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## Profitable and productive farming systems for management of Nolba catchment

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Nolba Focus Catchment Group

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Eastough, B R, and Nolba Focus Catchment Group. (2002), *Profitable and productive farming systems for management of Nolba catchment*. Department of Primary Industries and Regional Development, Western Australia, Perth. Report 247.

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Department of Agriculture  
Government of Western Australia



**PROFITABLE AND  
PRODUCTIVE FARMING  
SYSTEMS FOR  
MANAGEMENT OF NOLBA  
CATCHMENT**

*Compiled by Belinda Eastough*



May 2002



**RESOURCE MANAGEMENT  
TECHNICAL REPORT 247**

**Resource Management Technical Report 247**

**Profitable and productive farming systems for  
management of Nolba catchment**

**Compiled by Belinda Eastough  
for the  
Nolba Focus Catchment Group**

**May 2002**



**Department of Agriculture  
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# 1. INTRODUCTION

The Nolba Catchment Group formed in 1991, and farm and catchment planning was completed in 1992. The growers mapped existing features on individual farms and the erosion hazards and proposed works were mapped and completed in grower workshops with then catchment planning officer, Mike Clarke. In 1993, 1994 and 1998 the group successfully applied for NLP funding, Greening Australia funding and a Lotteries Commission Grant. This success contributed greatly to the impetus, which followed the catchment planning exercise. Since 1992, members of the group have fenced off many kilometres of creeklines, fenced off and planted trees to stabilise wind erosion prone areas. They have converted to no-till to minimise broadacre wind erosion and are experimenting with perennials such as lucerne and summer crops to use more water in the catchment.

When the group was selected as a focus catchment the members decided a series of workshops and two demonstrations were the tools required to build on their existing knowledge of integrated catchment management. The workshops needed to demonstrate profitable solutions to land management problems to encourage adoption. The workshops focussed on production solutions to land management issues. The group believes it is important to investigate environmental and production issues together to discover profitable solutions to environmental degradation.

The areas addressed in the workshops and demonstrations in 1999 and 2000, 2001 growing seasons were:

- Low recharge farming systems
- Impact on the Environment of Integrated Weed Management
- Management of Organic Matter in Soils within the Catchment
- Dune Stabilisation Ground Water Hydrology

The specialists responsible for the information provided in the workshops and for the reports included in this document were:

## **Department of Agriculture**

Vanessa Stewart	Development Officer
Mike Clarke	Regional Revegetation Officer
Russell Speed	Regional Hydrologist
Andrew Blake	Pasture Research Officer
Keith Devenish	Pasture Development Officer
David Rogers	Farming Systems Development Officer
Caroline Peek	Farming Systems Research Officer
Peter Newman	Herbicide Resistance Research Officer
Derk Bakker	Cropping Systems Research Officer
Dave Tennant	Natural Resources Research Officer

## **Other specialists**

Richard Quinlan	Agronomist, Elders
Margaret Roper	Research Officer, Plant Industries, CSIRO

This report aims to provide the farmers in the catchment with a summary of the main points covered at each of the workshops. This was completed by Belinda Eastough.

## 2. LOW RECHARGE FARMING SYSTEMS

*Workshop conducted by Derk Bakker, Albany; Andrew Blake and Keith Devenish, Northam; Peter Newman, Caroline Peek and David Rogers, Geraldton; David Tennant, South Perth, Department of Agriculture.*

### 2.1 Leakage in the current system

Water available to grow crops is a precious commodity, given that the Nolba catchment is situated in a 350-400 mm annual rainfall zone. Any water that drains away from the roots of crops is a potential productivity loss and has the potential to contribute to dryland salinity. The upper catchment consists of predominantly deep yellow sandplain in a lupin/cereal rotation and the lower catchment is predominantly red loam in a pasture cereal or lupin cereal rotation. The yellow sandplain acts as a very high recharge area and contributes considerably to groundwater rise within the catchment (See Section 6 Groundwater Hydrology)

The amount of water leakage from a wheat paddock on yellow sandplain in the Nolba catchment can be calculated using the Drainage Calculator developed by Department of Agriculture. Calculation below for Deep yellow sand.

#### CVT Zone M1 Year 1999 Annual rainfall 551.50 mm

Paddock No.	Soil	Land use	Leakage factor	Leakage (mm)	Area (ha)	Total leakage (mm/ha)
4A	Deep yellow sand	Wheat	0.04	22	94	2,074 mm

In order to reduce recharge, several options were discussed and sites evaluated with the group.

- a) Increase water use of annual crops and pastures
- b) Use of lucerne and other perennials to dewater soil profiles
- c) Use of summer cropping to use out of season recharge
- d) Use of raised beds on mildly saline land - using water at the discharge site.

### 2.2 Increasing water use using annual crops and pastures

*David Tennant*

Shallow-rooted annual crops and pastures are currently sown over 90% of the agricultural landscape in the Nolba catchment. There is currently much discussion regarding the potential for increasing water use of annual species. Also the group evaluated potential yield calculations based on available rainfall.

A replicated farmer demonstration to look at water use by crops and nitrogen efficiency was set up in the focus catchment which was discussed and evaluated in the field at this workshop.

By improving nitrogen efficiency the amount of soil water used by the plant can be increased which will aid in reducing leakage from the system. This is especially important in the yellow sandplain at the top of the catchment, which acts as a recharge area that contributes to the salinity on the properties further down the catchment. A summary of the results is presented below. The water use of different varieties was also compared to isolate a high productivity package.

The aim of the demonstration was to identify limits to annual crop water use based on the assumption that higher productivity annual pasture and crops use more water. This was not proven due to reduced evapotranspiration in denser crops and pastures.

### High productivity farmer scale demonstration

Table 1 shows the soil test results from the demonstration site.

**Table 1: Soil test results from Nolba Catchment Demonstration**

YEAR	P (ppm)	K (ppm)	OC%	pH (CaCl <sub>2</sub> )	Reactive Fe	S
2/01/1991	12	69	0.37	6.05 (H <sub>2</sub> O)	202	
20/01/1998 (17 cm depth)	16	21	0.30	4.9	189	4
31/01/00	14	35	0.42	5.1	587	4

### Seeding information

Sown 17/5/99 on Yellow sandplain (Mallee) seeding rate – 67 kg/ha Calingiri, Brookton, Carnamah, Arrino, 65 kg/ha Ajana sown using a flexicoil 2320 box + 820 bar using superseeder points and press wheels.

100 kg/ha Agstar was applied at seeding. Herbicides 29/4/99 0.8 L/ha glyphosate (450 g ai) + 5 g/ha chlorsulfuron + 1% ammonium sulphate + 0.2% wa, 18/6/99 0.4 L/ha MCPA amine + 3 g/ha chlorsulfuron + 3 g/ha metsulfuron. Demonstration was harvested using a Kingaroy Plot Harvester (1.8 m width x 20 m length). 2 strips were taken from each treatment and averaged to give final yield.

Urea rates applied - 11 June 1999 (after 160 mm of rain from 23-25 May).

Rates of 0, 35, 70, 105, 140 and 175 kg/ha urea were applied using a Marshall Multispreader across all varieties.

Rainfall for the trial was above long-term average as shown in Table 2.

**Table 2. Rainfall in the Nolba catchment compared with long-term average (1911–1993)**

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1999	0	0	15	41	229	34	60	37	66	22	0	49	553
Ave	10	14	20	21	49	75	65	45	24	14	9	7	353

### *Summary of results*

Brookton variety averaged a 60% water use efficiency at the 70 kg urea rate while other varieties had 40 to 20% efficiency (using yield potential 20 kg/ha/mm growing season rainfall).

There was a negative response to applied nitrogen above 70 kg urea, shown to be due to low levels of soil potassium and therefore plants were not able to use the nitrogen supplied. From grain testing, sulphur and copper were also shown to be marginal especially at high rates of nitrogen. Due to the presence of nutritional yield limiting factors, water not used by the crop was substantial.

### *Conclusion*

Although a healthy crop may have a more vigorous root system making more use of available water, it may also have a denser canopy meaning less water is able to evaporate from the soil surface. This is being researched by David Tennant to give a clear message regarding the impact of growing higher yielding crops on available water. Trials have been set up at Esperance and Merredin to examine the water use of high productivity versus low productivity crops looking at soil water measurements and evapo-transpiration. The project aims to provide information on how factors such as productivity and crop maturity interact to affect total water use and how we might use annual crops and pastures to reduce the impact of dryland salinity.

## **2.3 Use of lucerne and other perennials to dry soil profiles**

### **Lucerne and pastures**

*Andrew Blake, Keith Devenish, Peter Newman and David Rogers*

As more land is lost to degradation and salinity becomes more prevalent, the commonly suggested answer is to introduce more perennials into the system. Hydrologists now suggest that some 70 to 80% of the landscape needs to be planted to deep-rooted perennials to have a significant impact on rising groundwater. This is believed to be unattainable until the perennials we incorporate into the system are as economically viable as current annual systems.

Perennials will be adopted initially to niche areas that are already too marginal to risk for cropping but have the potential to be very productive with waterlogging and salt-tolerant plants. Some perennials that may have a part to play are pastures. The Northern Agricultural Region has the benefit of milder winters and earlier warmer weather in spring which would suit sub-tropical perennial pasture varieties.

Minnie Mitcherton has a site on his property that has a growing problem with a shallow saline watertable. The site is a winter-waterlogged area with a brackish watertable at 1 m. It is dominated by barley grass and in some areas was beginning to bare off and become a salt scald.

Figure one shows the trial site at Minnie Mincherton after preparation and just before seeding of the trial in 1999.





*Figure 1. Minnie Mincherton's site prior to seeding in 1999. Note the salt crystallising on the soil clods.*

It was decided to look at possibilities for this site and how it could be used more productively. A mixed perennial sward was sown on 19 September 1999 into a seedbed that had been prepared by scarifying. It was sown using a culti-trash with press plates to a depth of 1 cm. Varieties sown included:

- Lucerne at 3 kg/ha
- a strawberry (Palestine) white clover mix at 1 kg/ha
- panic grass (Bambatsi) at 2 kg/ha
- setaria grass (Kazangular) at 2 kg/ha
- rhodes grass (Callide) at 1 kg/ha
- tall wheat grass at 1 kg/ha
- and a small amount of forage sorghum as a carrier.

The seed was sown with 60 kg/ha of DAP fertiliser.

Figure 2 shows the trial site at Minnie Mincherton's three months after seeding the site when initial establishment was quite good.

Establishment was very patchy with some areas being dominated by grasses, some by lucerne and others bare. This was probably due to varying seeding depths. Grasses need to be sown very shallow (less than 1 cm deep) and then pressed firmly into the soil.



Figure 2. Minnie Mincherton’s site, December 1999 showing good initial establishment.

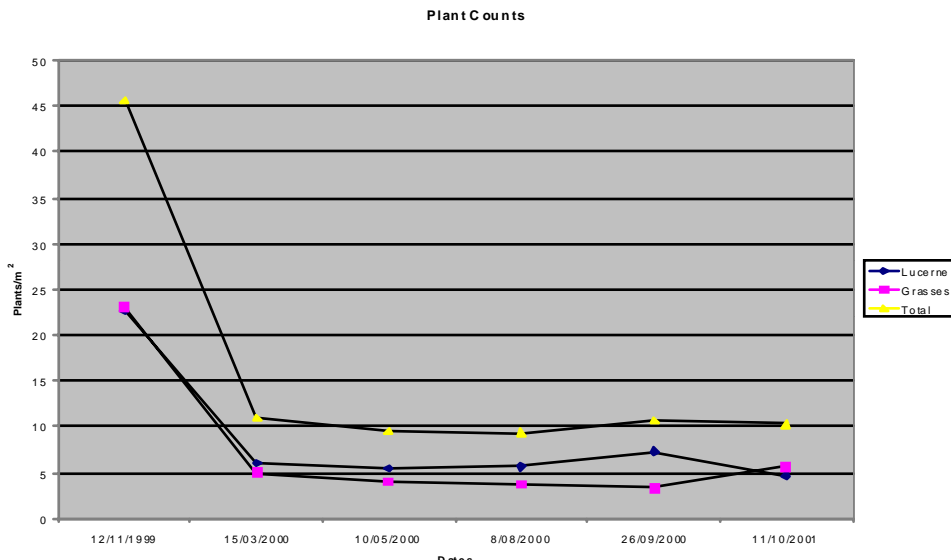


Figure 3. Plant numbers at Minnie Mincherton’s salt-affected site.

Plant counts were taken after germination and throughout the summer. Stock were allowed their first grazing in mid-February. Initial plant counts were 50 plants/m<sup>2</sup> and were 50% lucerne and 50% grasses. After some hard grazing in February numbers dropped to about 11 plants/m<sup>2</sup> in March and were maintained throughout the winter (Figure 3). Plant numbers dropped significantly through summer which was due to:

- deaths through the hot dry conditions
- natural thinning of the stand as it was sown at a high rate
- heavy grazing pressure in February
- a combination of all of the above.

Perennial grasses need time to establish before grazing can be allowed. This is to ensure the secondary roots develop to secure the plant to the ground. If grazing is allowed before secondary root development, the sheep will pull out the whole plant.

Even at these low numbers the pasture seemed productive with an annual pasture re-establishing during winter amongst the mixed perennials.

The site was very productive after the high rainfall event in March and the farmer gained some valuable grazing from the area (Figure 4). The grasses that established are mostly Rhodes and setaria with a few Bambatsi plants. This may also be in part due to the early grazing pressure. Bambatsi is the most palatable and nutritious of the grasses and may have been grazed preferentially.

As expected, neither the strawberry nor the white clover established very well. While these varieties can be perennial, they have a large moisture requirement and autumn establishment may have been better.

Since the perennials have been established the watertable has dropped from close to the surface to more than 2.5 m deep. However this is most likely due to low rainfall over the past two years and not to any impact of the perennials.

The site has been very successful but it will be interesting to note if there are changes in pasture composition and how watertable responds to another wet year.

In summary, sub-tropical grasses have potential to increase productivity on these sites. In conjunction with a good annual pasture, they provide the possibility of green feed throughout most of the year on similar sub-irrigated sites. They are also very drought-tolerant and will shut down if there is no moisture.



*Figure 4. Early lush growth at the Mincherton site in 2000.*

However because they are perennial they can take advantage of any out of season rainfall and are very good at providing quick early feed after the opening rains. Minnie Mincherton's site went from bare ground (from heavy grazing), to thick lush pasture in four to six weeks following heavy rains in March 2000.

**David's tips for successful sub-tropical grass establishment**

Weed control	Good weed control is essential. Even slight competition during establishment can greatly affect the establishment of the stand.
Time of sowing	The best time to sow seems to be from mid-August to mid-September. These plants need at least one rainfall event after sowing to instigate germination, but if you sow too early the plant will germinate, but develop slowly due to cold conditions. Subsequent weed germination could then put added pressure on the grass seedlings.
Seeding depth	Seed needs to be sown shallow 0.5 cm. See Figure 5.
Pressing	Sub-tropical grasses need to be firmly pressed into the soil at seeding. Vast improvements in establishment have been obtained through firm pressing.
Seeding rate	3-4 kg/ha but with good seeding equipment with accurate seed placement and press wheels this can be reduced to 2-3 kg/ha.
Grazing	Should be grazed rotationally as set stocking will thin the stand. The first grazing needs to be timed carefully as grazing too early can destroy the stand. These types of plants need to develop their secondary root systems in order to anchor them to the ground before grazing. If this has not occurred and they are grazed, livestock will pull the whole plant out of the ground. Secondary root development can occur any time between 6 weeks and 6 months after germination, depending on rainfall.



*Figure 5. Sub-tropical grasses on Tim Pannel's property. Seed at left was shallow sown; on the right seed was dropped on the top of the ground behind the tyre of the seeder. Note the difference in establishment.*

## Lucerne

*David Rogers*

Lucerne is currently being tried by John Stokes as part of a GRDC project supervised by Keith Devenish. It is expected to play a large part in managing rising watertables in Western Australia and is the best perennial available. Lucerne is renowned for its ability to dry the soil profile as it has the capacity to extend roots deeper than annual crops and pastures. Lucerne is also able to use nutrients beyond the reach of other plants such as nitrates responsible for soil acidification. It has been shown to create a buffer capable of storing 50 mm of soil water in trials at Katanning.

### *Rotation*

Lucerne has little impact on stored subsoil moisture until the second summer following establishment, therefore it is generally in a three-year phase before most growers switch back to crop. Researchers are investigating how quickly a soil profile refills when crops are grown after lucerne. The refilling of the buffer depends on the type of crop grown and the timing and amount of rainfall. The impact of lucerne on the following crop was also discussed and at some sites there has been an increase in grain protein.

### *Grazing value*

A well managed lucerne stand of 20-40 plants/m<sup>2</sup> should be able to carry 4 DSE/winter-grazed hectare in this area. The trial has been crash grazed to stimulate growth so it is difficult to estimate stocking rate. Lucerne should have similar total annual legume pasture production with more out-of-season production.

### *Tips for grazing*

Grazing of lucerne needs to be managed correctly as the grazing pressure placed upon the stand directly affects its persistence and productivity. A stand that is continuously grazed will not persist as long as one that is rotationally grazed.

Lucerne is able to recover from grazing quickly due to its ability to use energy stores in its crown to facilitate budding and regrowth. For continued productivity the plant needs time between grazing to restore energy. Continually stocked stands do not get a chance to restock energy and the continual need to reshoot eventually drains the crown of reserves. The plant is then at high risk of being grazed out.

Grazing during the establishment year is the most critical as the plant has not had time to develop a mature crown. The stand should not be grazed until flowering and then only a light grazing of five to seven days. Once well established it should be rotationally grazed with rests of four to six weeks or longer depending on rainfall and production. Grazing periods should only be as long as there is no damage to the fresh buds on the crown. As soon as significant damage to the buds is likely stock should be moved on. Do not overgraze on sandy soils as sheep can dig out crowns and kill plants. Rabbits can also dig out crowns and do extensive damage.

### *Select the right soil type*

Free draining soil with pH greater than 4.8<sub>(CaCl<sub>2</sub>)</sub>. Apply lime where soil pH is 4.8 to 5.5. Lucerne will not tolerate waterlogging or saline soils. It will persist longer and be more productive on deeper soils. On shallow soils with barriers to rooting depth persistence and production will be reduced.

### *Weed control*

Plan well ahead and control weeds the previous season. Delay seeding until after good weed germination and apply a knockdown herbicide.

Control grasses with grass selective herbicides. Trifluralin is also another good option to control ryegrass.

Lucerne is a poor competitor in the establishment year but after 12 months plants with an established crown have excellent tolerance to a range of herbicides. Discussion within the group of the results from the herbicide tolerance trial at John Stokes' property (Research Officer - Peter Newman) highlighted once the crown is established lucerne can be completely defoliated and make a full recovery. The winter cleaning method was trialled here and the paddock was grazed intensely for a short period to defoliate lucerne and weeds. The paddock was then destocked for one week before being sprayed with herbicides with the aim of killing the weeds and allowing the lucerne to recover. The treatments that gave the best weed control with the least damage to the lucerne and subterranean clover were Sprayseed® + Diuron + Simazine and Sprayseed® + Diuron. The control of the doublegee and capeweed was less than optimal due to the large weed size when sprayed. The weeds should be no older than six weeks. In this trial lucerne appeared to be sensitive to MCPA.

### *Varieties*

Use winter-active varieties such as Eureka, Trifecta, Genesis, Sceptre, Aquarius, Pioneer I69, Pioneer L90 and Salado. In general, the higher the winter activity of a variety the less time it will persist. For short phase farming use very highly winter active varieties but for more persistent stands use more moderately winter active varieties.

### *Sowing*

Sow as early as possible without compromising weed control. If seeding has not occurred before mid-June (the coldest part of winter) it should be delayed until early August.

Seeding depth is critical. Sow no deeper than 1 cm into wet soil using 4 kg/ha (2 kg/ha for precision machinery). Deep cultivation combined with shallow seeding is very successful.

### *Fertiliser*

Use 10-12 kg/ha of phosphorus (depending on soil tests) and topdress (do not drill) potassium at 15-20 kg/ha on mildly acid soils. Some soils may also require trace elements. Inoculate seed with group AL inoculant; lime pellet if mixing with fertiliser.

Sow lucerne separately, as under-sowing does not appear to be as successful. Alternate row sowing has had some success.

### *Insect control*

Seedling lucerne is extremely vulnerable to redlegged earth mite and lucerne flea so be ready to spray at emergence five to seven days after seeding. Aphids can be a problem in spring.

### **Other perennials**

Lucerne is not suited to acid or waterlogged soils, therefore work is being done to isolate new perennials suited to the wheatbelt. Seven hundred perennial legume lines and several perennial grass varieties are being evaluated with the aim of having a short list of perennial legumes by 2004 and information about the suitability of perennial grasses for phase farming.

## **August lucerne establishment highly successful in 2001**

### **Nolba M1**

*David Rogers*

- August-sown lucerne established very well.
- August-sown lucerne provided valuable grazing after only 11 weeks.
- Sowing lucerne in a deep furrow on a light soil may have potential benefits to grazing management and persistence of the stand.
- Seeding depth affected germination and establishment in sub-tropical perennial grasses.

### *Background and aim*

Lucerne is the most promising perennial legume currently available that could fit into farming systems offering rotational benefits, recharge control and possible herbicide resistance weed management options. We established lucerne on a sandplain soil to look at its productivity, persistence and any management issues including erosion concerns. We also established a small area of sub-tropical perennial grasses to assess their possibilities on this type of soil.

### *Demonstration details*

	<b>Site 1</b>
Property	Tim and Tanya Pannel, Blue Gums
Soil type	Yellow sand over gravel, surface pH 6 (CaCl <sub>2</sub> ) at 20 cm depth 4.7 (CaCl <sub>2</sub> ) and has since had 2 tonnes/ha lime sand spread over the site.
Sowing date	9 August 2001
Fertiliser	30 kg Summit pasture copper zinc; 50 kg Super Boost
Paddock rotation & History	Canola 2000 Wheat 1999
Herbicides	18 June 2001 – Roundup CT 2.1 L/ha 8 August 2001 - Sprayseed 2.4 L/ha
Treatments	1) 4 ha of Eureka lucerne sown at 4 kg/ha 4 ha of Genesis lucerne sown at 5 kg/ha 2) 1 ha of Lucerne Grass Mix sown at 5 kg/ha 3) 3 ha of Grass Mix sown at 3 kg/ha 4) 8 ha of L-90 & L-55 lucerne sown at 5 kg/ha (4 kg/ha L-90, 1 kg/ha L-55) Grass Mix contained an even mix of: Bambatsi, Solander setaria, Guinea grass, Callide Rhodes Lucerne Grass Mix contained: 3 parts Eureka lucerne; 2 parts Genesis lucerne; 3 parts Grass Mix



## Results

After sowing on 9 August there was an almost immediate germinating rainfall event. This facilitated an excellent germination of lucerne with all varieties having initial numbers of 70 to 80 plants/m<sup>2</sup> with no significant difference in plant numbers between varieties.

Initial germination of the sub-tropical perennial grasses was very poor, however subsequent germination increased numbers to 5-6 plants/m<sup>2</sup>. This delay in germination is most likely due to low soil temperatures in August and the subsequent germinations occurred when the soil temperatures rose. It was interesting to note that seeding depth also had an effect on this germination timing and numbers. Seed from rows where the seed had been deposited on the soil surface germinated much earlier and in higher numbers than rows seeded 5 mm deep.

With the soft finish to the season and ample late rains, lucerne growth was prolific and by late October it was over 400 mm high. On 25 October Tim, put 530 weaner lambs into the 20 ha paddock for two weeks taking them out just as new buds were shooting from the crowns of the lucerne. The weaner lambs put on an average of 4 kg/ head and Tim said that at today's prices that grazing event was worth about \$200/ ha.

This site continue to be monitored over the next couple of years to look at the persistence and productivity of the lucerne varieties and possible erosion issues on this soil type.

## Comments

- Tim sowed the lucerne 1 cm deep on 300 mm row spacings in 100 mm furrows. Sowing lucerne in a furrow this deep on sands may have an advantage. During the first grazing the movement of the stock filled in the furrows burying the crown of the lucerne plants 25 to 50 mm deep. This will hopefully inhibit the ability of the stock to graze the crowns increasing the chances of persistence of the stand. The risk will be that a large rainfall or wind event after sowing may fill in the furrows burying the seed too deep leading to poor establishment.
- The later sowing of the stand allowed excellent weed control and the paddock could be grazed for longer prior to seeding which was quite valuable this year.
- The germination in warmer temperatures in August stimulated faster growth in the lucerne allowing the first grazing only 11 weeks after sowing. However the good late rainfall in August and early October was clearly very beneficial and this may not always occur. Tim felt that the lucerne would still have established well without the late rains but they allowed the early grazing which was a great bonus.
- Sub-tropical perennials need to be sown very shallow and in some cases it may be best to simply drop the seed on the surface and then press it in.
- Ideally the sub-tropical species should be sown at the end of August when soil temperatures are higher.

## Economics of perennials

*Caroline Peek and David Rogers*

To introduce a perennial into a broadacre crop system, the economic returns compared with cropping or annual pasture would need to be increased or maintained. The group went through several exercises to evaluate the profitability of introducing a perennial into their system. Table 2 shows the results of the analysis by Caroline Peek.

**Table 2. Minimum pasture establishment costs**

	Establishment costs \$/ha	Longevity
Subterranean clover	67	Lifetime
Cadiz for seed production	150	1 year
Cadiz from own seed	54	1 year
Lucerne/perennial	113	3-5 years

The costs include basic herbicides, insecticides, fertiliser (no potash) and seed, plus machinery costs and interest on plant capital.

For lucerne established in a phase cropping rotation of three years, initial establishment costs at least \$40/ha/year. This needs to come out of the gross margins. So getting the optimum production out of these phase perennials is going to be critical. Table 3 is an analysis of gross margins for current practice.

**Table 3. Cropping gross margins**

Crop	Yield (t/ha)	Price (\$/t)	Total variable costs (\$/ha)	Gross margin (\$/ha)
Wheat on lupins	2.1	160	217	132
Wheat on pasture	2.1	160	201	148
Wheat on green manure	2.1	160	191	148
Wheat on lupins-resistance	2.0	160	232	100
Lupins	1.6	150	215	39
Lupins-resistance	1.5	150	230	9
Green manure lupins	0	0	80	-81
Canola	1	320	258	59

**Table 4. Livestock gross margins**

Flock	Wool kg/ha	Wool \$/kg	Stocking rate DSE/ha	Av sheep sales \$/hd	Total variable costs \$/ha	Gross margin \$/ha
Ave Merino flock	21.9	2.8	4.9	16.98	70	22.45
Low input Merino	15.6	2.8	3.5	17.04	46	20.82
High input Merino	35.1	2.8	8	16.92	121	27.90
Merino sub. clover	26.6	2.8	6	17.16	87	23.26
Dorper sheep	0	0	6	27.08	54	52.66

Based on a total pasture of 900 ha this does not include pasture establishment costs.

- The Dorper flock is based on mating 2,400 ewes and 50% marking. Lambs are sold for \$30/hd in spring. The pasture is subterranean clover.
- The high input Merino flock is based on 3,250 mated ewes with an 85% marking and includes establishment of 350 ha of Cadiz each year.
- The average Merino flock is based on 2,000 mated ewes, 85% marking, low legume sandplain pasture.

Associated costs with improved pasture management and production can eat away at increased returns from higher stocking rates.

**Adding a perennial into the system**

Perennials have potential to increase stocking rate and marking percentage of a prime lamb producing flock. Perennials can also increase the stocking rate of the Merino enterprise. Tables 5 & 6 show a sensitivity analysis of stocking rate on gross margin.

**Table 5. Dorper/prime lamb enterprise at fixed variable cost of \$60/ha**

Dorper Stocking Rate (DSE/ha)	150% marking (\$/ha)	200% marking (\$/ha)
5	43	58
6	53	72
7	63	86
8	74	100

**Table 6. Merino enterprise at fixed variable cost of \$109/ha**

Merino Stocking Rate (DSE/ha)	Wool price \$3.36 kg/greasy (\$/ha)	Wool price \$2.80 kg/greasy (\$/ha)
5	43	58
6	53	72
7	63	86
8	74	100

## 2.4 Summer cropping

*David Rogers*

Summer crops are being tried by growers in the catchment on waterlogged sites to use available soil moisture and reduce groundwater recharge. The group looked at several species including forage sorghum, which was performing very well on the Mincherton property. Results from summer 1999/2000 show unprofitable grain yields at Mullewa Research Station (Table 7).

**Table 7. Summer cropping treatment characteristics and results**

	Spacing	54 cm		108 cm	
	Agras rate	60 kg/ha	120 kg/ha	60 kg/ha	120 kg/ha
Sunflower	Yield t/ha	0.107	0.144	0.122	0.144
Grain sorghum	Yield t/ha	0.048	0.065	0.047	0.073

The plants ran out of moisture just at flowering and seed set and yields were poor. Even the highest yielding treatment would have resulted in financial loss. While warm season grain crops do not appear to be viable, warm season fodder crops still show good possibilities as an option to use water out of season.

### Summer fodder crops

*Sorghums*

Sorghums are a summer growing grass that can be very productive where there is access to suitable subsoil moisture. The plant is classified as a semi-perennial as most stands only last two or three years. Where there is sufficient moisture and correct management, some stands may persist and be productive for many years. These plants may produce some toxins (prussic acid) when the plant is under water stress. Correct grazing management will reduce the risk of poisoning. Newer varieties have much lower levels of prussic acid than older varieties. Grain sorghum should not be used as forage as it has high levels of prussic acid.

*Millet*

Millet, like sorghum, is a summer active forage crop. Japanese millet is a semi-perennial but does not seem to persist as well as sorghum with very few stands persisting into and past the second year. The plant also does not recover as well or as quickly from grazing compared to sorghum. However it contains no toxins so poisoning is not an issue. Nutrafeed is another millet that unlike Japanese millet, has similar productiveness and persistence to forage sorghum.

These summer grasses are temperature sensitive and need to be planted in August/September. They will be productive through the summer as long as moisture is available. They will then become dormant through winter, resprouting in spring. Crops can be very productive on suitable sites and have potential for filling feed gaps in a pasture grazing system. They can also be harvested for fodder conservation, producing good quality silage or hay.

## **2.5 Profitable use of saline land - raised bed farming**

*Derk Bakker*

Raised beds are working successfully on soils prone to waterlogging in southern areas of the State and yield increases over the control have been substantial.

The beds are required to be loose and porous to ensure drainage of excess water and the clay subsoil should be incorporated into the raised beds. The main goal is to optimise porosity and also to minimise wind erosion during construction.

If raised beds are properly constructed and farmed they are permanent in the landscape. The site needs to be carefully selected and a site at the Mincherton's farm was looked at as part of the workshop. The safe control and disposal of excess water entering the beds is essential therefore catch drains are recommended every 600 m along the length of the beds depending on the site.

The area examined at the Mincherton's was a mildly saline discharge area which was considered suitable for the beds, however cost of construction is a limiting factor when only small areas are being considered. In the meantime Minnie has the site sown to forage sorghum which is surviving well.

### 3. IMPACT OF INTEGRATED WEED MANAGEMENT

*Vanessa Stewart, Merredin and Richard Quinlan, Elders, Geraldton*

Herbicide resistance was seen as the biggest threat to production and hence profitability. Management of weeds in a cropping system within the catchment has several management implications e.g. green manuring may increase recharge, burning and cultivation exacerbate wind erosion exposure and organic matter decline. The group participated in a workshop run by Vanessa Stewart, David Bowran (Department of Agriculture), Rick Llewellyn and Anne Bennett (West Australian Herbicide Resistance Initiative) looking at different ways of managing herbicide resistance and the implications on profitability and the weed seed bank (using RIM).

Integrated weed management (IWM) is a flexible system implemented by farmers to manage weeds in an economic and sustainable manner. A good IWM system has the following characteristics:

- Targets a broad spectrum of weed species
- Targets weeds at various stages of their life cycles
- Uses chemical, mechanical, cultural/agronomic and biological control approaches
- Never relies solely on one control approach and therefore exerts minimal selection pressure for resistance
- Reduces overall herbicide reliance
- Provides management options for herbicide resistant weeds
- Complements other farm management practices
- Requires active planning to ensure timely application of control options
- Is a long-term planning activity with built in flexibility to allow tactical response to seasonal conditions.

The workshop covered types of resistance such as metabolic and target site resistance. Several weed control strategies that have environmental impacts were discussed.

#### **Burning**

The concerns raised focused on wind erosion as a consequence of burning, and there was a lot of discussion regarding destroying organic carbon by burning.

#### **Cultivation**

The issues were wind erosion, mineralisation of nitrogen and soil structure decline on the red loams.

**Pastures**

Profitability of pastures was questionable at the time of the workshop although meat and wool prices have improved considerably since then. From an environmental perspective, pastures were perceived to be invaluable in building organic matter which leads to improved water holding, soil structure and nutrient availability.

**Green manuring**

Concerns raised with green manuring were increasing the non-wetting properties of the sandplain. The opportunity cost of not having a paddock in crop was also discussed as was the possibility of adding to recharge as a result of not being able to utilise rainfall from early September.

### Example of case study in RIM in crop rotation with or without a green manure in year 1

Strategy	10 year ave gross margin \$/ha	Ryegrass seed bank in year 2 no/m <sup>2</sup>
Green manure in Year 1	65	155
No green manure in Year 1	42	5,000

The study was based on ryegrass. The following strategies were available for use by workshop participants and the percentage of grass control expected is from years of trial data. Environmental concerns were not factored into the profitability of each rotation when RIM was used, however the concerns were raised by the group as they worked through the strategies.

Season	Management tool or farming	% ryegrass control expected
Autumn	Stubble grazing	Low, less than 20%
	Pasture grazing, pasture phase	To 30%
	Autumn burn low fuel, heavy grazing, not as effective as ungrazed. Stubble: >2 tonnes best. In pasture, result depends on amount of fuel present.	70% (20-95%)
	Autumn tickle	25% (10-40%)
	Delayed sowing of weedy paddocks, cultivate to kill weeds	60% (40-90%)
	Pre-sowing knockdown - allowing time for germination before planting	As for cultivation
	Trifluralin	70% (50-90%)
	Simazine in lupins	70% (40-90%)
	Post-seeding sprays, non-selective pre-emergence application of non selective herbicides as a burn-off	80% (30-90%)
	Post-seeding sprays - selective herbicides	90% (50-98%)
Winter	Good agronomy, suppress weeds with healthy crops	15-30%
	Sheep grazing in winter is effective only if the ryegrass density is very low	Low
	Pasture manipulation and sheep grazing	90% (80-90%)
	Selective herbicides - rotate herbicide groups. Only if resistance to new group has not yet developed. Depends on product.	90% (70-90%)



Spring	Spray topping	85% (50-95%)
	Green manure crops	90% (70-90%)
	Spring grazing - for good results needs to be sufficiently intense so as to prevent seed set	70% (20-95%)
	Hay cutting	80% (65-90%)
	Hay freezing - early, before viable seed set	90% (70-90%)
	Crop topping - lupins, peas, chickpeas, faba Paraquat only	80% (50-90%)
Summer	Trailing bins	60% (40-80%)
	Summer grazing	low

### 3. MANAGEMENT OF SOIL ORGANIC MATTER

*Dr Margaret Roper, CSIRO, Wembley*

The group invited Margaret Roper to run a workshop as she is working on the impact of no-till farming systems on associated soil micro-organisms. Soil micro-organisms can be classified as protozoans, amoeba, fungi, bacteria and viruses which are supported by the organic matter fraction. The areas covered are outlined below.

#### **Stubble breakdown**

The activities of micro-organisms in the soil can be limited by the availability of a food source such as carbohydrates or sugars, however stubble retention alleviates this problem. Stubbles remaining after harvest are high in carbon (40%) and contain large amounts of carbohydrates in the form of celluloses, sugars and simpler compounds. The soil micro-organisms are responsible for decomposing organic matter and cycling nutrients from stubble.

Many minerals are transformed by micro-organisms to forms plants can use, e.g. phosphorus, sulphur and potassium. Micro-organisms also play a key role in nitrogen cycling as trials have shown that nitrogen fixation by free-living bacteria and micro-organisms which convert organic nitrogen into plant available forms (nitrate and nitrite) are increased by stubble retention.

As a limitation, stubble retention can cause nitrogen immobilisation making it temporarily unavailable to plants. Immobilisation is a result of uptake of N by micro-organisms responsible for breaking down the stubble, and holds nitrogen in the upper soil layers.

Once the stubble is broken down, the micro-organisms die and release N back into the soil for use by plants. Predation of bacteria and fungi by protozoa and larger organisms also releases immobilised nutrients (N, P, S) for plant use.

#### **Managing microbial populations, the herbicide and fertiliser impacts**

In a natural ecosystem microbial populations are in balance, however farming changes that balance. Cultivation, export of nutrients, applications of fertilisers, herbicides and insecticides alter the activities and in some cases the survival of particular groups of nutrients.

Some herbicides are readily decomposed by micro-organisms and others can have a direct toxic effect or diminish microbial activity such as decomposition of crop residues. Nitrifying bacteria seem to be the most sensitive to herbicide application.

**Table 8. Impact on cellulolytic micro-organisms of applying herbicides (from CSIRO Adelaide)**

Herbicide	Bacteria mpn/g stubble	Fungi mpn/g stubble
Control	389,000	335,000
Ally®	3,640	6,510
Hoegrass®	38,900	313

Negative impacts on fungal and algal populations have been observed in a range of herbicides such as paraquat, simazine and atrazine (see Table 8). Paraquat and glyphosate can reduce the decomposition of crop residues but increase the rate of nutrient loss from litter by altering microbial activity. Herbicides can also impact on the severity of root diseases e.g. chlorsulfuron increased *Rhizoctonia solani* impact and glyphosate increased the incidence of take all and seedling root rot disease. However the impact of reducing micro-organisms and management options to deal with possible adverse effects is yet to be evaluated.

Fertilisers affect soil micro-organisms in various ways. Nitrogen increases stubble breakdown but decreases nitrogen fixation. Nitrogen can increase the numbers of nitrifying and denitrifying bacteria. Nitrogen and sulphur applications alter the protozoan populations. The application of phosphorus may reduce infection of roots with mycorrhizae, which normally facilitate the supply to plants.

### Soil fertility and soil structure

The interactions between micro-organisms and organic matter largely determine the fertility of the soil. Soils with a high clay content may support a greater range and number of micro-organisms because clays concentrate nutrients and provide protection against predators, parasites and desiccation. As sands are less reactive than clays the organic matter content is lower but just as important.

### Reduced tillage

Under no tillage systems with stubble retention there is an increase in the microbial biomass with a concentration nearer the soil surface. This has two advantages: plentiful supply of oxygen to micro-organisms to support their activity; and rapid microbial response to stubble breakdown.

Cultivation also will break up the existing microbial structure in the soil and alter microbial activity e.g. mineralisation of nitrogen after cultivation.

### Rotations

Disease cycles caused by micro-organisms can be broken if the next crop is not a host to the pathogen. Brassica species (canola, mustard etc.) actively suppress disease by producing volatile isothiocyanates as a breakdown product of the plant tissue. Isothiocyanates act as 'biofumigants' which suppress pests and pathogens (Kirkegaard *et al.* 1995) but probably suppress other soil micro-organisms as well.

## 5. DUNE STABILISATION

Mike Clarke, Department of Agriculture, Geraldton

Dune stabilisation was to be addressed as there is a large area of yellow sand in the catchment, prone to wind erosion if not managed carefully. Due to over-clearing and previous wind erosion events, several dunes have formed on members' properties and the group was interested in examining a cost-effective means of reclaiming those dunes. The following demonstration was monitored over two years.

### ***Dune stabilisation project***

#### **Aim**

To demonstrate a quick cost effective means of stabilising bare yellow sand dunes by direct seeding cereal rye and native plant seed in a one pass operation.

#### **Location**

A & B Eastough's property, Yuna

#### **Methods**

Site deep ripped on 4/4/2000

The site was sown with cereal rye @ 50 kg/ha on 8/07/2000 by hand broadcasting. Site was sown with the native seed on 11/07/2000 by mixing it with a fertiliser Agstar® (15.4% N, 13% P, 11% S and 00.4% Z) @ 30 kg/ha and sowing through a seed drill. The seed and fertiliser were dropped on the surface just behind the discs. The discs roughed up the sand surface to a depth of 12 cm. This occurred the morning after 13 mm of rain. The following amounts of seed were sown.

Species		Amount of seed (grams)
Actinostrobos arenarius*	Sandplain cypress	130
Gyrostemon ramulosa	Corky bark	250
Banksia sceptrum*	Sceptre banksia	27
Acacia saligna		1000
Acacia blakelyi*	Sandplain wattle	240
Acacia spathulata*	Spoon-leaved wattle	170
Acacia scirpifolia*		220
Calothamnus quadrifidus*	One-sided bottlebrush	25
Hakea coriacea*	Pink spike hakea	5
Grevillea eriostachya*	Flame grevillea	30
Allocasuarina heugeliana*	Rock oak	120
Calothamnus sanguineus*		24

\*indicates seed smoked

Total: 2,241 grams

## Results

The acacias were the most successful species to establish. The plant counts below indicate the numbers per square metre.

Weeks after sowing	Acacias per square metre
6	1.83
8	1.73
11	1.66
14	1.20
17	0.73

Cereal rye began to emerge a week after sowing. *Allocasuarinas* (rock oak) and *Actinostrobus* (sandplain cypress) began to emerge at week six and banksias were noted after eight weeks, but numbers of all these species are very low i.e. 0.06/m<sup>2</sup> or lower.

The exciting result of this demonstration was that the native plants were able to establish under the protection of the cereal rye cover crop during a dry year, despite initial concerns over competition for moisture. The general recommendation for wind eroded sites such as this, is to establish the cereal rye in the first year to provide stubble cover for the native plants sown the following year. The seedlings were still growing well into summer, long after the rye had died, however rabbits grazed most of the remaining plants during late December and January.

I am confident that with suitable rabbit control, this technique would provide farmers with a one-pass operation to stabilise similar landscapes with local native plants. Also by opportunistically sowing the seed earlier, in years when opening rains are received in April for example, this would increase the likelihood of successful native plant establishment.

## 6. GROUNDWATER HYDROLOGY

*Russell Speed, Hydrologist, Department of Agriculture, Geraldton*

The Nolba catchment straddles the granitic basement of the Northampton Block to the west and sediments of the Perth Basin to the east.

On the Northampton Block soil types tend to range from gravelly sands to gritty clay loams lower in the landscape. Drainage lines are typically salt-affected.

The Perth Basin corresponds generally to the undulating sandplain. Surface drainage is poorly defined and the undulating sandplain is typically internally draining. As yet, salinity is not widespread in this area but threatens to become a significant issue over the next couple of decades.

### **Northampton Block**

A typical Northampton Block profile in the Nolba catchment is a loamy soil overlying ~10 m of gritty clay derived from chemical decomposition of the granitic basement. Toward the base of this profile there is a transition from deeply weathered saprolite clays to partially weathered granitic rock and eventually competent (solid) crystalline granitic basement.

The granitic basement of the Northampton Block exhibits a degree of deep fracturing from which groundwater can be drawn. However, prospecting for fractured rock aquifers can be a very hit and miss process. For the purposes of describing and managing salinity, the top of the granitic basement is considered to be an impermeable base to the catchment profile.

The relatively thin profile does not take long to fill with water from increased recharge. Drainage lines are likely to have become saline within a few years after clearing.

There is a reasonable amount of salt stored in the profile and groundwater quality typically ranges from brackish to saline. The highest groundwater salinities tend to occur where there has been evaporative concentration of salt in discharge areas, for example, as measured in the observation bore (shallowest bore) at site CV11 (Figure 6), and down gradient, for example, as measured at site CV12 (Figure 6).

Figure 6 shows a cross-section along a short eastward flowing drainage line beginning in Chardie Smith's property. The cross-section helps to explain why many of these drainage lines are saline in their upper parts where they overlie granitic basement and why they are currently not saline downstream in the sandplain overlying the Perth Basin. As the drainage lines cross the edge of the Northampton Block the depth of profile increases dramatically. Increased recharge following clearing is yet to fill the deeper sedimentary profile in the Perth Basin and the watertable in this example is still some 17 m below the surface at site CV13.

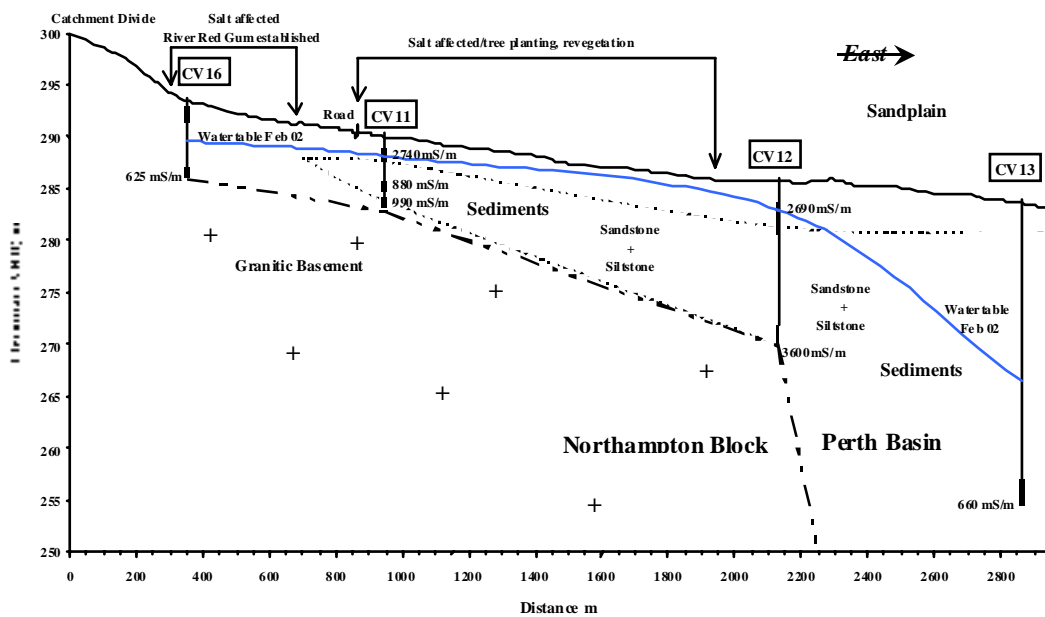


Figure 6. Cross-section along a drainage line beginning in Chardie Smith’s property and terminating in a sandplain hollow.

The area of salinity in the parts of the catchment that overlie granitic basement is not expected to increase unless there is further clearing. The relatively thin profile filled quickly after clearing resulting in salinity in low lying areas (groundwater discharge by evaporation) and a new hydrological equilibrium appears to have been established.

Watertables fluctuate in response to seasonal rainfall but no longer term trends are apparent. Figure 7 shows a hydrograph for a piezometer at site CV14 located on a low ridge between two drainage lines on what used to be Mike Flannigan’s property.

Figure 8 shows a hydrograph for the piezometer at site CV16 located at the head of a drainage line (see Figure 6 for its position in the cross section). From Jan 94 to Jun 00 the groundwater level fluctuated between the surface and about a metre below ground in response to seasonal rainfall. Groundwater salinity is not excessive but the evaporative concentration of salt was further degrading this area over time.

Chardie began establishing river red gum (*Eucalyptus camaldulensis*) in the salt-affected area in July 1997. The groundwater level has plummeted dramatically since about mid-2000. Comparison of the current groundwater levels in CV14D (Figure 7) with CV16D (Figure 8) indicates the trees have significantly lowered the watertable. While the groundwater level in CV14D is at an eight year low it is not significantly lower than the troughs observed in 1995 and 1996. However, the current groundwater level in CV16D is significantly lower than previously observed indicating the trees have dried the profile to a depth of nearly 4 metres, albeit assisted by consecutive dry seasons.

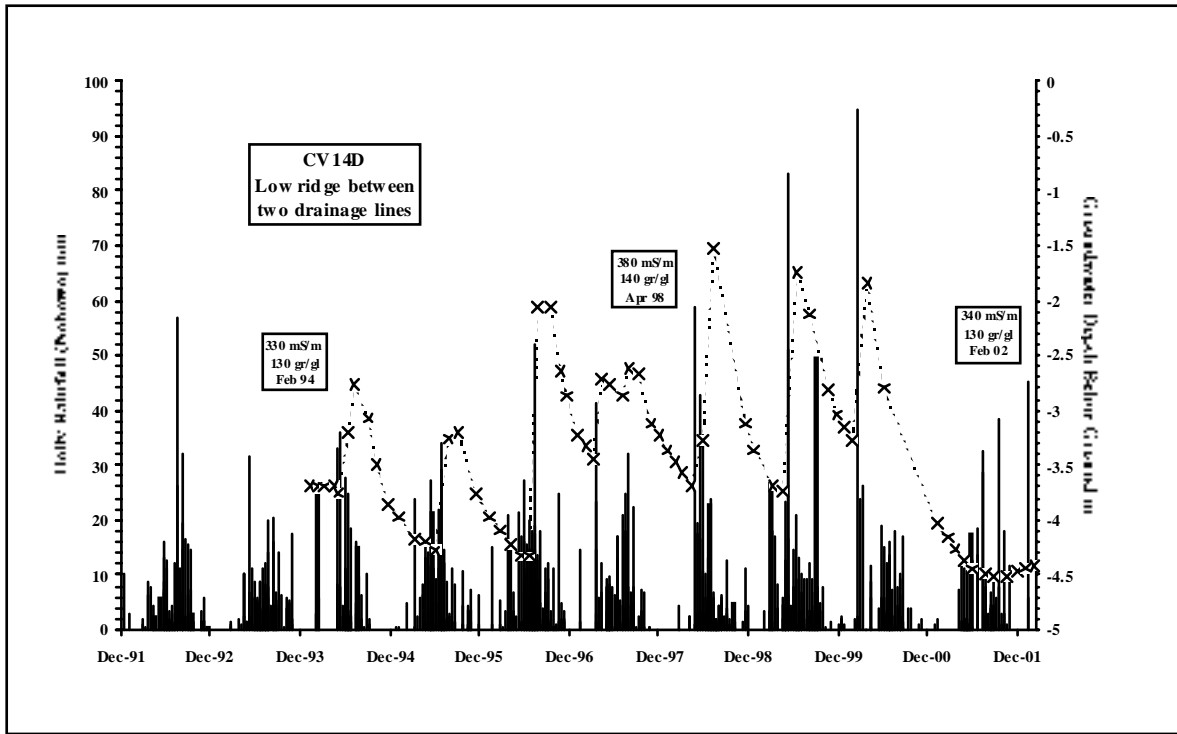


Figure 7. Hydrograph for piezometer CV14D. Groundwater level fluctuates in response to seasonal rainfall but no long-term trends are apparent.

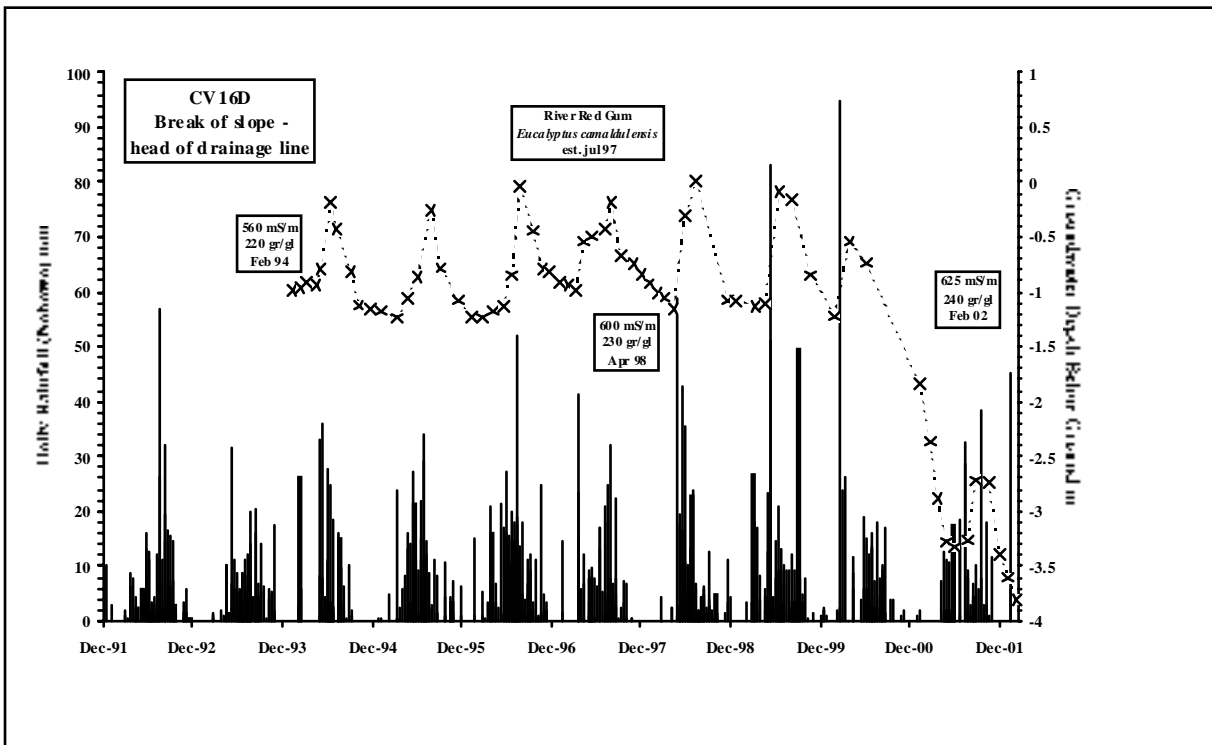


Figure 8. Hydrograph for piezometer CV16D. Groundwater level has declined significantly since mid-2000 in response to tree establishment from July 1997.



Figure 9 shows a cross-section down the length of a barley grass/salt-affected depression on Minnie Mincherton's property. Minnie has been experimenting with perennials, long season annuals and summer cropping on this site for some years (see report by David Rogers). Figures 10 and 11 show hydrographs for sites CVM2 and CVM6 at each end of the cross-section. Current groundwater levels are at historic lows for the period of monitoring probably due more to seasonal conditions over the last two years than the effects of management.

Current groundwater levels do provide some opportunities. The site could probably be safely cropped with barley in the forthcoming season as it is reasonable to expect that it would take two years for groundwater to rise to the surface again.

Alternatively, as there is at least 1.7 m of unsaturated profile throughout the whole site, it might be an opportune time to establish perennials with the aim of completely invading the profile with plant roots to a depth of ~2 m giving the perennials a good chance to take hold. It is reasonable to expect that the deeper the rooting, the more opportunity a plant has to use soil moisture as it moves down the profile thus reducing the amount of recharge.

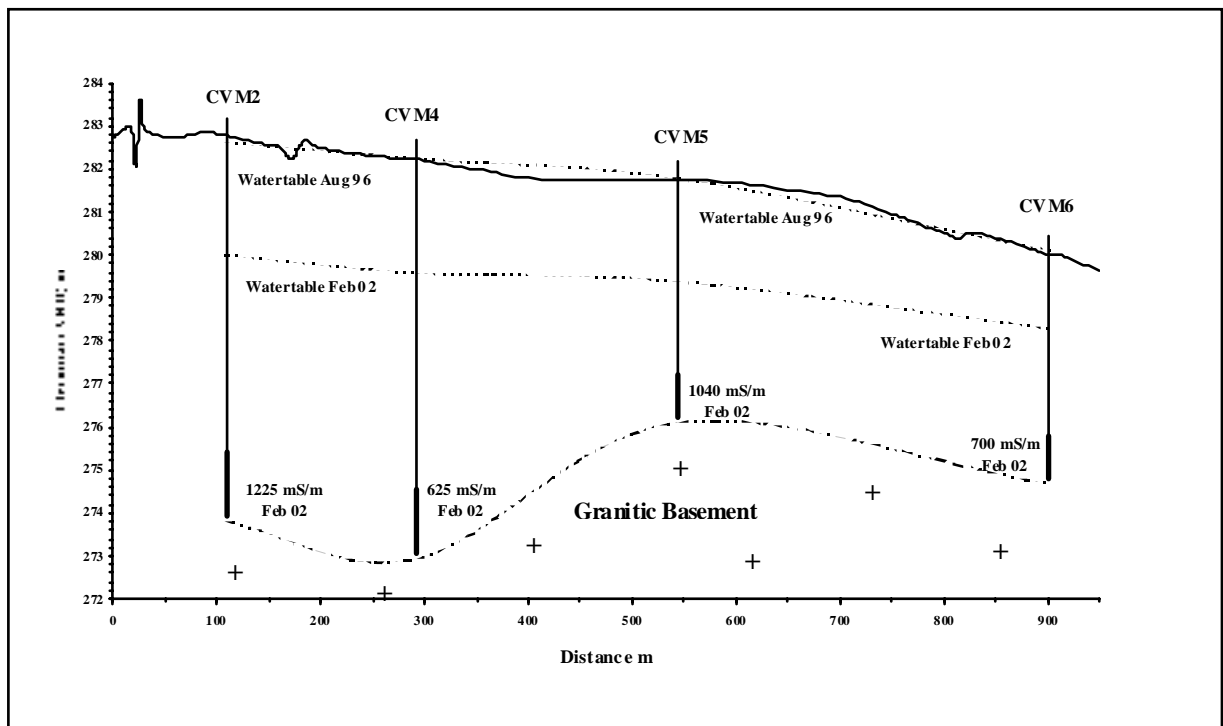


Figure 9. Cross-section down the length of a barley grass/salt-affected depression on Minnie Mincherton's property.

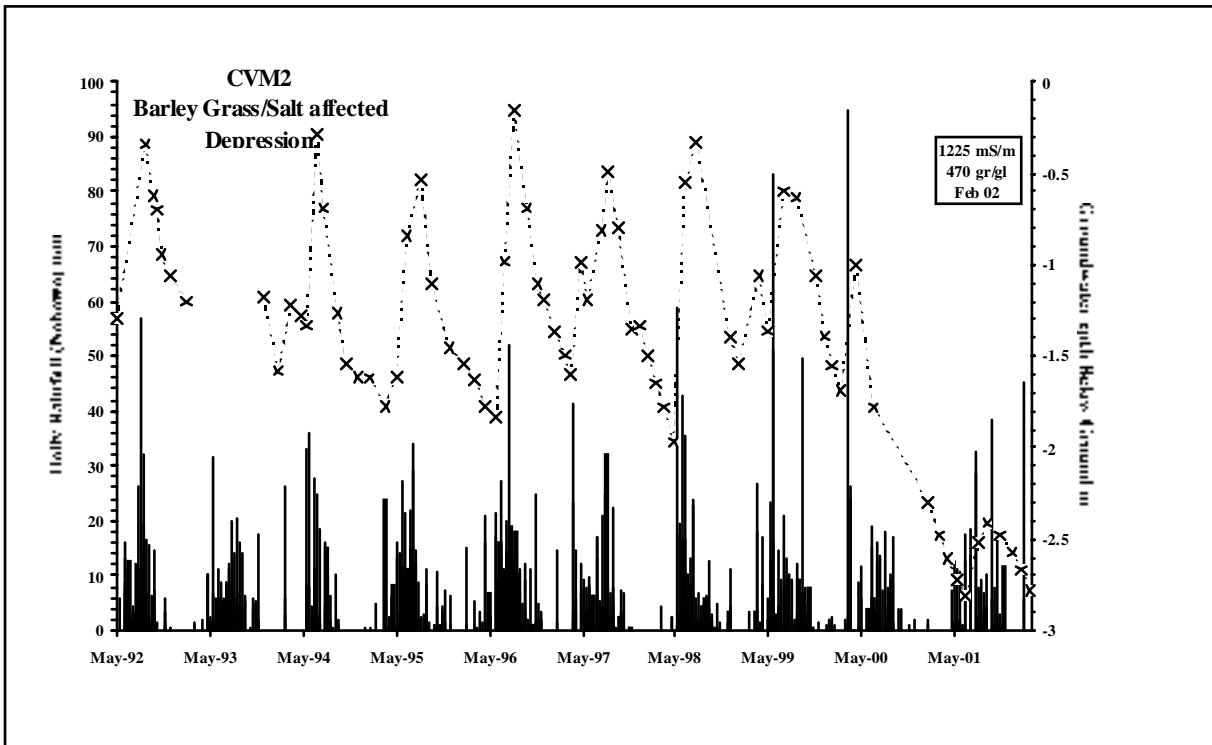


Figure 10. Hydrograph for site CVM2

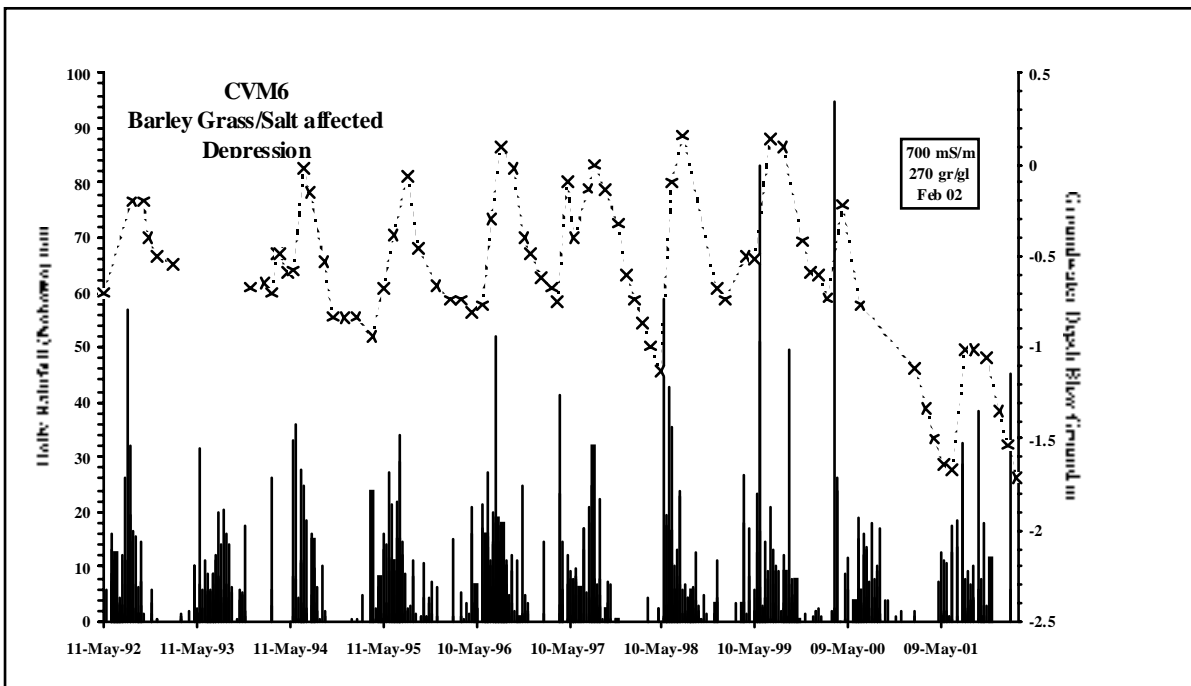


Figure 11. Hydrograph for site CVM6

## Perth Basin

The undulating sandplain overlies a deep sequence of sediments (hundreds of metres) in the north of the Perth Basin. Groundwater is typically brackish, and while generally useable for stock it is typically too salty for domestic or garden use.

The deep sedimentary profile is taking longer to fill from increased recharge after clearing, hence salinity is not yet widespread in this area. However groundwater is rising at an alarming rate posing an extensive threat over the next couple of decades. Figure 7 shows the hydrograph for the observation bore at site CV13 (see Figure 6 for its position in the cross-section).

In contrast to hydrographs of groundwater levels on the Northampton Block (Figures 7, 8, 10 and 11) where there is seasonal watertable rise and fall, groundwater in the Perth Basin (undulating sandplain) appear to be continuously rising. The only seasonal variation appears to be in the rate of groundwater rise.

The rate of rise was accelerating resulting from wetter than average conditions throughout 1999. Likewise there was a decrease in the rate resulting from a drier period throughout 2000 and 2001. But the most concerning aspect during this latter period is that groundwater continues to rise.

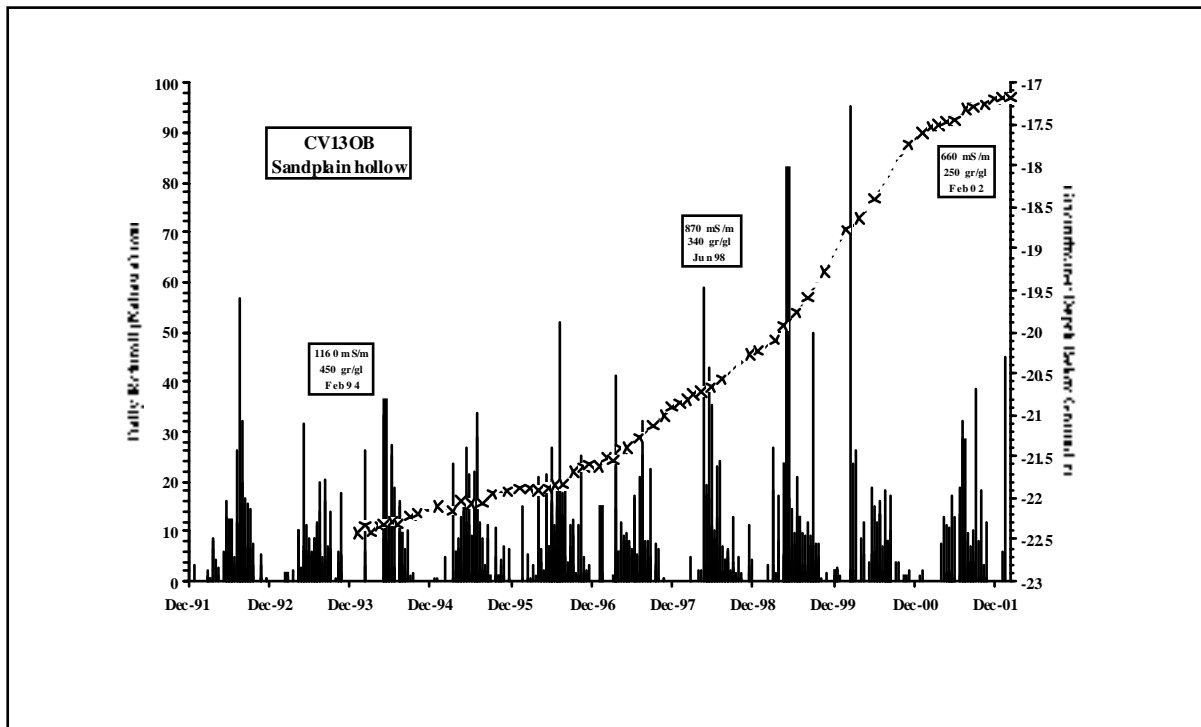


Figure 12. Hydrograph for observation bore CV13. Groundwater rise is virtually continuous with seasonal conditions affecting the rate.

Figure 13 shows a hydrograph for piezometer CV9D in the middle of Wathala Swamp. There are clear similarities in groundwater responses measured in CV9D (Figure 13) and CV13OB (Figure 12), the major difference is depth. The groundwater level in piezometer CV9D has risen above the ground surface (become artesian) and Wathala Swamp is expected to become a permanent lake in the near future.

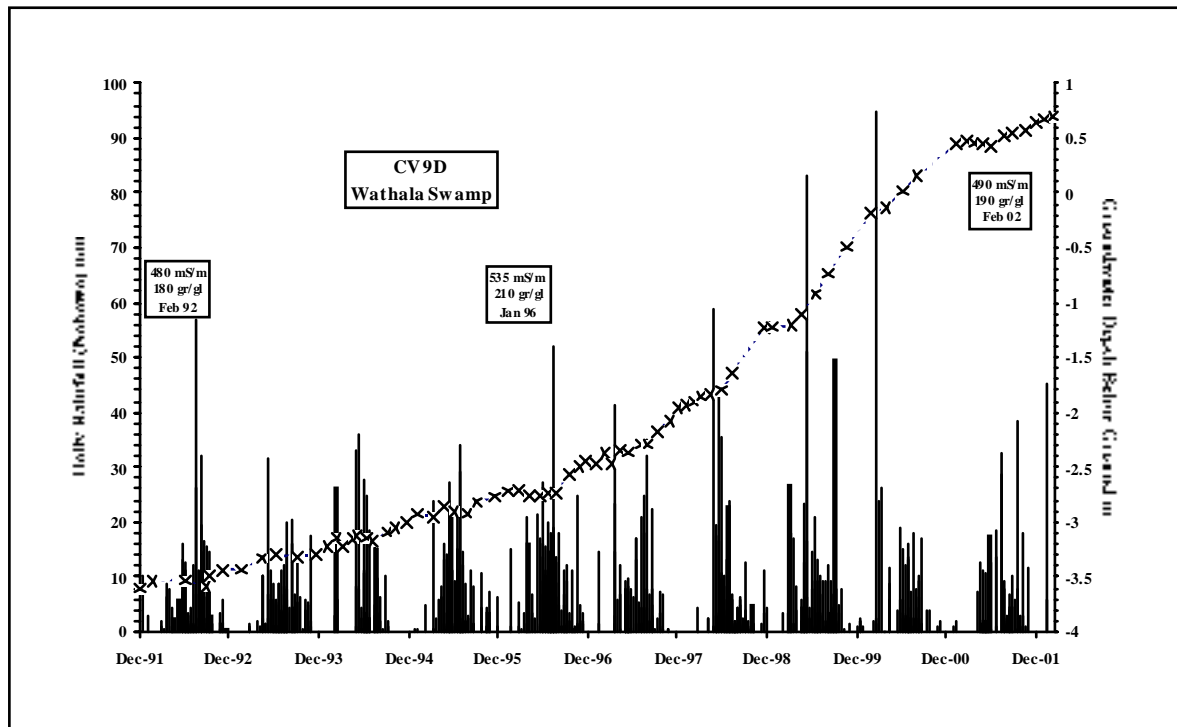


Figure 13. Hydrograph for piezometer CV9D in the middle of Wathala Swamp

While it is clear that rising groundwater poses a serious salinity threat in the undulating sandplain overlying the Perth Basin it is not known how long before widespread salinity might occur and just how extensive it may become.

At site CV13 it will take more than a decade before the watertable reaches the ground surface. What is not known is whether the elevation of the watertable at CV13 is the same as at CV9. To put this another way, is the watertable relatively flat beneath the undulating sandplain and rising uniformly allowing predictions of when areas will become saline based on surface elevation? Alternatively, does the watertable undulate requiring widespread groundwater monitoring to make predictions of when salinity will occur?

At some point a new hydrological equilibrium will be reached where the amount of recharge will be balanced with discharge by evaporation through wet/saline areas where the watertable intersects the land surface. Obviously the discharge areas will develop in the topographic lows. What is not known is how much of the landscape will become discharge areas. Recent Land Monitor products indicate topographic lows prone to becoming discharge areas may occupy more than 30% of the landscape.

However, most of this landscape is either internally draining or better described as dunes and swales. The algorithm that generates the Digital Elevation Model used to predict the areas prone to becoming discharge/saline areas is known to become unstable in internally draining terrain. Further investigation is required in the sandplain region of the Nolba catchment to assess when salinity is going to become a significant issue and how widespread it may become.

## 7. CONCLUSION

The Nolba catchment straddles the granitic basement of the Northampton Block to the west and sediments of the Perth Basin to the east.

### Northampton Block

A typical Northampton Block profile is a loamy soil overlying ~10 m of gritty clay derived from chemical decomposition of the granitic basement.

The area of salinity in the parts of the catchment that overlie granitic basement is not expected to increase unless there is further clearing. The relatively thin profile filled quickly after clearing resulting in salinity in low lying areas (groundwater discharge by evaporation) and a new hydrological equilibrium appears to have been established.

### Perth Basin

The Perth Basin corresponds generally to the undulating sandplain. Surface drainage is poorly defined and the sandplain is typically internally draining. As yet, salinity is not widespread in this area but threatens to become a significant issue over the next couple of decades.

The deep sedimentary profile is taking longer to fill from increased recharge after clearing, hence salinity is not yet widespread. However **groundwater is rising at an alarming rate** posing an extensive salinity threat over the next couple of decades. While it is clear that rising groundwater poses a serious salinity threat in the undulating sandplain overlying the Perth Basin it is not known how long before widespread salinity might occur and just how widespread it may become.

At some point a new hydrological equilibrium will be reached where the amount of recharge will be balanced with discharge by evaporation through wet/saline areas where the watertable intersects the land surface. Obviously the discharge areas will develop in the topographic lows. What is not known is how much of the landscape will become discharge areas.

### Future work

Further investigation is required in the sandplain region of the catchment to assess when salinity is going to become a significant issue and how widespread it may become.

In the interim, landholders are encouraged to adopt profitable farming systems that maximise water use in order to slow the rate of groundwater rise. It is hoped that the trials and workshops provided to the farmers in the catchment will assist them in making informed decisions on what options are currently available.

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