



Department of  
Primary Industries and  
Regional Development

Digital Library

---

Soil conservation survey collection

Natural resources research

---

6-1993

## The Mobrup catchment working plan - A resource inventory and strategies

Steven Garrad

Follow this and additional works at: [https://library.dpird.wa.gov.au/lr\\_scsc](https://library.dpird.wa.gov.au/lr_scsc)



Part of the [Agriculture Commons](#), [Biodiversity Commons](#), [Botany Commons](#), [Geology Commons](#), [Hydrology Commons](#), [Other Plant Sciences Commons](#), and the [Soil Science Commons](#)

---

### Recommended Citation

Garrad, S. (1993), *The Mobrup catchment working plan - A resource inventory and strategies*. Department of Primary Industries and Regional Development, Western Australia, Perth. Report.

This report is brought to you for free and open access by the Natural resources research at Digital Library. It has been accepted for inclusion in Soil conservation survey collection by an authorized administrator of Digital Library. For more information, please contact [library@dpird.wa.gov.au](mailto:library@dpird.wa.gov.au).

Miscellaneous Publication 25/93  
ISSN 0725 - 847X

**THE MOBRUP CATCHMENT  
WORKING PLAN -  
A resource inventory and strategies**

**Compiled by Steven Garrad  
June 1993**



**Corrections:**

pg 22 In the paragraph on Vegetation it should read "... sixteen melaleucas, four callistemons, eighteen eucalypts - often with growth form and habit - ..."

pg 39 In Table 2 the W-Drain should have: "Used on low slopes of about 0.5% and flats ..."

## Contents

	Page
<b>Acknowledgements</b>	2
<b>Section 1. Introduction</b>	3
1.1 Background to the Catchment Plan	3
1.2 Development of the Plan	3
1.3 Format of the report	4
<b>Section 2. Data on the catchment</b>	6
2.1 Climate	6
2.2 Geology	6
2.3 Surface hydrology	7
2.4 Sub-surface hydrology	8
<b>Section 3. Land management units</b>	11
3.1 Jarrah-marri duplexes	11
3.2 Deep sands	13
3.3 Dyke soils	15
3.4 Heavy clays	15
3.5 Gravels	17
3.6 Paperbark sands	18
3.7 Yate flats	20
3.8 Salt affected	21
3.9 Swamp complex	22
<b>Section 4. Balancing cropping and stocking - the MIDAS model</b>	25
<b>Section 5. Reserves in the Catchment</b>	26
5.1 Reserves managed by CALM	26
5.2 Land managed by WA Water Authority	27
<b>Section 6. Management of remnant vegetation</b>	28
6.1 Wetlands	28
6.2 Drainage lines	29
6.3 Remnants on the gravel & jarrah-marri LMUs	29
<b>Section 7. Demonstration/trial sites</b>	30
7.1 <i>Eucalyptus camaldulensis</i> clones trial site	30
7.2 High water use trial site	33
7.3 Balansa & Persian clovers trial on waterlogged flats	34
<b>Section 8. Site specific recommendations</b>	35
8.1 Stabilisation of 'Talye-Para' drain	35
8.2 South Moberup Road direct seeding of trees	36
8.3 Earthworks	37
Appendix 1 Rainfall and temperature records	40
Appendix 2 Moberup catchment design points	41
Appendix 3 Electrical conductivities in lower Moberup catchment	42
Appendix 4 Recording from driller's log at installation of piezometers	43

## Acknowledgements:

The Mobrup LCDC has persevered for three years with its efforts to produce a catchment plan. They readily acknowledge that their work is just beginning as they now wrestle with this working plan to form something which will have application on each individual's enterprise to ensure a sustainable future for this catchment.

This report is a collation of their ideas, an inventory of works done in the catchment and the best advice which research and local knowledge can provide. To this end invaluable assistance and direction has been provided to me by Digby and Nikki Stretch, as well as the hospitality and interest by all the landholders in the catchment who are listed below.

Thank you also to Peter Tillie and Heather Percy for their assistance in developing the Land Management Units, to Dr Richard George for guidance in the catchment's hydrogeology and Martin Van Bueren and John Young for the description of the MIDAS model and its findings.

Funding provided by the National Soil Conservation Program enabled this project to be undertaken.

---

*"If you are thinking a year ahead  
plant seeds,  
If you are thinking 10 years ahead  
plant a tree,  
If you are thinking 100 years ahead,  
educate the people."*

Kuan-Tzu (4th - 3rd Century BC) China

---

BIGWOOD, Simon & Rowan	566 219
DAWES, Terry & Sue	337 530
EVANS, Chris & Robin	337 528
FORRESTER, Fenn	337 526
HEWSON, John & Rosie	336 224
HUGHES, Nick & Bev	337 523
LADYMAN, Derek & Ali	337 516
LEWIS, Norman & Marjorie	323 013
LUCEV, Tim & Vicki	337 515
OWEN, Chris & Francis	336 291
PARKER, Warren & Cynthia	337 552
STAPLETON, Royce & Joyce	337 553
STRETCH, Digby & Nikki	(President & Secretary) 337 521
STRETCH, Bill & Margot	337 520
TAYLOR, Peter	812 782
WARBURTON, Kent & Mary	337 517
WILSON, Rob & Bay	323 036

## **1. Introduction**

### **1.1 Background of the Catchment Plan.**

The Moberup Land Conservation District was formed in 1984 and was gazetted in 1985. Like many of the early LCDs its boundary was defined by the physical sub-catchment. In particular this 11,000 ha catchment is part of the headwaters of the Tone River and therefore also lies within the Warren River Catchment as defined by the WA Water Authority.

The catchment is located about 35 km south along and to the west of the Kojonup-Frankland Road (Figure 1).

The aims of the 17 landholders in the Moberup LCD are to:

1. arrest and reverse salt encroachment;
2. alleviate winter flooding on the broad valley floor; and
3. minimise soil erosion.

In May 1990 a Project Officer was appointed on a share basis to the Moberup LCDC with funding from the National Soil Conservation Program. The outcome desired by the Committee was a catchment plan that addressed the above aims.

### **1.2 Development of the Catchment Plan.**

Emphasis was on the landholders having as great a part as possible in the development of this plan, which must be of clear relevance to them and be viewed as a means of examining ideas and issues. What are perceived as the problems must be defined as symptoms of inappropriate land management. What changes are necessary to restore some stability and ecological diversity and stability to the land must intend to complement or enhance farm production.

An aim of the plan is to provide a framework for blending basic ecological principles into agricultural systems. These basic principles used were:

- the use of homogeneous units of land based on natural features such as soil type, slope, drainage and vegetation rather than on arbitrary boundaries made by people
- that each of these land units should be managed according to its potential and its limitations (or potential to degrade)
- to incorporate the elements of existing natural systems into management of the catchment (stability, resilience and ability to recover from disturbance) which characterise a sustainable system
- to ensure integration of improvements in the catchment such as revegetation, drainage and protection of remnant vegetation.

This can be achievable without great expense, given plenty of lateral thinking and sufficient commitment to finding a better way.

Soil pits were excavated in April 1991 to illustrate the range of soil types in the catchment. The group's attendance of a tour of these pits and the day's discussions provided a basis for the development of the Land Management Units (section 3).

A Farm Planning Workshop was conducted in July 1991 after a series of night meetings to discuss the concepts in planning, define expectations of the group and ensure the date and program for the workshop met most landholders' needs.

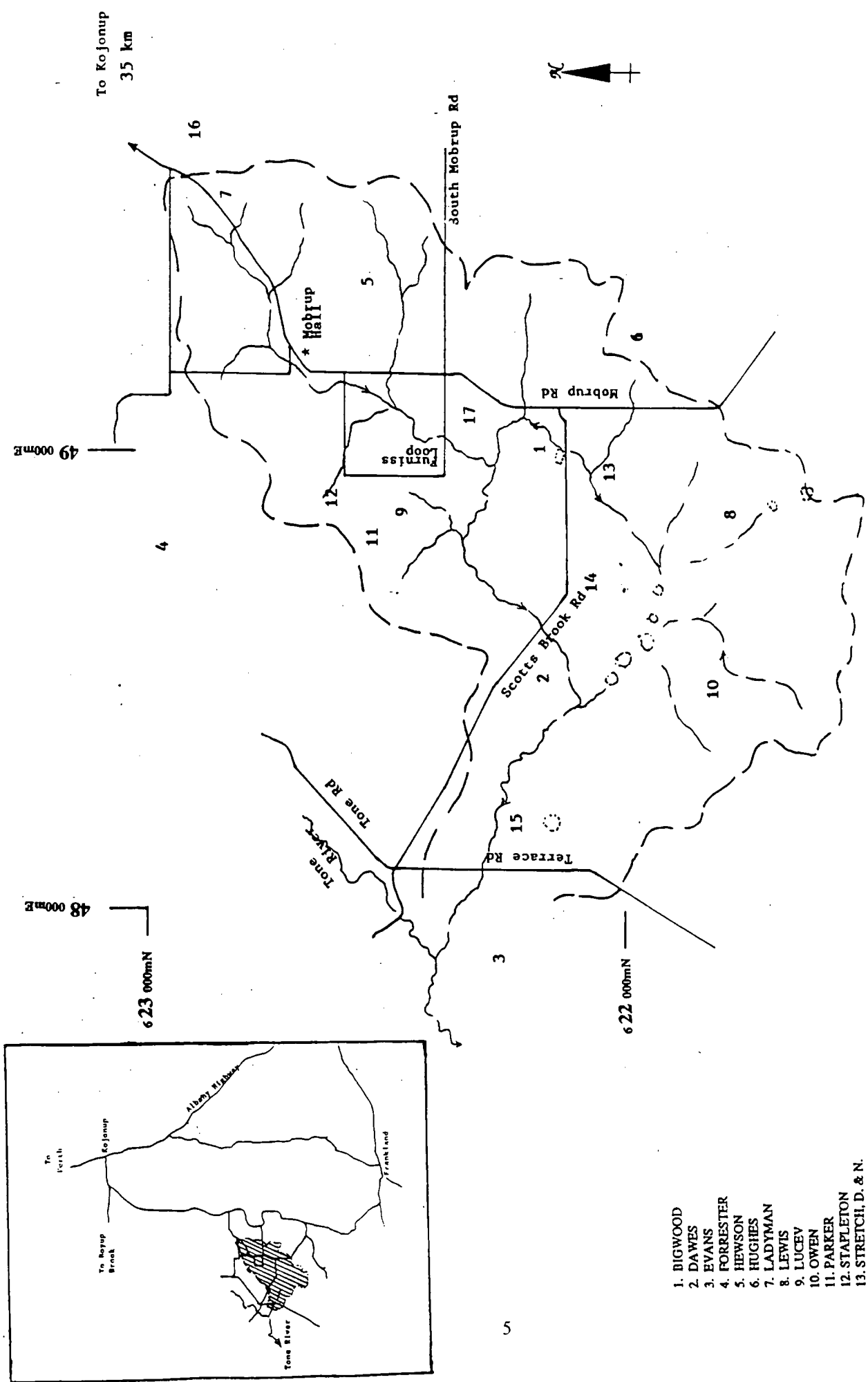
At the workshop participants focussed mostly on the drainage system in the catchment and the management of floodwaters. Also a production theme was stressed with the LMUs being described in terms of maximising water usage by increasing yield, use of perennial pastures and management of remnant vegetation and strategic tree plantings. The role of grade banks and reverse bank seepage interceptors to protect slopes, in particular under the multiple cropping regimes, became an apparent feature of the planning.

Those landholders who participated found the exercise made it possible to accept the idea of somewhat radical changes to the existing farm layout or enterprise. Careful mapping and consideration of details as ideas developed made the workshop a good starting point for the catchment plan. Unfortunately, only a minority of landholders from the catchment attended. The participants' ideas and mapping are integrated in the catchment plan but the remainder was done by air photo interpretation with field checks and individual visits and discussion. Hence the catchment plan varies in detail and accuracy with ideas sourced from either the workshop, the visits or are solely from the thoughts of the Project Officer.

### **1.3 Format of the report**

This report consists of eight sections. The next two sections describe the catchment and its Land Management Units and proposed optimum management. Economic considerations in changing to optimum rotations is introduced in section four which describes the MIDAS model and its general outcomes. An inventory and description of the land not being used for agriculture in the catchment is in section five. A summary of the benefits of preserving the remaining bushland on freehold land is covered in section six. A description of some of the better known trial and demonstration work done in Mobrup is in sections seven and eight, concluding with a general guide to earthworks.

The appendices contain most of the data on the catchment, including the official rainfall records, the stream flows and road culvert dimensions, the descriptions of the piesometer sites and the measured conductivities of the swamps.



To Kojonup  
35 km

49 000mE

48 000mE

623 000mN

622 000mN



1. BIGWOOD
2. DAWES
3. EVANS
4. FORRESTER
5. HEWSON
6. HUGHES
7. LADYMAN
8. LEWIS
9. LUCEV
10. OWEN
11. PARKER
12. STAPLETON
13. STRETCH, D. & N.
14. STRETCH, B. & M.
15. TAYLOR
16. WARBURTON
17. WILSON

Figure 1: Location of the Mobrur Catchment and Landholders.



## 2. Data on the catchment.

The Moberup LCDC is attracting attention and resources from various government and non-government agencies. Consequently there is a growing body of data and this section is certain to be expanded over time.

### 2.1 Climate

The climate is typically mediterranean with hot dry summers and cool wet winters. The nearest meteorological station is Kojonup and the data collected there are presented in Appendix 1. The mean daily maximum temperatures range from 14.3°C in July to 29.4°C in January. Mean daily minimum temperatures range from 5.8 °C in August to 13.9°C in February.

The average annual rainfall recorded at Kojonup is 538 mm. The nearby Bokerup Meteorological station's (No. 009673) rainfall records show a mean annual rainfall of 587.2 mm (Appendix 1). The majority of the rain falls between May and September.

Mean annual evaporation from a 'class A' pan for Kojonup is 1452.3 mm with a minimum of 39 mm per day in June and a maximum of 238.7 mm in January.

The wind speeds and duration are highly variable. Generally farm plans cater for the north-west to south-west winds in winter and the north-easterly dry winds of summer.

### 2.2 Geology

The Moberup catchment falls in the north-east corner of the WA Geological survey of the Pemberton-Irwin Inlet 1:250,000 sheet (SI/50-10, SI/50-14 of the international series), 1984, compiled by S.A. Wilde and I.W. Walker.

It describes the Moberup landscape as undulating, about 300 m above sea level and generally overlying various Precambrian rocks (about 2800 million years old). These are granitic or gneissic rocks with the oldest ones representing the south-western edge of the Yilgarn Block. This is a huge mass of rock extending north and east which underlies most of the wheatbelt. It is most evident where the soils are shallow and the valley slopes are steep.

An exception in the catchment is a coarse even-grained type of granite which is from the latest magmatic phase (1800 million years ago) and occupies an area of about 30 km<sup>2</sup> on the north-western ridge of the catchment.

There are numerous very small and irregular quartz veins and altered dolerite dykes in these granitic terrains. Large examples are not common but where they occur they generally have an easterly trend.

The ridges about the catchment are described as remnants of an extensive deep lateritic soil profile formed in the Cainozoic period (about 130 million years ago). The laterite has developed mainly from the *in situ* weathering of underlying rocks where various elements are either leached out or precipitated as complex compounds. In some places, the gravels are cemented forming a massive undulating duricrust capping or 'ironstone sheet'. Elsewhere the laterite is of loose gravel in thin, more dissected profiles. The broad regional mapping of the Avon Province has this catchment defined as part of the Darling Range

area. The broad gravelly plateau formations, deeply dissected by the drainage lines, are a feature of this area (H. Percy, pers. comm. 1992).

Beneath the gravelly-sand topsoils is the white kaolinitic clay (the pallid zone grading to saprolite) often seen in dam walls. Where the laterite surfaces have been greatly dissected this layer is often exposed on the slope or covered by thin colluvial deposits. This clay has been identified as sodic and containing much of the stored soluble salts in the landscape. It is when these salts are mobilised by the hydrological changes resulting from clearing that the problems of salinity begin to appear.

Often there is an accumulation of iron and silcrete above the pallid zone which forms silcrete. This is a very hard layer often brought up when digging dams or is sometimes exposed on the surface.

A variation of the Cainozoic geology is the terraced lateritised alluvial surface which makes up the southern limits of the catchment. It is a broad flat formation some 1 to 2 m higher than the valley floor and evident today as the chain of swamps and the harder, irregular shaped, laterite knolls.

The broad tracts of sandy alluvium on the valley floor mark the former courses of Tertiary (more recent) drainage systems. They are mapped on the catchment plan as the Paperbark Sands LMU. There are some ancient irregular sand dunes or hummocks traversing these deposits which are partly lateritised and dissected by the present drainage and give some relief to the valley floor. Underlying these broad valley floors are sediments laid down about 45 million years ago (as dated from pollen analysis).

### **2.3 Surface hydrology.**

Mobrup catchment is about 112 km<sup>2</sup>. The main watercourse flows south-westerly to the wide, ill defined drainage on the valley floors where it joins with the west flowing waters from the swamps and areas of moderate to low relief.

The catchment's peak run-off rates could be calculated once the Land Management Units were mapped; accounting for those factors listed below such as the LMUs with a higher run-off compared with the gravelly/ sandy units and the percentage of the area cleared.

Factors which affect surface hydrology are:

<b>A</b>	<b>B</b>
Rainfall over catchment area	Percentage of cleared area in the catchment
Soil types	Cultivation practices
Rainfall intensity	Surface cover
Slope	Amount of surface compaction
Soil Moisture	Surface roughness
Shape of the catchment	Run-off control earthworks
Main creek length & slope	
Evaporation	

Factors in column B are determined by farm management. Landholders within the catchment have the ability to change these factors to reduce run-off (e.g. see section 8.3 for run-off control earthworks).

## **Clearing**

From early accounts and continuing observation it is widely accepted that clearing of the native bushland increases run-off. Returning about 20% of the cleared catchment to trees located in strategic positions in the landscape can improve farm productivity and reduce land degradation. However, this vegetation may not reduce run-off significantly.

## **Cultivation practices**

Much of the poor soil structure in the catchment results from working the heavier soils when they are too wet or too dry, at too high speeds of working and/or too many times in the season. Minimum tillage plays an important part in maintaining soil structure by building up organic matter.

Contour cultivation has proved to be an effective way of controlling some water erosion and can improve yields and increase the time for run-off to occur. It is particularly useful where water repellence is a problem, it does not involve major capital works and does not restrict paddock accessibility.

## **Surface cover and compaction**

Vegetation cover and management of stock play a major role in reducing run-off and increasing rainfall infiltration. Retention of a previous crop's stubble gives a protective layer to the soil against erosion and promotes higher rates of infiltration. This is achieved with machinery which enables direct drilling, lighter grazing of the stubble and by keeping those matches in the pocket.

The heavier soils are most vulnerable when wet to stock trampling and loss of surface structure. Deferred grazing of these areas for up to six weeks after the break of the season will prevent structure decline. Preserving soil structure in the pasture phase can reduce cultivation in the following cropping year.

Calculation of peak run-off rates was carried out at design points 1 to 16 which were generally sited at road culverts or on selected farm boundaries (see Figure 2). At each design point is:

- the total area (A) in hectares which contributes water to that point and
- the calculated volume of flow ( $m^3$  per second) for a 1 in 10 ( $Q_{10}$ ) or 1 in 20 ( $Q_{20}$ ) year event. The  $Q_{20}$  was calculated for the lower reaches of the catchment. The dimensions of the catchment's culverts, their relevant design points and observations/ recommendations are in Appendix 2.

## **2.4 Sub-surface hydrology and salinity**

Any land becomes saline if the groundwater gets to within 1.5 m of the surface. The land and stream salinisation which Moberup is experiencing is the result of the changes in the landscape's hydrology brought about by altered land use. At present there is an imbalance in the water balance owing to extra recharge to groundwater since clearing. This is making the water-table rise. Strategies to use up more water than at present include higher yielding cropping rotations, early seeded crops, trees and other perennial vegetation on discharge sites and drainage lines.

Salinity may take the following forms:

- **Dyke induced seeps**

Some of the hillside salinity problems in the catchment are the result of water backing up behind the weathered remains of intruded dykes. The subsoil water is impounded upslope of the barrier where it builds up and finally reaches the surface; it then seeps over the barrier, depositing salts until it reinfilters lower down.

- **Basement high induced seeps**

It is common in the catchment to find impermeable layers of clay or rock on hillsides, exposed by the weathering processes. These can have water perched above them which is ultimately discharged at the soil surface.

- **Concave slope changes**

Where there is a naturally dished shape in the landscape, similar to that of an amphitheatre, there is often a build-up of water to the surface. This is simply caused by the subsoil waters slowing down when they encounter the flatter gradients of the lower slope and the 'bottleneck' restricting the flows.

- **Deep sand seeps**

It is common to find seeps at the base of the Deep sand LMU. This is where the water which rapidly infiltrated through the profile encountered an impermeable layer (usually clay) and then has been directed laterally to the surface.

- **Valley floor salinity**

The catchment's broad valley floor is under threat from this type of salinity which is a product of a larger groundwater system. A shallow regional watertable is 2.5m to 4m from the surface. This may be under pressure, as is the case where deep semi-confined aquifers have a path of least resistance to the surface, or from waters being drawn to the surface by the soil's capillary forces. The salt source may be in the deep lacustrine sediments which were deposited during periods of marine incursion but the problem is compounded by poor drainage and run-off accumulation and floods.

## **2.5 Piezometers in the catchment**

Eight nests of piezometers - a shallow and a deep well - have been installed in positions in the lower catchment (see Figure 3). Data from these may be compared to identify subcatchments with higher salt loads in their groundwaters, those with rising water tables and where changes in the catchment are influencing the subsurface hydrology. Recordings at the time of drilling are summarised in Appendix 4.

Regular monitoring of these is essential for them to be of any worth with further piezometers recommended where the need for more detail becomes apparent.

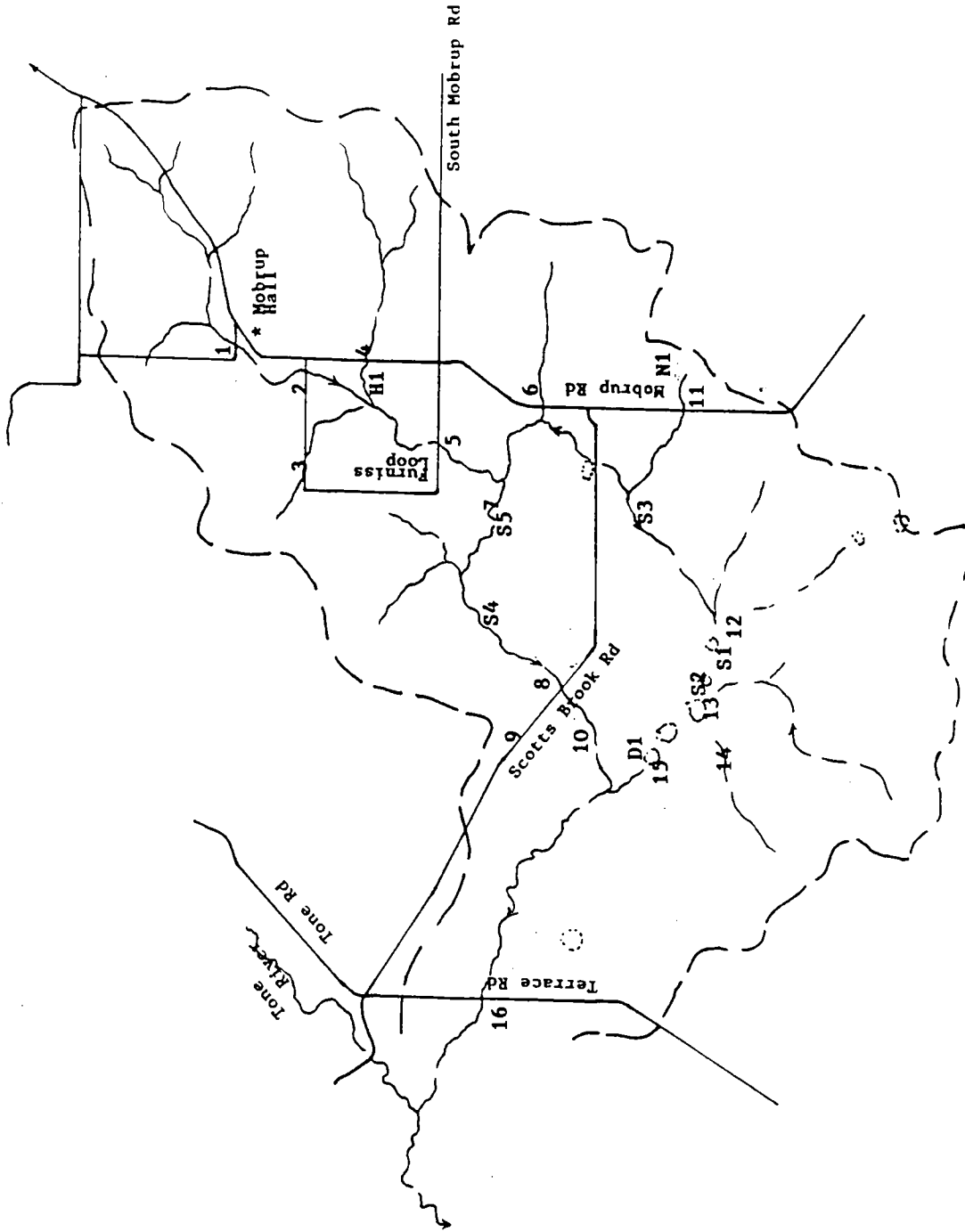


Figure 2: Location of Surface flow design points and piezometers in the Mobrur Catchment

### 3. Land Management Units

Land Management Units (LMUs) are areas of land with common soils, landforms and drainage patterns which should be managed in a similar way in order to maximise their production and minimise the potential for land degradation.

This section describes the nine LMUs used in the catchment's planning workshops. It is quite flexible and if there are sufficiently different soils or landforms not catered for in the mapping it is appropriate to sub-divide them out from these standard LMUs.

Nine Land Management Units were identified in the catchment. These were the:

1. Jarrah-marri duplex
2. Deep sand
3. Dykes
4. Heavy
5. Gravels
6. Paperbark sands
7. Yate flats
8. Salt affected
9. Swamp complex

The idealised slope cross-section in Figure 3 depicts the position in the landscape which these LMUs may occupy and the progression from one to the other is described as the catena. The Salt affected LMU was not included as it can occur in most of the described positions.

**3.1 Jarrah-marri duplex (L)** Soils of this LMU have a brown sandy or sandy loam surface 25 to 50 cm deep over a clayey subsoil (Duplex soils).

**Identification:**

This LMU can be identified by its sandy-brown duplex soils and the jarrah and marri vegetation. It is a very broad unit encompassing a wide range of the lighter textured surface soils, including those where gravel may be present.

**Occurrence:**

This is the dominant LMU in the Moberup catchment's sloping landforms. It often occurs in association with the Gravels LMU and adjoins the other LMUs on the lower slopes.

**Vegetation:**

The natural vegetation is a woodland mix of jarrah (*Eucalyptus marginata*) and marri or red gum (*Eucalyptus calophylla*). White gum (*Eucalyptus wandoo*) can also be present.

**LMU Qualities**

**Water availability:** Moderate in the sandier surface layers though most plants can also obtain water from the clay subsoil. Water repellency of the surface can be a problem and will be at its worst after a legume dominant pasture or lupins.

- Nutrient status:** Moderate though phosphorus is a major limiting nutrient, closely followed by potassium. Soil pH should be monitored as acid conditions can cause, amongst other problems, aluminium toxicity. Soil acidification can occur under wheat-lupin rotations and those clover pastures which one could consider cutting for hay.
- Rooting conditions:** Good in the loose sandy topsoil though may become more restricted in the clay subsoil.
- Trafficability:** Generally few problems for machinery access but can be boggy in wet years.
- Soil workability:** The light textured topsoil is easy to work. If the topsoil is shallow, caution should be exercised to avoid bringing the clay up through cultivation as it will cause crusting of the soil surface.
- Soil conservation**
- Water Erosion hazard:** Sheet and rill erosion can occur on sloping lands, especially if there is run-on from upslope.
- Wind erosion hazard:** Moderate with the sandy soil surface capable of blowing if ground cover is poorly managed. Minimum cover to aim for is about 25% or 0.8 tonnes of stubble per ha. Bare fallows should be avoided above all.
- Flood hazard:** Low.
- Salinity risk:** Saline areas can appear in distinct patches on the lower slopes of this LMU where clay or rock is close to the surface.
- Soil structure decline:** Traffic compaction pans may develop in sandy topsoil following repeated cultivations.
- Groundwater recharge:** Rainfall generally rapidly infiltrates into the sandy topsoil except where water repellency of the surface is a problem. The clay subsoil may present a barrier for percolation to the water-table although water can move through preferred pathways (e.g. root channels). Good performance of pastures and crops on this LMU will result in high water usage and thereby minimise groundwater recharge.
- Waterlogging:** Generally only mild waterlogging occurs though it can be more severe on the lower slopes. This is a result of the water from upslope draining laterally and perching above the clay; this contributes to and exacerbates the saturated conditions.
- Water conservation**
- Water supply:** The sub-soil is suitable for dam construction. Any planned system of grade banks should also consider dams and dam sites to harvest water into.
- Agronomic practices**
- Crops:** Cereal crops with break crops (e.g. lupins) can yield well in good to average years. Wheat-lupin rotations are successful on this LMU providing waterlogging is not an issue.
- Pastures:** Good pasture of subterranean clovers can be achieved although performance is not so good where the sandy topsoils are deep. Most perennial pastures should grow well.

## Recommendations

This LMU contains some of the most productive portions of many farms. They should be used to their full potential to maximise production and achieve higher water usage. It is largely because the water that is available to this LMU is underused that there is significant groundwater recharge with the resultant salinity problems that are occurring in the catchment.

To this end a high yield cropping package for wheat is recommended for this LMU, though it can fit in other LMUs where there is a high yield potential (see section 4 - the MIDAS model). A conclusion from the application of this bio-economic model is that there is scope to increase the amount of area cropped in the Moberup catchment to around 20 to 30 per cent of the farmed area. This expansion is most recommended on this LMU or on other areas with a high yield potential.

High value crops such as canola may also be considered for the very well drained sites. Plant tissue testing should be built into any cropping program to ensure that fertilising does overcome yield limiting deficiencies.

The protection against water erosion offered by earthworks becomes essential whenever this cropping package is planned. Careful siting of grade banks will also have water harvesting benefits and reduce waterlogging. Reverse bank seepage interceptor drains should be considered if the clay is more than 50 cm deep.

Also the ground cover should be maintained in summer and autumn to reduce the risk of wind and water erosion.

The options of high water using perennial pastures, fodder crops and trees should also be considered but only in more site specific roles such as holding paddocks, timber lots, windbreaks and around saline areas.

### 3.2 Deep sand (DS): Pale grey 'gutless' loose sands over 80 cm deep.

#### Identification

This LMU can be identified by its loose, pale, sandy topsoil, poor pasture and crop growth and a shrubby heath natural vegetation. As depth of sand is important, a hole may have to be dug and the subsoil examined.

#### Occurrence

Found in pockets, often where either wind or water has deposited the coarse fraction eroded from adjacent areas. Often in hollows below a gravel LMU and grading into a Jarrah-marri duplex. The long dunes (or lunettes) on the eastern edge of some larger swamps are not a Deep sand because they are of a heavier loam or clay material.

#### Vegetation

Distinguishing vegetation is commonly the banksia species (eg *B. grandis* and *B. littoralis*), Christmas tree (*Nuytsia floribunda*) and the *Melaleuca* species.

#### LMU qualities

##### Water

##### availability

Poor, because water infiltration is often hampered by non-wetting properties. What enters the soil passes rapidly through the root zone and soils are dry soon after rains.



**Nutrient availability:** Poor, owing to rapid leaching of the nutrients making it known as a 'hungry soil'.

**Rooting conditions:** Roots penetrate to depth easily.

**Trafficability:** Generally good though it is possible to get dry bogged.

**Soil workability:** Easy to work.

### **Soil conservation**

**Water erosion hazard:** Low.

**Wind erosion hazard:** High, because the loose sand grains are readily moved by wind velocities as low as 8 km/hour. Ground cover is essential over summer and autumn.

**Flood hazard:** Nil

**Acidification:** Soil pH should be tested before any sowing. Monitor for changes if a rotation with legumes is used.

**Soil structure decline:** It is a structureless soil which may be prone to compaction pans from traffic.

**Salinity risk:** Very low except on or adjacent to the valley floor flats where seeps or springs have gone saline.

**Groundwater recharge:** Very high as the LMU freely drains to water-tables with little water used by crops and pastures.

**Waterlogging:** Usually very well drained.

### **Water conservation**

**Water supply:** This LMU is often upslope of springs of fresh or stock quality water in limited supply but may provide sufficient quantities for restricted pumping. The water quality should be monitored for any changes. No potential sites for dams.

### **Agronomic practices**

These LMUs are unsuitable for conventional crops and pastures as their productivity is so low. This LMU then becomes a prime site for the recharging of groundwaters and is vulnerable to wind erosion.

### **Recommendations**

Ideally this LMU should not be cleared but where it has been, there is the option of selected perennial grasses and fodder shrubs (e.g. tagasaste). Managed light grazing is essential as sheep do prefer to camp on this LMU, rendering it bare and disturbed, and the perennials do not persist under set stocking. Freshly cleared areas may regenerate readily to the native vegetation once stock are excluded.

### **3.3 Dykes (D)** Grey-brown sandy loam overlying a reddish-yellow medium clay.

#### **Identification**

The surface colour can be misleading for this LMU as it is the reddish clays with depth that feature in the catchment. The presence of dolerite rock outcrops is the clearest preliminary indication of this LMU. Dolerite is a dark coloured rock without the quartz crystals of granite.

#### **Occurrence**

Tends to occur as long narrow strips as they are formed on top of dolerite dykes. Found along ridges mostly. Is a very minor LMU within the catchment.

#### **Vegetation:**

No native vegetation association for this LMU has been observed in the catchment.

#### **Soil conservation**

The mapping of the dykes is mostly to attempt to understand the nature of saline outbreaks in the catchment. As an LMU it is of an insignificant area and usually too small to be managed separately although it has a very fertile soil.

Where the dykes occur they can form barriers to the movement of groundwater, causing water to rise to the ground surface with evaporation concentrating the salts into a saline scald. Where this is the case high water using species such as trees should be planted upslope of the site.

#### **Water conservation**

Dams sited on this LMU have a history of poor retention of the stored waters. There is also a risk of striking rock in construction causing dams to be too shallow to be effective.

#### **Recommendations**

There are exceptional areas of this LMU of a sufficient size to be isolated and managed separately from the surrounding soils. These should be used to their full potential and are a very productive cropping unit. When rockiness restricts cultivation then planting of pastures or trees should be considered for maximum water use.

Hardsetting of the topsoils may occur with repeated cultivation so minimum tillage is recommended and gypsum may be necessary.

### **3.4 Heavy soils (H)** Grey sandy loam to sandy clay loam overlying a sandy clay to a medium clay 20 to 30 cm deep. Some gravel may be in the shallow surface layer.

#### **Identification**

This LMU can be identified by its grey topsoil and hardsetting surface. They are typically very wet and boggy in winter with any wheel ruts remaining for a long time.

#### **Occurrence**

Usually found on the relatively flat areas in the lower slopes or alongside drainage lines, but mostly above the valley floor. Can cover sizeable areas and be considered the 'problem soils' of a paddock.

## **Vegetation**

White gum (*Eucalyptus wandoo*) dominates a flooded gum (*Eucalyptus rudis*) or marri red gum (*Eucalyptus calophylla*) mix. Toad rush (*Juncus bufonis*) and Mediterranean barley grass (*Hordeum geniculatum*) are poor quality grasses indicating waterlogged pastures on this LMU.

## **LMU qualities**

### **Moisture**

**availability:** Moderate as the soils tend to remain moist underneath a hard dry surface crust.

### **Nutrient**

**availability** Moderate but good responses have been recorded from the application of potassium with superphosphate.

### **Rooting**

**conditions** Hardsetting topsoils may cause problems with seedling establishment; especially if sheet erosion has previously occurred.

### **Trafficability**

Very boggy during winter months with the wheel ruts and cultivation tracks setting hard and making the surface rough.

### **Soil workability**

Often known as the 'Sunday soils' because there is generally a narrow moisture range when it can be worked - too hard when dry and too boggy when wet.

## **Soil conservation**

### **Water erosion**

#### **hazard**

High run-off rates (water shedding) from this LMU can cause rilling and sheet erosion. Often the topsoil is quickly lost and the clay subsoil remains which is difficult to revegetate. Strategic placement of grade banks can greatly improve this LMU's productivity.

### **Wind Erosion**

#### **hazard**

The loamy topsoil has the potential to be lost; especially if it has been pulverised by stock, excessive cultivation or cultivation when too dry and hard.

### **Flood hazard**

Flooding can occur along drainage lines and in positions on the landscape where there is an abrupt change in slope.

### **Salinity risk**

Salinity is a problem on this LMU, mostly where it occurs along drainage lines.

### **Soil structure**

#### **decline**

Traffic pans and hardsetting of the topsoil are common; particularly if cultivation is done when soils are too wet.

### **Groundwater**

#### **recharge:**

The high rates of run-off from this LMU will contribute to the recharging of groundwaters in the valley floor.

### **Waterlogging:**

A major problem of this LMU in winter, severely reducing pasture and crop yields.

## **Water conservation**

### **Water supply**

Soils are generally suitable for dam construction but salty seeps or future salt encroachment may be a concern if situated low in the landscape.

## **Agronomic practices**

**Crops** The waterlogging and what salinity is present causes poor crop performance in most years. In the drier years reasonable yields can be achieved. Barley and oats may be best adapted to these conditions.

**Pastures** Annual pasture performance can be lifted on this LMU by using waterlogging tolerant (but not salt tolerant) clovers such as Balansa, Persian and Strawberry. These could be grown also with perennial grasses. Tall wheat grass, phalaris and puccinellia are recommended.

## **Recommendations**

Efforts to grow annual pastures and crops on this LMU could be better directed to the more productive LMUs first. Waterlogging and the threat of salinity can be reduced with drainage and grade banks and then perennial pastures, fodder shrubs and trees can be successfully established, providing valuable feed in the autumn.

**3.5 Gravels (G)** Loose 'ironstone' (ferruginous) gravel present on the surface and proportionately increasing with depth to a light clay at 40 to 70 cm.

### **Identification**

Surface of a brown loamy sand with loose ironstone gravel, often of variable sizes.

### **Occurrence**

A major LMU found on the ridges, hills and mid slopes of the upper landscape.

### **Vegetation**

Jarrah (*Eucalyptus marginata*) and *Banksia grandis* are found where the gravels are deeper and of a uniform size. White gum (*Eucalyptus wandoo*) and marri (*Eucalyptus calophylla*) appear most where the clay is closer to the surface. Areas of shallow laterite often have thickets of parrot bush (*Dryandra sessilis*).

## **LMU qualities**

### **Moisture**

#### **availability**

Usually moderate but can dry out rapidly if gravel layer is shallow. Water repellency is common in this LMU, allowing very limited penetration of water after rainfall.

### **Nutrient**

#### **availability**

Phosphorus is often a limiting nutrient as it can be fixed to iron-rich compounds in a form unavailable to plants. This LMU is known for its good levels of potassium levels.

### **Rooting conditions**

Good in the loose topsoil with the clay layer appearing to offer little resistance.

### **Trafficability**

Few problems for machinery access though wet years may produce some boggy areas in the lower slopes.

### **Soil workability**

The light topsoil is easy to work however large rocks may be encountered close to the surface.

## **Soil conservation**

### **Water erosion**

#### **hazard**

Moderate levels of water-caused erosion occurs on the steep and/or long slopes. This is exacerbated by this LMU's water repellency and the looseness of the soil surface. If grade banks are to be constructed it is important to know the depth to clay.

<b>Wind erosion hazard</b>	The gravel can mitigate against wind erosion by providing a surface roughness. Extreme events have occurred in late summer where the organic matter and fine clay has been lost, leaving only the coarse sands and gravel.
<b>Flood hazard</b>	No danger of inundation of this LMU.
<b>Salinity risk</b>	Salinity can appear in small patches on the lower slopes where clay or rock is close to the surface.
<b>Soil structure decline</b>	There is some risk of compaction by traffic in cultivations.
<b>Groundwater recharge</b>	This LMU is often identified as a recharge area. Once the surface soil is wet it has a high permeability to the clay through which water can move freely along old root channels and cracks.
<b>Waterlogging</b>	Generally only mild waterlogging occurs though can be more severe in a wet year in the lower sloping locations or where the clay is close to the surface.
<b>Water conservation</b>	
<b>Water supply</b>	Subsoil is suitable for dam construction. Some dams may need roaded catchments if they fail to fill from light falls of rain.
<b>Agronomic practices</b>	
<b>Crops</b>	On the better areas of this LMU cereal crops with break crops (e.g. lupins) can yield well in good to average seasons.
<b>Pastures</b>	Subterranean clover performs well with annual rye grass.

### **Recommendations**

The high yield cropping package in section 4 is relevant to areas of this LMU with good potential. If this rotation is applied, careful siting of earthworks will be necessary to minimise erosion and harvest water into dams. Also chemical weed control and tillage on the contour will improve infiltration.

It is common to see these LMUs preferentially grazed by sheep, exposing the soil surface in the late summer. Management should keep at least a minimum of vegetative cover in that period.

### **3.6 Paperbark sands (Fp) Organic crust over pale sand (40-50 cm) on hard duricrust.**

#### **Identification**

The loose pale sand visible through the organic material and the poor pasture growth gives the initial impression of a Deep sand. However, the flat landscape, the very hard ironstone duricrust (or 'coffee-rock') 40 - 50 cm below the surface and the paperbark trees distinguishes this LMU from the Deep Sands.

#### **Occurrence**

This LMU dominates the valley floor landscape unit which has flat gradients, poor drainage, fluctuating water-tables and frequent areas of alluvium deposition.

#### **Vegetation**

The paperbarks (*Melaleuca* species) with a growth habit of a medium tree is characteristic of this LMU. Some flooded gum (*Eucalyptus rudis*) and Christmas Tree (*Nuytsia floribunda*) occur in patches and on the edges of the LMU.

## **LMU qualities**

### **Moisture availability/**

**Waterlogging** The surface is extremely non-wetting owing to waxes from the organic material. Once infiltrated the water moves rapidly to the duricrust layer where it then builds up causing saturated (waterlogged) soil conditions. Drainage though appears to be rapid hence droughty conditions quickly follow. A difficult LMU for plants.

### **Nutrient**

**availability** Poor with nutrients being rapidly leached.

**Rooting conditions** Good.

**Trafficability** Vehicle access is unrestricted. Even when the LMU is covered by water it can be driven over without fear of bogging.

**Soil workability** Easy to cultivate.

## **Soil conservation**

### **Water erosion**

**hazard** Low risk of erosion except where earthworks or drains concentrate water flows, quickly stripping the sand down to the duricrust.

### **Wind erosion**

**hazard** High, because the loose sand grains are susceptible to winds from as low as 8 km/hour; especially in dry conditions and where the organic cover has been lost.

**Flood hazard** Is regularly inundated in winter by slow moving broad flows of waters that may not clear for several weeks. Flooding in summer has not been recorded.

### **Salinity risk**

These flats are at a moderate to high risk from salinity caused by groundwaters rising to levels where the capillary effect can transport the salts to the soil surface in summer. The first signs of this will be the soaks and nearby swamps registering progressively higher salinity readings. Currently the seasonal flooding may be flushing most salts out of the system, but in the long term this may not be sufficient.

### **Soil structure decline**

What structure is present in this soil is essentially from organic matter weakly cementing the grains of sand together. Otherwise this soil has no structure.

### **Groundwater recharge**

The valley floors have high levels of recharge as there are sufficient cracks in the duricrust layer for water to move through to the water-table. Little water is used by the pastures, especially when the LMU is waterlogged or inundated.

## **Water conservation**

### **Water supply**

It is locally held that soaks providing good quality stock water can be found at depths of about 3 m if excavations are near the larger of the paperbark trees.

## **Agronomic practices**

### **Crops**

The cultivation of oats can be successful on the slightly higher edges of the LMU though the economics are questionable .

### **Pastures**

Generally of a poor quality of species unsuited to the LMU.

## Recommendations

The Balansa and Persian varieties of clover are waterlogging tolerant and have performed well in trials (see Section 7.3). If combined with perennial grasses like tall wheat grass, this LMU will become more productive.

Strategic siting of W-drains by observing areas of ponding in late winter, as the waters drain, and constructing broad shallow works with the spoil mounded in the centre (i.e. W-drains) can assist the clearing of the flood waters. Deeper drains have proven to be unstable.

**3.7 Yate flats (Fy)** A very shallow hardsetting sandy loam over a domed sandy light clay. The subsoil at 40-50 cm is highly alkaline.

### Identification

Grey topsoil with a hard cracked surface, poor productivity and vegetation dominated by the flat topped yate.

### Occurrence

The LMU borders the Valley floor landscape unit and is in association with the Paperbark sands LMU. It forms the broad drainage systems.

### Vegetation

Predominantly flat topped yate (*Eucalyptus occidentalis*) with some white gum (*Eucalyptus wandoo*) and *Melaleuca* species and groups of black boys (*Xanthorrhoea preissii*).

### LMU qualities

#### Moisture

**availability** Moderate as there tends to be moisture within the clay layer.

#### Nutrient

**availability** Poor in the shallow surface loam and unavailable to plants not suited to the highly alkaline subsoil.

**Rooting conditions** Hardsetting surface makes for difficult seedling establishment. Roots tend to penetrate the clay subsoil, growing between the domes.

**Trafficability** Bogging is not a problem, even when covered by water. If the clay has been brought to the surface by cultivation it can be sticky and slippery.

**Soil workability:** Poor unless the top sandy layer is more than 15 cm deep. Any working which would bring the dense clay to the surface is to be avoided.

### Soil conservation

#### Water erosion

**hazard** High as it is essential to protect the shallow surface layer from erosive water flows and avoid exposure of the clay subsoil.

#### Wind

**erosion hazard** Low

**Flood hazard** Is regularly inundated with broad slow moving winter flows but the waters drain from this LMU quite quickly.

**Salinity risk** There is a moderate to high risk from salinity caused by rising groundwaters mobilising the salts stored in the clays and bringing them to the surface.

#### Soil structure

**decline** The hardsetting surface needs to be carefully managed.

**Groundwater recharge**

The main pathways for recharging the watertable are restricted to between the domes of the clay layer which causes it to be poorly permeable.

**Waterlogging:**

What water infiltrates the shallow surface layer perches on the clay, which is very poorly drained, and saturates the rooting zone of plants.

**Water conservation****Water supply**

Construction of dams on this LMU is not recommended because of the risk of salt and the dispersive nature of the clays.

**Agronomic practices**

This LMU is not suited to conventional agriculture and any programs to modify it (such as deep ripping and incorporating gypsum) are very expensive.

**Recommendations**

Waterlogging tolerant pasture species offer a good option with puccinellia, some of the medics and tall wheat grass. Shallow drainage works such as W-drains can be appropriate.

**3.8 Salt affected (S)**

Where management is determined by the presence of salts restricting plant growth.

**Identification**

Poor performance of crops and pastures, tree deaths, presence of white crystalline deposits on soil surface in summer, invasion of Mediterranean barley grass (*Hordeum geniculatum*) or occurrence of bare scalds.

**Occurrence**

Mostly as hillside seeps where clay or rock barriers are forcing groundwaters close to the surface. Flat areas on the lower landscape can have salt accumulating and being concentrated by evaporation of ponded waters but the problem may be primarily the waterlogging. Soils are usually highly variable and mixed.

**Soil conservation**

These areas require separate and appropriate management to stabilise and develop the LMU as a productive area of the catchment.

**Water erosion hazard**

Sheet erosion occurs soon after the vegetative cover has been lost to salinity; especially if the site is on lower sloping position.

**Recommendations**

Interception and diversion of surface run-on waters with grade banks above the site is essential. Installing of shallow drainage works to clear any ponding may be necessary also.

Fencing stock out of the area allows much natural stabilisation to occur. If the decision is to then grow trees there are salt tolerant species available to select from. Mounding and ripping for the tree and shrub species is crucial.

If a grazing value from the area is being sought there are several perennial grasses to sow and a mix of species is recommended to allow for the niches of different soils and variable salinity and waterlogging.



Ensure that grazing is delayed for at least 20 months after sowing to allow good establishment. Saltbush is generally not an option in areas of more than 500 mm of annual rainfall. *Acacia saligna* is proving to be a worthwhile fodder shrub in this situation; however research of its nutritive value has not been completed to date.

**3.9 Swamp complex (v)** Areas of permanent or seasonal inundation with vegetation and features associated with wetlands.

#### **Identification**

Surrounds of permanent shallow bodies of water which may include a raised sandy, loam crescent (lunette) about the eastern edge of the larger swamps. Outflows are broad and ill-defined.

#### **Occurrence**

A feature of the lowest areas of the valley floor. Often the swamps are linked in a 'chain' which align with the flat gradients and broad courses of the southern drainage lines. Several swamps are located on the mid-slope (e.g. Bigwood's) and one is on the plateau of the southern boundary of the catchment (Cootayerup Nature Reserve — see section 5).

#### **Vegetation**

Offers a diverse range of wetland species. Identified species in swamps within the catchment, or nearby, include sixteen melaleucas, four calistomons, eighteen eucalypts — often with variations in growth form and habit — and an unknown number of water grasses, rushes, sedges and reeds.

#### **LMU qualities**

Variable soil types including the peaty, organic sands, the aeolian (borne and deposited) sandy loams in the lunettes and the grey sandy clays of weathered silt deposits.

The swamp surrounds are flat and easily traversed even when inundated. Winter flooding may last for several weeks and it is this and the associated waterlogging which limits the establishment and growth of most pasture species.

There is insufficient information to determine whether the swamps are linked by subterranean flows and water-tables. The measured salinities in the swamps show little pattern or trend (see Appendix 3). For instance Talyelwelup Lake is less than half as saline of the two swamps on either side of it. This implies that each swamp is quite self-contained; perhaps above a clay, or other impermeable material. Surface flows would then provide the linkage between the swamps to various degrees.

#### **Soil and water conservation**

This LMU is at a moderately high risk of salinisation. Piezometers installed about the swamps show the more saline water in the shallow bores. This indicates that the LMU is accumulating salts in the surface layers from the annual inundations. Monitoring however will determine whether the deeper groundwaters are rising and at what rate. If that is the case then valley floor salinity will become widespread.

## **Recommendations**

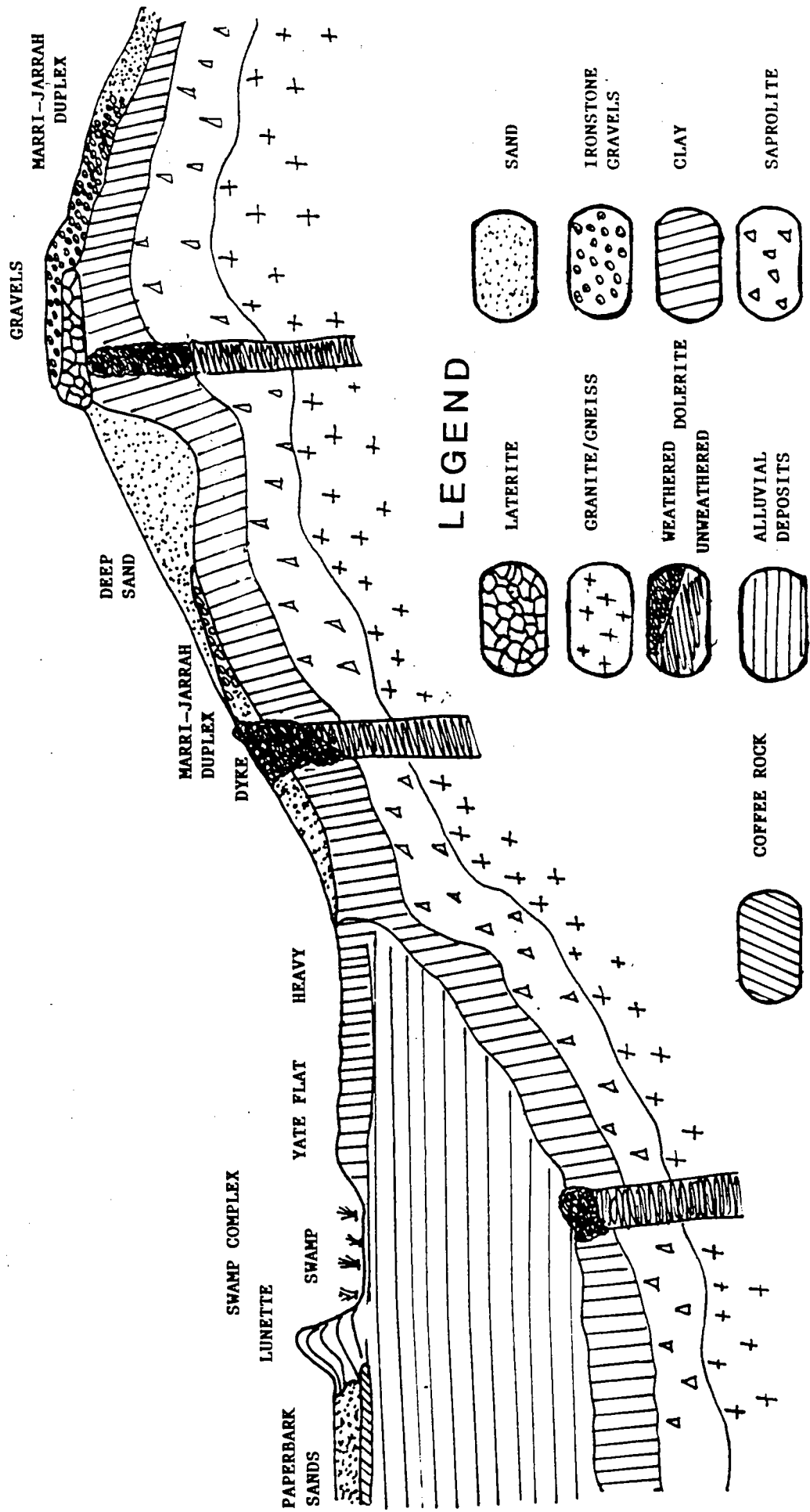
In the past these swamps have served as a water source for stock. Since the construction of dams with the trend of increasing salinity in the swamps, this function has largely been removed. Fencing of the swamps to include much of their surrounds which clear flood waters last is strongly recommended. Once stock are excluded regeneration will occur in places and will require management which considers the specialised ecology of the wetlands (see Section 6.1).

Swamp alongside significant slopes, such as that on Bigwood's, would have a grade bank surveyed to divert good quality water into them. This would flush the swamp annually and assist rapid regeneration.

At the time of printing the Environmental Protection Agency (EPA) is drafting policy would better describe wetlands and their management. Involvement of the LCDC will provide valuable input to the policy and select which category the catchment's swamps will fit under. The officer responsible is Vaughan Cox on (09) 222 7000.

Also there will be the opportunity for the community to name their local swamps where it has not been done before.

Figure 3: Idealised Slope Cross-Section of the Mobrup Catchment



#### 4. Balancing cropping and stocking - the MIDAS model

The inclusion of a Landcare Economics section as part of the catchment plan was a high priority set by the Moberup LCDC. This was an outcome from a presentation to the group in May 1991 by Paul Mackenzie who was then developing the MIDAS model for the Great Southern Region.

MIDAS is an acronym for 'Model of an Integrated Dryland Agricultural System'. It is designed to select farm management strategies which maximise profit subject to resource, technical and environmental constraints. Its use in Landcare is to provide a guide to management practices which are both financially and biologically sustainable. It does this by indicating the size of financial penalties associated with pursuing non-profit goals or management which degrades land capability.

The WA Department of Agriculture has developed a Landcare Economics workshop. It explains the assumptions and scope of MIDAS and assists farmers to develop their own gross margins for rotations. Economic benefits of landcare projects and practices are summarised by way of example budgets.

##### **Outcomes from applying the MIDAS model**

Using a 1000 ha property in Kojonup, the model analysed 12 different rotations for their economic sustainability. The mix of LMUs on this property were:

Salt affected	100 ha
Deep sands	50 ha
Gravels	500 ha
Jarrah-Marri Duplex	200 ha
Waterlogged Valley	<u>150 ha</u>
<b>Total =</b>	<b><u>1000 ha</u></b>

Over a wide range of commodity prices the following all held true:

1. Cropping to soil type, as opposed to indiscriminately choosing paddocks, is very important.
2. Multiple cropping with cereals and break crops (such as lupins, canola and field peas) on suitable LMUs is more profitable than multiple cropping with no break crops or single cropping (i.e. a cropping year separated by a pasture phase).
3. The Jarrah-Marri Duplex and the Gravel LMUs are favoured for multiple cropping with break crops while a long pasture rotation (about 8 to 10 years) is more profitable on the other LMUs.
4. The optimum rotation was cereal-lupin-cereal-canola on the best land. A high yield cropping package was assumed which involved the above points as well as:
  - i) controlling grass weeds in the previous break crop
  - ii) sowing early with the correct variety,
  - iii) controlling weeds early, and
  - iv) using adequate fertiliser.

##### **Discussion of outcomes**

When using the above high yield package, 15 to 30% crop was found to be the optimum range; assuming the following net on farm commodity prices (wheat \$130, oats \$85, lupins

\$155, canola \$260, barley \$125, wool 650 c/kg MI). This crop area is double the district's current practice of cropping between 10 and 15% of the farm.

Another major finding of the model was that even if wool prices increased to 800 c/kg MI, the above findings still held true. In other words the optimum area of crop was found to vary only slightly over a large range of grain and wool prices.

The main factors contributing to the increase in farm profit are:

- higher crop yields;
- an expansion of the area cropped; and
- better pasture productivity on paddocks which were cropped less frequently.

### **The landcare benefits**

In terms of landcare, adopting the management strategies suggested by MIDAS should result in:

- reduced rate of soil degradation through better paddock selection for cropping and grazing
- greater water use in recharge areas before it has a chance to swell ground waters
- higher profits which can be channelled into landcare projects which have long term benefits.

### **Additional factors**

The individual needs to consider the following areas *not* built into the MIDAS program:

- a) Where herbicide resistance is likely to be a problem a slightly lower level of cropping may be optimal.
- b) The cost of changing to the optimum crop area (e.g. larger machinery to gear up to the high yield level) may be greater than the returns from doing so.
- c) The mix of LMUs varies from farm to farm. However even those dominated by poorer cropping LMUs have an optimum area of about 15%.
- d) Business structure, availability of labour, managerial skills and preferences of the individual are to be weighed up.

### **Summary**

MIDAS indicates that the high yield cropping package is more effective than the traditional district practice of a one in three (or longer) pasture-cereal crop rotation. Greater net farm income can be expected from adopting more intensive cropping on suitable LMUs and expanding crop area. This finding holds true over a large range of commodity prices.

### **Recommendation**

That the Moberup LCDC facilitate the running of the Landcare Economics workshop in the catchment.

## **5. Reserves in the Catchment**

### **5.1. Reserves managed by CALM.**

There are three such reserves within the catchment totalling 245 ha.

<b>Res 16031 Cootayerup Nature Reserve (40 ha)</b>	Located on the plateau which defines the southern boundary of the catchment and at the head of the mapped Swamp Complex LMU which flows to the north-west.
--	--

This A class reserve is unique in being a freshwater swamp and is vested in the NPNCA for the conservation of flora and fauna. Surveys since 1984 have regularly identified about

20 species of birds and recorded the main vegetation associations. Two or three rabbit warrens have become well established despite gassings in 1988 and 1990.

**Human activity:** Several times the reserve's ringlock fence has been lifted to allow sheep to graze, severely disturbing the understorey and fauna. Dumping of sheep carcasses and cutting of old wandoos for strainer posts has also occurred.

**Res 17340** A small triangular area which nonetheless has exceptional  
**[opposite Mobrur diversity of flora - about 70 native species have been identified.**  
**Hall] (4 ha)**

An A class reserve which is vested in the Shire of Kojonup for the conservation of flora. It plays a role in protecting the landscape against salt encroachment. Exotic species (grasses and garden plants) have invaded the areas adjacent to the watercourse.

**Human activity:** Signs of old timber cutting and grazing of stock. Dumping of rubbish is frequently reported.

**Res 24057** A reserve on a prime groundwater recharge site of the  
**[opposite junction Gravels LMU and the Jarrah-Marri Duplex LMU. It**  
**of Scotts Brook & became a C class reserve for conservation of flora and**  
**Mobrur Roads] fauna, vested in the NPNCA, in 1991. Previously it**  
**(192 ha) was a 'Timber for Settlers requirements' reserve.**

It has a rich and diverse flora and fauna and is the largest reserve within a 15 km radius, containing vegetation and wildlife not represented in any other reserves. Two colour variations of flora not reported elsewhere have been recorded. Birdlife surveys have regularly listed about 13 species and 98 species of flora are currently identified. It is of sufficient size to provide a good habitat for fauna.

**Human activity:** The reserve has been a past source of good quality gravel and timber. Small amounts of stone, wandoo logs and jarrah burl continue to be removed and the practice is now illegal. Risk of infection with jarrah dieback (*Phytophthora cinnamomi*) remains high owing to unrestricted vehicle traffic. This reserve had the polocrosse grounds and associated dams excised and vested in the Shire of Kojonup in 1991 with its change of status. Unfortunately this reserve has been largely undervalued by the community in the past.

### **Recommendations**

The catchment plan has a focus on these reserves by attempting to link them with the major drainage lines and adjoining remnant vegetation on freehold land.

It is recommended that the LCDC facilitate the development of a working plan with CALM which would involve the landholders in its implementation. It should deal with all the reserves and address issues such as fire hazard reduction, control of feral animals, management of kangaroo populations, restriction of vehicle access and education of the community to appreciate the reserves' value.

## **5.2 Reserves and freehold titles managed by the WA Water Authority**

The catchment was incorporated in the program to control salinity in the Warren River in 1986. A total clearing ban was instituted with compensation to landholders where a previous application to clear was refused.

Also holdings which were uncleared were purchased by the WA Water Authority and remain as freehold titles. There are four such holdings in the Mobrur catchment totalling

about 885 ha. They are parts of portions 12369, 12370 and 8148 located in the lower and western part of the catchment.

The Reserves are becoming a problem to the WA Water Authority which have no budget allocations or programs in place for their management. Leasing to adjacent landholders sometimes occurs but it not uncommon for illegal grazing to occur. Areas of the vegetation on WA Water Authority land is degrading, they offer havens to feral animals and heavy populations of kangaroos and emus and they represent a high fuel area for fires.

### **Recommendation**

That the Moberup LCDC facilitate the development of a working plan with WA Water Authority which would actively involve landholders in its implementation. It would need to address the issues of fire hazard reduction, management of fauna populations and monitoring of vegetation.

## **6. Management of remnant vegetation**

The remaining bushland on privately owned freehold land is a natural resource deserving of protection and separate management to the grazing regime currently being practised. There is no regeneration of the vegetation to replace the adult tree deaths from natural attrition, fire, land degradation such as salinity, ringbarking by stock or felling. These remaining stands of natural timber offer a diversity and fulfil an ecological need in the catchment which should be appreciated and preserved.

### **6.1 Wetlands**

The fresh to brackish wetlands must have a very high priority for protection in the catchment. Their past contribution to agriculture has essentially been as a stock water source with limited and poor grazing. The water qualities in them are now rapidly deteriorating to where their value as watering points is questionable and the fringing vegetation is sparse and severely altered.

Arguably their contribution to the catchment is now more their water use with plant species already present which are suited to the waterlogged and variously saline conditions; particularly with the deeper piezometers revealing the presence of highly saline aquifers beneath the swamps. Aside from this their conservation value to native fauna is ranked very high and integral to the life and breeding cycles of many species with, as yet, poorly understood implications for nearby agriculture.

Fencing of a generous perimeter about these areas to exclude stock is strongly recommended. Management of the regeneration may include reseeding (or laying of cut, seed bearing branches), planting of species that are local and likely to spread naturally, rabbit control, ripping lines for local water harvesting and mulching.

Fire is used only very rarely in regeneration activities with the wetlands though, as their development was in isolation of frequent burns and the species are generally poorly adapted to coping with the events. A fire, in particular the intense burns of spring or early summer, will favour instead the pioneer species such as acacias, destroy any remaining habitats of dense shrub for birdlife and have little of the original vegetation resprouting or living long enough to set more seed.

## **6.2 Drainage lines**

The catchment plan recommends the fencing out of the major drainage lines. Total area for this is about 256 ha. This ensures that a belt of high water using vegetation will exist along the feature of the catchment most likely to exhibit the first signs of salinity. Groundwaters generally are closest to the surface in the drainage lines.

This would also provide much of the wildlife corridors required to link patches of remnant vegetation and the reserves. More needs to be understood about the role these corridors can play in the movement of pests, ferals and fire as well as their conservation role with the lesser observed wildlife.

If the competition from grasses is not too great the flooded gums (*Eucalyptus rudis*), yates (*E. occidentalis*) and the understorey can regenerate well from seed. Spraying of grass selective herbicides such as Fusilade® or Sertin® in spring can produce remarkable results. The effort and expense of this fencing and management is much less than that required in a program of establishing tree seedlings.

A rotational grazing plan of this 'long paddock' is then possible which allows the regeneration that occurs to grow sufficiently to withstand a moderate grazing pressure while keeping fire fuel levels down.

## **6.3 Remnant bush on the Gravel and Jarrah-marri duplex LMUs**

All the woodlands on the ridges and slopes in the catchment which have regular grazing throughout them display the symptoms of moderate to partial degradation.

These are plant communities which are simplified with sparse or absent shrub and ground layers, extensive invasion by weeds, signs of chemical and fertiliser drift, erosion and changes in soil structure and with adult deaths of the larger species occurring every year or two.

A need exists to fence out the least degraded patches, particularly those which are interconnected and on areas of high recharge such as rock outcrops, spillway sands and deep gravels. Consideration of the nature conservation of the stand is also worthwhile with an understanding of rare flora, plans to control ferals, retention of hollow trees and logs and monitoring of the changes over time (easiest with photographs).

A very good guide for WA landowners wanting to preserve their remnant vegetation is a book by B.M.J. Hussey and K.J. Wallace called 'Managing your bushland' (1993).



## 7. Demonstration/trial sites

### 7.1 *Eucalyptus camaldulensis* (river red gum) clones trial site

#### Introduction

A program of selection of superior salt tolerant river red gum (*Eucalyptus camaldulensis*) was initiated at the University of Melbourne in the early 1980s. Cloning of the selected lines was a means of rapidly propagating known qualities for timber and saltland revegetation in large quantities. This was successfully done at CSIRO in Canberra with the stocks of clones being passed on to Alcoa of Australia in 1983.

Several field trials using these stocks were established in areas with 500 to 800 mm rainfall per annum. These were to determine their tolerance to soil salinity, soil type preferences, tree form, growth rate and wood properties with the aim of extending the geographic and site range for commercial timber crops.

At the time of this work with the clones the WA Department of Agriculture wanted to establish a block planting of *Eucalyptus camaldulensis* seedlings taken from seven different provenances. A partnership with CALM increased this number to fifteen, developing the commercial planting theme of the trial further.

#### The site

An area of 10.5 ha on the eastern extremity of R. and J. Stapleton's property was one of six sites selected in the south-west of WA.

A major feature of the site is the main drainage line of the upper Moberup catchment which flows down the middle of the broad valley floor. It is located in the northern corner of the Moberup and Furniss Loop Roads (Figure 4).

#### Preparation and planting

The landholder fenced out the site and deep ripped (to 0.7 m) and mounded the rows about 4 m apart, orientating them for free drainage. The materials were subsidised by the Department of Agriculture through the LCDC.

Weed control was by CALM with a spraying program of simazine (5 litres per hectare) applied as a 1.5 m band over the mounds.

Nine *E. camaldulensis* clones were planted in the winter of 1990. Three replicates per clone were planted with 49 trees per replicate. Casuarinas were planted in the worst of the salty areas with flat topped yate (*Eucalyptus occidentalis*) in the intermediate areas and in between the plots to better define them.

The trees in the commercial planting trial received fertiliser tablets (5 g of Agras No. 1 - applied 20 cm from the base) two weeks after planting.

Four nests of piezometers were installed and ongoing monitoring carried out. A planting with casuarinas and *Acacia saligna* was done by the landholder in 1993 where tree deaths were the highest.

#### Results and discussion to date

There are large variations in growth characteristics between the clones of this tree species. This makes it difficult to directly attribute tree height to soil salinity. Measurements of tree height, survival percentage and assessment of tree vigour demonstrate to date the limitations of selecting traits in plants from only the glasshouse trials.

Salt tolerance was an important criteria at an early stage and seen as necessary for revegetation of saline areas. The soil electrical conductivity was measured with an EM-38 instrument. When the readings were compared with the tree survival and growth a good relationship was found to exist, especially with the shallow (0 to 0.75 m) readings. This could be used as a guide for land managers when planning discharge site plantings of *E. camaldulensis*.

However, the ultimate growth characteristics of the trees are difficult to assess at the seedling stage. The differences between the clones ranged from single stemmed upright trees to bushy multi-stemmed forms. This made the relationship between soil electrical conductivity and measured tree height poorer.

Secondary benefits from planting trees must be encouraged more; even though they may be fulfilling the first reason for their planting which is water use. Such uses include timber, pulp, post, firewood, fodder, shelter and shade, wind and water erosion control, honey, oils and aesthetics.

Generally the groundwaters are less than 0.5 m from the surface with electrical conductivities ranging within 2000 to 300 mS/m. It is too early to state that the water use by the trees is lowering the groundwater levels below the planting though previous study has shown that tree densities as low as 80 trees per hectare can significantly lower water-tables on mid-slope sites.

Monitoring may show a change in the next few years but the possibility of greater rates of discharge than anticipated at the valley floor needs to be allowed. Also the waterlogging the planting is experiencing will make it more susceptible to the effects of salt and reduce timber production.

**Recommendation:**

That the Moberup LCDC continue monitoring the site, and assess the commercial value of the plantings and the returns to the landholder from sites with different salinity levels (as measured with an EM-38 instrument).

That the landholder introduce tall wheat grass into the trial site in 1994-95 and measure the grazing potential under the trees.

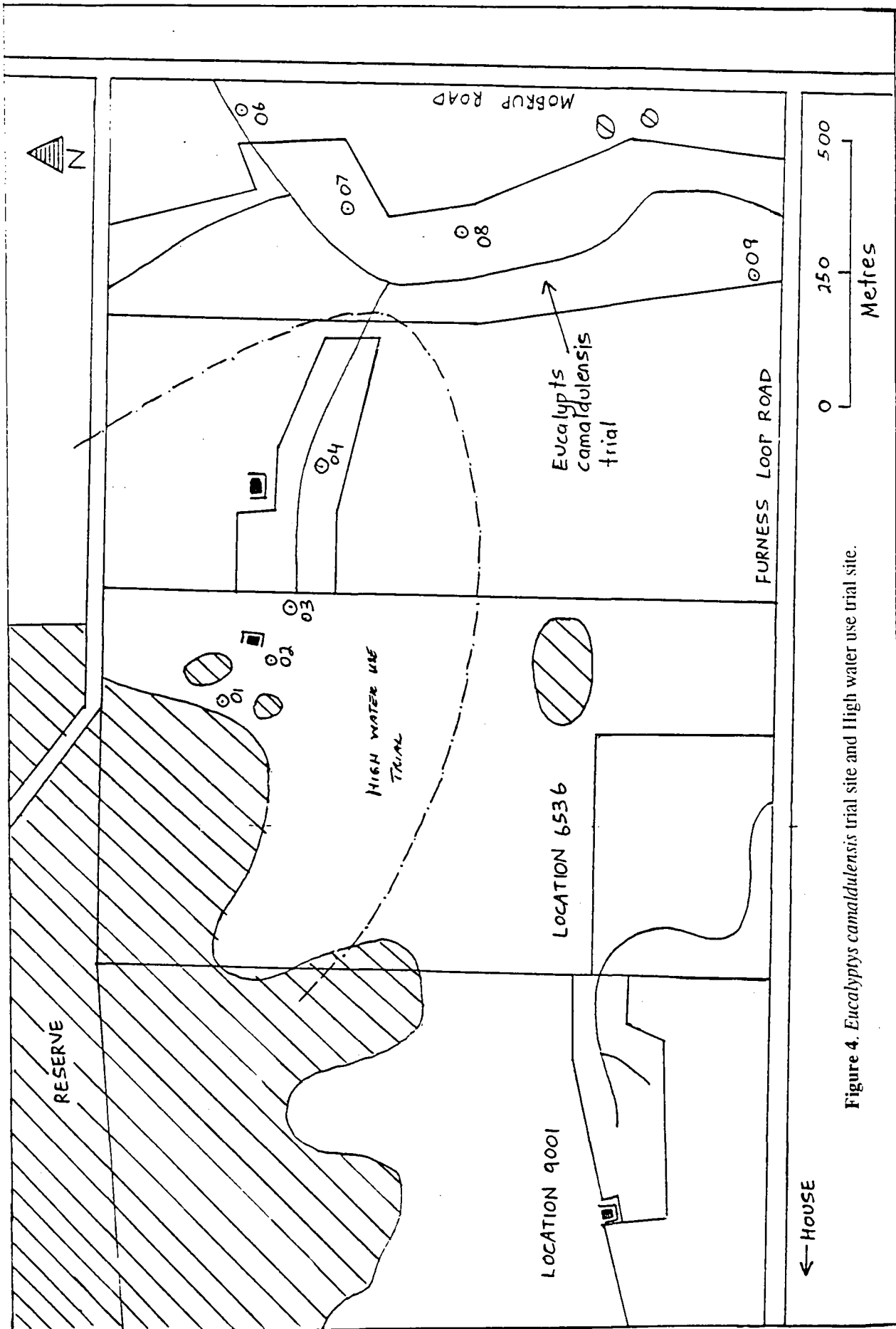


Figure 4. *Eucalyptus camaldulensis* trial site and High water use trial site.

## 7.2 High water use trial site

### Background

High water using systems are needed in an agricultural context as a means of returning some balance to the landscape's hydrology. However, measurements of the productivity changes in such systems, as well as their impact on the hydrology, were scarce. A project to develop six sites in the south-west of WA to demonstrate and monitor these systems received funding from the Land and Water Resources R & D Corporation in 1990.

Potential sites inspected throughout the south-west had to meet the following criteria:

- A totally self-contained subcatchment of 100 to 200 ha - some symptoms from a rising groundwater (e.g. salt outbreak, changes in pasture composition)
- a landholder prepared to be active in the planning and implementation process and the monitoring of the system.

The project found so many suitable sites that they created two categories of sites:

- those which are closest to the project objectives and to receive the majority of the resources and
- the sites where low input planning will be carried out to complement existing work and be implemented by the landholder.

The site in Mobrurp catchment on Royce Stapleton's property fell into the low input category and has been planned to the monitoring systems stage.

### The site

The subcatchment of about 125 ha is located below one of the largest stands of marri/jarraah remnant bush in the catchment. It is on a Gravel LMU ridge grading into a Heavy LMU about a saline drainage line. Below and adjoining is the *Eucalyptus camaldulensis* trial site (section 7.1) where the waters leaving the subcatchment flow into the main stream of the upper Mobrurp catchment. Landuse is predominantly grazing of annual pastures with a crop every five or six years.

The salinity problem originating from the subcatchment had already been fenced out (figure 4). Casuarinas and salt tolerant eucalypt trees were planted alongside the fence, saltbush on the patchy barley grass and bare scald, and tall wheat grass established on the remainder. Many of the trees died and the saltbush was not successful but the tall wheat grass is growing on all but the worst of the salt affected area.

Three piezometers have been installed down the length of the subcatchment and the recorded groundwater levels to date show the greatest fluctuations about the 'problem area' with the piezometers higher in the subcatchment being relatively static.

### The plan

The Project Officer responsible for this site, Tony Smith at Bunbury WA Department of Agriculture, has developed with the landholder a plan which builds on the system which Royce has started. It features a revised fencing layout, planting of trees in strategic strips and in a block above the salt, and extending the successful use of perennial grasses further up the drainage line. The tall wheat grass growing on the site has been a good source of seed for Royce, who has sown a large area alongside the Furniss Loop Road with it in 1992 which established well.

### **7.3 Balansa and Persian clover trial - D. Stretch**

The Balansa and Persian clovers are annual legumes which are aerial seeders and able to withstand wet, waterlogged conditions during winter. This trial is located on the Paperbark sands LMU where pasture suffered from the effects of waterlogging. It was sown in late May, 1992, by Research Officer Pedro Evans (Katanning Department of Agriculture District Office) with Digby Stretch.

The site was sprayed and scarified before topdressing the seed with 200 kg/ha of a super/potash mixture. Sowing rate was 10 kg/ha for all species including commercial controls (Kyanbro, Paradana and subclovers). There were 28 Persian, 5 Balansa, 6 subclovers and 1 arrowleaf clover with commercial cultivars used as controls.

#### **Results**

First year production averaged more than 5000 kg/ha up to November 1992. From January 1993 the trial has been continuously grazed by sheep with the rest of the paddock. An average germination of 2000 plants/m<sup>2</sup> occurred after the mid-March rains, with a subsequent dry period reducing the number to 1200 plants/m<sup>2</sup> at the end of June.

Hard grazing continued until 1 September 1993 when the trial was closed for measurements of dry matter production, botanical composition and seed yields after eight months of set stocking.

#### **Discussion**

A similar trial under the same grazing regime was conducted at Peter Hewson's, Katanning. It had two germinations; in March and again in early May. Volunteer lotus and trigonella was stimulated by the fertilising and inflated the dry matter production at the Moberup trial site.

The data collected to date verify the suitability of the species to waterlogged sites with moderate to low levels of salinity. A specific cultivar for these conditions in the south-west of WA will be selected from trials such as this one at the end of 1993.

## 8.1 Stabilisation of 'Talye-Para' drain

### Introduction

Flows that originate from about 60 per cent of the Moberup catchment traverse T. Dawes' property, 'Talye', after crossing the Mullidup Road, and go on into 'Para' owned by P. Taylor; quickly becoming the main drainage line to the Tone River. The course of the water along this section is dictated by a grader built drain constructed in 1986. The work is essentially an extension of earlier upstream work by Lucev and White which extends well up into the catchment.

All landholders directly affected believe this helped the flats to clear flood waters much faster with visible improvements to the woodlands and grasses.

### The problem

Large flows which occur every three or so years break out of this channel at a left-hand bend near the Dawes-Taylor boundary. These are channelled by an old drain, possibly originally constructed for a dam in 'Para'. There is significant erosion and flooding about the property boundary when this happens.

A grader built bank constructed along the boundary fence on 'Para' attempts to intercept these flows and protect the dam from silting. The bank has been overtopped and been eroded in its current state now diverts significant flows to the corner of the paddock.

What remains in the original drain is confined until it has crossed the boundary fence and has continued some 150 m before reaching a zone of deposition where the water's pathway becomes poorly defined.

The erosion that has occurred has gone to the ironstone layer 25-40 cm below the surface, which is a feature of the Paperbark sands LMU (section 3.7). The sides of the channel continue to erode in places but show signs of becoming stable.

### Option 1 - Make no changes.

The situation will reach an equilibrium in time where the channel becomes stable, and the water flowing from the outlet and into 'Para' will deposit less sand and silt. It will however continue to flood and waterlog the melaleuca-sedge area adjoining the drainage line.

Any increases in the current stocking rates, levels of traffic or volumes of water flow will reactivate the erosion-deposition cycle.

### Option 2 - Construction of a steering bank and strategic fencing.

The overflow from the channel in large events can be intercepted and returned to the channel with a 0.75 m high (unsettled) bank which curves to run parallel to, and a minimum of 30 m from, the existing channel for about 70 m. Construction *must* be from the outside so that the flows are presented with a bank on an undisturbed soil surface, thereby reducing the damage of the concentrated waters.

This will protect the dam on 'Para' but may place more pressure on the point where the flows cross the boundary. For this reason the removal of sections of the boundary fence and part of an internal fence on 'Para' is recommended to better exclude the area of concern. Flood fences can define the new grazing boundaries if so desired.

Levelling of the grader constructed earthworks which parallel the boundary fence will be necessary as all it does now is divert and concentrate the waters instead of allowing water to spread and thus be less erosive.

### **Option 3 - Construction of a levee system within the refencing.**

This aims to have the flows contained in the ideal width of 65 m with the water moving at non-erosive velocities between two levee banks constructed to 0.6 m (expected to settle to 0.45 m). The soil surface must remain undisturbed in between these banks and this is achieved by construction of the levees from the outside.

This gives the opportunity to 'straighten out' the sharp left-hand corner where the flows first break out and contribute to much of the problem. The original spoil from the existing channel will need to be removed for the system to work effectively. The channel remains where it is but the sides need to be shaped into 4:1 batters and stabilised with grasses such as concorde ryegrass and kikuyu.

## **8.2 Direct seeding of trees**

The establishment of trees by sowing their seeds into a prepared area can have many advantages. These include:

- the low cost per seedling
- the appearance of the resultant stand is natural and without the rows
- a diversity of plants with those establishing being the most suited to that particular site
- slightly less effort.

Derek Ladyman has had an attempt in using this method on bare and eroding marri-jarrah LMU slopes in 1990 near the South Moberg Road.

### **Site preparation**

Derek approached the task in much the same way as for a crop, with good weed control seen as vital. He achieved this with an early knockdown spray in autumn and two or three workings to a fine seedbed. A follow-up knockdown spray was not considered necessary as good control was achieved.

### **Seed**

He bought much of the seed of various trees and shrubs from Nindethana Seed Service (098-54 1066). He also later collected a good deal of seed about his property by observing the state of the seed capsules, gathering the branches or clusters and drying them on a spread tarpaulin or old children's wading pool. He did not bother separating the seed from the chaff and stored it all in paper bags in a cool place.

A test of viability is recommended. This can be done by sprinkling two pinches of seed (about 0.4 g) onto wetted absorbent material and counted after two weeks of light and moisture.

### **Sowing**

Derek first scattered the seed from a motorcycle with a tin punched full of holes - a bit like a pepper shaker. He does not recommend this as it is very labour intensive. In later efforts he broadcast the seed, in June or July, from a Viccon top dresser with the seed bulked in sawdust .

Dragging light harrows turned upside down or an old carpet is recommended as it generally puts the seed at a good depth and helps get the contact with the soil. Seeding with a combine is possible and is worth considering if there is a large area.

### **The result**

Derek's attempts were spectacularly unsuccessful. By working up the area to a fine state he left it particularly vulnerable to water erosion. The sites were on the lower slopes of quite steep undulating country and the winter rainfalls caused massive soil loss and buried or removed the seed.

Derek concludes that part of the site preparation must first be the interception and diversion of surface waters away from where the soil will be tilled to any degree. This can be done with a grade bank surveyed to dispose of the water into a dam or stable drainage line. If you are attempting direct seeding for the first time select an easy site with good surface water control, fertile soils and good weed control. Avoid the hazards and it can be worth the effort.

## **8.3 Earthworks**

### **Grade banks**

Banks are essential for controlling run-off from high water-shedding areas such as the shallow or water repellent gravels, laterite crests or shallow duplex soils and for diverting point sources of run-on from other areas. There are times in every season when the soil is completely saturated and any rainfall will run off and also, less frequently, the downpours which exceed the infiltration rates of most soils.

The siting of an earth bank to intercept and channel water in a particular direction must be done with a means of finding *the level of the land*. A clear plastic hose filled with water with the ends fixed to marked staffs is often used. A more rapid method is with a surveyor's level on a tripod and sighting onto a staff. Never try and judge it by eye, because water will either pond or, more likely, be flowing down too steep a gradient and eroding the channel and depositing silt. The gradient usually employed is 0.5%, which is 0.5 m fall along the bank for every 100 m traversed. A safe range of gradients one can work within is as low as 0.15% and up to 1.0% if the bank is very short.

Maximum *bank length* is generally about 1000 m before considering using a dozer to achieve the necessary capacity. If there is a large area of land which will contribute water to that bank, then again the use of a dozer may be needed to achieve safe capacity regardless of the length of the work. A minimum *bank height* is 0.5 m unsettled; 0.38 m settled (see table 1).

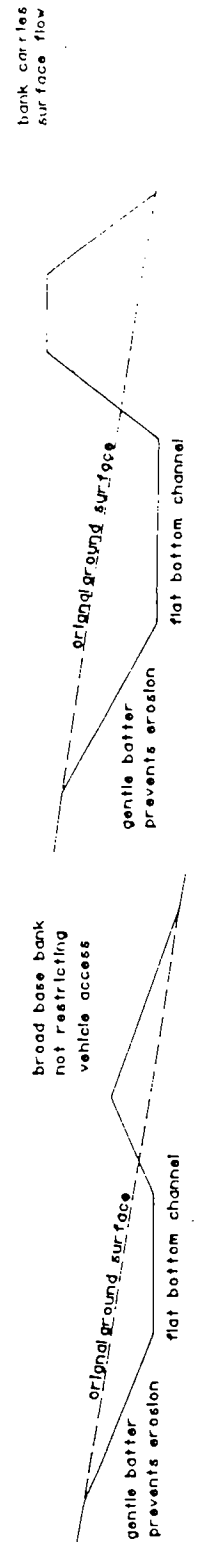
Most earthworks are sited and surveyed from *the outlet*, i.e. the point where the water is to be disposed of. This may be a dam or a stable section of a drainage line which is vegetated and free of actively eroding banks or gullies. The surveying may go on a level grade for the first 40 m or simply be the chosen grade of the whole bank, but never have it steepening, or turned down the hill to 'clear the water out' or it will most certainly erode that section badly.

*Regular maintenance* is required to build up any low points in the bank such as stock tracks or breaches and to clear silt deposits from the channel. Otherwise the bank could easily fail; releasing diverted run-off downslope and causing extreme erosion and flooding and possibly overloading other structures to where they would fail also.



**Table 1. Selection of soil conservation earthworks**

Structure	Construction machine	Position in landscape	Purpose	Slope	Grade along channel	Channel depth	Channel width	Bank dimensions
Grade bank	Grader, bulldozer or tractor and plough	Upper to mid-slope	To control surface runoff and erosion	2-15%	0.25%-0.5%	20-30 cm	3-4 m	Height 50-60 cm+
Level/absorption bank	Grader up to (50 cm high) Bulldozer (+50 cm high)	Upperslope and below breakways, etc.	To control surface runoff and erosion, mainly where there are no safe waterways	Up to 20% or more.	Nil: Pegged on contour. Channel blocks can be used along the channel if seepage areas are present, e.g. sand seams	20-30 cm higher for absorption banks	3-4 m with flat bottom	Usually 90 cm in height settled. Up to 1.2 m settled for large absorption bank
Reverse banks interceptor	Grader or bulldozer	Mid to lower-slope	To control surface and sub-surface flow	2-6%	0.8-1% and up to 2% at outlet end to exit channel	Maximum 75 cm: to extend 20 cm into clay sub-soil	2.5 m. Best soil duplex with depth to clay 20-50 cm.	2.5 m at base. Height 50 cm settled.
Diversion bank	Bulldozer	Mid to lower slope	To divert large flows	1-7%	0.2-0.4%	30-60 cm	4-6 m	Height 60-120 cm



**Grade or level bank**

**Diversion bank**

**Reverse bank seepage interceptor**

It is rare to find that one bank will solve all the problems within a paddock. A *system approach* is needed where a top bank may control run-on waters, midslope banks which are sited to intercept run-off before it begins to rill, and the lowest bank may be more to control seepage above the clay and thereby reduce waterlogging where the slope and/or the soils change.

### Drains to relieve inundation

Inundation is the water which has accumulated in low areas after seasonal rain or after a flood. This causes soils to waterlog, increases infiltration and therefore recharge to the groundwater and degrades soil structure. Waterlogging is not just a problem where water is seen on the surface; waterlogging in the root zone of plants also reduces yields significantly.

Any efforts to join and drain away lower ponded areas are most likely to be economic. This is best done with shallow channels with wide, flat bottom structures to prevent erosion in the channel and not hinder paddock access (see Table 2).

### Community Landcare Technicians (CLTs):

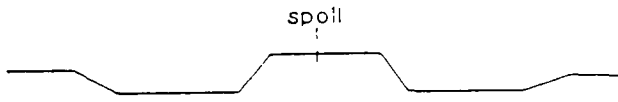
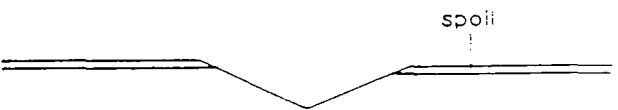

CLTs are trained in this and other areas and are well worth contracting for such work.

Local CLTs are:

- \* Peter Coffey (098-33 6268),
- \* Ken Ritson (097-65 1074),
- \* Peter Shedden (097-69 1018).

For extensive works it is advisable to have the surveyor return at the time of construction to inspect critical areas.

**Table 2. Relief drains designed to allow water in from both sides.**

<p>W-DRAIN (grader) Used on low slopes. 5% and flats to cope with larger volumes.</p>	
<p>SPOON DRAIN (grader) Used to drain flats. Generally feed into larger drains. Spoil spread thinly over surface to allow water into the drain.</p>	
<p>SCRAPER DRAIN (scraper) Used on flats to take larger volumes. Spoil used to fill in waterlogged depressions.</p>	

## APPENDIX 1

Mean records for Kojonup and Bokerup Meteorological Stations using all available data

### Kojonup

Month	Rainfall (mm)	Temperature		Evaporation (mm daily pan x days)
		Min	Max	
Jan	14	13.3	29.4	238.7
Feb	15	13.9	28.6	190.4
Mar	22	12.6	26.0	161.2
Apr	32	10.5	21.7	96.0
May	68	8.3	17.9	62.0
Jun	91	6.8	15.0	39.0
Jul	89	5.9	14.3	40.3
Aug	74	5.8	14.7	55.8
Sep	53	6.2	16.7	72.0
Oct	42	7.6	20.0	114.7
Nov	23	9.8	23.5	159.0
Dec	15	11.9	27.5	223.2
Totals	538			1452.3

### Bokerup

Month	Rainfall (mm)
Jan	16.9
Feb	21.3
Mar	18.6
Apr	41.7
May	68.9
Jun	91.8
Jul	97.3
Aug	78.4
Sep	58.2
Oct	45.7
Nov	35.8
Dec	15.0
Total	587.2

## APPENDIX 2

### Mobrup Catchment Design Points

Number	Site description	Area (ha) period (years)	Return Q (m <sup>3</sup> /sec)	Flow	Culvert dimensions
<b>The Upper Catchment Drainage Line:</b>					
1	Enters Res.17340 near Mobrup Hall	1400	1 in 10	4.96	3 x 0.30 m pipes
2	Exits <i>E. camaldulensis</i> trial site - north arm of Furniss Loop Road	1800	1 in 10	5.65	4 x 0.37 m pipes
3	Exits Ridgedale, crosses Furniss Loop Road	187	1 in 10	2.35	1 x 0.37 m pipe
4	Crosses Mobrup Road	815	1 in 10	3.70	6 x 0.30 m pipes
5	South arm of Furniss Loop Road	3200	1 in 20	7.60	Floodway
6	Crosses Mobrup Road at Polo Crosse grounds	690	1 in 10	3.43	1 x 0.37 m pipe
7	Bigwood-Tangarri boundary	4425	1 in 20	9.97	N/A
8	Two sets of culverts at east end of Scotts Brook Road	5530	1 in 20	10.20	3x 0.38 m pipes per set
9	Two sets of culverts at west end of Scotts Brook Road	190	1 in 10	1.74	3 x 0.38 m pipes per set
10	Talye-Para boundary	6020	1 in 20	10.60	N/A
11	Exits Hughes - crosses Mobrup Road	160	1 in 10	1.02	1 x 0.30 m pipe
<b>The Chain of Swamps Drainage Line:</b>					
12	WAWA reserve-Barwanda boundary	515	1 in 10	2.60	N/A
13	Barwanda-Talye boundary	1775	1 in 20	5.60	N/A
14	Tarbolten-Talye boundary	1040	1 in 20	3.85	N/A
15	Talye-WAWA reserve boundary	3230	1 in 20	7.68	N/A
16	Terrace Road bridge	10030	1 in 20	16.50	Constructed, with sleepers 6 m x 1.2 m

### APPENDIX 3

#### Electrical Conductivities in the lower Moberup Catchment

Lake/Swamp	Date	Electrical conductivity mS/m	Comments
Cootayerup Nature Reserve	18.7.91	48	Very healthy fresh water swamp.
	18.6.92	52	
	15.12.92	59	Water levels still high
	3.3.93	61	
Bush Swamp Barwanda	1.4.80	889	From D. Stretch's records
	26.3.81	689	"
	24.2.84	1165	"
	10.3.87	1620	"
	24.9.87	641	"
	28.1.88	1330	"
Plains Swamp Barwanda	1.4.80	766	From D. Stretch's records
	26.3.81	944	"
	7.3.85	525	"
	10.3.87	920	"
	28.1.88	1332	"
	14.4.91	1455	Tested for stock quality
	15.3.92	1587	
	15.4.93	1820	Tested at time of siting nearby piezometer
	Small East Swamp Talye	14.4.91	1225
15.3.92		1275	Heavy use by stock - muddy
15.4.93		1475	
Talyelwelup Lake Talye	7.2.91	560	Good quality water
	18.11.91	578	Taken with P. Sheddon for Remnant Protection scheme grant Fencing of lake from stock completed
	10.12.91	560	
	15.3.92	560	
	15.4.93	565	
Western Lake Talye	18.11.91	1080	Healthy, thick fringing vegetation
	15.3.92	1230	Tested at time of siting nearby piezometer
	15.4.93	1170	
Main Drainage Para'	15.12.92	1012	In a pool near Lake Clabburn - still waters
Terrace Road	15.12.92	1225	Still waters

## APPENDIX 4

Recordings from the driller's log at the installation of the Moberup piezometers.

### S 1

*Landholder:* Digby Stretch

*Date:* 7th April, 1993

*Site Description:* On the chain of swamps where the flows which originate at the Cootayerup Nature Reserve enter D. Stretch's property from the WA Water Authority freehold.

#### *Soils Sampled:*

Depth (m)	Description
0-0.25	Pale Sands below an organic stained surface.
0.25-0.75	Sandy Clay with orange-brown mottles.
0.75-1.75	Red-brown Clay
1.75-4.0	Coarse Sand with red clay

	<u>Shallow</u>	<u>Deep</u>
Depth (m)	3.15	7.20
Water-table (m)	3.00	1.95
Electrical conductivity (mS/m)	415	260

### S 2

*Landholder:* Digby Stretch

*Date:* 14th April, 1993

*Site Description:* Along the chain of swamps below smallest swamp (Plains) and near boundary with 'Talya'.

#### *Soils Sampled:*

Depth (m)	Description
0-0.25	Pale Sand with organic staining
0.25-0.80	Sandy Clay with orange-brown mottles
0.80-2.0	Gravel Ironstone in red medium clay
2.0-3.0	River Sand with red mottles
3.0-4.0	Wet, grey, sandy slurry.

	<u>Shallow</u>	<u>Deep</u>
Depth (m)	3.51	10.20
Water-table (m)	2.80	9.38
Electrical conductivity (mS/m)	3280	2270

### S 3

*Landholder:* Digby Stretch

*Date:* 14th April, 1993

*Site Description:* Near proposed laneway in broad valley floor - Yate Flats LMU, which leads from house and yards to cross the Scotts Brook Road and on to 'Tangarri'.

#### *Soils Sampled:*

Depth (m)	Description
0-0.2	Pale Sand and scattered gravel
0.2-0.5	Coarse sand and irregular ironstone gravel
0.5-1.5	Red clay with gravel and sand
1.5-2.0	Red sandy clay slurry
2.0-5.0	Brown light to medium clay (hard drilling)
5.0-5.5	Moist pink light clay with a talc feel
5.5-7.5	Grey-pink light clay (easier drilling)
7.5- water	Smelly black clay - coal? (Drilling gets hard again)

	<u>Shallow</u>	<u>Deep</u>
Depth (m)	2.42	8.50
Water-table (m)	-	+0.50 (above ground)
Electrical conductivity (mS/m)	-	3320

### S 4

*Landholder:* Digby Stretch

*Date:* 14th April, 1993

*Site Description:* On Paperbark Flats LMU on 'Tangarri' below confluence of flows from Bigwoods and upper catchment. Near old traffic crossing and old troughs.

#### *Soils Sampled:*

Depth (m)	Description
0-0.5	Coarse sand grading to clay
0.5-1.5	Light yellow-brown sandy light clay.
1.5-4.0	Reddish-yellow sandy light clay
4.0-5.5	Reddish-brown sandy light clay
5.5-7.5	Wet twistings of yellow sandy clay
7.5-water	Drilling gets very hard - scope for a deeper piezometer (15m).

	<u>Shallow</u>	<u>Deep</u>
Depth (m)	3.63	8.35
Water-table (m)	2.91	5.43
Electrical conductivity (mS/m)	3 050	2590

### S 5

*Landholder:* Digby Stretch

*Date:* 15th April, 1993

*Site Description:* Alongside boundary with Bigwood and in south corner of main drainage line.

*Soils Sampled:*

Depth (m)	Description
0-0.25	Brown loam
0.25-1.50	Pallid clay
1.50-3.50	Yellow clay
3.50-7.00	Moist sandy brown clay
7.00- water	Red clay

	<u>Shallow</u>	<u>Deep</u>
Depth (m)	4.1	11.55
Water-table (m)	-	3.93
Electrical conductivity (mS/m)	-	2450

**D1**

*Landholder:* Terry Dawes

*Date:* 15th April, 1993

*Site Description:* On boundary with Peter Taylor and at the end of the chain of swamps.

*Soils Sampled:*

Depth (m)	Description
0-0.6	Pale sand
0.6-1.0	White weathered clay
1.0-7.5	Grey sandy clay

NB deep drilling collapsed before casing but the shallow bore is in the one large saturated layer.

	<u>Shallow</u>	<u>Deep</u>
Depth (m)	3.18	-
Water-table (m)	1.40	-
Electrical conductivity (mS/m)	>20,000	-

**H1**

*Landholder:* John Hewson

*Date:* 15th April, 1993

Site Description: On west side of Mobrur Road on edge of bare scald alongside drainage line (runs from remnant bush on east side of road via culvert).

*Soils Sampled:*

Depth (m)	Description
0-0.4	Yellow sand
0.4-1.2	Orange-brown sandy light clay



1.2-2.75 Gleyed mottled clay  
 2.75-3.5 Red clay  
 3.5-5.5 Calcareous red clay

	<u>Shallow</u>	<u>Deep</u>
Depth (m)	2.43	5.50
Water-table (m)	-	3.17
Electrical conductivity (mS/m)	-	>20,000

## N 1

*Landholder:* Nick Hughes

*Date:* 14th April, 1993

*Site Description:* Across the road and upslope from Stretch's tree planting on Moberup Road. Below largest CALM reserve. Sited beside a stump where surface flows divide in large events about 550 m east of the road.

### *Soils Sampled:*

Depth (m)	Description
0-0.25	Gravelly loam
0.25-1.25	Yellow-brown medium clay
1.25-5.0	White, gleyed clay (pallid zone)
5.0-water	Yellow brown medium clay with coarse sand throughout

	<u>Shallow</u>	<u>Deep</u>
Depth (m)	1.86	6.40
Watertable (m)	-	5.87
Electrical conductivity (mS/m)	-	5600