ECONOMIC EVALUATION OF OPTIONS

in the

JEMALONG LAND AND WATER MANAGEMENT PLAN

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1. EXECUTIVE SUMMARY

The Jemalong Land and Water Management Plan area covers approximately 90,000 hectares in central west New South Wales near the town of Forbes. This consists of the Jemalong Irrigation District (JID) with water supplied from the Lachlan River. Issues of salinity and waterlogging were perceived as the major factors affecting the environment over the thirty-year period of the plan, and the plan incorporates measures to minimise damage. While the area is predominantly agricultural land, the plan area is near Lake Cowal, an ephemeral lake and wetland of international significance.

The economic evaluation of the 'No Plan' scenario consisted of quantifying the costs incurred if no further action were undertaken to minimise salinity and waterlogging. The economic evaluation of the 'No Plan' Scenario, which represents the increase in salinity and waterlogging over a thirty year period if the Plan were not implemented, indicated that the present value of agricultural yield losses in the area could be at least $54 million to $57 million. Estimates indicated that by the year 2025, 34,000 hectares in the Jemalong Irrigation District would be affected by salinity greater than 2dS/m. By that time, estimates were that 4.1 percent of the irrigation area would have salinity greater than 4dS/m, while 31.9 percent of the JID dryland area would be in a similar position. Additional costs from road damage extended the no plan losses to $59 million.

The 'With Plan' evaluation consisted of quantifying and qualifying the benefits and costs of implementing the plan. The purpose of the economic evaluation was to establish the economic viability of the proposed plan. The stream of benefits and costs were discounted over thirty years to determine their values in today's dollars, called the present value.

Economic viability is indicated with an overall benefit cost ratio of greater than one, meaning that the net benefits of the plan were positive. All options in the Plan were evaluated for benefits and costs, but not all options were themselves viable. However, their implementation was considered important either to the community, the environment or to the economic viability of other options.

The economic evaluation of the Jemalong Land and Water Management Plan considered the following options;

- on-farm,
- channel seepage,
- floodway management,
- surface drainage and
- vegetation strategies.

The on-farm options included landforming, development plans, whole farm irrigation design, bay sensors, soil tests and planting improved pastures and lucerne. The net present value of this option was $12.8 million.

The channel seepage option consisted of minimising accessions to the watertable by planting lucerne along the channel in parts. It had a net present value of $548,000.

Floodway management consisted of reducing accessions by building a series of levees to isolate floodwater from highly permeable soils. This option had a negative net present value of minus $135,000. However this option was seen to underpin the benefits of other activities to reduce accessions and lower the watertable.

Surface drainage consisted of storages for rain rejection and survey costs for drains to direct surface runoff into storages. This was to reduce the incidence of waterlogging. The net present value was minus $526,000.

Vegetation strategies consisted of protecting remnant vegetation and new plantings. Quantified benefits resulted in a negative net present value of minus $1 million.

Table A summarises the total benefits and costs of the Jemalong Land and Water Management Plan. Benefits were measured in several ways. Generally, a value was given to avoided accessions, removal of water from the soil profile and increases in water available for reuse. Reductions in salinity and waterlogging were valued by the ensuing marginal impact on gross margins. Environmental benefits were identified but not quantified. They included improvements in flora and fauna habitats as well as in aquatic habitats. Environmental benefits from the vegetation option were improvements in biodiversity and aesthetic benefits.

TABLE A TOTAL BENEFITS AND COSTS JLWMP
$ '000

Option	Water Benefits	Other Benefits	Total Benefits	Total Costs
On-farm Options	632	76,866	77,498	22,198
Channel Seepage	-	1,787	1,787	-
Floodway	173	0	173	349
Surface Drainage	246	-	246	1,389
Vegetation	3,073	832	3,905	5,631
Implementation	0	0	-	4,885
Total	4,124	79,486	83,610	34,451

errors due to rounding

Table B indicates the benefit cost ratios (BCR) of each option, as well as present values of benefits and costs. The economic results indicated that the plan was economically viable, with a benefit cost ratio of 1.6 and a net present value of $9.6 million.

TABLE B PRESENT VALUE OF TOTAL BENEFITS AND COSTS JLWMP
$ '000

Option	Water Benefits	Other Benefits	PV Benefits	PV Costs	Net Present Value	BCR
On-farm Options	197	24,213	24,410	11,603	12,807	2.1
Channel Seepage	0	548	548	0	548	-
Floodway	51	0	51	186	(135)	0.3
Surface Drainage	66	0	66	592	(526)	0.1
Vegetation	772	209	982	2,029	(1,047)	0.5
Implementation	0	0	0	2,022	(2,022)	-
Total	**1,087**	**24,971**	**26,057**	**16,432**	**9,625**	**1.6**

errors due to rounding

From Table B, the overall plan appears economically viable. However some options do not appear viable. There is the assumption that the floodway management option maximises the success of other options in achieving impacts on salinity and waterlogging. Again the unquantified benefits need to be recognised. The unquantified environmental benefits were perceived as minimising the threat of salinity to Lake Cowal, improving habitats and biodiversity through improved and expanded native vegetation areas, and more productive riverine habitats. Aesthetic values from increased vegetation were not quantified.

Based on the options proposed and targets being reached, the Jemalong Land and Water Management Plan appeared to be an economically sound investment.

2. INTRODUCTION

The Jemalong Land and Water Management Plan is designed to reduce the impact of salinity and waterlogging over thirty years. The area affected is 90,000 hectares situated near Forbes in central west New South Wales. There is an extensive irrigation area supplied with water from the Lachlan River as well as some dryland agricultural land. The main environmental issue was the protection of Lake Cowal.

This report outlines the methodology applied in the economic evaluation of the differences between the 'No Plan' Scenario and the 'With Plan' Scenario. The 'With Plan' scenario evaluated the benefits and costs of implementing the proposed Jemalong Land and Water Management Plan. This study outlines the options within the plan, describes the method of evaluation and presents the final results. A sensitivity analysis was also undertaken to assess the importance of some variables on the outcomes of the evaluation.

This report incorporates adjustments following the LWMPAT review, particularly in relation to the starting date of the plan, which was determined in that review to be 1995. Therefore, a number of different option start dates were altered from year 1 to year 6. Further details of the options evaluated can be found in the supporting documents referenced throughout this report.

3. ECONOMIC EVALUATION

An economic evaluation is used to estimate benefits and costs over a predetermined period of time. These benefits and costs, which are incurred at different stages, are then discounted so that they can be compared in today's dollars and are called present value benefits and present value costs. To determine if a course of action is considered economically viable, the difference between present value benefits and costs, called the net present value, needs to be positive. A similar measure of economic viability is the benefit cost ratio of equal to or greater than one, which is the present value of benefits divided by the present value of costs.

The economic evaluation employed on the Jemalong Land and Water Management Plan (JLWMP) took into consideration the economic benefits and costs of implementing the Plan over a period of 30 years. The benefits of the Plan were valued in terms of increased agricultural production, reduced losses of production, reduced damages to roads, increased water available for irrigation and reduced accessions to the watertable. The costs were those costs incurred in implementing the options in the Plan.

Initially the costs of not undertaking a plan need to be identified and quantified. Called the 'No Plan' Scenario, it indicates what actions are being and will be undertaken by the community to combat rising watertables and salinity. The benefits and costs of the plan are the marginal benefits and costs compared to the No Plan Scenario.

One of the most difficult benefits to value is water. In this study, water that was saved and clearly available for reuse was given an economic value of $18 per megalitre (McClintock and Jones 1995). Accessions saved were treated conservatively and, like water that was

removed from the soil profile, were given a value of $2 per megalitre (Marsden and Jacobs, personal communication). In some cases these values may overstate and/or understate the value but are the best estimates available.

A sensitivity analysis was undertaken on key variables in the study such as discount rate, value of water and gross margins. If altering a key variable resulted in a significant change in results, this indicates that such movements in values of that input could significantly influence the outcome of the study.

3.1. 'NO PLAN' SCENARIO

Under the No Plan Scenario the costs incurred due to salinity and waterlogging in the JLWMP area were calculated and discounted. This action recognises that activity to combat salinity and waterlogging was being undertaken and will continue to be undertaken in the area. Under the No Plan Scenario activities such as landforming, development plans, whole farm irrigation designs, recycling systems, lucerne planting along channels, bay sensors and soil tests are being carried out to some extent. The benefits and costs of these are excluded from the With Plan Scenario, otherwise the economic evaluation would be double counting.

The No Plan Scenario looked at the costs incurred in lost agricultural production due to ongoing and increasing problems with rising watertables (Lyall and Macoun 1997) and salinity (NSW Agriculture 1995). Damage to roads over the next thirty years due to waterlogging and salinity was also costed. Evaluation of the No Plan Scenario considered the two areas of the irrigation district and the dryland area within the irrigation district, (referred to as JID).

3.1.1. Areas of Salinity

The JLWMP Steering Committee commissioned studies on the areas within the Plan that would be affected by salinity. This work was undertaken for the Jemalong Irrigation District (JID). The extent of areas expected to be affected by salinity in the irrigation area is shown in Tables 1 and 2.

TABLE 1 SOIL SALINITY PREDICTIONS 1995-2025
Jemalong Irrigation District-irrigation area (ha)

Soil salinity level dS/m	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**
2-3	1078	1038	1256	908	1258	1595	2208
3-4	4	140	139	600	772	968	961
4-6	4	344	346	335	62	101	312
6-8	242	5	143	139	456	475	455
>8	4	244	246	350	487	648	791
Total >2 dS/m	**1332**	**1771**	**2130**	**2332**	**3035**	**3787**	**4727**

Source; van der Lely (1997), DLWC (1997a) p. 5

TABLE 2 SOIL SALINITY PREDICTIONS 1995-2025
Jemalong Irrigation District-irrigation area
(percentage of total irrigation area)

Soil salinity level dS/m	1995	2000	2005	2010	2015	2020	2025
0-2	96.5	95.3	94.4	93.9	92.0	90.0	87.5
2-3	2.8	2.7	3.3	2.4	3.3	4.2	5.8
3-4	0.0	0.4	0.4	1.6	2.0	2.6	2.5
4-6	0.0	0.9	0.9	0.9	0.2	0.3	0.8
6-8	0.6	0.0	0.4	0.4	1.2	1.2	1.2
>8	0.0	0.6	0.7	0.9	1.3	1.7	2.1

Errors due to rounding
Source; van der Lely (1997)

Tables 3 and 4 indicate the dryland area within JID affected by increasing levels of soil salinity over the period of the study under the 'most likely' scenario. Van der Lely (1997) calculated soil salinity areas under two scenarios for the dryland area, called the 'most likely' scenario and the 'worst case' scenario. In year 30, only 42.6 percent of the dryland area was expected to have soil salinity under 2 dS/m in the most likely scenario.

TABLE 3 SOIL SALINITY PREDICTIONS 1995-2025
JID dryland area - most likely scenario
(ha)

Soil salinity level dS/m	1995	2000	2005	2010	2015	2020	2025
2-3	8038	7228	7333	7226	7170	7006	6813
3-4	6662	6460	6434	6529	6482	6277	6223
4-6	6976	7135	7232	7437	7718	7864	8156
6-8	2205	2359	2496	2683	2799	2859	3022
>8	709	1790	2236	2680	3155	4328	5101
Total >2 dS/m	**24590**	**24972**	**25731**	**26555**	**27324**	**28334**	**29315**

Source; van der Lely (1997)

TABLE 4 SOIL SALINITY PREDICTIONS 1995-2025
JID dryland area - most likely scenario
(percentage of total JID dryland area)

Soil salinity level dS/m	1995	2000	2005	2010	2015	2020	2025
0-2	51.9	51.1	49.7	48.0	46.5	44.6	42.6
2-3	15.7	14.1	14.3	14.1	14.0	13.7	13.3
3-4	13.0	12.6	12.6	12.8	12.7	12.3	12.2
4-6	13.7	14.0	14.2	14.6	15.1	15.4	16.0
6-8	4.3	4.6	4.9	5.3	5.5	5.6	5.9
>8	1.4	3.5	4.4	5.2	6.2	8.5	10.0

Errors due to rounding
Source; van der Lely (1997)

Tables 5 and 6 indicate the dryland area within JID expected to be affected by increasing levels of soil salinity over the period of the study under the 'worst case' scenario. In 30 years, only 36.3 percent of the dryland area was expected to have soil salinity under 2 dS/m.

TABLE 5 SOIL SALINITY PREDICTIONS 1995-2025
JID dryland area - worst case scenario
(ha)

Soil salinity level dS/m	1995	2000	2005	2010	2015	2020	2025
2-3	8245	7100	7227	7035	6915	6665	6388
3-4	6726	6352	6327	6458	6374	6129	6018
4-6	7273	7537	7659	7969	8419	8594	9032
6-8	2296	2518	2747	3060	3249	3304	3564
>8	868	2501	3182	3847	4573	6361	7555
Total>2 dS/m	**25408**	**26008**	**27142**	**28369**	**29530**	**31053**	**32557**

Source; van der Lely (1997)

TABLE 6 SOIL SALINITY PREDICTIONS 1995-2025
JID dryland area - worst case scenario
(percentage of total JID dryland area)

Soil salinity level dS/m	1995	2000	2005	2010	2015	2020	2025
0-2	50.3	49.1	46.9	44.5	42.2	39.2	36.3
2-3	16.1	13.9	14.1	13.8	13.5	13.0	12.5
3-4	13.2	12.4	12.4	12.6	12.5	12.0	11.8
4-6	14.2	14.8	15.0	15.6	16.5	16.8	17.7
6-8	4.5	4.9	5.4	6.0	6.4	6.5	7.0
>8	1.7	4.9	6.2	7.5	8.9	12.5	14.8

Errors due to rounding
Source; van der Lely (1997)

3.1.2. Impact of Salinity

In the NSW Agriculture model (McClintock and Jones 1995) the effects of soil salinity and waterlogging on agriculture within the irrigation area were calculated in terms of losses in regional gross margins (measured as total revenue less variable costs). Gross margins are a return on capital and labour. Table 7 indicates the impact of soil salinity on annual gross margins on both the most likely and worst case scenarios in the irrigation area. In year 30 the annual impacts of soil salinity on gross margins were estimated to be $268,000 and $354,000 respectively.

TABLE 7 IMPACT OF SOIL SALINITY ON GROSS MARGINS
Jemalong Irrigation District 1995-2025
$ '000

Year	Loss due to soil salinity *most likely scenario*	Loss due to soil salinity *worst case scenario*
1995	121	130
2000	163	190
2005	184	221
2010	170	214
2015	196	249
2020	238	308
2025	268	354

Source; McClintock and Jones (1995), van der Lely (1997)

Because of the long time frame between valuing the impacts of increased waterlogging and salinity and ultimately completing the plan, these costs in Table 7, which were calculated in 1995 dollars, were indexed to indicate their magnitude in 1998 dollars, as shown in Table 7A.

TABLE 7A IMPACT OF SOIL SALINITY ON GROSS MARGINS IN 1998 DOLLARS
Jemalong Irrigation District 1995-2025
$ '000

Year	**Loss due to soil salinity** *most likely scenario*	**Loss due to soil salinity** *worst case scenario*
1995	127	137
2000	171	200
2005	193	232
2010	179	225
2015	206	262
2020	250	324
2025	282	372

Source; McClintock and Jones (1995), van der Lely (1997) indexed to NSW All Groups CPI September 1998

This NSW Agriculture model allowed for on-farm responses to changes in soil salinisation such as adjusting crops grown in order to minimise losses in farm profitability as salinity increased. The model selected the most profitable enterprises to maximise profits and included the impacts of landforming which were incorporated into the No Plan Scenario.

The overall impact of soil salinity on gross margins in the JID is shown in Table 8 under different discount rates. At 7 percent discount rate the impacts over 30 years of soil salinity were present values of $2.1 million 'most likely' scenario and $2.6 million 'worst case scenario'. Thus, under the 'worst case' scenario there was a further 7.6 percent of area with soil salinity greater than 4 dS/m in year 30, resulting in a present value cost of $0.43 million. Note that these estimates of soil salinity were only calculated for JID, not for the whole plan area, and therefore underestimate the impact of soil salinity in the No Plan Scenario.

TABLE 8 PRESENT VALUE OF GROSS MARGIN LOSSES DUE TO SOIL SALINITY 1995-2025
Jemalong Irrigation District
$ '000

	Discount rate	Most likely scenario	Worst case scenario
Present value	4 percent	3,152	3,839
	7 percent	**2,150**	**2,582**
	10 percent	1,566	1,857

Source; DLWC (1997a)

Again these results were indexed to 1998 dollars from 1995 dollars when the study was originally undertaken, as shown in Table 8A. The present values of gross margin losses due to soil salinity were $2.3 million and $2.7 million in the 'most likely' and 'worst case' scenarios respectively at 7 percent discount rate.

TABLE 8A PRESENT VALUE OF GROSS MARGIN LOSSES 1998 DOLLARS DUE TO SOIL SALINITY 1995-2025
JID
$ '000

	Discount rate	Most likely scenario	Worst case scenario
Present value	4 percent	3,285	4,035
	7 percent	**2,260**	**2,714**
	10 percent	1,646	1,952

Source; DLWC (1997a) indexed to NSW All Groups CPI September 1998

3.1.3. Areas of Waterlogging

The economic evaluation considered the effects on yields in the JID that were estimated to occur if no further action was undertaken to reduce waterlogging. Note that ARI, the average recurrence interval, refers to the average interval of time between events.

TABLE 9 AREAS AFFECTED BY WATERLOGGING ON CURRENT AGRICULTURE
JID
'000 ha

Waterlogging effect	Cropping system	2 year ARI	5 year ARI	10 year ARI
Some loss	winter	23.4	28.8	28.8
	summer	6.5	8.0	8.0
	dryland	35.1	43.2	43.2
	Total	**65.0**	**80.0**	**80.0**
Severe loss	winter	21.8	28.8	28.8
	summer	4.0	8.0	8.0
	dryland	13.5	41.0	43.2
	Total	**39.3**	**77.8**	**80.0**
Complete loss	winter	7.9	28.8	28.8
	summer	0.4	6.7	8.0
	dryland	1.9	35.1	43.2
	Total	**10.2**	**70.6**	**80.0**

Source; Lyall and Macoun (1997),

Lyall and Macoun (1997) estimated the change in area waterlogged over 30 years. Table 10 shows the change in area of anticipated waterlogged areas by 2025.

TABLE 10 CHANGE IN WATERTABLE CONDITIONS 1995-2025
JID
'000 ha

Waterlogging Effect	Cropping system	2 year ARI	5 year ARI	10 year ARI
Some loss	winter	1.1	0	0
	summer	0.3	0	0
	dryland	1.6	0	0
	Total	**3.0**	**0**	**0**
Severe loss	winter	0.7	0	0
	summer	0.5	0	0
	dryland	1.1	1.6	0
	Total	**2.3**	**1.6**	**0**
Complete loss	winter	0.4	0	0
	summer	0.1	0.9	0
	dryland	0.3	1.6	0
	Total	**0.8**	**2.5**	**0**

Source; Lyall and Macoun (1997),

The areas of severe yield loss are a subset of the area showing some yield loss. The area suffering complete yield loss is separate.

3.1.4. Impacts of Waterlogging

Gross margins, the difference between total income and variable costs, were calculated based on the weighted average gross margins throughout the Jemalong LWMP area. The losses in gross margins were calculated as 10% for some waterlogging, 30% for severe waterlogging and 100% for complete waterlogging. The initial source of information for gross margins in this region was NSW Agriculture. Table 11 shows the gross margins that were applied to estimate losses from waterlogging.

TABLE 11 GROSS MARGINS IN JID
$/ha

Waterlogging effect	Landuse	Weighted average gross margin	
		Before waterlogging loss	After waterlogging loss
Some loss	winter crops	72	64
	summer crops	541	487
	dryland	57	51
Severe loss	winter crops	72	50
	summer crops	541	379
	dryland	57	40
Complete loss	winter crops	72	0
	summer crops	541	0
	dryland	57	0

Source DLWC (1998)

Table 12 also shows the losses due to waterlogging given the anticipated increases in area waterlogged as shown in Table 10. This was based on the assumption that the areas of increased waterlogging started occurring from year 15, a timeframe applied purely to determine the impact of uncertainty and variations due to a different starting date.

TABLE 12 PRESENT VALUES OF GROSS MARGIN LOSSES
JID
$ '000

	Present Value		
	4%	**7%**	**10%**
No change in waterlogged area	72,433	51,979	39,488
With projected increase	1,993	1,085	610
Total	**74,426**	**53,064**	**40,098**

Source; DLWC (1998)

If the waterlogged areas occurred later the losses would be lower and vice versa, if the increase in area occurred earlier, the losses would be greater. Table 13 shows the impact on gross margins if the areas waterlogged increased in five years time, earlier than calculated in Table 12. The difference at 7 percent discount rate is an increase of $1.5 million in agricultural losses over thirty years if waterlogging increased earlier.

TABLE 13 PRESENT VALUE OF GROSS MARGIN LOSSES
projected increase in waterlogging in year 5
JID
$ '000

	Present Value		
	4%	**7%**	**10%**
No change in area	72,433	51,979	39,488
With projected increase	4,045	2,671	1,852
Total	**76,478**	**54,650**	**41,340**

Source DLWC (1998)

The actual value of losses will be dependent on the time frame in which they start. Using weighted average gross margins was appropriate in that they reflected areas and severity of impacts.

3.1.5. Impacts on Roads and Infrastructure

The local Shires, Forbes and Lachlan, as well as the Roads and Traffic Authority were consulted as to road costs due to salinity and waterlogging in the Jemalong LWMP area. For information on on-farm roads NSW Agriculture was consulted. This approach resulted in the advice that currently only 2.5 km of gravel roads were salt affected, requiring resealing every 4 years instead of the usual 8 years and also an extra two grades per annum were required. For bitumen roads, only one km of road was salt affected and required repairs every two

years. To date it was considered that no additional on-farm costs were being incurred as there were no salinity effects on on-farm roads. No projections were estimated by the councils as to future damage to roads but costs were calculated incorporating an increase factor for road lengths being affected.

A range of estimated increases in length of road damaged was calculated. All costs were calculated based on the 30 year planning period for the Plan and discounted at 7 percent. With no increase in roads affected the present value of damage was $166,000 while this increased to $1.3 million with a 15 percent increase in the length of sealed and gravel roads being repaired.

TABLE 14 LENGTH AND COSTS OF ROAD REPAIRS USING COUNCIL DATA

Rate of increase in length of damaged road	Length of sealed road in year 30 km	Length of gravel road in year 30 km	Present value $'000
0%	1	2.5	166
1%	1.3	3.3	183
10%	15.9	39.7	575
15%	57.6	143.9	1,289

Source; DLWC (1997a)

The present values of costs of road repairs were sensitive to the discount rate, as demonstrated in Table 15

TABLE 15 PRESENT VALUES OF DAMAGED ROADS COSTS
4% 7% and 10% discount rates
$ '000

Rate of increase in length of damaged road	4%	7%	10%
0%	230	**166**	126
1%	260	**183**	137
10%	976	**575**	364
15%	2,373	**1,289**	747

Source; DLWC (1997a)

Outside of the plan area, salinity also appeared to be apparent near the saleyards in Forbes and near Lake Forbes (S. Hamilton pers. comm. 1995). However after speaking to the Shire Engineers and the Roads and Traffic Authority, there was little awareness of further problems due to salinity. Waterlogging on-farm roads was not perceived to be a problem (Ian Smith pers. comm. 1995). Even if extra maintenance costs of say $10,000 per year were incurred

throughout the JLWMP area the present value would be $124,000 at 7 percent discount rate ($173,000 and $94,000 at 4 percent and 10 percent respectively).

3.1.6. Summary of No Plan Scenario

Table 16 shows the present value over 30 years of losses if a land and water management plan were not undertaken. The present value of losses due to waterlogging and salinity were estimated to range from $54 to $59 million.

TABLE 16 SUMMARY OF PRESENT VALUE OF LOSSES IN JLWMP NO PLAN SCENARIO
at 7% Discount Rate

Losses due to	$ '000
Salinity	2,260-2,714
Waterlogging	51,979-54,650
Road damage	290-1,413
Total	**54,529-58,777**

3.1.7. Non Quantified Impacts

Beyond the above quantifiable economic effects of continuing high watertables, with the resulting increases in salinity and waterlogging, are adverse outcomes that are more difficult to evaluate in dollar terms and were not included in the No Plan Scenario. Considerable environmental changes due to rising watertables and soil salinity would be expected over the period of study. Damage could continue to occur to areas of remnant vegetation and aquatic habitats.

Close to the JLWMP area are wetlands, with many areas either degraded or totally obliterated (Lyall and Macoun 1998) but are still considered to retain intrinsic wetland values and maintain some ecological functionality. Wetlands provide an important filtering function in the landscape, removing nutrients, sediment, synthesising chemicals and recycling organic matter. Wetlands are often identified as being amongst the most productive ecosystems on earth.

Wetlands provide breeding, nursery, residence and colonisation areas for numerous plants, invertebrates, amphibians, mammals, reptiles, fish and waterbirds. The periodic explosion of productivity in ephemeral wetlands, such as Lake Cowal and Nerang Cowal, is perhaps most notable where a seemingly unproductive area can fill with water and play host to many types of flora and fauna. Plants and animals found in wetland areas have adapted to the sudden availability of nutrient and water, responding with rapid growth and productivity (Maher (1984), Crome (1986)).

Vegetation prevents erosion and maintains soil quality and biodiversity. Booth (1996) noted that very few shrubs remain in the plan area to indicate the original diversity. The isolated paddock trees are aging, in poor condition and dwindling in number. Severe tree decline and death has occurred along the lower reaches of Bogandillon Creek, with redgums in other sections of the creek showing obvious signs of dieback.

The importance for biodiversity of the wetland systems present, as well as the larger remnant terrestrial vegetation areas is apparent given that 222 birds, 29 mammals, 31 reptiles and 11 amphibians have been recorded. Shelley (1997) noted that... "The relatively large number of fauna species, both threatened and non-threatened, known from within the LWMP area indicates how important the maintenance of the wetland systems and remnant vegetation patches are to the region's biodiversity."

Thus the dollar summary of the impacts of the 'No Plan' Scenario in Table 16 underestimates the overall impact of salinity and waterlogging in the Plan area and surrounds.

3.2. 'WITH PLAN' SCENARIO

The 'With Plan' Scenario considered the benefit and costs estimated to be achieved over the period of the Plan. The Jemalong Land and Water Management Plan contained a number of options, or courses of action, which were to be implemented. The majority of these options were to be implemented over fifteen years, although the benefits were calculated over the life of the plan, being thirty years. Table 17 lists those options, indicating their components. The options were evaluated to establish benefits and costs over the life of the plan, with the overall results presented in section 3.3. The main categories of options were on-farm options for the JID, vegetation management, channel seepage reduction measures, surface drainage, floodway management and implementation costs.

TABLE 17 LIST OF OPTIONS JEMALONG LWMP

Option Name
On-farm Options - Jemalong Irrigation District
Laser Landforming
Development plan
Whole farm irrigation designs
On-farm recycling=storages
On-farm recycling=pumps
Soil testing - irrigation
Soil testing - fertility
Improved pastures irrigated area
Improved pastures dryland light soils
Improved pastures dryland heavy soils
Lucerne for seepage area
Lucerne for dryland area- light soils
Lucerne for dryland area- heavy soils
Channel Seepage
Lucerne
Floodway Management
Levees 1-5
Surface Drainage
Surface drainage storages
Surface drainage basins
Vegetation
Remnant Area (existing vegetation)
New Tree Plantings
Implementation

In some cases the benefits and costs of each option were independent while in other situations the options were interdependent. This was taken into account in the economic evaluation.

3.2.1. On-farm Options

The On-farm Options evaluated were as itemised in NSW Agriculture (1996) and amended as per more recent advice (pers comm. Ian Smith, Andrew Turner 1999, Buttenshaw 2000). Their aim was to reduce waterlogging and salinity. Data for those options for the plan area were based on the actions implemented due to the plan, and do not include activities that would be undertaken under the 'No Plan' Scenario. Thus the following figures will not directly relate to implementation rates as indicated in *On-Farm Options* (NSW Agriculture 1996) which were based on total implementation (i.e. With Plan and No Plan implementation).

On-farm Options for the Jemalong Irrigation District

Landforming

Some landforming is expected to continue without the Plan, therefore the costs of landforming were based on those areas that would be landformed under the Plan.

Costs

The evaluation assumed that landforming would start in year 1 and continue over 10 years, with a per unit cost of $490 per ha, and a total area landformed under the plan of 9,600 ha, at an annual rate of 1,280 hectares over years 1-5, and 640 hectares over years 6-10 (NSW Agriculture 1996, p. 14, Ian Smith pers. comm. 1998, Andrew Turner 1999).

The costs calculated also included a repolishing cost of $147 per ha every five years and maintenance costs for drains and channels of $65 per ha every five years.

Benefits

Benefits from landforming include accessions saved and removal of water from the soil profile (NSW Agriculture communication Oct 1996, Nov 1998) at the rates of 0.02 ML/ha/pa and 0.005 ML/ha/pa respectively.

Development Plans

Costs

Development plans will be undertaken in the Plan over 10 years at an annual rate of 1,298 hectares over years 1-5, and an annual rate of 650 hectares over years 6-10 at a cost of $12 per ha.

Benefits

Benefits will be from accessions saved and removal of water from the soil profile at rates of 0.009 and 0.002 ML/ha/pa respectively.

Whole Farm Irrigation Design

Costs

Whole farm irrigation designs will be undertaken in the Plan over 10 years at an annual rate of 2,600 hectares over years 1-5, and an annual rate of 1,300 hectares over years 6-10 at a cost of $50 per hectare.

Benefits

Benefits will be from water saved from accessions and removal from the soil profile at rates of 0.002 and 0.0005 ML/ha/pa respectively.

Recycling systems

Costs

Over 10 years there will be 240 storage sites and 140 pumping units with costs of $15,000 and $7,500 each respectively. Annually 30 sites will be undertaken in years 1-5 and annually 18 sites in years 6-10. Annually 16 pumping units will be installed in years 1-5 and 10 in years 6-10.

Benefits

Benefits will be from water saved from accessions and removal from the soil profile at rates of 1.18 and 0.26 ML/site/pa respectively.

Soil Tests

Costs

Soil tests for irrigation over 10 years will be implemented at a rate of 140 tests per year (based on 20 ha per test on 28,000 ha).

For soil tests for fertility over 30 years, 460 tests will be undertaken a year at $50 per test. Note that under the 'No Plan' Scenario, 40 tests are expected to be undertaken, and are therefore excluded from the costs and benefits of the Plan.

Benefits

Benefits will be from water saved from accessions and removal from soil profile at rates of 0.044 and 0.01 ML/test/pa respectively.

Improved pastures

Costs

Over a period of 15 years, 3,000 ha in the irrigated area will be planted to improved pastures at a cost of $20 per ha (NSW Agriculture 1996).

However costs would be expected to be similar for both annual and perennial pasture enterprises except for increased seed and fertiliser costs for the latter (NSW Agriculture Forbes 1998). Of the dryland area, 1,409 ha of annual pastures on light soils are to be converted to improved pastures and 6,164 ha on heavy soils, both at a cost of $10 per ha, being the extra costs of seeds and fertiliser. This approach assumed that there would be sufficient water available to irrigate the change in pastures from annual to perennial.

Benefits

Benefits are from the increased carrying capacity of improved pastures. In the irrigation areas it was estimated that carrying capacity would increase by 25 DSE (dry sheep equivalents) per ha from annual to improved pastures for 60 percent of farms and 17.5 DSE for 40 percent of farms, giving an average increase of 22 DSE. In the dryland areas it was calculated that carrying capacity would increase from 5 DSE per ha to 10 DSE per ha. This was valued at $18 per DSE (NSW Agriculture Yanco 1998).

NSW Agriculture (1996) calculated benefits from water saved from accessions and removal from the soil profile were calculated as being 0.18 and 0.05 ML/ha/pa for irrigated areas, 0.02 and 0.13 ML/ha/pa for light soil in dryland areas. Benefits from removal of water from the soil profile were 0.3 ML/ha/pa due to conversion to improved pastures on dryland heavy soils. However, these benefits were excluded from the final evaluation because to include values for these water savings as well as values from improved carrying

capacity was considered to be double counting, and thus would overstate the benefits from this option.

Lucerne

Costs

Over the next 15 years under the plan 100 ha in the seepage area to be grown with lucerne (note that under the 'No Plan' Scenario 300 ha are expected to be sown). In the dryland light soils, 4,259 ha are expected to be sown to lucerne. In the dryland heavy soils area, 203 ha are to be sown to lucerne.

Benefits

The benefits of growing lucerne were calculated as the difference in gross margins between the landuse that was prior to the lucerne sowing and the gross margin from irrigated lucerne for hay. These calculations included the cost of establishing the lucerne stand, a five-year rotation with two years of cropping before establishing lucerne again.

NSW Agriculture (1996) also calculated benefits from water saved and removal of water from the soil profile as being 0.7 and 1.2 ML/ha/pa respectively for seepage area lucerne, 1.226 and 1.233 ML/ha/pa respectively for lucerne on dryland light soils and 0.12 and 0.71 ML/ha/pa on dryland heavy soils. However, these were excluded from the final evaluation because to include values for these water savings and avoided accessions as well as values from increased gross margins from lucerne growing was considered to be double counting, and thus would overstate the benefits from this option.

Summary of Benefits and Costs of On-Farm Options

Appendix 1 shows the benefits and costs of On-farm Options over the period of the Plan by option. Table 18 and 19 show the total on-farm benefit and costs. Total value of benefits and costs are the sum of the stream of benefits and costs over the thirty years, and present value of benefits and costs are that the discounted stream of net benefits and costs.

TABLE 18 TOTAL VALUE OF ON-FARM BENEFITS AND COSTS
$ M

Option	Water Benefits	Other Benefits	Total Benefits	Total Costs
Total	**0.6**	**76.9**	**77.5**	**22.2**

TABLE 19 PRESENT VALUE OF ON-FARM BENEFITS AND COSTS
$ M

Option	Water Benefits	Other Benefits	PV Benefits	PV Costs	BCR
Total	**0.2**	**24.2**	**24.4**	**11.6**	**2.1**

3.2.2. Channel Seepage

The evaluation of costs and benefits from channel seepage are based on the losses from the Warroo channel. Table 20 shows the details of the treatment for channel seepage in the Jemalong Irrigation District. Lucerne will be grown at a 20-metre width along both sides of the channel.

TABLE 20 DETAILS OF CHANNEL SEEPAGE OPTION

Option	Length of Channel Km	Lucerne Ha/yr	Accessions Saved ML/yr
Lucerne 1	44.2	176.7	230
lucerne 2	10.1	40.5	52
lucerne 3	5.4	21.5	28
Total	**59.7**	**238.7**	**310**

Implementation would be over 5 years, with the majority of the lucerne being planted from years 6-10 (176.7 ha), while other lucerne areas, (41 ha) would occur in years 7-11, and the balance of lucerne planting (22 ha), would occur in years 6 and 7.

Costs
Costs incurred were of planting lucerne (Kinhill Engineers 1995). These were incorporated in the gross margins applied to benefits and thus did not appear specifically as costs. Any landforming costs for lucerne planting were included in the landforming costs and targets of the whole area under the On-Farm Options (Ian Smith pers. comm. 1998).

Benefits
Benefits from planting lucerne were reduced accessions from the channel and gross margin returns on lucerne plantings over and above the current landuse. Planting lucerne was estimated to reduce accessions at a rate of 1.3 megalitres/ha/per year. However, benefits were calculated as the gross margin from lucerne, which reflected the benefits of reduced accessions. To value both the increased gross margin and reduced accessions would be double counting. Thus the water benefits were in fact reflected in the 'other benefits' category in Table 21.

Lucerne planting followed the pattern of losses in year 1 of planting where costs were incurred with no return, positive returns in years 2-5 from lucerne, and much smaller positive

returns from wheat in years 6 and 7. Note that these costs and returns recognised that returns were being received on that land prior to lucerne planting and so the gross margins applied were net of returns in the no plan case. This method of applying net gross margins over the period of planting lucerne (with negative returns in year 1), increasing and then decreasing returns over the lucerne rotation and then smaller returns with wheat provided results which did not specifically identify costs of these activities. However, the marginal cost of these activities was included in the modelling, but as net gross margins. The final impact on results is similar. The same methodology was utilised in establishing benefits from growing lucerne in the on-farm options.

The benefits of addressing channel seepage are shown in Tables 21 and 22.

TABLE 21 TOTAL NET BENEFITS FOR ADDRESSING CHANNEL SEEPAGE
$ '000

Option	Water Benefits	Other Benefits	Total benefits
Channel seepage	0	1,787	1,787

see text for treatment of costs

TABLE 22 PRESENT VALUE OF NET BENEFITS FOR CHANNEL SEEPAGE OPTION
$ '000

Option	Water Benefits	Other Benefits	PV Benefits	PV Costs	BCR
Channel seepage	0	548	548	0	-

see text for treatment of costs

3.2.3. Floodway Management

The floodway option consisted of reducing accessions through building a series of levees (Forbes Rigby 1996) with the aim of isolating floodwater from soils known to be highly permeable, therefore reducing accessions. The proposed option consists of constructing levees within five areas in the floodway that were considered critical in terms of accessions. Providing protection against a 30 year ARI was expected to remove a total average of 3,940 ML per year.

Costs

In area 1 the partial isolation of sandy zones through lower levees within the floodway was preferred with 12 km of low height levees recommended. This would cost $57,000 to construct (including construction costs and removal costs) based on a variable levee height of between 0.5 and 1.2 metres and save accessions of 600 ML per year.

In area 2 (Warroo) construction of 2.2 km of levee was considered to reduce accessions by 310 ML per year at a construction cost of $39,600.

In area 3 (17-mile breakout) 7 km of levees needed raising or building to reduce accessions by 1410 ML per year at a construction cost of $126,000.

In area 4 (Jemalong West), 2 km of levees were expected to reduce accessions by 710 ML per year on average, at a construction cost of $36,000.

In area 5 (Wilbertroy Forest), 4.5 km of levee were proposed at a construction cost of $27,000, plus $5,000 for installing a flap gate and associated works.

For all areas an operation and maintenance cost of 5% of capital cost every 5 years was included. This would save 910 ML per year in accessions. Costs of construction were based on Forbes and Rigby (1996).

This economic evaluation assumed that levee construction would start in year 6 and continue to year 10.

Benefits

The avoided accessions to groundwater were the benefits of this floodway management option. Accessions totalling 3,940 ML per year were achieved in year 10 when all works were completed. The benefit was valued at $18 per megalitre of accession saved.[1]

[1] In the 'No Plan' Scenario there was considered to be a danger of rupturing the bed of Lake Cowal (Forbes and Rigby 1996). The floodway management option was also considered to have further benefits in lowering the risk of salinisation for Lake Cowal. An imputed value for Lake Cowal could be based on the opportunity costs of the resource, which is the value of its next best use. Forbes and Rigby (1996) suggested that the alternative value of $1.2 billion could be given to Lake Cowal when the Carr Labour Government denied North Limited a development consent for the proposed gold mine. This figure was based on the value of gold extraction and processing. Imputing a value for Lake Cowal necessitated assumptions as to the probability of the Lake bed rupturing some time in the future and the reduced probability if undertaking the floodway options, the cost of repairing ensuing environmental damage and the reduction in accessions required to minimise damage (Forbes and Rigby (1996) p. 61).

TABLE 23 TOTAL BENEFITS AND COSTS FOR FLOODWAY MANAGEMENT OPTION
$ '000

Option	Water Benefits	Other Benefits	Total benefits	Total costs
All levees	173	0	173	349

TABLE 24 PRESENT VALUE OF BENEFITS AND COSTS FOR FLOODWAY MANAGEMENT OPTION
$ '000

Option	Water Benefits	Other Benefits	P V Benefits	P V Costs	BCR
All levees	51	0	51	186	0.3

3.2.4. Surface Drainage

Surface drainage was initially considered in the plan to reduce the incidence of waterlogging, defined as conditions where agricultural losses occur due to lower plant growth, or constraints on carrying out farmwork (Lyall and Macoun 1998). Waterlogging occurs due to extended wet weather, particularly in winter when evaporation is low. It is exacerbated by low slopes and poor draining soils.

Costs

This option and costs consisted of two components. The major component was the construction of storages to collect rain rejection water, which would be available for reuse at six sites and constructed over 10 years, starting in year 6. Costs included the survey, design and contingency allowance and the capital costs of the storages and pumps ($665,000). Annual operation and maintenance costs were also included ($16,625).

The second component was the survey and design costs for 5 basins (basins 2,4,6-8 in Lyall and Macoun 1998). This cost was $309,600.

Benefits

The benefits from the storages were estimated at 700 megalitres per annum of captured runoff water which would be reused on-farm.

TABLE 25 TOTAL BENEFITS AND COSTS FOR SURFACE DRAINAGE OPTION
$ '000

Option	Water Benefits	Other Benefits	Total benefits	Total costs
Storages	246	0	246	1079
Basin design	-	-	-	310
Total	246	0	246	1,389

TABLE 26 PRESENT VALUE OF BENEFITS AND COSTS FOR SURFACE DRAINAGE OPTION
$ '000

Option	Water Benefits	Other Benefits	P V Benefits	P V Costs	BCR
Storages	66	0	66	437	
Basin design	-	-	-	155	
Total	66	0	66	592	0.1

3.2.5. Vegetation

Several vegetation options were considered in order to lower the waterTable. The preferred options consisted of (Booth Associates 1996);

- increasing perenniality in dryland pastures
- reducing length and extent of fallowing
- increasing native woodlands

The first two options were covered in the On-farm Options (see section 3.2.1). This section discusses the last option.

Currently remnant cover is approximately 21% of the Plan area (Cunningham 1998). Initially it was thought that considerably less area was vegetated so there was a target of having 10% tree cover on every farm. Of course, the 21% cover is an average figure over the whole Plan area and some farms won't have nearly this amount of cover. Increasing vegetation cover;

- adds to overall biodiversity
- accesses biopumping
- improves aesthetics
- reduces damage to roads from high waterTables.

Most remnant areas are along roads, along the floodway between the Lachlan River and the Lakes, within Crown, public and travelling stock reserves, within the Wilbertroy State Forest and within and around drainage run-off areas.

At this stage the remnant vegetation option under the LWMP for vegetation consists of fencing 4,633 ha over a period of fifteen years. A further 1,524 ha were to be revegetated over a similar period (A.Turner 15/5/99). Other costs incurred were direct seeding costs in year 6, (Andrew Turner pers. comm. 1998, Beumer 2000), and fence maintenance costs. Some loss of gross margins from grazing in the early establishment years and some improvements in grazing in latter years, and particularly in drought periods, can be expected.

Other benefits were based on accession benefits and stock shelter (Booth Associates 1996). These assumed that most of the benefits of vegetation on accessions commenced in 5 years after the start and reached their full effect in 15 years, while some benefits accrued from year 1. The benefits from stock shelter were based on an increase in yield for every hectare of trees over 10 years old. Initial analysis by Stanton (1996) was based on an increase in carrying capacity of 5 DSE/ha valued at $18 per DSE, the increase in gross margin per hectare was $22.50, and averaged over the 30 years of the study was $18 per hectare (Booth Associates 1996)[2]. However, later review (I Smith, P Rooke NSW Ag Sept 1998) considered that while the increase could be up to 5 DSE /ha, a more appropriate figure was 2.5 DSE/ha which was then incorporated into this report.

Table 27 shows the total benefits and costs over the thirty-year period of the study. The benefit cost ratio, without the inclusion of any environmental benefits, was 0.5 with a net present value of minus $1 million.

TABLE 27 TOTAL BENEFITS AND COSTS FOR VEGETATION OPTION
$ '000

Option	Water Benefits	Other Benefits	Total Benefits	Total Costs
Remnant vegetation	2364	646	3010	3307
New plantings	709	186	895	2324
Total	**3073**	**832**	**3905**	**5631**

[2] Other benefits from protecting native vegetation include improved wildlife habitat, biodiversity and aesthetic values. Aesthetic values were recognised by calculating the benefits (Booth Associates 1996) of an increase by an arbitrary 2% of farm value given increased native vegetation areas. This gave an increase in value of $16 per hectare due to improved aesthetics, and was an attempt at recognising and quantifying the environmental benefits of this option. The present value of this benefit was $1.7 million dollars for both components of the vegetation option.

TABLE 28 PRESENT VALUE OF BENEFITS AND COSTS FOR VEGETATION OPTION
$ '000

Option	Water Benefits	Other Benefits	PV Benefits	PV Costs	BCR
Remnant vegetation	594	162	757	1181	0.6
New plantings	178	47	225	848	0.3
Total	**772**	**209**	**982**	**2029**	**0.5**

3.2.6. Implementation Costs

The costs of implementing the JLWMP are shown in Table 29. They were based on annual costs of $160,500 over a thirty-year period which included salaries and on-costs for an executive officer, one scientific officer and outsourcing of GIS information. Expenditure included lease and running costs for two vehicles. Purchase of office and field equipment ($30,000) was included in year 6 and updated every ten years at an estimated cost of $20,000 each time (A. Turner 15/5/99).

The benefits of implementation were effectively included in the benefits throughout the Plan in meeting targeted adoption rates, and were not specifically apportioned and calculated.

TABLE 29 COSTS OF IMPLEMENTATION
$ '000

Option	Total Cost	Present Value Cost
Implementation	4,815	1992
Capital equipment	70	30
Total	**4,885**	**2,022**

3.3. SUMMARY OF ECONOMIC RESULTS

Each option was evaluated in terms of costs incurred and benefits flowing from implementation over a period of 30 years. These benefits and costs were calculated on the basis that all options as listed in the Plan were undertaken and benefits and costs reflected any interrelationships between options.

Benefits in terms of megalitres saved and available for reuse, were given a value considered to be close to the value of water in the JLWMP area (McClintock and Jones 1995). The figure used was $18 ML (rounded up from the estimated 1995 figure of $17.48 ML).

Accessions saved and runoff were given a value of $2 ML These benefits are reflected in the 'water benefits' column. Benefits from other sources as outlined in the preceding section, such as improved agricultural returns, are summed in the 'other benefits' column.

The total benefits and costs over the 30 years of the Plan implementation are shown in Table 30. This flow of benefits and costs was discounted to represent values in today's terms. Table 31 shows the present value of benefits and costs and the benefit cost ratio at a 7% discount rate over 30 years.

TABLE 30 TOTAL BENEFITS AND COSTS JLWMP
$ '000

Option	Water Benefits	Other Benefits	Total Benefits	Total Costs
On-farm Options	632	76,866	77,498	22,198
Channel Seepage	-	1,787	1,787	-
Floodway	173	0	173	349
Surface Drainage	246	-	246	1,389
Vegetation	3,073	832	3,905	5,631
Implementation	0	0	-	4,885
Total	**4,124**	**79,486**	**83,610**	**34,451**

errors due to rounding

TABLE 31 PRESENT VALUE OF TOTAL BENEFITS AND COSTS JLWMP
$ '000

Option	Water Benefits	Other Benefits	PV Benefits	PV Costs	NPV
On-farm Options	197	24,213	24,410	11,603	12,807
Channel Seepage	0	548	548	0	548
Floodway	51	0	51	186	(135)
Surface Drainage	66	0	66	592	(526)
Vegetation	772	209	982	2,029	(1,047)
Implementation	0	0	0	2,022	(2,022)
Total	**1,087**	**24,971**	**26,057**	**16,432**	**9,625**
Benefit Cost Ratio	**1.6**				

errors due to rounding

The results indicate that the Jemalong Land and Water Management Plan as proposed is economically viable with a positive net present value of $9.6 million over thirty years and a benefit cost ratio of 1.6 Table 31 indicates that not all options within the plan appear economically viable, with present values of costs higher than present values of benefits.

The benefits quantified in Table 31 do not include evaluation of environmental benefits such as aesthetic and existence values (Hill 1994) of wetlands or native vegetation, for example, or of protecting Lake Cowal and improving flora and fauna habitats. Therefore, clearly the benefits of implementing the plan are even greater than indicated in Table 31.

3.3.1. Sensitivity Analysis

The economic analysis results were also tested for sensitivity to a range of variables including discount rate, changes in gross margins and the value of water.

The discount rate applied to the plan evaluation was 7 percent. Under the sensitivity analysis the rate was varied to 4 percent and 10 percent, with results as shown in Table 32. The economic evaluation was reasonably sensitive to discount rate changes.

TABLE 32 SENSITIVITY ANALYSIS ON DISCOUNT RATES
$ '000

	4%	**7%**	**10%**
Present Value Benefits	41,305	**26,057**	17,334
Present Value Costs	21,682	**16,432**	13,040
Net Present Value	19,623	**9,626**	4,294
Benefit Cost Ratio	**1.9**	**1.6**	**1.3**

The overall results were not sensitive to changing the value of water. Halving the value of water merely halved the benefits from water and doubling the value doubled the benefit. Neither of these water value movements significantly affected the final results. Changing gross margins had a similar impact, as shown in Table 33, but had a larger effect on results.

TABLE 33 SENSITIVITY ANALYSIS ON GROSS MARGINS
$ '000

	gross margins halved	gross margins as for plan	gross margins doubled
Present Value Benefits	20,031	**26,057**	38,110
Present Value Costs	16,432	**16,432**	16,432
Net Present Value	3,599	**9,626**	21679
Benefit Cost Ratio	**1.2**	**1.6**	**2.3**

3.4. CONCLUSION and DISCUSSION

The economic evaluation showed that under the 'No Plan' Scenario, the loss to the Jemalong Land and Water Management Plan area could amount to a present value of $54 million to $59 million over 30 years. The evaluation of the 'With Plan' Scenario showed that overall the Plan was economically viable with a net present value of $9.6 million and a benefit cost ratio of 1.6 at a 7% discount rate over 30 years.

There were a number of environmental benefits that would accrue from implementation of the plan. These included enhanced flora, fauna and aquatic habitats through improved conditions of vegetation and wetlands. Quantification of these benefits can be time consuming and costly. However, the implementation of the proposed Plan supported the protection of these substantial environmental assets.

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APPENDICES

Appendix 1

Table 1 Start and finish years for options as at April 2000

IMPLEMENTATION PARAMETERS	Start Year	Finish Year
Jemalong on-farm options - irrigation- JIL		
Laser Landforming	1	5
development plan	1	5
whole farm irrigation designs	1	5
on-farm recycling=storages	1	5
on-farm recycling=pumps	1	5
soil testing -irrigation	1	10
soil testing- fertility	1	30
improved pastures irrigated area	1	15
improved pastures dryland light soils	1	15
improved pastures dryland heavy soils	1	15
lucerne for seepage area	1	15
lucerne for dryland area- light soils	1	15
lucerne for dryland area- heavy soils	1	15
Jemalong on-farm options - second timeframe		
Laser Landforming	6	10
development plan	6	10
whole farm irrigation designs	6	10
on-farm recycling=storages	6	10
on-farm recycling=pumps	6	10
Vegetation		
Remnant Areas (Existing Vegetation)	6	20
new plantings	6	20
Channel Seepage		
lucerne 1	6	10
lucerne 2	7	11
lucerne 3	6	7
surface drainage		
surface drainage storages	6	15
surface drainage basins	6	15
floodway management		
levees 1-5	6	10
Implementation	1	30
Note: Year 1 = FY 1995/96 Year 6 = FY 2000/01		

Source Jemalong LWMP Committee April 2000

Table 2 Present Value of Benefits and Costs for on-farm options

On-farm options	**PV Benefits**	**PV Costs**	**Net Present Value**
Laser Landforming	$4,474	$6,473,804	($6,469,330)
Development plan	$1,816	$86,667	($84,852)
Whole farm irrigation designs	$909	$723,046	($722,137)
On-farm recycling-storages	$5,926	$2,634,403	($2,628,476)
On-farm recycling-pumps	$0	$1,122,014	($1,122,014)
Soil testing - irrigation	$1,221	$196,660	($195,439)
Soil testing - fertility	$0	$285,408	($285,408)
Improved pastures irrigated area	$8,085,010	$36,432	$8,048,579
Improved pastures dryland light soils	$864,891	$8,555	$856,335
Improved pastures dryland heavy soils	$3,793,607	$36,417	$3,757,190
Lucerne for seepage area	$244,004	$0	$244,004
Lucerne for dryland area- light soils	$10,991,008	$0	$10,991,008
Lucerne for dryland area- heavy soils	$417,183	$0	$417,183
Total	$24,410,049	$11,603,406	$12,806,643

Appendix 2 Cash Flow for Jemalong LWMP

Cash Flow for Jemalong LWMP	discount rate 0.07	calculated 6/4/2000

Jemalong on-farm options	Total	Year	1	2	29	30	total		PV
		Capital	1,402,714	1,402,714	23,000	23,000	11,549,946		8,251,133
		Recurrent	0	4,000	35,000	35,000	870,000		293,901
		Renewal	0	0	407,040	407,040	9,777,600		3,058,372
		Total Costs	1,402,714	1,406,714	465,040	465,040	22,197,546		11,603,406
		benefits water	0	2,000	28,492	28,492	632,099		196,690
		benefits other	103,582	331,801	3,423,294	3,423,294	76,866,192		24,213,358
		Total Benefits	103,582	333,801	3,451,786	3,451,786	77,498,291		24,410,049
		Net	-1,299,132	-1,072,913	2,986,746	2,986,746	55,300,745	NPV	12,806,643

Laser Landforming	JI01+JDO1	Year	1	2	29	30	total		PV
		Capital	627,200	627,200	0	0	4,704,000		3,488,417
		Recurrent	0	0	0	0	0		0
		Renewal	0	0	407,040	407,040	9,497,600		2,985,387
		Total Costs	627,200	627,200	407,040	407,040	14,201,600		6,473,804
		benefits water	0	68	513	513	13,003		4,474
		benefits other	0	0	0	0	0		0
		Total Benefits	0	68	513	513	13,003		4,474
		Net	-627,200	-627,132	-406,527	-406,527	-14,188,597	NPV	-6,469,330

development plan	JI02+JD02	Year	1	2	29	30 total		PV
		Capital	15,576	15,576	0	0	116,880	86,667
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	0	0	0	0
		Total Costs	15,576	15,576	0	0	116,880	86,667
		benefits water	0	28	208	208	5,276	1,816
		benefits other	0	0	0	0	0	0
		Total Benefits	0	28	208	208	5,276	1,816
		Net	-15,576	-15,548	208	208	-111,604 NPV	-84,852

whole farm irrigation designs	JI03+JD03	Year	1	2	29	30 total		PV
		Capital	130,000	130,000	0	0	975,000	723,046
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	0	0	0	0
		Total Costs	130,000	130,000	0	0	975,000	723,046
		benefits water	0	14	104	104	2,641	909
		benefits other	0	0	0	0	0	0
		Total Benefits	0	14	104	104	2,641	909
		Net	-130,000	-129,986	104	104	-972,359 NPV	-722,137

on-farm recycling=storages	JI04+JD04	Year	1	2	29	30	total	PV
		Capital	450,000	450,000	0	0	3,600,000	2,634,403
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	0	0	0	0
		Total Costs	450,000	450,000	0	0	3,600,000	2,634,403
		benefits water	0	86	691	691	17,359	5,926
		benefits other	0	0	0	0	0	0
		Total Benefits	0	86	691	691	17,359	5,926
		Net	-450,000	-449,914	691	691	-3,582,641 NPV	-2,628,476

on-farm recycling=pumps	JI05+JD05	Year	1	2	29	30	total	PV
		Capital	120,000	120,000	0	0	1,050,000	755,128
		Recurrent	0	4,000	35,000	35,000	870,000	293,901
		Renewal	0	0	0	0	280,000	72,985
		Total Costs	120,000	124,000	35,000	35,000	2,200,000	1,122,014
		benefits water	0	0	0	0	0	0
		benefits other	0	0	0	0	0	0
		Total Benefits	0	0	0	0	0	0
		Net	-120,000	-124,000	-35,000	-35,000	-2,200,000 NPV	-1,122,014

soil testing –irrigation	JI07	Year	1	2	29	30 total		PV
		Capital	28,000	28,000	0	0	280,000	196,660
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	0	0	0	0
		Total Costs	28,000	28,000	0	0	280,000	196,660
		benefits water	0	15	150	150	3,668	1,221
		benefits other	0	0	0	0	0	0
		Total Benefits	0	15	150	150	3,668	1,221
		Net	-28,000	-27,985	150	150	-276,332 NPV	-195,439

soil testing- fertility	JI08	Year	1	2	29	30 total		PV
		Capital	23,000	23,000	23,000	23,000	690,000	285,408
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	0	0	0	0
		Total Costs	23,000	23,000	23,000	23,000	690,000	285,408
		benefits water	0	0	0	0	0	0
		benefits other	0	0	0	0	0	0
		Total Benefits	0	0	0	0	0	0
		Net	-23,000	-23,000	-23,000	-23,000	-690,000 NPV	-285,408

improved pastures irrigated area	JI09	Year	1	2	29	30	total	PV
		Capital	4,000	4,000	0	0	60,000	36,432
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	0	0	0	0
		Total Costs	4,000	4,000	0	0	60,000	36,432
		benefits water	0	94	1,404	1,404	30,888	9,544
		benefits other	0	79,200	1,188,000	1,188,000	26,136,000	8,075,466
		Total Benefits	0	79,294	1,189,404	1,189,404	26,166,888	8,085,010
		Net	-4,000	75,294	1,189,404	1,189,404	26,106,888	NPV 8,048,579

improved pastures dryland light soils	JI10	Year	1	2	29	30	total	PV
		Capital	939	939	0	0	14,090	8,555
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	0	0	0	0
		Total Costs	939	939	0	0	14,090	8,555
		benefits water	0	28	426	426	9,372	2,896
		benefits other	0	8,454	126,810	126,810	2,789,820	861,995
		Total Benefits	0	8,482	127,236	127,236	2,799,192	864,891
		Net	-939	7,543	127,236	127,236	2,785,102	NPV 856,335

improved pastures dryland heavy soils	JI11	Year	1	2	29	30 total		PV
		Capital	3,998	3,998	0	0	59,976	36,417
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	0	0	0	0
		Total Costs	3,998	3,998	0	0	59,976	36,417
		benefits water	0	222	3,326	3,326	73,172	22,609
		benefits other	0	36,984	554,760	554,760	12,204,720	3,770,998
		Total Benefits	0	37,206	558,086	558,086	12,277,892	3,793,607
		Net	-3,998	33,207	558,086	558,086	12,217,916 NPV	3,757,190

lucerne for seepage area	JI12	Year	1	2	29	30 total		PV
		Capital	0	0	0	0	0	0
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	0	0	0	0
		Total Costs	0	0	0	0	0	0
		benefits water	0	26	384	384	8,448	2,610
		benefits other	2,173	4,347	32,600	32,600	749,800	241,394
		Total Benefits	2,173	4,372	32,984	32,984	758,248	244,004
		Net	2,173	4,372	32,984	32,984	758,248 NPV	244,004

lucerne for dryland area-light soils	JI13	Year	1	2	29	30 total		PV
		Capital	0	0	0	0	0	0
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	0	0	0	0
		Total Costs	0	0	0	0	0	0
		benefits water	0	1,396	20,945	20,945	460,792	142,375
		benefits other	97,673	195,346	1,465,096	1,465,096	33,697,208	10,848,633
		Total Benefits	97,673	196,742	1,486,041	1,486,041	34,158,000	10,991,008
		Net	97,673	196,742	1,486,041	1,486,041	34,158,000 NPV	10,991,008

lucerne for dryland area-heavy soils	JI14	Year	1	2	29	30 total		PV
		Capital	0	0	0	0	0	0
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	0	0	0	0
		Total Costs	0	0	0	0	0	0
		benefits water	0	23	340	340	7,480	2,311
		benefits other	3,735	7,470	56,028	56,028	1,288,644	414,872
		Total Benefits	3,735	7,493	56,368	56,368	1,296,124	417,183
		Net	3,735	7,493	56,368	56,368	1,296,124 NPV	417,183

Vegetation	0 Year	1	2	29	30 total		PV
	Capital	0	0	0	0	4,906,085	1,852,878
	Recurrent	0	0	49,988	49,988	724,819	175,886
	Renewal	0	0	0	0	0	0
	Total Costs	0	0	49,988	49,988	5,630,904	2,028,764
	benefits water	0	0	198,254	198,254	3,072,931	772,450
	benefits other	0	0	53,699	53,699	832,327	209,224
	Total Benefits	0	0	251,952	251,952	3,905,258	981,674
	Net	0	0	201,965	201,965	-1,725,646 NPV	-1,047,090

Remnant areas (existing vegetation)	V01	Year	1	2	29	30 total		PV
		Capital	0	0	0	0	2,802,965	1,058,594
		Recurrent	0	0	34,748	34,748	503,839	122,263
		Renewal	0	0	0	0	0	0
		Total Costs	0	0	34,748	34,748	3,306,804	1,180,856
		benefits water	0	0	152,518	152,518	2,364,035	594,253
		benefits other	0	0	41,697	41,697	646,304	162,463
		Total Benefits	0	0	194,215	194,215	3,010,338	756,716
		Net	0	0	159,468	159,468	-296,466 NPV	-424,141

New plantings	V02	Year	1	2	29	30	total	PV
		Capital	0	0	0	0	2,103,120	794,284
		Recurrent	0	0	15,240	15,240	220,980	53,624
		Renewal	0	0	0	0	0	0
		Total Costs	0	0	15,240	15,240	2,324,100	847,907
		benefits water	0	0	45,735	45,735	708,896	178,197
		benefits other	0	0	12,002	12,002	186,023	46,761
		Total Benefits	0	0	57,737	57,737	894,919	224,958
		Net	0	0	30,495	30,495	-1,615,204 NPV	-669,710

Channel Seepage	0	Year	1	2	29	30	total	PV
		Capital	0	0	0	0	0	0
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	0	0	0	0
		Total Costs	0	0	0	0	0	0
		benefits water	0	0	0	0	0	0
		benefits other	0	0	77,823	77,823	1,787,227	548,161
		Total Benefits	0	0	77,823	77,823	1,787,227	548,161
		Net	0	0	77,823	77,823	1,787,227 NPV	548,161

lucerne 1	CS01	Year	1	2	29	30 total		PV
		Capital	0	0	0	0	0	0
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	0	0	0	0
		Total Costs	0	0	0	0	0	0
		benefits water	0	0	0	0	0	0
		benefits other	0	0	57,604	57,604	1,324,897	406,716
		Total Benefits	0	0	57,604	57,604	1,324,897	406,716
		Net	0	0	57,604	57,604	1,324,897 NPV	406,716

lucerne 2	CS04	Year	1	2	29	30 total		PV
		Capital	0	0	0	0	0	0
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	0	0	0	0
		Total Costs	0	0	0	0	0	0
		benefits water	0	0	0	0	0	0
		benefits other	0	0	13,210	13,210	290,609	85,543
		Total Benefits	0	0	13,210	13,210	290,609	85,543
		Net	0	0	13,210	13,210	290,609 NPV	85,543

lucerne 3	CS05	Year	1	2	29	30 total		PV
		Capital	0	0	0	0	0	0
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	0	0	0	0
		Total Costs	0	0	0	0	0	0
		benefits water	0	0	0	0	0	0
		benefits other	0	0	7,009	7,009	171,721	55,901
		Total Benefits	0	0	7,009	7,009	171,721	55,901
		Net	0	0	7,009	7,009	171,721 NPV	55,901

surface drainage	Total	Year	1	2	29	30 total		PV
		Capital	0	0	0	0	974,600	488,052
		Recurrent	0	0	16,625	16,625	324,188	87,734
		Renewal	0	0	9,000	9,000	90,000	16,335
		Total Costs	0	0	25,625	25,625	1,388,788	592,121
		benefits water	0	0	12,600	12,600	245,700	66,493
		benefits other	0	0	0	0	0	0
		Total Benefits	0	0	12,600	12,600	245,700	66,493
		Net	0	0	-13,025	-13,025	-1,143,088 NPV	-525,628

surface drainage storages	SD01	Year	1	2	29	30 total		PV
		Capital	0	0	0	0	665,000	333,013
		Recurrent	0	0	16,625	16,625	324,188	87,734
		Renewal	0	0	9,000	9,000	90,000	16,335
		Total Costs	0	0	25,625	25,625	1,079,188	437,082
		benefits water	0	0	12,600	12,600	245,700	66,493
		benefits other	0	0	0	0	0	0
		Total Benefits	0	0	12,600	12,600	245,700	66,493
		Net	0	0	-13,025	-13,025	-833,488 NPV	-370,589

surface drainage design	SD02	Year	1	2	29	30 total		PV
		Capital	0	0	0	0	309,600	155,039
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	0	0	0	0
		Total Costs	0	0	0	0	309,600	155,039
		benefits water	0	0	0	0	0	0
		benefits other	0	0	0	0	0	0
		Total Benefits	0	0	0	0	0	0
		Net	0	0	0	0	-309,600 NPV	-155,039

Floodways-levees 1-5	f01	Year	1	2	29	30	total	PV
		Capital	0	0	0	0	290,600	169,907
		Recurrent	0	0	0	0	0	0
		Renewal	0	0	2,906	2,906	58,120	15,650
		Total Costs	0	0	2,906	2,906	348,720	185,557
		benefits water	0	0	7,880	7,880	173,360	51,030
		benefits other	0	0	0	0	0	0
		Total Benefits	0	0	7,880	7,880	173,360	51,030
		Net	0	0	4,974	4,974	-175,360	NPV -134,528

Implementation 1		Year	1	2	29	30	total	PV
		Capital	160,500	0	0	0	160,500	150,000
		Recurrent	0	160,500	160,500	160,500	4,654,500	1,841,651
		Renewal	0	0	0	0	0	0
		Total Costs	160,500	160,500	160,500	160,500	4,815,000	1,991,651
		Benefits	0	0	0	0	0	0
		Net	-160,500	-160,500	-160,500	-160,500	-4,815,000	NPV -1,991,651

Implementation 2	Year	1	2	29	30	total	PV
	Capital	0	0	0	0	30,000	19,990
	Recurrent	0	0	0	0	0	0
	Renewal	0	0	0	0	40,000	10,219
	Total Costs	0	0	0	0	70,000	30,209
	Benefits	0	0	0	0	0	0
	Net	0	0	0	0	-70,000	NPV -30,209

totals	Year	1	2	29	30	total	PV
	Capital	1,563,214	1,402,714	23,000	23,000	17,911,731	10,931,960
	Recurrent	0	164,500	262,113	262,113	6,573,506	2,399,172
	Renewal	0	0	418,946	418,946	9,965,720	3,100,576
	Total Costs	1,563,214	1,567,214	704,059	704,059	34,450,957	16,431,708
	benefits water	0	2,000	247,225	247,225	4,124,090	1,086,663
	benefits other	103,582	331,801	3,554,815	3,554,815	79,485,745	24,970,743
	Total Benefits	103,582	333,801	3,802,040	3,802,040	83,609,835	26,057,406
	Net	-1,459,632	-1,233,413	3,097,982	3,097,982	49,158,878	9,625,698