. The land use option categories with production benefits are:

- Table 1 (Page 22). **Farm forestry**
- Table 2 (Page 23). **Perennial pastures**
  Fodder shrubs
- Table 3 (Page 24). **Intensive Agriculture**
  Opportunistic (Summer) cropping

To be able to apply the high water use tables you need to understand the landscape information on your farm maps. The landscape information affects what type of farm system you can implement in the paddock.

In your high water use table there are three main Establishment Landscape Variables being soil landscape type, soil drainage, and rainfall.

Rainfall

Specific Rainfall information for your property is not included in the Farm Kit. You are considered the best source of information for knowing what the annual rainfall is on your property.

The rainfall classes that cover the variability across the catchment in the table are:

- 350-400mm
- › 400-450mm
- › 450-500mm
- › 550-600mm

Rainfall for your property will affect what landuse options are available to increase water use.

Soil Drainage

Soil drainage is classed in the high water use tables as:

- Well drained;
- Waterlogged (Includes seasonally and permanently waterlogged.); and
- Saline (Requires you to site assess the concentration of salinity.).

Waterlogged, winter wet, and salt affected sites on your property are displayed on your farm maps as different colour filled areas. Refer to the map legend for the colour code given to these areas.

Soil Landscape Type

The codes supplied in this component of the table represent part of the Soil Landscape Information Package (SLIP) developed for the catchment by Brendan Nicholas (Ag West Esperance). These codes are referred to as a SLIP unit. The SLIP units represent dominant soil groups and related landforms throughout the catchment.

The dotted lines on your farm base map represents a SLIP area. Within this area is a code, for example 245Es_2. The area that you may be interested in implementing a high water use system will occur on one of these soil landscape units. Once you have identified the soil landscape unit on your farm map, you then apply it to your high water use table to see what landuse options are currently available. In the tables the map unit code is shortened, for example 245Es_2 is Es2. Table 4 on page 21 provides a summary explanation of the soil landscape codes. (Appendix 1.0 and 2.0 describe the main soil types for the Lake Warden Catchment, Sandplain and Mallee in detail)

How do I use the high water use tables?

The high water use tables are only a preliminary guide to planning where a high water use option could occur on your farm. A ✓in the table means that yes it is likely that a landuse option can be established under this condition. A ***C*** in the table means that conditions apply to establishing a landuse. For example, concentration of salinity, soil type and irrigation requirements are limiting establishment conditions.

Once you have identified the areas and water use options suitable for those areas on your farm using the tables then the next step is to contact the relevant technical expertise. The contact people for further expertise required is supplied in table 5.

The following example is a step-by-step guide to applying your farm maps to the high water use tables to help plan increasing water use on-farm. CALM and Ag West will also conduct workshops to show you how to gain maximum benefit from your farm kit.

High Water Use Scenario - Waterlogged paddock.

On your farm map you have a waterlogged area in the middle of the paddock. This area was once dry but has become seasonally water logging over the last ten years. It is costing you production and has no potential conservation benefit if revegetated with natives. What are the short and long-term production based landuse options available for this site and the surrounding recharge area?

Example 1
The first step is to call on your local knowledge of the history of the site. You have identified that this site was once productive cropping country. Now you need to determine why this site has become waterlogged and if the problem can be managed on your property. Where do you believe the water is coming from?

The second step is to record what information you have on your farm maps and local knowledge as a summary.

Rainfall:	430mm
Soil Landscape:	245Es_1 or Es1
Drainage:	Waterlogged

Table 4 shows that 78% of the landscape unit Es1 is a grey deep sandy duplex soil. There is a strong possibility that the waterlogging is a result of water perching on the clay layer of this soil type during the winter months.

The next step is to apply the summary information to the Water use tables. Look for landuse options that can occur in a waterlogged site, a 450mm rainfall area and on an Es1 landscape. For a potential land use option, a ✓ or **C** must correspond with both the Landuse option and Establishment Landscape Variable. In this waterlogged scenario the following suitable options are derived from the high water use tables on pages 22 to 24:

- Tall wheat grass as a perennial pasture or *Acacia saligna* as a fodder shrub.
- Sorghum as an opportunistic crop, which water logging is conditional (**C**) to establishment.
- No current farm forestry options, or intensive agricultural options are available for this site.

Example 2
On the northern half of the paddock, there is a change in the soil landscape unit. The unit has changed to an Es2 on your farm map. Table 4 shows that 80% of the Es2 landscape unit is a pale deep sandy soil. Your local knowledge also shows that this is a deep sandy ridge that has a tendency to be non-wetting and prone to wind erosion.

This site has been identified as a major source of the waterlogging problem you have on the Es1 landscape. Rather than just addressing the waterlogged site, you may decide to tackle the cause of the problem being the sandy ridge. By using water on the deep sandy ridge there is an opportunity to prevent the waterlogged site from increasing in area or you may even be successful in drying out the site. What landuse options are available for the Es2 deep sandy ridge in your water use tables?

To address the local cause of the problem on the deep sandy ridge above the waterlogged site, the following options are derived from the high water use tables:

- Maritime pine;
- Lucerne, Perennial veldt grass, Rhodes grass and Tagasaste; and
- Seed potato and sunflower.

The options are more varied for this site to build into your farming system looking at forestry, pastures or cropping. These options are more likely to help address the cause of the problem and the symptom. By looking at your landscape components you can begin to apply this planning process across your property. This can help you aim to maintain production and benefit the Lake Warden Wetlands through increased water use.

It is important to question the information on your farm maps. You need to go out into the paddock and have a closer look at the sites in question. If you believe that you have an option you would like to implement then contact the person referenced in the high water use table. Look at what the landscape is doing around you. Soils, topography and hydrology do not recognise property boundaries or paddock fence lines.

Table 4: Percentage of soil groups within map units

Map unit code	WA Soil Group	Percentage
Co1	Pale deep sand	90
	Grey deep sandy duplex	5
	Alkaline grey deep sandy duplex	5
Es1	Grey deep sandy duplex	78
	Pale deep sand	15
	Moderately deep sandy gravel	5
	Grey non-cracking clay	1
	Grey shallow sandy duplex	1
Es2	Pale deep sand	80
	Grey deep sandy duplex	20
Es3	Grey deep sandy duplex	70
	Salt lake soil	20
	Calcareous loamy earth	10
Es4	Grey shallow sandy duplex	35
	Grey deep sandy duplex	30
	Pale deep sand	25
	Alkaline grey deep sandy duplex	5
	Saline wet soil	5
Es7	Grey deep sandy duplex	50
	Saline wet soil	30
	Alkaline grey shallow sandy duplex	10
	Pale deep sand	10
Es9	Grey deep sandy duplex	80
	Grey shallow sandy duplex	10
	Pale deep sand	10
Go2	Saline wet soil	45
	Alkaline grey deep sandy duplex	30
	Pale deep sand	15
	Calcareous deep sand	5
	Bare rock	5
Go3	Saline wet soil	100
Go4	Alkaline grey deep sandy duplex	10
	Pale deep sand	85
	Other soils	5
Ne1	Bare rock	75
	Yellow/brown shallow sand	25
Ne2	Grey deep sandy duplex	70
	Pale deep sand	20
	Grey non-cracking clay	5
	Shallow gravel	5

Table 4 continued.

Map unit code	WA Soil Group	Percentage
Ne3	Grey deep sandy duplex	75
	Pale deep sand	20
	Shallow gravel	5
To1	Calcareous deep sand	53
	Calcareous shallow sand	35
	Pale deep sand	10
	Bare rock	2
To5	Calcareous deep sand	69
	Pale deep sand	20
	Calcareous shallow sand	10
	Other soils	1
Ha1	Alkaline grey shallow sandy duplex	40
	Salt lake soil	20
	Calcareous loamy earth	15
	Pale deep sand	15
	Alkaline grey deep sandy duplex	10
Ha4	Alkaline grey shallow sandy duplex	60
	Alkaline grey deep sandy duplex	15
	Calcareous loamy earth	10
	Salt lake soil	10
	Pale deep sand	5
Sc1	Alkaline grey shallow sandy duplex	77
	Calcareous loamy earth	15
	Pale deep sand	5
	Alkaline grey deep sandy duplex	3
Sc2	Alkaline grey deep sandy duplex	15
	Alkaline grey shallow sandy duplex	50
	Pale deep sand	35
Sc7	Alkaline grey shallow sandy duplex	75
	Alkaline red shallow loamy duplex	25
Sc9	Alkaline grey deep sandy duplex	80
	Grey shallow sandy duplex	15
	Saline wet soil	5
Wm2	Alkaline grey shallow loamy duplex	30
	Alkaline grey shallow sandy duplex	30
	Grey deep sandy duplex	10
	Grey non-cracking clay	10
	Pale deep sand	10
	Shallow gravel	10

Source: Brendan Nicholas, Soils Research Officer (1999) Ag West Esperance.

Appendix 1.0 and 2.0 describe the main soil types for the Lake Warden Catchment, Sandplain and Mallee, in detail.

Farm Forestry Table

Information supplied by Rob Johnstone (1999) South East Forestry Foundation &
Gavin Wornes (1999) Department of Conservation and Land Management (South Coast Sharefarms)

✓ = Yes

C = Conditions apply

Establishment Landscape Variable

Landuse option	Soil Landscape																						Rainfall (mm)					Drainage		
	Co1	Es1	Es2	Es3	Es4	Es7	Es9	Go2	Go3	Go4	Ne1	Ne2	Ne3	To1	To5	Ha1	Ha4	Sc1	Sc2	Sc7	Sc9	Wm2	350-400	>400-450	>450-500	>500-550	>550-600	Saline	Waterlogged	Well drained
Farm Forestry																														
Blue Gum (*E. globulus*)		✓			✓		✓			✓					✓												✓			✓
Maritime Pine (*P. pinaster*)	✓	✓	✓		✓	✓	✓			✓		✓	✓	✓	✓				✓					✓	✓	✓	✓			✓
Montery Pine (E. radiata)		✓								✓				✓	✓												✓			✓
Oil Mallee (*E. angustissima*)				✓								✓				✓	✓	✓	✓		✓	✓	✓	✓	✓	✓		C		✓
(*E. loxophleba*)				✓								✓	✓			✓	✓	✓	✓		✓	✓	✓	✓	✓	✓				✓
(*E. polybractea*)												✓	✓			✓	✓	✓	✓		✓	✓	✓	✓	✓	✓				✓
Sugar Gum (*E.cladocalyx*)						✓	✓						✓			✓	✓	✓			✓		✓	✓	✓	✓				✓
Yate (*E. occidentalis*)				✓		✓	✓									✓	✓				✓		✓	✓	✓	✓		C	✓	
Tuart (*E. glomphocephala*)	✓	✓												✓	✓											✓	✓			✓
River Gum (*E. camaldulensis*)				✓			✓									✓	✓	✓			✓			✓	✓	✓	✓	C		✓

Comments

It is hopeful that these recommendations will be used as a guide to assist farmers with the design of integrated farm forestry. While there will be other species suited to varying soil types of the catchment, it has been my endeavour to select species that are currently supported through different stages of industry development. It is suggested that farmers source further information on the actual design and implementation phase.
Rob Johnstone - South East Forestry Foundation

Perennial Pasture and Fodder Shrub Table

Information supplied by Jamie Bowyer (1999) Agriculture Western Australia

✓ = Yes

C = Conditions apply

Establishment Landscape Variable

Landuse option	Soil Landscape																						Rainfall (mm)					Drainage		
	Co1	Es1	Es2	Es3	Es4	Es7	Es9	Go2	Go3	Go4	Ne1	Ne2	Ne3	To1	To5	Ha1	Ha4	Sc1	Sc2	Sc7	Sc9	Wm2	350-400	>400-450	>450-500	>500-550	>550-600	Saline	Waterlogged	Well Drained
Perennial Pastures																														
Lucerne	✓	✓	✓		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓			✓
Kikuyu	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓											✓	✓		✓	
Tall Wheat Grass	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Phalaris	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓										✓	✓	✓		✓	
Perennial veldt grass	✓	✓	✓		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓		✓				✓	✓	✓	✓	✓			✓
Rhodes grass	✓	✓	✓	✓	✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓			
Fodder Shrubs																														✓
Tagasaste	✓	✓	✓		✓	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	✓	✓					✓	✓	✓	✓			✓
Atriplex (Salt Bush)	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	C	✓
Acacia saligna	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	C	✓

Comments

Lucerne: Does not like waterlogging or soils with low pH. (Appendix 8.0 pg 55)

Kikuyu: Most suited to grey deep sandy duplex soils. Will not perform on pale deep sand unless watertable is close to the surface (Appendix 9.0 pg 56).

Tall Wheat Grass: Tolerates waterlogging and salinity. Not suited to pale deep sand unless water is available.

Phalaris: Tolerates waterlogging. Not suited to pale deep sand unless water is available.

Perennial Veldt Grass: Most suited to pale deep sand.

Tagasaste: Most suited to pale deep sand. Does not tolerate waterlogging (Appendix 10.0 pg 58)

Rhodes Grass: Most suited to medium soils, not heavy clays.

Intensive and Opportunistic High Water use Farming Table

Information supplied by Andrea Hills (1999) Agriculture Western Australia

✓ = Yes

C = Conditions apply

Establishment Landscape Variable

Landuse option	Soil Landscape																						Rainfall (mm)					Drainage		
	Co1	Es1	Es2	Es3	Es4	Es7	Es9	Go2	Go3	Go4	Ne1	Ne2	Ne3	To1	To5	Ha1	Ha4	Sc1	Sc2	Sc7	Sc9	Wm2	350-400	>400-450	>450-500	>500-550	>550-600	Saline	Waterlogged	Well Drained
Intensive Agriculture																														
Seed Potato	✓	✓	✓	C	C	✓				✓		✓	✓	C	C				✓				C	C	C	C	C			✓
Olives	✓	✓	✓	C	C	✓				✓		✓	✓	C	✓				✓				C	C	C	C	C	C		
Opportunistic Cropping																														
Sorghum	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	C	C	
Sunflower	✓	✓	✓	✓	C	✓	✓	C		✓		✓	✓	✓	✓	C	C	C	C					✓	✓	✓	✓			✓

Comments

In all 3 high water use tables c = Conditional. The following limitations may apply to the above landuse options:

- Limited to specific soil types in the landscape unit; or
- Limited by the need for irrigation; or
- Limited by concentration of salinity.

For further information about seed potato and olives, refer to Appendix 11.0 page 60. For opportunistic cropping (summer cropping) refer to Appendix 12.0 page 61.

Support for Landholders

The State Salinity Action Plan has stated that the Government will provide additional resources to Recovery Catchments under cost-sharing arrangements, where necessary to develop partnership agreements and voluntary adoption to achieve the recovery project objectives (SSC 1998).

The degree of Government contribution in any cost-sharing arrangement will reflect the public benefit component. Government investment in the Recovery Catchment will be over a longer period of time than will be the case in focus catchments. During this early stage of the project, the recovery catchment is receiving the catchment support team services that focus catchments receive (SSC 1998).

The Esperance catchment support team have provided support on catchment soils, hydrology, high water use farming systems, access to data and computer mapping equipment. It is up to you to utilise the Esperance catchment support team as a resource. Contact details are provided in Table 5 on page 26.

CALM's Nature Conservation Division has accessed State Salinity funds for Recovery Catchments. These funds are shared amongst other Recovery Catchments throughout the State. The funds are to be used in the Recovery Catchment and are administered locally at a district level by the Recovery Catchment Officer.

The funds are available for maintaining and enhancing natural diversity values throughout the Lake Warden Catchment. CALM will provide assistance to you for on-farm nature conservation works. The scope for assistance includes:

- Local native seedlings;
- Local native seed;
- Access to Ripper-Mounder machinery and Direct Seeding machinery;
- First year supply of chemical for weed and insect control on revegetation works;
- Feral animal control;
- Fence materials for remnant vegetation and revegetation protection;
- Supplying Recovery Farm Kits with specific farm information.
- Planning.

The amount of financial assistance for the scope of these works will be reflected by the amount of public benefit gained from the on-farm conservation works. You can negotiate this component locally with your Recovery Catchment Officer. Clear communication is the key to this negotiation process.

CALM may offer additional assistance within the Natural Heritage Trust (NHT) guidelines to farmers who utilise the NHT funds. The Lake Warden NHT project has a newly appointed Project Administrator. Refer to Table 5 for contact details.

You are also encouraged to utilise other funding sources such as the:

- State Revegetation Scheme;
- Remnant Vegetation Protection Scheme;
- Gordon Reid Foundation;
- South Coast Productivity Grants.

Catchment Contacts

Table 5: Catchment contacts.

Surname	First Name	Position	Phone No.	Address (Town)
Agnew	Marg	Neridup Landcare Group Rep.	90782018	Wittenoom Hills
Alderman	Angela	Lake Warden NHT Project Administrator	90716130	PO Box 368 Esperance
Alford	Liz	Bandy Creek Landcare Group Rep.	90767042	
Bourke	John	Mallee Landcare Development Officer	90831111	AGWEST Esperance
Bowyer	Jamie	Development Officer High Water Use Systems	90831111	AGWEST Esperance
Charleton	Lorna	Education Interpretation Materials	90713733	CALM Esperance
English	Garry	Coramup Creek Landcare Group	90754045	Coramup
English	Ted	Oil Mallee Association - Esperance	90720628	Coramup
Gee	Steve	Information Technology Technician	90831111	AGWEST Esperance
Haberley	Bernie	District Wildlife Officer	90713733	CALM Esperance
Hall	David	Plant Soil and Water Relations Research Officer	90831111	AGWEST Esperance
Halse	Stuart	Salinity - vegetation and invertebrate	93061136	CALM Woodvale
Hills	Andrea	Development Officer	90831111	AGWEST Esperance
Hopkinson	Kevin	Wetlands Officer - South Coast	98425760	W & RC Albany
James	Natasha	Pine Sharefarms Area Coordinator	90713733	CALM Esperance
Janicke	Steve	Water Quality Information	98425760	W&R Albany
Johnstone	Rob	South East Forestry Foundation	90831111	AGWEST Esperance
Jones	Harvey	Agricultural Economist	90831111	AGWEST Esperance
Kent	Joyce	Coramup Landcare Group	90713158	Esperance
Massenbauer	Tilo	Recovery Catchment Officer	90713733	CALM Esperance
Meiklejohn	Barbara	Wittenoom Hills Landcare Group	90767018	Wittenoom Hills
Middleton	Andrew	Neridup Creek Landcare Group	90759030	Neridup
Mischker	Volker	Bushcare Support Officer Greening Australia WA	90713733	CALM Esperance
Moore	Brendan	Soil Conservation Officer	90831111	AGWEST Esperance
Nicholas	Brendan	Soils Research Officer	90831111	AGWEST Esperance
Norris	Bernie	Esperance LCDC	90711341	
Pearson	Grant	Information on wetlands	93061163	CALM Woodvale
Short	Rod	Hydrogeology	90831111	AGWEST Esperance
Calzoni	Carina	Sandplain Landcare Development Officer	90831111	AGWEST Esperance
Simons	John	Hydrologist	90831111	AGWEST Esperance
Smith	Denis	Ribbons of Blue - High School	90712266	Esperance
Gude	Ellen	Planning for Esperance Shire	90710666	Esperance Shire
Tiedemann	Klaus	District Manager CALM Esperance	90713733	CALM Esperance
White	Peta	Environmental Education Officer	90831111	AGWEST Esperance
Wornes	Gavin	Pine Sharefarms Field Manager	90713733	CALM Esperance

References

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Department of Conservation and Land Management, forthcoming 2000, '*Lake Warden Catchment Recovery Plan*', compiled by John Duff and Associates.

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George, R., McFarlane. D. and Nulsen, R., 1997, '*Salinity threatens the viability of agriculture and ecosystems in Western Australia*.' Hydrogeology Journal v.5, no.1 p6-21.

Haberley, B. (Section Author), 1999, '*WA Bank West Landcare Conference Lake Warden Tour Handout*', Agriculture Western Australia.

Martin L. and Metcalfe J., 1998, '*Assessing the causes, impacts, costs and management of dryland salinity*', Occasional Paper No. 20/98 Revision Number One, National Dryland Salinity Program.

State Salinity Council, 1998, '*Western Australian Salinity Action Plan - Draft Update 1998*', Government of Western Australia.

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Appendices

Appendices Contents

Water and Rivers Commission

Agriculture
WESTERN AUSTRALIA

1.0 Soil information sheets for the Esperance Sandplain

Corinup Soil Series — Pale deep sand (Deep sand)

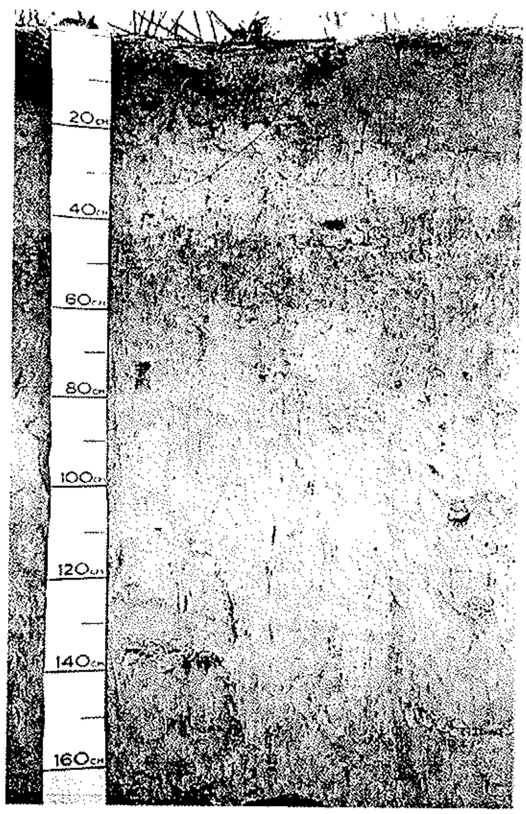
This is a deep fine sand, grey at the surface and grading to white then yellow.

Occurrence: The Corinup soil is very common over the Esperance and adjacent south coastal areas. It occurs as dunes and deep sand sheets on the sandplain, often associated with Fleming sand (moderately deep sand over ironstone gravel).

Native vegetation: Typical vegetation includes showy banksia (*Banksia speciosa*), Christmas tree (*Nuytsia floribunda*) and coastal jugflower (*Adenanthos cuneatus*).

Soil profile description

Depth (cm)	
0-12	Dark grey fine sand; water repellent; acidic (pH_w 6.0); very low salinity; clear boundary.
12-65	Pale brown (bleached) fine sand; acidic (pH_w 6.5); very low salinity; gradual boundary.
65-120	Brownish yellow fine sand; near neutral (pH_w 7.0); very low salinity; gradual boundary.
120-150	Yellow clayey fine sand, with white mottles; near neutral (pH_w 7.0); very low salinity.



Characteristic soil properties

- Fine sand throughout
- Slightly acidic topsoil over neutral subsoil
- Well drained
- Nutrient leaching
- Effective rooting depth can exceed 2 m

Soil classification
Australian Soil Classification: *Basic Arenic Bleached-Orthic Tenosol*
Northcote PPF: *Uc2.21*
Map unit: G3a-d, Y2, E3a-h on Esperance region soil-landscape, Es3 and Co3 on Condingup

Compiled by Tim Overheu, Brendan Nicholas and Paula Needham
Natural Resources Assessment Group, Agriculture Western Australia, 1996

Agricultural land use and management

Corinup Soil Series   Pale deep sand (Deep sand)

Nutrient status is low. Suitable for cereal/lupin rotations using minimum till and stubble retention, or revegetated with trees for shelter belts or agroforestry.

Crops: This is a very versatile soil and with reasonable annual rainfall, high yields can be obtained using high fertiliser input. The most appropriate crops are cereals rotated with lupins. Other options include barley, canola and oats. Stubble retention systems are essential to maintain ground cover. Minimum tillage and/or direct drilling are recommended with occasional deep ripping to alleviate subsoil compaction. If water repellence develops, it may be necessary to seed with press wheels.

Trees: Blue gums (*Eucalyptus globulus*) or *Pinus radiata* can be grown commercially in areas receiving 500 mm of rainfall. Rooting depth is good but saline groundwater at 200 cm will affect growth in some places.

Annual pastures: Sub. clover grows with difficulty. Serradella is an alternative.

Perennial pastures: A mix of serradella and veldt grass provides the best long-term option. Lucerne is suitable but insects are a problem. Other options include phalaris, fescue or brumby perennial ryegrass. Console lovegrass, tagasaste and Rhodes grass have potential.

Favourable qualities

Well drained, unlikely to waterlog, easy to cultivate, and good volume of subsoil for root development.

Soil characteristics and land conservation

Dams & catchments	Flat batter dams are a viable option but only when clay is within 90 cm of the surface. Not suitable for roaded catchments.
pH	The slightly acidic pH is within the tolerable range for most recommended cereals. This is not affecting plant growth, but will increase after longer agricultural production.
Salinity	Very low, except in areas with shallow saline groundwater.
Structural decline	Low risk.
Water availability	Low. Water draining through this soil can add significantly to groundwater recharge.
Water erosion	Generally unlikely, however will occur if saturated and experiencing surface flow (e.g. along drainage lines in wet year).
Water repellence	Moderate risk. May become a problem, especially if legumes are grown.
Waterlogging	Low risk. This is a free-draining soil in which waterlogging is unusual.
Wind erosion	High risk. Surface cover must be maintained as wind erosion can be extreme due to the loose, fine sandy topsoil.
Workability	Good. Compacted layers may form between 15 and 30 cm because of cultivation. Deep ripping may be an option (not generally recommended).

Fleming Soil Series — Grey deep sandy duplex (gravelly) (Fleming sand) (moderately deep gravel phase)

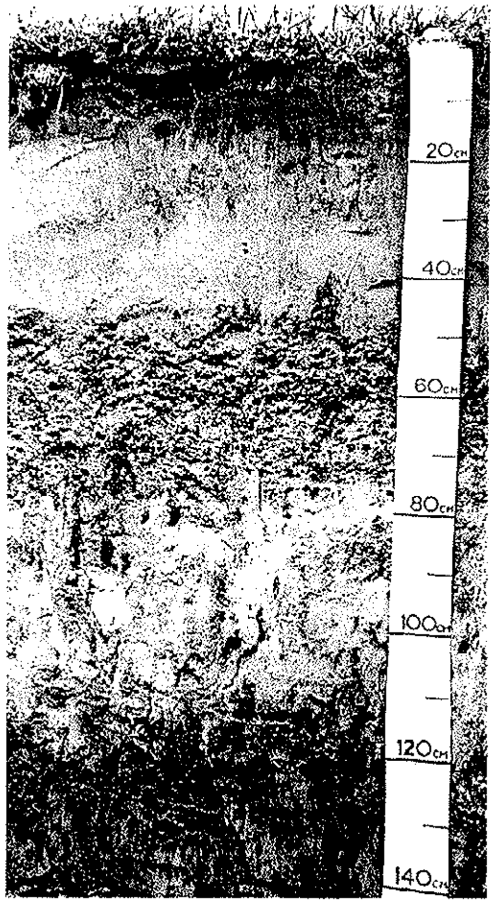
This is a deeper gravelly duplex with the depth of sand overlying the gravel layer between 30 and 80 cm. A slightly dispersive, yellowish brown to grey mottled clay layer underlies the gravel.

Occurrence: Occupies about 30% of the lower Esperance area and many landforms across the Esperance and south coastal sandplain, in association with either Fleming shallow gravelly phase or Corinup deep sand. Usually found on level to gently undulating areas, where the relief is extremely low (less than 9 m) and slope to 5%.

Native vegetation: Dominant vegetation is blue mallee (*Eucalyptus tetragona*), chittick (*Lambertia inermis*) and Christmas tree (*Nuytsia floribunda*) with dense low heath.

Soil profile description

Depth (cm)	
0-10	Greyish brown fine sand; acidic (pH_w 6.5).
10-55	Light grey (bleached) fine sand; near neutral (pH_w 7.0).
55-65	Light yellowish brown (bleached) sand with more than 50% ironstone gravel; alkaline (pH_w 7.5).
65-140	Light yellowish brown sandy clay; slightly dispersive; prominent medium grey mottles and a few small soft ironstone gravels; alkaline (pH_w 7.5).



Characteristic soil properties

- Gravel can often occur as a thin layer less than 20 cm over the clay
- Topsoil may become acidic with time
- Effective rooting depth is 30 to 80 cm
- Slightly acidic topsoil grading to neutral in the subsoil
- Topsoil can become water repellent

Soil classification
Australian Soil Classification: *Ferric Mottled-Subnatric Yellow Sodosol*
Northcote PPF: *Dy5.82*
Map unit: E2a-f on the soil-landscape map of the Esperance Region

Compiled by Tim Overheu, Brendan Nicholas and Paula Needham
Natural Resources Assessment Group, Agriculture Western Australia, 1996

Agricultural land use and management

Fleming Soil Series **Grey deep sandy duplex (Fleming sand) (moderately deep gravel phase)**

This is a versatile and productive soil with a moderately deep layer of sand over clay. However, all nutrients leach from these deep sands, especially potash. A cropping rotation using minimum tillage and stubble retention would be suitable.

Crops: The best options are lupin/wheat or wheat/pasture rotations. Barley, oats and canola can also be gown on these soils. Peas are not suitable because of the high risk of wind erosion. It is necessary to maintain stubble in multiple cropping operations and advisable to use direct drilling or minimum tillage.

Trees: Blue gums (*Eucalyptus globulus*) may be planted for shelter but not for high production because of the limited depth of sand over clay and possible high watertables.

Annual pastures: Subterranean clover is the best choice.

Perennial pastures: A mix of serradella and veldt grass provides the best long-term option. Lucerne dislikes waterlogging and may not be suitable in some of these soils. Other options include phalaris, fescue, brumby and perennial rye grass. Console lovegrass and Rhodes grass have potential.

Favourable qualities

Good nutrient availability within the rooting zone (except for potash), good workability, good production potential.

Soil characteristics and land conservation

Dams & catchments	Suitable for dam construction. Flat batter dams are a viable option. Catchments are expensive due to depth of overburden.
pH	Not limiting to plant growth at present, but could become a concern in time.
Salinity	Low risk, although can be a problem in low lying areas.
Structural decline	Low, because of the sandy surface. The subsoil clay is slightly dispersive, and could cause problems if brought to the surface.
Water availability	Low water-holding capacity because of the light textured sandy topsoil, but availability can be higher on level ground, where run-on water is received.
Water erosion	Low risk. Increases where soils are saturated and receive large volumes of water from upslope.
Water repellence	Moderate risk, especially if legumes are used in the rotation.
Waterlogging	Generally well drained but depends on the depth of sand and gravel over the clay. If sand and gravel layers are shallow, waterlogging may occur (see Fleming gravelly sand).
Wind erosion	High risk, so the surface must be protected at all times.
Workability	Good.

Fleming Soil Series

Grey deep sandy duplex (Fleming gravelly sand) (shallow gravel phase)

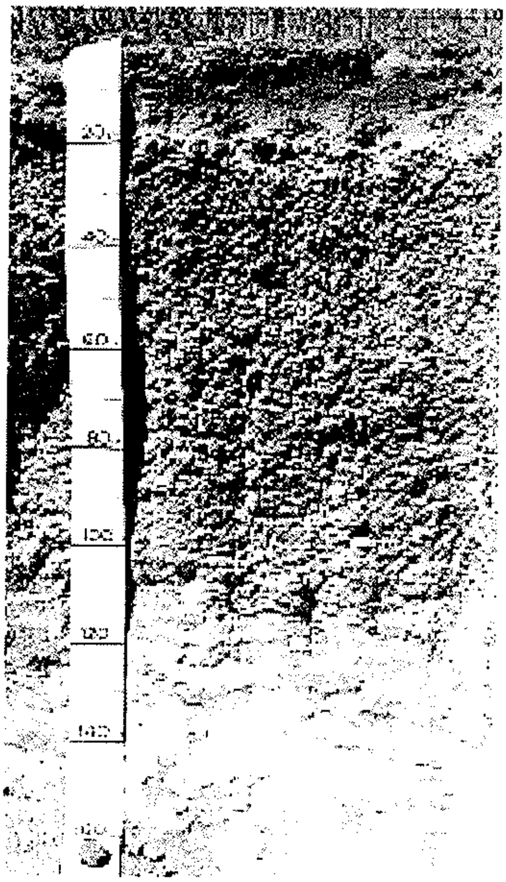
This is a deep duplex soil with less than 30 cm of sand over a gravel layer over a clay subsoil.

Occurrence: On a wide range of landforms across the Esperance and south coastal sandplain. It occupies about 50% of the lower Esperance area usually on level to gently undulating sandplain where the relief is extremely low (less than 9 m) and the slope is less than 5%.

Native vegetation: Dominant vegetation comprises blue mallee (*Eucalyptus tetragona*) and ridge-fruited mallee (*E. incrassata*) with dense low heath including *Dryandra* and *Melaleuca* species. Where the soil is associated with shallow rock outcrops, vegetation will include square-fruited mallee (*E. tetraptera*) and one-sided bottlebrush (*Calothamnus quadrifidus*).

Soil profile description

Depth (cm)	
1-10	Dark greyish brown, water repellent loamy fine sand; acidic (pH_w 6.5).
10-20	Light grey fine sandy gravel (over 50% ironstone gravel); near neutral (pH_w 7.0).
20-60	Light yellowish brown sandy gravel (over 50% ironstone gravel); near neutral (pH_w 7.0).
60-140+	Light yellowish brown slightly cemented sandy clay; grey mottles and a few soft gravels; structureless; near neutral (pH_w 7.0).



Characteristic soil properties

- Fine surface sand
- 'Shallow' means the depth of sand over gravel, not the depth over clay
- Effective rooting depth is 60 cm
- pH is neutral throughout but often slightly acidic at the surface

Soil classification
Australian Soil Classification: *Ferric Mottled-Subnatric Yellow Sodosol*
Northcote PPF: *Dy5.82*
Map units: E1a-f on Esperance region soil-landscape, Es1 on the Condingup soil-landscape map

Compiled by Tim Overheu, Brendan Nicholas and Paula Needham
Natural Resources Assessment Group, Agriculture Western Australia, 1996

Agricultural land use and management

Fleming Soil Series — Grey deep sandy duplex (Fleming gravelly sand)

The most suitable land use is determined by the depth of sand to the clay. If the sand is deep, the soil will behave more like a Fleming moderately deep gravel or a Corinup sand. If the sand is shallow, waterlogging may limit options.

Crops: Cereals grow well on sites free of waterlogging. Cereal/pasture rotations using minimum tillage, or continuous pasture may be suitable. Lupins, wheat and canola are suitable on well drained soil. If prone to waterlogging, avoid wheat and lupins, and crop barley or oats infrequently. Stubble retention is necessary in multiple cropping, and direct drilling or minimum tillage should be adopted.

Trees: May not grow well because of restricted rooting depth and risk of waterlogging.

Annual pastures: If poorly drained, it is necessary to plant Balansa or sub. clovers such as Trikkala which tolerate waterlogging. Serradella is an option if the soil is well drained.

Perennial pastures: Serradella and veldt grass are options for well drained sites. On poorly drained areas, pastures such as phalaris, fescue, brumby, perennial rye or tall wheat grass will tolerate the waterlogging.

Favourable qualities

Reasonably good nutrient availability, good soil workability.

Soil characteristics and land conservation

Dams & catchments	Suitable for dam construction. Flat batter dams are a viable option.
pH	Could become a problem, but not yet affecting plant growth. High risk of surface or topsoil acidification so monitoring is required.
Salinity	Low to moderate risk, although risk can increase over low lying areas associated with waterlogging.
Structural decline	Low risk.
Water availability	Low to moderate water-holding capacity.
Water erosion	Moderate risk; may occur on sloping sites if the sand layer is shallow and becomes saturated.
Water repellence	High; topsoil can become strongly water repellent.
Waterlogging	Moderate to high risk. Unless on a sloping site, drainage may be a problem because of the depth to clay.
Wind erosion	High risk, unless there is more than 50% gravel on the surface.
Workability	Good.

2.0 Soil information sheets for the Mallee area

Scaddan Soil Series — Alkaline grey shallow sandy duplex (Scaddan sand)

This is a light-surfaced duplex soil with alkaline, sodic and domed subsoils. It is often confused with the Circle Valley soil in the Salmon Gums area but the clay subsoil has a strongly domed, very hard surface.

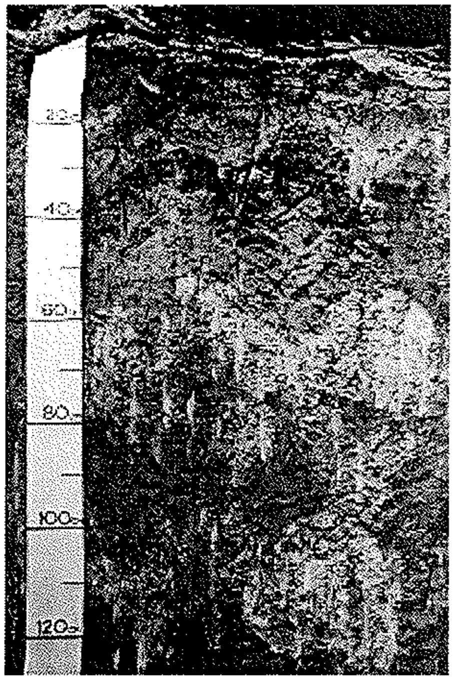
Occurrence: Widely distributed over the mallee areas of the South Coast. In the Mount Beaumont area it is common in drainage lines and often associated with Beete and Karlsberg soils.

Native vegetation: Changes with depth of fine sand over the domed clay layer. The deeper the fine sand, the sparser the vegetation. Mallee and open shrubs such as Alexander River mallee (*Eucalyptus micranthera),* Hopetoun mallee *(E. leptocalyx),* hook-leaved mallee (*E. uncinata),* tangling melaleuca (*Melaleuca cardiophylla)* and *M. pentagona* are typical.

Soil profile description

Depth (cm)

0-5	Grey fine sand, slightly crusted; near neutral (pH_w 7.0); abrupt boundary.
5-10	Light brownish grey (fine) sand; near neutral (pH_w 7.0); wavy boundary.
10-20	Yellowish brown sandy clay loam; columnar structure; strongly alkaline (pH_w 9.0); tongues of sand from upper layer between domes of clay; clear boundary.
20-50	Pale olive light clay; blocky structure; calcareous nodules; alkaline (pH_w 8.5); gradual boundary.
50-150	Brown and olive mottled clay; prismatic structure; many small calcareous nodules; alkaline (pH_w 8.0).



Characteristic soil properties

- Low salinity above 20 cm
- Sodic subsoil below 20 cm (ESP 10 to 30)
- Moderately saline below 20 cm (EC 75 mS/m)
- Effective rooting depth is 10 to 30 cm depending on sand thickness. Roots can exploit sand-filled cracks between domes of clay

Soil classification
Australian Soil Classification: *Supracalcic Hypernatric Yellow Sodosol*
Northcote PPF: *Dy4.43*
Map unit: Soil 6 on Mount Beaumont soil map, S1 on Esperance sheets, Sc1 on Condingup, ScS on Salmon Gums survey

Compiled by Tim Overheu, Brendan Nicholas and Paula Needham
Natural Resources Assessment Group, Agriculture Western Australia, 1996

Agricultural land use and management

Scaddan Soil Series — Alkaline grey shallow sandy duplex (Scaddan sand)

This soil has high production potential in a good year with adequate rainfall. Nutrient availability is low because of soil alkalinity. Boron toxocity can be a problem.

Crops: Suitable for cereal/canola/pasture rotation using minimum tillage and stubble retention. Peas should be avoided because of the risk of wind erosion. It is possible to grow lupins on the deeper areas, but the sand must be at least 25 cm deep. Reduced tillage is recommended to reduce risk of wind erosion.

Trees: Various trees and shrubs suit this soil. Factors to consider are depth to clay, waterlogging and subsoil pH.

Annual pastures: Acid-tolerant medics such as burr medic are suitable, or sub. clover.

Perennial pastures: Low rainfall reduces the number of suitable varieties. Where the soil is moist in summer, tall wheat grass, perennial veldt grass, phalaris, Rhodes grass and possibly lucerne may be appropriate. In salt-affected areas, puccinellia and saltwater couch are suitable.

Favourable qualities

Moderately well drained, good workability, low risk of soil acidification, high production potential in a good year.

Soil characteristics and land conservation

Dams & catchments	Dams are effective and hold water well. Shallow country is ideal for roaded catchments. Shallow scraped catchments with minimal subsoil disturbance are best. Take care not to disturb deeper layers which contain carbonate, especially during catchment maintenance.
pH	Very low risk of acidification.
Salinity	Moderate to high. Subsoil salinity is a problem, and low-lying, waterlogged areas may show effects.
Structural decline	Prone to surface structural decline due to mixing topsoil and subsoil. When topsoil clay content is above 10%, hardsetting develops causing problems with water infiltration and workability.
Water availability	Moderate. Varies with the depth of sand over the clay.
Water erosion	High risk in sloping areas.
Water repellence	Moderate. The sandy topsoil can be water repellent.
Waterlogging	Widespread over all areas.
Wind erosion	High risk. The sandy surface is prone to erosion as it is generally too shallow to protect the highly dispersive clayey subsoil.
Workability	Good, due to the light sandy topsoil.

Scaddan Soil Series

Alkaline grey shallow loamy duplex (Scaddan sandy loam)(degraded form)

This is a hardsetting variant of Scaddan Series known locally as dog shit clay. The topsoil has been lost through wind erosion or mixed with subsoil material by cultivation. This has changed the hazards and opportunities in managing this soil.

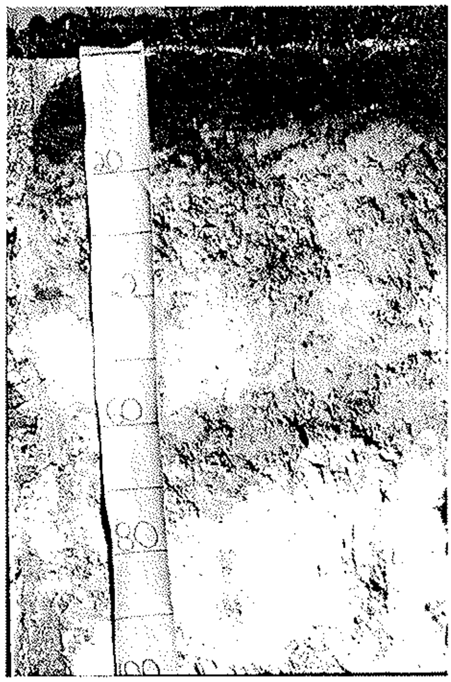
Occurrence: This soil is the result of past farming practices during the development of the mallee area. The history of wind erosion and cultivation determines the level of degradation of the original Scaddan sand. It occurs in the farmed area of the mallee, usually in association with Scaddan sand and Beete soils.

Native vegetation: Fuchsia mallee (*Eucalyptus forrestiana*) is common, also hook-leaved mallee (*E. uncinata*), with a characteristic understorey of melaleuca species. *Melaleuca cardiophylla* (tangling melaleuca) and *M. pentagona* are common.

Soil profile description

Depth (cm)

0-15	Very dark greyish brown sandy loam; massive structure; firm consistence; neutral (pH_w 7.5) modified by cultivation; non-saline, EC 14 mS/m; sharp boundary.
15-24	Light grey light medium clay; massive structure; very firm consistence; alkaline (pH_w 9.0); slightly saline, EC 50 mS/m; gradual boundary.
24-40	Pale yellow light medium clay; non-calcareous; massive structure; very firm consistence; few fine calcareous segregations; alkaline (pH_w 9.5); saline, EC 108 mS/m; gradual boundary.
40-100	Pale yellow light medium clay; highly calcareous; polyhedral structure; very firm consistence; common medium calcareous segregations; alkaline (pH_w 9.5); saline, EC 170 mS/m.



Characteristic soil properties

- Low salinity above 20 cm
- Moderately saline below 20 cm (EC 75 mS/m)
- Hardsetting topsoil
- Clayey sand to sandy loam topsoil

Soil classification
Australian Soil Classification: *Supracalcic Hypernatric Yellow Sodosol*
Northcote PPF: *Dg 1.1*
Map unit: Occurs across the Scaddan and Cascade Systems

Compiled by Brendan Nicholas, Tim Overheu and Paula Needham
Natural Resources Assessment Group, Agriculture Western Australia, 1996

Agricultural land use and management

Scaddan Soil Series | **Alkaline grey shallow loamy duplex (Scaddan sandy loam)(degraded form)**

Magnesium and zinc availability is low because of soil alkalinity. Crop establishment and emergence can be hindered by hardsetting topsoils.

Crops: Wheat, barley and canola are successful. Field peas and faba beans can also be grown due to low wind erosion risk. Reduced tillage is recommended to reduce risk of structural decline. Soil moisture available to plants is low which can affect grain-filling on a tight finish to the season.
Trees: Various trees and shrubs suit this soil.

Annual pastures: Medic varieties such as Caliph, Santiago, Orion and Circle Valley are suitable.

Perennial pastures: Low rainfall reduces the number of suitable varieties. Where the soil is moist in summer, tall wheat grass, perennial veldt grass, phalaris, Rhodes grass and possibly lucerne may be appropriate. In salt-affected areas, puccinellia and saltwater couch are suitable.

Favourable qualities

Moderately well drained (but prone to waterlogging); low wind erosion risk.

Soil characteristics and land conservation

Dams & catchments	Dams are effective and hold water well. Shallow country is ideal for roaded catchments. Take care not to disturb deeper layers which contain carbonate. Earthworks will erode on sloping ground.
pH	Alkaline throughout; very low acidification risk.
Salinity	Low in topsoil, high in subsoil.
Structural decline	Prone to surface structural decline due to mixing of topsoil and subsoil resulting in sodic topsoils. When topsoil clay content is above 10% a hardsetting surface develops causing problems with water infiltration and workability. Responds to gypsum. Stubble retention is important to maintain organic matter in topsoil.
Water availability	Moderate.
Water erosion	High risk in sloping areas.
Water repellence	Low. The clayey sand/sandy loam topsoil is not repellent.
Waterlogging	Likely in level areas after large rainfall events.
Wind erosion	Low risk.
Workability	Moderate to poor, depending on topsoil clay content and degree of hardsetting. The soil can only be worked over a narrow moisture range. This led to the term 'Sunday country' as the soil is too wet on Saturday and too dry by Monday.

3.0 Geological History of the Esperance Region

Rod Short (Ag West, Esperance Hydrogeoligist)

The Esperance landscapes as we see it today is a product of geological events and processes that have occurred over billions of years. The sequence of geological events is discussed from the past to relatively recent times.

Geology

The Esperance district is underlain by Pre-Cambrian crystalline basement rocks from both the Archaean Yilgarn Craton or the Proterozoic Albany - Fraser Orogen. The Archaean basement rocks (about 2300 million years old) occur mainly to the west of Esperance and are similar to those in much of the WA wheatbelt. These basement rocks are comprised of granites and gneisses with some older greenstone belts occurring near Ravensthorpe. The Archaean rocks are divided from the basement rocks of the Albany - Fraser Orogen (rocks about 1800 million years old) along a line which runs approximately north-east from the Dalyup River. Basement rocks now form present-day coastal headlands, offshore islands or can be seen inland as high points in the landscape such as Wittenoom Hills or Mt Burdett.

Antarctica began to break away from Australia in the Cretaceous (between 135 to 64 million years ago) which resulted in the continental margin sagging to form the Bremer Basin (Cockbain and Hocking 1990). Basement rocks were overlain by Tertiary sediments (around 40 million years ago) of the Plantagent Group. These sediments deposited in a marine environment can been found as far north as Norseman. The marine transgression occurred in the Middle to Late Eocene (about 40 million years ago) depositing the Werillup Formation and the Pallinup Siltstone units of the Plantagenet Group in palaeodrainage lines and regional depressions in basement rocks. The Werillup Formation consists of a dark grey siltstone, sandstone, claystone and lignite (brown coal) and limestone deposited in low energy fluvial or lacustrine environments. The Pallinup Siltstone consists of siltstone and spongelite deposited in a marine environment.

The Darling Plateau began to be uplifted in the Oligocene (about 30 million years ago) resulting in the southern coastline tilting towards the south to form the Ravensthorpe Ramp; the hinge line is known as the Jarrahwood Axis (Cope 1974). The tilting diverted formerly east and west flowing river systems to the south. Drainage lines were partly rejuvenated and sand deposits were redistributed by the wind.

From the Oligocene through to the Quaternary (starting from 1.6 million years ago), the climate began to change from moist temperate – tropical to one that was much drier. Geologically the South Coast has remained fairly stable with erosion only occurring along some of the drainage lines to the coast. Ice ages in more recent times (12 000 years ago) have had an impact along the coast with major changes in sea levels. These sea level changes have eroded coastal sediments and cut back the shoreline to its present day position. In addition limestone dune systems formed along the coastline were blown inland by prevailing winds. Carbonate leaching and lateritisation have taken place to form the present topography and soil profiles.

Surface Drainage

The present surface drainage patterns are a product of the geological history of the South Coast of Western Australia. Prior to the Eocene (54 to 38 million years ago), drainage was to the west towards the Perth Basin and to the east towards the Eucla Basin. Chains of east – west trending elongated playa lakes are the remnants of these major drainage systems.

Uplifting of the Darling Plateau and tilting of the continental margin during the Tertiary Period (65 million years ago to the present) diverted drainage to the south. To the west of Esperance, ephemeral rivers and creeks have incised the Tertiary plateau. Here the drainage lines are well defined and terminate in coastal wetlands and estuaries. To the east of Esperance, drainage lines are internal and very poorly defined, with surface drainage terminating in paperbark (*Melaleuca* spp.) and yate (*Eucalyptus occidentalis*) swamps.

Table 3.1: Geological time scale.

Time (millions of years ago)	Era	Period	Epoch	Local Events
4500 – 3600 2400	PRE - CAMBRIAN		**Archaean** **Proterozoic**	Yilgarn Block Albany Fraser Orogen. Mt. Barren Beds
570 – 500 500 – 440 440 – 395 395 – 345 345 – 280 280 - 225	PALAEOZONIC	Cambrian Ordovician Silurian Devonian Carboniferous Permian		
225 – 190 190 – 136 136 - 65	MESOZOIC	Triassic Jurassic **Cretaceous**		Antarctic breaks from Australia - Bremer Basin formed.
65 – 54 54 – 38 38 – 26 26 – 7 7 – 1.8 1.8 – 0.01 0.01 – 0	CAINOZOIC	**Tertiary** **Quaternary**	Palaeocene **Eocene** **Oligocene** **Miocene** Pilocene **Pleistocene** **Holocene**	Plantagent beds Ravensthorpe ramp. Laterisation Coastal plain and dunes form Current landscapes form.

4.0 Esperance Hydrogeology

Rod Short (Ag West, Esperance Hydrogeologist)

The hydrology of the region is influenced by both its geological history and the weathering processes that have shaped the present landscape. In the Esperance Agricultural District, fourteen hydrogeological zones have been identified (Short et al 1994). The hydrogeological zones have been based on our understanding of the geology and geomorphology using interpretations of satellite imagery, geology maps and reports, field observations, drilling, airborne geophysics (BMR radiometrics and magnetics) and bore monitoring results.

Tertiary sediments overlie Precambrian basement rocks over much of the region. Sandplain soils mask the underlying geology. Basal sands of the Werillup Formation are restricted to lows in the basement topography and are relatively more permeable than the Pallinup Siltstone. Groundwaters in the Plantagenet Group and Werrillup Formation sediments are usually saline. The extent of the Werillup Formation under the sandplain is still unclear.

Studies in the Esperance region have shown that four aquifers may be present; a deep semi-confined / confined regional aquifer in weathered basement rocks; semi-confined / unconfined aquifers in overlying Tertiary sediments, shallow seasonal perched aquifers in duplex soils (responsible for waterlogging) and perched aquifers in deep sand sheets and dunes. These aquifers may be connected and, with the exception of the perched aquifers, are often saline.

Recharge to groundwater through Tertiary sediments is probably dominated by preferred pathways such as solution cavities and root channels. These pathways have been observed to extend to depths up to 8 m below the surface but may be being blocked by the precipitation of carbonate. Hydraulic gradients appear to be less than 0.1% and prior to clearing many aquifers were probably isolated by Precambrian bedrock barriers. Dolerite dykes do not intrude into the sediments and form barriers to groundwater flow. Bedrock highs are the major barriers that water can accumulate behind to form saline seeps.

Perched aquifers in deep sand sheets can contain water of stock quality (< 2,000 mS/m). Lateral movement of water through these sands towards topographic lows contributes to seasonal waterlogging. Other drainage end points, such as paperbark and yate swamps, may be either recharge or discharge sites for deeper regional aquifers.
Groundwater salinity increases away from the coast with fresh to brackish water occurring within 20 km of the coastline. Groundwater on the sandplain ranges from 45 to 5065 mS/m while groundwater salinity in mallee areas to the north may be as high as 13,300 mS/m. Although long-term and reliable water level records are scarce, groundwaters are generally rising at between 0.1 to 0.3 m/year and in some cases, at up to 0.5 m/year. In many areas of the sandplain and mallee areas, saline groundwaters are within 10 m of the surface. Salt storages in the top 6 m of the regolith range up to 850 t/ha in the mallee and 125 t/ha on the sandplain.

Short, R.J., Skinner,G., Ferdowsian, R. and McFarlane, D.J. (1994). Hydrology and geology in relation to salinity and waterlogging on the South Coast of Western Australia. GRDC Water Management Workshop, Esperance, CLIMA Technical Report 4 (in press).

5.0 Catchment Hydrology and Dryland Salinity

John Simons, (Ag West, Catchment Hydrology Group – Esperance Hydrologist)

Introduction

To understand the process of dryland salinity in the Lake Warden Recovery Catchment an introduction to some hydrology terms and concepts relating to geology and water movement through the landscape is required.

Water storage in, and movement through, the landscape is a complex process. Because, with the exception of rainfall and runoff, the water movement cannot be seen, it has become subject to a great deal of myth and legend which is often far removed from fact.

Hydrologic cycle

The hydrologic cycle is a continuous interchange of water between the land, water bodies (surface water) and the atmosphere.
The cycle has neither a beginning nor end, as water evaporates and is lifted, carried and temporarily stored in the atmosphere until it finally precipitates.

The **precipitated** water (rainfall) may be **intercepted** by plants, may **run off** over the land surface or may **infiltrate** into the soil. The infiltrated water maybe temporarily stored as **soil moisture** and **transpired** (evapotranspiration) by plants and/or **evaporates** from the soil surface. Water can also percolate down deeper to the watertable (**groundwater recharge**) adding to the **groundwater storage** that could then move on as **groundwater flow**. Ultimately (years later) the water may flow out (**groundwater discharge** / seepage) into water bodies or the land surface, where it is evaporated back into the atmosphere.

Catchment water balance

To **manage the complex processes of water movement and storage** in the landscape we need to understand the quantities of water involved and how the different components of the catchment water balance behave.

The quantities of water in even a relatively small catchment are very large. A millimetre of rain falling over a hectare of land equals 10 000 litres and weighs 10 tonnes. In a 400-millimetre rainfall area the annual deposition of water would be 4000 tonnes per hectare. So in a 10,000 ha catchment in a 400 mm rainfall zone the annual deposition of water is 40 million m^3 or 4,000 t/ha. Considering that a good wheat yield in such an environment might be 4 t/ha then a thousand tonnes of water has been involved in the production of each tonne of grain.

The concept of a catchment **water balance** is a simple accounting exercise of what <u>comes in</u> (*rainfall*) must be balanced by <u>what goes out</u> (*runoff, evaporation, groundwater flow and discharge*) and any <u>change in storage</u> (*soil water, surface water and groundwater*) (Diagram 5.1).

P	= R	+ G	+ (E +T) +	ΔS	+	ΔH	+	ΔD
Rainfall =	surface + runoff	ground + water flow	evaporation + transpiration (soil & plant)	change in soil water content	+	change in groundwater levels	+	change in surface storage

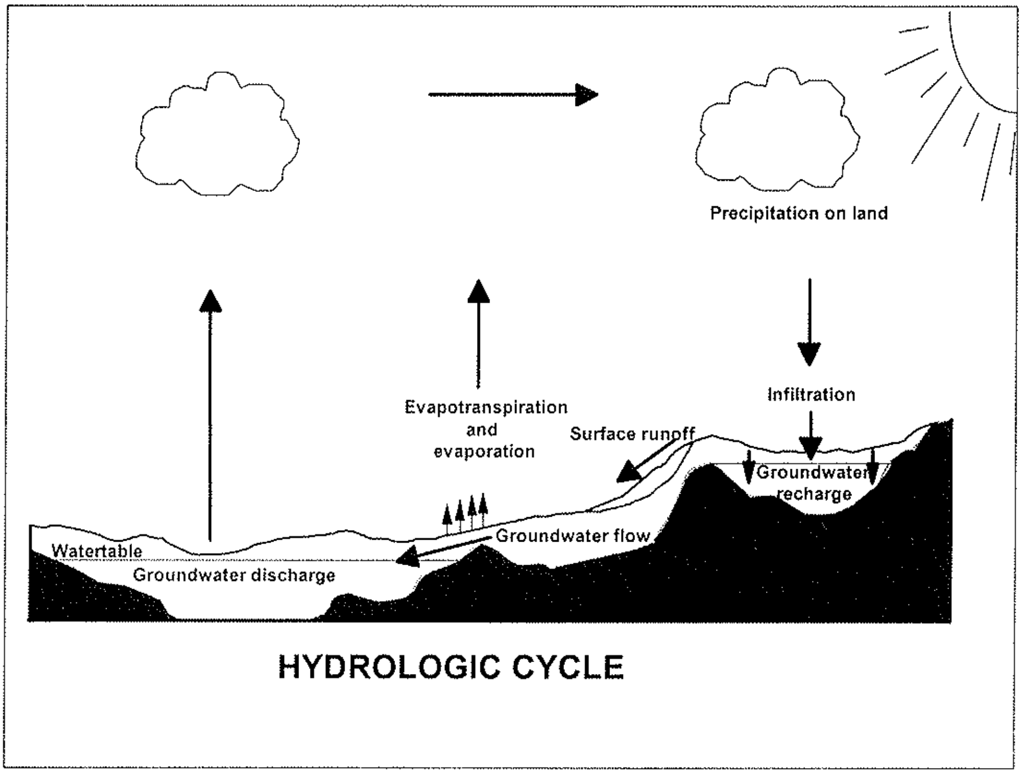


Diagram 5.1: The Hydrologic Cycle

Hydrogeology

- **Bedrock or Basement** rocks is a geological term used to describe the hard rock that has not been softened or broken down by the processes of weathering and erosion. It is still in a very similar form as when it was originally emplaced millions of years ago.
- Between the bedrock and the surface is the **regolith** (*a zone of in-situ weathered bedrock, sediments and other materials deposited by water, gravity and wind*). The regolith's **storage co-efficient** (*ability to store water*) and its **hydraulic conductivity** (*ability to transmit water*) along with its thickness can influence how and where salinity occurs. (*The regolith can be compared to a sponge sitting upon a solid block of concrete.*)

Groundwater and water flow in the landscape

Groundwater is the water held within the saturated portion of the regolith and in fractures within the bedrock. The material that holds this water is referred to as an **aquifer**. Aquifer types are divided on the basis of the materials that they consist of (sedimentary and fractured rock), how confined these materials are and their size (local, catchment and regional).

The storage and movement of groundwater through the landscape is a complex process. Groundwater moves through the gaps or pores in the soil and regolith. The ability of groundwater to move in the landscape is influenced by;

i. Ability of the regolith or soil material to transmit water. As mentioned previously the ease of flow through the aquifer material is referred to as the **hydraulic conductivity**. *(The finer the materials the smaller the pore space or gaps which water can move. Hence water flow through clays is much slower than sands)*

ii. **Groundwater gradient** or pressure to push or drive the water flow (similar to how a grade bank requires a gradient to move surface water). The actual water movement is very slow. *(Rainfall that infiltrates at the top of a hill is not the same water which seeps out further downslope, it is the added pressure at the top that pushes water out at the seepage zone.)*

iii. Adequate regolith and aquifer thickness across the catchment to provide an **area available** for the water to flow through. (*The cross sectional area is measured from the bottom of the aquifer usually the bedrock to the top of the watertable(height) and across the outflow of the aquifer*).

Source of salts in the regolith

The salt responsible for dryland salinity in Western Australia originated from the oceans surrounding our coast. However, contrary to popular belief, the salts were not left behind when the ocean covered the land, but have been deposited with rainfall. Over tens of thousands of years the native perennial vegetation has used most of the rainfall leaving behind the salt to accumulate in the sub-soil and regolith. There are hundreds to tens of thousands of tonnes of salt stored under each hectare of land depending on location and soil type. Today salts continue to be deposited (20 -200kg/ha/yr) on the landscape by the same process (*precipitation of sea salt in rain*).

Causes of dryland salinity

Salinity is a result of salt accumulation in the soil profile and in water bodies (rivers and lakes). It is caused by more water entering the landscape (referred to as recharge) than occurred under pre-clearing conditions (native vegetation). The extra water now entering the landscape causes groundwater levels (watertables) to rise, which then mobilises some of the salts stored in the regolith. When the watertable nears the surface (less than 2m from the surface) the groundwater discharges (seeps out), and evaporation concentrates the salts at the surface. A salt and waterlogging interaction in the topsoil is toxic to many plants[1], refer to table 5.1.

Table 5.1: Guide to interpreting soil salinity – soil EC

Salinity hazard	**Effect on plant growth**	**Class**	**EC of 1:5 soil/water extract (mS/m)**				
			sand/loamy sand	**Loam**	**Sandy clay loam**	**Light clay**	**Heavy clay**
Non-saline	Negligible effect	1	< 15	< 17	< 25	< 30	< 40
Slightly saline	Very sensitive crops affected	2	16-30	18-35	26-45	31-60	41-80
Moderately saline	Many crops affected	3	31-60	36-75	46-90	61-115	81-160
Very saline	Salt tolerant plants grow	4	61-120	76-150	91-175	116-230	161-320
Highly saline	Few salt tolerant plants grow	5	> 120	> 150	> 175	> 230	>320

Criteria for assessing soil salinity hazard (EC) and yield reduction for plants of varying salt tolerance. EC units are mS/m (millisiemens per metre).

Source: D. Reuta & J Walker (1996), 'Indicators of Catchment Health – A technical perspective", CSIRO.

Factors effecting development and extent of salinity

There are only three basic requirements for salinity to develop[2];

i. a store of salt,
ii. a supply of water,
iii. a mechanism to bring both of these into contact with the ground surface or a water body (rivers and lakes)

However there are a number of factors effecting the development of salinity in a catchment or landscape;

Natural factors

i. climate
- rainfall amount, frequency and pattern

ii. geology:
- depth to basement (regolith thickness),
- salt storage (regolith),
- shape and structure (faults and fractures) of bedrock

iii. hydrology:
- depth to groundwater
- rate of recharge
- rate of groundwater rise
- aquifer properties

iv. soils:
- degree of waterlogging
- type and permeability
- landscape characteristics and shape

Cultural factors

v. time since clearing

vi. historical and existing vegetation cover and condition

vii. land use and management
- water use
- water management

Groundwater recharge

Over the last 30 years considerable effort has gone into trying to identify specific recharge zones within catchments [4]. As our understanding of the hydrology of the agricultural areas has improved, the area thought to contribute recharge in Western Australia has progressively expanded. Subsequently the area considered to contribute recharge has expanded from the coarse textured (sandy) areas to almost the entire catchment[3].

It is a reasonable generalisation that recharge can occur in all areas of a catchment that are not discharging. In some catchments recharge can occur in an area during winter and the same area can be a discharge site in summer (i.e. valley floor). It also seems reasonable to assume that in most catchments there are zones of relatively higher recharge that will require separate attention in a catchment plan[4]. However we cannot concentrate purely on the 'high' recharge areas and disregard the recharge occurring across the rest of the catchment, as this will not address the recharge problem.

- "No single, simple, practical, universally applicable method exists to manage the water balance of catchments prone to land salinisation."
- "...the selection of treatments will largely depend on economics and practicality..."[4].

Salinity Management[1]

Salinity reclamation aims to restore previous levels of either agricultural production, water quality, or ecological diversity. This goal is the preferred objective of any remedial program, for a variety of reasons it is rarely possible to accomplish. More often, salinity **management** is all that can be practically achieved. Salinity management has connotations of "living with salinity" by reducing its severity, rate of spread, and eventual extent, and of protecting priority resources only (e.g., prime agricultural land, high-value water resources, towns, and important nature conservation areas).

To develop and apply an effective salinity-management system in priority areas requires:
1) the definition of salinity control practices,
2) the ability to utilise planning tools, and
3) existence of a community climate for action that is both politically and community driven.

- **Salinity-control practices** are the components of salinity management systems, such as trees, drains, or high-water use crops and pastures. These practices work by transpiring or disposing of the excess water that causes salinity.
- **Planning tools** are the basic and derived biophysical data (e.g., topography, soils etc....) and the support system such as Geographic Information Systems, simulation models, and catchment and farm planning.
- **Communication and cultural-change climate** is the capacity to transfer knowledge and build broad-based commitments to implementing the changes required to manage salinity.

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6.0 Water Quality Summary of the Lake Warden Catchment

An overview of water quality data collected from four creeks entering the Lake Warden Wetlands during 1998 and 1999

Four major creeks the Coramup, Bandy, Neridup and Melijinup discharge into the Lake Warden Wetland system. A stream gauging site was established in mid 1997 to monitor the Coramup Creek and subsequently sites installed on the other three creeks. The following information summarises the basic character of flows and water quality between June 1997 and October 1999. The dataset is longest for the Coramup followed by Bandy Creek and lastly the more ephemeral Melijinup and Neridup Creeks. The response of the creeks to the extreme floods in January 1999, estimated to occur on average only once in every 200 or so years, is a reminder that one or two years of data may not clearly reveal average underlying conditions. A more accurate analysis of stream hydrology requires at least 10 years of data.

During the flooding the flow gauging was not very reliable due to damage at the sites and the inability of the equipment to cope with such high flows. Nevertheless the monitoring results begin to reveal elements of the comparative condition and quantity of water in the creeks.

Fig 6.1 shows daily discharge during the period October 1997 to January 1999. Groundwater discharge maintained flows in Coramup and Bandy Creeks for most of the period. Neridup and Melijinup Creeks, like many other South Coast rivers and creeks, dry up completely for significant parts of the year.

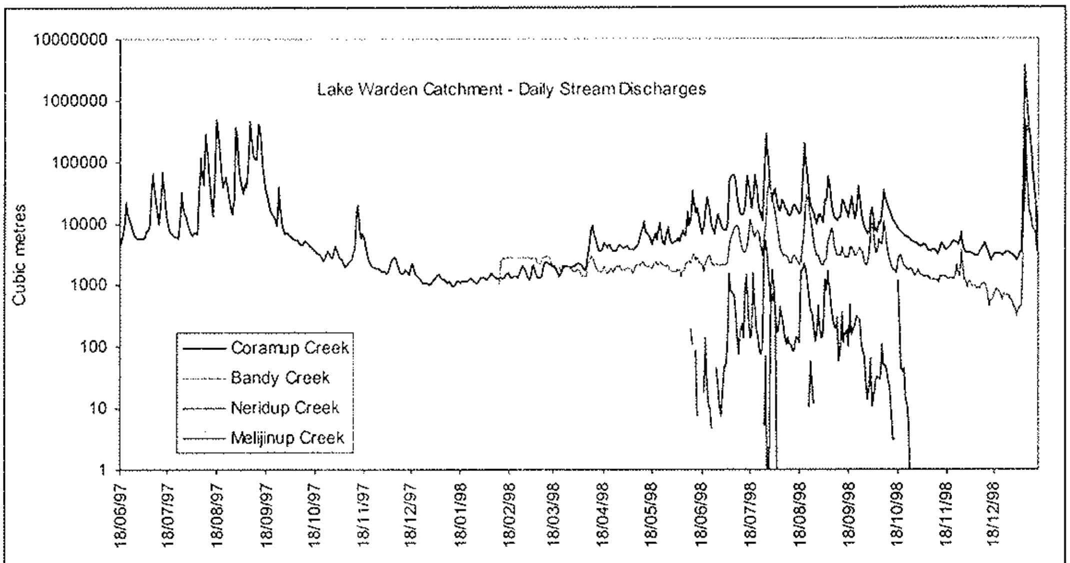
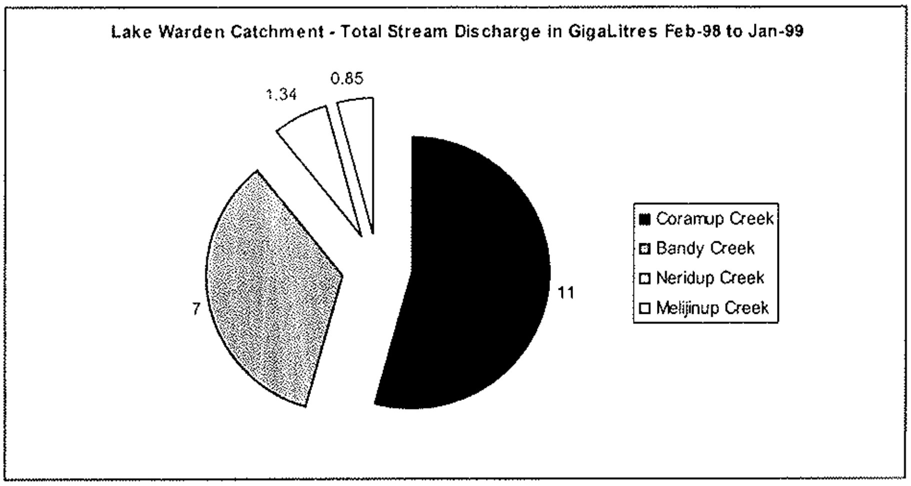


Fig 6.2 shows the relative discharge, in Gigalitres, from each of the four creeks during the year May 1998 to May 1999. A Gigalitre is the amount of water that would cover one square kilometre to a depth of one metre.

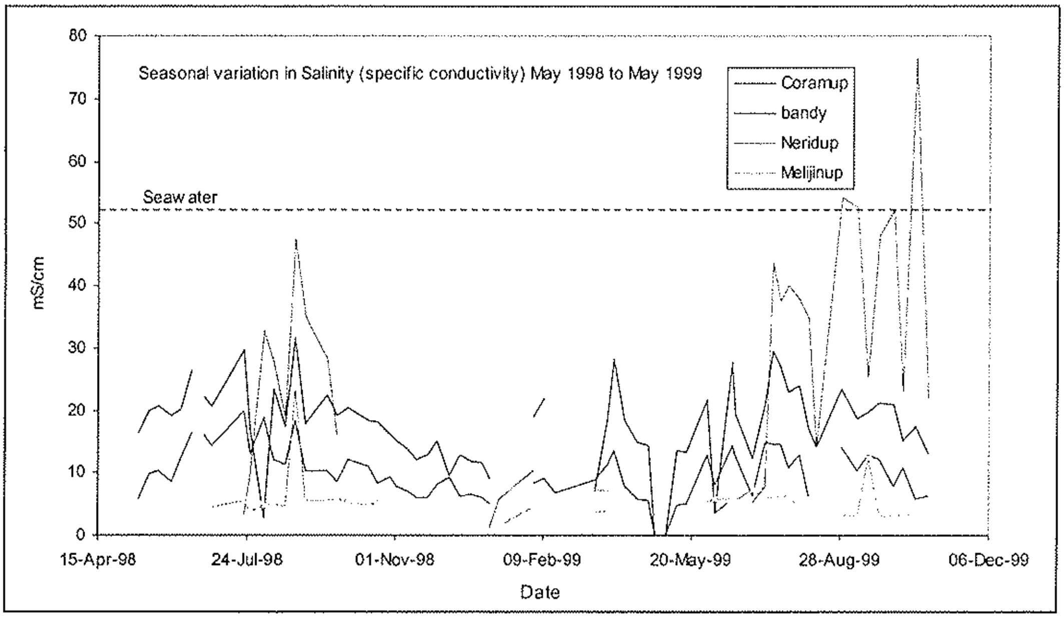


The total discharge and relative proportions of discharge were strongly biased by the January storm event, which was centred in a localised area around Esperance.

Approximate catchment areas:

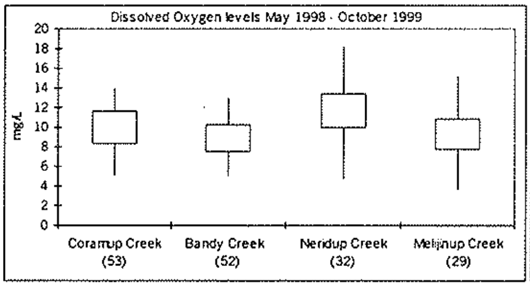
- Coramup Creek 310 Km^2
- Bandy Creek 505 Km^2
- Neridup Creek 626 Km^2
- Melijinup Creek 15 Km^2

Fig 6.3 shows the variation in electrical conductivity (salinity) for each of the four creeks over the period May-1998 to October-1999. An interesting feature for the period is the higher salinity values occurring in Coramup and Bandy Creeks during the winter and declining towards summer. This relates to the peculiarities of salt storage in the catchment, particularly the upper parts of the system and again suggests that these creeks are different from many other South Coast streams.



The following graphs, 1 – 7, compare the ranges of water quality values found in the four creeks. The maximum and minimum values are shown and the boxes span the middle 50% of the measurements. The figure in brackets below each creek name is the number of samples collected during the period.

1.



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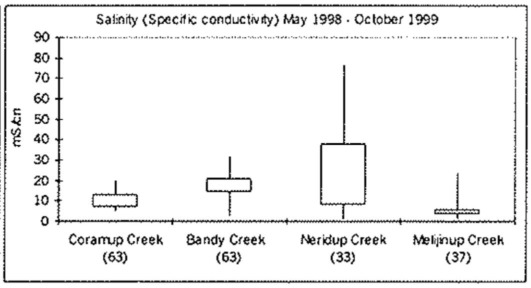

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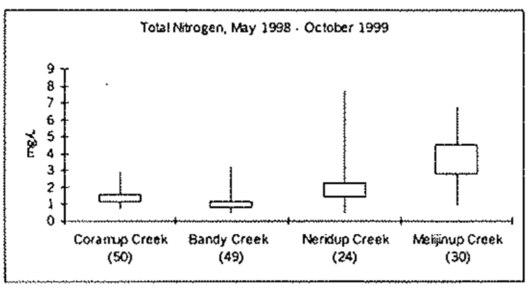

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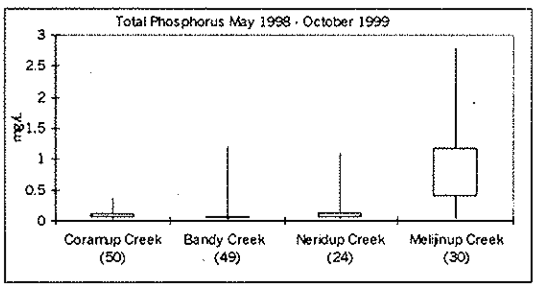

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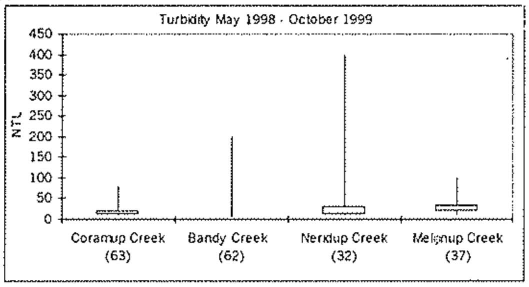
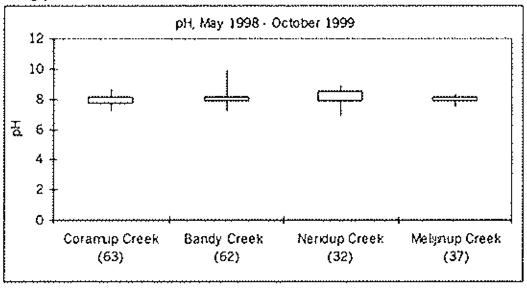
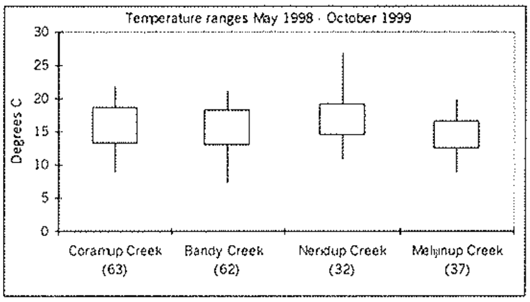


6.



7.



1. Dissolved Oxygen (DO)

Dissolved oxygen levels in waterways should not fall below about 6 mg/L if the natural ecological functions are to be maintained. The results from all four creeks show that DO levels are generally high and lack of oxygen does not appear to be a problem. A significant number of sample values occurred above 10 mg/L and this may reflect active algal growing in the system at certain times of the year.

2. Salinity

Some strong differences are suggested between the catchments. Melijinup Creek shows generally low levels in the marginal to brackish range while Neridup Creek appears considerably more saline than the others. The degree to which the average salinity has increased over the past decades is unknown. If experience elsewhere on the South Coast is a guide then fresher flows have possibly decreased as saline groundwater input has increased.

3. Total Nitrogen

The desirable upper limit for total nitrogen in natural streams is approximately 1 mg/L. All four creeks regularly exceeded this limit with Melijinup Creek producing quite high readings during the entire period. Bandy Creek gave the lowest values for most of the period. The nature of land use in this small more densely populated catchment adjacent to the town may be a significant contributing factor.

The highest value for Neridup Creek occurred on the 5^{th} of January 1999, following heavy rain the previous day and the first significant flow since October 1998. This was at the beginning of the January flood.

4. Total Phosphorus

The desirable upper limit for total Phosphorus is approximately 0.1 mg/L. It can be seen that Coramup, Bandy and Neridup Creeks have the larger proportion of values below or near this level. Some high values are likely to be attributable to specific storm events. Melijinup Creek however shows many very high values. A number of the highest readings occurred during the winter of 1998 and 1999, with the four highest values occurring during July 1999. Despite being the smallest catchment and having a relative contribution of less than 10% of the total estimated discharge into the wetlands, Melijinup Creek cannot be discounted as a significant source of nutrient input compared with the other larger systems.

5. Turbidity

Turbidity is a measure of the clarity of the water and as such reflects the amount of material suspended in the water. It does not indicate the source or type of material. Sediment and algal growth can both decrease the clarity. Generally values were quite low signifying clear water. The highest values and the greatest range were found in Neridup Creek. Un-vegetated stream banks are considered a major source of sediment eroding into our rivers and creeks.

6. pH

The pH range was acceptable in all four streams. Levels for natural stream waters should remain between 6.5 and 9.0. Values around pH 8 are common in other saline rivers on the South Coast. Inputs of fresh surface runoff during flood events can temporarily lower the pH. This was observed during the Esperance January 1999 floods.

7. Temperature

Temperatures were consistent between all four streams and generally stayed between 12 °C and 18 °C. Some higher values in Neridup Creek were probably a result of the more exposed nature of the gauging site and shallow flows. Water temperature will vary considerably from one site to another, even across a few metres, however shading of streams by fringing vegetation is an important function of healthy natural systems and will have a marked impact on average water temperatures. Shading can also reduce algal and weed growth.

<u>Estimating loads of nutrients entering the Esperance Lakes systems via the major creeks systems.</u>

If the average concentration of a nutrient in a volume of water moves past a gauging site then the total quantity carried is found by multiplying the volume by the concentration. Since nutrient concentrations and flow rates are constantly changing a continuous record of each is required to make good estimates of the load.
Continuous flow records are relatively easy to obtain but samples are usually collected infrequently, perhaps weekly or monthly. Currently the data set is too short to establish acceptable load estimates.

Some comments made by the water quality monitor

Creek	Date	Water Level	Comment
Coramup	27-Jul-98	High	Usually 3-4m wide, now 15m wide (off the bridge)
	05-Aug-98	Medium	Lots of algae on the bottom, 3-4m wide
Bandy	12-Aug-98	Medium	Lots of 'floaties', light drizzle
	16-Nov-98	Fall	Lots of vegetation on the surface
Neridup	05-Aug-98	High	Remarkably clear water compared to previous visits
	12-Aug-98	Low	Algae building up on the bottom
	02-Sep-98	Trickle	Almost still/stagnant, algae
	03-Feb-99	Static	Tadpoles swimming around
	25-Jul-99	Static	Lots of algae slime present
	30-Aug-99	Static	Algae present
	09-Sep-99	Static	Algae present
	04-Oct-99	Pool	Pool/Algae
	27-Oct-99	Falling	Pool/Algae
Melijinup	12-Aug-98	Medium	Tannin coloured water

Flow gauging sites maintained by Andrew Maughan and Shane Lawrence, WRC.
Water quality field data collected by Sharon Barber.
Summary by S. Janicke, WRC.

7.0 Nature Conservation

Tilo Massenbauer (CALM, Recovery Catchment Officer)

Native Vegetation Representation

The Lake Warden Catchment has 18% of its original native vegetation cover remaining. Most of the remaining vegetation throughout the catchment occurs in CALM managed reserves (7.6%) or on other reserves such as shire, aboriginal and DOLA managed lands (7.3%). The remaining 3.8% of native vegetation is fragmented over 83% of the catchment, which zoned farmland. This imbalance of native vegetation distribution across the catchment has resulted in water table rises, and loss of natural biodiversity.

Vegetation types can be closely associated to soil type, drainage, rainfall and topography. Agriculture also relies on these landscape factors, and by doing so, some areas of the catchment is more suitable for agriculture than others. The areas most suitable for cropping and grazing have been cleared for these landuses, resulting in a greater loss of certain vegetation types than others that were originally found in these landscapes.

Table 7.2 is a summary of vegetation types and their present cover across the catchment. The Lake Warden Catchment Recovery Plan uses the value of < 20% of a vegetation types original distribution across the catchment as being under represented. This is outlined in the plans Nature Conservation Strategy.

The Esperance Sandplain is a sub-region of the Esperance Vegetation system. The Sandplain vegetation types throughout the catchment are the most severely under represented. There is only 6.8% Mallee heath (*Eucalyptus tetragona*), 11.5% Scrub heath (*Banksia speciosa*) and 10.5% Scrub heath (mixed species) remaining throughout the Lake Warden Catchment.

Lake Warden Catchment Nature Conservation Project

The following summary is of the nature conservation works proposed by the farmers of the Lake Catchment as part of CALM's Natural Resource Survey project. Farmers were asked where they would like to revegetate areas using local native species and what remnant vegetation they would like to fence.

CALM then developed a Native Rehabilitation Plan, which is a zone that models where revegetation will have initial nature conservation and hydrological benefit for the catchment. The Native Rehabilitation Plan model is merely a preliminary guide to assist in prioritising nature conservation works. Further detailed assessment of proposals is required. This is discussed in the *On Farm Conservation Planning* section of the farm kit.

By analysing the information supplied by farmers with the aid a geographical information tool, Arc View, the following nature conservation actions for the Lake Warden Catchment were defined.

Farmers have proposed to revegetate 2530 ha of the catchment with local native species. By analysing, which farmer proposals intersect with the Native Rehabilitation Plan zone, 1730 ha (68%) of the farmer proposed works is considered to have initial conservation and hydrological benefits. A further 290 ha of farmer proposed works that are not incorporated by the Rehabilitation Plan model is also considered to have initial conservation and hydrological benefits.

A total of about 2020 ha of farmer proposed revegetation has conservation and hydrological catchment benefits. CALM will explore these proposals in further detail on a site-by-site basis to see if the public benefits of the proposal warrant financial assistance. This process also applies to the 505 km of fencing required to protect the proposed revegetation sites and a further farmer proposed 400 km of remnant vegetation fencing. Table 7.1 is a basic costing analysis of implementing nature conservation works proposed by farmers.

Table 7.1: Basic total costing of implementing farmer proposed nature conservation works.

Materials	Calculation	Cost $
Seed	1212 ha x 0.8 kg/ha @ $280/kg	271488
Seeding labour	1212 ha @ $30/ha	36360
Seedlings	808 ha x 1300 sl/ha @ $0.30/sl	351120
Planting Labour	1050400 sl @ $0.10/sl	105040
Chemical materials	2020 ha @ $30/ha	60600
Chemical application	2020 ha @ $30/ha	60600
Ripping & Mounding	2020 ha @ $50/ha	101000
Fencing Reveg Sites materials	505km @ $1550/km	782750
Fencing Labour	505 km @ $1000/km	505000
Fencing Remnants materials	400 km @ $1550/km	620000
Fencing Labour	400 km @ $1000/km	400000
	TOTAL	**3 293 958**

This equates to a very large nature conservation project that farmers have proposed for the Lake Warden Catchment. The project will only be successful if the community, through government agencies and catchment stakeholders, share the project costs in accordance to the benefits received by parties involved. CALM, through the State Salinity Action Plan, is committing considerable resources to on-ground nature conservation works throughout the catchment for the year 2000 and beyond.

Native Revegetation

It is important that when planning revegetation works across the catchment that sites be suitable for the re-establishment of under represented vegetation types. It is also important to realise that we cannot reconstruct exactly what was present prior to clearing. Weeds, vermin, altered soil conditions and fire management are issues that need to be considered when planning conservation works. Some native plants are difficult to establish, and the costs involved in reconstructing a site to its original native vegetation condition is often unrealistic.

Table 7.4 is a list of local native species that can be used over a range of different landscapes throughout the Lake Warden Catchment. Conservation and economic factors were used in compiling this list. Plant species dominance in differing plant community structures and fauna habitat requirements were important selection criteria. How easy is the seed to collect, the cost of seed and seedlings, viability of native seed, ease of germination, ability to withstand salinity, waterlogging and herbicides are some of the criteria used in the species selection process.

By using a balanced mixture of these local species under the right conditions, the structure of a plant community can be established with conservation and hydrological benefits. The Greening Australia, WA Bushcare Support Officer and CALM's Recovery Catchment Officer will provide assistance in planning native revegetation works. Refer to the contact list, page 26.

Table 7.2: Representativeness of Beard's vegetation types in the Lake Warden Catchment

Vegetation Type	Area of original cover (ha)	Area of original cover (% of catchment)	Proportion of original cover remaining (% of catchment)	Proportion of original cover remaining (% of vegetation type)
Bare Areas (sand, rock & salt lakes)	2295	1.5	0.3	84.0
Fanny Cove Vegetation System:				
Shrubland (*Banksia speciosa*)	10590	6.2	2.2	36.4
Shrubland (*Eucalyptus angulosa, Acacia species*)	3175	1.9	1.4	77.0
Tee Tree Scrub (Melaleuca species)	1530	0.9	0.1	12.4
Esperance Vegetation System (Esperance Sandplain Sub Region):				
Mallee Heath (*Eucalyptus tetragona*)	58315	34.1	2.3	6.8
Scrub Heath (*Banksia speciosa*)	33025	19.3	2.2	11.5
Scrub Heath (Mixed Species)	4920	2.9	0.3	10.5
Mallee (*Eucalyptus turnida – E. uncinata*)	5085	3.0	0.5	17.0
Yate Woodland (*E. occidentalis*)	1005	0.6	0.3	45.0
Ridley vegetation system (Mallee sub-region):				
Mallee (*Eucalyptus turnida – E. uncinata*)	50100	29.3	8.9	30.3
Mallee (*E. oleosa – E. eremophila*)	575	0.3	0.3	88.6
Saltbush steppe	265	0.2	0.03	18.6
TOTAL	**170880**	**100.0**	**18.83**	

Source: Beards 1:25000 vegetation data, Ag West and CALM.
Table developed by Tilo Massenbauer, CALM Recovery Catchment Officer

Table 7.3: Number of priority and declared rare flora species found in the Lake warden Catchment

Priority Listing	Number of Species
Rare	2
P1	7
P2	13
P3	5
P4	8
Total Species	**36**

Source: Priority and Rare flora data, CALM, Wildlife Conservation Section.
Table developed by Tilo Massenbauer, CALM Recovery Catchment Officer

Table 7.4: Native Revegetation species for the Lake Warden Catchment

No.	~~Salt Tolerant~~ Species	Life Form	Preferred Site
1	*Eucalyptus halophila*	Mallee tree form	Loam saline
2	*Eucalyptus rigens*	Mallee tree form	Loam saline
3	*Melaleuca calycina*	Shrubs 1.0-1.5m	Loam saline
4	*Melaleuca fissurata*	Shrubs 1.0-1.5m	Loam saline
5	*Anarthria laevis*	Sedges < 0.5	Sandy saline
6	*Acacia cyclops*	Trees > 5m	Sandy/Loam saline
7	*Acacia patagiata*	Shrubs 1.0-1.5m	Sandy/Loam saline
8	*Acacia mutabilis subsp. mutabilis*	Shrubs 1.0-1.5m	Sandy/Loam saline
9	*Acacia saligna*	Trees > 5m	Sandy/Loam saline
10	*Atriplex paladosa/vesicaria*	Shrubs 0.5-1.0m	Sandy/Loam saline
11	*Eucalyptus angustissima*	Mallee tree form	Sandy/Loam saline
12	*Eucalyptus occidentalis*	Trees 5-15m	Sandy/Loam saline
13	*Gahnia trifida*	Sedges > 0.5m	Sandy/Loam saline
14	*Hakea adnata*	Shrubs 1.5-2.0m	Sandy/Loam saline
15	*Isolepis nodosa*	Sedges > 0.5m	Sandy/Loam saline
16	*Melaleuca brevifolia*	Shrubs 1.5-2.0m	Sandy/Loam saline
17	*Melaleuca cuticularis*	Trees > 5m	Sandy/Loam saline
18	*Melaleuca thyoides*	Shrubs 1.5-2.0m	Sandy/Loam saline
19	*Banksia nutans*	Shrubs 1.0-1.5m	Sandplain
20	*Banksia pulchella*	Shrubs 0.5-1.0m	Sandplain
21	*Banksia repens*	Shrubs 0.0-0.5m	Sandplain
22	*Banksia speciosa*	Shrubs > 2.0m	Sandplain
23	*Nuytsia floribunda*	Trees > 5m	Sandplain
24	*Eucalyptus conferruminata*	Trees 5-15m	Sandplain/Coastal
25	*Eucalyptus platypus subsp heterophylla*	Mallee tree form	Sandplain
26	*Eucalyptus tetragona*	Mallee shrub form	Sandplain
27	*Eucalyptus tetraptera*	Mallee shrub form	Sandplain
28	*Eucalyptus uncinata*	Mallee tree form	Sandplain
29	*Hakea corymbosa*	Shrubs 1.0-1.5m	Sandplain
30	*Hakea nitida*	Shrubs 1.5-2.0m	Sandplain
31	*Isopogon trilobus*	Shrubs 0.5-1.0m	Sandplain
32	*Isopogon polycephalus*	Shrubs 1.0-1.5m	Sandplain
33	*Lambertia inermis*	Shrubs > 2.0m	Sandplain
34	*Melaleuca striata*	Shrubs 1.0-1.5m	Sandplain
35	*Melaleuca thymoides*	Shrubs 1.0-1.5m	Sandplain
36	*Phymatocarpus maxwellii*	Shrubs 1.0-1.5m	Sandplain
37	*Xanthorrhoea preissii*	Sedges > 0.5m	Sandplain
38	*Acacia acuminata*	Trees > 5m	Granite
39	*Calothamnus quadrifidus*	Shrubs 1.5-2.0m	Granite
40	*Dryandra armata*	Shrubs 0.5-1.0m	Granite
41	*Hakea laurina*	Shrubs > 2.0m	Granite
42	*Melaleuca elliptica*	Trees > 5m	Granite
43	*Melaleuca fulgens*	Trees > 5m	Granite
44	*Melaleuca uncinata*	Shrubs 1.5-2.0m	Granite
45	*Allocasuarina humilis*	Shrubs 1.5-2.0m	Sandplain/Granite
46	*Dryandra cuneata*	Shrubs 0.5-1.0m	Sandplain/Granite
47	*Dryandra nivea*	Shrubs 0.5-1.0m	Sandplain/Granite

Source: Tilo Massenbauer, CALM, Recovery Catchment Officer

8.0 Lucerne Case Study – A Multi Purpose Plant

Producers – Duncan & Michele McIlroy, 'Murrumboola', Speddingup

Duncan and Michele McIlroy have a mixed farm enterprise at 'Murrumboola' about 50 km north of Esperance. Wheat and barley make up most of the cropping program with wool production from around 1600 merino sheep and some beef production thrown in as well. Soils are predominantly circle valley sandy loams and annual rainfall is around 400 mm.

Shifting Sandy Rises

The farm has some deep sandy rises and these were proving to be a headache. Annual crop and pasture growth was poor and sheep would camp on these areas in summer causing blowouts. Low points in paddocks were also starting to go salty. The McIlroy's wanted to stabilise these areas and keep open the option of cropping in the future.

Lucerne

The first step was to fence off the rises so they could be managed as a separate unit. After chasing around for some advice a decision was made to plant Lucerne.

12 ha of Lucerne was sown in 1988 as a practise go. More was sown in 1992 and more has been added to the farm nearly every year since. The farm now has around 220 ha of Lucerne in six paddocks.

Benefits

Duncan is now able to get some useful production from the sandy rises without having to worry about them blowing away. The green feed in summer/autumn is very useful and can reduce or replace supplementary feeding. One important benefit is that saline hollows now have some cover and sub-clovers are returning to these areas.

Points to Watch

Establishment needs a bit of practise and Duncan recommends that you should be prepared to have a few attempts. Non-wetting soils can lead to poor establishment and these areas could be clayed. Cropping the paddock to barley in the preceding year will help to provide some weed control and a stubble to establish Lucerne into.

Summary

- Vegetate 'difficult' sandy rises
- Reduce wind erosion problems
- Summer/autumn green feed
- Reclaim saline areas
- Retain cropping option

Source: Jamie Bowyer, Ag West Development Officer Esperance

9.0 Kikuyu Case study - A Summer Active Perennial Grass

Producer - David Johnson, 'Ireland Farm' Gibson

Background

David Johnson has managed 'Ireland Farm' near Gibson for nearly thirty years. He has seen many changes in farming in that time and has always looked for new, more productive and sustainable ways of getting the job done.

'Ireland Farm' is a typical Esperance Sandplain property with soils ranging from deep infertile sands to shallow waterlogging prone duplex soils. Rainfall averages around 500 mm a year with some summer rainfall.

Beef production is the main enterprise with some share cropping. In the past wool production has also contributed to farm income.

The Problem

The medium to deep sands were unproductive under annual pastures and wind erosion was a real problem. David was keen to improve productivity of these areas of the farm as well as stabilize paddocks. Shallow duplex soils also presented a problem with winter waterlogging affecting pasture growth.

Salinity was not a big problem although some saline areas developing around a creek-line had David thinking about the problem.

Solutions

David began a search for pasture species that would stabilize the sandy soil and raise productivity at the same time. Initially, perennial veldt grass with serradella and clover were used. Unfortunately grazing with sheep presented too much of a wind erosion risk. David then decided to graze the deep sands with cattle and to keep sheep to less fragile soil types.

Lucerne was included and a definite improvement in productivity resulted. Stocking rates were nearly doubled and were now similar to those on the duplex soils. A perennial legume now formed the basis of a productive pasture on the medium to deep sands.

When Whittet Kikuyu was released David decided to try some in a paddock that was too wet for Lucerne. It didn't show for 2-3 years then patches slowly spread. As he was rotationally grazing the paddocks, it began to show in the Lucerne. This was a cheap and effective way of establishing the Kikuyu in other paddocks. As the Lucerne declined under insect attack the Kikuyu began to take over. The Kikuyu has slowly spread by runners and seed transported in cow dung. There are now approximately 425 ha of Kikuyu on the farm

Benefits

In the paddocks that have well established Kikuyu wind erosion has been eliminated. These paddocks can now be stocked quite safely right through summer and autumn to the break of the season. This allows more flexibility in the grazing enterprise.

The Kikuyu is using more water than annual pasture on the same soil type. Water use figures from Meat and Livestock Australia and Agriculture Western Australia research on the farm has shown that Kikuyu produced a ten-fold reduction in recharge compared to annual pasture over a two-year period. This is an excellent result.

The green feed provided over summer has allowed stock to maintain condition without supplementary feeding. The complimentary between Kikuyu and annual pasture paddocks has allowed an overall increase in carrying capacity.

Table 9.1: Gross margins and stocking rates of kikuyu and annual pasture in a wet and a dry year

	Wet year		Dry year	
	Kikuyu	**annual**	**Kikuyu**	**annual**
DSE/ha	10.6	8.1	9.3	8.5
Net return/ha	$138.68	$77.47	$112.23	$85.10

Point to Watch

Kikuyu can become long and rank unless well managed. It is important to stock Kikuyu with enough animals to prevent this happening. This allows annual legumes and grasses to regenerate at the break. This is important as a good legume provides nitrogen to drive production of the Kikuyu. Another reason for having a healthy annual component in winter is the quality of Kikuyu is not as good as annual pasture species at this time of the year.

Source: Jamie Bowyer, Ag West Development Officer Esperance

10.0 Tagasaste Case Study

Producer: Greg and Trudi Kleinig, 'Ebenezer' Dalyup

Greg and Trudi Kleinig run the family farm 'Ebenezer' 45 km west of Esperance on the south coast highway. The property is 1085 hectares of typical Esperance Sandplain with an average rainfall of 550 mm. About half of the arable soil on the farm is deep sand. Beef production is the mainstay of the property and some triticale and hay is grown as well.

Ebenezer's Dilemma

The deep infertile sands on the farm were unproductive and the carrying capacity with sheep was low. Greg wanted to improve the productivity of these sands and after much reading and research decided tagasaste was the ideal plant for the job.

Another problem with the poor sands was wind erosion. Poor annual pasture growth would lead to bare areas in summer that were prone to blowing. By establishing a perennial system the wind erosion problems were expected to reduce.

It was a brave decision to forge ahead as little tagasaste was growing in the Esperance area at the time. The desire to improve productivity was the driving force behind the change.

Putting The Plan Into Action

From June to September in 1987 around 320 hectares of tagasaste was direct seeded with a small amount of *Acacia saligna* (golden wattle) and *Acacia cyclops.* The tagasaste was planted in blocks with single rows and a 5m gap between rows.

Early sowings were too deep and resulted in poor germination. Greg soon rectified this by ensuring seed was reasonably shallow and better germination resulted.

Productivity Improvement

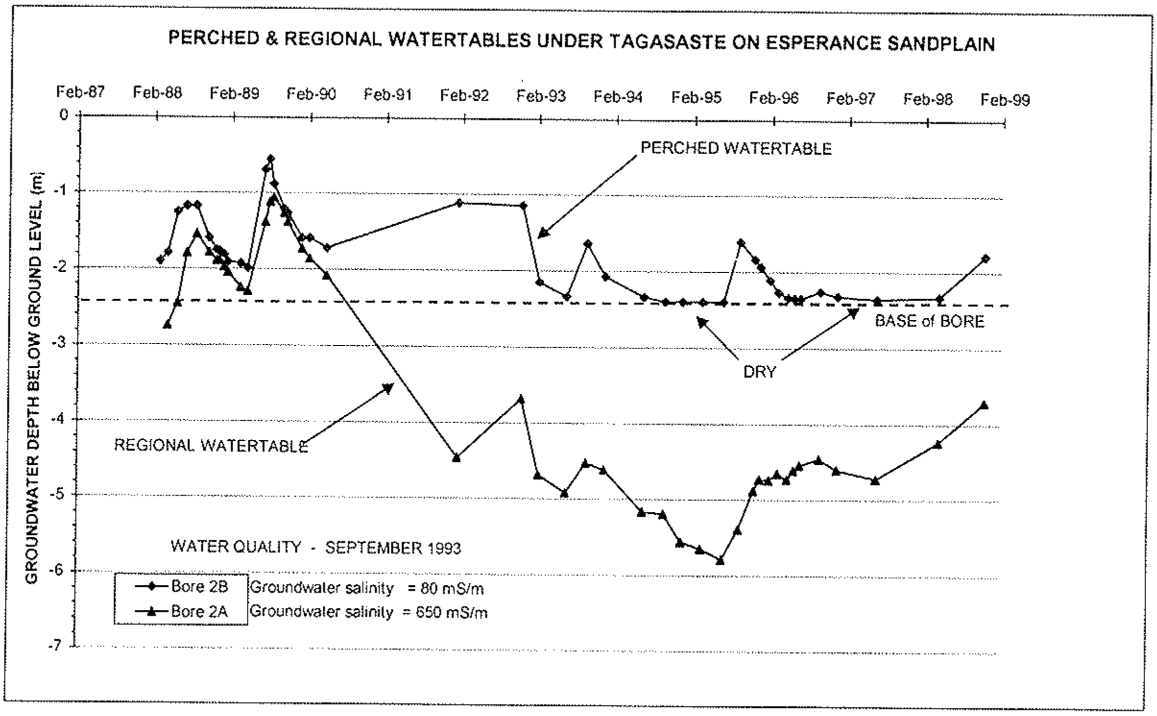
Before tagasaste was planted on the property Greg says the carrying capacity was around 1.75 dse/ha on the deep sands. Since planting tagasaste and converting to a beef production enterprise carrying capacity has increased. Greg says that one-year when the tagasaste was growing very well a 70 hectare paddock carried a cow/calf unit to the acre (2.4 units/ha)

There is also more flexibility to the enterprise, particularly if good summer rain provides extra growth on the tagasaste.

Environmental benefits

Deep sands are known to be high recharge areas with low water use of poor annual crops and pastures adding to the problem. Tagasaste, with its deep root system, can exploit and dry a much larger area of the soil profile throughout the entire year. A drier soil allows a greater capacity for the soil to receive rainfall in the following winter.

Bores have been monitored on the Kleinig farm since 1987. They show a drying of a perched, fresh watertable under the tagasaste. This perched system was recharging into the deeper regional watertable. The regional watertable below the tagasaste has also dropped in response to less drainage coming from the perched system.



Data supplied by Catchment Hydrology AgWest Esperance

Wind erosion has almost been eliminated. Once fragile paddocks can now be stocked in summer and late autumn when previously great care had to be taken. Greg says care needs to be taken with high traffic areas between the last tagasaste row and fences as this can bare off and become a problem. Sheeting with gravel is one solution.

Many farmers comment on how adding tree species to the farm make it a better place to live and work. Greg says that there are a lot more birds on the farm now and these must play a role in insect pest management.

Useful Tips

Greg now has a lot of practical experience growing and managing tagasaste. He has also direct seeded tagasaste for other farmers in the district. He has some good advice for producers using tagasaste.

- If cutting is required do so in mid winter when plants are under least environmental stress.
- Don't overgraze.
- Do ensure fertiliser requirements of plants are met

Future Plans

Greg is very happy with the contribution tagasaste has made to the family farm. He is planning to put another 160 ha of tagasaste onto similar deep sands. This time he is looking to widen the inter row gap to 10 m. He then plans to grow triticale in the inter row every second year.

He firmly believes tagasaste has a role to play in beef production enterprises along the south coast and feels that more research needs to be done on tagasaste in the Esperance area.

Source: Jamie Bowyer, Ag West Development Officer Esperance

11.0 Olives and Seed Potatoes

Andrea Hills (Ag West, Development Officer Esperance)

Seed Potatoes

Primary requirement for landholders is availability of large quantities of fresh water for irrigation. Estimates of water requirements are around 3 ML for winter crops (April to August) and 7 ML for summer crops (September to January).

Potatoes can be grown on a broad range of soil types, but most success has been on deep sands or deep duplex soils - waterlogging is not tolerated by this crop. Potatoes could be grown on the alkaline and calcareous sands, but high levels of trace elements would be needed. Windbreaks (eg. sorghum) are needed to prevent sand blasting of potatoes. Only a few hectares at a time are planted.

Since this is an annual, irrigated crop, there are limited water use benefits. Summer potato crops are in a position to use rainfall from summer storms that would otherwise be unused or grow weeds.

Diversification into this industry demands commitment - regional reputations in the potato industry are everything, so it is vital that only high quality seed should be sold from Esperance. Markets exist domestically with big potential for overseas (south east Asia) expansion. Esperance has a number of natural advantages over other seed production areas and the shire is soon to be gazetted as seed potato only to retain the quality necessary for seed production.

Olives

Olives are renowned for their ability to grow under adverse conditions (including poor soil fertility) and have good drought tolerance once established. However, most budgets for groves tend to assume that irrigation is possible since watering, even irrigation limited to a few strategic times of the season, can increase yields dramatically. So access to water is important. Water quality is debatable - while established trees may tolerate quite saline water, young trees do not.

Olive trees hate waterlogging, so shallow duplexes or other poorly drained soils are not suitable. Otherwise, olives can grow almost anywhere. Steep slopes are not a good idea since mechanical harvesting is expected to be the norm.

Olives grow in the Esperance area quite happily and live for a very long time. No Esperance groves are mature enough yet to know what sort of yields we can expect, but adult trees should average 40 kg/yr (with 250 trees /ha = 10 t/ha). Oil contents of the olive vary depending upon variety and management, but 20 % oil is a reasonable estimation. An olive tree variety trial is located on Peter Gelmi's property east out of town (6 varieties x 6 trees).

Costs to establish groves include: ripping, fertilising, trees, protection (from kangaroos and grasshoppers), weed control, staking, training/pruning, establishing irrigation, lag time to full production around 5 years. Example budgets are available from Andrea Hills.

Marketing is the big unknown here. The majority of olives are planted for oil. While extra virgin olive oil can command heady prices in the boutique market (up to $40/L), the reality is that only a small proportion of the harvest is of that quality and bulk olive oil sells for $3 - $6 /L. In Esperance it is still unknown how the trees will be harvested or oil and olives sold. A co-operative is probably the way to go for bulk olive oil marketing.

Further Reading

- **The Olive Industry - A Marketing Study.** DG McEvoy and EE Gomez. Published by RIRDC, Pub. No. 99/86 *$15*
- **Olive Production Manual.** University of California. Available through Olives Australia at; Reply Paid No. RP 30, Olives Australia, 16 McGarva Rd, Grantham Qld 4347. *$50*

- **Australian Olive Grower** (magazine - 5 issues/year) Published by Olives Australia. Reply Paid No. RP 30, Olives Australia, 16 McGarva Rd, Grantham Qld 4347. Subscription *$20 /year.*
- **Olive Pest Managment Guidelines**. University of California. Available through Olives Australia at; Reply Paid No. RP 30, Olives Australia, 16 McGarva Rd, Grantham Qld 4347. *$7*
- **Agricultural Cooperative Guides** (3 booklets). University of California. Available through Olives Australia at; Reply Paid No. RP 30, Olives Australia, 16 McGarva Rd, Grantham Qld 4347. *$25 set*
- **An Introduction To Olive Oil Processing**. University of California. Available through Olives Australia at; Reply Paid No. RP 30, Olives Australia, 16 McGarva Rd, Grantham Qld 4347. *$12*
- **Olives in Australia**. (VIDEO - vhs). Olives Australia at; Reply Paid No. RP 30, Olives Australia, 16 McGarva Rd, Grantham Qld 4347. *$25*
- **New Rural Industries Handbook.** Published by RIRDC, Pub. No. 98/34 *$40.* Also published on the web at: www.rirdc.gov.au.
- Plus many other sundries in my olive file! eg. an olive cost analysis for WA, back issues of the Australian Olive Grower, an international publication (Olivae), variety information, water requirements/agronomic information.

The Rural Industries Research and Development Corporation (RIRDC) can be contacted at: PO Box 4776, Kingston ACT 2604. Ph. 02 6272 4819 or Fax 02 6272 5877.

12.0 Summer Crop Notes

Andrea Hills (Ag West, Development Officer Esperance

Most knowledge in WA is based on the Eastern states agricultural departments 'farmnotes' or seed company information.

Summer crops can make good use of out of season rainfall and presumably use some stored soil moisture too. They are grown for a range of reasons: to dry out the soil profile (on failed crop areas, or on waterlogging prone paddocks before winter crops), to increase diversity in farming system, summer green feed for stock, profit, control of herbicide resistant ryegrass. For grain crops, very wide row spacings are recommended to ensure adequate moisture for consistent yields.

Markets exist, but are variable - the Grain Pool are offering prices below what some individual domestic contracts will pay, but it will be easy to flood the domestic market. Esperance and the south coast are probably less risky for growing summer crops since summer storms dump up to 25 % of rainfall over the spring and summer period.

Sorghum

Will grow over a wide range of soil types. Observations suggest it's fibrous root system can penetrate some of the tough subsoil alkaline clays found in the Scaddan area. Is more tolerant of salinity relative to sunflowers. A risky crop the further it is grown from the coast (moisture considerations). Grain or forage types available.

Sunflowers

Have a taproot, so don't do so well on the shallow duplex soils. Apparently they love to grow down into moisture but cannot handle waterlogging. Are very sensitive to SU herbicide carryover. Birdseed or oil types available.