Shepparton Irrigation Region Catchment Implementation Strategy

Surface Water Management Program

Five Year Review

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Volume 4 - Economics

GOULBURN BROKEN
CATCHMENT MANAGEMENT AUTHORITY

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Abbreviations

ABS	Australian Bureau of Statistics
ARI	Average Recurrence Interval
CM	Choice Modelling
CMA	Catchment Management Authority
CPI	Consumer Price Index
CSWMP	Community Surface Water Management Sub-Program
CSWMS	Community Surface Water Management System
DESM	Drainage Evaluation Spreadsheet Model
EC	Electrical Conductivity
GBCMA	Goulburn Broken Catchment Management Authority
GIS	Geographic Information System
G-MW	Goulburn-Murray Water
GSR	Great Southern Region (Western Australia)
LMIRSWMP	Loddon-Murray Irrigation Region Surface Water Management Plan
MDBC	Murray Darling Basin Commission
MRF	Murrumbidgee River Floodplain (New South Wales)
NCCMA	North Central Catchment Management Authority
PSWMP	Primary Surface Water Management Sub-Program
PSWMS	Primary Surface Water Management System
SIRCIS	Shepparton Irrigation Region Catchment Implementation Strategy
SKM	Sinclair Knight Merz
SMEC	Snowy Mountain Electricity Commission
SWMP	Surface Water Management Program
SWMS	Surface Water Management System

Contents

List of Tables

List of Figures

1 Executive Summary

A review of the Surface Water Management Program was conducted in 2007 to look at its achievements from 2000 to 2006. It also provided recommendations to ensure that the Program's strategy targets for the next five years (2006 to 2011) can be achieved.

As part of the review the economic impacts and to a certain extent the value of the environmental benefits of the Program were assessed. The analysis period is 30 years at 4% discount rate. The Base Case Scenario assumed that there is a 10% incremental net change from low value crops to high value crops. The opportunity cost of this change is equivalent to the dairy gross margin per hectare. The costs were assessed using System Cost and Period Cost methods.

The economic assessment is an *ex-poste* type of evaluation. The main tool used was the Drainage Evaluation Spreadsheet Model (DESM) developed by the Murray Darling Basin Commission in 1995. The current version was updated by Sinclair Knight Merz in 2003 for the Loddon-Murray Irrigation Region.

The results of the economic evaluation showed that the Surface Water Management Program is economic (using Systems Cost method) with Net Present Value of $4 million, Internal Rate of Return of 6.3% and Benefit Cost Ratio of 1.35:1. However, if there is no land use change associated with the provision of surface water management systems, the Program is not economic with Benefit Cost Ratio of 0.3:1.

Using Period Cost method, the Program is uneconomic with Benefit Cost Ratio of 0.86:1. The Primary Surface Water Management Sub-Program was marginally uneconomic with 0.96:1 Benefit Cost Ratio. The Community Surface Water Management Sub-Program has a Benefit Cost Ratio of 0.59:1.

The indicative present value of the environmental benefits is about $1 million at 4% discount rate. If the environmental benefits are added to the economic benefits and using System Cost method, the Net Present Value of the Program is $5 million, the Benefit Cost Ratio is 1.44:1 and the Internal Rate of Return increased to 6.9%. The Program remains uneconomic using the Period Cost method.

The cost of implementing the Program was shared by the government (89%) and landholders (11%) using the System Cost method. The government's contribution to the Community Surface Water Management Sub-Program was 58% and the landholders contributed 42%.

From the point of view of the government, the Surface Water Management Program is not economic with Benefit Cost Ratio of 0.38:1. The Community Surface Water Management Sub-Program, however, is economic with Benefit Cost Ratio of 1.54:1.

From the point of view of the landholders, the Community Surface Water Management Sub-Program is financially attractive with Benefit Cost Ratio of 1.64:1.

2 Introduction

The Surface Drainage Program (now called Surface Water Management Program) is one of the four programs of the Shepparton Irrigation Region Land and Water Salinity Management Plan, now Shepparton Irrigation Region Catchment Implementation Strategy (SIRCIS). The Program aims to enable the removal of excess rainfall run-off from irrigated areas as well as providing another outfall option for groundwater pumps (SMEC, 2001).

The 2006 review is the third in the series since the implementation of the Program in 1990. The 1995 review included a significant revision of the program for future implementation of surface water management works (GBCMA, 2007). The 2000 review was a revision of the priority works program for the next ten years to direct resources to the highest priority areas.

An evaluation of the economic impacts has been an integral part of the reviews of the Program. The assessments included in the 1995 and 2000 reviews were *ex-ante* (before implementation) evaluation of all catchments to determine the economic feasibility of the Program based on planned works and forecast of benefits and costs. The 2000 assessment also included a prioritisation of the catchments based on the predicted economic performance of the catchments. The 2006 economic evaluation is an *ex-poste* type of evaluation (after implementation) and covered both the ‘market' and ‘non-market' priced[1] benefits and costs of the Program. It used actual data and results from other studies to quantify the benefits and costs of the Program's achievements in 2000 to 2006. The analysis focused on the costs and benefits as a result of the investment in the Program and compared them with the situation as it would be ‘Without' the Program (Gittinger, 1982).

This report has seven main sections. Section 3 is an overview of the tools used in the analysis and the limitations of the evaluation. Section 4 covers the regional and combined sub-catchment data input to the evaluation models. Sections 5 and 6 discuss the models used in the evaluation. Section 7 covers the achievements and the costs of the Program. Section 8 shows the results of the evaluation. Section 9 presents the sharing of benefits and costs between public and private investors.

[1] A commodity has a market price if it can easily be traded. For example, milk is a ‘market' priced commodity with a farm gate price usually expressed as either cents per litre or $ per kg butterfat. ‘Non-market' goods such as environmental features have no explicit prices and must be given a pseudo-market price or a shadow price (Spash, 1998 p48).

3 Evaluation Methods

The Drainage Evaluation Spreadsheet Model (DESM) was used to calculate the economic costs and benefits of the Surface Water Management Program. The model was developed by the Murray-Darling Basin Commission in 1990 to provide a tool in evaluating projects it funds across the Murray-Darling Basin.

The Benefit Transfer Technique based on Choice Modelling (CM) results was used in valuing the environmental benefits of the Program.

The costs and benefits were adjusted by Consumer Price Index from nominal to real values.

The costs and benefits (in 2006 dollar values) were discounted at 4% and 8% real rate over 30 years as per Victorian Government guidelines. The project's performance is summarised using discounted cash flow evaluation criteria such as Net Present Value, Benefit Cost Ratio and Internal Rate of Return[2].

The definitions of some technical terms used throughout this report are in Appendix 1.

The results of the economic analysis presented in this report are the net of 'With' and 'Without' the project scenario.

The completed systems included in this assessment were:

Primary Surface Water Management Systems (PSWMS):

a. Campaspe Drain 3a
b. Old Deakin Drain 5 (Cornelia Creek Drain)
c. Mosquito Drain - Stage 9
d. Mosquito Drain 25 Stage 2
e. Muckatah Drain Stage 1a
f. Muckatah Drain Stage 1b
g. Muckatah Drain Stage 2
h. Muckatah Drain Stage 3
i. Muckatah Drain 3

Community Surface Water Management Systems (CSWMS):

a. Deakin 7/3P
b. Mosquito 6/25P
c. Mosquito 10/25P
d. Mosquito 11/25P
e. Mosquito 14/25P
f. Muckatah 2AP
g. Shepparton 3B/11P
h. Wyuna 5/7P

These systems are collectively referred to as sub-catchments in this document.

3.1 Scenarios

The base case scenario included a change in land use from low value to high value crops due to the provision of surface water management systems. The opportunity cost of high value crops is the dairy gross margin ($1,650 per ha) and the opportunity cost of low value crops is equivalent to the mixed farming gross margin ($250 per ha).

Two cost scenarios were assessed:

[2] The Internal Rates of Return of the scenarios in the sensitivity analysis that are not economic at 4% were not calculated; their Internal Rate of Return is less than 4%.

- Period cost which covers all the costs the Program spent during the review period 2000-1 to 2005-6.
- System cost covers the total cost of all systems completed during the review period 2000-1 to 2005-6. The costs included: survey; design; program support; project management; construction and property and legal costs.

The scenarios were:

- Community Surface Water Management System (System Cost)
- Community Surface Water Management System (Period Cost)
- Primary Surface Water Management System (System Cost)
- Primary Surface Water Management System (Period Cost)

3.2 Sensitivity analysis

The following variables were used in the sensitivity analysis:

a. Without land use change
b. Increase the value of road benefits to $3,000 per km of sealed roads (~$3,155 in 2006$)
c. Decrease gross margin of all enterprises by 20%
d. Discount rate is 5% and period of analysis is 50 years.

The minimum change in land use to make the Program economic was also calculated.

The analysis also covered the impacts of variables (b), (c), and (d) on the “without land use change” scenario.

3.3 Limitations of the review

The evaluation was subject to a range of assumptions and care must be taken when interpreting the results. Some of the data were averages across the Shepparton Irrigation Region and some were basin-wide averages. Data were also sourced from studies in New South Wales, Western Australia and the Murray-Darling Basin.

The current version of the DESM and some of the input data used in the model were taken from the Loddon-Murray Irrigation Region Surface Water Management Plan (LMIRSWMP) prepared by Sinclair Knight Merz (SKM) for the North Central Catchment Management Authority (NCCMA). Although these data were adjusted to suit the conditions in the Shepparton Irrigation Region they may present an over or under estimation of the results.

There might be some discrepancies in the data presented in this report and the data from other sources such as Surface Water Management Program and SIRCIS reports. The author is confident that the data used in this evaluation are correct.

The impacts of the following factors on the economics of the Surface Water Management Program may be significant that may result to either an increase in the use of SWMS (positive) or reduce the need for SWMS (negative). However, there are many variables and unknowns to enable a reasonable quantification of their impacts.

- Climate change that may result to extreme dry conditions (negative impact) or wet conditions (positive impact).

- Reduced drainage water due to water trading, modernisation of the irrigation systems, improved irrigation standards and/or improved water use efficiency. The impact of these factors may be minimal as SWMS are designed to take excess water due to rainfall events rather than due to excessive irrigation.
- Modernisation may present an opportunity for the SWMS to become an outfall to deliver environmental water downstream.

The sensitivity analysis included the calculation of the impact of a 20% reduction in gross margin on the economics of the Program as proxy variable for unknown factors that may have negative effects on the Program.

4 Regional and Combined Surface Water Management Systems Data

4.1 Agriculture

In order to quantify the economic value of lost production due to salinisation, waterlogging and flooding, assumptions are required as to the impact of such losses on the cost structure of affected farms (MDBC, 1995 p9). The 'gross margin' approach was preferred over the 'income effect' approach. The 'gross margin' approach tends to counterbalance the over estimate of benefits that results from the assumptions implicit in the Drainage Evaluation Spreadsheet Model, that farmers do not adjust their levels of inputs in areas with significant salinity, waterlogging and/or flooding problems.

The gross margin and enterprise data were used to calculate the value of agricultural production 'With' and 'Without' the project.

The gross margin estimates for the various enterprises are shown in Table 1.

Table 1 Gross margin per hectare, Shepparton Irrigation Region (2006$)

Enterprise	Gross Margin ($/ha)
Dairy farming	$1,650
Mixed farming	$250
Horticulture (vegetables)	$4,300

Using the datasets generated by the Geographic Information System (GIS) Group at the Department of Primary Industries in Tatura, Victoria, a number of assumptions were made to estimate the area for each land use and soil type in the sub-catchment (Maxwell, 2007 personal communication). The assumptions are:

- The proportion of the different land uses and soil types found in the catchment is the same as in the sub-catchments. For example, if 20% of the area in the Mosquito Catchment has modified pasture, then 20% of the area in the Mosquito 6/25P sub-catchment has modified pasture.
- The GIS datasets did not contain sufficient information to identify whether pasture is on dairy farms or mixed farms. Thus it was assumed that a certain percentage of each pasture land use is for dairy farming and the balance is for mixed farming. The list of agricultural land use categories are in Appendix 2.

- Appendix 2There is no dryland land use as the difference between area serviced and the total area in the sub-catchment is minimal.
- Horticulture is represented by vegetables as it is likely that tomatoes are grown in the sub-catchments rather than perennial horticulture such as stone and pome fruits.

The predominant enterprise in the sub-catchments is mixed farming (Table 2).

Table 2 Enterprise mix in the sub-catchments

Enterprise	CSWMS (ha)	PSWMS (ha)
Dairy farming	947.3	8,241.0
Mixed farming	1,322.3	11,616.8
Horticulture (vegetables)	104.5	296.3
Total	**2,374.2**	**20,154**

Note: Rounding off errors

The soil profile data were used to determine the agricultural losses due to waterlogging, flooding and salinisation.

The definition of the six soil classes was provided in Skene et al (1966) cited by SKM (2003) as follows:

- Group 1: 'Good and fair soils for citrus, apricots, plums, vines, vegetables and lucerne, but doubtful soils for peaches, apples and shallow rooting crops'.
- Group 2: 'Good and fair soils for apricots, plums, apples, pears, vines, vegetables, lucerne, summer fodder crops, cereals, perennial and annual pastures'.
- Group 3: 'Good and fair soils for vines, vegetables, lucerne, summer fodder crops, cereals, and perennial and annual pastures; doubtful or unsuitable for most fruit trees. Group 3a soils are 'moderately permeable and watertable are likely to develop in the absence of tile drainage'.
- Group 4: 'Good and fair soils for lucerne, summer fodder crops, cereals, and perennial and annual pastures; mainly doubtful for vegetables'. 'The principal disability of (4a soils) is the slow permeability of the subsoils, and deep subsoils'.
- Group 5: 'Saline soils requiring appropriate reclamation measures and careful irrigation; when reclaimed should support most of the Group 3 crops, summer fodder crops, cereals and annual pastures'. 'Pastures and lucerne might be successful provided careful attention is given to management practices'.
- Group 6: 'Soils generally not recommended for irrigation because of elevation above gravity supply level, liability to intermittent flooding, or high salinity.'

The predominant soil type in the sub-catchments is Group 3 which accounts for about 41% (Table 3).

Table 3 Soil types in the sub-catchments

Soil Types	CSWMS (ha)	PSWMS (ha)
1	64.1	544.2
2	391.7	3,325.4
3	975.8	8,283.3
4	500.9	4,252.5
5	194.7	1,652.6
6	246.9	2,096.0
Total	**2,374.1**	**20,154.0**

4.2 Road network

One of the benefits of providing surface water management systems is reduced construction and maintenance costs to the road system.

Using the GIS data, it was assumed that the proportion of the different road types found in the catchment is the same as those in the sub-catchments. It was further assumed that the ratio of road length to the area of the catchment is the same as in the sub-catchment.

There are about 210 km of road system in the sub-catchments, mainly gravelled roads (Table 4).

Table 4 Length of road network in the sub-catchments

Road Type	CSWMS (km)	PSWMS (km)
Main Sealed Road	4.8	18.2
Other Sealed Road	8.2	31.2
Gravel Road	31.7	116.5
Total	**44.7**	**165.9**

5 Drainage Evaluation Spreadsheet Model

The Drainage Evaluation Spreadsheet Model (DESM) is a model used to assess the economics of surface and sub-surface drainage projects. It takes into account the 'market price' of benefits and costs of providing drainage in irrigation areas across the Murray-Darling Basin.

The version used in this review was an update from the 1995 version done by SKM (2003) for the LMIRSWMP in 2003. Additional information on the updated model can be found in Appendix 3.

The following sub-section discusses the data values for model parameters.

5.1 Agricultural production losses due to waterlogging and flooding

The DESM identified two types of agricultural production losses due to waterlogging (MDBC, 1995 p16):

- Micro-waterlogging due to soils with poor internal drainage characteristics

  Waterlogging due to irrigation is caused by poor, uneven layouts and lack of on-farm drainage. Waterlogging due to rainfall is similar in cause and impact to irrigation waterlogging. It may occur throughout the whole year although it is usually worst in spring and/or winter.

- Macro-waterlogging (flooding) due to run-off from other areas on the farm

  The duration is longer than micro-flooding and the effects are more severe.

The presence of shallow watertables probably exacerbates the severity of waterlogging and flooding.

The model requires data on yield losses and area affected.

It is estimated that production losses due to waterlogging could be up to 25% on dairy farms and 16% on mixed farms (Table 5). Waterlogging can reduce horticultural production by up to 100%. SKM (2003 p14) assumed that the areas prone to waterlogging are those with soil classes 4 to 6. A correction factor of 0.7 has been applied to represent that 30% of the soils would be in elevated locations and the impact of waterlogging would be less pronounced.

Table 5 Area affected by waterlogging and yield loss

Enterprise	Annual yield loss (%)	Affected land area
Dairy	25%	70% of the soil classes 4 to 6
Mixed	16.3%	
Horticulture (vegetable)	100%	

Flooding can cause production losses by up to 65% on dairy farms and 50% on mixed farms (Table 6).

The assumptions on yield losses due to flooding and area affected in horticulture were the same as those in the Loddon-Murray Irrigation Region (SKM 2003 p14). The area affected (dairy and mixed farming) was from DESM Manual (MDBC, 1995 p20).

Table 6 Area affected by flooding and yield loss

Enterprise	Annual yield loss (%)	Affected land area
Dairy	65%	10%
Mixed	50%	10%
Horticulture (vegetable)	100%	14%

5.2 Agricultural production losses due to salinity

The loss in agricultural production due to salinity was calculated using the Salinity Loss Function Method. This method requires time series data of the extent of shallow watertables (Table 7). The model then calculates the effective area lost to salinity and the resulting economic value of this loss (MDBC, 1995 p10).

Table 7 Area affected by shallow watertable

Age of Shallow Water Tables	Area Affected (%)	Area affected CSWMS (ha)	Area affected PSWMS (ha)
-40 (1966)	0%	0	0
-30	1%	24	202
-20	15%	354	3,023
-10	19%	449	3,829
0 (2006)	22%	520	4,434
10	24%	567	4,837
20	28%	662	5,643
30	30%	709	6,046
40	30%	709	6,046
50 (2056)	30%	709	6,046

Salinity losses are a function of the amount of salt accumulated in the root zone (MDBC, 1995 p11). This amount is basically a function of:

- time since the onset of shallow water tables
- the groundwater salinity
- the net volume of water passing up through the soil to the surface and evaporating
- This volume equals the volume of accessions (ignoring deep drainage), and hence will be a function of irrigation intensity, soil type, land use, amount of landforming, channel condition, etc.

The model has a series of values covering high and low salinity situations and different irrigation intensities. The proportional yield loss shown in Table 8 is for low salinity groundwater with irrigation intensity of 5ML/ha (MDBC, 1995 p12).

Table 8 Salinity loss function

Years from the onset of shallow water tables	Yield loss (%)
0	0
10	16
20	22
30	25
40	27
50	28
60	29
70	29
80	29
90	30

5.3 Effectiveness of works

The DESM was designed to calculate the impacts of a range of measures to mitigate the effects of waterlogging and salinity (MDBC, 1995 p21). These measures are:

- surface drainage
- sub-surface drainage
- on farm works such as landforming, on farm drainage and re-use systems

The model requires separate estimates of the effectiveness of these measures in terms of the reduction in potential losses. The reductions are likely to differ according to the type of measure adopted and the model allows the user to specify them for each possible combination of surface drainage, sub-surface drainage and on-farm works.

For the purpose of this evaluation, the effectiveness of surface water management systems is the only measure to be considered (Table 9). The effectiveness of systems with 1:2 Average Recurrence Interval (ARI) level of service to reduce flooding losses was adjusted from the 1:3 ARI level of service used in the Loddon-Murray Irrigation Region (SKM, 2003 p17 and p18).

Table 9 Effectiveness of surface water management systems

Level of service	Outcome	Effectiveness (%)
1 in 2 ARI	Reduce salinity losses (note 1)	10
1 in 1 ARI	Reduce salinity losses (note 1)	10
1 in 2 ARI	Reduce waterlogging losses (note 1)	10
1 in 1 ARI	Reduce waterlogging losses (note 1)	10
1 in 2 ARI	Reduce flooding losses (note 2)	40
1 in 1 ARI	Reduce flooding losses (note 2)	25

Notes: 1 MDBC, 1995 p23
2 SKM, 2003 p17 and p18

Table 9 also shows that the surface water management systems have minimal impact on reducing salinity and waterlogging losses but are very effective in reducing flooding losses. Systems with 1:1 ARI and 1:2 ARI level of service have the same effectiveness in reducing salinity and waterlogging losses, by up to 10%. The level of service mattered in reducing the losses due to flooding. Systems with 1:2 ARI level of service can reduce up to 40% of the flooding losses whilst 1:1 ARI systems can only reduce the losses by up to 25%.

5.4 Road benefits

The DESM Manual (MDBC, 1995) provided typical road benefit values for each of the major road types and also estimated the benefits to the on-farm road system. It was assumed that increased agricultural productivity due to the provision of surface water management systems will increase heavy vehicle traffic in the region by 1% per year (Table 10).

Table 10 Drainage benefits to the road system

Road Type/farm type	Drainage Benefits (2006 $/km)
Main Sealed Road	$1,975
Other Sealed Road	$1,053
Gravel Road	$658
Dairy Farm road benefits ($ha/yr)	$105
Mixed Farm road benefits ($ha/yr)	$13

Note: These values were adjusted by Consumer Price Index (ABS, 2008) from LMIRSWMP (SKM, 2003 p23)

The provision of surface drainage in an area will have a beneficial effect on farm roads or tracks (MDBC, 1995 p39). The much higher values in the case of dairying reflect the greater importance of the farm road or track network for daily movement of the herd and generally daily access for milk tankers.

The other variables used in calculating the benefits to the road system (MDBC, 1995 p37 and p38) are:

- Average annual rainfall. Losses with all categories of road will be dependent on the extent and duration of ponding, and are likely to be roughly proportional to annual rainfall. The long term average annual rainfall in the Shepparton Irrigation Region is 493mm based on the reading at the Tatura Weather Station (Finger, 2008 personal communication).
- Average annual Class A pan evaporation. From the surface drainage viewpoint this is considered relevant only on gravelled roads. Drying out of sub-grade and pavements will be approximately proportional to this variable. Benefits to drainage will reduce with increasing evaporation. The long term (1942 to 2001) evaporation rate in Tatura is 1,365mm (Finger, 2008 personal communication).
- Coefficient for natural drainage. The benefits of surface drainage to the road systems are greater where the natural drainage in the catchment is poor. The values for the coefficient range from 1.3 where drainage conditions are poor to 0.7 where they are good. The suggested default value is 1.0.

- Soil type coefficient. This allows for the differences in sub-grade strength with soil type. Benefits from SWMS will be greatest in areas where the soils have the highest plasticity and least strength. The values for the coefficient range from 0.7 for low plasticity soils to 1.3 for high plasticity soils. The suggested default value for the model is 1.0.
- Road reserve width coefficient. Surface drainage benefits will be greatest in areas with narrow (20m or less) road reserves because table drains must be much closer to the pavement edges. The suggested model default value is 1.0.
- K = I/45 where I is irrigation intensity. The degree to which any given road length will be affected by run-off from irrigated land, and hence will benefit from surface drainage, will be influenced by the irrigation intensity. This is defined as the proportion of the catchment area that is irrigated, ie, total irrigated area divided by total farm area. The value of 45 represents the overall intensity of irrigation in the central Murray-Darling Basin (expressed as percentage) based on the Kerang, Shepparton, Murray and Murrumbidgee regions.

5.5 Downstream impact

The downstream impact is measured as the benefit of reducing salt loads in the River Murray. The original DESM considered the downstream impact as a cost, not a benefit (SKM, 2008 p28). The proxy economic value is $240,000 per EC at Morgan, South Australia (SKM, 2003 p20). Table 11 shows the impact at Morgan per km of water management system.

The model has two methods of calculating salt loads:

- Method 1 calculates the salt loads from the data on groundwater salinity; lengths of surface water management systems in several depth classes; annual rate of groundwater extraction (for sub-surface drainage schemes) and the proportions of the surface and sub-surface drainage water re-used before reaching the main stream of the River Murray. The estimated groundwater salinity in the sub-catchments is 5,000 EC (Hunter, 2008 personal communication).
- Method 2 caters for projects where the salt loads have already been calculated.

This evaluation used Method 2.

Table 11 Downstream salinity impact at Morgan (South Australia)

	Impact at Morgan (EC/km/year)
Community Surface Water Management Systems (1)	-0.00089
Primary Surface Water Management Systems (2)	-0.00220

Sources
1 SKM, 2008 p28
2 Anonymous, 2006

5.6 Re-use and landforming benefits

The benefits of landforming and re-use of irrigation water were not included in the analysis. It was assumed that farmers would have incorporated these management options on their farm even without the Program.

6 Benefit Transfer Technique

The Benefit Transfer Technique[3] was used to value the environmental impacts of the Program and applied the results from the Choice Modelling studies undertaken in Western Australia and New South Wales. Choice Modelling is a method of valuing non-market goods where respondents evaluate a number of options or scenarios.

Choice modelling is a technique that can be used to estimate the value of non-market goods. Bennett (2005) describes Choice Modelling as:

> *"A 'stated preference' technique that involves a sample of people who are expected to experience the benefits/costs being asked a series of questions about their preferences for alternative future resource management strategies. Each question called a 'choice set' presents to respondents the outcome of usually three or four alternative strategies. The alternatives are described in terms of a common set of attributes.*
>
> *The alternatives are differentiated one from the other by the attributes taking on different levels. One of the alternatives – that relating to the 'business as usual' (BAU) option – is held constant and is included in all the choice sets."*

In the Choice Modelling studies conducted by van Bueren and Bennett (2000, 2004) and by Whitten and Bennett (2001), respondents were presented with a number of policy options that affect a number of financial, social and environmental attributes. The respondents were then asked to choose the options that they like most by looking at the levy amount and the effects that the projects are expected to have on the environment and country communities (van Bueren and Bennett, 2004 and 2000 p61, Whitten and Bennett, 2001). In the Western Australian study, the levy per household is paid annually for 20 years whilst in the New South Wales study, the levy per household is a one-off payment.

6.1 Natural resource attributes

The studies started with a survey of policy makers and their advisers to establish a list of possible generic attributes to describe land and water degradation impacts and the environmental goods to be assessed and compared. This was followed by focus groups to gain an appreciation of the general public's understanding of these issues. In the Western Australian study, household surveys were conducted in Perth and Albany and other selected metropolitan and non-metropolitan areas nationally. In the New South Wales study, the household surveys were conducted in Griffith and Wagga Wagga as well as Canberra and Adelaide.

The attributes chosen are shown in Table 12 and Table 13.

3 Under Benefit Transfer Technique, the value estimates that have been developed for other cases ("source" estimates) are used to make informed decisions where an environmental exercise is not warranted given the scale of the proposed changes or cannot be afforded neither in terms of time nor money (the "target/policy" case). (Bennett and Morrison, 2001 p7)

Table 12 **Attributes selected for Choice Modelling Technique, Great Southern Region (GSR) Western Australia**

Attribute	Variable	Attribute Description
Endangered native species	Species	Species Protection, measured by the number of endangered species protected from extinction
Countryside aesthetics	Look	Landscape Aesthetics, measured by the area of farmland repaired and bush protected (hectares)
Waterway health	Water	Measured by the length of waterways restored for recreational purposes (fishing or swimming) – km
Country communities	Social	Social impact, viability of country communities measured by the net loss of population from country towns each year

Source: van Bueren and Bennett, 2000 p16 & p38

Table 13 **Attributes selected for Choice Modelling Technique, Murrumbidgee River Floodplain (MRF) New South Wales**

Attribute	Attribute Description
Cost	Size of levy
Wetlands	Area of healthy wetlands (ha)
Birds	Population of native water and woodland birds
Fish	Population of native fish
Farmers leaving	Number of farmers leaving

Source: Whitten and Bennett, 2001 p8 & p22

6.2 Strengths of Choice Modelling

Choice Modelling has a number of strengths as a non-market environmental valuation tool such as:

- Specifically targets environmental attributes that can not be estimated in related markets.
- Can be used in a regional context.
- Socio-economic differences between the target population and the survey population can be accounted for.
- Forces respondents to consider natural resource trade-offs rather than a single issue. This generates more realistic values.
- Can be used in conjunction with other environmental valuation techniques.
- The result of a Choice Modelling study can be used as a “source” estimate in a Benefit Transfer Technique.

6.3 Attributes used in this evaluation

The ‘Look’ and ‘Wetlands’ attributes were used in this evaluation.

The value of the ‘Look’ environmental feature was estimated using the implicit price, based on the study by Bennett and van Bueren in the Great Southern Region of Western Australia in 2000. The implicit price is the price that each household pays to protect 10,000 ha of bush for 20 years.

The study by Whitten and Bennett in the Murrumbidgee River Floodplain in New South Wales was used in estimating the value of ‘Wetlands’. The implicit price is a one-off price that each household pays to protect 1,000 ha of wetlands.

The implicit price was adjusted to account for the socio-economic differences between the population and income of the “study site” and the “policy site”[4].

The following is an excerpt from a URS critique:

> The income adjustment for both national and international benefit transfers to estimate the mean Willingness to Pay at the policy site (WTP_p) is:
>
> $$WTP_p = WTP_s * [Y_p/Y_s]$$
>
> where:
>
> WTP_p = the original benefit estimates from the study site;
>
> WTP_s = the original benefit estimate from the policy site;
>
> Y_p = the income levels at the policy site;
>
> Y_s = the income levels at the study site
>
> Policy site = Victoria
>
> Study site ('Look') = Western Australia
>
> Study site ('Wetlands') = New South Wales
>
> ‘Look’ attributes:
> The WTP in this context is $/10,000 ha of protected/repaired farmland and native bush. Y_p and Y_s are the average yearly total incomes in 1999-2000[5] for Victoria and Western Australia, respectively.
>
> For the ‘Wetlands’ study, the WTP is $/1,000 ha of protected/ repaired wetlands. Y_p and Y_s are the average yearly total incomes in 1999-2000[6] of the study sites and policy sites, respectively.

The present value (PV) of the environmental benefits was calculated using 4% and 8% discount rates. PV is the total amount that a series of future payments is worth now. The formula to calculate PV is

$$PV = S_t * [1/(1+i)^t]$$

where:

S = sum of money (benefits or costs);

t = year;

i = discount rate

4 The “study sites” for the ‘Look’ attribute are the Great Southern Region and Perth in Western Australia and the “study sites” for the ‘Wetlands’ attribute are Adelaide, Canberra and Wagga Wagga and Griffith in New South Wales. The “policy sites” for the ‘Look’ attribute are the Goulburn Broken Catchment and Melbourne; and the “policy sites” for the ‘Wetlands’ attribute are Melbourne, Canberra, Greater Shepparton and Benalla, respectively.

5 The average annual total incomes for Western Australia (Perth and Great Southern Region), Victoria (Melbourne and Goulburn Broken Catchment) and Canberra were taken from the National Regional Profile published by the Australian Bureau of Statistics, ABS cat. no. 1379.0.55.001.

6 The average annual total incomes for Melbourne, Benalla, Greater Shepparton and Canberra were taken from the National Regional Profile published by the Australian Bureau of Statistics, ABS cat. no. 1379.0.55.001.

7 Achievements and Costs of the Program, 2000 to 2006

This section discusses the achievements of the Surface Water Management Program and the cost associated in implementing the Program. The first part covers the Primary Surface Water Management Sub-Program (PSWMP) followed by the Community Surface Water Management Sub-Program (CSWMP). The third part summarises the total cost of the Program.

The costs were classified as either nominal or real.

7.1 Primary Surface Water Management Sub-Program

Nine Primary Surface Water Management Systems (PSWMS) were completed during the review period and directly service about 6,000 ha of farm land (Table 14). An estimated 14,000 ha more could be drained indirectly by providing outfall for the Community Water Management Systems (CSWMS).

Table 14 Area serviced and length - Primary Surface Water Management Systems

	Drained area (direct) (ha)	Area indirectly served (ha)	Length of system (km)*
Campaspe Drain 3a	186	2,675	5.3
Old Deakin Drain 5 (Stage 1)	907	522	8.0
Mosquito Drain - Stage 9	373	100	4.2
Mosquito Drain 25 Stage 2	610	932.2	4.3
Muckatah Drain Stage 1a	380	988	4.3
Muckatah Drain Stage 1b	592	208	7.3
Muckatah Drain Stage 2	1,020	3,041	12.7
Muckatah Drain Stage 3	1,290	3,155	13.3
Muckatah Drain 3	415	2,760	3.6
Total	**5,773**	**14,381**	**63.0**

* Length of systems constructed includes system remodelling

The total cost (2006$) of constructing these PSWMS was $15.4 million at an average of $244,100 per km (Table 15).

Table 15 Total capital cost - Primary Surface Water Management Systems

	Total cost (nominal)	Total cost (2006$)	Average cost (2006$/km)
Campaspe Drain 3a	$581,879	$653,954	$123,388
Old Deakin Drain 5 (Stage 1)	$1,392,251	$1,579,662	$197,458
Mosquito Drain - Stage 9	$820,490	$985,663	$234,682
Mosquito Drain 25 Stage 2	$714,299	$878,849	$204,383
Muckatah Drain Stage 1a	$2,009,695	$2,386,057	$554,897
Muckatah Drain Stage 1b	$1,414,406	$1,641,283	$224,833
Muckatah Drain Stage 2	$3,048,888	$3,367,200	$265,134
Muckatah Drain Stage 3	$2,810,789	$2,973,341	$223,559
Muckatah Drain 3	$861,764	$911,096	$253,082

	Total cost (nominal)	Total cost (2006$)	Average cost (2006$/km)
Total	**$13,654,461**	**$15,377,105**	
Average			**$244,081**

Table 16 shows that the annual costs (System Cost method) varied from year to year. In the early stages of the process, the costs incurred are mainly for survey and design. The cost increased as the construction of the systems commenced. The cost incurred in 2006-2007 financial year was included because it was part of the total cost of the systems[7].

Table 16 Annual capital cost - Primary Surface Water Management Systems,

Year	System cost		Period cost ($M)	
	Total cost (nominal)	Total cost (2006$)	Total cost (nominal)	Total cost (2006$)
1993/94	$1,875	$2,535		
1994/95	$45,452	$59,833		
1995/96	$51,757	$65,658		
1996/97	$106,780	$133,764		
1997/98	$32,816	$41,144		
1998/99	$1,129,385	$1,403,091		
1999/00	$2,075,229	$2,511,680		
2000/01	$2,963,597	$3,382,464	$4.38	$4.99
2001/02	$2,304,101	$2,557,841	$3.87	$4.30
2002/03	$2,022,744	$2,174,775	$3.17	$3.41
2003/04	$2,121,767	$2,231,718	$3.20	$3.37
2004/05	$543,691	$560,483	$3.09	$3.18
2005/06	$133,984	$133,984	$3.73	$3.73
2006/07	$121,283	$118,137		
Total	**$13,654,461**	**$15,377,107**	**$21.44**	**$22.98**

The operating and maintenance cost was $1,200 per km (2006$).

The estimated Program Support cost was about $150,000 (2006$) per system. These were incurred in proportion to system cost per year (Eaton, 2008 personal communication). For the period cost scenario, the Program Support Cost was $200,000 (2006$) per year (Table 17).

Table 17 Annual Program Support cost - Primary Surface Water Management Sub-Program (2006$)

Year	System cost	Period cost
1993/94		
1994/95	$3,110	
1995/96	$4,304	
1996/97	$8,716	

7 All of the systems constructed during the period 2000 to 2006 incurred expenses in 2006-07 financial year. The lowest cost (2006$) was $182 (Old Deakin Drain 5 Stage 1) and the highest was $57,500 (Muckatah Drain Stage 3).

Year	System cost	Period cost
1997/98	$2,176	
1998/99	$91,209	
1999/00	$171,342	
2000/01	$259,554	$177,200
2001/02	$207,617	$182,000
2002/03	$187,812	$188,000
2003/04	$201,089	$192,200
2004/05	$52,920	$196,000
2005/06	$13,500	$200,000

7.2 Community Surface Water Management Sub-Program

The construction of 34 km of CSWMS was completed in 2000 to 2006 servicing 2,200 ha of farmland (Table 18).

Table 18 Area serviced and length - Community Surface Water Management Systems

	Sub-catchment area (ha)	Directly drained area (ha)	Length of system (km)
Deakin 7/3P	45.1	45	0.55
Mosquito 6/25P	125.8	118	2.5
Mosquito 10/25P	91.0	91	1.9
Mosquito 11/25P	85.0	78	2.1
Mosquito 14/25P	836.8	820	11.1
Muckatah 2AP	52.0	52	0.7
Shepparton 3B/11P	430.0	292	6
Wyuna 5/7P	708.4	706	8.9
Total	**2,374.1**	**2,202**	**33.75**

Source: Pagon, 2008 personal communication

The total cost of the constructed systems in real terms was $2.2 million at an average of $66,200 per km (Table 19).

Table 19 Total capital cost - Community Surface Water Management Systems

	Total cost (nominal)	Total cost (2006$)	Average cost (2006$/km)
Deakin 7/3P	$86,458	$92,580	$168,328
Mosquito 6/25P	$107,757	$117,722	$47,089
Mosquito 10/25P	$115,588	$125,981	$66,306
Mosquito 11/25P	$140,215	$157,415	$74,960
Mosquito 14/25P	$527,036	$565,638	$50,958
Muckatah 2AP	$26,514	$30,004	$42,862
Shepparton 3B/11P	$402,383	$411,973	$68,662
Wyuna 5/7P	$633,655	$733,980	$82,470

	Total cost (nominal)	Total cost (2006$)	Average cost (2006$/km)
Total	**$2,039,608**	**$2,235,293**	
Average			**$66,231**

Note: The total cost excluded Program Support costs not associated with the construction

The annual costs varied from year to year and were high during the construction phase (Table 20). The cost incurred in 2006-07 financial year was included because it was part of the total cost of the system (Muckatah 2AP).

Table 20 Annual capital cost - Community Surface Water Management Systems

Year	System cost		Period cost	
	Total cost (nominal)	Total cost (2006$)	Total cost (nominal)	Total cost (2006$)
1992/93	$34,650	$47,791		
1993/94	$12,870	$17,399		
1994/95	$18,614	$24,504		
1995/96	$26,762	$33,950		
1996/97	$31,074	$38,926		
1997/98	$12,870	$16,136		
1998/99	$762	$947		
1999/00	$39,543	$47,860		
2000/01	$597,852	$682,350	$378,552	$432,056
2001/02	$160,458	$178,128	$1,163,143	$1,291,235
2002/03	$205,017	$220,427	$454,341	$488,489
2003/04	$536,099	$563,880	$741,043	$779,444
2004/05	$0	$0	$381,933	$393,729
2005/06	$361,437	$361,437	$630,996	$630,996
2006/07	$1,600	$1,559		
TOTAL	**$2,039,608**	**$2,235,293**	**$3,750,008**	**$4,015,949**

The operating cost of CSWMS was $463 per km at 2006$ value.

The estimated Program Support cost was about $40,500 (2006$) per system (Paganini, 2008 personal communication). The costs were incurred in proportion to system cost per year and included support by the Environment Program (Table 21).

Table 21 Annual Program Support cost - Community Surface Water Management Sub-Program (2006$)

Year	System cost	Period cost
1992/93	$4,037	
1993/94	$1,529	
1994/95	$2,272	
1995/96	$3,391	
1996/97	$3,987	
1997/98	$1,648	
1998/99	$98	

Year	System cost	Period cost
1999/00	$5,248	
2000/01	$84,210	$540,817
2001/02	$23,213	$689,886
2002/03	$30,639	$484,909
2003/04	$81,904	$647,997
2004/05	$0	$841,981
2005/06	$57,461	$747,363

7.3 Surface Water Management Program

The total cost of constructing 97km of the PSWMS and CSWMS was about $17.6 million (Table 22) and the total cost of Program from 2000 to 2006 (excluding other Program Support costs) was $27 million in 2006$.

Table 22 Annual capital cost - Surface Water Management Systems

Year	System cost		Period cost ($M)	
	Total cost (nominal)	Total cost (2006$)	Total cost (nominal)	Total cost (2006$)
1992/93	$34,650	$47,791		
1993/94	$14,745	$19,934		
1994/95	$64,066	$84,337		
1995/96	$78,519	$99,608		
1996/97	$137,854	$172,690		
1997/98	$45,686	$57,280		
1998/99	$1,130,148	$1,404,038		
1999/00	$2,114,773	$2,559,540		
2000/01	$3,561,449	$4,064,814	$4.75	$5.43
2001/02	$2,464,558	$2,735,969	$5.03	$5.59
2002/03	$2,227,761	$2,395,202	$3.62	$3.90
2003/04	$2,657,866	$2,795,598	$3.94	$4.15
2004/05	$543,691	$560,483	$3.47	$3.58
2005/06	$495,421	$495,421	$4.36	$4.36
2006/07	$122,883	$119,696		
TOTAL	**$15,694,069**	**$17,612,400**	**$25.19**	**$27.00**

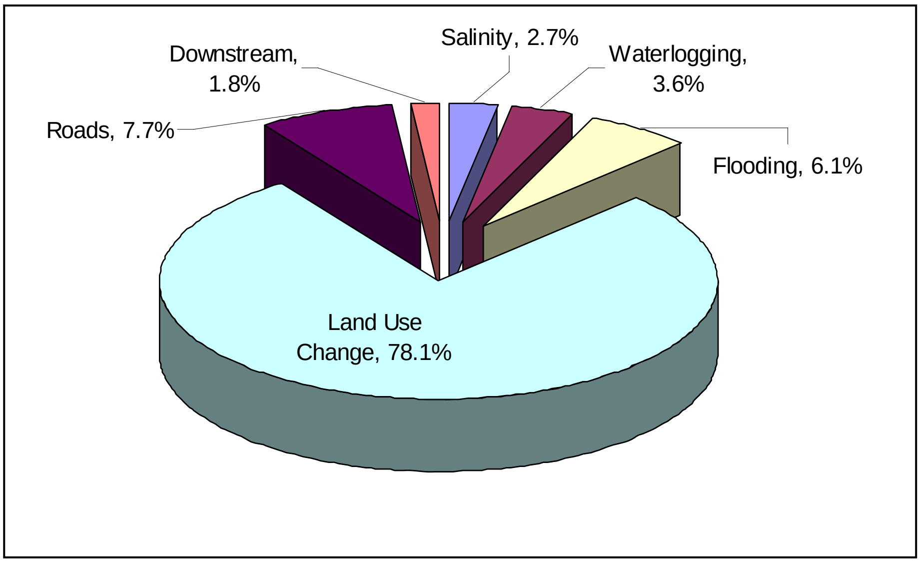
8 Results

8.1 Economic evaluation

The Surface Water Management Program is estimated to generate economic benefits of about $15.5 million (using System Cost method) or $22.6 million (using Period Cost method).

Figure 1 is a graphic presentation of the benefits of the Program discounted at 4% for 30 years. Majority of the benefits (78%) was due to land use change.

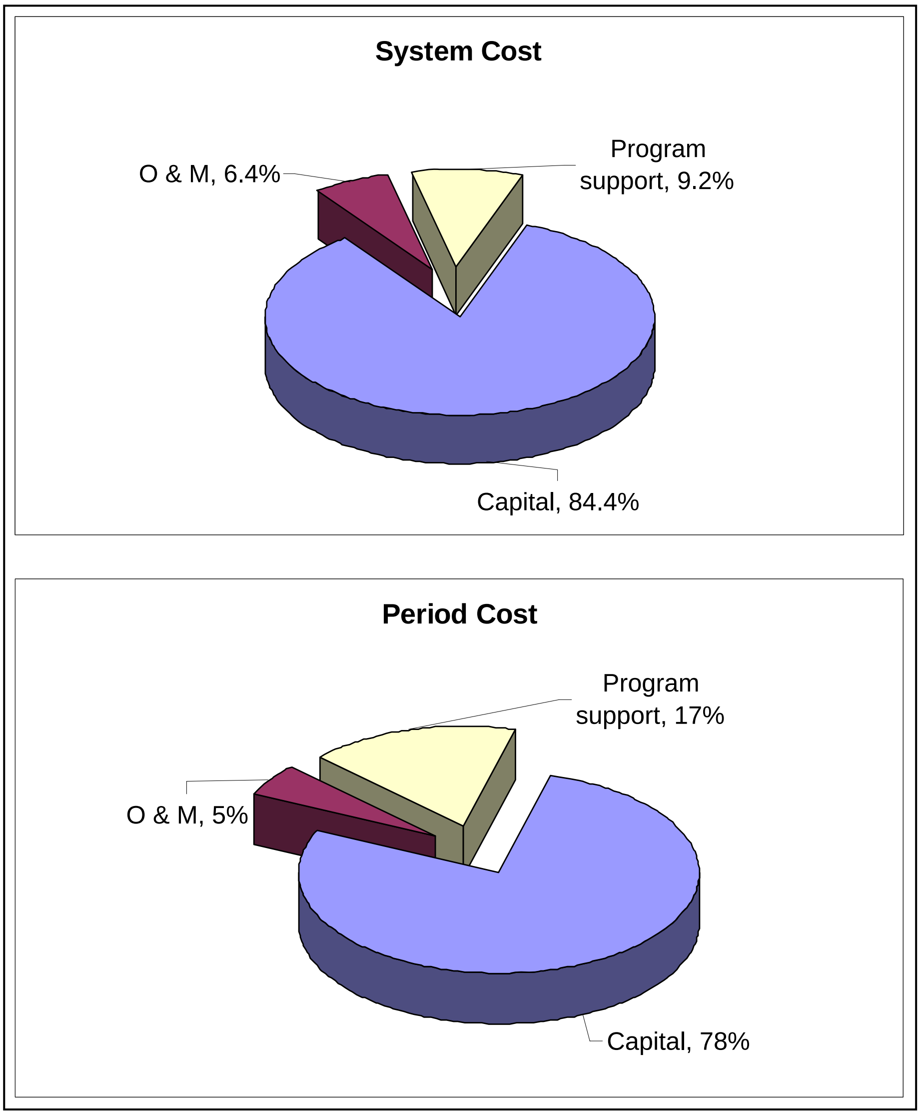
Figure 1 Breakdown of benefits of Surface Water Management Program with land use change: 4% discount rate, 30-year analysis



Using System Cost approach, 84% of the cost of the Program was capital cost. The capital costs covered the construction, survey, design, project management and establishment costs of new crops (Figure 2).

Using Period Cost approach, about 78% of the cost of the Program was capital cost and 17% was spent on Program Support.

Figure 2 **Breakdown of cost of implementing the Surface Water Management Program (System Cost method) with land use change: 4% discount rate, 30-year analysis**



The Surface Water Management Program is economic when the System Cost method was used, generating a Net Present Value of $4 million and Benefit Cost Ratio of 1.35:1 (Table 23). This means that for every dollar invested, $1.35 worth of economic benefits is generated over the 30-year period. The Internal Rate of Return is 6.3%. A project is economic when the Net Present Value is positive and the Benefit Cost Ratio is at least 1:1 at a chosen discount rate and analysis period. Both the Community and Primary Surface Water Management Sub-Programs were economic with positive Net Present Values and Benefit Cost Ratios of 1.91:1 and 1.27:1, respectively.

Table 23 Economic analysis results: 4% discount rate, 30-year analysis ($M)

	System cost			Period cost		
	CSWMP	PSWMP	Program Total	CSWMP	PSWMP	Program Total
Benefits Agriculture						
- Salinity	$0.12	$0.29	$0.41	$0.15	$0.35	$0.50
- Waterlogging	$0.20	$0.36	$0.56	$0.28	$0.51	$0.79
- Flooding	$0.57	$0.37	$0.94	$0.82	$0.53	$1.35
- Land Use Change	$1.25	$10.83	$12.08	$1.82	$15.81	$17.63
-TOTAL	**$2.14**	**$11.85**	**$13.99**	**$3.07**	**$17.20**	**$20.27**
Reuse						
Roads	$0.54	$0.65	$1.19	$0.73	$0.89	$1.62
Downstream	$0.07	$0.21	$0.28	$0.12	$0.56	$0.68
Other						
TOTAL	**$2.75**	**$12.71**	**$15.46**	**$3.92**	**$18.65**	**$22.57**
Costs						
Capital	$1.11	$8.54	$9.65	$3.00	$17.36	$20.36
Operation and maintenance	$0.13	$0.60	$0.73	$0.24	$1.12	$1.36
Program Support	$0.20	$0.85	$1.05	$3.43	$0.99	$4.42
TOTAL	**$1.44**	**$9.99**	**$11.43**	**$6.67**	**$19.47**	**$26.14**
Investment Summary						
NPV	**$1.31**	**$2.72**	**$4.03**	**($2.75)**	**($0.82)**	**($3.57)**
BC ratio	1.91	1.27	1.35	0.59	0.96	0.86
Internal Rate of Return	10.2%	5.9%	6.3%			

Using Period Cost method, the whole Program is uneconomic with Benefit Cost Ratio of 0.86:1. The Primary Surface Water Management Sub-Program is marginally uneconomic with Benefit Cost Ratio of 0.96:1.

The Period Cost method has a higher cost base because there were partially completed projects on the ground that required funding but not yet generating benefits. Also, the Program Support for the Community Surface Water Management Sub-Program was significant at about 51% of its total cost.

By extending the analysis period to 50 years, there are extra flows to the benefit side of the equation and only operating and maintenance on the cost side. Table 24 shows that the Surface Water Management Program is marginally uneconomic using Period Cost method with Benefit Cost Ratio of 0.994:1. The construction of PSWMS was economic with Net Present Value of $1.8 million and Benefit Cost Ratio of 1.08:1. The construction of CSWMS (Period Cost method) is still uneconomic with Benefit Cost Ratio of 0.7:1.

Table 24 Economic analysis results: 4% discount rate, 50-year analysis ($M)

	System cost			Period cost		
	CSWMP	PSWMP	Program Total	CSWMP	PSWMP	Program Total
Total benefits	$4.05	$18.54	$22.59	$5.24	$24.49	$29.73

	System cost			Period cost		
	CSWMP	PSWMP	Program Total	CSWMP	PSWMP	Program Total
Total costs	$1.80	$12.28	$14.08	$7.24	$22.66	$29.90
Net Present Value	$2.25	$6.26	$8.51	($2.00)	$1.83	($0.17)
Benefit cost ratio	2.25	1.51	1.60	0.72	1.08	0.994
Internal Rate of Return	10.7%	6.7%	7.2%		4.4%	

At 8% discount rate, the Community Surface Water Management Sub-Program is economic (System Cost method) with Net Present Value of $260,000 and Benefit Cost Ratio of 1.23:1 but uneconomic using Period Cost method (Table 25). The whole Program, however, is not economic, generating a Benefit Cost Ratio of 0.83:1 (System Cost method) and 0.52:1 (Period Cost method).

Table 25 Economic analysis results: 8% discount rate, 30-year analysis ($M)

	System cost			Period cost		
	CSWMP	PSWMP	Program Total	CSWMP	PSWMP	Program Total
Benefits Agriculture						
- Salinity	$0.06	$0.14	$0.20	$0.08	$0.19	$0.27
- Waterlogging	$0.10	$0.18	$0.28	$0.16	$0.30	$0.46
- Flooding	$0.28	$0.18	$0.46	$0.46	$0.30	$0.76
- Land Use Change	$0.63	$5.44	$6.07	$1.05	$9.15	$10.20
-TOTAL	**$1.07**	**$5.94**	**$7.01**	**$1.75**	**$9.94**	**$11.69**
Reuse						
Roads	$0.27	$0.33	$0.60	$0.42	$0.51	$0.93
Other	$0.03	$0.09	$0.12	$0.08	$0.36	$0.44
Downstream						
TOTAL	**$1.37**	**$6.36**	**$7.73**	**$2.25**	**$10.81**	**$13.06**
Costs						
Capital	$0.92	$7.29	$8.21	$2.98	$17.27	$20.25
Operation and maintenance	$0.06	$0.29	$0.35	$0.15	$0.67	$0.82
Program Support	$0.13	$0.62	$0.75	$3.00	$0.87	$3.87
TOTAL	**$1.11**	**$8.20**	**$9.31**	**$6.13**	**$18.81**	**$24.94**
Investment Summary						
NPV	**$0.26**	**($1.84)**	**($1.58)**	**($3.88)**	**($8.00)**	**($11.88)**
BCratio	1.23	0.78	0.83	0.37	0.58	0.52

The land use change benefits are benefits that accrue directly to the landholders. The base case scenario shows that these benefits constituted almost 50% of the total benefits of providing CSWMS (Refer to Table 23).

There would also be production benefits from reduced salinisation, flooding and waterlogging, assumed to be about 25% of these benefits.

From the landholders' point of view, investing in CSWMS will give them $1.64 worth of benefits for every dollar invested (Table 26). The discount rate used in calculating the benefits and costs was 8%.

Table 26 Landholders' financial benefits and costs - Community Surface Water Management System (System Cost method): 8% discount rate, 30-year analysis

	With land use change	Without land use change
Benefits	0.74	0.11
Costs	0.45	0..43
Benefit Cost Ratio	1.64	0.26
Internal Rate of Return	15.9%	

8.2 Evaluation of environmental impacts

The Surface Water Management Program enabled the revegetation of 36 hectares of bushland and the protection of two wetlands (Table 27). Bray's Swamp in the Mosquito 24 sub-catchment (80 ha) and Kinnairds Wetlands in the Muckatah Depression (93 ha) are the two main wetlands protected by the Surface Water Management Program in the last six years.

Table 27 Revegetation adjacent to Surface Water Management Systems

Year	Area Planted (ha)
2000/01	4.9
2001/02	12.65
2002/03	7.55
2003/04	8.47
2004/05	0.40
2005/06	1.60
TOTAL	35.57

The indicative value of revegetated land ('Look' attribute) is $46.87 per hectare per year for 20 years. The 'Wetlands' attribute has indicative values at 4% and 8% discount rates of $339 and $563 per hectare per year for 30 years, respectively. Appendix 4 shows the assumptions used in calculating the value of environmental benefits.

The present values of the environmental benefits are almost $1 million at 4% discount rate and $950,000 at 8% (Table 28).

Table 28 Present value of environmental benefits: 30-year analysis

	4%	8%
Look	$21,759	$13,926
Wetlands	$964,431	$935,994
TOTAL	**$986,190**	**$949,920**

If the environmental benefits are added to the economic benefits, the Net Present Value of the Program will be $5 million and the Benefit Cost Ratio is 1.44:1 using System Cost method (Table 29). The Internal Rate of Return is 6.9%. However, the Benefit Cost Ratio of the Program is still less than 1:1 when Period Cost method was applied.

Table 29 Summary of the value of economic and environmental benefits with land use change: 4% discount rate, 30-year analysis

	Economic		Economic & environmental	
	System cost	**Period cost**	**System cost**	**Period cost**
Present value - Benefits	$15.46	$22.57	$16.45	$23.56
Present value - Cost	$11.43	$26.14	$11.43	$26.14
Net Present Value	$4.03	($3.57)	$5.02	($2.58)
Benefit Cost Ratio	1.35	0.86	1.44	0.90
Internal Rate of Return	6.3%	3.2%	6.9%	3.4%

8.3 Sensitivity analysis

Sensitivity testing of the main variables was conducted to determine their effect on the economics of the Program.

The detailed results of the analyses are in Appendix 5.

8.3.1 Without land use change[8]

If there is no land use change due to the provision of SWMS, the Surface Water Management Program is not economic under the two cost scenarios (Table 30).

The Community Surface Water Management Sub-Program (System Cost method) was marginally economic if there is no change of land use with Net Present Value of minus $60,000 and Benefit Cost Ratio of 1.04:1.

Table 30 Sensitivity test - without land use change: 4% discount rate, 30-year analysis ($M)

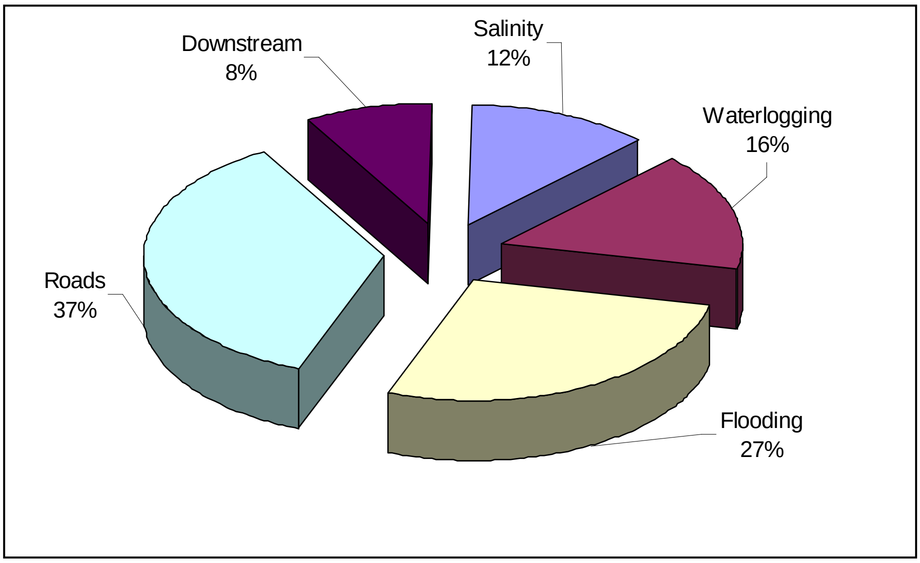
	System cost			Period cost		
	CSWMP	**PSWMP**	**Program Total**	**CSWMP**	**PSWMP**	**Program Total**
Base case scenario						
Net Present Value	**$1.31**	**$2.72**	**$4.03**	**($2.75)**	**($0.82)**	**($3.57)**
Benefit cost ratio	1.91	1.27	1.35	0.59	0.96	0.86
Internal Rate of Return	10.2%	5.9%	6.3%			
No land use change scenario						
Net Present Value	$0.06	($7.87)	($7.81)	($4.66)	($16.31)	($20.97)

8 The opportunity cost of low value crops is equivalent to the gross margin per hectare of mixed farming and the opportunity cost of high value crops is equivalent to the gross margin per hectare of dairy farming.

	System cost			Period cost		
	CSWMP	PSWMP	Program Total	CSWMP	PSWMP	Program Total
Benefit cost ratio	1.04	0.19	0.30	0.29	0.14	0.18
Internal Rate of Return	4.6%					

Without land use change, the benefits to the road system accounted for 37% of the total benefit (Figure 3).

Figure 3 Breakdown of benefits of surface water management using System Cost method, without land use change: 4% discount rate, 30-year analysis



The Community Surface Water Management Sub-Program will become economic if there is a change of land use from low value to high value crops by at least 1%.

The minimum change of land use due to the provision of Primary SWMS is 8% to make the Sub-Program economic.

8.3.2 Downstream impact a cost not a benefit

The effect of treating the calculated downstream impact as a cost not a benefit has a marginal effect on the Net Present Values and Benefit Cost Ratios of the scenarios (Table 31).

Table 31 Sensitivity test - downstream impact as a benefit: 4% discount rate, 30-year analysis ($M)

	System cost			Period cost		
	CSWMP	PSWMP	Program Total	CSWMP	PSWMP	Program Total
With land use change						
Base case scenario						

	System cost			Period cost		
	CSWMP	PSWMP	Program Total	CSWMP	PSWMP	Program Total
Net Present Value	$1.31	$2.72	$4.03	($2.75)	($0.82)	($3.57)
Benefit cost ratio	1.91	1.27	1.35	0.59	0.96	0.86
Internal Rate of Return	10.2%	5.9%	6.3%			
Downstream impact as cost						
Net Present Value	$1.17	$2.30	$3.47	($2.99)	($1.94)	($4.93)
Benefit cost ratio	1.77	1.23	1.30	0.56	0.90	0.82
Internal Rate of Return	9.7%	5.6%	6.1%			
Without land use change						
Downstream impact as cost						
Net Present Value	($0.08)	($8.29)	($8.37)	($4.88)	($17.43)	($22.31)
Benefit cost ratio	0.95	0.16	0.27	0.27	0.11	0.15
Internal Rate of Return						

8.3.3 Increase value of road benefits

Wilson (1999) estimated that the additional repair and maintenance cost due to salinisation ranges from $101 to $42,000 per km depending on the severity of the impact and road classification (Table 32). These values were used in the preparation of the Port Phillip and Western Port Bay Salinity Management Plan in 2007.

Table 32 Additional repair and maintenance cost due to effect of salinity by road class and severity of damage ($/km/year in 2006$)

Road Class	Very Slight Impact	Slight Impact	Moderate Impact	Severe Impact
National and State Highway	$1,077	$1,615	$4,846	$41,975
Main Sealed Road	$269	$606	$2,154	$23,319
Minor Sealed Road	$135	$404	$942	$1,615
Unsealed Road	$101	$269	$673	$1,077

Source: Wilson, S.M. 1999, Dryland Salinity - What are the impacts and how do you value them? An Ivey ATP and Wilson Land Management Services report prepared for the Murray Darling Basin Commission and the National Dryland Salinity Program, Canberra (cited in the Port Phillip & Western Port Salinity Management Plan, 2007).
Note: The values were adjusted using the Consumer Price Index (General Construction)

If the value of road benefit is increased to $3,000 per km (equivalent to $3,155 in 2006$) as an upper bound limit (SKM, 2003), the Net Present Value and Benefit Cost Ratio improved marginally. The main findings from Table 33 are:

- The scenarios under the Period Cost method remained uneconomic; Primary Surface Water Management Sub-Program is marginally uneconomic with Benefit-Cost Ratio of 0.98:1.
- The Community Surface Water Management Sub-Program without land use change (System Cost method) became economic.

Table 33 Sensitivity test - increase road benefits of sealed roads: 4% discount rate, 30-year analysis ($M)

	System cost			Period cost		
	CSWMP	**PSWMP**	**Program Total**	**CSWMP**	**PSWMP**	**Program Total**
With land use change						
Base case scenario						
Net Present Value	$1.31	$2.72	$4.03	($2.75)	($0.82)	($3.57)
Benefit cost ratio	1.91	1.27	1.35	0.59	0.96	0.86
Internal Rate of Return	10.2%	5.9%	6.3%			
Increase road benefits						
Net Present Value	$1.58	$3.04	$4.62	($2.22)	($0.39)	($2.61)
Benefit cost ratio	2.10	1.30	1.40	0.67	0.98	0.90
Internal Rate of Return	11.2%	6%	6.7%			
Without land use change						
Increase road benefits						
Net Present Value	$0.33	($7.55)	($7.22)	($4.31)	($15.87)	($20.18)
Benefit cost ratio	1.23	0.22	0.35	0.35	0.17	0.21
Internal Rate of Return	6%					

8.3.4 Reduce gross margin by 20%

The sensitivity analysis included the calculation of the impact of a 20% reduction in gross margin on the economics of the Program as proxy variable for unknown factors that may have negative effects on the Program like climate change and changes in the gross margin that are likely to occur within the 30-year analysis period.

The results in Table 34 show that:

Using System Cost method:

- The Program and Sub-Programs are still economic with land use change.
- The Community Surface Water Management Sub-Program becomes marginally uneconomic without land use change with Benefit Cost Ratio of 0.92:1
- The Primary Surface Water Management Sub-Program is uneconomic without land use change with Benefit Cost Ratio of 0.17:1
- The Surface Water Management Program is uneconomic without land use change; the Benefit Cost Ratio is 0.26:1.

Table 34 Sensitivity test - decrease gross margin: 4% discount rate, 30-year analysis ($M)

	System cost			Period cost		
	CSWMP	**PSWMP**	**Program Total**	**CSWMP**	**PSWMP**	**Program Total**
With land use change						
Base case scenario						
Net Present Value	$1.31	$2.72	$4.03	($2.75)	($0.82)	($3.57)
Benefit cost ratio	1.91	1.27	1.35	0.59	0.96	0.86

	System cost			Period cost		
	CSWMP	**PSWMP**	**Program Total**	**CSWMP**	**PSWMP**	**Program Total**
Internal Rate of Return	10.2%	5.9%	6.3%			
Reduce gross margin						
Net Present Value	$0.89	$0.36	$1.25	($3.36)	($4.27)	($7.63)
Benefit cost ratio	1.62	1.04	1.11	0.50	0.78	0.71
Internal Rate of Return	8.4%	4.3%	4.8%			
Without land use change						
Reduce gross margin						
Net Present Value	**($0.12)**	**($8.06)**	**($8.18)**	**($4.89)**	**($16.56)**	**($21.45)**
Benefit cost ratio	0.92	0.17	0.26	0.26	0.13	0.16
Internal Rate of Return	3.8%					

8.3.5 Increase discount rate to 5% and analysis period to 50 years

The previous economic assessments of the Surface Water Management Program discounted the costs and benefits using 5% discount rate over 50 years.

The results of the sensitivity analysis are shown in Table 35 and Table 36. The main findings from Table 35 are:

- As expected, the Net Present Value and Benefit Cost Ratio decreased when higher discount rate was applied.
- If the System Cost method was used, the Program posted a Benefit Cost Ratio of 1.2:1.
- The whole Program is not economic if the Period Cost method is used.

Table 35 Sensitivity test - 5% discount rate over 30 years

	System cost			Period cost		
	CSWMP	**PSWMP**	**Program Total**	**CSWMP**	**PSWMP**	**Program Total**
With land use change						
Base case scenario	**4% over 30 years**					
Net Present Value	$1.31	$2.72	$4.03	($2.75)	($0.82)	($3.57)
Benefit cost ratio	1.91	1.27	1.35	0.59	0.96	0.86
Increase discount rate	**5% over 30 years**					
Net Present Value	$0.98	$1.16	$2.14	($2.87)	($3.29)	($6.16)
Benefit cost ratio	1.74	1.12	1.20	0.54	0.83	0.76
Without land use change						
Increase discount rate	**5% over 30 years**					
Net Present Value	($0.07)	($7.67)	($7.74)	($4.51)	($16.63)	($21.14)
Benefit cost ratio	0.95	0.17	0.26	0.27	0.13	0.16

The main findings from Table 36 are:

Using System Cost method:

- The Program is economic with land use change with a Benefit Cost Ratio of 1.39:1. The 2006/2007 Final Report of the Five Year Review (GBCMA, 2007) showed that the Benefit Cost Ratio of the Program is 1.16:1. This ratio was calculated by adjusting the 2000 evaluation results by CPI. The 2000 Review used a discount rate of 5% over 50 years.
- The Community and Primary Surface Water Management Sub-Programs are economic with land use change with Benefit Cost Ratios of 2:1 and 1.3:1, respectively.
- The Community Surface Water Management Sub-Program without land use change is still economic with Benefit Cost Ratio of 1.1:1

The Primary Surface Water Management Sub-Program with land use change and using Period Cost method became uneconomic with Benefit Cost Ratio of 0.92:1 (from 1.08:1 at 4% discount rate).

Table 36 Sensitivity test - 5% discount rate over 50 years

	System cost			Period cost		
	CSWMP	**PSWMP**	**Program Total**	**CSWMP**	**PSWMP**	**Program Total**
With land use change						
Base case scenario	**4% over 50 years**					
Net Present Value	$2.25	$6.26	$8.51	($2.00)	$1.83	($0.17)
Benefit cost ratio	2.25	1.51	1.60	0.72	1.08	0.994
Increase discount rate & analysis period - 5% over 50 years						
Net Present Value	$1.62	$3.39	$5.01	($2.38)	($1.69)	($4.07)
Benefit cost ratio	2.02	1.30	1.39	0.64	0.92	0.857
Without land use change						
Increase discount rate & analysis period - 5% over 50 years						
Net Present Value	$0.16	($8.80)	($8.64)	($4.44)	($18.32)	($22.76)
Benefit cost ratio	1.10	0.20	$0.31	0.33	0.14	$0.19

9 Sharing the Benefits and Costs of the Program[9]

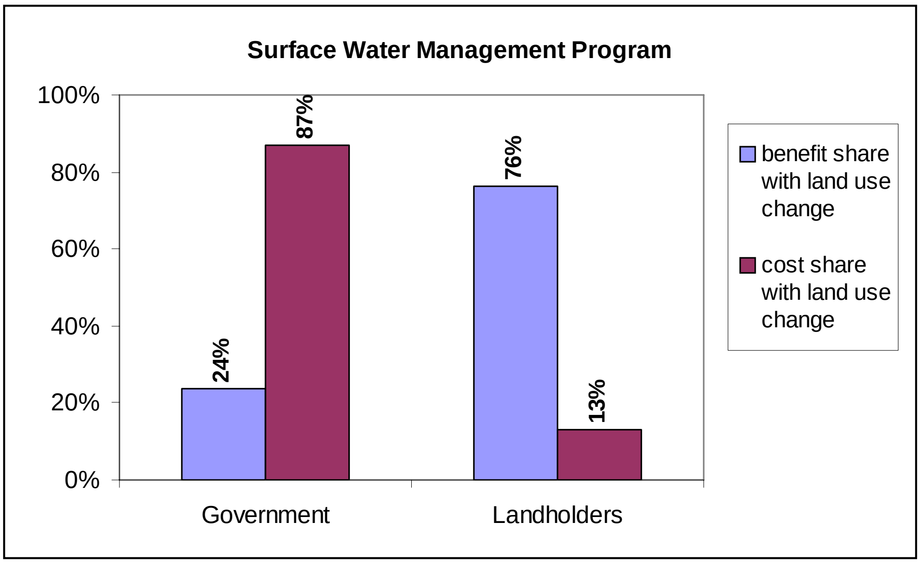
This section covers an analysis of how the benefits and costs of implementing the Program are shared between the government (public) and the landholders (private). The first part covers the Base Case Scenario ("with land use change") and the second part briefly discusses the "without land use change" scenario. The latter scenario was included in the analysis to show the impact of land use change on the sharing of benefits and costs.

9.1 Base case scenario (with land use change)

The government received 24% ($3.9 million) of the total value of economic and environmental benefits from its investment of almost $10 million, equivalent to 87% of the total cost of the Surface Water Management Program (Figure 4 and Table 37). On the other hand the landholders received 76% of the benefits from their 13% share of the cost.

The government benefits are 75% of the salinity, waterlogging and flooding benefits; roads, downstream and environmental benefits. The landholders' benefits included the salinity, waterlogging and flooding benefits (25%) and the benefits of land use change from low to high value crops.

Figure 4 Sharing of economic and environmental benefits and costs - Surface Water Management Program (System Cost method): 4% discount rate, 30-year analysis



Note: The costs included the residual value of capital cost of SWMS

Table 37 Sharing of economic and environmental benefits and costs - Surface Water Management Program (System Cost method): 4% discount rate, 30-year analysis

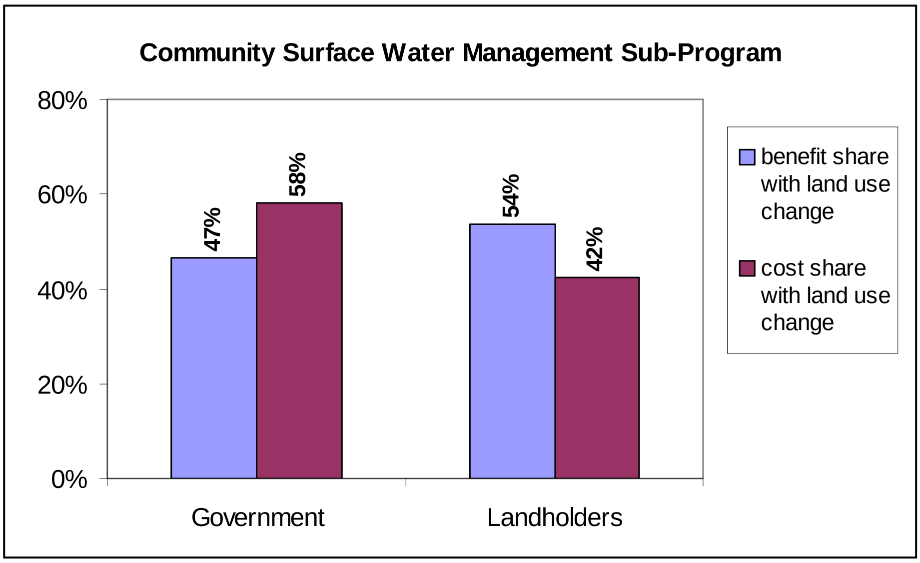
9 Government investment is also referred to as public investment and landholders' investment also means private investment.

	Government ($M)	Landholders ($M)	TOTAL ($M)	Government (%)	Landholders (%)
Surface Water Management Program					
Economic and environmental benefits	$3.89	$12.56	$16.4	24	76
Economic and environmental costs	$9.93	$1.50	$11.43	87	13
Benefit Cost Ratio	0.39	8.37	1.43		

Note: The costs included the residual value of capital cost of SWMS

In the Community Surface Water Management Sub-Program, the government received 47% ($1.3 million) of the total value of benefits from its investment of almost $830,000, equivalent to 58% of the total cost (Figure 5). On the other hand the landholders' contribution to the cost of the Program was 42% and they received 54% of the benefits.

Figure 5 Sharing of benefits and costs - Community Surface Water Management Sub-Program (System Cost method): 4% discount rate, 30-year analysis

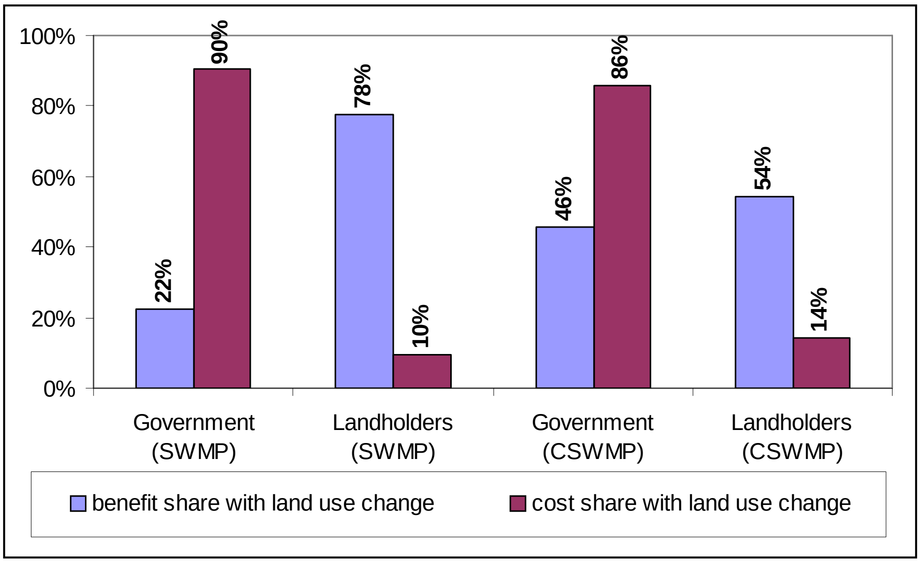


Note: The costs included the residual value of the capital cost of CSWMS

Using the Period Cost method (with land use change), the government received 22% of the benefits from its 90% share of the total cost of the Surface Water Management Program (Figure 6). From its contribution of 86% towards the implementation of the Community Surface Water Management Sub-Program, the government's share of the benefits is 46%.

The landholders contributed 14% of the cost of the Community Surface Water Management Sub-Program and received 54% of the benefits. The details of the cost sharing in the Community Surface Water Management Sub-Program are shown in Appendix 6.

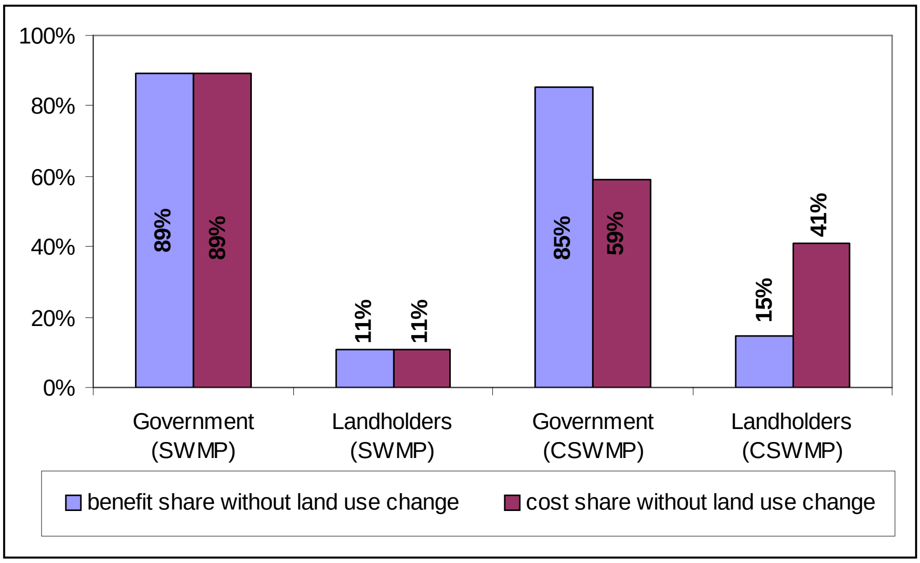
Figure 6 **Sharing of benefits and costs - Surface Water Management Program and Community Surface Water Management Sub-Program (Period Cost method): 4% discount rate, 30-year analysis**



9.2 Without land use change scenario

Without land use change (System Cost method), the government's share of the benefits is 89% and its contribution to the implementation of Surface Water Management Program is 89% (Figure 7 and Table 38). The landholders received 11% of the benefits and contributed 11% of the total cost.

Figure 7 **Sharing of benefits and costs - Surface Water Management Program and Community Surface Water Management Sub-Program (Without Land use Change - System Cost method): 4% discount rate, 30-year analysis**



The government received 85% of the benefits of the Community Surface Water Management Sub-Program and contributed 15% of the total cost. The landholders received 15% of the benefits and contributed 41% of the cost.

Table 38 Sharing of benefits and costs - Surface Water Management Program and Community Surface Water Management Sub-Program (Without Land use Change - System Cost method): 4% discount rate, 30-year analysis

	Government ($M)	Landholders ($M)	TOTAL ($M)	Government (%)	Landholders (%)
Surface Water Management Program					
Economic and environmental benefits	$3.83	$0.46	$4.29	89.3	10.7
Economic and environmental costs	$9.93	$1.18	$11.11	89.4	10.6
Benefit Cost Ratio	0.38	0.39	0.39		
Community Surface Water Management Sub-Program					
Economic benefits	$1.255	$0.215	$1.47	85	15
Economic costs	$0.83	$0.58	$1.41	59	41
Benefit Cost Ratio	1.51	0.37	1.04		

Note: The total cost shown here included the residual value of the capital cost of SWMS.

10 Conclusions

Investing in the Surface Water Management Program is economic. For every dollar of investment it will generate $1.35 worth of agricultural and road benefits over 30 years at 4% discount rate. The Net Present Value is $4 million and the Internal Rate of Return is 6.3%. Additionally, the indicative value of protecting and enhancing the bushland and wetlands adjacent to the systems is almost $1 million. If the environmental benefits are added to the economic benefits and using System Cost method, the Net Present Value of the Program is $5 million, the Benefit Cost Ratio is 1.44:1 and the Internal Rate of Return increased to 6.9%. The Program remains uneconomic using the Period Cost method.

The process of getting 97km of SWMS on the ground started in 1992 and the construction was completed between 2000 and 2006. The present value of all the costs associated with the construction and other farm costs is almost $11.4 million as shown in Table 23. This will generate an estimated $15.5 million worth of benefits.

Changing land use from low to high value crops could be financially attractive to landowners in areas serviced by CSWMS. For every dollar of their investment, they will receive $1.64 worth of benefits.

Without a net land use change from low to high value crops associated with the provision of SWMS, the investment is not economic. The provision of CSWMS is marginally economic with Benefit Cost Ratio of 1.04:1. The construction of PSWMS will require a change in land use from low to a high value crop of about 8% to become economic.

The government provided 87% of the total cost of implementing the Surface Water Management Program (System Cost method) and the landholders funded 13%. The high cost share of government was due to the 100% funding of the Primary Surface Water Management Sub-Program.

The results of the analysis show the importance government plays in providing a catalyst for private investment.

11 References

Anonymous, 2006. Goulburn-Murray Water Management Option – For constructed systems: Commonly asked questions (Unpublished, updated 14/11/06)

Australian Bureau of Statistics, 2008. Consumer Price Index

Australian Bureau of Statistics, 2007. National Regional Profile published by the Australian Bureau of Statistics, ABS cat. no. 1379.0.55.001

Bennett, J., 2005. Economics Techniques Series: Fact sheet No.1 Choice modelling: A step-by-step guide. Produced by the Economics Branch, Policy Division, EPA, April 2005

EPA website: www.epa.qld.gov.au/environmental_management/planning and guidelines/environmental economics/

Bennett, J and M Morrison, 2001. "Valuing the environmental attributes of NSW Rivers" Final Draft. Report prepared for the NSW Environmental Protection Agency, March 2001.

Eaton, Daryl, 2008. Goulburn-Murray Water, Tatura Victoria (personal communication)

Finger, Lucy, 2007. Department of Primary Industries, Tatura Victoria (personal communication)

GBCMA, 2007. SIRCIS Surface Water Management Program Five Year Review 2006-2007 Volume 1 - Final Report

Gittinger, J. P., 1982. Economic Analysis of Agricultural Projects, John Hopkins University Press, Baltimore. Published for the Economic Development Institute of the World Bank.

Hunter, Terry, 2008. Goulburn-Murray Water, Tatura Victoria (personal communication)

Makeham, J. P. and Malcolm, L. R., 1993. The Farming Game Now. Cambridge University Press

Maxwell, Richard, 2007. Department of Primary Industries, Tatura Victoria (personal communication)

Murray-Darling Basin Commission, 1995. Drainage Evaluation Spreadsheet Model Manual

Paganini, Mark, 2008. Department of Primary Industries, Echuca Victoria (personal communication)

Pagon, Jen, 2008. Department of Primary Industries, Echuca Victoria (personal communication)

SKM, 2003. Loddon-Murray Irrigation Region Surface Water Management Plan: Technical Background Paper F7 - Economic Evaluation of Options

SKM, 2008. Murray-Darling Basin Salinity Management Strategy - Victoria's 2007/08 Annual Report (Draft B, 22 September 2008)

SMEC, 2001. Shepparton Irrigation Region Surface Water Management Strategy Review, Project 3 Report Strategy 2000 - Volume 1

Spash, Clive, 1998. Investigating individual motives for environmental action: lexicographic preferences, beliefs and attitudes. In Ecological Sustainability and Integrity: Concepts and Approaches. Edited by John Lemons, Laura Westra and Robert Goodland. Kluwer Academic Publishers pp.46-62.

URS, 2006. Shepparton Irrigation Region Catchment Implementation Strategy Sub-Surface Drainage Program Critique

van Bueren and Bennett, 2000. "Estimating community values for land and water degradation impacts". Final report prepared for the National Land and Water Resources Audit, Project 6.1.4.

van Bueren and Bennett, 2004. 'Towards the development of a transferable set of value estimates for environmental attributes', Australian Journal of Agricultural and Resource Economics, vol 48, pp 1-32

Whitten, S. M. and J. W. Bennett, 2001. "Non market values of wetland Private and Social Values of Wetlands Research Reports

Wilson, S. M., 1999. Dryland Salinity - What are the impacts and how do you value them? An Ivey ATP and Wilson Land management services report prepared for the Murray Darling Basin Commission and the National Dryland Salinity Program, Canberra (cited in the Port Phillip & Western Port Salinity Management Plan, 2008)

http://www.bom.gov.au/hydro/has/ari_aep.shtml

http://www.dallasfed.org/data/basics/nominal.html

12 Appendices

Appendix 1 Definition of terms

Benefit-cost ratio is the ratio of the present value of project benefits to the present value of project costs. The higher the Benefit-Cost Ratio, the more economically viable is the project because it is earning more than the required rate of return. A Benefit-Cost Ratio of 1.04 means that for every dollar spent on the project, the benefits generated were valued at $1.04.

Internal rate of return is the break-even discount rate. It is the discount rate at which the present value of the benefits from a project equals the present value of the costs of the project. The higher the Internal Rate of Return, the more economically attractive is the project.

Net present value is the difference between the discounted values at a required discount rate of the future benefits and costs associated with the project. The higher the Net Present Value the more economically viable the project because the project is earning at that rate plus some more. If the Net Present Value is negative, the project is not economically viable.

Past and future flows of cost and benefit are converted at a common point in time using discount rates.

Real discount rate is the rate that has been adjusted to eliminate the effect of expected inflation. It is used to discount constant-dollar or real benefits and costs.

Nominal discount rate reflects the effect of inflation

Costs and benefits can be expressed in nominal or real terms.

Nominal dollar**:** The value of an economic variable in terms of the price level at the time of its measurement; or, value with any inflation effects included.

Real dollar**:** The value of an economic variable adjusted for inflation; refers to the purchasing power of the dollar

Sources: http://www.dallasfed.org/data/basics/nominal.html
Makeham, JP and Malcolm LR. 1993. The Farming Game Now. Cambridge University Press

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The following was taken from the Bureau of Meteorology website (http://www.bom.gov.au/hydro/has/ari_aep.shtml)

The Average Recurrence Interval (ARI) and the Annual Exceedance Probability (AEP) are both a measure of the rarity of a rainfall event.

ARI is defined as the average, or expected, value of the periods between exceedances of a given rainfall total accumulated over a given duration. It is implicit in this definition that the periods between exceedances are generally random.

AEP is defined as the probability that a given rainfall total accumulated over a given duration will be exceeded in any one year.

How does AEP relate to ARI?

With ARI expressed in years, the relationship is:

$AEP = 1 - \exp\,(-1 \div ARI)$ which results in the following conversion table:

ARI (years)	**AEP**
1	0.632
2	0.393
5	0.181
10	0.095
20	0.049
50	0.020
100	0.010

ARI greater than 10 years are very closely approximated by the reciprocal of the AEP.

For a more detailed account, see *Back to Basics on Flood Frequency Analysis by E.M. Laurenson*, Civil Engineering Transactions, 1987, pp. 47 to 53.

Why use AEP instead of ARI?

Australian Rainfall and Runoff (Institute of Engineers Australia, 1987), states:

> *Use of the terms "recurrence interval" and "return period" has been criticised as leading to confusion in the minds of some decision makers and members of public. Although the terms are simple superficially, they are sometimes misinterpreted as implying that the associated magnitude is only exceeded at regular intervals, and that they are referring to the elapsed time to the next exceedance.*

The use of the term ARI can lead to confusion. It is preferable, therefore, to express the rarity of a rainfall event in terms of AEP. For example, *a rainfall total of 159mm falling in 3 hours at Darwin Regional Office has a 0.010 (i.e. 1%) probability of being equalled or exceeded in any one year* can be easier to understand than the equivalent statement of *a rainfall total of 159mm in 3 hours has an average recurrence interval of 100 years.*

Last Modified: 12 December 2003, Hydrometeorological Advisory Service.

Appendix 2 Agriculture and environmental land use categories

- Aquaculture
- Cereals
- Channel/aqueduct
- Cropping
- Grazing modified pastures
- Grazing natural vegetation
- Intensive animal production
- Irrigated cropping
- Irrigated hay and silage
- Irrigated legumes
- Irrigated modified pastures
- Irrigated oleaginous fruits
- Irrigated pasture legumes
- Irrigated perennial horticulture
- Irrigated tree fruits
- Irrigated tree nuts
- Irrigated vegetables and herbs
- Irrigated vine fruits
- Lake
- Landscape
- Legume/grass mixtures
- Livestock grazing
- Manufacturing and industrial
- Marsh/wetland
- Marsh/wetland - conservation
- Marsh/wetland - production
- Natural feature protection
- Oil seeds
- Other conserved area
- Pigs
- Plantation forestry
- Poultry
- Production forestry
- Rehabilitation
- Remnant native cover
- Residual native cover
- River
- Supply channel/aqueduct

Appendix 3 Excerpt of the SKM Report - Loddon-Murray Irrigation Region Surface Water Management Plan Economics of Options

Loddon-Murray Irrigation Region Surface Water Management Plan

TECHNICAL BACKGROUND PAPER NO. F7

ECONOMIC EVALUATION OF OPTIONS

- Draft C
- 28/09/2003

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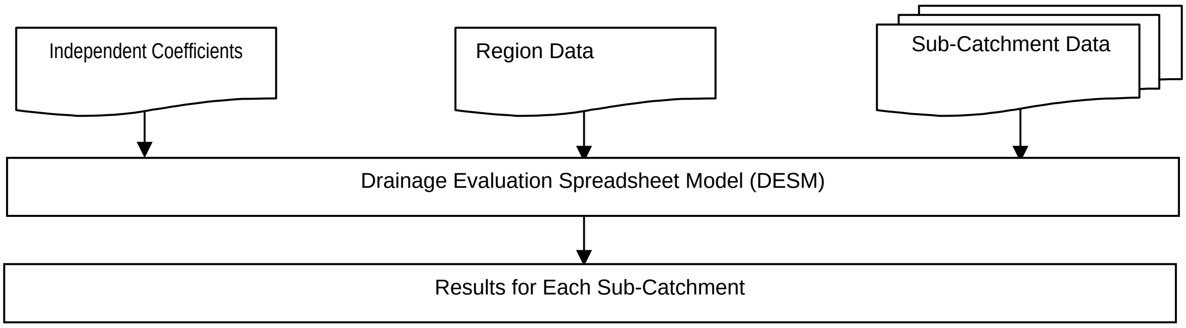
1. Modifications to the DESM

1.1 Separation of Data Inputs

The original form of the DESM was modified to allow consistent evaluation of each sub-catchment within the Strategy. The model developed by Sinclair Knight Merz allowed viewing all of the information relevant to the region or a sub-catchment on one page, with cell links then used to transfer the data into the DESM.

Where model coefficients are independent of both the region and sub-catchment data, these were applied within the DESM model directly. The structure of data entry is provided in Figure 1. The model structure allows easy sensitivity analysis of key variables.

Figure 1 Structure of the Evaluation Model



A summary of the data applicable to each of the categories above is presented in Table A. Independent coefficients are discussed in relevant sections within the report.

Table A Allocation of Inputs to DESM

Independent Coefficients	Region Data	Sub-Catchment Data
Yield Loss – Flooding, Waterlogging	Economic Value of Land Use	Land Use Profile
Area Affected – Flooding	Typical Irrigation Intensity of Land Use	Soil Profile, Drainage Coefficients
Effectiveness Factors	Road Economic Value	Historical & Forecast Shallow Water Tables
Fixed Road Parameters	Road Traffic Escalation	Typical Groundwater Salinity
	Groundwater Salinity Loss Functions	Economic Impact of Downstream Salinity Consequences
	Cost of On-Farm Works (Unit Rates	Implementation Works, Extent and Cost
	Value of Reuse Water	Estimated Volume of Reuse
		Corrections for Overlap of Works

1.2 Additional Implementation Works

The original DESM has capability to include only three categories of surface drainage works, namely landforming, sub-surface drainage, and surface drainage. For each of these categories a single coefficient is adopted for its effectiveness for each category of works throughout the catchment. This approach is suitable where the works are consistently applied throughout the catchment area, however the proposals within the Loddon Murray region are more complex.

Firstly, the number of works is increased, and the levels of service are likely to vary considerably between each proposed works category. It is also possible that works are co-located in some areas, where an additive benefit is not received, rather a coefficient to represent a 'synergy' benefit should be applied. It is also realised that the *possibility* of achieving particular economic benefits is dependent upon the implementation of specific works that will not generate agricultural benefits in isolation.

To simplify the approach taken, a review of the major relationships that exist in the DESM was undertaken prior to adjusting the calculation methodology. The major relationships that have existed in benefit calculation are:

- **Salinity Impacts** associated with shallow saline watertables are best mitigated through sub-surface drainage (either tile drainage, or groundwater interception). Implementing surface drainage and landforming may reduce accessions, but the benefits are relatively small in comparison to sub-surface drainage.
- **Waterlogging Impacts** associated with poor soil drainage characteristics are best mitigated through landforming of affected areas. Improved irrigation practice that allows tightly controlled application rates would also be expected to minimise the impact of waterlogging.
- **Flooding Impacts** that are associated with poor drainage layout or catchment hydraulic characteristics are best mitigated through the implementation of surface drainage works throughout the catchment. Landforming does provide some benefit in this regard, however the majority of flooding losses relates to inadequate management of off-farm disposal of surface water.

Based on the relationships presented above, the mitigation of waterlogging losses was adjusted to include two categories, landforming and conversion to sprinkler system. Separate 'effectiveness' coefficients were applied to each category. It is expected that these works would be completed in mutually exclusive location, therefore the benefits obtained would be additive.

As several different categories of works are proposed under the umbrella of surface drainage works, more detailed analysis is required. In addition to landforming and sprinkler conversion, the following works are expected to mitigate the agricultural impacts of flooding:

- **G-MW Operated Primary Drain:** This drainage system is typical of the larger coordinated drainage systems across the Goulburn Valley. These drains would be expected to have a design level of service of a 1 in 3 ARI rainfall event.
- **Community Surface Water Management System – High Level of Service:** Similar to a community surface drainage network in place in the Goulburn Valley Plains. These drains would be expected to have a design level of service of a 1 in 3 ARI rainfall event.
- **Community Surface Water Management System – Low Level of Service:** Similar to a community surface drainage network in place in the Tragowel Plains. These drains would be expected to have a design level of service of a 1 in 1 ARI rainfall event.
- **Nutrient Reduction Reuse System:** This infrastructure will be installed where coordinated drainage provision cannot be provided to a property. This can broadly be described as a reuse system with increased capacity for storage of rainfall events. The level of service for this system is estimated at a 1 in 5 ARI rainfall event.
- **Reuse System:** Reuse systems have been implemented across the region over the last twenty years. In previous DESM evaluations, the value of reuse in mitigating flooding benefits has been assumed to be negligible as they have been implemented in areas with existing surface drainage. Even without the presence of drainage the benefits generated are likely to be limited. The level of service for this system is estimated at a 1 in 1 ARI rainfall event.

It is assumed that primary drains, CSWMS, and NRR are located in mutually exclusive areas and would result in additive benefits. For areas where works exist in combination, a correction is required to reflect the reduction in the incremental benefit. It is assumed that for all of the surface water management works proposed above, that the sufficient on-farm drain networks are constructed to maintain the level of service specified.

The implementation of reuse is also expected to have economic value by replacing volumes of water otherwise supplied by the channel network. The reuse volumes applied in the model were calculated with reference to the number of reuse systems implemented, and the likely extent of drainage diversion on coordinated drainage systems.

1.3 Capital and Operational Expenditure Projections

The original DESM model has several variables for entering capital, operating, and overhead costs associated with drainage works infrastructure. The original model did allow direct entry of cash flows for capital expenditure, but transitions to reflect annual expenditure of a portfolio of works that exhibited different commencement times, and periods of implementation could not be undertaken for each sub-catchment automatically.

To ensure that present value of calculations accurately reflected the transition of works within each sub-catchment, VBA functions were written to provide for the flexibility required. A capital expenditure cash-flow schedule was constructed for each category of works based on the commencement of implementation, and period of implementation. It was assumed that capital expenditure was spread evenly over this period. The sub-catchment capital expenditure profile was constructed by aggregating each category of works.

Similarly, an operations and maintenance expenditure profile was constructed for each category of works. It was assumed that after commencement of the works, the expenditure profile increased proportionally to the total amount of capital invested. At completion the expenditure profile remained constant. The operational and maintenance expenditure profile for each catchment was developed by aggregating the information for each works category.

Array functions were used to enable easy updates to the information. Asset residual value calculations were based on the assumption that the works, once implemented, have a useful life of 50 years. Because of this assumption, no allowances for renewals were required.

1.4 Reuse Calculations

Reuse volumes calculated in the DESM are based on a certain percentage of the total volume of irrigation water applied. It is expected that the works proposed in the Strategy will provide different levels of reuse benefit due to their type, location, and expected water quality. To capture this variation, the model used in this evaluation has been modified such that the estimates are based on targeted volumes for each catchment, and the period for uptake.

It is recognised that the development of growth in reuse volumes is likely to proceed, although at a reduced rate, in the case that coordinated works are not implemented in the catchment. Projection of this nature has been excluded from the model.

1.5 Downstream Impact Calculations

The salinity impact calculations were modified slightly to allow input for various sub-catchment data. As the commencement of coordinated surface drainage works will vary across sub-catchments, the cash flow profile for the accumulation of benefits (or costs) will be different. An additional array has been included (based on the commencement year for surface drainage works) for calculation of downstream impacts.

1.6 Model Structure, Navigation and Export Facility

To enable easy navigation between sheets, calculation and export of batch evaluations an additional sheet has been included in the model (‘Menu’) with automation code activated through buttons, and drop-down boxes. A summary of each of the sheets include in the model is provided.

Table B Model Structure

Sheet Name	Purpose	Hidden?
Menu	Navigation, Calculation, and Batch Evaluation	No
Array Lists	Used to enable sheet pointer changes	Yes
Region_TEMPLATE	Template spreadsheet to be used for entry of region data	Yes
R_A, R_B, R_C, R_D	Spare Region Templates	Yes
R_Loddon-Murray	Sheets containing regional data applicable to the analysis	No
R_LM_GM20%neg	Sheets containing regional data applicable with a reduction in Gross Margins of 20%	Yes
Catchment_TEMPLATE	Template spreadsheet to be used for entry of catchment data	Yes
Barr Creek, Boort West, Calivil Creek, Fish Point, Gunbower, Loddon, Kerang Lakes, Koondrook Benjeroop, Pyramid Creek, Swan Hill, Wandella,	Sheets containing individual sub-catchment data	No
AP_WOP	Agricultural Production – Without Project	No
AP_WP	Agricultural Production – With Project	No
SALINITY	Agricultural Production Losses Due to Salinity	No
WATLOG	Agricultural Production Losses Due to Waterlogging	No
DL_EFF	Effectiveness of Drainage and On Farm Works	No
DL_WOP	Drainage and On Farm Works – Without Project	No
DL_WP	Drainage and On-farm works – With Project	No
ROAD	Road Benefits	No
DOWNSTREAM	Downstream Impacts	No
REUSE	Reuse Benefits	No
CASHFLOW	Listing of all Cashflows for Calculation	No
ECO_SUM	Economic Results and Summary	No
Data Input Summary	Summary of Model Inputs – Superseded in some cases	No
Summary	Used to report results for batch evaluations	Yes

2 Independent Coefficients

2.1 Waterlogging and Flooding Losses

Two categories of agricultural losses are associated with waterlogging of soils, specifically:

- Micro-waterlogging which is due to poor internal drainage in soils. Soil classification data is used to estimate the total area that may be subject to this risk. A topographic assessment would find that soils in some areas would have reduced risk of waterlogging due to their elevated location. Waterlogging can be compounded through poor irrigation techniques, and ineffective irrigation layout.
- Macro-waterlogging, or flooding, is the result of run-off from other parts of the farm or other areas upstream. The duration is more severe than micro-waterlogging, with shallow water tables exacerbating the problem to some extent

The estimate of program benefits requires consideration of the area affected, and the accompanying yield loss over that area.

For micro-waterlogging it has been assumed that the area of waterlogging is assumed to be the area of soil classes 4 to 6. A correction factor of 0.7 has been applied to represent that 30% of soils would be in elevated locations, and the impact of waterlogging would be less pronounced. The loss factors that are applied in the model are presented in Table C

Table C Waterlogging – Yield Loss and Area Affected

Crop	Annual Yield Loss (%)	Affected Land Area (ha)
Dairy	25%	Based on proportion of soil classes within the groups 4 to 6 within the catchment, factored for elevated areas (30%)
Mixed (AP, Lucerne, Cropping)	12.5%	
Vegetables	100%	
Citrus	100%	
Grapes	N/A[1]	N/A[1]
Stonefruit	N/A[1]	N/A[1]
Dryland	N/A[1]	N/A[1]

Notes: 1) Assumed not to exist in soil types 4 to 6

A detailed approach has been undertaken for estimating the impacts associated with on-farm macro-waterlogging (‘flooding’) losses for the Loddon Murray region. The approach taken was similar to that described in MDBC (1995:3), and is described in SKM Report Appendix A. Essentially it assumed that flooding losses are due to inadequate farm access to drainage for major rainfall events, consequently water is retained on the property. A summary of the results is provided in Table D below.

The maximum area affected could be calculated from hydraulic calculations, and the overall productivity loss based on the duration and extent of flooding. It was assumed that

Citrus, Grape, Stonefruit, and Dryland production enterprises would not exist in areas where insufficient access to drainage was provided.

Table D Flooding Loss – Yield Loss and Area Affected

Crop	Annual Yield Loss (%)	Affected Land Area (ha)
Dairy	65%	14%
Mixed (AP, Lucerne, Cropping)	50%	14%
Vegetables	100%	14%
Citrus[1]	100%	0%
Grapes[1]	100%	0%
Stonefruit[1]	100%	0%
Dryland[1]	100%	0%

Notes: 1) Assumed not to exist in soil types 4 to 6

The approach taken should ensure that the impacts are conservative, which will translate into conservative benefit estimates associated with implementation of works.

2.2 Effectiveness of Works

Due to the range or works proposed, and the possible implementation of several types of works within one catchment, the effectiveness factors for each category of works will need to reflect this added complexity. For example, implementation of additional reuse systems in areas with surface drainage provision will have reduced incremental benefit as compared to those located in areas without this service.

Traditionally, the works have been separated into the sub-surface drainage, surface drainage and the landforming with identical levels of service across the catchment. Guideline effectiveness figures were provided in MDBC (1995:1) for each category of works, and for combinations of works within these categories.

The analysis of this package of works is more complicated because the levels of service vary within each major works category. As a result, more input data is required to explain the effectiveness factors of different combinations of works. To avoid exploring each combination, a number of observations and assumptions have been made:

1. Sub-surface Drainage does not appear in the program of works for the Strategy. Consequently, while capacity has been left in the model for these works, the accuracy of effectiveness factors and the analysis of these combinations with sub-surface drainage can be ignored.

2. The primary method for mitigation of salinity impacts is through sub-surface drainage works. Alternative surface drainage and landforming measures provide relatively small

benefits to salinity impacts (up to 30% in combination), corrections for overlapping works for this impact have been ignored.

3. The primary method for mitigation of micro-waterlogging impacts (‘waterlogging’) is through landforming. While conversion to sprinkler irrigation has also been considered under this program, it is anticipated that this will be pursued in well draining soils to curb water use in areas where landforming is not pursued. The main objective to avoid increases in the areal extent of shallow saline water tables, and groundwater discharge to nearby waterways

4. The combinations of activities between the co-ordinated surface drainage works (including primary drains, community surface drains, and low level of service community service drains), and on-farm surface drainage works (including reuse systems and nutrient reduction reuse systems) and landforming is likely to be important to the analysis. The effectiveness will be based on the level of service provided by each of the works (see SKM Report Appendix A). DESM calculations have been modified specifically to estimate the proportion of on-farm works that intersect with surface drainage works

5. Without specific locations of proposed works and the areal extent described as part of GIS system, the DESM can serve only to approximate the areas of intersection between different categories of works. Increased precision in calculation would not necessarily translate to improved estimation of the benefits attributed to surface water management works.

Based on the assumptions above, the effectiveness of works has been summarised in Tables E and F. As detailed in the assumptions, the effectiveness benefits for the salinity and waterlogging impact mitigation have been assumed additive for works in combination.

Table E Effectiveness of Works to Reduce Salinity Impacts

Category	Sub-Category	Isolation	In Combination		
			Surface Drainage Works - Drains	Surface Drainage Works - Reuse	Landforming
Subsurface Drainage		90%			
Surface Drainage	1 in 3 ARI Drains	10%			30%
Surface Drainage	1 in 1 ARI Drains	10%			30%
Surface Drainage	Nutrient Reduction Reuse Systems	10%			30%
Surface Drainage	Reuse Systems	10%			30%
Landforming	Landforming	15%	30%	30%	
Landforming	Sprinkler Conversion	15%	30%	30%	

Note: 1) Grey areas indicate combinations not considered as part of the analysis

Table F Effectiveness of Works to Reduce Waterlogging Impacts

Category	Sub-Category	Isolation	In Combination: Surface Drainage Works - Drains	In Combination: Surface Drainage Works - Reuse	In Combination: Landforming
Subsurface Drainage		10%			
Surface Drainage	1 in 3 ARI Drains	10%			70%
Surface Drainage	1 in 1 ARI Drains	10%			70%
Surface Drainage	Nutrient Reduction Reuse Systems	10%			70%
Surface Drainage	Reuse Systems	10%			70%
Landforming	Landforming	40%	70%	70%	
Landforming	Sprinkler Conversion	0%	10%	10%	

Notes: 1) Grey areas indicate combinations not considered as part of the analysis
2) Conversion to sprinkler irrigation would not be pursued in areas subject to waterlogging

DESM calculations have been modified to account for the effectiveness of different surface drainage works, and different combinations that may apply. As the figures indicate there is no additional benefit provided by low level of service reuse systems win combination with the drains.

Table G Effectiveness of Works to Reduce Flooding Impacts

Category	Sub-Category	Isolation	In Combination: Surface Drainage Works - Drains	In Combination: Surface Drainage Works - Reuse	In Combination: Landforming
Subsurface Drainage		10%			
Surface Drainage	1 in 3 ARI Drains	45%		55%	55%
Surface Drainage	1 in 1 ARI Drains	25%		25%	35%
Surface Drainage	Nutrient Reduction Reuse Systems	55%	55%		65%
Surface Drainage	Reuse Systems	25%	25%		35%
Landforming	Landforming	10%	55%	35%	
Landforming	Sprinkler Conversion	10%	65%	35%	

Notes: 1) Grey areas indicate combinations not considered as part of the analysis

2.3 Road Benefits

The DESM estimates the economic benefits of drainage works to roads using an algorithm that requires the length of sealed and un-sealed road, natural drainage characteristics, soil type, salinity characteristics and regional irrigation intensity. The economic benefits of road protection have been included as part of the 'regional data' and lengths of roads and catchment drainage characteristics is entered as part of catchment data'. The remaining assumptions have been fixed within the model structure. These are:

- Annual Rainfall: Assumed to be 378mm based on Kerang Weather Station data
- Annual Evaporation: Assumed to be 1436mm based on Kerang Weather Station data
- Road Width Coefficient (C): In the absence of information provided by the local councils, it has been assumed that 50% of main sealed road reserve widths are at less than 30m, and 75% of road reserve widths are less 30m for other road categories. The benefits to roads are greater where narrow road widths exist because table drains must be located closer to the road. The road benefit value is very sensitive to this coefficient.

Modifications to the calculation structure have ensured that only co-ordinated regional surface drainage works are used for the calculation of benefits to main sealed roads, other sealed roads and gravel roads. The benefits for road and track infrastructure within the farm was calculated based on the total service area of co-ordinated surface drainage works, as well as that of reuse systems and nutrient reduction reuse systems, but reduced for areas where both off-farm and on-farm works existed.

The area of road benefit also included the proposed areas of Drainage Course Declarations in the Wandella Creek and Loddon Catchments. This action assumed the implementation of works that returned existing carriers to natural drainage capacity with obstruction removal. This is likely to benefit road infrastructure that would otherwise be flooded for extended periods of time.

There are some key assumptions embedded in the calculation of road benefits. The rate of benefits outlined above should be adjusted if:

- It is likely that there are permanent watertables within 1 to 2 m of the pavement surface level, (after drainage implementation) surface drainage is unlikely to improve the performance of road pavements in these areas. Groundwater contour mapping was not available across the entire region for periods of 12 months, so assessments in this regard could not be completed.
- Surface flooding for a day or two per year will have a significant effect of pavement performance. Reducing the annual probability that this occurrence will significantly improve economic benefits.
- Water ponded further than 6m from the pavement edge is not likely to adversely affect pavement performance.

The impact of these assumptions has not been tested. Further analysis would require detailed information on the extent of shallow groundwater in relation to road alignment, the drain alignments, and also the hydraulic characteristics of floodways and bridges.

2.4 Salinity Impact Calculation

The DESM methodology for the calculation of salinity benefits was based on the assumption that the area subject to saline shallow watertables is forecast to increase in the future. The function is unable to calculate an expected salinity benefit from a baseline of a declining water level. As surface drainage is implemented primarily for management of flooding and waterlogging losses, the function was modified to ensure positive salinity benefits were calculated where applicable.

2.5 Residual Economic Value Calculation

Based on the implementation costs and timeframe, a cash schedule was developed for each sub-catchment. Based on the cash schedule, the residual value of the assets at the end of the period of analysis has been calculated. These values have been calculated for both 50 year periods of analysis, and 30 year periods of analysis as part of the DESM model and are included in the relevant output table.

2.6 Downstream Impact Calculation

The implementation of drainage works for some sub-catchments will have implications for downstream waterways. In the cases where there is expected to be a change in River Murray salinity, and economic value can be attached using market proxy values. A cost of $140,000/annum for a 1 EC positive increment at Morgan, South Australia, has been adopted in the model. It is expected that there would be examples of net increases, net decreases, and no impact for the various sub catchments under consideration.

At present, the application of the GHD (1999) work is under review by the Murray Darling Basin Commission. They have advised that it is possible that the estimates for salinity impacts within the River Murray may increase at the conclusion of the review. The current estimate is between $90,000/EC/annum to $140,000/EC/annum and this could conceivably increase to $240,000/EC/annum. While unconfirmed, Sinclair Knight Merz understands that the majority of this difference will be with regard to industry impacts in South Australia.

The modified DESM also has capacity to include the annual costs that might be associated with impacts to other waterways (eg. Kerang Lakes). At this stage, the Kerang Lakes Agricultural Economic Model has not been used to quantify impacts to irrigators within this system.

3 Catchment Input Data

3.1 Shallow Water Tables, Groundwater Salinity and Salinity Impact

The economic impact of salinity mitigation associated with the drainage works within the Loddon Murray region can be categorised into three main groups:

- Reduced area susceptible to saline shallow watertables
- Economic impact of changed salinity concentrations to diverters from the Kerang Lakes system
- Economic impact of changed salinity concentrations for diverters downstream in the River Murray system

The form of calculation for each of these impacts differs significantly, and an explanation of each benefit calculation is described below.

3.2 Extent of Shallow Watertables

The calculation of agricultural production losses due to salinity requires an estimate of the amount of salt accumulated in the root zone. The DESM methodology assumes that this amount 'is basically a function of (i) the time since the onset of shallow watertables, (ii) the groundwater salinity, and (iii) the net volume of water passing up through the soil to the surface and evaporating' (MDBC, 1995). Another method using historical data and projected soil salinity relationships can be used, however the intensive modelling required for input data was beyond the scope of this assessment.

To allow DESM to estimate the amount of salt accumulation in the root zone, the proportion of shallow watertables in each catchment is required for the period that commences 40 years before the present, and is projected forward over the coming 50 years. This period is necessary to capture the age profile of the saline shallow water tables. The extent of shallow water tables is defined as the area subject to watertables within 2 metres of natural surface.

The groundwater assessment was based on time-series waterlevel data information from the Groundwater Database (GDB). Based on the water level data, contour plots for the entire region were created. More detailed assessment was required for each sub-catchment to understand the 'age and extent' profile for salinity impact calculations. A summary of the analysis is provided below,

The most recent waterlevel data for each bore was then sorted into waterlevels above and below 2m depth to natural surface. This information was then used to assign a proportion of the catchment subject to shallow watertables at present (defined as year 'zero').

To develop assumptions regarding the 'age and extent' of the shallow watertable profile, three to five representative bores were selected within each sub-catchment. The hydrographs of the selected bores were then analysed to determine historical trends.

In most cases, shallow watertables have dropped considerably in recent years as a result of dry conditions and low irrigation allocations. The extent of the decline in watertable depth in recent years is illustrated by the difference between 1991 and 2001 which show indicative watertable contours in September 1991 and 2001 respectively. The marked reduction in groundwater levels over this period may be partially due to increased water use efficiency, however it is not possible to easily estimate the influence of this and other underlying influences given the recent dry conditions.

To avoid taking into account the influence of relatively dry years, the selected bore hydrographs were analysed up to 1996 by fitting linear trend lines to the data over the most recent period (to 1996) which appeared to show a distinct pattern or trend. These trends then provided the basis for future estimation of shallow watertable extent.

Although the method outlined above may have questionable accuracy, the analysis of all catchments using a more rigorous method is not considered appropriate at this time given the available data, the resources required and the likely impact on the results. Once all data is collated to similar degrees of accuracy, a sensitivity analysis may be carried out for each of the catchments using various time series patterns of shallow water table extent to determine the impact that this may have on the overall viability of each option.

3.3 Groundwater Salinity

The shallow bores detected using the GDB were also categorised into groups according to their typical salinity level, with bores grouped according to the following salinity ranges:

- Less than 10,000 EC
- Between 10,000 EC and 30,000 EC
- Greater than 30,000 EC.

Once categorised, the salinity ranges were mapped over each catchment to assist in determining an overall indicative shallow groundwater salinity.

It should be noted that the treatment of agricultural salinity impacts in DESM only discerns between groundwater salinities of above and below 10,000 EC. Thus in the DESM input a figure of either 5,000 EC or 15,000 EC has been inserted to reflect the first 2 categories in the list above, and were in excess of 30,000 EC, this input was recorded to provide more representative summary information.

4. References

MDBC (1995:1), Drainage Evaluation Model User Manual Version 3, October 1995, Murray Darling Basin Commission

MDBC (1995:2), Evaluation of the Economics of Drainage Projects, Drainage Program Technical report No 2, October 1994, Murray Darling Basin Commission

MDBC (1995:3), Review of Surface Drainage Design Standards for Southern New South Wales. Drainage Program Technical Report No. 3

MDBC 1997, Evaluation of the Economics of Drainage Projects – Part 2, Drainage Program Technical Report No 4. May 1997, Murray Darling Basin Commission

Skene, J and Sargent I. (1996) Soils and Land Use near Swan Hill, Victoria Department of Agriculture, Victoria, Australia. Technical Bulletin, No. 20 Melbourne 1966

URS (2003) Review of DESM as part of the Loddon-Murray Irrigation Region Surface Water Management Plan – Economic Evaluation of Options. Prepared for North Central Catchment Management Authority A01557/URS REVIEW 01 Unpublished

SKM Report: Appendix A - Review of Flooding Loss Factors

At the request of the Loddon Murray Surface Water Technical Working Group, Sinclair Knight Merz were asked to investigate the flooding loss factors that were applied in the DESM model. Several of the proposed surface water management works in the catchment will target removal of on-farm flooding issues, but at different levels of service than currently assumed in the DESM. Such differences are to be captured in the DESM model used for evaluation.

A.1 Current Assumptions in the Model

Based on the values presented in the DESM Manual, the current assumptions in the model relating to flooding are as follows:

- The area affected by on farm flooding (without surface drainage) is in the order of 5%
- The productive losses of on-farm flooding are 100% for dairy, 100% for tomatoes, 0% for dryland, 82% for mixed farms (production loss is measured in terms of gross margin)
- The effectiveness of surface drainage is 50%, or 70% where implementation is accompanied by landforming
- Landforming without surface drainage is assumed to have much less effectiveness (10%) in the current DESM model. It is assumed that while on-farm landforming will move water towards the property boundary, restricted access to drainage networks will still result in on-farm flooding.

A.2 Review of Assumptions

In October 1995, a review of Surface Drainage Design Standards for Southern New South Wales completed for the MDBC reviewed the major assumptions behind surface drainage, and those benefits associated with reduced duration of land inundation. The analysis presented in the attached documentation has sourced data from the MDBC review where possible.

The DESM model requires the level of service of particular measures to be related to agricultural losses. This is achieved by assessing the total impact without the measures in place (the ‘without project’ scenario), and comparing this to works in place (‘with project scenario’). The ‘with project’ scenario is calculated by applying an ‘effectiveness’ factor to the estimated impact without the works, representing the level of mitigation. The key relationships to be determined is the quantification of economic loss, and the effectiveness of the various methods employed as part of the surface water management process

When analysing drainage performance, it is important to consider the design philosophy. The level of service of a drainage network will be governed by the presence of a downstream throttle. Identification of this throttle, and its capacity, will be the determinant of the level of service to a particular location within the drainage network. It is possible that the throttle exists not within the constructed drainage network, but at the farm level (eg. undersized culvert to access network).

The ‘level of service’ of a drainage network is often stated as the rainfall event with the highest recurrence interval where the network has capacity to avoid agricultural productivity losses. The effectiveness of a particular drainage method will be reflected in the avoided annual average damages resulting from implementation. This requires estimation of the level of impact across a range of rainfall events, factored for probability of recurrence. For example, a 1 in 2 ARI drainage network design will remove all losses up to and including a rainfall event of 2 year recurrence interval. It will also provide improved mitigation of rainfall events of lower probability. The effectiveness factor needs to reflect average annual mitigation of costs.

The following process is applied to calculate total losses associated with flooding :

1) For the following analysis, it is assumed that the level of service constraint is the farm inlet to a drain. This isolates on-farm flooding extent that would occur at a specific rainfall recurrence intervals, given different drainage capabilities of the methods employed. As the level of service is defined as the ability to remove a certain event (such that the enterprise has zero productivity), the method employed can be associated with a rainfall recurrence interval.
2) If it is assumed that farm access to drainage is infinite, it can be expected that if a throttles regularly existed in the downstream drainage system, these would impose similar on-farm flooding impacts to a drainage method from the farm with a specified level of service (specified in terms of a rainfall recurrence interval).
3) It can therefore be concluded that regardless of whether the throttle is located at the farm access, or at some point in the downstream network, that similar economic impacts would be imposed upon agricultural production for a given level of service (specified in terms of a rainfall recurrence interval)

In essence, this means that relationships can be derived from assessing the drainage impacts on farm, and assessing the level or productivity loss associated with certain rainfall recurrence intervals. In practice, the standard sizes for drainage inlets may provide a MINIMUM level of service at the farm boundary, however the over-riding constraint will be the drainage network, which it is assumed provides the same level of service throughout the drainage network.

The recognised limitations of applying the results of the study to the current DESM models are:

- The data was collated for the Riverina region of New South Wales
- The review did not adequately cover the ‘no drainage service’ scenario. ie. What would be the expected area and period of inundation if no drainage service existed?

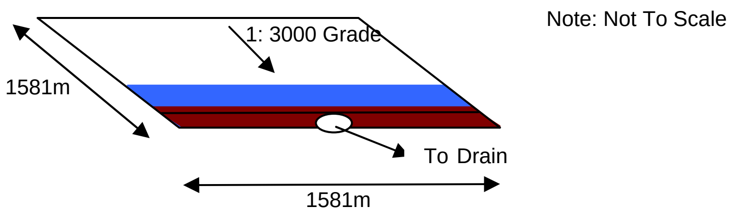
- The results were specific to a 250ha property requiring drainage, and therefore the assumption is made that the observed impacts are proportional to area.
- The impact of the landforming within of the property in conjunction with surface drainage was not assessed.

The modelling undertaken for MDBC focused on the development of loss curves for three nominal drainage rates (for a 250 ha farm). These were 3ML/d, 5.5ML/d and 8ML/d. Provided sufficient drain capacity exists, these drain inlets correspond with removal of 1 in 2 ARI, 1 in 5 ARI, and 1 in 8-10 ARI events respectively.

A.3 Assumptions Applied for the Most Recent Modelling

With the limitations considered above, the following assumptions have been made in the most recent modelling relating to the Loddon-Murray Irrigation Region:

- The climatic data is approximately similar for the Kerang region as compared to the average of Wakool, Deniliquin, Finley, Coleambally, Griffith, and Leeton.
- A 250 ha property is considered appropriate unit for a single drainage inlet. This unit is expected to be square, with drainage on the lower boundary. The grade throughout the property is estimated to be 1:3000. It is assumed that the results for this 'theoretical' property are reasonable representations of those within the Loddon Murray Irrigation Region, which vary between 100ha to 230ha.



- For a 250ha property 'no existing drainage' scenario, it is assumed that 10% of inundation area is removed after 20 days, with 100% removed within 50 days. No rainfall losses were incorporated in estimates.

Trapezoidal integration methods were used to estimate average annual productivity losses, based on probability curves constructed from the data available.

A.4 Key Outcomes from the assessment

The key outcomes from the assessment were:

- The mean area inundated for a 1 in 1 ARI rainfall event was in the order of 13.9% of the total farm area. This is higher than the default estimate applied in the DESM that used 5.5% of the total farm area.
- The mean annual production loss varies depending on the enterprise as shown in Table 1. Considering that the irrigated proportion of the Loddon Murray Irrigation Region will be mostly perennial and annual pasture, the loss applied over the 13.9% area affected is closer to 60%, rather than 100% as presented in the Model.

- The relative effectiveness varies depending on the enterprise as shown in Table H. Considering that the default DESM model values represent a 1 in 2 ARI in the Muckatah Catchment, the current effectiveness figures (with landforming) are greater than the more recent modelling.

Table H Enterprise Productivity Loss & Effectiveness Factors

Enterprise	Productive Loss due to On-Farm Flooding (as % of total area production value)			
	Natural Drainage	3 ML/d Inlet	5.5 ML/d Inlet	8 ML/d Inlet
Perennial Pasture	9.04%	4.24%	2.06%	0.75%
Annual Pasture	7.60%	4.05%	2.12%	0.79%
Dryland Crops	0.00%	0.00%	0.00%	0.00%
Crops	5.20%	2.23%	0.99%	0.34%
Rice	0.71%	0.39%	0.37%	0.34%
Enterprise		On-Farm Flooding Mitigation Effectiveness over area affected		
		3 ML/d Inlet	5.5 ML/d Inlet	8 ML/d Inlet
Perennial Pasture		53%	77%	92%
Annual Pasture		47%	72%	90%
Dryland Crops		Ignored	Ignored	Ignored
Crops		57%	81%	94%
Rice		45%	49%	52%
Average		**51%**	**67%**	**82%**

Note: It is expected that dryland crop production would not take place in areas prone to on-farm flooding

Natural Drainage: Assumes 3.6ML/d inlet flow, after 20 days detention of 90% volume associated with a rainfall event

While the individual enterprise data provided above aggregates area and loss information, it is suggested that the DESM area affected be estimated at 13.9% and the productive loss over this area be estimated at 65% for dairy, 50% for mixed farms, 100% for horticulture. The productive loss applies to the gross margin of each enterprise, which suggests that enterprises may plant within areas subject to on-farm flooding, but derive no profit on average from this area. By providing drainage and reducing the extent of on-farm flooding, the value of production would be expected to increase.

The effectiveness figures presented above for the 3ML/d option are close to those presented in the DESM as default values.

Recommendations

Based on the assessment above, it is suggested that the Loddon-Murray Technical Working Group adopt the effectiveness factors in Table I for general analysis. These values will then be applied in the DESM modelling of the Loddon Murray Irrigation Region.

Table I Suggested Effectiveness Factors

Level of Service	Effectiveness factors to be applied in DESM	
	Without Landforming	With Landforming
1 in 2 ARI (Min 225mm outlet per 250ha and Drain Capacity)	40%	50%
1 in 5 ARI (Min 300mm outlet per 250ha and Drain Capacity)	55%	65%
1 in 8-10 ARI (Min 375mm outlet per 250ha and Drain Capacity)	70%	80%
Values Adopted for Loddon Murray Surface Water Management Plan		
Primary Drains and Community SWMS (1 in 3 ARI Level of Service)	45%	55%
Low Standard Community SWMS (1 in 1 ARI Level of Service)	25%	35%
Nutrient Reduction Reuse Systems (1 in 5 ARI Level of Service)	55%	65%

- The figures presented above will apply over all catchments within the Loddon Murray Irrigation Region. The figures for the 1 in 2 ARI resemble those used as default values within the DESM
- It is assumed that in combination with landforming (as per the MDBC study) that effectiveness of loss mitigation is increased by 10%
- The buffer zone measure is not expected to have any benefit for reducing on-farm flooding.

Major Technical References:

MDBC (1995:3) Review of Surface Drainage Design Standards for Southern New South Wales. Drainage Program Technical Report No. 3

MDBC (1995:1), *Drainage Evaluation Model User Manual Version 3*, October 1995, Murray Darling Basin Commission

Appendix 4 Assumptions used in calculating the value of environmental benefits

Table 39 Cumulative area of bushland and wetlands protected by the Surface Water Management Program that are subject to valuation, 2000 to 2006 implementation period

Year	Area of bush (ha)	Wetlands (ha)	Year	Area of bush (ha)	Wetlands (ha)
2000	-	-	2016	35.57	173
2001	-	-	2017	35.57	173
2002	4.90	34.6	2018	35.57	173
2003	17.55	69.2	2019	35.57	173
2004	25.10	103.8	2020	35.57	173
2005	33.57	138.4	2021	35.57	173
2006	33.97	173	2022	30.67	173
2007	35.57	173	2023	18.02	173
2008	35.57	173	2024	10.47	173
2009	35.57	173	2025	2.00	173
2010	35.57	173	2026	1.60	173
2011	35.57	173	2027		173
2012	35.57	173	2028		173
2013	35.57	173	2029		173
2014	35.57	173	2030		173
2015	35.57	173	2031		173

Note that the implicit price is the payment/levy that each household would pay annually for 20 years. The cumulative area protected increases, but the area subject to valuation will decrease overtime. Whilst the values of some assets can last, the value of the land protected and species protected can only be estimated for 20 years. This is because the original work (Western Australia study) specified “how much each household would pay as a yearly environmental levy for 20 years”.

The valuation is similar to the principle of depreciation where the book value of an asset becomes zero when it reached its estimated life span, although that asset still has “productive value”.

It was assumed that there is a lag of one year before benefits accrue, that is the area protected in 2000-01 will have a value in 2001-02.

Table 40 Implicit price per ha of environmental attributes (2006$)

Year	'Look' $/ha	Wetlands ($/ha)	Year	'Look' $/ha	Wetlands ($/ha)
2000	$35.32	$307	2016	$53.29	$392
2001	$38.18	$312	2017	$54.03	$397
2002	$40.02	$318	2018	$54.76	$402
2003	$41.90	$322	2019	$55.49	$408
2004	$43.38	$328	2020	$56.21	$413
2005	$45.12	$333	2021	$56.93	$418
2006	$45.87	$339	2022	$57.59	$422
2007	$46.61	$344	2023	$58.23	$427
2008	$47.35	$349	2024	$58.86	$431
2009	$48.10	$355	2025	$59.48	$436
2010	$48.84	$360	2026	$60.09	$440
2011	$49.59	$365	2027	$60.67	$444
2012	$50.33	$371	2028	$61.24	$448
2013	$51.07	$376	2029	$61.78	$452
2014	$51.81	$381	2030	$62.31	$456
2015	$52.56	$387	2031	$62.82	

The implicit price of wetlands was annualised at 4% for 30 years.

Appendix 5 Details of the results of sensitivity analysis

Table 41 Sensitivity analysis (details) - without land use change: 4% discount rate, 30-year analysis ($M)

	System cost			Period cost		
	CSWMP	PSWMP	Program Total	CSWMP	PSWMP	Program Total
Benefits Agriculture						
- Salinity	$0.12	$0.28	$0.40	$0.14	$0.33	$0.47
- Waterlogging	$0.19	$0.34	$0.53	$0.26	$0.48	$0.74
- Flooding	$0.55	$0.35	$0.90	$0.74	$0.50	$1.24
- Land Use Change						
-TOTAL	**$0.86**	**$0.97**	**$1.83**	**$1.14**	**$1.31**	**$2.45**
Reuse						
Roads	$0.54	$0.65	$1.19	$0.69	$0.88	$1.57
Downstream	$0.07	$0.21	$0.28	$0.11	$0.56	$0.67
Other						
TOTAL	**$1.47**	**$1.83**	**$3.30**	**$1.94**	**$2.75**	**$4.69**
Costs						
Capital	$1.08	$8.25	$9.33	$2.95	$16.95	$19.90
Operation and maintenance	$0.13	$0.60	$0.73	$0.22	$1.12	$1.34
Program Support	$0.20	$0.85	$1.05	$3.43	$0.99	$4.42
TOTAL	**$1.41**	**$9.70**	**$11.11**	**$6.60**	**$19.06**	**$25.66**
Investment Summary						
NPV	**$0.06**	**($7.87)**	**($7.81)**	**($4.66)**	**($16.31)**	**($20.97)**
BC ratio	1.04	0.19	0.30	0.29	0.14	0.18

Table 42 Sensitivity analysis (details) - increase road benefits with land use change: 4% discount rate, 30-year analysis ($M)

	System cost			Period cost		
	CSWMP	PSWMP	Program Total	CSWMP	PSWMP	Program Total
Benefits Agriculture						
- Salinity	$0.12	$0.29	$0.41	$0.15	$0.35	$0.50
- Waterlogging	$0.20	$0.36	$0.56	$0.28	$0.51	$0.79
- Flooding	$0.57	$0.37	$0.94	$0.82	$0.53	$1.35
- Land Use Change	$1.25	$10.83	$12.08	$1.82	$15.81	$17.63
-TOTAL	**$2.14**	**$11.85**	**$13.99**	**$3.07**	**$17.20**	**$20.27**
Reuse						
Roads	$0.81	$0.97	$1.78	$1.26	$1.32	$2.58
Downstream	$0.07	$0.21	$0.28	$0.12	$0.56	$0.68
Other						
TOTAL	**$3.02**	**$13.03**	**$16.05**	**$4.45**	**$19.08**	**$23.53**

	System cost			Period cost		
	CSWMP	PSWMP	Program Total	CSWMP	PSWMP	Program Total
Costs						
Capital	$1.11	$8.54	$9.65	$3.00	$17.36	$20.36
Operation and maintenance	$0.13	$0.60	$0.73	$0.24	$1.12	$1.36
Program Support	$0.20	$0.85	$1.05	$3.43	$0.99	$4.42
TOTAL	**$1.44**	**$9.99**	**$11.43**	**$6.67**	**$19.47**	**$26.14**
Investment Summary						
NPV	$1.58	$3.04	$4.62	($2.22)	($0.39)	($2.61)
BC ratio	2.10	1.30	1.40	0.67	0.98	0.90

Table 43 Sensitivity analysis (details) - increase road benefits without land use change: 4% discount rate, 30-year analysis ($M)

	System cost			Period cost		
	CSWMP	PSWMP	Program Total	CSWMP	PSWMP	Program Total
Benefits Agriculture						
- Salinity	$0.12	$0.28	$0.40	$0.14	$0.33	$0.47
- Waterlogging	$0.19	$0.34	$0.53	$0.26	$0.48	$0.74
- Flooding	$0.55	$0.35	$0.90	$0.74	$0.50	$1.24
- Land Use Change						
-TOTAL	**$0.86**	**$0.97**	**$1.83**	**$1.14**	**$1.31**	**$2.45**
Reuse						
Roads	$0.81	$0.97	$1.78	$1.04	$1.32	$2.36
Downstream	$0.07	$0.21	$0.28	$0.11	$0.56	$0.67
Other						
TOTAL	**$1.74**	**$2.15**	**$3.89**	**$2.29**	**$3.19**	**$5.48**
Costs						
Capital	$1.08	$8.25	$9.33	$2.95	$16.95	$19.90
Operation and maintenance	$0.13	$0.60	$0.73	$0.22	$1.12	$1.34
Program Support	$0.20	$0.85	$1.05	$3.43	$0.99	$4.42
TOTAL	**$1.41**	**$9.70**	**$11.11**	**$6.60**	**$19.06**	**$25.66**
Investment Summary						
NPV	**$0.33**	**($7.55)**	**($7.22)**	**($4.31)**	**($15.87)**	**($20.18)**
BC ratio	1.23	0.22	0.35	0.35	0.17	0.21

Table 44 Sensitivity analysis (details) - reduce gross margins with land use change: 4% discount rate, 30-year analysis ($M)

	System cost			Period		
	CSWMP	PSWMP	Program Total	CSWMP	PSWMP	Program Total
Benefits Agriculture						
- Salinity	$0.10	$0.24	$0.34	$0.12	$0.28	$0.40
- Waterlogging	$0.16	$0.29	$0.45	$0.22	$0.41	$0.63
- Flooding	$0.46	$0.30	$0.76	$0.66	$0.42	$1.08
- Land Use Change	$1.00	$8.66	$9.66	$1.45	$12.64	$14.09
-TOTAL	**$1.72**	**$9.49**	**$11.21**	**$2.45**	**$13.75**	**$16.20**
Reuse						
Roads	$0.54	$0.65	$1.19	$0.74	$0.89	$1.63
Other	$0.07	$0.21	$0.28	$0.12	$0.56	$0.68
TOTAL						
Costs	**$2.33**	**$10.35**	**$12.68**	**$3.31**	**$15.20**	**$18.51**
Capital						
Operation and maintenance	$1.11	$8.54	$9.65	$3.00	$17.36	$20.36
Downstream	$0.13	$0.60	$0.73	$0.24	$1.12	$1.36
Program Support	$0.20	$0.85	$1.05	$3.43	$0.99	$4.42
TOTAL	**$1.44**	**$9.99**	**$11.43**	**$6.67**	**$19.47**	**$26.14**
Investment Summary						
NPV	**$0.89**	**$0.36**	**$1.25**	**($3.36)**	**($4.27)**	**($7.63)**
BC ratio	1.62	1.04	1.11	0.50	0.78	0.71

Table 45 Sensitivity analysis (details) - reduce gross margins without land use change: 4% discount rate, 30-year analysis ($M)

	System cost			Period cost		
	CSWMP	PSWMP	Program Total	CSWMP	PSWMP	Program Total
Benefits Agriculture						
- Salinity	$0.09	$0.22	$0.31	$0.11	$0.27	$0.38
- Waterlogging	$0.15	$0.28	$0.43	$0.20	$0.39	$0.59
- Flooding	$0.44	$0.28	$0.72	$0.60	$0.40	$1.00
- Land Use Change						
-TOTAL	**$0.68**	**$0.78**	**$1.46**	**$0.91**	**$1.06**	**$1.97**
Reuse						
Roads	$0.54	$0.65	$1.19	$0.69	$0.88	$1.57
Other	$0.07	$0.21	$0.28	$0.11	$0.56	$0.67
TOTAL						
Costs	**$1.29**	**$1.64**	**$2.93**	**$1.71**	**$2.50**	**$4.21**
Capital						

	System cost			Period cost		
	CSWMP	PSWMP	Program Total	CSWMP	PSWMP	Program Total
Operation and maintenance	$1.08	$8.25	$9.33	$2.95	$16.95	$19.90
Downstream	$0.13	$0.60	$0.73	$0.22	$1.12	$1.34
Program Support	$0.20	$0.85	$1.05	$3.43	$0.99	$4.42
TOTAL	**$1.41**	**$9.70**	**$11.11**	**$6.60**	**$19.06**	**$25.66**
Investment Summary						
NPV	**($0.12)**	**($8.06)**	**($8.18)**	**($4.89)**	**($16.56)**	**($21.45)**
BC ratio	0.92	0.17	0.26	0.26	0.13	0.16

Table 46 Sensitivity analysis (details) - with land use change: 5% discount rate, 50-year analysis ($M)

	System cost			Period cost		
	CSWMP	PSWMP	Program Total	CSWMP	PSWMP	Program Total
Benefits Agriculture						
- Salinity	$0.16	$0.37	$0.53	$0.18	$0.42	$0.60
- Waterlogging	$0.23	$0.41	$0.64	$0.30	$0.55	$0.85
- Flooding	$0.66	$0.43	$1.09	$0.89	$0.58	$1.47
- Land Use Change	$1.43	$12.38	$13.81	$1.96	$17.00	$18.96
-TOTAL	**$2.48**	**$13.59**	**$16.07**	**$3.33**	**$18.55**	**$21.88**
Reuse						
Roads	$0.65	$0.78	$1.43	$0.83	$1.00	$1.83
Other	$0.08	$0.26	$0.34	$0.13	$0.59	$0.72
TOTAL						
Costs	**$3.21**	**$14.63**	**$17.84**	**$4.29**	**$20.14**	**$24.43**
Capital						
Operation and maintenance	$1.31	$9.91	$11.22	$3.42	$19.77	$23.19
Downstream	$0.15	$0.71	$0.86	$0.25	$1.19	$1.44
Program Support	$0.13	$0.62	$0.75	$3.00	$0.87	$3.87
TOTAL	**$1.59**	**$11.24**	**$12.83**	**$6.67**	**$21.83**	**$28.50**
Investment Summary						
NPV	**$1.62**	**$3.39**	**$5.01**	**($2.38)**	**($1.69)**	**($4.07)**
BC ratio	2.02	1.30	1.39	0.64	0.92	0.86

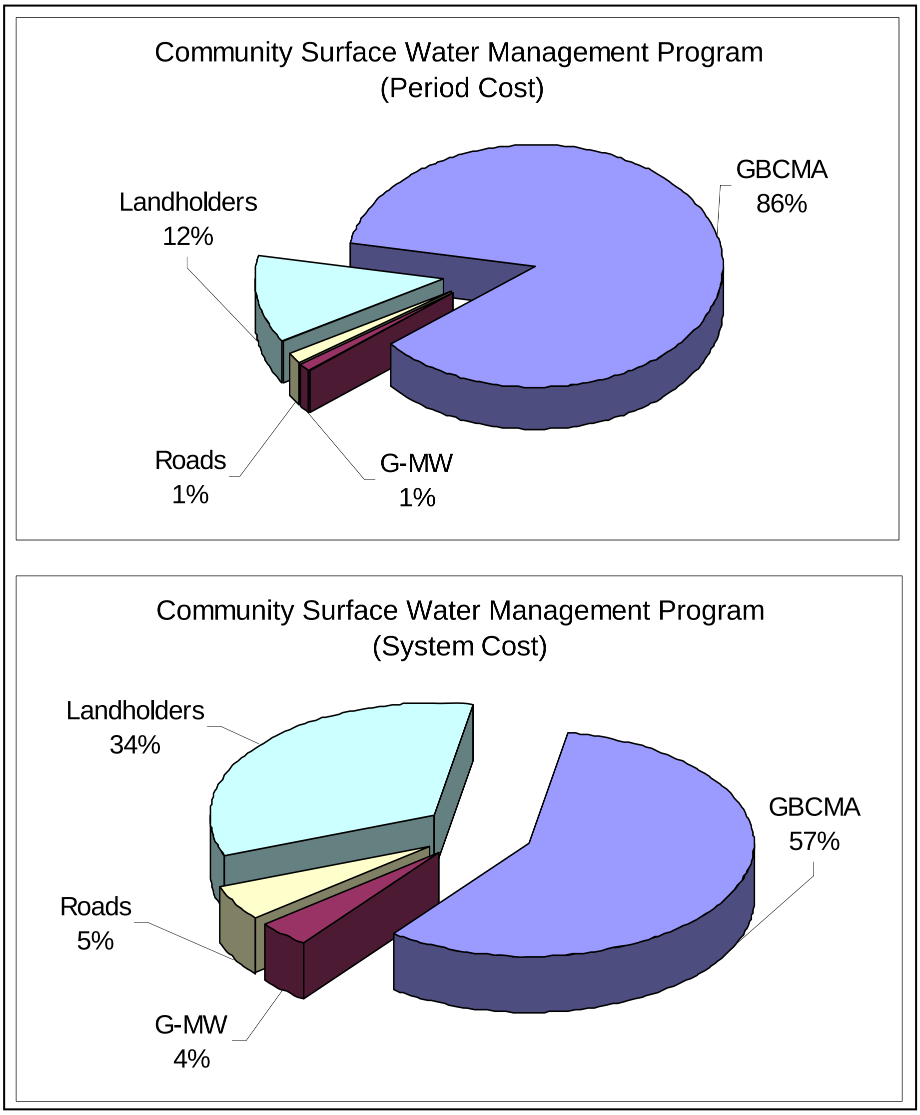
Table 47 Sensitivity analysis (details) - without land use change: 5% discount rate, 50-year analysis ($M)

	System cost			Period cost		
	CSWMP	PSWMP	Program Total	CSWMP	PSWMP	Program Total
Benefits						
Agriculture						
- Salinity	$0.15	$0.35	$0.50	$0.17	$0.40	$0.57
- Waterlogging	$0.22	$0.39	$0.61	$0.28	$0.52	$0.80
- Flooding	$0.63	$0.40	$1.03	$0.82	$0.54	$1.36
- Land Use Change						
-TOTAL	**$1.00**	**$1.14**	**$2.14**	**$1.27**	**$1.46**	**$2.73**
Reuse						
Roads	$0.64	$0.77	$1.41	$0.79	$0.99	$1.78
Other	$0.08	$0.26	$0.34	$0.12	$0.59	$0.71
TOTAL						
	$1.72	**$2.17**	**$3.89**	**$2.18**	**$3.04**	**$5.22**
Costs						
Capital						
Operation and maintenance	$1.28	$9.64	$10.92	$3.38	$19.30	$22.68
Downstream	$0.15	$0.71	$0.86	$0.24	$1.19	$1.43
Program Support	$0.13	$0.62	$0.75	$3.00	$0.87	$3.87
TOTAL	**$1.56**	**$10.97**	**$12.53**	**$6.62**	**$21.36**	**$27.98**
Investment Summary						
NPV	**$0.16**	**($8.80)**	**($8.64)**	**($4.44)**	**($18.32)**	**($22.76)**
BC ratio	1.10	0.20	0.31	0.33	0.14	0.19

Appendix 6 Cost share - Community Surface Water Management Sub-Program

The government funded about 88% of the total cost of implementing the Community Surface Water Management Sub-Program and the landholders contributed 12% (Period Cost method). The contributions of the various government agencies and the landholders are shown in Figure 8 and Table 48.

Figure 8 Sharing of costs - Community Surface Water Management Sub-Program: 4% discount rate, 30-year analysis



Notes: The data used in the graphs did not include residual values of capital costs
Based on the present value of costs discounted at 4%

Table 48 Sharing of annual cost - Community Surface Water Management Sub-Program (Period Cost method) at 2006$

Year	Public investment			Private investment	TOTAL
	GBCMA	**Goulburn-Murray Water**	**Vic Roads/ local government**		
2000/2001	$910,570	$7,626	$4,167	$50,510	$972,873
2001/2002	$1,530,532	$54,210	$51,606	$344,773	$1,981,121
2002/2003	$838,198	$9,755	$12,320	$113,125	$973,398
2003/2004	$1,179,651	$5,568	$29,954	$212,268	$1,427,441
2004/2005	$1,203,572	$461	$2,123	$29,554	$1,235,710
2005/2006	$1,193,491	$2,007	$14,216	$168,645	$1,378,359
TOTAL	**$6,856,014**	**$79,627**	**$114,386**	**$918,875**	**$7,968,902**
Present value	$5,976,618	$72,850	$101,257	$806,918	$6,957,643
Share (%)	85.9%	1.05%	1.46%	11.6%	100%

Notes: Goulburn Broken Catchment Management Authority cost includes all extension (Program Support) costs.
Present value calculated at 4% discount rate.
The residual value of the capital cost of CSWMS was not included in the calculation

Using the System Cost method, the Federal and Victorian State Governments contributed 57% through the GBCMA (Table 49). The landholders' contribution of 34% included the capital costs (survey, design and construction), operating and maintenance costs for 30 years and costs associated with land use change.

Table 49 Sharing of total cost: Community Surface Water Management Sub-Program (System Cost method): 4% discount rate, 30-year analysis

	Present value of cost share	**% of cost share**	
GBCMA	$859,716	46.3%	note 1
Landholders	$502,673	27.1%	
G-MW	$60,163	3.2%	
Vic Roads/Local Government	$75,445	4.1%	
Sub-total, construction cost	**$1,497,997**		note 2
Landholders - operating & maintenance cost	$130,033	7.0%	note 3
Landholders - land use change cost	$30,918	1.7%	
GBCMA - Program Support	$197,791	10.7%	note 4
TOTAL	**$1,856,739**	**100%**	note 5

Notes:
1 Includes all Program Support and extension costs incurred from the consultation phase to construction phase.
2 The residual value of the capital cost of CSWMS was excluded from the calculation.
3 Operating and maintenance of the systems for 30 years.
4 Other Program Support cost.
5 Rounding off error.