Kyeamba Valley Landcare Area
Land and Water Management Plan:
Economic Evaluation

July 1999

SOCIO-ECONOMIC SERVICES UNIT
Department of Land and Water Conservation
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ISBN 0734751575

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1 EXECUTIVE SUMMARY

Kyeamba Valley is situated east of Wagga Wagga in southwest New South Wales. Predominantly an agricultural area, it is adversely affected by a rising watertable, which is causing waterlogging and salinity problems. The Kyeamba Land and Water Management Plan (LWMP) is a community-based initiative intended to address such environmental problems as soil salinisation, soil acidification and erosion of gullies and riverbanks. The objective of the Kyeamba LWMP is to seek a level of agricultural development and management that is consistent with sustaining a healthy environment.

An economic evaluation of the proposed land and water management plan was commissioned to quantify the benefits and costs of actions to be undertaken. The evaluation quantified the "No Plan" case and the benefits and costs of the "With Plan" case over time periods of 30 and 50 years using a spreadsheet modelling approach. The analysis provided an indication as to whether the overall Plan was economically viable or not. Economic indicators used were net present values and benefit cost ratios. Because of uncertainty about the extent and impact of degradation throughout the plan area over those time periods, a range of results are presented.

The evaluation of the plan looked at five broad groups of options;

Pasture Options: management of existing native pastures and the replacement of annual pastures with perennial pasture species

Trees, Shrubs and Groundcover Options: planting trees, rehabilitating existing vegetation or controlling weeds and pests that threaten vegetation.

Farm Management Options: application of nutrients, improved rotational grazing techniques and the revegetation of bare areas.

Soil Management Options: directly addressed degradation such as soil acidity, erosion and salinity.

Implementation Options: a general category that included options such as education, administration and performance monitoring. While these options have no direct benefits, they are essential for implementing the plan.

The results are presented in the following tables. Table 1.1 outlines the present value of costs incurred in the plan for both a 30-year timeframe (NSW Treasury guidelines) and a 50-year timeframe (Murray Darling Basin Commission Guidelines).

Table 1.1 Present values of costs of the Kyeamba Land and Water Management Plan

	Project Period (Yrs) :	30	50
	Discount Rate (%) :	7%	5%
		$	$
Project Costs		37,036,808	40,561,211
Recurrent Costs		38,468,368	64,412,643
Renewal Costs		15,538,793	31,771,272
Total (30 Yr Project Period)		**$91,043,970**	**na**
Total (50 Yr Project Period)		**na**	**$136,745,126**

The present values of benefits by category for the plan over 30 years and 50 years are outlined in Table 1.2 and Table 1.3. Clearly, increased carrying capacity due to changes in farm management from annual to perennial pastures was estimated to have a significant impact on the plan outcome. Because much of the data required were not available or there was uncertainty as to exact impacts, the study incorporated calculations using a lower and upper bound of estimated benefits as indicated.

Table 1.2 Present values of benefits of the Kyeamba LWMP over 30 years

	lower bound	upper bound
Discount Rate (%) :	7%	7%
	$	$
Increased carrying capacity*/windbreaks	65,891,651	65,891,651
Sheet and rill erosion	557,754	836,631
Gully erosion	1,250	27,973
Streambank erosion	2,028	6,180
Dryland salinity	75,874	151,748
Waterlogging	2,722,680	7,755,799
Soil acidity	451,187	1,103,935
Weed infestation	17,547	452,845
Road damage (watertables/salinity)	55,698	55,698
Siltation of roads	7,739	18,644
On-farm infrastructure	14,619	30,602
Other infrastructure	26,637	93,231
EC impact at Morgan	534,608	1,135,037
TOTAL	**$70,359,273**	**$77,559,974**

* no distinction between lower and upper bound for increased carrying capacity or the benefits from windbreaks. Note that the increased carrying capacity was $64.6 million, with the balance of $1.3 million due to windbreak benefits.

Table 1.3 Present values of benefits of the Kyeamba LWMP over 50 years

	lower bound	upper bound
Discount Rate (%) :	5%	5%
	$	$
Increased carrying capacity*/windbreaks	104,551,509	104,551,509
Sheet and rill erosion	1,342,026	2,013,040
Gully erosion	6,083	45,836
Streambank erosion	4,173	11,176
Dryland salinity	252,451	504,903
Waterlogging	5,837,303	13,313,352
Soil acidity	928,241	1,778,640
Weed infestation	36,100	733,244
Road damage (watertables/salinity)	148,538	148,538
Siltation of roads	15,847	31,038
On-farm infrastructure	38,682	61,377
Other infrastructure	28,349	99,221
EC impact at Morgan	1,520,371	2,495,072
TOTAL	**$114,709,675**	**$125,786,947**

Final results are shown in **Table 1.4**. The benefit cost ratios of less than one and the negative net present values of the quantified benefits and costs indicate that on these economic criteria the plan is not viable. However, incorporation of the currently unquantified benefits, such as benefits from improved flora and fauna habitats, avoided impacts on downstream users and existence values would be expected to enhance the attractiveness of the plan.

Table 1.4 Results for the Kyeamba LWMP

OVER 30 YEARS

	NSW Treasury	
Guidelines:	lower bound	upper bound
Discount Rate (%) :	7%	7%
Benefit-Cost Ratio :	**0.77**	**0.85**
Net Present Value :	($20,684,697)	($13,483,996)

OVER 50 YEARS

	MD BC	
Guidelines:	lower bound	upper bound
Discount Rate (%) :	5%	5%
Benefit-Cost Ratio :	**0.84**	**0.92**
Net Present Value :	($22,035,451)	($10,958,179)

2 INTRODUCTION

Kyeamba Valley, situated 15 kilometres east of Wagga Wagga in southwest New South Wales, consists of the Kyeamba Creek, Corienbob Creek and Mates Gully catchments, over an area of 100,070 hectares. Predominantly an agricultural area, it is adversely affected by a rising watertable, which is causing waterlogging and salinity problems. Other related issues in the area are soil acidity, soil erosion and weeds. While last century there were extensive areas of white box, iron bark, red gum, stringy bark and grey box, currently significant tree cover is less than 10 percent of the area (ABARE 1996). These changes in natural vegetation have contributed to an increase in groundwater recharge and rising water tables.

The Kyeamba Land and Water Management Plan (LWMP) is a community-based initiative intended to address such environmental problems as soil salinisation, soil acidification and erosion of gullies and riverbanks. The objective of the Kyeamba LWMP is to seek a level of agricultural development and management that is consistent with sustaining a healthy environment. Thus an economic evaluation of the proposed land and water management plan was commissioned to quantify the benefits and costs of actions to be undertaken.

Prior to this study, the LWMP process to date had concentrated on the identification and technical evaluation of the many options for approaching sustainable development, and on the construction of an overall strategy made up of these options that met the community's needs, capabilities and resources.

2.1 STUDY OUTLINE AND OBJECTIVES

This economic evaluation applied a similar economic modelling approach to that used in the irrigated land and water management plans. However, this economic evaluation, in being tailored to the Kyeamba LWMP, required quantification of a broad range of land degradation impacts.

The brief did not require this analysis to consider alternative Plan strategies, but instead accepted a Plan as constituted through the above process of technical research and consensus. The results of this economic analysis cannot therefore be interpreted as an endorsement of the Plan as the most economically efficient way of achieving its objectives. The economic analysis can provide an indication as to whether the overall Plan is economically viable or not. In determining this, the overall Plan was compared to a future without the Plan in order to present only those costs and benefits that can be attributed to the proposed implementation of the Plan.

The purpose of the evaluation was to obtain a practical range of economic results. Technical review was sought from the Kyeamba Valley Landcare group and from DLWC regional staff on a draft economic evaluation report. To facilitate a review and understanding of the complexities of such an evaluation, assumptions used in the evaluation are presented as comprehensively and explicitly as possible.

2.2 STATUS OF THIS REPORT

This final report follows a draft report, which in turn was the successor to an interim report published in December 1996. The interim report laid the groundwork for the economic analysis by documenting the proposed basis on which the analysis would be carried out. Comment from the Kyeamba Valley Landcare group was sought before the analysis commenced, consistent with the basic LWMP principle of keeping the Plan a community-driven process.

The draft report set out the methodology used in the analysis and provided initial results of the economic analysis for discussion and review by the community representatives. This final report is the outcome of that review and differs only slightly in results.

This report comprises the following:

- A description of the economic evaluation process (Section 3);
- A listing of the key economic assumptions and values used in the economic analysis (Section 4);
- A description of the economic methodology employed in analysing such issues as recharge, shallow watertables and soil salinisation (Section 5);
- A description of the economic methodology employed in analysing other land and water degradation issues such as soil acidification, soil erosion and damage to infrastructure (Section 6);
- A presentation of the estimates of the economic impact of natural degradation occurring in the "Do-nothing-at-all" case and the "No Plan" case (Section 7);
- A consolidated list of the options in the Kyeamba Plan being evaluated (Section 8);
- The percentage impacts of the "With Plan " case and "No Plan" case on natural resource degradation. This data contains assumed values and estimates provided by the Kyeamba Valley Landcare group (Section 9);
- The presentation of results and discussion of the economic evaluation (Section 10)

Appended to the report are tables of percentage impact data, road maintenance costs and cost and implementation data for the plan options.

3 ECONOMIC EVALUATION PROCESS

Section 3.1 documents the general methodology used in the evaluation. Similarities and differences with the methodologies used in irrigated LWMPs are discussed. Also, the role of the Interim Report (December 1996) is discussed in Section 3.2.

Methods and assumptions are presented in a detailed and explicit manner throughout this document.

It is understood that no formal process for the economic appraisal of Dryland Plans has yet been set out by State or Federal Governments.

3.1 KEY COMPONENTS OF THE EVALUATION

The approach by which the economic evaluation of the plan was carried out was broadly based on evaluations and modelling conducted for the irrigated LWMPs. However, there were physical processes such as soil acidification and soil erosion which were not assessed in the irrigated LWMPs. This meant that there were aspects of the Kyeamba LWMP evaluation for which there were no precedents in the irrigated LWMP evaluations. In addition, data were not always available in the form required in irrigated LWMP evaluations. Thus a customised approach was required for the assessment of the Kyeamba LWMP.

Following is a summary of the main components of the economic evaluation process.

3.1.1 Specification of the "No Plan" case and the "Do-nothing-at-all" case

The existing information on Kyeamba's natural resource degradation actually referred to the "Do-nothing-at-all" case. This is a hypothetical case where landholders undertake no further action to address natural resource degradation. It is different to the "No Plan" case, in which landholders continue to undertake some works such as liming or planting of perennial pastures, albeit at a slower rate than the "With Plan " case.

By using rigorous definitions for the "Do-nothing-at-all" and "No Plan" cases, it was possible to calculate the losses that would occur in both these scenarios.

3.1.2 Identifying the range of possible impacts of the "With Plan" and "No Plan" cases

Information was obtained as to the likely lower bound and upper bound impacts of the Plan on natural resource degradation losses in the "Do-nothing-at-all" case. These impacts were considered in percentage terms. Similarly, the judgement of the Kyeamba Valley Landcare group was sought as to the impacts of the "No Plan" case on losses that would occur in the "Do-nothing-at-all" case.

A) Recharge reduction (mm) "No Plan":

Upper bound	10%
Lower bound	0%

Recharge reduction (mm) Do Nothing at All

Upper bound	2%
Lower bound	0%

B) Percentage impact of "No Plan" on:

Waterlogging	0 - 15%
Soil acidity	0 - 15%
Gully erosion	0 - 15%
Weeds	5 - 30%
Siltation of roads	1 - 15%
E.C. impact at Morgan	0 - 15%

3.1.3 Identifying option components

The preferred Kyeamba Plan strategy initially comprised 32 options. While this provided the facility for detailed technical appraisal, the choice of so many narrowly defined options created risks of duplication, omission and misinterpretation in evaluating benefits and costs.

In order to avoid these risks, the first step in the evaluation process was to ensure that the list of option components comprising the proposed Plan strategy was in agreement with the community's intentions. The documentation of the options is set out in Section 8. It was intended that the presentation of the options would assist community discussion and understanding of the economic evaluation.

3.1.4 Evaluating generic benefits

The benefits, which arose from the Kyeamba Plan, could be broadly classified as generic benefits and option-specific benefits. Generic benefits were given their title because it was practical to assess these benefits on a broad basis over the whole plan area.

Generic benefits included:

- avoided losses caused by soil salinity;
- avoided losses caused by waterlogging;
- avoided costs from road damage caused by high watertables;
- avoided costs from road damage caused by siltation;

- avoided costs from damage to other infrastructure, caused by salinity and high watertables;
- avoided salinity impacts downstream of the junction of Kyeamba Creek and the Murrumbidgee River;
- avoided losses caused by soil acidification; and
- avoided losses or costs caused by sheet, rill, gully and streambank erosion.

Generic benefits were calculated by:

- estimating Kyeamba's natural resource degradation losses which would occur in the "Do-nothing-at-all" case;
- deriving or using judgement to obtain lower bound and upper bound percentage impacts of the "No Plan" case on land and water degradation;
- adopting lower bound and upper bound percentage impacts of the "With Plan" case on land and water degradation;
- subtracting the "No Plan" impacts from the "With Plan" impacts to establish the impacts which can be attributed to the Kyeamba LWMP itself; and
- applying the resultant percentage impacts to the losses occurring the in "Do-nothing-at-all" case.

At this stage it was assumed that all farms involved in the Plan were uniform. However, in assessing the benefits of salinity control, a distinction was drawn between the different terrain classes.

3.1.5 Evaluating individual option benefits and costs

In this evaluation, option-specific benefits referred only to those benefits arising from "new" productivity, rather than the avoidance of losses. These benefits would accrue to the particular landholder who implemented a given plan initiative.

Option-specific benefits included:

- agricultural yield increases due to switches between pasture species;
- agricultural yield increases due to the impacts of windbreaks from increased tree cover
- agricultural yield increases due to improved soil fertility and soil structure.

The study identified and quantified the increases in carrying capacity with the proposed change from annual to perennial pastures. As well, net benefits were calculated due to the positive impact of windbreaks on productivity. Applying net benefits took into account the foregone income from the loss of production of those areas planted to trees for windbreaks.

3.1.6 Overall plan evaluation

Equipped with the generic benefits and the costs and benefits associated specifically with the Plan options, an economic cash flow model was constructed representing the entire Plan over both a 30 year evaluation period and a 50 year evaluation period.

This cash flow model was developed by the Resource Economics Group in the Department of Land and Water Conservation to NSW Treasury standards according to its *Guidelines for Economic Appraisal* (NSW Treasury 1990). The model is able to test the economic impacts of changes in key data and assumptions. This feature enables various sensitivity tests to be undertaken to determine the Plan's economic robustness.

3.2 THE ROLE OF THE INTERIM REPORT (DECEMBER 1996)

An interim economic report, which laid an initial groundwork for the economic analysis, was produced in December 1996. The reaction of the Working Group to this groundwork was sought so that modifications and improvements could be incorporated in the economic evaluation.

The interim report set out the following three groundwork components for community scrutiny and comment:

- A detailed listing and definition of the Plan strategy components;
- A listing of the key economic assumptions and methods to be used in the economic analysis; and
- A summary of the process intended to be used for the economic assessment of the proposed Plan.

The Interim Report (December 1996) had adopted the type of approach used in irrigated LWMPs. However, after its release, it became apparent that a more "customised" approach to the evaluation of the Kyeamba LWMP was required.

One major change was that data for the impact of the Plan on land and other degradation was then obtained on a plan wide basis, not an option-by-option basis. While this approach still had similarities to the approach used in the main economic assessments of irrigated LWMPs, there were two important differences:

- a range of economic results was generated, rather than one result; and
- the percentage impact of the overall Plan was used to determine the impacts of the Plan on different forms of land and water degradation.

One advantage of this range approach is that it makes explicit the degree of certainty as to the Plan's impacts. Another advantage is that it enables the designers of the Kyeamba LWMP to exercise judgement as to the impacts of the LWMP. That is, the analysis is not solely confined to areas where "hard data" exists.

While none of the main economic evaluations of irrigated LWMPs used percentage impacts as input, the Murray-Darling Basin Commission's "Drainage Evaluation Spreadsheet Model" (DESM) reads in such inputs. Therefore, there is a general precedent for using percentage data as input.

4 ECONOMIC ASSUMPTIONS

4.1 RATIONALE OF THE "NO PLAN" CASE

The "Guidelines for Land and Water Management Plans", developed by the Murray and Murrumbidgee Catchment Management Committees, specify that the Plan strategy is to be presented against a "No Project" or ""No Plan"" case. This separates the benefits and costs of the Plan from those benefits and costs that would occur in the absence of a Plan. This scenario has a range of titles, including: "No Plan" scenario; "No Plan" case, "No Project" scenario; and "Base" case.

In this document, the scenario without a plan is referred to as the "No Plan" case. The comparison of any project or plan against a "No Plan" case is a conventional approach to economic feasibility evaluations, and is also a requirement of the "NSW Government Guidelines for Economic Appraisal" (NSW Treasury; 1990; pgs 51-52).

The "No Plan" case is defined as the future that can be expected to take place without the implementation of the proposed Plan. The "No Plan" case does not assume that nothing will change. Indeed, the recent past indicates that the Kyeamba agricultural community will continue to find imaginative and constructive ways to safeguard sustainable agriculture that is both commercially and environmentally viable even without the Plan. One of the main roles of the Plan is to further and accelerate this process by advocating a concerted community-wide effort and by seeking public funding assistance to support its cause.

This evaluation has made a distinction between the "No Plan" case and the "Do-nothing-at-all" case. As discussed in Section 3.1, the "Do-nothing-at-all" case is a hypothetical situation where landholders undertake no further action to address natural resource degradation. It is different to the "No Plan" case, in which landholders continue to undertake some works such as liming or planting of perennial pastures. For the purpose of estimating economic losses caused by natural resource degradation, it was important to distinguish between the "No Plan" case and the "Do-nothing-at-all" case.

4.2 STUDY AREA

The Kyeamba LWMP area covers 100,070 hectares. Most of the agricultural land use is used for grazing, with approximately 5% of the area cultivated each year for wheat, oats, lucerne or pasture improvement (Kyeamba Valley Landcare Group, undated, Section D). A list of Kyeamba's general land uses is provided below.

Table 4.1 Agricultural and other land uses in Kyeamba Valley

Land use class	area (ha)
Pasture	89,370
Cropping	5,020
Timber	5,650
Water	4
Urban	11
Quarries	15
Total	**100,070**

Source: Kyeamba Valley Landcare Group; undated; Table 4.

4.3 CROP MIX AND AGRO-ECONOMIC DATA

The economic spreadsheet model developed to assess this plan assumed that oats, perennial pasture and annual pasture were Kyeamba's agricultural land uses. This indicated that the gross income value of production was $11.6 million while the gross margin value of production was $8.2 million.

Table 4.2 Land uses in the Kyeamba Valley Plan Area

Land use class	area (ha)	%
Annual pasture	68,795	73
Perennial pasture	20,575	22
Oats	5,020	5
Total	**94,390**	100

Source: Greg Bugden (Nov 1996); Kyeamba Valley Landcare Group; (undated; Table 4).

Cost, price and yield data were obtained for the farming activities. The data, presented in Table 4.3 were used to derive gross margins and gross incomes as presented in Table 4.4.

Table 4.3 Initial cost, price and yield data

Crop / Pasture	establish. cost (a) $/ha	maint. cost (a) $/ha	variable cost (a) $/ha	production (a) units/ha	on-farm price (b) $/unit
Annual pasture	21	17	20	5.7	16.67
Perennial pasture	211	37	69	11.6	16.67
Oats	121	0	121	2.2	100.00

Sources: (a) ABARE (1996), p.64; (b) ABARE (1995), p. 57.

Table 4.4 Derived gross income and gross margin

Crop / Pasture	gross income ($/ha)	gross margin ($/ha)
Annual pasture	95.0	75.0
Perennial pasture	193.4	124.4
Oats	220.0	99.0

Source: Derived from ABARE (1996).

4.4 DERIVED ECONOMIC UNIT IMPACTS OF LAND AND WATER DEGRADATION

For all types of generic benefits, a corresponding natural resource degradation unit loss in the "Do-nothing-at-all" case was estimated. These losses were calculated on a per hectare or per kilometre basis. That is, the impact of a particular form of resource degradation on a hectare or kilometre basis was derived. This provided a practical link between technical data and economic results. Also, the calculation of unit impacts enabled ease of comparison with other economic studies on Kyeamba.

Table 4.5 Derived unit economic impacts of land and water degradation

Form of land / water degradation	unit	annual loss/unit	results in prior studies	
			Thorne (a)	ABARE (b)
Sheet and rill erosion (minor)	$/ha	8.70	9.50	na
Sheet and rill erosion (mod-severe)	$/ha	43.50	47.50	na
Gully erosion	$/ha	87.10	95.00	na
Streambank erosion	$/ha	87.10	95.00	na
Dryland salinity	$/ha	30.70	34.20	32.40
Waterlogging	$/ha	na	66.50	na
Waterlogging - flooding	$/ha	123.10	na	na
Waterlogging - ordinary	$/ha	8.20	na	na
Soil acidity *	$/ha	*2.20	10.00	na
Weed infestation	$/ha	1.23	0.95	na
Road damage	$/valley	633,000	200,000	212,400
Siltation of roads	$/valley	3,000	3,000	na
On-farm infrastructure	$/ha	0.80	na	0.80
Other infrastructure	na	na	na	na
EC impact at Morgan (Year 1)	$	96,676	not given	97,000
EC impact at Morgan (Year 30)	$	133,595	not given	135,000

*The soil acidity losses were calculated for current crop and pasture activities which are currently affected. The foregone potential to plant further perennial pastures on acidified areas was not included. For the purpose of calculating benefits, the higher carrying capacity of perennial pastures was included elsewhere in the analysis. Further discussion is provided in Section 6.

na- 'not available'
(a) Thorne (1991). (b) ABARE (1996)

4.5 LAND AND WATER DEGRADATION IN THE "DO-NOTHING-AT-ALL" CASE

As discussed in Section 3.1, the "Do-nothing-at-all" case referred to the hypothetical situation in which landholders ceased to undertake works to combat land and water degradation. That is, there would be no liming, planting of perennial pastures or similar measures. Areas discussed below refer to those affected by land and water degradation in the "Do-nothing-at-all" case.

It was assumed that 14,970 ha would be affected by sheet and rill erosion. Also, gully erosion and streambank erosion would affect 80 ha and 18 ha in the "Do-nothing-at-all" case, respectively. The analysis adopted the assumption that the areas affected by the different forms of erosion would remain constant over the next 50 years (. G. Bugden; March 1997).

Data on the extent of dryland salinity were available for 1991 and a forecast was available for 2020. The respective estimates of areas affected by salinity were 218 ha and 11,000 ha (ABARE 1996; p.52). The analysis assumed a linear rate of increase between these years. A further assumption was that the same rate of increase would extend from 2020 to 2047 (Year 50 of the Plan).

In 1991, the area in Kyeamba affected by waterlogging was estimated to be 24,430 ha (Thorne; 1991; p.5). It was also estimated that this area would increase to 33,000 ha by 2005. This is consistent with a rate of increase of 612 ha per year. The Kyeamba Valley Landcare group indicated that it would be reasonable to assume that this rate of increase would persist over the next 50 years (. G Bugden; DLWC; November 1996).

It was assumed that, on average, 8,230 ha of the Kyeamba Valley experienced losses caused by flooding. It was also assumed that ordinary waterlogging would affect 24,430 ha, 46,467 ha and 58,710 ha in Years 1, 30 and 50 respectively. The potential waterlogging caused by high watertable conditions was estimated at 17,000 ha. The evaluation also assumed that the increase in the area affected by ordinary waterlogging would be driven by rising watertable conditions.

The areas affected by soil acidity and weed infestation in the "Do-nothing-at-all" case were assumed to be 95,067 ha and 66,073 ha respectively.

Roads currently affected by shallow watertables would be 5% in the first year and the proportion was likely to be 10% in 30 years time (Allan Pottie, Wagga Wagga City Council, Asset Manager). The proportion of roads affected would be similar across the three categories of roads (ie regional sealed roads, other sealed roads and unsealed roads). The potential cost to road maintenance caused by shallow watertables was estimated to be $9,395 in year 1, $40,554 in year 30 and $54,537 in year 50.

Similarly an estimate of $3,000 per annum was used for the road costs due to siltation (Thorne; 1991; p.6).

It was assumed that on-farm infrastructure within the area affected by dryland salinity would be subject to damage from the soil salinity. This is not to say that damage to on-farm infrastructure literally occurs on the areas presented in the table below. Rather, these are potential areas of damage. A low unit loss estimate of $0.80 per hectare was applied, to reflect this fact (ABARE; 1996; p.53).

The analysis assumed the current rate of salt load increase would persist for the next 50 years. Thus it was assumed that surface water and groundwater combined would generate a 3.58 EC increase in the salinity at Morgan in year 50.

The technical data used to estimate the economic impacts of salt loads were drawn from prior economic studies. Also, extrapolation was applied to determine impacts after year 30, as mentioned above. Further discussion of the estimation of the impacts of salt loads leaving Kyeamba is in Section 6.13.

Table 4.6 Extent of degradation in the "Do-nothing-at-all" case

Form of degradation		Year 1	Year 30	Year 50
Sheet and rill erosion	ha	14,970	14,970	14,970
Gully erosion	ha	80	80	80
Streambank erosion	ha	18	18	18
Dryland salinity	ha	2,821	13,603	21,038
Waterlogging	ha	28,715	46,467	58,710
Soil acidity	ha	95,067	95,067	95,067
Weed infestation	ha	66, 073	66, 073	66, 073
Road damage	$/pa	9,395	40,554	54,537
Siltation of roads	$/pa	3,000	3,000	3,000
On-farm infrastructure	ha	2,821	13,603	21,038
Other infrastructure		na	na	na
EC impact at Morgan	EC	0.84	2.46	3.58

Source: ABARE (1996); Thorne (1991); Greg Bugden (November 1996); DLWC Resource Economics and Sociology Unit
na 'not available'

4.6 LAND AND WATER DEGRADATION IN THE "NO PLAN" CASE

At this stage of the evaluation, the losses in the "No Plan" case were not expressed in physical terms. Instead, physical and economic losses were determined for the "Do-nothing-at-all" case, and percentage impacts were applied to determine economic losses in the "No Plan" case.

A) Recharge reduction (mm) "No Plan"

Upper bound	10%
Lower bound	0%

"With Plan" target 40mm/year

B) Percentage impact of "No Plan" on

Waterlogging	0 - 15%
Soil acidity	0 - 15%
Gully erosion	0 - 15%
Weeds	5 - 30%
Siltation of roads	1 - 15%
E.C. impact at Morgan	0 - 15%

4.7 ECONOMIC EVALUATION PARAMETERS

There were certain basic parameters in the process of economic evaluation of a project, which were incorporated in the evaluation. These parameters are discussed below.

4.7.1 Input of technical data

The technical data used for the economic analysis was taken for the most part from a previous economic study by the former Department of Conservation and Land Management (Thorne; 1991), an economic study by ABARE (1996) and technical investigations carried out by Department of Water Resources scientific officers (Woolley; 1991).

4.7.2 Project evaluation period

Normally, the project life adopted for financial or economic evaluation reflects the expected economic life of the principal asset. However, as specified by NSW Treasury, with assets that have a very long life, a cut-off point should be imposed and a residual value for the asset at that cut-off point calculated. In such cases a project life of preferably 20 years, but no more than 30 years, should be used.

On the other hand, the MDBC specifies that a project life of 50 years be used and a discount rate of 5 per cent per annum (MDBC; 1995a; p.53). Therefore, all cashflows in this economic model were constructed over 50 years, with the facility for deriving economic results for both 30 year and 50 year evaluation periods.

4.7.3 Treatment of residual values

Residual values are normally included in an evaluation where relevant. The economic residual value of an asset at the end of the evaluation period is estimated to be a weighted average of the asset's project costs over time. The weights varied according to the year in which the project cost is incurred; the earlier the year, the smaller the weight. The Kyeamba Valley Landcare Group advised that there would be no physical assets with a resale or reuse value at the end of year 30 or year 50. Therefore, there were no residual values of assets calculated for this evaluation.

Because of the long timeframes of the study, 30 years and 50 years, there were also no residual values of benefits calculated. However, in reality, the ongoing benefits of the plan would be expected to continue well past the study time.

4.7.4 Discount rate selection

In order to compare the costs and benefits flowing from a project over a period of many years, it was necessary to adjust them to a common time dimension that took account of the time value of money. This was done by discounting the value of future costs and benefits in order to determine their present value. The process of discounting was simply compound interest worked backwards. It is applied to future sums to show what their value would be in today's dollars.

To determine the net present value (NPV) and benefit cost ratio (BCR) of the various options under consideration, a discount rate of 7% per annum was used as per the requirements of NSW Treasury. In addition, a discount rate of 5% was used in accordance with MDBC requirements (MDBC; 1995a; p.53). As well, alternative discount rates of 4% and 10% were used in the sensitivity analysis.

5 METHOD FOR ASSESSMENT OF SOIL SALINISATION AND SHALLOW WATERTABLES

The areas of the Plan which were assessed in the most detail were soil salinisation and watertable conditions. A separate discussion of these issues is provided in Section 5.

5.1 SOIL SALINISATION

Data were available for areas of land affected by salinisation, according to different levels of severity. These different levels were termed “affected by severe salt scalds”, “minor to moderate scalds” and “early stages of development as a salt scald”. It was assumed that this set of descriptions referred to soil salinity ranges 8-16 dS/m, 4-8 dS/m and 2-4 dS/m (Kyeamba Valley Landcare Group, undated, Issues 2 & 3).

A simplifying assumption was made that while the overall area salinised would increase, the proportions of areas affected by different severities of salinity would remain constant. It was also assumed that there would be no area affected by soil salinity greater than 16 dS/m.

Table 5.1 Salinity affected areas in 1991

Soil salinity level	assumed dS/m range	area (ha)	%
Affected by severe salt scalds	8-16	20	9
Minor to moderate scalds	4-8	45	21
Early stages of scald development	2-4	153	70
Total		218	100

Source: Kyeamba Valley Landcare Group; undated; Issues 2&3.

5.1.1 Physical impact of soil salinity on pasture and crop yields

The biological effects of soil salinity on crops and pasture were modelled in terms of yield loss of the characteristic species at various degrees of soil salinity. There is a general threshold at which a given crop or pasture will start to experience yield loss (MDBC 1995a; Chpt 4). The assumed impacts of soil salinity on yields are shown below.

Table 5.2 Impact of soil salinity on yields

Soil salinity level	likely range dS/m	centre of range	% loss at centre of range		
			annual pastures	perennial pastures	oats
Severe salt scalds	8-16	12	100.0	93.6	100.0
Minor to moderate scalds	4-8	6	70.5	39.6	40.3
Early stages of scald development	2-4	3	25.5	12.6	1.3

Source: MDBC (1995a), p.14. The crop mix and agro-economic data (presented in Section 4.3) were used to derive the above table.

5.2 ECONOMIC IMPACT OF SOIL SALINITY ON PASTURES AND CROPS

The quantification of soil salinity impacts required assumptions relating to the impact of salinity induced losses on the cost structure of affected farms as discussed in the MDBC report (1995a). On the one hand, it could be assumed that farmers maintained the same level of inputs on salinised areas, but obtained reduced output. On the other hand, farmers could adjust their inputs to take account of the declining levels of outputs.

The true position is likely to lie between the two extremes. During the initial phases of salinisation when the impacts are hard to detect, farmers are likely to utilise the same inputs. However, after the effects of salinisation become apparent, it is possible for farmers to accordingly adjust their cost structures (MDBC, 1995a; p. 9).

In line with the recommendations of MDBC (1995a), it was assumed farmers immediately adjusted their inputs to take account of the declining levels of outputs. For the purposes of quantification, this meant that gross margin data were used (as opposed to gross income data).

Equipped with gross margin data (presented in Section 4.3) and the yield loss effects of salinity, it was possible to derive dollar impacts of salinity. These derived impacts are presented below.

Table 5.3 Economic impact of soil salinity on pastures and crops

Soil salinity level	likely range	centre of range	$ loss/ha		
	dS/m		annual pastures	perennial pastures	oats
Severe scalds	8-16	12	75	116	99
Minor – moderate	4-8	6	53	49	40
Early stages	2-4	3	19	16	1

5.2.1 Derivation of average per hectare soil salinity losses

Firstly, weights were derived based on the areas affected by different levels of salinity. Next, these weights were used to derive weighted average impacts for each pasture and crop. Thirdly, weights were calculated based on the area devoted to each crop and pasture. Finally, these percentage results were used to weight the impacts on each crop and pasture. The result was a weighted average impact for the whole Kyeamba Valley, with an estimate that on average (ie across all pasture/crop types and soil salinity levels), the economic impact of soil salinisation would be $30.70 per hectare.

The calculation of the average impact of soil salinity is shown in Table 5.4.

Table 5.4 Calculation of the average economic impact of soil salinity on the Kyeamba Valley

Salinity affected areas	area(ha)	salinity area weight (%)	salinity area weight * loss $/ha annual pastures	perennial pastures	oats
Affected by severe salt scalds	20	9.2	6.9	10.7	9.1
Minor to moderate scalds	45	20.6	10.9	10.2	8.2
Early stages of scald development	153	70.2	13.4	11.0	0.9
Total loss for given crop / pasture ($/ha):			31	32	18
Weight to reflect crop / pasture area:			73%	22%	5%
Weighted average soil salinity loss for Kyeamba Valley($/ha):					**30.70**

5.2.2 Relationship between recharge, shallow watertables and soil salinity

Extensive literature is available on the processes leading to soil salinisation. While recognising these complex processes, it was necessary to simplify the modelling. In particular, assumptions were required to model the links between recharge and soil salinity. This was because most of the available technical data were expressed in terms of recharge or recharge reduction.

In the economic analysis, there were assumed to be two important lags between recharge and the onset of salinity:

- the lag between water seeping through the ground and occurrence of increased shallow watertables (the recharge - shallow watertable lag); and
- the lag between the occurrence of a new shallow watertable area and the onset of soil salinity above the new area (the shallow watertable - soil salinity lag).

As a result of the above reasoning, it was further assumed that reductions in recharge would not lead to an immediate benefit in terms of avoided soil salinity losses. It might take several years to achieve such a benefit, and even more years to achieve maximum effect.

The exception to this rule is tree planting. Once trees are relatively mature, their root system actively lowers the watertable and reverses the soil salinisation process.

This study assumed that recharge reductions would either have no impact on soil salinity during the lead-time, or would have full impacts after the lead-time. The lags assumed in the analysis are set out below. A range of estimates was used in the analysis.

Table 5.5 Default lags between recharge and soil salinity

Land type	recharge - shallow watertable lag (range in years)	shallow watertable - soil salinity lag (range in years)
Drainage plains	1 - 4	1 – 4
Flood plains	2 - 10	2 – 10
Foot slopes	1 - 4	1 – 4
Mid side slopes	2 - 10	2 – 10
Upper side slopes	10 - 20	10 – 20
Crests	30 - 50*	30 – 50*

** It is unlikely that there would be shallow watertables below crests.*

5.2.3 Assessment of recharge rates in the Kyeamba Valley

As the impact of the Kyeamba Plan on soil salinity was expressed in terms of recharge reduction (mm/year) for the whole plan area, it was necessary to derive the average level of recharge that currently occurs in Kyeamba.

The Kyeamba Valley Landcare Group advised that the average watertable was rising at a rate of 0.5 metre per annum. The recharge rate is likely to be between 40 mm and 45 mm per year (Pers comm, Greg Bugden, Oct 1997). Therefore, an average recharge rate of 42.5 mm per annum was adopted in the economic assessment.

As the recharge rate in the "Do-nothing-at-all" case was assumed to be 42.5 mm per year it was estimated that the Kyeamba Plan would cause a 47% - 94% reduction in recharge.

5.2.4 Physical impact of the Kyeamba LWMP on soil salinity

As discussed, the analysis allowed for the lag between reductions in recharge rates and the resultant impact on soil salinity conditions. That is, there is a lead-time before recharge-reducing activities such as planting perennial pastures would have an impact on soil salinity. The simplifying assumption was made that recharge reductions would either have no impact on soil salinity during the lead-time, or would have full impact after the lead-time.

For the evaluation, a range of time lags was used to generate lower bound and upper bound estimates of the impact of the Kyeamba Plan on soil salinity.

The lower bound estimates were based on:

- recharge - shallow watertable lags of 10 years for each land type;
- shallow watertable - soil salinity lags of 10 years for each land type; and
- an assumed recharge reduction of 20 mm per year in the "With Plan" case (relative to the "Do-nothing-at-all" case).

The upper bound estimates were based on:

- recharge - shallow watertable lags of 2 years for each land type;

- shallow watertable - soil salinity lags of 2 years for each land type; and
- an assumed recharge reduction of 40 mm per year in the "With Plan" case (relative to the "Do-nothing-at-all" case).

The estimates of the percentage reduction in the area salinised, derived using the above assumptions, are presented in Table 5.6. Under the lower bound estimates, the percentage reductions in area salinised due to implementation of the plan were 15.8% in year 30 and 25.4% in year 50, compared to higher estimates of 31.6% and 50.7 % respectively.

Table 5.6 Estimates of the percentage reduction in the area salinised: the "With Plan" case compared to the "No Plan" case

Lower bound estimates

Year	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
%	**0%**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.2**
Year	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
%	**0.4**	**0.8**	**1.2**	**1.7**	**2.4**	**3.1**	**3.9**	**4.8**	**5.8**	**6.9**
Year	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*
%	**8.2**	**9.6**	**11.2**	**11.6**	**12.0**	**12.6**	**13.2**	**14.0**	**14.8**	**15.8**
Year	*31*	*32*	*33*	*34*	*35*	*36*	*37*	*38*	*39*	*40*
%	**16.8**	**18.0**	**19.2**	**20.6**	**22.0**	**22.0**	**22.0**	**22.0**	**22.0**	**22.0**
Year	*41*	*42*	*43*	*44*	*45*	*46*	*47*	*48*	*49*	*50*
%	**22.0**	**22.1**	**22.3**	**22.5**	**22.8**	**23.2**	**23.6**	**24.2**	**24.7**	**25.4%**

Upper bound estimates

Year	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
%	**0%**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.1**	**0.4**
Year	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
%	**0.9**	**1.5**	**2.4**	**3.5**	**4.7**	**6.1**	**7.8**	**9.6**	**11.6**	**13.8**
Year	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*
%	**16.3**	**19.2**	**22.5**	**23.2**	**24.1**	**25.2**	**26.5**	**28.0**	**29.7**	**31.6**
Year	*31*	*32*	*33*	*34*	*35*	*36*	*37*	*38*	*39*	*40*
%	**33.6**	**35.9**	**38.4**	**41.1**	**44.0**	**44.0**	**44.0**	**44.0**	**44.0**	**44.0**
Year	*41*	*42*	*43*	*44*	*45*	*46*	*47*	*48*	*49*	*50*
%	**44.1**	**44.3**	**44.6**	**45.1**	**45.7**	**46.4**	**47.3**	**48.3**	**49.5**	**50.7%**

5.2.5 Physical impact of the Kyeamba LWMP on shallow watertables

The impact of the Kyeamba LWMP on watertable conditions was assessed in a similar manner to the Plan's impact on soil salinity. However, the only lag considered was the recharge - shallow watertable lag. That is, the shallow watertable - soil salinity lag was not included.

The results are shown in Table 5.7. Under the lower bound estimates, the percentage reductions in area affected by shallow watertables due to implementation of the plan were 42.5% in year 30 and 47.1% in year 50, compared to higher estimates of 85.1% and 94.1 % respectively.

Table 5.7 Estimates of the percentage reduction in the area with shallow watertables: the "With Plan" case compared to the "No Plan" case

Lower bound estimates

Year	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
%	**0%**	**0**	**0**	**0**	**1.6**	**3.2**	**4.7**	**6.3**	**7.9**	**9.5**
Year	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
%	**12.1**	**14.5**	**17.3**	**19.9**	**22.6**	**25.2**	**27.8**	**30.4**	**33.0**	**34.1**
Year	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*
%	**35.4**	**36.8**	**38.2**	**39.5**	**40.9**	**41.2**	**41.6**	**41.9**	**42.2**	**42.5**
Year	*31*	*32*	*33*	*34*	*35*	*36*	*37*	*38*	*39*	*40*
%	**43.1**	**43.6**	**44.1**	**44.6**	**45.1**	**45.3**	**45.5**	**45.7**	**45.9**	**46.1**
Year	*41*	*42*	*43*	*44*	*45*	*46*	*47*	*48*	*49*	*50*
%	**46.3**	**46.5**	**46.7**	**46.9**	**47.1**	**47.1**	**47.1**	**47.1**	**47.1**	**47.1%**

Upper bound estimates

Year	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
%	**0%**	**0**	**0**	**0**	**3.2**	**6.3**	**9.5**	**12.6**	**15.8**	**19.0**
Year	*11*	*12*	*13*	*14*	*15*	*16*	*17*	*18*	*19*	*20*
%	**24.2**	**29.4**	**34.7**	**39.9**	**45.1**	**50.4**	**55.6**	**60.8**	**66.1**	**68.1**
Year	*21*	*22*	*23*	*24*	*25*	*26*	*27*	*28*	*29*	*30*
%	**70.9**	**73.6**	**76.3**	**79.1**	**81.8**	**82.4**	**83.1**	**83.8**	**84.4**	**85.1**
Year	*31*	*32*	*33*	*34*	*35*	*36*	*37*	*38*	*39*	*40*
%	**86.1**	**87.1**	**88.2**	**89.2**	**90.3**	**90.7**	**91.0**	**91.4**	**91.8**	**92.2**
Year	*41*	*42*	*43*	*44*	*45*	*46*	*47*	*48*	*49*	*50*
%	**92.6**	**93.0**	**93.3**	**93.7**	**94.1**	**94.1**	**94.1**	**94.1**	**94.1**	**94.1%**

5.2.6 Benefits of avoided soil salinity losses

The benefits of avoided soil salinity losses were calculated as being:

- the percentage reduction in the area affected by soil salinity (deducting the impact of the "No Plan" case from the "With Plan" case's impact); multiplied by
- the economic losses occurring in the "Do-nothing-at-all" case.

A summary of the estimated benefits of avoided salinity losses is provided in Table 5.8. Over a period of 30 years, implementation of the plan would result in avoided losses of from $76,000 to $152,000 (present values).

Table 5.8 Estimates of the benefits of avoided salinity losses

	lower bound	upper bound
Year 1 Benefit	$11	$22
Year 10 Benefit	$2,468	$4,935
Year 30 Benefit	$31,453	$62,906
Year 50 Benefit	$67,208	$134,417
Present Value (30 yr, 7%)	$75,874	$151,748
Present Value (50 yr, 5%)	$252,451	$504,903

6 METHOD FOR ASSESSMENT OF OTHER ON-FARM AND OFF-SITE EFFECTS

6.1 INCREASED AREAS UNDER PERENNIAL PASTURES

Several reports that contributed to the Kyeamba LWMP contained the main recommendation replacing annual pastures with perennial pastures throughout the Kyeamba Valley (ABARE; 1996; and Kyeamba Valley Landcare group; undated). The perennial pasture species use more soil moisture than annual pasture species and therefore reduce recharge, compared with existing annual pastures. Another benefit is that perennial pastures have a higher carrying capacity.

This study considered several methods of quantifying the change from annual to perennial pastures. One was the representative price received for fat lamb and wool production from an ABARE (1995) study. The price was $16.67 per dry sheep equivalent (DSE) (ABARE; 1996; p.57).

The carrying capacities of annual and perennial pastures were assumed to be 5.7 DSE/ha and 11.6 DSE/ha respectively. Also, the analysis used variable costs of $20/ha and $69/ha for annual pastures and perennial pastures respectively (ABARE; 1996; p.64). The resultant gross incomes were $95/ha and $193/ha for annual pastures and perennial pastures, while the respective gross margins where $75/ha and $124/ha. Therefore the farm revenue increase attributed to the switch from annual to perennial pastures would be $98/ha (rounded).

The assessment of pasture losses caused by soil salinity and erosion was based on gross income and variable cost data. However, the analysis of the farm revenue increase from switching pastures used gross income, establishment cost and maintenance cost data.

This is a critical part of the Kyeamba LWMP. The literature indicated that data on pasture conversions varied substantially. In some cases, estimates of gross incomes and gross margins were much higher than those used in ABARE (1996), while in other cases the estimates were considerably lower. The results presented in this study applied a marginal gross margin increase of $127 per hectare, based on a review of the literature.

6.2 BENEFITS FROM TREE PLANTING

Estimates of the benefits of windbreaks from increased areas being planted to trees were included in the analysis. These estimates were based on the increase in productivity of pastures due to windbreaks (Hill 1996, p 10). The study assumed that the areas being planted to trees (options T02-06 and T9-10 in Table 8.1) provided an average of equivalent area increases in pasture productivity. The benefits were calculated at $10 per hectare. There would be other benefits from tree planting such as increased and improved habitats as well as aesthetic values. These values were not quantified.

6.3 SHEET AND RILL EROSION

Shallow “sheets” of water flowing over the soil surface cause sheet erosion. These very shallow moving sheets of water are seldom the detaching agents, but the flow transports soil particles that have been detached by raindrop impact. The shallow surface flow rarely moves as a uniform sheet for more than a few feet before concentrating in the surface irregularities (Goldman *et al*; 1986; p.1.6).

Rill erosion begins when shallow surface flow starts to concentrate in low spots in the soil surface. As the flow changes from sheet flow to deeper flow in these low areas, the velocity and turbulence of flow increase. The energy of this concentrated flow is able to both detach and transport soil particles. This action begins to cut tiny channels called rills. Rills are small but well-defined channels that are at most only a few inches deep (Goldman *et al*; 1986; p.1.6).

It was assumed that 14,970 ha would be affected by sheet and rill erosion. As mentioned, in Section 4.5, it was predicted that the areas affected by sheet and rill erosion would remain constant over the next 50 years (G. Bugden; March 1997).

The areas experiencing moderate to severe types of sheet and rill erosion covered 2,160 ha while the areas experiencing minor effects covered 12,810 ha. The production losses on these areas were believed to be 50% and 10% respectively (Thorne; 1991; p.2). A weighted average annual gross production of $87/ha was derived (using the simplified agro-economic data discussed in Section 4.3). From this, loss estimates of $43.50/ha and $8.70/ha were derived for moderately-severely affected areas and minor affected areas respectively.

6.4 GULLY EROSION

Gully formation is a complex process. Some gullies are formed when runoff cuts rills deeper and wider or when the flows from several rills come together and form a large channel. Water flowing over the headwall of a gully causes under-cutting. In addition, large chunks of soil can fall from a gully headwall. This soil is later carried away by stormwater runoff (Goldman *et al*; 1986; p.1.6).

It was assumed that gully erosion would affect 80 hectares in the Kyeamba Valley, and that this area would remain the same over time (G. Bugden; March 1997).

6.5 STREAMBANK EROSION

A total length of 93.5 km of streambank is affected by erosion. It is characterised by undercutting of the streambank, or by flows over the bank severely rilling the sides of the bank. In many cases, particularly in Tarcutta Creek, willows have created islands or obstructions which diverted flows into adjacent banks and undermined them (Kyeamba Valley Landcare Group, undated ; Issues 5 & 6).

The estimate used in the economic evaluation was that 18 hectares were currently affected by streambank erosion (Thorne; 1991; p.3). As for the other types of erosion, it was assumed that the extent of this degradation would remain constant over the next 50 years.

6.6 WATERLOGGING

The economic evaluation sought to divide "waterlogging" into the following three categories:

- waterlogging caused by high watertable conditions estimated to be 17,000 ha;
- ordinary waterlogging - that is, waterlogging caused by surface ponding of water for short periods of time estimated at 24,430 ha; and
- flood events affecting 8,230 ha.

For the purposes of this study the first two categories of waterlogging were combined under the title "ordinary waterlogging".

In order to quantify the impacts of flooding and ordinary waterlogging, loss coefficients from the Murray Darling Basin Commission's "Drainage Evaluation Spreadsheet Model" (MDBC, 1995b) were used with some adjustment for Kyeamba's agricultural activity being dryland.

A "topography coefficient" of 60% was used to adjust ordinary waterlogging losses. This coefficient reflected the fact that the total area containing waterlogging-prone soils would sometimes be in elevated locations. Such higher areas would not actually suffer waterlogging. The value of 60% is the default estimate used in the MDBC's Drainage Evaluation Model and was applied to the Kyeamba LWMP evaluation (MDBC; 1995b; p.18).

The data for ordinary waterlogging or "micro-waterlogging", as per MDBC (1995a), were based on irrigated crops and pastures. In irrigated areas, micro waterlogging is caused by waterlogging due to irrigation and waterlogging due to rainfall. At present, the proportions of micro-waterlogging losses caused by rainfall and by irrigation are not known. However, this evaluation adopted the assumption that 50% of ordinary waterlogging losses were caused by rainfall in irrigated areas. Thus, the loss coefficients applicable to irrigated areas were multiplied by 50% to obtain loss coefficients for dryland crops and pastures.

Losses from waterlogging and flooding were assumed to be a function of gross income, not gross margin. This was because waterlogging and flooding events cannot be easily anticipated. By contrast, salinisation losses were assumed to be a function of gross margin. Salinised areas can be identified, once they are significantly affected, and farm activity can be suitably adjusted. Thus, there is some justification for assuming that both production and variable costs would be lower or nil on salinised areas. In the case of waterlogging and flooding affected areas, it was assumed that only production would be lower.

Table 6.1 Gross income and yield effect data for ordinary waterlogging and flooding

		Irrigated crops/pastures: yield loss due to:	
Crop / Pasture	gross income ($/ha)	ordinary waterlogging (a)	flooding (b)
Annual pasture	95	21%	100%
Perennial pasture	193	24%	100%
Oats	220	24%	100%

Source : (a) MDBC; 1995a; p.16; (b) MDBC; 1995a; p.17.

Table 6.2 Derivation of ordinary waterlogging losses

Crop / Pasture	topography coefficient	dryland coefficient	dryland ordinary waterlogging $ loss / ha
Annual pastures	0.6	0.5	5.99
Perennial pastures	0.6	0.5	13.92
Oats	0.6	0.5	15.84

It was estimated that 33% of Kyeamba Valley was presently affected by waterlogging and flooding and that this would increase to 35% by 2005 (G Bugden; October 1997). Furthermore it was estimated that 24% of the Kyeamba Valley was affected by ordinary waterlogging and this rate would increase to 27% in 2005.

The Kyeamba Valley Landcare group indicated that it was reasonable to assume that the area affected by waterlogging would increase over the next 50 years (G Bugden; March 1997). This assumption was combined with available data to determine affected areas over 50 years. A summary of the derived data is shown in Table 6.3.

Table 6.3 Initial estimates of areas affected by ordinary waterlogging and flooding

	Year 1	Year 30	Year 50
Area affected (ha/pa):			
Ordinary waterlogging	24,430	33,460	41,430
Flooding (average annual)	8,230	8,230	8,230
Total (ha)	***32,660***	***41,690***	***49,660***
Losses ($/pa):			
Ordinary waterlogging	201,310	275,719	341,394
Flooding (average annual)	1,013,152	1,013,152	1,013,152
Total losses ($/pa)	***1,214,462***	***1,288,872***	***1,354,547***

6.7 SOIL ACIDIFICATION

Soil acidification is an insidious process that develops under most modern agricultural systems. In general, the greater the productivity, the greater the potential soil acidification rate. Soil acidity impairs nodulation and nitrogen fixation by legumes, causes nutrient deficiencies and / or toxicities and alters soil micro-organism populations. The net result is poor plant growth and yield, particularly acid sensitive species, and the creation of an unfavourable environment for sustained production (Neeson *et al*; 1995; p.72).

Neeson et al (1995) defined soil acidity as referring to soil with a pH of less than 5.0. In the Kyeamba Valley, approximately 90% of all soils have a pH equal to or less than this level (Kyeamba Valley Landcare Group, undated, Section D). The pH level of 5 is also important as deep rooted species such as phalaris and lucerne cannot be established below this level (Thorne P; 1991; p.4). These pasture species are an essential component of the Kyeamba LWMP in terms of groundwater control. Therefore, the issue of acidification must be addressed before the problems of waterlogging and soil salinisation can be dealt with.

The main processes contributing to acidification are:

- leaching of nitrogen as nitrate;
- product removal; and

- soil organic matter build-up (Neeson *et al*, 1995; p.72).

One method of quantifying the impacts of soil acidification in the "No Plan" scenario was to calculate the costs of amelioration (Thorne; 1991; p.4). However, methods of amelioration, such as liming, were included in the Kyeamba LWMP itself. Therefore, an alternative method of quantifying the benefits of acidity control was adopted as described below.

As noted in Thorne (1991), crop and pasture selection is skewed towards tolerant and often less tolerant crops. Therefore, there are two components to soil acidification loss, comprising:

- losses which occur on crops and pastures which have already been chosen and are currently grown; and

- the skewing of crop and pasture selection, amounting to foregone production on higher return activities such as perennial pastures.

Thus, there is a loss component which can be observed in practice and a loss component because a hypothetical higher level of pasture production is not possible. Only the former loss component has been quantified, for reasons explained below.

6.7.1 Losses occurring on existing crops and pastures

For a given crop or pastures species, there is an optimal pH level at which yield is at a maximum. For pH below this optimal level, yield will gradually decline. In the economic evaluation this has been referred to as "minor decline". However, for small decreases in the pH below the optimal level, the crop / pasture would still be financially viable. It is unlikely that such small changes in soil pH are quickly noticed by the landholder.

However, it was assumed that, for a given crop or pasture, there is a pH level at which a serious decline in yield begins. This is referred to as "major decline". It is believed that most soils in Kyeamba Valley have pH levels between 4.3 and 4.8 (Thorne; 1991; p.4).

Table 6.4 Effects of acid soils on crops and pastures

	Assumed pH at which decline begins *		Assumed loss per pH reduction	
	minor decline	major decline	minor decline	major decline
Annual pastures	5.0	4.3	20%	40%
Perennial pastures	5.5	4.3	20%	40%
Oats	4.5	4.1	20%	40%

*These are the levels at which yields losses commence for existin*g* crops/pastures, not levels at which new crops/pastures cannot be grown.

It was assumed that on acidified areas, perennial pastures were not planted in the first place or landholders would undertake the necessary liming. This concept was amplified to create the strong assumption that there were actually no losses caused by soil acidification on existing perennial pastures. It was also assumed that no losses were incurred on oats. The reason for this is oats' higher tolerance of acid conditions.

The result was an average loss of $2.20 per ha for the areas in Kyeamba affected by acidic soils. If it was assumed that existing perennial pastures incurred the full losses specified in the table above, the estimate increased to $6 per ha.

6.7.2 Losses due to hypothetical production foregone on perennial pastures

The above estimates are applicable to current agricultural activities in Kyeamba. However, it is possible that in the absence of any impediment from acid soils, a far greater area in Kyeamba would be planted with perennial pastures. Estimates of soil acidification losses would be much higher if this assumption were incorporated. Preliminary estimates indicated that the losses would be considerably higher than the $10/ha proxy estimate used in Thorne (1991).

However, the benefits of switching from annual pasture to perennial pasture were included elsewhere in the analysis. Therefore it would be double counting to incorporate the assumption of more perennial pasture activities in the calculation of acidification losses. That is, it would be incorrect to count the benefits of mitigating soil acidification to facilitate more perennial pasture growth, and at the same time, count the increased gross income from switching from annual to perennial pasture.

6.8 WEED INFESTATION

Weed infestation in the valley is widespread and reduces pastoral and crop production. The evaluation incorporated the current estimates that weeds affect 70% of the Kyeamba Valley (G.Bugden; March 1997). Thorne (1991) cited evidence that the estimated yield reduction was 1%. Using an average gross income of $123 per ha, a unit loss of $1.23 per ha was derived.

6.9 WATERTABLE AND SOIL SALINISATION EFFECTS ON ROADS

The economic effects of elevated watertables on the utility of roads and other infrastructure could be considered as the additional cost of maintenance of those assets.

The cost of maintaining roads increases significantly as they become affected by groundwater rising to within 2m of the ground surface, which saturates the roadway subgrades. This cost might be in the form of more frequent maintenance, or higher maintenance expenditure on affected sections but at the same frequency, or a combination of both.

The loading on roadways, especially those subjected to frequent trucking traffic, penetrates downwards, albeit at lessening pressures, to 1.5 metres and deeper. If the subgrade at these depths is saturated by shallow watertables, movement of the material under transitory traffic loading is common, especially in clayey materials. This subgrade movement is transmitted upwards through the roadway substructure and eventually results in local subsidence in the running course, cracking of bitumen surfaces and penetration of surface water into the upper road formation.

The extent by which roads are affected by water depends upon a number of influences in addition to shallow watertables. The other considerations were intensity of use, rainfall, groundwater salinity, elevation of the road above the surrounding ground, quality of road drainage and condition of the bitumen seal.

Although normal road maintenance and its associated costs are inescapable responsibilities, the above phenomenon brought about by water ponding and shallow watertables causes premature failure of roadways and requires more frequent and more costly maintenance.

Data were collected for the total lengths of regional, other sealed and unsealed roads in Kyeamba. Similarly, estimates were obtained for the maintenance costs incurred on these road types with and without high watertables (Greg Bugden; March 1997). This data is presented in Appendix 2. Currently 5% of roads in the Kyeamba Valley are affected, with the proportion likely to be affected in thirty years as high as 10% (Allan Pottie October 1997).

6.10 WATERTABLE AND SOIL SALINISATION EFFECTS ON ON-FARM INFRASTRUCTURE

As discussed in ABARE (1996), waterlogging and soil salinisation may cause farm buildings, fences and internal roads to deteriorate at a faster rate than they otherwise would. The economic analysis used the annual damage cost of $0.80 per hectare, which was used in the ABARE study (ABARE; 1996; p.53).

It was assumed that the area salinised would be 2,821 ha in Year 1 (1998), rising to 13,603 ha in Year 30 and 21,038 ha in Year 50.

6.11 WATERTABLE AND SOIL SALINISATION EFFECTS ON OTHER INFRASTRUCTURE

It is understood that the sewerage system at Ladysmith was being adversely affected by high watertable conditions (Pers.comm; Budgen G, Cregan P; November 1996). The septic systems at Ladysmith failed to work satisfactorily due to the high saline groundwater throughout the village. The capital cost of the Ladysmith sewerage system was estimated at $1 million and was considered as part of the “With Plan” scenario. The study assumed that this expenditure would be incurred over years 1-4 of the plan and that ongoing maintenance was no higher than septic disposal maintenance and other incurred costs in the “No Plan” case.

6.12 SILTATION EFFECTS ON ROADS

Thorne (1991) stated that each year sediment blocked culverts, drains and channels along Main Road 384 (Tumbarumba Road). The Kyeamba Valley Landcare group indicated that the extent of such sedimentation was likely to change significantly over the next 50 years (Pers.comm. G. Bugden; March 1997). If grazing commodity prices remained low and landholders were forced to sow cash crops, siltation to roads could increase by 25%. It was assumed that losses would remain fixed at $3,000 per year (Thorne; 1991; p.6).

6.13 SALT LOAD IMPACTS ON MURRUMBIDGEE AND MURRAY RIVERS

There are large areas in Kyeamba in which the pressure head of groundwater is above ground level. Such conditions would provide the driving force to cause groundwater to flow to the surface, if a passageway was available. However, in the lower parts of the Kyeamba Valley, there was considered to be a confining layer of impermeable material (Woolley D; 1991). This layer currently prevents groundwater rising from the lower aquifer. At present, a significant component of the lower aquifer drains into the Kyeamba and O'Briens Creeks. However, if recharge in the higher parts of the Kyeamba Valley were not reduced in the future, pressure would increase in the aquifer. This would result in an increase in the rate of drainage of saline water into the alluvial deposits along the Kyeamba and O'Briens Creeks. (Another result is that pressure would increase on fracture sites in the rock layer that confines the aquifer. This would be likely to cause an increase in the number and size of salinised locations in the lower areas in the Plan area.)

Based on the MDBC's estimate that only 10 per cent of salt loads from the Kyeamba Valley would enter the Murray River, Thorne (1991) estimated that surface water and groundwater from Kyeamba has raised the salinity concentration of the Murray River by 0.22 EC and 0.23 EC respectively. If there was a continuation of the groundwater process described above, the groundwater from the Valley would increase the salinity of the Murray River by 2.07 EC in 2020 (ABARE; May 1996; p.56).

The analysis assumed that this rate of increase would persist for the next 50 years. Thus it was assumed that surface water and groundwater combined would generate a 3.58 EC increase in the salinity at Morgan. The technical data used to estimate the economic impacts of salt loads were drawn from prior economic studies. Also, as mentioned above, extrapolation was applied to determine impacts after year 30.

7 ECONOMIC LOSSES IN THE “NO PLAN” CASE

As discussed in Section 4.1, NSW Treasury guidelines state that an economic evaluation must specify the “state of the world” that would have existed in the absence of the project. Moreover, it has been customary in LWMP evaluations to estimate the economic losses that would be incurred in the “No Plan” case.

It appears that the economic information from previous studies on Kyeamba’s natural resource degradation may have referred to the “Do-nothing-at-all” case. This is a hypothetical case where landholders undertake no further action to address land and water degradation. It is different to the “No Plan” case, in which landholders continue to undertake some works such as liming or planting of perennial pastures, albeit at a slower rate than the “With Plan” case. This economic evaluation compared the “With Plan” case with the “No Plan” case to determine the benefits of the Kyeamba LWMP.

7.1 ESTIMATES OF LOSSES IN THE “DO-NOTHING-AT-ALL” CASE’

Estimates of losses in the “Do-nothing-at-all” case are presented in Table 7.1 below. As discussed, different interpretations could be made as to what soil acidification losses represent. The calculation of soil acidification losses is an example of the practical difficulties in calculating losses in the “Do-nothing-at-all” case. These losses are equal to the production, which would occur in an Ideal-World scenario less the production occurring in the “Do-nothing-at-all” case. However, the specification of the Ideal-World scenario is subjectively based.

The soil acidification losses used to calculate the Kyeamba LWMP’s benefits in the analysis were measured according to the losses, which occurred on existing areas of crops and pastures.

The benefits of planting greater areas of perennial pastures were included elsewhere in the analysis. It would have been double counting to include foregone production on larger areas of perennial pasture in the soil acidification losses, and base the Plan’s benefits on these losses.

Table 7.1 Present value estimates of losses in the "Do-nothing-at-all" case

Form of land / water degradation	Present values of losses (discount rate of 7%)	
	30 years 7%	50 years 5%
Sheet and rill erosion	3,479,718	5,815,610
Gully erosion	86,419	127,138
Streambank erosion	19,444	28,606
Dryland salinity	2,452,821	4,748,153
Waterlogging	15,307,508	23,130,064
Soil acidity	*2,595,305	3,818,159
Weed infestation	1,009,339	1,484,919
Road damage (watertables/salinity)	236,417	448,599
Siltation of roads	37,227	54,768
On-farm infrastructure	63,981	123,855
Other infrastructure	846,803	886,488
EC impact at Morgan	1,937,982	3,797,168
Total	**$28,072,965**	**$44,463,526**

•*Note that applying an average loss of $6 per hectare to soil acidity increased the loss due to soil acidity to $7,078,105 over 30 years (see section 6.7)

7.2 ESTIMATES OF LOSSES IN THE "NO PLAN" CASE

As mentioned previously, it was necessary to distinguish between the "No Plan" case and the more pessimistic "Do-nothing-at-all" case. There was limited data as to the likely impact of the "No Plan" case on natural resource degradation. In most cases, a wide range of assumptions were made (discussed further in Section 9).

The resulting lower bound and upper bound estimates of "No Plan" losses are presented in Table 7.2, Table 7.3 and Table 7.4. Table 7.2 shows the lower and upper bounds of the present value of losses over 30 years.

Table 7.2 Present value estimates of losses in the "No-Plan" case

Form of Land / Water Degradation	Present values of losses (30 years, 7%)	
	lower bound ($)	upper bound ($)
Sheet and rill erosion	3,270,561	3,479,718
Gully erosion	84,916	86,419
Streambank erosion	19,106	19,444
Dryland salinity	2,452,821	2,452,821
Waterlogging	14,490,704	15,307,508
Soil acidity	2,459,949	2,595,305
Weed infestation	904,057	991,792
Road damage (watertables/salinity)	191,858	225,277
Siltation of roads	35,286	37,200
On-farm infrastructure	57,957	63,539
Other infrastructure	833,484	846,803
EC impact at Morgan	1,804,330	1,937,982
Total	**$26,605,029**	**$28,043,808**

Table 7.3 and Table 7.4 show actual dollar losses in three time instances, in years 1, 30 and 50. While year 1 was the same for both lower and upper bound estimates, the difference for year 30 was $377,000 and for year 50, $454,000.

Table 7.3 Lower bound estimates of losses in the "No Plan" case

Form of Degradation	Year 1	Year 30	Year 50
	$	$	$
Sheet and rill erosion	212,498	352,363	470,804
Gully erosion	6,964	6,616	6,616
Streambank erosion	1,567	1,489	1,489
Dryland salinity	86,504	417,179	645,230
Waterlogging	1,214,462	1,129,001	1,214,753
Soil acidity	209,146	177,774	177,774
Weed infestation	81,339	56,937	56,937
Road damage (watertables/salinity)	9,395	24,332	32,722
Siltation of roads	3,000	2,550	2,500
On-farm infrastructure	2,256	8,706	13,465
Other infrastructure	250,000	0	0
EC impact at Morgan	81,308	279,465	482,908
Total	**$2,158,440**	**$2,456,412**	**$3,105,248**

Table 7.4 Upper bound estimates of losses in the "No Plan" case

Form of Degradation	Year 1	Year 30	Year 50
	$	$	$
Sheet and rill erosion	212,498	414,544	553,887
Gully erosion	6,964	6,964	6,964
Streambank erosion	1,567	1,567	1,567
Dryland salinity	86,504	417,179	645,230
Waterlogging	1,214,462	1,328,237	1,429,121
Soil acidity	209,146	209,146	209,146
Weed infestation	81,339	77,272	77,272
Road damage (watertables/salinity)	9,395	36,498	49,084
Siltation of roads	3,000	2,970	2,970
On-farm infrastructure	2,256	10,338	15,989
Other infrastructure	250,000	0	0
EC impact at Morgan	81,308	328,782	568,127
Total	**$2,158,440**	**$2,833,498**	**$3,559,358**

8 LWMP STRATEGY COMPONENTS

8.1 CONSOLIDATED LIST OF PLAN OPTIONS

The traditional approach used in economic assessments of LWMPs is to have a list of Plan options that are separate from each other. This approach is particularly useful when identifying and presenting the costs of a LWMP, as well as negotiating with funding bodies.

The full list of the options that constitute the Kyeamba LWMP is presented in Table 8.1. Descriptions of the options are provided in subsequent parts of Section 8. Templates of data requirements for implementation levels, phase-in periods, and cost estimates are provided in Appendix 3.

The Plan evaluation was separated into five broad groups of options as follows:

Pasture Options

These options included the management of existing native pastures and the replacement of annual pastures with perennial pasture species.

Trees, Shrubs and Groundcover Options:

The Kyeamba LWMP contained several options that involved planting trees, rehabilitating existing vegetation or controlling weeds and pests which threatened existing vegetation.

Farm Management Options:

Farm Management Options related to general operations such as the application of nutrients, improved rotational grazing techniques and the revegetation of bare areas.

Soil Management Options:

Soil Management Options directly addressed degradation such as soil acidity, erosion and salinity. Some of the options in other categories also address these issues. However, the Soil Management category was chosen to make presentation and analysis simpler.

Implementation Options:

This is a general category that included options such as education, administration and performance monitoring. These options normally have no direct measured benefits. However, they are essential for implementing the Plan.

Each plan option was given a code for ease of identification. The first letter of the code represents the group to which the Plan option belongs. For example, Liming / other ameliorants on acidic soils has the code S02. This means that this Plan option is the second one in the group titled “Soil management options”.

Table 8.1 Economic assessment of Kyeamba LWMP: Consolidated list of options

Option	Code
Group: Pasture Options	
Improved management of existing native pastures	P01
Increased area under perennial based pastures	P02
Regular fertiliser use on existing native / perennial pastures	P03
Group: Trees, Shrubs and Groundcover Options	
Weed and pest control	T01
Increased tree cover	T02
Filling; revegetation and earthworks in gullies	T03
Fencing of regenerating tree areas	T04
Fencing of existing tree areas	T05
Protection of existing remnant vegetation	T06
Planting of trees on discharge areas	T07
Planting of trees on eroded areas	T08
Maintain and enhance trees on public land	T09
Maintain and enhance trees on crown land	T10
Group: Farm Management Options	
Improved rotational grazing techniques	F01
Revegetate bare areas	F02
Regular application of nutrients	F03
Monitor management techniques	F05
Property planning	F06
Group: Soil Management Options	
Soil testing	S01
Liming / other ameliorants on acidic soils	S02
Planting of acid tolerant species	S03
Early sowing to reduce nitrogen leaching	S04
Split fertiliser application	S05
Control of sheet erosion	S06
Fencing of eroded gullies	S07
Diversion of water to more stable areas	S08
Fencing of salinity affected areas	S09
Diversion of surface run-off away from discharge areas	S10
Minimum tillage or direct drill techniques	S11
Group: Implementation Options	
Education	I01
Administration	I02
Performance monitoring	I03

(Note option F04 is not missing, it was deleted as a feasible option following an earlier review of options)

8.2 COST AND IMPLEMENTATION DATA FOR THE KYEAMBA LWMP OPTIONS:

A substantial amount of data on the Kyeamba LWMP options was provided by the Kyeamba Valley Landcare group and DLWC regional officers. This enabled the generation of economic results. The data are presented in Appendix 3.

9 IMPACTS OF THE "NO PLAN" CASE AND "WITH PLAN" CASE ON RESOURCE DEGRADATION

The benefits of the Plan were estimated to be the differences between the losses occurring in the "No Plan" case and the losses occurring in the "With Plan" case, for the duration of the Plan. In order to calculate the losses occurring in the "No Plan" and "With Plan" cases, supplied or assumed information was used to assess the impact of these scenarios on natural resource degradation. Specifically, the evaluation used data on the percentage impact of the "No Plan" case and the "With Plan" case on land and water degradation. Much of these data were based on a wide range of default estimates.

9.1 IMPACTS OF THE "NO PLAN" CASE ON RESOURCE DEGRADATION

There were limited data as to the likely impact of the "No Plan" case on natural resource degradation. Most cases necessitated assumptions to be made. Default data and data provided by the Kyeamba Valley Landcare group are presented in Table 9.1. The latter form of data is highlighted in bold.

Table 9.1 Lower bound impact of the "No Plan" case (measured against the "Do-nothing-at-all" case)

% reduction in land/water degradation

		Year					
	Unit	1	10	20	30	40	50
Sheet and rill erosion	ha	0	0	0	**0**	0	0
Gully erosion	ha	0	0	0	**0**	0	0
Streambank erosion	ha	0	0	0	**0**	0	0
Dryland salinity	ha	< 10% of corresponding "With Plan" impact >					
Waterlogging	ha	0	0	0	**0**	0	0
Soil acidity	ha	0	0	0	**0**	0	0
Weed infestation	ha	0	1.7	3.3	**5**	5	5
Road damage (w'tables/salinity)	Valley	0	3.3	6.7	**10**	10	10
Siltation of roads	valley	0	0	0	**1**	1	1
On-farm infrastructure	ha	0	0	0	**5**	5	5
Other infrastructure	na	0	0	0	**10**	10	10
EC impact at Morgan	EC	0	0	0	**0**	0	0

Table 9.2 Upper bound impact of the "No Plan" case (measured against the "Do-nothing-at-all" case)

		% reduction in land/water degradation					
		Year					
	Unit	1	10	20	30	40	50
Sheet and rill erosion	ha	0	5	10	**15**	15	15
Gully erosion	ha	0	1.7	3.3	**5**	5	5
Streambank erosion	ha	0	1.7	3.3	**5**	5	5
Dryland salinity	ha	< 50% of corresponding "With Plan" impact >					
Waterlogging	ha	0	5	10	**15**	15	15
Soil acidity	ha	0	5	10	**15**	15	15
Weed infestation	ha	0	10	20	**30**	30	30
Road damage (w'tables/salinity)	valley	0	13.3	26.7	**40**	40	40
Siltation of roads	valley	0	5	10	**15**	15	15
On-farm infrastructure	ha	0	6.7	13.3	**20**	20	20
Other infrastructure	na	0	10	20	**30**	30	30
EC impact at Morgan	EC	0	5	10	**15**	15	15

*Bold type indicates data supplied by the Kyeamba Valley Landcare Group. All other data were based on interpolation.

9.2 IMPACTS OF THE "WITH PLAN" CASE ON RESOURCE DEGRADATION

There were also limited data on the possible impact of the "With Plan" case on natural resource degradation. In most cases, assumptions were made. Data used in the evaluation are presented in Table 9.3 and Table 9.4. Data provided by the Kyeamba Valley Landcare group or derived by Resource Economics (in the case of dryland salinity) are highlighted in bold.

Table 9.3 Lower bound impact of the "With Plan" case (measured against the "Do-nothing-at-all" case)

		% reduction in land/water degradation					
		Year					
	Unit	1	10	20	30	40	50
Sheet and rill erosion	ha	0	13	27	**40**	40	40
Gully erosion	ha	0	0	0	**20**	20	20
Streambank erosion	ha	0	10	20	**30**	30	30
Dryland salinity	ha	**0**	**0**	**0**	**19**	**43**	**43**
Waterlogging	ha	0	17	33	**50**	50	50
Soil acidity	ha	0	17	33	**50**	50	50
Weed infestation	ha	0	3	7	**10**	10	10
Road damage (w'tables/salinity)	valley	0	20	40	**60**	60	60
Siltation of roads	valley	0	20	40	**60**	60	60
On-farm infrastructure	ha	0	17	33	**50**	50	50
Other infrastructure	na	0	20	40	**60**	60	60
EC impact at Morgan	EC	0	20	40	**60**	60	60

Table 9.4 Upper bound impact of the "With Plan" case (measured against the "Do -nothing-at-all" case)

		% reduction in land/water degradation					
		Year					
	Unit	1	10	20	30	40	50
Sheet and rill erosion	ha	0	25	50	**75**	75	75
Gully erosion	ha	0	50	50	**50**	50	50
Streambank erosion	ha	0	47	47	**70**	70	70
Dryland salinity	ha	**0**	**11**	**71**	**71**	**71**	**71**
Waterlogging	ha	0	80	80	**90**	90	90
Soil acidity	ha	0	70	70	**70**	70	70
Weed infestation	ha	0	80	80	**90**	90	90
Road damage (w'tables/salinity)	valley	0	30	60	**90**	90	90
Siltation of roads	valley	0	80	80	**90**	90	90
On-farm infrastructure	ha	0	70	70	**70**	70	70
Other infrastructure	na	0	80	80	**90**	90	90
EC impact at Morgan	EC	0	80	80	**90**	90	90

* Bold type indicates data which has been supplied by the Kyeamba Valley Landcare Group or mathematically derived by DLWC Resource Economics. All other data were based on interpolation.

10 INDICATORS OF THE ECONOMIC VIABILITY OF THE KYEAMBA LWMP

Given the limitations in the current availability of data, it was considered more appropriate to quote a range of Benefit-Cost Ratio results.

The economic results are summarised in Section 10.5

10.1 PRINCIPLES BEHIND UPPER BOUND / LOWER BOUND ANALYSIS

Estimates of the Plan's benefits were computed in terms of lower and upper bounds. The reasons for this were:

- physical processes (such as soil salinisation and acidification) were well understood in concept but difficult to quantify using single estimates; and
- the exact physical impact of the plan on land and water degradation was not known - rather, judgement was used as to what would be a realistic range of outcomes.

Care needs to be taken in the interpretation of the lower and upper bound results. The average of upper bound and lower bound results is not a reliable indicator of the average possible economic outcome in reality. This is because the upper bound and lower bound assumptions are both extreme. However, the upper bound assumptions may be more extreme than the lower bound assumptions, or *vice versa*.

10.2 ESTIMATES OF BENEFITS

The initial range of estimates of the Plan's benefits is shown in Table 10.2. Other benefits that were not quantified included:

- reduced sediment load reaching Kyeamba Creek and the Murrumbidgee River. It was expected that with the adoption of the plan there would be a 30% reduction in sediment load (G. Bugden; March 1997).
- productive use of bore water.
- existence values placed on such environmental goods as improved flora and fauna habitats and landscape aesthetics (Hill, 1994).

Table 10.1 Benefits of the Kyeamba LWMP over 30 years

PRESENT VALUES		
	lower bound	upper bound
Discount Rate (%) :	7%	7%
	$	$
Increased carrying capacity*/windbreaks	65,891,651	65,891,651
Sheet and rill erosion	557,754	836,631
Gully erosion	1,250	27,973
Streambank erosion	2,028	6,180
Dryland salinity	75,874	151,748
Waterlogging	2,722,680	7,755,799
Soil acidity	451,187	1,103,935
Weed infestation	17,547	452,845
Road damage (watertables/salinity)	55,698	55,698
Siltation of roads	7,739	18,644
On-farm infrastructure	14,619	30,602
Other infrastructure	26,637	93,231
EC impact at Morgan	534,608	1,135,037
TOTAL	**$70,359,273**	**$77,559,974**

Table 10.2 Benefits of the Kyeamba LWMP over 50 years

PRESENT VALUES		
	lower bound	upper bound
Discount Rate (%) :	5%	5%
	$	$
Increased carrying capacity*/windbreaks	104,551,509	104,551,509
Sheet and rill erosion	1,342,026	2,013,040
Gully erosion	6,083	45,836
Streambank erosion	4,173	11,176
Dryland salinity	252,451	504,903
Waterlogging	5,837,303	13,313,352
Soil acidity	928,241	1,778,640
Weed infestation	36,100	733,244
Road damage (watertables/salinity)	148,538	148,538
Siltation of roads	15,847	31,038
On-farm infrastructure	38,682	61,377
Other infrastructure	28,349	99,221
EC impact at Morgan	1,520,371	2,495,072
TOTAL	**$114,709,675**	**$125,786,947**

* no distinction between lower and upper bound for increased carrying capacity or the benefits from windbreaks. Note that the increased carrying capacity was $64.6 million, with the balance of $1.3 million due to windbreak benefits.

In some cases, the lower bound and upper bound assumptions were extreme, giving a broad range of estimates. Examples include the quantification of gully erosion and weed infestation.

10.3 ESTIMATES OF COSTS

Cost data were collected for the options in the Kyeamba LWMP and are presented below.

Table 10.3 Estimates of the costs of the Kyeamba LWMP

	Project Period (Yrs) :	30	50
	Discount Rate (%) :	7%	5%
		$	$
Project Costs		37,036,808	40,561,211
Recurrent Costs		38,468,368	64,412,643
Renewal Costs		15,538,793	31,771,272
Total (30 Yr Project Period)		**$91,043,970**	**na**
Total (50 Yr Project Period)		**na**	**$136,745,126**

10.4 INDICATORS OF ECONOMIC VIABILITY

The standard indicators of a project's economic viability are the Net Present Value (NPV) and the Benefit-Cost Ratio (BCR). These indicators are shown in Table 10.4 Results for the Kyeamba LWMP

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Table 10.4 Results for the Kyeamba LWMP

OVER 30 YEARS

	Guidelines:	NSW Treasury	
		lower bound	upper bound
	Discount Rate (%) :	7%	7%
Benefit-Cost Ratio :		**0.77**	**0.85**
Net Present Value :		($20,684,697)	($13,483,996)

OVER 50 YEARS

	Guidelines:	MD BC	
		lower bound	upper bound
	Discount Rate (%) :	5%	5%
Benefit-Cost Ratio :		**0.84**	**0.92**
Net Present Value :		($22,035,451)	($10,958,179)

10.5 SUMMARY OF RESULTS

Two important economic issues relating to the Kyeamba LWMP are:

- the viability of the Kyeamba LWMP (as estimated by measures such as the Benefit-Cost Ratio, Net Present Value); and
- the economic losses, which would occur in the "No Plan", case.

Estimates that address these losses are presented in Table 10.5 below:

Table 10.5 Summary of results for the Kyeamba LWMP and losses in the "No Plan" case

Indicator	Initial estimates
Benefit-Cost Ratio (BCR) [lower bound and upper bound]:	
• 30 year project period / 7% discount rate (NSW Treasury)	0.77 - 0.85
• 50 year project period / 5% discount rate (MDBC)	0.84 - 0.92
Losses in the "No Plan" case:	million
• Losses in Year 1	$6
• Losses in Year 30	$3.1 - $2.5
• Losses in Year 50	$2.8 - $2.1
• Net Present Value @7% over 30 yrs	($21 - $13)

The results indicate that based on the benefit cost ratio of less than one, and consequentially a negative net present value, the plan is not economically viable. However, inclusion of the currently unquantified environmental benefits would alter these indicators and improve the plan's viability.

For the plan to be at least breakeven, the net present value of the currently unquantified benefits would need to range from $21 million to $13 million over 30 years, or from $22 million to $11 million over 50 years.

10.6 SENSITIVITY ANALYSIS AND DISCUSSION

To test the impact of key variables, a sensitivity analysis was undertaken. For this study key variables that were adjusted to assess their impact on results were

- discount rate,
- gross margins for change from annual to perennial pastures

Given the construction of the economic modelling to assess impacts of changes in variables, changes in inputs had a direct impact on changes in the net present value and benefit cost ratio. Table 10.6 outlines the impact of changes in the discount rate over a 30 year time period for lower and upper bounds. Varying the discount rate adjusted the net present value of the lower bound estimate from ($26 million) to ($18 million) over 30 years. Varying the discount rate adjusted the net present value of the upper bound estimate from ($14.5 million) to ($13 million) over 30 years. However, this affected the benefit cost ratios by only 0.08 in both scenarios.

Table 10.6 Sensitivity analysis- discount rate

LOWER BOUND ESTIMATES

Guidelines:		NSW Treasury	
Project Period (Yrs) :	30	30	30
Discount Rate (%) :	4%	7%	10%
Benefit-Cost Ratio :	**0.81**	**0.77**	**0.73**
Net Present Value :	($25,6115,974)	($20,684,697)	($18,129,342)

UPPER BOUND ESTIMATES

Guidelines:		NSW Treasury	
Project Period (Yrs) :	30	30	30
Discount Rate (%) :	4%	7%	10%
Benefit-Cost Ratio :	**0.89**	**0.85**	**0.81**
Net Present Value :	($14,478,545)	($13,483,996)	($13,025,645)

Table 10.6 outlines the percentages of the total to which each category of benefits contributed. Clearly the increased carrying capacity category (which also included a small proportion of windbreak effects) contributed the most to overall benefits in both lower (94%) and upper (85%) bounds. The second major contributor to overall benefits was reduced waterlogging effects of 4% and 10% for lower and upper bounds. Therefore a halving of the estimated gross margins applied to the switch from annual to perennial pastures would reduce the contribution of increased carrying capacity by $35 million, and thus decrease the already negative net present value by that amount.

Table 10.7 Lower bound estimates of the benefits of the Kyeamba LWMP

PRESENT VALUES	30 years 7% $	% of total
Increased carrying capacity*/windbreaks	65,891,651	94%
Sheet and rill erosion	557,754	0.8%
Gully erosion	1,250	0.0%
Streambank erosion	2,028	0.0%
Dryland salinity	75,874	0.1%
Waterlogging	2,722,680	3.9%
Soil acidity	451,187	0.6%
Weed infestation	17,547	0.0%
Road damage (watertables/salinity)	55,698	0.1%
Siltation of roads	7,739	0.0%
On-farm infrastructure	14,619	0.0%
Other infrastructure	26,637	0.0%
EC impact at Morgan	534,608	0.8%
TOTAL	$70,359,273	100%

Table 10.8 Upper bound estimates of the benefits of the Kyeamba LWMP

PRESENT VALUES	30 years 7% $	% of total
Increased carrying capacity*/windbreaks	65,891,651	85.0%
Sheet and rill erosion	836,631	1.1%
Gully erosion	27,973	0.0%
Streambank erosion	6,180	0.0%
Dryland salinity	151,748	0.2%
Waterlogging	7,755,799	10.0%
Soil acidity	1,103,935	1.4%
Weed infestation	452,845	0.6%
Road damage (watertables/salinity)	55,698	0.1%
Siltation of roads	18,644	0.0%
On-farm infrastructure	30,602	0.0%
Other infrastructure	93,231	0.1%
EC impact at Morgan	1,135,037	1.5%
TOTAL	$77,559,974	100%

These proportions of benefits were very similar for the 50 year study. Changing the impacts of the plan on salinity and waterlogging would also change the impact on final results. However these impacts would have to be very large to significantly affect the final results.

The results indicated that those unquantified benefits would need to have values of at least the magnitude of the net present values for the project to break even and be considered economically viable. This would amount to an annualised value of $1.7 million to $1 million each year over the 30 years of the plan, or $1.5 million to $0.8 million over 50 years.

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12 APPENDIX 1 PERCENTAGE IMPACT DATA FOR THE “WITH PLAN” CASE AND “NO PLAN” CASE

Table 12.1 Estimates for the percentage impact of the Kyeamba LWMP on degradation

“With Plan” case versus “Do-nothing-at-all” case:

	% reduction in degradation in Year 30	
	likely lower bound	likely upper bound
Sheet and rill erosion	40 a	75 a
Gully erosion	20 a	50 a
Streambank erosion	30 a	70 a
Dryland salinity	43 b	71 b
Surface waterlogging	50 a	90 a
Area with shallow watertables	50 a	70 a
Soil acidity	50 a	70 a
Weed infestation	10 a	90 a
Road damage due to salinity/watertables	60 a	90 a
Siltation of roads	60 a	90 a
On-farm infrastructure	50 a	70 a
Other infrastructure eg sewerage	60 a	90 a
EC impact at Morgan	60 a	90 a

(a) Estimates provided by Kyeamba Valley Landcare group
(b) Derived by DLWC Resource Economics Group.

Table 12.2 **Data template for the percentage impact of landholder actions undertaken in the absence of the Kyeamba LWMP**

“No Plan” case versus “Do-nothing-at-all” Case:

	% reduction in degradation in Year 30	
	likely lower bound (a)	likely upper bound (a)
Sheet and rill erosion	0	15
Gully erosion	0	5
Streambank erosion	0	5
Dryland salinity	10	50
Surface waterlogging	0	15
Area with shallow watertables	5	40

"No Plan" case versus "Do-nothing-at-all" Case (Continued):

	% reduction in degradation in Year 30	
	Likely lower bound	Likely upper bound
Soil acidity	0	15
Weed infestation	5	30
Road damage due to salinity/watertables	10	40
Siltation of roads	1	15
On-farm infrastructure	5	20
Other infrastructure eg sewerage	10	30
EC impact at Morgan	0	15

(a) Estimates provided by Kyeamba Valley Landcare group.

13 APPENDIX 2 ROAD MAINTENANCE COSTS AND SHALLOW WATERTABLES

Data were available for the total lengths of regional, other sealed and non-sealed roads in Kyeamba. Estimates also existed for the maintenance costs with and without high watertables that were being incurred on these road types. The proportion of affected roads was similar across the three categories of roads. The percentage of roads currently affected by shallow watertables was estimated at 5% and likely to be 10% in thirty years (Pers.comm. Allan Pottie October 1997). This data is shown in Table 13.1 below.

Table 13.1 Road length and maintenance cost data

	road length	road costs non-affected ($/km/pa)	affected ($/km/pa)	extra costs due to SWT $ pa	% affected by SWT
Regional sealed roads	175	6,000	6,500	500	5%
Other sealed roads	875	4,000	4,500	500	5%
Unsealed roads	1,080	1,000	1,100	100	5%

SWT –shallow watertables

14 APPENDIX 3 INPUT DATA FOR THE KYEAMBA LWMP OPTIONS

Table 14.1 Cost data for the plan options

			UNIT COSTS ---------------->			Renewal
	Code	**Unit**	**Project**	**Recurrent**	**Renewal**	**Cycle (Yrs)**
			$/unit	**$/unit pa**	**$/unit**	(Default = 20)
PASTURE OPTIONS						
Improved management of existing native pastures	P01	ha	21	11	21	20
Increased area under perennial based pastures	P02	ha	190	20	190	9
Regular fertiliser use on existing native / perennial pastures	P03	ha	40	25	40	20
TREES, SHRUBS AND GROUNDCOVERS						
Weed and pest control	T01	ha	60	10	60	20
Increased tree cover	T02	ha	376	3	376	20
Filling; revegetation and earthworks in gullies	T03	km	7000	25	25	20
Fencing of regenerating tree areas	T04	ha	534	5.34	53.4	20
Fencing of existing tree areas	T05	ha	534	5.34	53.4	20
Protection of existing remnant vegetation	T06	ha	534	5.34	53.4	20
Planting of trees on discharge areas	T07	ha	700	175	700	20
Planting of trees on eroded areas	T08	ha	376	94	376	20
Maintain and enhance trees on public land	T09	ha	600	6	600	20
Maintain and enhance trees on crown land	T10	ha	600	6	600	20
FARM MANAGEMENT OPTIONS						
Improved rotational grazing techniques	F01	ha	125	2	40	20
Revegetate bare areas	F02	ha	300	3	300	20
Regular application of nutrients	F03	ha	12	1.2	1.2	20
Monitor management techniques	F05	d/yr	15	15	0	20
Property planning	F06	ha	10	0	0	20

Table 14.1 Cost data for the plan options			**UNIT COSTS ---------------->**			**Renewal**
	Code	**Unit**	**Project**	**Recurrent**	**Renewal**	**Cycle (Yrs)**
			$/unit	**$/unit pa**	**$/unit**	(Default = 20)
SOIL MANAGEMENT OPTIONS						
Soil testing	S01	ha	3	0.3	3	20
Liming / other ameliorants on acidic soils	S02	ha	190	19	380	20
Planting of acid tolerant species	S03	ha	190	19	190	20
Early sowing to reduce nitrogen leaching	S04	ha	10	1	10	20
Split fertiliser application	S05	ha	8	0.8	8	20
Control of sheet erosion	S06	ha	80	8	80	20
Fencing of eroded gullies	S07	ha	700	7	700	20
Diversion of water to more stable areas	S08	ha	150	15	150	20
Fencing of salinity affected areas	S09	ha	534	5.34	534	20
Diversion of surface run-off away from discharge areas	S10	ha	80	8	80	20
Minimum tillage or direct drill techniques	S11	ha	45	4.5	45	20
IMPLEMENTATION OPTIONS						
Education	I01	district	100,000			20
Administration	I02	district	80,000	30,000		1-10, 10-20
Performance monitoring	I03	district	30,000			10

Table 14.2 Implementation data for the plan options

			"With Plan"	Start	Finish	"With Plan"
	Code	Unit	Units	Year	Year	Units
			(incl No	Default=1	Default=10	(excl No
PASTURE OPTIONS			Plan)			Plan)
Improved management of existing native pastures	P01	ha	11,888	1	10	11,888
Increased area under perennial based pastures	P02	ha	61,727	1	5	51,727
Regular fertiliser use on existing native / perennial pastures	P03	ha	0	1	10	0
TREES, SHRUBS AND GROUNDCOVERS						
Weed and pest control	T01	ha	100,070	1	10	75,070
Increased tree cover	T02	ha	20,000	1	15	18,000
Filling; revegetation and earthworks in gullies	T03	km	300	1	10	200
Fencing of regenerating tree areas	T04	ha	95	1	15	75
Fencing of existing tree areas	T05	ha	95	1	15	85
Protection of existing remnant vegetation	T06	ha	325	1	10	325
Planting of trees on discharge areas	T07	ha	1,000	1	15	990
Planting of trees on eroded areas	T08	ha	1,000	1	15	980
Maintain and enhance trees on public land	T09	ha	90	1	10	90
Maintain and enhance trees on crown land	T10	ha	6	1	10	6
FARM MANAGEMENT OPTIONS						
Improved rotational grazing techniques	F01	ha	35,000	1	10	15,000
Revegetate bare areas	F02	ha	500	1	10	480
Regular application of nutrients	F03	ha	39,000	1	10	19,000
Monitor management techniques	F05	d	370	1	10	370
Property planning	F06	ha	100,037	1	10	95,037

Table 14.2 Implementation data for the plan options			**"With Plan"**	**Start**	**Finish**	**"With Plan"**
	Code	**Unit**	**Units**	**Year**	**Year**	**Units**
			(incl No	Default=1	Default=10	**(excl No**
SOIL MANAGEMENT OPTIONS			**Plan)**			**Plan)**
Soil testing	S01	ha	43,000	1	10	3,000
Liming / other ameliorants on acidic soils	S02	ha	57,000	1	10	47,500
Planting of acid tolerant species	S03	ha	36,455	1	10	34,455
Early sowing to reduce nitrogen leaching	S04	ha	6,000	1	10	6,000
Split fertiliser application	S05	ha	4,000	1	10	3,000
Control of sheet erosion	S06	ha	14,970	1	10	14,170
Fencing of eroded gullies	S07	ha	340	1	10	140
Diversion of water to more stable areas	S08	ha	33,000	1	10	32,500
Fencing of salinity affected areas	S09	ha	218	1	10	168
Diversion of surface run-off away from discharge areas	S10	ha	168	1	10	138
Minimum tillage or direct drill techniques	S11	ha	75,000	1	10	45,000
IMPLEMENTATION OPTIONS						
Education	I01	district	1	1	10	1
Administration	I02	district	1	1	10	1
Performance monitoring	I03	district	1	1	10	1