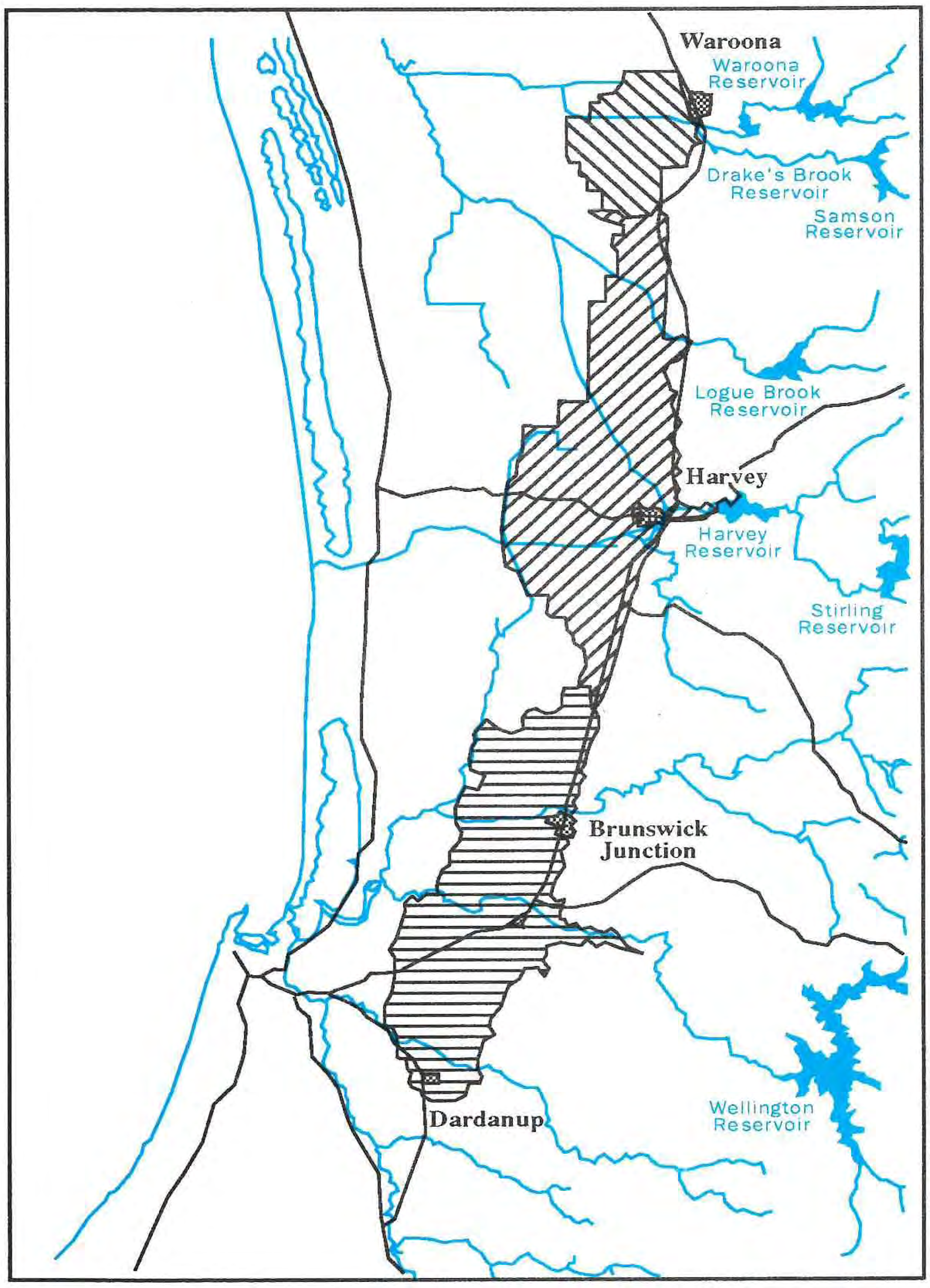
THE SOUTH-WEST IRRIGATION AREA STRATEGY STUDY

PHASE 2 TECHNICAL REPORT

An evaluation of options for the future South-West Irrigation Service in Western Australia



November 1992

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An evaluation of options for the future South West Irrigation Service in Western Australia

Prepared by the Technical Working Group for the Consultative Committee to the South-West Irrigation Area Strategy Study

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Water Authority of Western Australia
November 1992

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1. INTRODUCTION

1.1 Background and aim of the Study

In 1989 the Water Authority of Western Australia (Water Authority) initiated a study to assist in the development of a Government policy on the long-term direction of public irrigation in the South-West of Western Australia. The Water Authority recognised that many structures associated with irrigation were reaching or had exceeded their design life, and that significant capital investment would be necessary to maintain the South-West Irrigation Scheme.

The Water Authority also recognised that any major decision to invest significant capital in irrigation went well beyond the scope of the Water Authority alone. The study would need to address agricultural, economic, environmental, social and engineering issues. From the beginning, the study was planned to be multi-disciplinary and to actively involve the communities in the study region.

The primary objective of the Study is to develop a long-term strategy for the rehabilitation and/or modernisation of current irrigation systems and practices, subject to the constraints of economic sustainability; financial feasibility; and social and environmental acceptability.

The study should provide a basis for ongoing planning of:

- the redevelopment, operation and maintenance of the Water Authority's irrigation supply systems over the next thirty years; and,
- farm redevelopment and operations.

1.2 Study Approach and Progress

The Study is divided into six distinct phases.

Phase 1: Background Development and Issue Identification
Phase 2: Option Development and Analysis
Phase 3: Public Review of Future Strategy Options
Phase 4: Review of Submissions and Preparation of Draft Strategy
Phase 5: Environmental Protection Authority Review and Stakeholder review of the Draft Strategy
Phase 6: Adoption by Government of a Long Term Irrigation Strategy.

Phase 1 **Background Development and Issue Identification**

Phase 1 was completed in 1990[1] and provided preliminary evidence that the rehabilitation and continued operation of the South-West Irrigation Scheme was an economic proposition. However, revenue from water sold was just meeting operating and maintenance expenditure and the continuation of the scheme would require major capital expenditure in the future. A number of issues were identified for investigation in Phase 2 of the Study. These included

- what would the demand for irrigation water and land be under different future industry scenarios for dairy, grazing and horticulture;
- what other demands would be place on the water other than for irrigated farming;
- would it pay to replace the open channel distribution channel with a piped scheme;
- would irrigators be better off if the supply of irrigation water was privatised and controlled by irrigators;
- should some existing irrigation areas be closed down and should other areas be opened up.
- was salination and land degradation increasing in the irrigation area; and,
- what would be the social impact of any reduction in the area irrigated.

Phase 2 **Option Development and Analysis**

The issues raised in Phase 1 were translated into a series of options which irrigators and other stakeholders wished to see evaluated. The options were developed during a series of consultative workshops conducted at the start of Phase 2. The evaluation of the identified options was then undertaken, following the preparation of required data and information by members of the Technical Working Group and other contributors. Economic, financial, social impact and environmental aspects of options were prepared.

Phase 3 **Public Review of Future Strategy Option Report**

Phase 3 of the study is a public review of the future options for the irrigation scheme and it commences with the publication of the Phase 2 Reports.

The major tasks of Phase 3 will be the promotion of the report and the encouragement of stakeholders to prepare a submission on the future of the irrigation service. Stakeholders will be encouraged to use the Phase 2 reports as background to

- establish a vision or long term goal for the irrigation service;

- discuss the reasons for the establishment of this goal; and,

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[1] "The Irrigation Strategy Study, South-West Western Australia, Phase 1 Report, Summary of background papers and identification of issues," July 1990, Report No. WP95, Water Authority of Western Australia.

- propose a strategy for achieving that goal and address the economic, financial, social and environmental effects of the proposed strategy.

Submissions are expected from the major government agencies, including the Water Authority, the Environmental Protection Authority and the Department of Agriculture as well as farmer, industry and environmental groups.

Phase 4 Review of Submissions and Preparation of Draft Strategy

During Phase 4 an independent Task Force, to be appointed by Government, will review submissions from various stakeholders and prepare a draft strategy for the future of the irrigation service.

Phase 5 EPA and Stakeholder Review of Draft Strategy

The draft strategy will be reviewed by the Environmental Protection Authority and stakeholders and modified if necessary.

Phase 6 Final Adoption of Long-Term Irrigation Strategy by Government

The final strategy will be prepared and considered by Government for adoption.

1.3 The South-West Irrigation Area Today

1.3.1 Agriculture

The area of productive agricultural land within the boundary of the South-West Irrigation Area is 34,370 hectares. The South-West Irrigation Area is divided into 3 districts - Waroona, Harvey and Collie. The boundary of these three areas (running from North to South) can be seen in Figure 5.

A summary of information about agricultural activity in the Area is shown in Table 1 below. The table is based on data provided from a number of sources including the Water Authority's client database, the Australian Bureau of Statistics, data from the annual agricultural survey and surveys of irrigation farmers by the Technical Working Group and the Western Australian Farmers Federation (dairy enterprises). The data is for the 1989/90 financial year.

Table 1 Details of Agricultural Activity in the South-West Irrigation Area (1989/90)

	Waroona	Harvey	Collie	Total
Agricultural land (ha)				
Permanent Irrigation	1,350	4,582	4,200	10,132
Early germinated annual pasture	477	1,379	1,499	3,355
Annual Pasture	2,647	8,689	9,546	20,882
Total	4,474	14,650	15,245	34,369
Productivity[1] (ha)				
High	3,277	9,559	10.081	22,917
Medium	630	1,461	3,055	5,146
Low	568	3,631	2,109	6,308
Total	4,475	14,651	15,245	34,371
Current Enterprise Use (ha)				
Permanent Irrigation				
Dairy	366	3,589	3,255	7,210
Grazing	908	748	892	2,548
Horticulture - Vegetables	76	173	17	266
- Fruit	-	72	36	108
Total	1,350	4,582	4,200	10,132
Early Germination				
Dairy	137	1,141	1,177	2,455
Grazing	340	238	322	900
Total	477	1,379	1,499	3,355
Annual Pasture				
Dairy	600	4,235	4,059	8,894
Grazing	2,047	4,454	5,487	11,988
Total	2,647	14,650	9,546	20,882
Number of Farm Enterprises (Main activity)				
Horticulture	4	12	3	19
Dairy	9	80	80	169
Grazing (Commercial)[2]	16	45	57	118
Grazing (Part/time or hobby)	26	72	41	139
Total	55	209	181	445

Notes: [1] Based on degree of salinity
[2] TWG estimates

Key features from this table are:

- the area of permanent irrigation comprises 30 per cent of the land area;
- two thirds of the land area is classed as productive;
- dairying is the main enterprise using irrigation except in Waroona; and,
- there are 445 enterprises using irrigation in the South-West Irrigation Area.

1.3.2 The Irrigation Scheme

The irrigation infrastructure servicing the South-West Irrigation Area is shown in Figure 1 below:

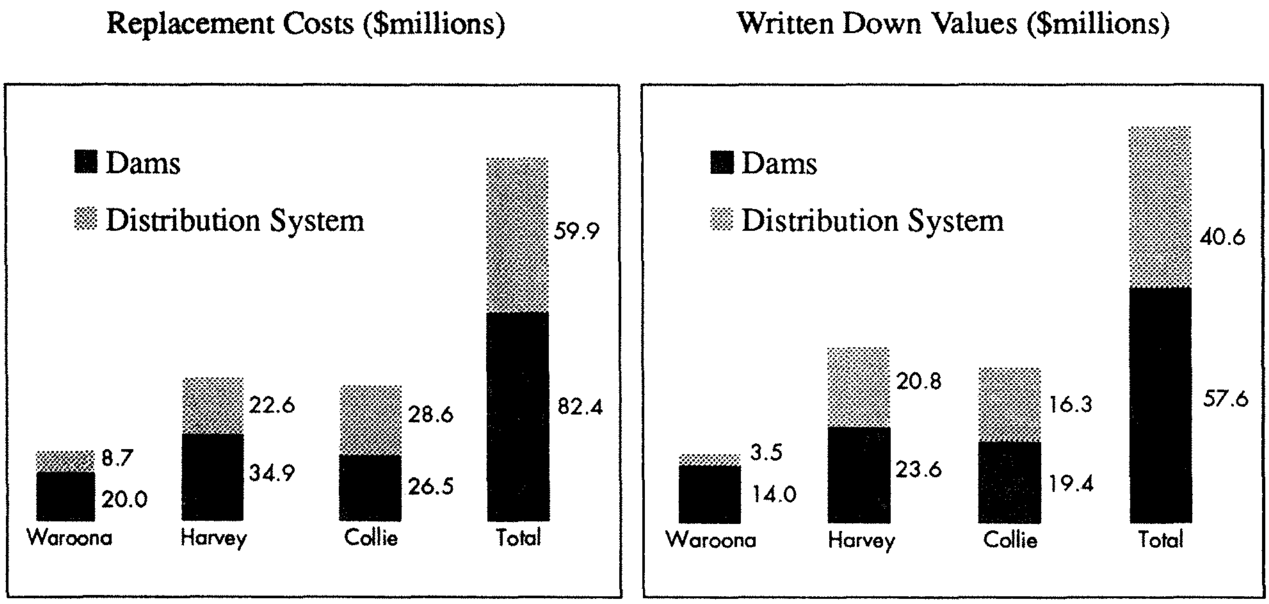


Figure 1 *Summary of Water Authority's Financial Assets in the South-West Irrigation Area*

Note: These figures have been corrected for this study and therefore differ from the official asset register.

Like all engineering assets the dams and distribution system need to be maintained and ultimately rebuilt when the cost of ongoing maintenance exceeds their replacement cost.

With the exception of the earlier development of the central Harvey area, most of dams and irrigation distribution system were originally constructed in the 1930's and expanded and/or replaced to meet demands during the period 1950 to 1970.

The average age of the channel linings in the Waroona, Harvey and Collie Districts are 50, 45 and 25 years respectively. Much of this lining is no longer effective in preventing seepage, and leakage from the system is increasing. Periodic failures of the channel lining currently occur and require immediate repair to keep the service operational. As the lining continues to age these patching tasks become more frequent until it becomes cost effective to implement a systematic program of replacement before failure occurs. In addition many of the structures are nearing the end of their effective lives. Most significantly many of the dams require modifications to meet new Australian design standards for spillway capacity and earthquake resistance.

1.3.3 The Financial Performance of the South-West Irrigation Service

The maintenance cost of the Irrigation Service will increase substantially in real terms over the next 30 years. The current financial performance of the Irrigation Service is summarised in Table 2. It shows the relationship between revenue received and expenditure by both the Water Authority and Government over the past three years.

Revenue raised in 1990/91 exceeded operating costs but did not cover total costs. Note the large cost for depreciation and the interest on the previous capital that was used to construct the Scheme.

From the State perspective, and under currently accepted accounting practices, the Irrigation Service is losing over $5 million per year. Neglecting the Government interest on past borrowing the Water Authority is losing over $2.7 million per year.

The Water Authority is no longer a recipient of any Government Funds. Indeed it is required to pay a 4% levy (up from 3% in 1990/91) on it previous year's revenue to the Government.

The Water Authority's shortfall is therefore met by cross subsidies from other Water Authority customers. As the cost of maintaining the scheme increases in the years to come this cross-subsidy will increase.

Deciding the scale of the maintenance/rehabilitation programme, and how it is to be funded are major issues for the irrigation strategy.

Table 2 Comparison of Costs and Revenues from South-West Irrigation Service ($ million)

	1988/89	1989/90	1990/91
TOTAL REVENUE	1.929	2.220	2.702
COSTS			
Operational Costs			
Operating & Maintenance	1.723	1.632	1.688
Salaries & Admin	.510	.557	.630
Total Operating	2.233	2.189	2.318
Depreciation			
Historic	.592	.601	.619
Replacement Provision	1.572	1.753	1.903
Total Depreciation	2.164	2.354	2.522
Interest on Past Borrowings			
Water Authority Borrowings	.330	.510	.488
Government Borrowings	2.317	2.341	2.419
Total Interest	2.647	2.850	2.907
Statutory Levy (3% on previous year's revenue)[1]	.055	.059	.067
TOTAL COSTS	7.099	7.452	7.814
NET RESULT	-5.170	-5.232	-5.112
TOTAL WATER SOLD (megalitres)	88,700	84,900	91,700

SOURCE: Water Authority of Western Australia

Notes: Costs as calculated by current Water Authority financial accounting method.

[1] This has been increased to 4% from 1991/92

2. THE OPTIONS EVALUATED FOR THE FUTURE OPERATION OF THE SOUTH-WEST IRRIGATION SCHEME

2.1 The process used to develop the options

Workshops were held for irrigators and Water Authority personnel during July/August 1990 to discuss the Phase 1 report and define possible future options for the Irrigation Service. Discussions were also held with other stakeholders (e.g. horticultural groups, the EPA) to establish a comprehensive range of future options that considered the major concerns from all stakeholder groups.

Results of the workshop outcomes (Supplementary Paper 7) and related discussions were combined with an approach to the Phase 2 analysis and presented to an invited group of stakeholders in November 1990 (Supplementary Paper 8). The output from that workshop formed the basis of options to be evaluated in Phase 2.

2.2 Factors Incorporated in the Development of the Options

The key factors that irrigators and other stakeholders identified as necessary to incorporate into the options to be evaluated were:

(a) Future Demand for Irrigated Land

The scale of any rehabilitation programme should be governed by the expected demand for irrigated land. This, in turn, is a complex function of market demands for the dairy, horticulture and grazing industries, government policy for the Dairy Industry, on-farm productivity improvements and water prices.

Different scenarios defining the demand for irrigation land were presented to stakeholder groups during the July/August 1990 Workshops.

The need to address a range of areas to be served by the future irrigation scheme was accepted by all stakeholders.

(b) Rehabilitation and Engineering Strategies

Farmers expressed the view that a comprehensive piped scheme should be investigated. Whilst capital intensive, piped systems reduce operating and maintenance costs, have low losses relative to channel systems and therefore save water and reduce groundwater recharge.

The desirability of minimising costs was also recognised and a minimum maintenance program similar to that use in the Phase 1 approach, was also proposed for evaluation.

(c) Salinity Mitigation Strategies

The importance of salinity mitigation to the future of the Irrigation Service was established in Phase 1 and discussed at the workshops. Following detailed investigations of the salinity issues, two approaches to improving pasture productivity were proposed. The first involved redesign of on-farm irrigation infrastructure to maximise water efficiency and pasture productivity and the second involved additional sub-surface drainage on salt affected and marginal land in the Irrigation Area, in addition to the improved on-farm practices.

(d) Water Demand Scenarios

The workshop discussions highlighted the need to specifically address the impact of high and low market demand for enterprises conducted on irrigated land and the impact of the price of water on the demand for irrigation water.

In this way the extremes of high and low future demands for irrigated land and water could be evaluated.

(e) Water Charging Policy

Currently water volumes are committed to irrigation by the area of rated land within the district. Two water charging policies were considered. The first maintained the current mix of a fixed rate charge and a volumetric charge. An alternative, to be run in conjunction with a Transferable Water Entitlement Market, and based on a 100% volumetric charge was also investigated.

Under the second approach water not used for irrigation could realise its value for other purposes in the following year. In other words, water no longer required could be allocated to other irrigators and to other uses including industrial and domestic uses.

2.3 Description of the Options

A total of 45 different options were identified for evaluation derived from various combinations of four different factors:

- Different land areas based on land productivity, environmental and enterprise criteria;
- On-farm irrigation practices and scheme engineering strategies for water delivery, drainage and salinity mitigation;
- High and low water demand scenarios; and,
- Current or TWE water charging policies.

Figure 2 provides a summary of the factors used to define the options. A description of these factors follows. Each of the 45 options was evaluated for the three irrigation districts of Waroona, Harvey and Collie as well as for the irrigation area as a whole.

2.3.1 Areas

The scale of any rehabilitation programme should be governed by the expected demand for irrigated land. This in turn is a complex function of market demands, government policy for the Dairy Industry, potential productivity from different regions of the irrigation area, on-farm improvements and water prices.

Farmers at the July/August 1990 workshops presented a range of possible areas which could be supplied with an irrigation service given different future scenarios and market outlooks.

Given an optimistic outlook farmers expected that the existing area would remain. Possible expansion of additional horticulture, upslope from the main supply channels and on the Myalup Sands towards the coast, was also highlighted. This was treated as a sub-option for which a preliminary estimation of the financial viability was carried out.

Given more pessimistic outlooks, in which increased costs would force partial or significant restructuring of the services, farmers expected that the service would contract.

A wide range of views were presented on the scale of the expected contraction. However, there was a general recognition that the more productive regions of the districts would be more likely to remain. For defining the options to be evaluated, three broad productivity regions were defined and associated area options developed.

These are summarised below and shown in Figure 3.

Area Option A: Existing area of service- includes high, medium and low productivity regions.

Area Option B: The existing area less the low productive Western portion of the existing districts - includes the high and medium productivity regions.

Area Option C: The high productivity area of the existing districts - excludes the low and medium productivity (salt affected and marginally salt affected) soils in the Western and Central portion of the existing districts.

High Productivity Region: The region where only localised areas of salt affected pasture exist and where high productivity should be able to be maintained. The region tends to be on the Eastern portion of the existing districts and includes the most fertile soils.

Medium Productivity Region: The region where significant areas of marginally salt affected pastures occur.

Low Productivity
Region: The region where extensive areas of salt affected pastures currently exist. The region tends to be on the Western edge of the current districts.

The productivity regions are only broadly defined. There are major variations in the productivity between paddocks, within farms, and between farms within the same productivity region. Local variation is affected by soil type, topography and local drainage, and particularly by farmer (water and pasture) management. Nevertheless, regional zones of averaged productivity were considered appropriate to use for the purpose of assessing the economic impact of different options for the future irrigation service. A survey by the Department of Agriculture in 1986 was used to delineate the three broad land productivity classifications. Minor modification of these boundaries were made to link in with cadastral boundaries and to update productivity areas in the Collie district.

Environmentalists and EPA staff considered that any long term strategy for irrigation should specifically investigate ways of redressing nutrient discharge in the Peel-Harvey Estuary.

An Option D was proposed at the November 1990 Workshop which would restrict irrigation to Dardanup Loam soils in a modified Peel-Harvey Catchment.

In Option D (Figure 4) it was proposed to redirect the headwaters of the Harvey Main Drain from the Peel-Harvey catchment via an extension to the Mangosteen Drain. This involved extending the drain approximately 10 kilometres to the north and east and was proposed in the early 1980's as one of the original options for controlling the algae growth problems of the Peel-Harvey estuary.

The drain extension enables 2,100 ha of current irrigable land in the heavy soils of the Plains Paddock Channel region to be retained while reducing the catchment area of and nutrient input to the Peel-Harvey Catchment.

At the November workshop it was decided that the component costs of the drainage and the benefits of maintaining the 2,100 hectares of irrigable land should be compared. Consequently an Option E was formulated that did not involve the Mangosteen Drain extension and restricted all irrigation north of the Harvey Main Drain except on the Dardanup loams in the core of the Waroona Irrigation District. By comparing the economics of Option D and E the value of the drainage works could be determined. Option E is shown in Figure 5.

Many stakeholders indicated the high quality of the loamy soils and the water resources of the Harvey and Waroona Districts and considered that the districts' long term future would be based on horticulture. A Horticultural Option - Option H - was therefore developed and is shown in Figure 5.

It was designed to investigate the economics of using the best loam soils of the district and the available water to service a modern export driven horticultural industry. This Option assumes the restriction of the irrigation area to the Dardanup loams in Harvey and Waroona and the sole land use being horticulture. No large scale horticulture development was proposed for the Collie District because of the salinity constraint of the water supply.

In evaluating the close down option (Option CD) it was clear that the piped network in the central Harvey Area could continue to operate cost effectively for many more decades without major additional capital injection. Consequently an option based on maintaining the central piped scheme (Option P) was defined. Option P is also shown in Figure 5.

Figure 2

AREAS

In each of the Waroona, Harvey and Collie Districts plus for the total South-West Irrigation Area

	A	B	C	D	E	H	P	CD
Total district served after 15 years	Existing area	Drop Western fringe (salt affected)	Drop marginal & salt affected land	Contract to Dardanup loams on Peel-Harvey Catchment Redirect 5,100ha of drainage from the Peel-Harvey Catchment	Contract to Dardanup loams on Peel-Harvey Catchment No change in Catchment drainage	Intensive horticulture (100%) on Dardanup loams	Close down irrigation except fully piped Harvey No 1 area Area all used for horticulture	Close down all irrigation between years 5 and 15
Irrigable Area	15,000 ha	12,900 ha	10,600 ha	9,100 ha	7,000 ha	3,800 ha	1,259 ha	
Water Allocated (megalitres)	110,000	94,700	79,100	68,500	52,200	72,400	11,500	

ON FARM IRRIGATION PRACTICES & ENGINEERING STRATEGIES FOR WATER DELIVERY & SALINITY MITIGATION

For each A, B, C, D & E area evaluate three different engineering and salinity mitigation options:

	STRATEGY 1	STRATEGY 2	STRATEGY 3
	On-farm • Current practices (including laser levelling)	**On-farm** • Redesign for improved water & pasture management • 10% of land area planted to trees	**On-farm** • As for Strategy 2 plus • Groundwater reduction by sub-surface drainage & regional pumping via bores
	Scheme	**Scheme**	**Scheme**
Distribution System	Minimum maintenance	Minimum maintenance	Fully piped
Wellington Catchment Reforestation	Yes	Yes	Yes

	STRATEGY (H)	STRATEGY (P)
	On-farm • 40ha properties • Farmers to supply head to distribute water on farm • Watering by sprinkler, trickle or spray	**On-farm** • 40ha properties • Farmers to supply head to distribute water on farm • Watering by sprinkler, trickle or spray
	Scheme	**Scheme**
Distribution System	Minimum maintenance	Minimum maintenance
Wellington Catchment Reforestation	Yes	Yes

WATER DEMAND SCENARIOS

All options to then be evaluated for two water demand scenarios:

	SCENARIO H	SCENARIO L
Market outlook for agricultural enterprises	Favourable	Conservative
Improvement in enterprise productivity	Low	High
Estimated increase in real water prices	Increase at same rate as inflation rate	Full cost recovery

WATER CHARGING POLICY

All options to then be evaluated for water charging policies:

CURRENT	TWEs
Current pricing policy ie a mix of rates and volume charges	Transferable Water Entitlements No rates, 100% volume charge

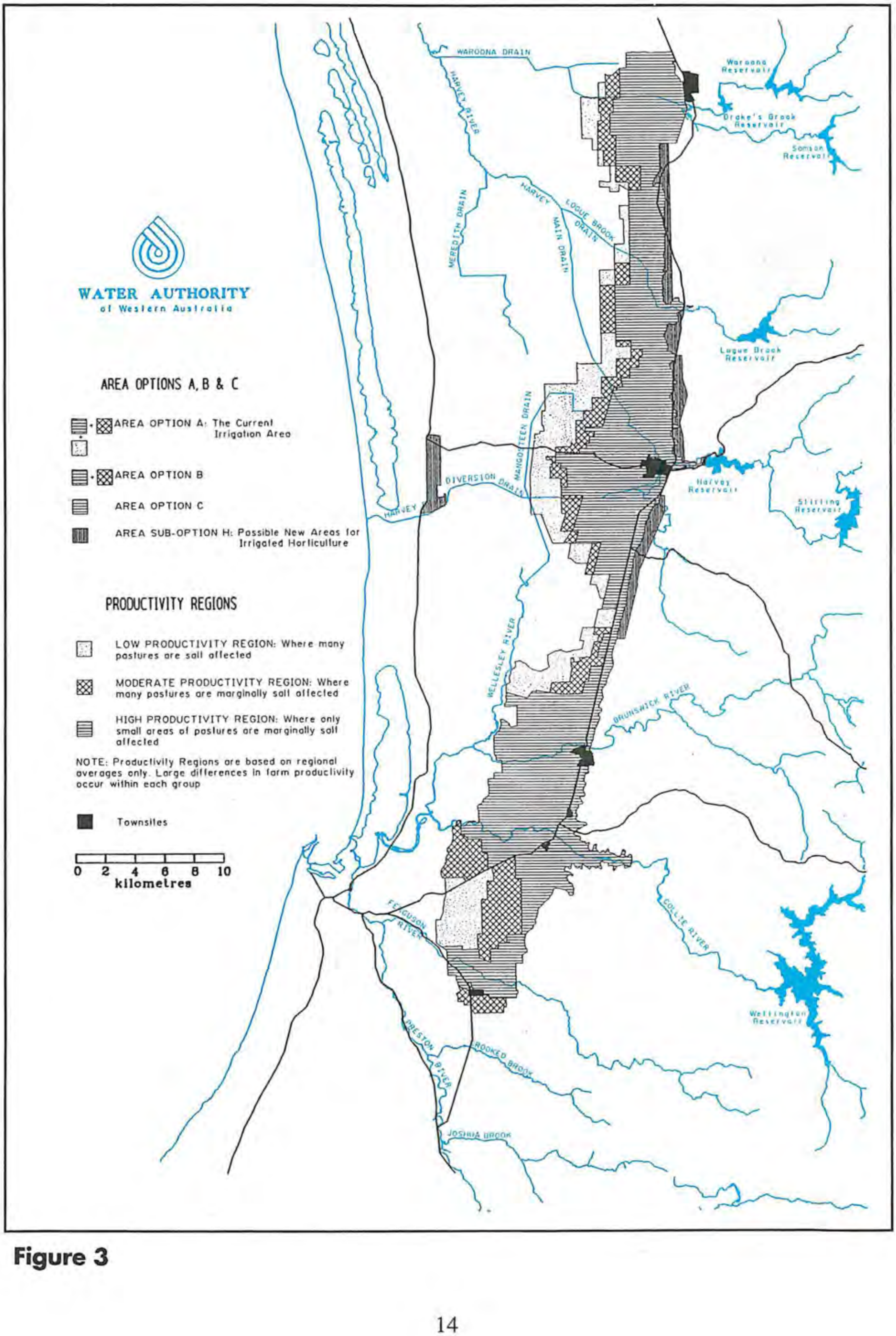

WATER AUTHORITY
of Western Australia
AREA OPTIONS A, B & C
AREA OPTION A: The Current Irrigation Area
AREA OPTION B
AREA OPTION C
AREA SUB-OPTION H: Possible New Areas for Irrigated Horticulture
PRODUCTIVITY REGIONS
LOW PRODUCTIVITY REGION: Where many pastures are salt affected
MODERATE PRODUCTIVITY REGION: Where many pastures are marginally salt affected
HIGH PRODUCTIVITY REGION: Where only small areas of pastures are marginally salt affected
NOTE: Productivity Regions are based on regional averages only. Large differences in farm productivity occur within each group
Townsites
0 2 4 6 8 10
kilometres
WAROONA DRAIN
HARVEY RIVER
Waroona Reservoir
Drake's Brook Reservoir
Samson Reservoir
MEREDITH DRAIN
HARVEY
LOGUE BROOK DRAIN
MAIN DRAIN
Logue Brook Reservoir
MANGOSTEEN DRAIN
DIVERSION DRAIN
HARVEY
Harvey Reservoir
Stirling Reservoir
WELLESLEY RIVER
BRUNSWICK RIVER
FERGUSON RIVER
COLLIE RIVER
Wellington Reservoir
PRESTON RIVER
CROOKED BROOK
JOSHUA BROOK

Figure 3

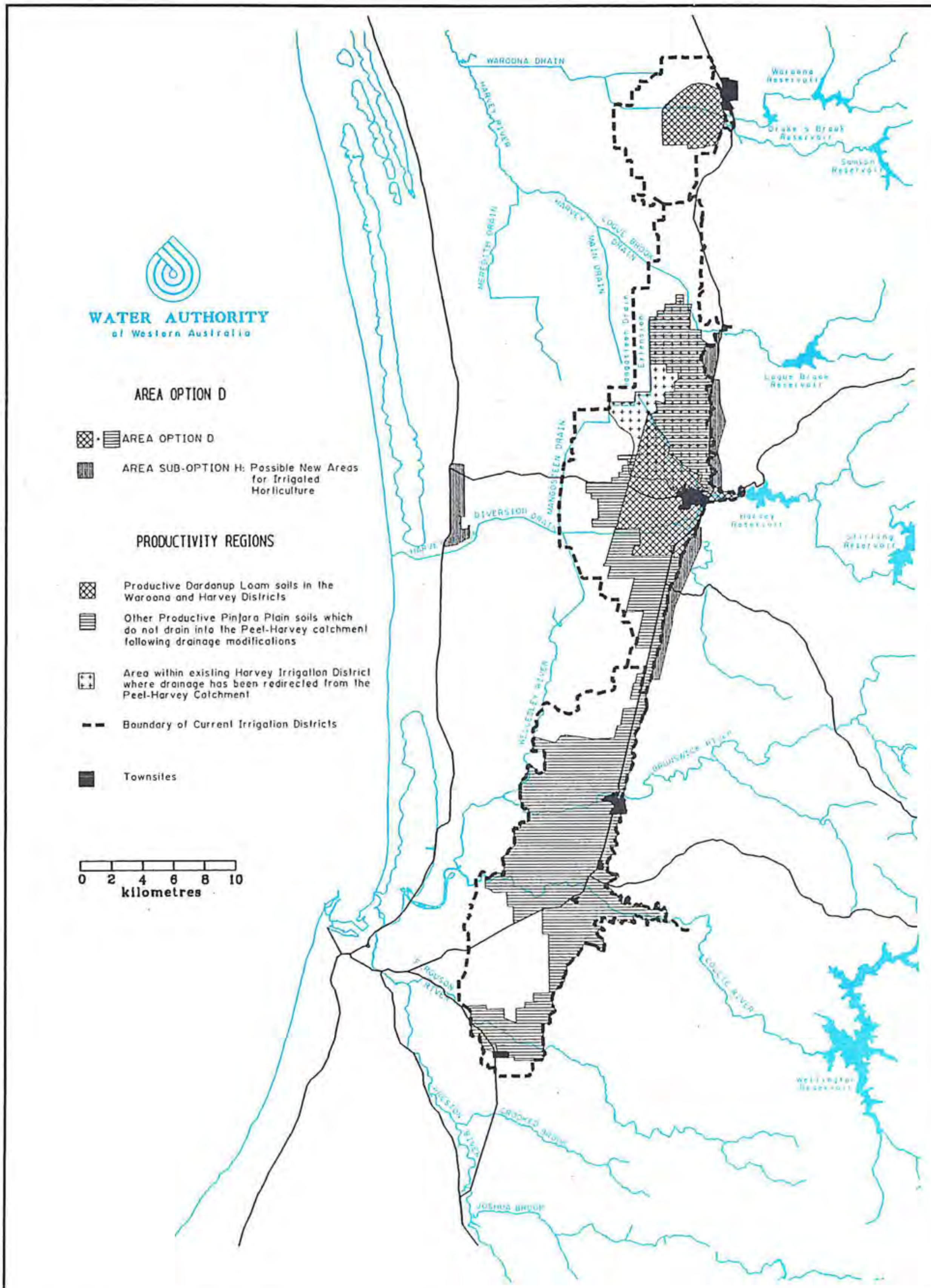
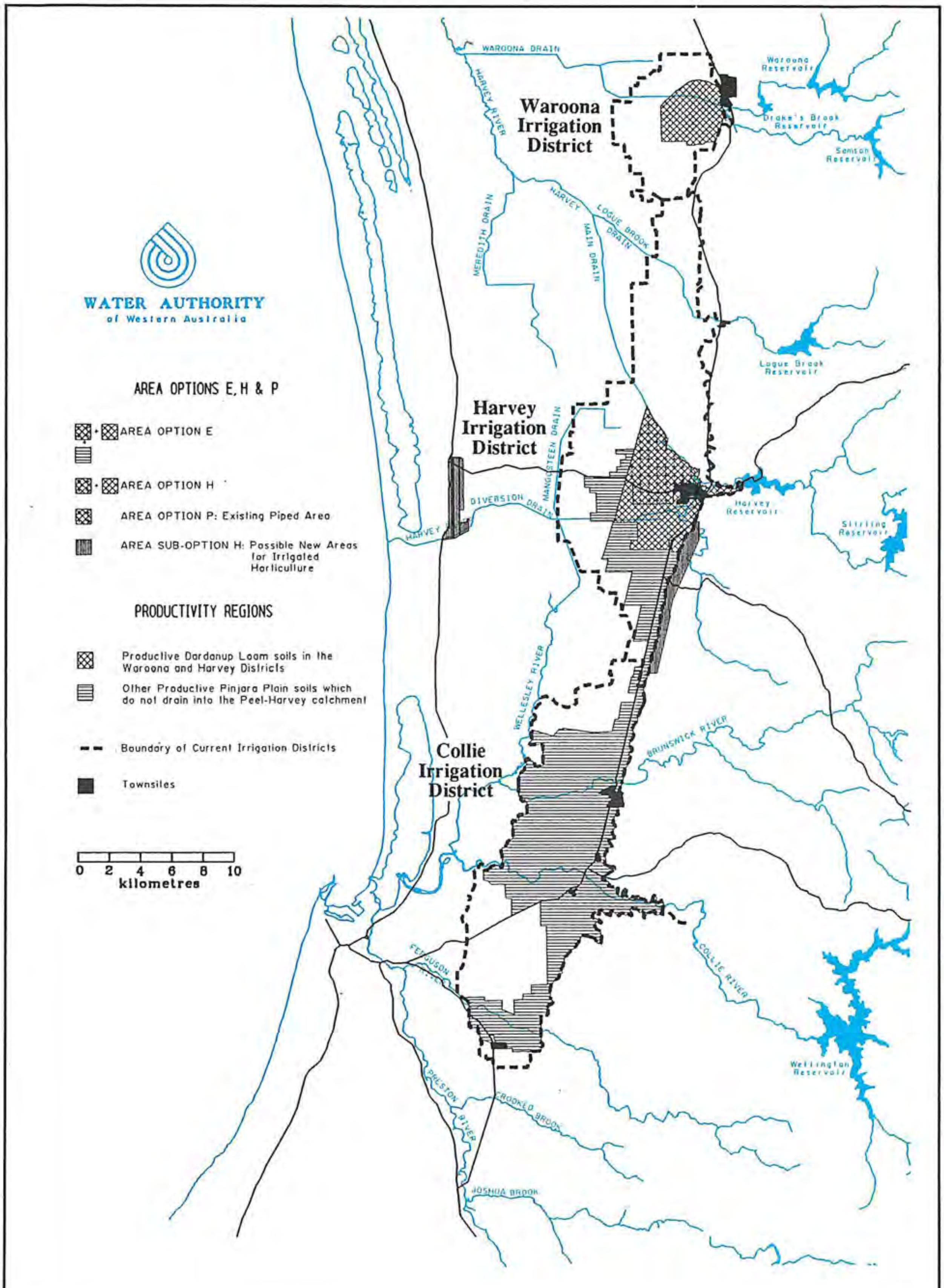

WATER AUTHORITY
of Western Australia
AREA OPTION D
AREA OPTION D
AREA SUB-OPTION H: Possible New Areas for Irrigated Horticulture
PRODUCTIVITY REGIONS
Productive Dardanup Loam soils in the Waroona and Harvey Districts
Other Productive Pinjara Plain soils which do not drain into the Peel-Harvey catchment following drainage modifications
Area within existing Harvey Irrigation District where drainage has been redirected from the Peel-Harvey Catchment
Boundary of Current Irrigation Districts
Townsites
0 2 4 6 8 10
kilometres
WAROONA DRAIN
DIVERSION DRAIN

Figure 4


WATER AUTHORITY
of Western Australia
AREA OPTIONS E, H & P
AREA OPTION E
AREA OPTION H
AREA OPTION P: Existing Piped Area
AREA SUB-OPTION H: Possible New Areas for Irrigated Horticulture
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Productive Dardanup Loam soils in the Waroona and Harvey Districts
Other Productive Pinjara Plain soils which do not drain into the Peel-Harvey catchment
Boundary of Current Irrigation Districts
Townsites
0 2 4 6 8 10
kilometres
Waroona Irrigation District
Harvey Irrigation District
Collie Irrigation District
WAROONA DRAIN
HARVEY RIVER
MEREDITH DRAIN
HARVEY MAIN DRAIN
LOGUE BROOK DRAIN
MANGOSTEEN DRAIN
DIVERSION DRAIN
HARVEY
WELLESLEY RIVER
BRUNSWICK RIVER
COLLIE RIVER
FERGUSON RIVER
PRESTON RIVER
CROOKED BROOK
JOSHUA BROOK
Waroona Reservoir
Drake's Brook Reservoir
Samson Reservoir
Logue Brook Reservoir
Harvey Reservoir
Stirling Reservoir
Wellington Reservoir

Figure 5

2.3.2 On-farm Irrigation Practices and Engineering Strategies

The importance of salinity mitigation to the future of the irrigation service was established in Phase 1 and discussed at the workshops. Following detailed investigations of the salinity issues, two approaches to improving pasture productivity were proposed. The first involved redesign of on-farm irrigation infrastructure to maximise water efficiency and pasture productivity and the second involved additional sub-surface drainage to the salt affected and marginal lands in the district.

There were three on-farm irrigation practice and engineering strategies for water delivery and salinity mitigation evaluated:

Strategy 1 Minimum Maintenance of Scheme and Current On-farm Practices.

The desirability of minimising costs was recognised and a minimum maintenance program, similar to that used in the Phase 1 approach, was proposed for evaluation.

Irrigation Scheme
- minimum maintenance of current distribution system
  - in 10 years time (Year 2000) commence a program of channel patchup and replacement of all channels 50 to 55 years of age with the aim of covering 50 per cent of the Area over 20 years;
  - conduct essential replacements of Dethridge wheels and control structures;
- dam safety upgrades;

On-farm
- current irrigation practices, including laser levelling but no additional salinity mitigation work.

Strategy 2 Minimum Maintenance of Scheme, Improved On-farm Practices

Irrigation Scheme
- minimum maintenance of current distribution system
- dam safety upgrades

On-farm
- re-design irrigation layout for improved water and pasture management incorporating
  - whole farm planning;
  - bay, head ditch and tail drain reforming;
  - 6 to 8 day watering capability; and,
  - surface ripping and mole draining.
- shade, shelter and limited recharge control by 10% tree planting adjacent to drains and channels
- the net result would be a 10% improvement in water efficiency (i.e. 10 per cent less water applied).

Strategy 3 Fully Piped Scheme, Best On-farm Practices

Farmers expressed the view that a comprehensive piped system should be investigated. Whilst capital intensive, piped systems reduce operating and maintenance costs, have low losses relative to channel systems and therefore save water and reduce groundwater recharge.

The aim would be to achieve water savings from both on-farm practices and a reduction of seepage loss from the distribution scheme

Irrigation Scheme	-	fully piped scheme
	-	dam safety upgrades
On-farm	-	as for Strategy 2 plus groundwater reduction in the marginal and salt affected regions by installing subsurface drainage and de-watering bores. Assume the adoption of most profitable option depending on the situation: • sub surface drainage at 15 metre spacing beneath permanent pasture; or • aquifer de-watering by "Yoganup Bores" every 15 hectares

2.3.3 Demand Scenarios

Market outlooks for irrigated agricultural produce and water prices will influence the future demand for irrigation land and water. These factors were considered in the development of two scenarios that covered the minimum and maximum likely demand for irrigated land and irrigation water over the next 30 years.

To enable the comparison of the options under high and low water demand conditions two water demand scenarios were examined for each of the three agricultural enterprises (dairying, grazing and horticulture) in the South-West Irrigation Area.

The high and low water demand scenarios for grazing and horticulture were developed by the Department of Agriculture and the Technical Working Group.

The high and low demand scenarios for the dairy enterprise were developed with the assistance of the Manager of the Dairy Industry Authority (see reference to Supplementary Paper 2).

(a) Water Pricing

At the July/August 1990 workshops many farmers argued that the price of irrigation water should be kept at the same real price (i.e. rise at no more than the inflation rate) as current prices were already affecting their water usage. If prices were further increased the current irrigation assets would not be fully used and the full benefits of irrigated agriculture would not be realised.

This approach was incorporated into the High Water Demand Scenario.

However, maintaining the increases in the price of irrigation water at CPI will result in an increasing subsidy to irrigated farm enterprises as the cost of maintaining the service increases.

A second water pricing approach based on a "User Pays" or "Beneficiaries Pays" approach was included in the Low Water Demand Scenario at the request of other stakeholders.

Many farmers argued that, if a "beneficiaries pays" approach were to be introduced then all the beneficiaries of the service should be asked to contribute. In particular the recreational benefit of the reservoirs and the Town Water Supply benefits to the State should be assessed.

A review of the recreational value of Logue Brook and Waroona Reservoir was therefore commissioned as part of this study (Supplementary Paper No. 1). By adopting standard assumptions used in recreation benefit analysis in the USA, the Waroona and Logue Brook Reservoirs were assessed as likely to provide recreational benefits of $2.6 million over 30 years.

Future recreational benefits are likely to increase over the 30 year study period. Increased usage of Logue and Waroona Reservoirs could be expected over the next 30 years. Additional recreational benefits are likely to develop from Wellington Reservoir as limited and controlled passive recreation increases. A generous upper limit on the likely increases in overall recreational benefit would be between 3 and 4 times the current estimates.

Additional benefits to Harvey Town Water Supply also accrue from the existence of the Harvey Weir. Other towns in the district are supplied from sources independent of the irrigation reservoirs. The construction and maintenance of a small storage just to supply Harvey Town is estimated to be about $2.0 million over 30 years.

The resulting estimates of the benefits (over 30 years) of the irrigation reservoirs are:

- $9.0 million for recreation (3.5 times current estimates)
- $2.0 million for town water supply
- $63.6 million for net irrigated agricultural production (Phase 1 estimate)

$74.6 million for total reservoirs benefits

Based on these estimates, over 85% of the benefits of the reservoirs are for irrigated agricultural production.

Consequently, under a "Beneficiaries Pays" philosophy costs incurred by the irrigators would be the:

- operational costs;
- capital costs of distribution system; and,
- 85% of capital costs for dams and headworks.

This approach was used to determine the water price for the low water demand Scenario.

(b) Market Demands

Reviews of the future market outlooks were considered by the TWG for grazing and horticulture.

- **High Demand**

  The high demand scenario was based on:

  - Favourable market outlooks for dairy, beef and horticulture industries and a modest rate of productivity improvement for the dairy and grazing industries.

    - dairying A demand of 128 million litres of milk from the Irrigation Area by Year 30 compared to 91 million litres of milk in 1989/90 based on the:

      - current quota system remaining;
      - share of State' milk production remaining at 34% from the Irrigation Area;
      - WA population to grow at 2.29% for 10 years to Year 2000, then 1.53% after that; and,
      - interstate imports of fresh milk products stabilising at 5% of market

      Assuming per cow productivity continues at 2% per year to the Year 2000 and then slows to 1% per year after that the total hectares required for dairying in 30 years time would be as shown in Table 3 below. The slowing of the productivity improvement rate actually results in a higher water demand and area irrigated (more grass needs to be consumed) for the same milk output than would be the case if productivity continued to improve at 2% per annum.

    - other grazing The high demand scenario assumes the current area of irrigated land is still required for other non-dairying grazing. There may be some structural change in this scenario. For example, more studs and part-time or hobby farm grazing activities compared to commercial beef and sheep grazing enterprises could develop.

    - horticulture Demand for horticultural land increases linearly from 374 hectares in 1989/90 to 1,250 hectares in 30 years time.

  - No increase in the real price of water.

    Water prices increasing at no more than the inflation rate, that is no increase in the real price of water.

- **Low Demand**

The low demand scenario was based on:

- Conservative market outlooks for dairy beef and horticulture industries and a continuation of the current rate productivity improvements of the dairy and grazing industries.

  - dairying A demand of 65 million litres of milk to be supplied from the Irrigation Area by Year 30 compared to 91 million litres in 1989/90 based on the:
    - quota system being replaced by a contract supply system between producers and dairy companies;
    - share of State's milk production falling to 20% from the Irrigation Area;
    - WA population growing more slowly - 1.64% to the Year 2000 and thereafter at 0.94%
    - interstate imports of fresh milk products increasing to become 20% of sales in 30 years time.

  Assuming per cow productivity continued to increase at 2% per annum the demand for irrigation land under this scenario is shown in Table 3.

  - grazing Assumes 50 per cent of current area is required for grazing activities in 30 years time.

  - horticulture Demand for horticulture land increases more slowly - from the current area of 374 hectares to 750 hectares in 30 years time.

- Full cost recovery water pricing policy

  Water prices to increase over a ten year period to full cost recovery levels so that by the Year 2000 water prices are meeting:

  - operational costs;
  - the capital costs of the distribution system; (on a renewals accounting basis) and,
  - 85% of capital costs for dams and headworks.

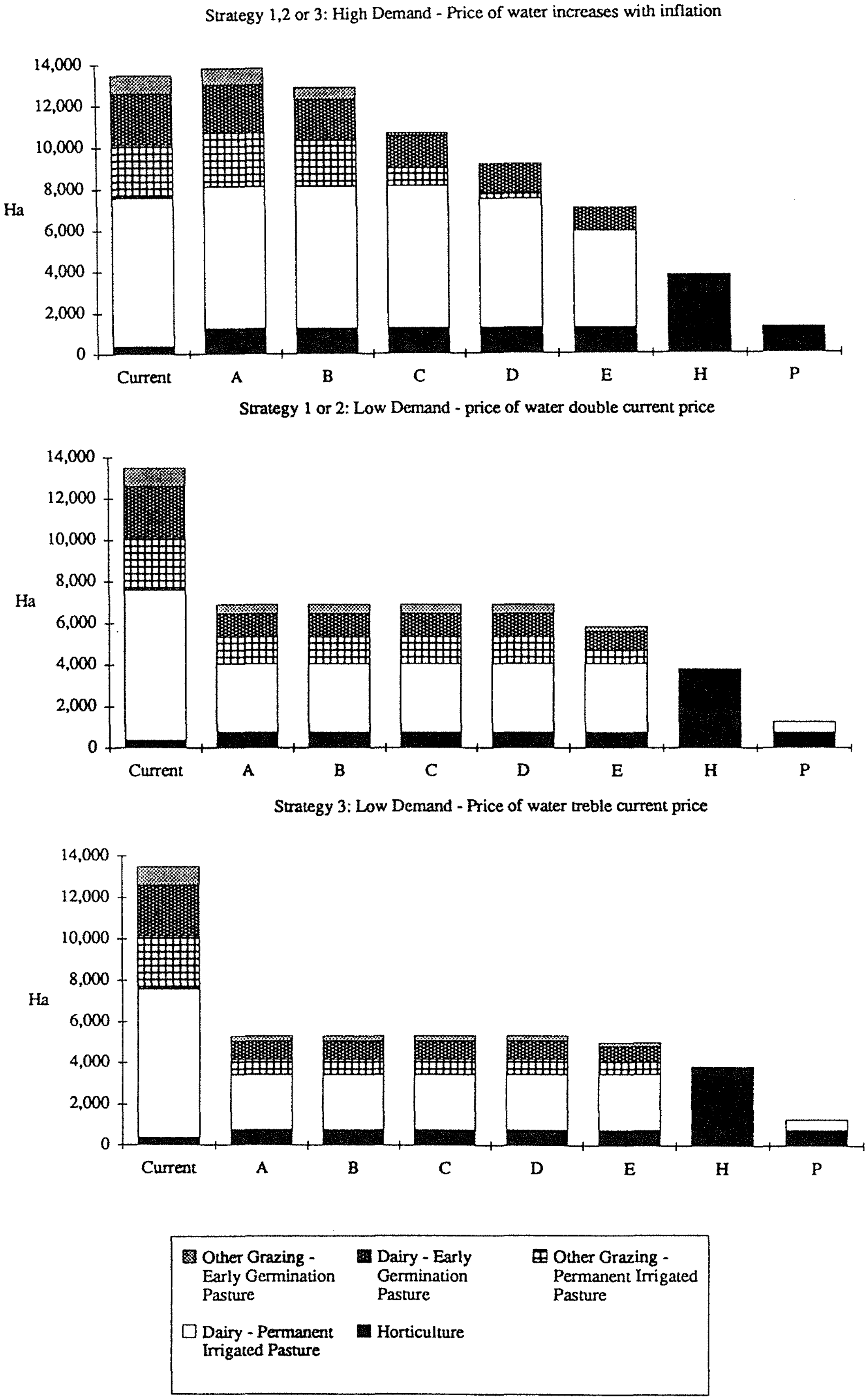
Table 3 Comparison of Areas of Irrigated Land Required in 30 Years Time under High and Low Demand Scenarios (hectares)

Water Demand	Current	High	Low Market Effect Plus Impact of price doubling	Low Market Effect Plus Impact of price trebling
Dairy				
Permanent Pasture	7,210	6,866	3,281	2,668
Early Germination	2,455	2,338	1,117	908
Grazing				
Permanent Pasture	2,548	2,548	1,274	713
Early Germination	900	807	449	251
Horticulture	374	1,250	750	750
Total				
Permanent Irrigation	10,132	10,664	5,305	4,131
Early Germination	3,355	3,145	1,566	1,159

The low water demand scenario incorporates a requirement for water prices to meet the full recovery of the cost of rehabilitating and operating the irrigation service. For options with a minimum maintenance strategy for the Irrigation Service (Strategies 1 and 2) the price of water would need to at least double to meet full costs. For the construction and operation of a fully piped scheme (Strategy 3) the price of water would need to at least treble. As a result of higher water prices the adoption of Rehabilitation Strategy 3 would result in further reductions in the area of land irrigated and a reduced demand for irrigation water when compared to the adoption of Strategy 2.

The composition of high and low demand for irrigated land is shown under the three engineering strategies in Figure 6.

FIGURE 6 The Composition of Demand for Irrigated Land in 30 Years Time Under Different Engineering Strategies and Demand Scenarios



2.3.4 Water Charging Policies

Two water charging policies were considered. The first was based on the current fixed allocation approach. The second was designed to represent one possible approach to water charging following the establishment of a Transferable Water Entitlement market.

- **Current (Fixed Allocation) Approach**

  Under this approach the current proportions of a fixed charge per rated hectare and a charge per megalitre of water used were maintained. The financial analysis of each option involved determining the required increases in the rates and volumetric charge components to meet the costs of each option. Also determined was the average cost per megalitre of water sold necessary to cover the costs of each option.

  The water allocated to irrigation in each option was based on the total rated area of the districts. In the economic analysis the opportunity cost of water was based on this fixed water volume, even if the actual volume used declined as real prices increased. Under the current system water could not be re-allocated to alternative uses. It remained "reserved" for irrigation purposes only.

- **Transferable Water Entitlement (TWE) Market Approach (or Variable Water Allocation Approach)**

  A different approach to charging is possible if a TWE market is established. The rated area has traditionally defined the volume of water allocated. However, with a Transferable Water Entitlement marketing operating, the volume of water allocated to irrigation can change over time, although only if irrigators are prepared to sell their entitlement. As the water entitlement would be separated from a particular area of land a water charging policy related to a rated area would no longer be necessary.

  For the purposes of the financial analysis under this approach, all charges were incorporated in the cost per megalitre of water used. No fixed charge component, based on rated area was included. Other possible combinations of variable charges and fixed charges (based on other than the rated area) are possible. These are discussed in the results section (Section 4.3).

  In the economic analysis the water not being used for irrigation was considered available for other uses. Consequently the opportunity cost of water under this charging approach is less than under the current (fixed allocation) approach.

2.3.5 Time scales for Implementation of Options

(a) Area Option and Engineering Strategies

Expenditure on dam safety upgrades and on many Dethridge Wheel replacements will need to be completed within the next 10 years. Some increased expenditure on channel maintenance will be required but major expenditure on planned replacement programs of old structures and channel lining will not have to commence until the year 2000.

There is therefore a ten year period (from 1990) for restructuring to reshape the districts before major expenditure on the distribution system is required.

Consequently in the cost benefit analysis the options which involve a reduction in the area served were shown as being implemented over a 15 year period. Small reductions were shown to occur over the first five years with the majority of the changes being implemented between years 6 and 15. The timing of the adjustment in land areas is illustrated in Figure 7 for Strategies 1 and 2.

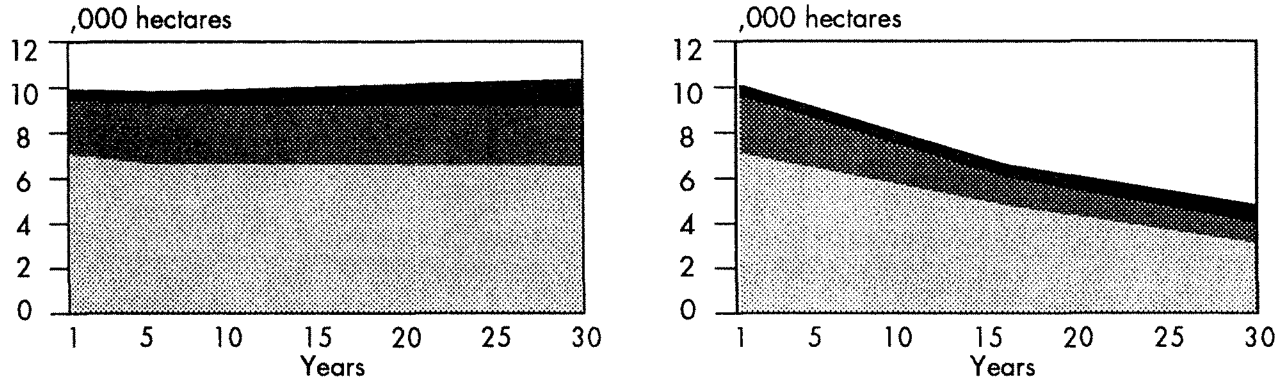
(b) Water Charging Policies

The low water demand scenario involves at least a doubling of water charges to cover the full cost of the minimum maintenance strategy for the existing channel scheme, and at least a trebling of the price to cover the full cost of a piped distribution scheme.

In the analysis water price increases were introduced in ten equal increments over a ten year period to the Year 2000.

High Water Demand Scenario

Low Water Demand Scenario



- Optimistic market demand
- Water prices do not increase in real terms (increase at or below inflation rate)

- Pessimistic market demand
- Water prices rise to meet full cost recovery

■ Horticulture ▩ Other Grazing ░ Dairy

NOTES: Assumes minimum maintenance strategy is followed by the Water Authority for maintaining the Scheme.

Figure 7 *Area of Permanent Irrigation Land Required*

The irrigation responses to these changes would lay behind the price increases. The adopted time frame of significant reductions in the area irrigated and the area served between years 5 and 15 is appropriately consistent. A typical example of the changes in areas irrigated and water charges is shown in Table 4 for Harvey District, Area D Strategy 1 and the Low Water Demand Scenario options.

Table 4 Example of Changes in Area Irrigated and Water Charges under the Current and TWE Water Charging Policies

(Harvey Area D: Engineering Strategy 1: Low Water Demand Scenario)

Water Charging Policy	Current				With TWE Market			
Year	Current (1989/90)	+5	+10	+30	Current (1989/90)	+5	+10	+30
• Permanent Irrigation (ha)	4,582	4,205	3,529	2,542	4,582	4,205	3,529	2,542
• Early Germination (ha)	1,379	1,243	948	652	1,379	1,243	948	652
• Price of Water to meet full cost recovery ($/ml)	24.30	43.30	62.30	62.30	24.30	42.20	60.1	60.1

2.4 Extending the Irrigation Services

During the Phase 2 workshops the question was asked whether it would be profitable to extend the current irrigation service to the Myalup Sands to the West of the main Irrigation Area and the foothills of the Darling Scarp (East of the South West Highway).

Two sub options were developed to evaluate these ideas.

- Myalup Sands

  The Myalup sub-option involved pumping water from the Main Harvey Drain to an area of approximately 600 hectares on the Myalup Sands, west of Harvey.

- The Foothills

  The pumping of water from existing irrigation channels into farm storage dams on foothills properties with suitable soils adjacent to the channels was also examined.

2.5 Other Factors Considered in Option Formulation

A number of additional points, were raised by stakeholders in the option development phase. These are discussed below.

2.5.1 Alternative Uses for Land Which is Currently Irrigated

A number of farmer groups raised points as to what land uses could be employed for land that was retired from irrigation. Issues such as subdivision of land and possible industrial development were raised. However, it was decided that the Phase 2 analysis should be based on a comparison of irrigated and dryland agriculture only. The current land zoning is "rural" throughout the area and for the purpose of Phase 2 analysis it is assumed to remain so.

Subdivision and industrial zoning possibilities were seen as important land planning issues that are better directly addressed in regional land planning studies following the finalisation of the Government's Irrigation Strategy or taken into account following stakeholder submissions in Phases 3 and 4.

2.5.2. Alternative Uses for Water

A number of stakeholder groups, (environmental and water industry) argued that the benefits of using some or all of the water currently allocated to irrigation should be specifically included in the analysis. At the November 1990 workshop it was proposed to prepare a specific discussion paper on the alternatives for the land and water resources retired from irrigated use.

The costs and benefits of alternative water uses are included in this report (Section 3.4).

2.5.3 Transferable Water Entitlements (TWEs)

At the November 1990 workshop, conducted to refine the Phase 2 options to be evaluated, it was recognised that one of the issues that would need to be addressed would be how the necessary restructuring for different options could take place in an equitable way. It was recognised that transferable water entitlements (TWEs) could pay a vital role in the achievement of restructuring. A survey of 55 irrigators (10% of irrigators) conducted in Phase 1 of the Irrigation Strategy Study revealed that 67% believed it would be fair to introduce TWEs, 10% were undecided and 23% believed the introduction of TWEs would be unfair.

TWEs involve the granting of water rights to current holders to ensure that water is efficiently and equitably allocated between users. It is based on the assumption that users with higher productive values for water will be willing to buy water from those with lower productivity values for water.

Many irrigators see TWEs as a means of guaranteeing their right of access to water. Under a TWE system individuals would be free to judge for themselves whether they were better off buying or selling water at the market price, and there would be no compulsion to sell.

The introduction of a system of TWEs could be expected to have the following results:

- increased allocation to higher value agricultural enterprises;
- increased adoption of water saving technologies (because water saved could be potentially sold);
- decreased use of water on land which was poorly suited to irrigation. TWEs gives property owners a means of selling water without selling their land, or getting more for their property by separately selling the water and the land; and,
- the provision of a mechanism for the Water Authority, to buy water for other uses (e.g. urban or industrial) if there is a higher value use for the water than irrigated agriculture.

Of course the introduction of a TWE system would need some rules to constrain the movement of water to ensure any adverse effects on remaining irrigators were minimised and environmental considerations were taken into account.

Further information on the role of TWEs in Australian irrigation water allocation policy can be found in the report of an international seminar and workshop on transferability of water entitlements held in July 1990 at the Centre for Water Policy Research, University of New England (Ref. 8).

Attempts to implement a trial of TWEs in the Collie Irrigation District in 1990 were shelved in favour of a policy whereby farmers may temporarily lease water to others under drought or low supply conditions. The main reason for shelving the trial was that irrigation water supply in the Collie Irrigation District currently exceeds the farmers' demand for it and accordingly there is no significant benefit to be gained by introducing TWEs in this area. Moreover TWEs would more appropriately be discussed in the overall context of this strategy study.

2.5.4 Commercial Tree Planting

The general low productivity from dryland grazing on the heavier poorly drained soils, mainly in the western portion of the Irrigation Area, suggested that commercial tree growing may be a viable alternative "agricultural" land use if these areas were retired from irrigation. Gavin Ellis from CALM, Manjimup was asked to carry out an initial assessment of the commercial potential of Eucalyptus Globulus (Tasmanian Blue Gum) on Pinjarra Plain soils (Reference 5). Estimates were preliminary and conservative as few trial plots are old enough to provide reliable tree growth. The results indicated that it is doubtful that Eucalyptus globulus plantations could compete financially with dryland grazing on the heavier soils, even if relatively high final tree crop prices were assumed. This conclusion may change if current trial plantings perform better than expected. However, the value of integration of trees into an overall farm plan and their additional value for shade and shelter, particularly for dairy cattle, was reviewed by Richard George, Department of Agriculture, Bunbury (Reference 6). He argued that their combined benefit to an irrigation farm had been previously underestimated. He quoted cases where farm profitability and net production were maintained when up to 20% of the farm was planted to trees.

Trees have the potential to improve profitability through shelter effects resulting in increased milk and livestock production, to limit water logging and accession to the water table and promote pasture production. Additional benefits from reduced nutrient runoff, diversification of farm income and the development of an aesthetically attractive and more environmentally acceptable landscape also exist. However, these benefits will have to be demonstrated locally before they will be adopted on any large scale.

Consequently strips of trees integrated into the farm and covering about 10% of an irrigated farm were included in the improved on-farm management practices of Strategy 2. However, no further analysis of the broader benefits of tree plantations on areas retired from irrigation was conducted.

2.5.5 An integrated Pipe Network System

Farmer groups in the July/August 1990 workshops proposed that a large supply main running the full north-south distance could be planned to tie in with a longer term system to deliver water to Perth and Mandurah. In this way some of the large capital cost could be shared with Metropolitan Users.

This concept was considered carefully but not analysed in Phase 2 for the following reasons.

Firstly, capital costs for pipelines are high. It is most efficient to only invest when the need can no longer be avoided. It is unlikely that the need for the irrigation network and bulk transport main to Mandurah/Perth would coincide. This is particularly the case in the area south of Harvey.

Secondly, if an integrated system was used all water would have to meet drinking water standards. Expensive unnecessary treatment of irrigation water could be required in an integrated system.

It would be more cost effective to separate the supply storages, use the highest quality water for domestic supply and try to avoid all treatment except disinfection.

Thirdly, it would be difficult to design and efficiently operate a dual system with very different seasonal draw patterns.

3. ECONOMIC EVALUATIONS OF THE OPTIONS

This section describes the methodology used to conduct the economic cost benefit analysis of the 45 proposed options derived from the factors discussed in the previous section.

3.1 Methodology

3.1.1 Introduction

The objective of the economic evaluation is to assess whether it is economically viable to rehabilitate and continue operation of the irrigation service in each of the three Irrigation Districts. Expressed differently, the objective is to assess whether it is a prudent decision to invest in an upgrading of the irrigation infrastructure.

In order to undertake such an assessment the following have to be evaluated:

- the benefits and costs attributable to the Base Case. The base case involves a close down of the irrigation system, thereby enforcing a change from irrigated to dryland agriculture. For the purpose of the study, it is assumed that the irrigation system will be closed down over a 15 year period (to the Year 2005). The Base Case involves the following works:

  - bringing the supply dams up to acceptable Australian standards for floods and earthquakes;
  - making the channel system safe and re-establishing winter flows; and
  - provision of on-farm water supply systems.

- the benefits and costs attributable to the other options for rehabilitating the irrigation systems.

Each option evaluated would be classed as being economic, provided the net benefits generated from rehabilitating the irrigation systems outweighed the net benefits which would be generated if the systems were closed down (i.e the Base Case).

The benefits attributable to both the options being considered and the Base Case largely relate to the value of agricultural/horticultural production within the study area. Further, the net benefit attributable to the options will largely be a reflection of the higher productivity achieved from irrigated land compared with that from dryland.

The costs associated with each option comprise:

- the capital costs associated with rehabilitating the systems - both for the headworks (dams) and the distribution system (channels and drains);

- the annual costs associated with operating and maintaining the Service;

- the costs of salinity mitigation works necessary to maintain or improve productivity on irrigated land; and

- the value foregone by using the water for irrigation rather than for some alternative purpose (the opportunity cost).

3.1.2 Overview of Methodology

The major assumptions underlying the evaluation are defined in together with comments relating to their limitations.

Standard project evaluation (benefit cost) techniques incorporating discounted cash flow procedures were used to evaluate the incremental difference between the Base Case and each option. Such techniques allow ranking of the options on the basis of net present value. An 80 year period was used to calculate NPVs to ensure a long enough time for the evaluation of different capital options with long asset lives (e.g. pipe networks).

In broad terms, the approach used to evaluate the incremental benefits and costs between the Base Case and each option involved the following steps:

- estimation of the enterprise mix on a per hectare basis for irrigated (permanent and early germination) land and dryland;

- estimation of the difference in carrying capacity between irrigated and dryland pastures;

- estimation of the incremental value of agricultural production, with the incremental value being the difference between the net value of agricultural production achieved under the Option being investigated and the value achieved under the Close Down Case (the Base Case); and

- estimation of the incremental benefits and costs over time attributable to moving away from a situation of dryland agriculture, as would exist under the Base Case, to one of irrigated agriculture existing under the option. The incremental benefits and costs take into account: agricultural benefits; the capital and operating costs associated with the option and Base Case; the cost of providing salinity mitigation works; and, the opportunity cost associated with using the water for irrigation rather than some alternative use.

3.2 Value of Agricultural Output

3.2.1 Sources of Data for Current Agricultural Activities

Various sources of data were used to compile the value of current and projected agricultural output.

(a) Number of current enterprises

The Water Authority's Billing System was used to identify the number of enterprises specialising in different enterprises. Enterprises were classed as mainly dairy, grazing, horticultural or part-time/hobby farms. The distribution of these enterprises is shown in Table 1.

(b) Area of Land used for different enterprises

The Australian Bureau of Statistics were commissioned to prepare data for properties within the three Irrigation Districts. This was used to compile allocations of land area within the Irrigation Area to various enterprises. A problem arose due to the inability of this data to distinguish run off blocks operated outside the Irrigation Area by dairy farmers. Data from the 1989/90 Dairy Industry Authority Farm Survey, and then improved data from a special survey conducted by the Western Australian Farmers' Federation, was used to obtain a profile of the average dairy farm.

Areas of land used for horticultural and grazing enterprises were derived from the ABS, Water Authority's Billing System and from a specially commissioned survey of 55 irrigators conducted during Phase 1 of the Irrigation Strategy Study.

(c) Land Productivity

Land was divided into 3 categories - high, medium (marginally salt affected) and low salt affected) productivity land. The definition of the three land types was based on a 1986 survey conducted by the Department of Agriculture. The area of land in each of these land productivity classes is shown in Table 1.

The TWG then set about preparing estimates of average enterprise outputs for each of these land types for dairy and grazing enterprises. It was assumed all horticultural activities would take place on high productive soils.

Table 5 shows the estimates prepared in terms of useable tonnes of dry matter produced and estimated carrying capacities of the different land types.

Table 5 Estimated Productivity of Different Land Types

Tonnes of Useable Dry Matter per hectare[1]

Pasture Type	High Productive Land	Medium (Marginally Affected)	Low (Salt Affected)
Irrigated Perennial	7.6	5.7	3.8
Early Germination	6.0	4.8	3.0
Annual	4.4	3.8	2.2

Carrying Capacity (DSE/ha)[2]

Pasture Type	High Productive Land	Medium (Marginally Affected)	Low (Salt Affected)	Average
Irrigated Perennial	25	19	13	22
Early Germination	20	16	10	17.5
Annual	15	13	7	13
Average	17	14.5	8	15

Notes: [1] Assumes salt affects yields from all pasture types in the same proportion.
[2] Carrying capacity is measured in Dry Sheep Equivalents (DSE's) per hectare. It is assumed here that 1 DSE is equivalent to 300 kgms of useable dry matter.

(d) Value of Agricultural Output

Peter Eckersley of the Department of Agriculture prepared gross margins for average irrigated and dryland dairy beef and horticultural enterprises for 1989/90. These were based on gross margins prepared for the Phase 1 analysis but updated using data from the 1989/90 DIA dairy survey and research into the other enterprises. Estimates of fixed costs were also supplied. Further details can be found in Supplementary Paper 6.

Beef cattle gross margins were calculated and used as an indicator for the returns from all grazing enterprises.

Horticultural gross margins were calculated using indicator crops of citrus and a composite vegetable enterprise comprising tomatoes, sweetcorn, rockmelons and pumpkins.

With the assistance of Dr David Morrison of the Department of Agriculture economic and financial market milk prices were calculated to enable a true economic return for the dairying enterprise to be calculated. This produced a shadow price of 26 cents per litre for market milk compared to 37 cents per litre used for the financial analysis.

This implies that in 1989/90, if there had been no quota system in operation, the average price paid for milk would have been 26 cents.

The economic and the financial prices used for beef and horticulture output are the same as there are no market distortions or major differences between the economic and the financial returns for these enterprises.

Table 6 shows the summary of the estimated agricultural gross margins and fixed costs per hectare for land used for the different enterprises.

The agricultural gross margin represents the returns after all variable operating costs are deducted with the exception of irrigation costs.

The fixed costs are the cost of the owner/operator and administration fixed costs such as shire rates, accountants charges and so on.

(e) On-farm Irrigation Development and Salinity Mitigation Costs

The on-farm costs of adopting irrigation and salinity mitigation strategies as set out in Strategies 2 and 3 is shown in Table 7.

Table 7 also shows the expected percentages by which pasture productivity would improve with the adoption of Strategy 2 or 3.

Table 6 Agricultural Gross Margins and Fixed Costs used in Phase 2 Analysis

	Land Productivity	Gross Margins $/ha High	Medium	Low	Fixed Costs $/ha High	Medium	Low	Typical Enterprise Size (Ha's)
DAIRY								
(Financial)	Perennial Irrigated	836	627	418	216	188	160	230
	Annual Irrigated (EG)	660	528	330	193	175	149	
	Dryland	484	418	242	169	160	137	
DAIRY								
(Economic)	Perennial Irrigated	530	397	265	216	188	160	230
	Annual Irrigated (EG)	418	335	209	193	175	149	
	Dryland	307	265	153	169	160	137	
GRAZING								
(Beef)	Perennial Irrigated	430	266	176	181	157	133	284
	Annual Irrigated (EG)	340	224	139	161	145	108	
	Dryland	249	177	102	140	133	88	
CITRUS		3,404			1,550			20
DARDANUP LOAM MARKET GARDEN		4,648			1,550			20
MYALUP SANDS MARKET GARDEN		4,909			1,550			20
FOOTHILLS MARKET GARDEN		4,780			1,550			20
(Sub option - pumped)		4,823			1,550			20

SOURCE: ACIL Peter Eckersley et al, Department of Agriculture : 2/6/92

TABLE 7

COSTS AND PRODUCTIVITY IMPROVEMENTS FROM ON FARM IRRIGATION DEVELOPMENT AND SALINITY MITIGATION MEASURES

	Capital Cost ($/ha)	Lifetime (Yrs)	Annual Cost ($/ha)	Equivalent Annual Cost ($/ha)	% Pasture Productivity Improvement					
					Western (Low)		Central (Marginal)		Eastern (High)	
					Perm Irrig	Annual Dry&EG	Perm Irrig	Annual Dry&EG	Perm Irrig	Annual Dry&EG
On Farm Irrigation Development										
• Planning and redesign - better system design (head ditch, tail drain, culverts) $350/ha - pasture management Re-seed every 5 instead of 10 years, i.e. 15 ha instead of 7.5 ha each year $125/ha - topsoiling (12.5% area) $200/ha	550	20	25	52.50						
• Surface ripping work - mole draining $57/ha every 2 years	-	-	30	30.00						
Salinity Mitigation Costs										
• Tree planting(2)	-	-	-							
				82.50	35	20	30	10	25	0
• The above plus sub surface drainage of permanent pasture area at 15m spacing at 2.3 metre depth or • Regional pumping(50:50)(3)	4,500	25		180.00						
				262.50	115	25	120	15	NA	NA

Notes: (1) Option 2 may include automation of irrigated areas if the benefits exceed the costs for the individua producer. Automation would cost approximately $500 per hectare, based on one auto unit per 1 ha bay, sensor, air tube, installation, freight, insurance.
(2) Assume Costs equal extra benefits from improve shade and shelter and economic returns from trees.
(3) Regional pumping $1,300 capital per ha (20 years) plus $160 per hectare annual costs. One bore for every 15 ha. One in three success rate.
(4) NA Not applicable

These percentages were used to multiply the current agricultural gross margins to obtain an output estimate for adoption of the relevant strategy.

In addition it was estimated that if any substantial tracts of previously irrigated land reverted to dryland the improvements in dryland productivity would be as follows: zero on high productive land; +25 per cent on marginal land and + 50% on salt affected land.

(f) Other Costs

As the mix of enterprises changes over time there are changes in capital costs associated with the establishment of horticultural enterprises, the selling or buying of livestock and the cost of developing new pastures when land is changed from irrigation to dryland or vice versa. Further details on the conversion costs used in the Phase 2 analysis can be found in Attachment 8.

3.2.2 Calculating the Net Agricultural Benefit

The net agricultural benefit for each option was then calculated as the Net Present Value over 80 years at a 6 per cent discount rate. This was done by deducting the NPV of all additional costs of the option from the NPV of the agricultural gross margin. The net agricultural benefit relative to close down was also calculated. Further details on the calculation of the on-farm costs and agricultural returns for all options can be found in Attachment 4.

3.3 The Cost of Providing Water

Future cash flows of expected expenditure on operations, maintenance and capital upgrades for both the headworks and distribution systems were estimated over the 80 year study period for each option evaluated. The concept used was to look forward and estimate required expenditure rather than consider a depreciation allowance to cover past capital that has been expended and is being "consumed" as the existing assets age. This approach has loosely been termed "renewals accounting" and is a future cash flow analysis.

Essentially there were two engineering strategies - a minimum scheme maintenance strategy (Strategy 1) and the construction of a fully piped system (Strategy 3).

The third strategy (Strategy 2) has the same minimum scheme maintenance program as Strategy 1 but adopts an improved on-farm irrigation design and salinity mitigation program.

3.3.1 Distribution System Maintenance and Renewal

Programs of replacement and patching up of the distribution system were developed for each district based on the average age of the asset and the likely time a systematic replacement programmed would be required. Details of the assumptions involved in the minimum maintenance and piped engineering options for each option are given in

Attachment 5 and the results are presented in Section 3.5. A brief summary is provided below.

Under Strategy 1 major increases in expenditure on the distribution system should not be required for about 10 years.

Some additional capital will be required to trial automation, commence replacement of some water structures and Dethridge Wheels and some increase in costs associated with responding to sudden failures of channels particularly in the Waroona District. However the major expenditure on replacing channel lining is not likely to reach its peak until well after 10 years.

Waroona has the oldest channel linings and increased expenditure is likely to occur there first. Increased expenditure is likely to occur next in Harvey (in about 10 years) and then the Collie District (in about 20 years). Details are provided in Attachment 5.

A period of restructuring for irrigation farm enterprises and consequent modifications to the demand for irrigation water could take place during the 10 year transition phase to the Year 2000 and before major expenditure on the distribution system would be required.

Details of the design and the scale of the rehabilitation program could therefore be made as a clear picture of the future size, location and demand for irrigation water emerged.

It was for these reasons that the cost benefit analysis used a 10 to 15 year period for the phasing in of the various options.

Similarly the piped scheme (Strategy 3) would also be designed and constructed between years 10 and 15 after rationalisation of the service.

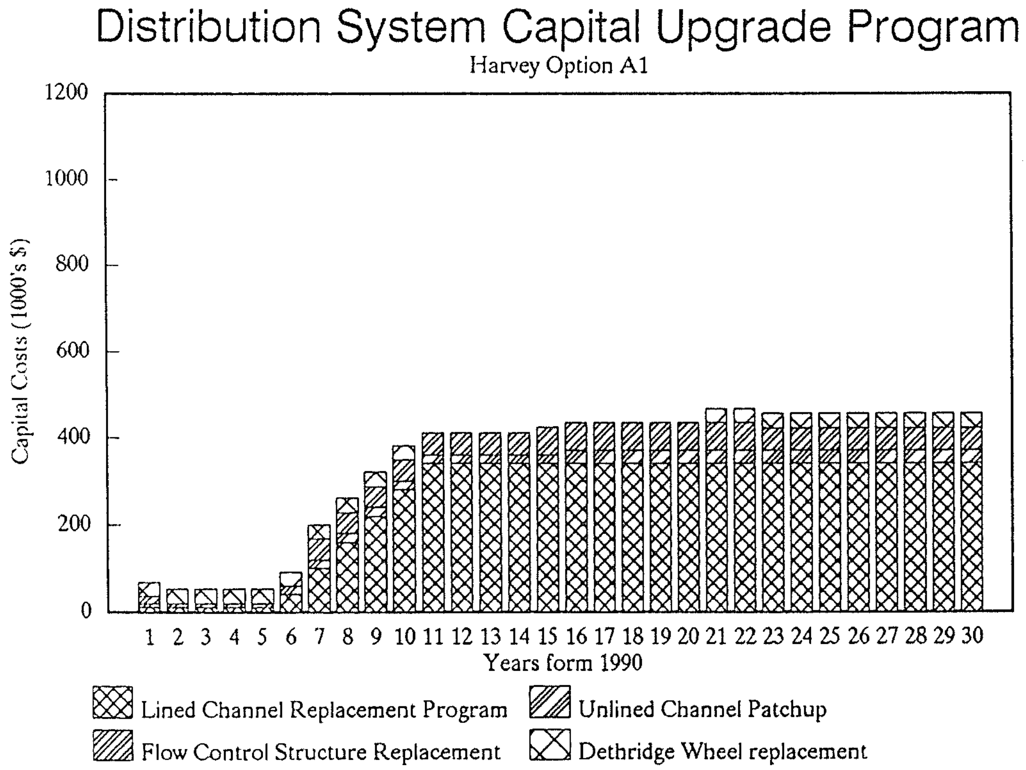
As the Irrigation Area served reduces, operations and maintenance costs reduce and capital upgrade and remedial work is avoided. These aspects had to be specifically taken into account in the engineering cost modelling so that realistic costs and benefits could be established for the different area options. In addition the relative proportion of water allocated to irrigation from the reservoirs also had to be determined so that the appropriate proportion of headworks costs could also be assigned to the irrigation service.

The approach taken was to define the operational, maintenance and capital upgrade costs into components that were functions of either the number of supply points, the length of channels, or the length of drains. The proportion of supply points, channels and drains in each of the area options was defined. The appropriate proportion of the existing operating costs could then be assigned to each area option. The proportion of time taken to visit supply points (from the Water Authority's MODAPS Study) was used to assess the relative water delivery costs of each option. The headworks costs were proportioned on the volume of water used for irrigation relative to the current (Area Option A) volume used over the 80 years.

(a) Capital Costs - Strategy 1

Examples of the components and cash flow costs of upgrading the channel distribution system over the next 30 years for the Harvey District Area A and Area D cases are shown in Figure 8. Area Option D shows a similar pattern to Area Option A although at a slightly reduced scale as the area to be served is reduced. The Area Option D also shows the capital spent on the extensions of the Mangosteen Drain in years 11 to 13.

FIGURE 8 Distribution System Capital Upgrade Program - Harvey Area Options A1 and D1



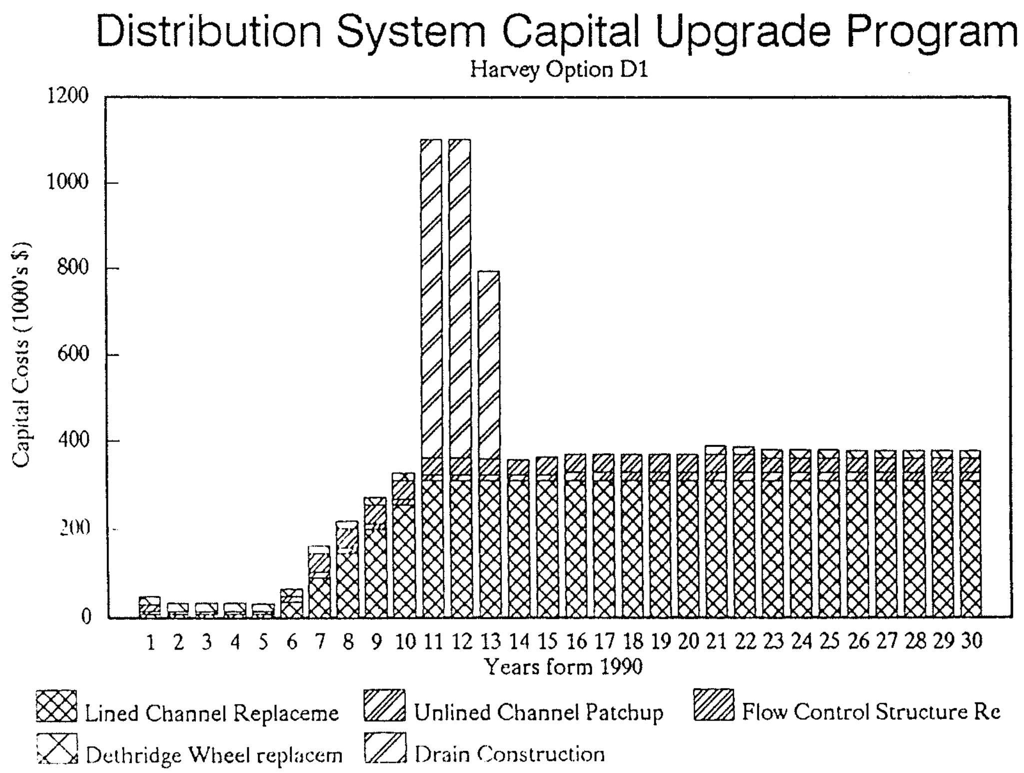
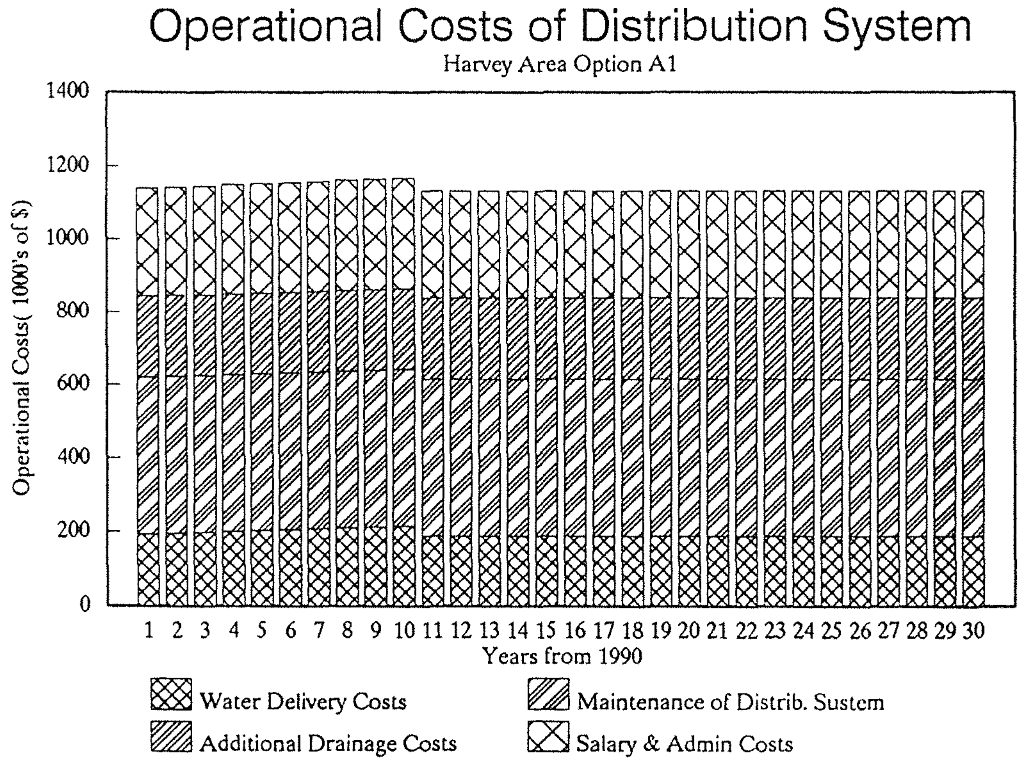
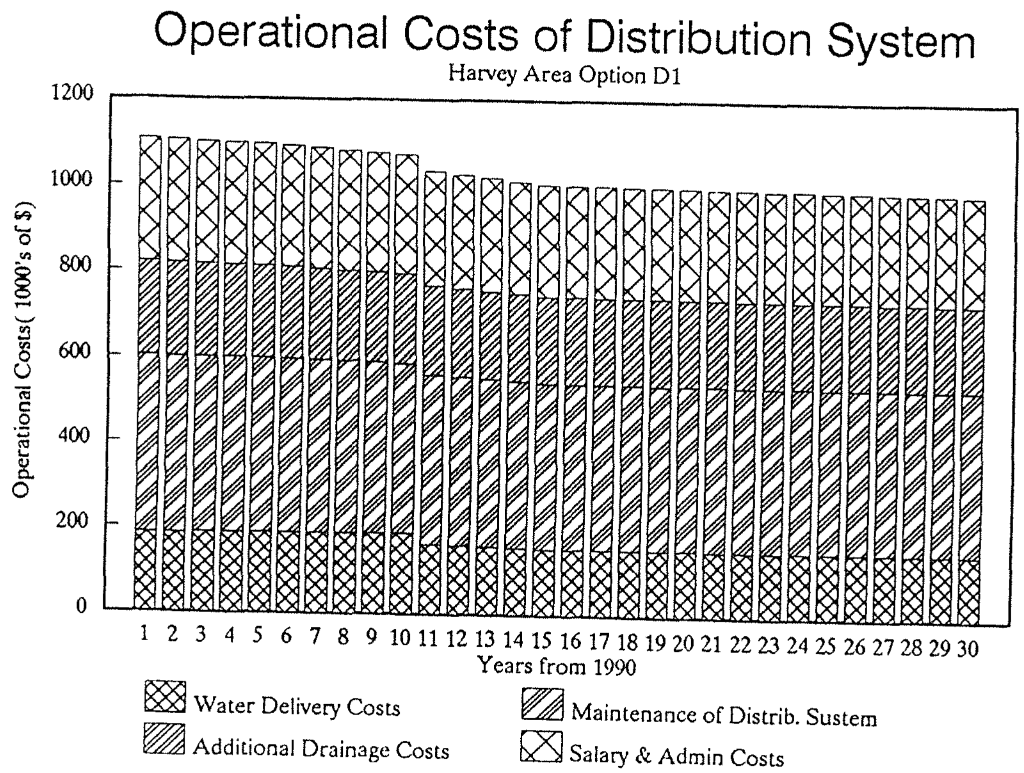


FIGURE 9 Operational Costs of the Distribution System - Harvey Area Options A1 and D1





(b) **Operational Costs**

Figure 9 shows the operational costs of providing irrigation water to Area A and Area D. The reductions in cost as the area served is reduced (shown here in Area D) is contrasted with the ongoing cost of maintaining Area A.

Similar cash flows have been calculated for all combinations of Area Options and High and Low Water Demands.

(c) **Capital Costs - Strategy 3**

Figure 10 shows the capital upgrade costs for the fully piped distribution system for Option A and D. The large capital injections between years 9 and 15 are apparent. These figures dominate small expenditures in maintaining the outlined channels and Dethridge Wheels prior to the construction of the pipe network.

(d) **Operation Costs**

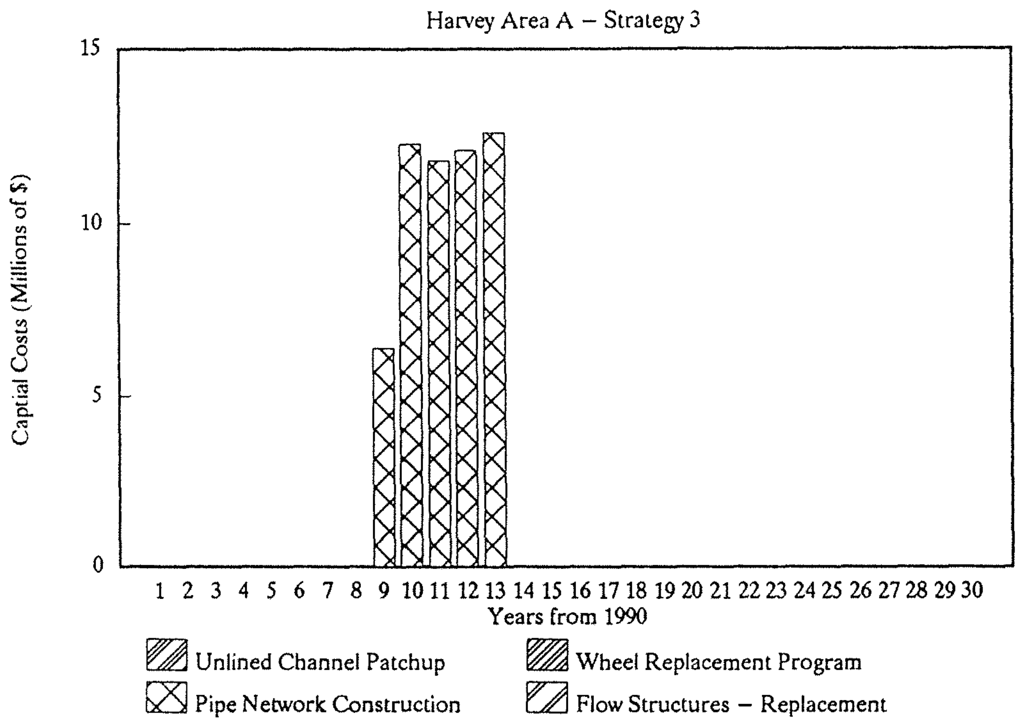
Figure 11 shows the respective operational costs. Significant operation cost saving occur following construction of the pipe network.

3.3.2 Headworks

As discussed in the Phase 1 Report major expenditure on the dams is essential over the next 10 years to ensure they meet acceptable standards of safety to resist floods and earthquakes. Minor changes to the timetable for this expenditure and the need for re-tensioning for the Harvey Weir every 15 years are the only changes from the Phase 1 Analysis.

Table 8 provides preliminary cost estimates for dam modification to meet the currently accepted dam safety standards in Australia.

FIGURE 10 Pipe Network Capital Upgrade (Strategy 3) Costs
- Harvey Area Options A and D



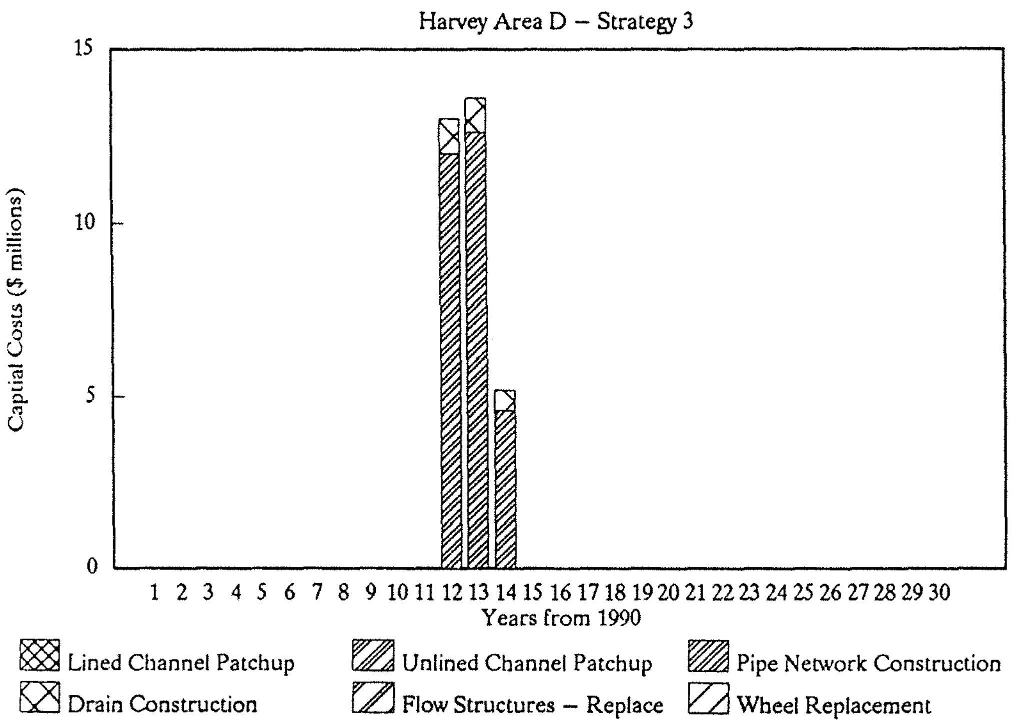
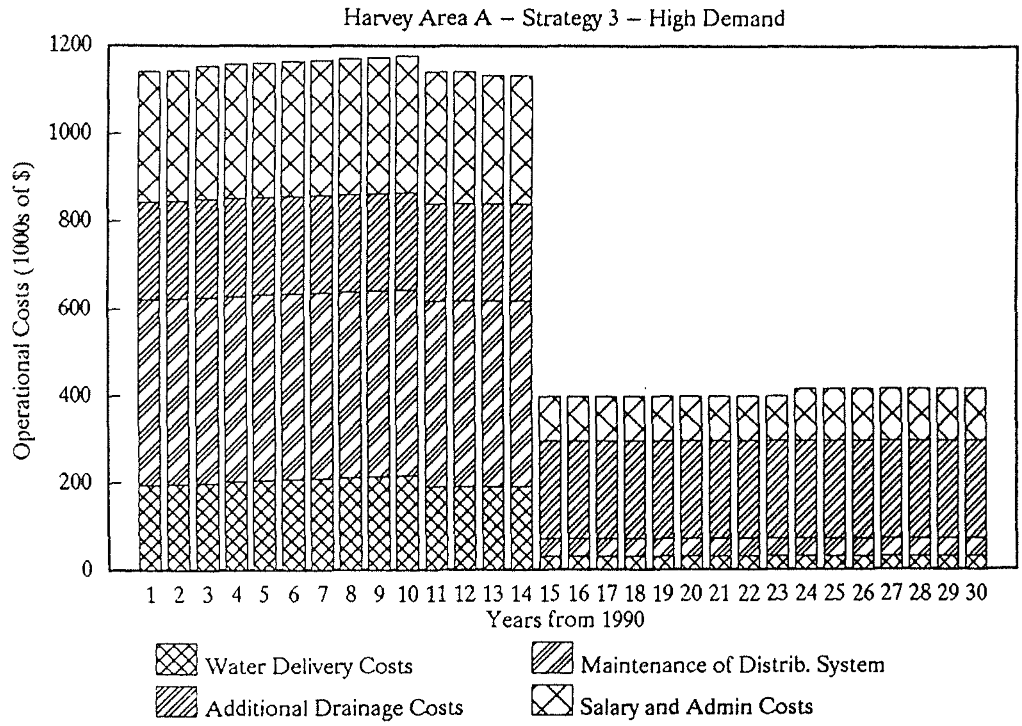


FIGURE 11 Operational Costs of the Distribution System (Strategy 3)
- Harvey Area Options A and D



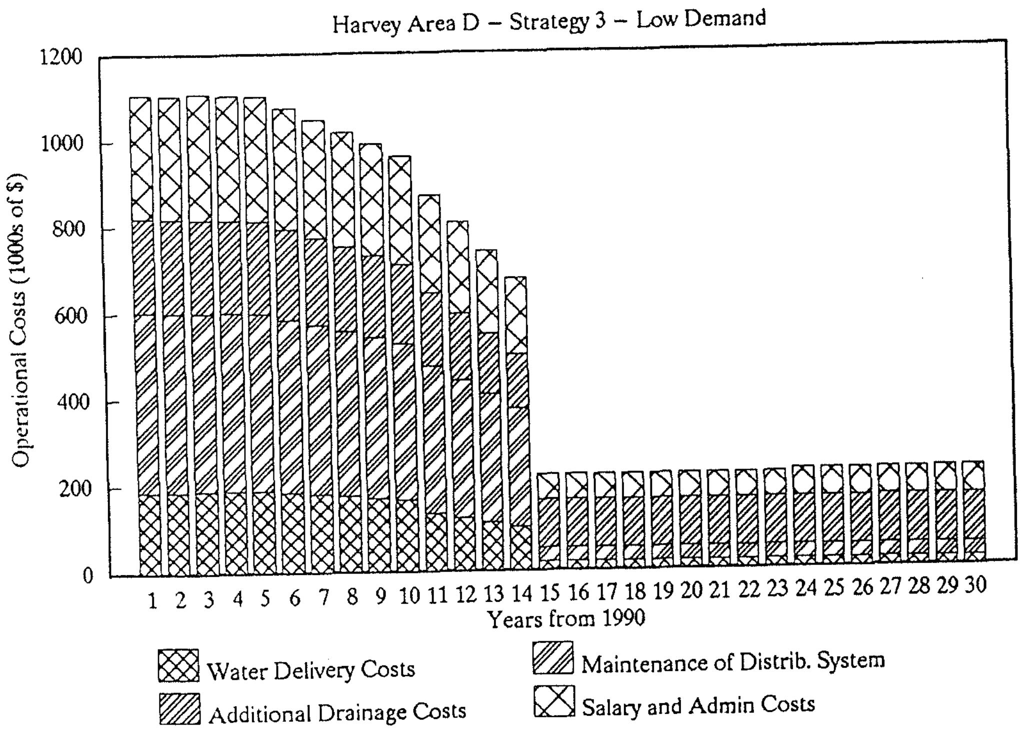


Table 8 Preliminary Cost Estimates for Dam Modification to meet new Australian Standards for Floods and Earthquakes
(Values in $millions)

Year	Dam	District W	H	C	Total
Year 2	Collie River Diversion			0.3	0.03
Year 3					
Year 4	Logue Brook Spillway		2.6		2.6
Year 5	Harvey Weir Re-Tensioning		1.0		
	Waroona Dam (Part Spillway)	2.3			3.3
Year 6	Waroona (Part Spillway & Toe stability)	2.3			2.3
Year 7	Harvey Weir Spillway (epoxy coating)		2.0		2.0
Year 8	Stirling Spillway		0.6		0.6
Year 10	Drakes Brook Spillway	0.3			0.3
Year 20	Re-tensioning of Harvey Weir		1.0		1.0
	Salaries and Administration	0.6	0.6	0.02	1.2
TOTAL		8.2	7.8	0.3	16.3
Net Present Value of Total at 6%		5.5	4.9	0.3	10.7

W - Waroona District
H - Harvey District
C - Collie District

Waroona District requires an expenditure of over $8 million over the next ten years primarily on the Waroona and Samson Dam spillways. This is a substantial cost burden for the Waroona District. The Harvey District requires an expenditure of almost $7 million over 10 years with the Logue Brook Dam Spillway being the most expensive. An additional $1 million is required to retension the Harvey Weir in Year 20, and every subsequent 15 years if it is not replaced. Expenditure on the Collie District is just $0.3 million. No dam safety work is required on the main Wellington Reservoir. These differences between districts are significant and indicate that, if a full partitioned user pays approach to pricing was introduced, different water prices between districts could result.

3.3.3 Summary of Results

Table 10 summarises the Net Present Values for the Capital and Operating Costs of Option A and D for the high and low Demand Scenario for the Harvey District. The other results are summarised in Section 3.5 and examples of the spreadsheets used are included in Attachment 5. The table contrasts the high capital intensive piped system (Strategy 3) and the minimum maintenance of the existing channels (Strategy 1). It also shows the differences in costs between the high and low water demand. The closedown case (CD) is also included.

Further comparisons of options are made in the Phase 2 Options report.

3.4 The Opportunity Cost of Water

Water currently used for irrigation may be able to be used for other economic purposes. In the cost benefit analysis the benefits forgone to the State by not being able to use the water for a higher economic return is a cost against maintaining the irrigation supply.

To determine the opportunity cost of water alternative uses of irrigation water need to be identified. New industrial developments close to the irrigation area are potential competitors for the irrigation water. However, there is over 20 megalitres (10^6 m^3) of water per annum from Wellington Reservoir which could be used to satisfy this demand without competing with the existing irrigation allocation.

In the medium term the only clearly definable competing demand is likely to come from the need for water to service the integrated supply system serving Perth, Mandurah and Goldfields and Agricultural Water Supply (G & AWS) schemes.

Table 9 **Net Present Value of Providing Irrigation Water - Harvey District Strategy 1 and Strategy 3 for Area Options A and D ($millions in 1989/90 dollar terms at a 6% discount rate over 80 years)**

	Area Options, Demand Scenario & Water Charging Policy				
Strategy 1	**A1** High Demand (Current)	**A1** Low Demand (TWE)	**D1** High Demand (Current)	**D1** Low Demand (TWE)	**CD** High Demand (Current)
Capital	12.3	9.3	10.9	9.1	0.4
Operating	19.0	17.0	15.0	14.1	9.0
Total	31.3	26.3	25.9	24.0	9.3

Strategy 3	A3 High Demand (Current)	A3 Low Demand (TWE)	D3 High Demand (Current)	D3 Low Demand (TWE)
Capital	40.0	25.2	19.4	15.1
Operating	14.2	12.5	12.2	11.1
Total	54.2	37.7	31.6	26.2

The cost of supplying this system with reallocated water from irrigation was investigated relative to alternative future source developments. When the cost of using the irrigation water becomes cheaper than any other known source, there is an opportunity cost of irrigation water.

Therefore, estimation of the opportunity cost of irrigation water requires knowledge of the future source options for the integrated Perth, Mandurah and G & AWS system.

Review of previous source planning figures indicated that the sources close to Perth would remain cheaper than redirecting irrigation water to Perth for about 15 years.

A simplified Source Development Spreadsheet (SDS) was developed to estimate the future source development costs for supplying the Perth, Mandurah and G & AWS system to the year 2072.

It was designed to readily vary the available yields from different sources to determine their impact on the overall cost of future water supplies. In this way the effect of different irrigation options could be evaluated.

The available sources in any particular run are ranked from lowest to highest in terms of their cost per kilolitre. The spreadsheet selects the cheapest source available to meet the expected demand growth past the year 2005. When the demand grows beyond the maximum yield of the first source it selects the next cheapest source to contribute to the total system demand. A sequence of sources are thereby selected to meet the demand to the year 2072. The cost in (1990) Net Present Value terms is then calculated. Different future source development costs are calculated for different combinations of available sources.

The engineering cost estimates for each source are based on the capital and operating costs for constructing the new headworks and conveying the water yield to the integrated Perth, Mandurah and G & AWS system. In the case of the irrigation sources the costs of linking up the existing storages to the integrated delivery system was included. In addition an estimate of the cost of purchasing "Water Rights" was included. It was based on the difference in land prices between irrigated and non-irrigated land in the region and assigning that difference to the volume of irrigation water allocated to the irrigated land.

Table 10 gives an example of the spreadsheet for the case when no irrigation water is available to meet future water demands (i.e. Area Option A, Strategy 1 and the current mix of rated and volumetric charges). No water is available from Waroona, Samson, Drakes Brooke or Stirling Dams. The yields from the New Harvey and Wellington and Lower Collie Reservoirs are additional to current irrigation allocations.

The spreadsheets summarises the Net Present Value of flows and costs for the particular run shown and compares this cost with the case where all irrigation water is available. The cost difference, in this case $45.2 million (Table 10), is the opportunity cost for the A1 current rates area approach.

Table 10 Example of Spreadsheet for Costing Future Source Developments - Area Option A, Strategy 1, Current Water Charging Policy

Maintain Irrigation All Areas A1 - all Districts Sources Past 2005	Source Number	Maximum Yield (GL/a)	Cost (c/kl)	Avail. Yield This Run (GL/a)	Year Source is used First	NPV of Costs ($ millions)	% of Total	NPV of Flows NPV of Flows GL	% of Total
Waroona Dam	1	7.9	32.3	0.0	0	0.0	0	0.0	0
Samson & Drakes Brook Dams	2	9.8	35.2	0.0	0	0.0	0	0.0	0
Logue Brook Dam	3	12.0	36.0	0.0	0	0.0	0	0.0	0
Stirling dam	4	39.0	40.3	0.0	0	0.0	0	0.0	0
NW Coastal GW (Excl. Quinns)	5	44.4	44.0	44.4	2005	110.7	35	251.7	39
Karnup GW	6	7.4	43.9	7.4	2012	14.2	4	32.2	5
Dandalup GW	7	10.6	44.3	10.6	2013	18.9	6	42.6	7
Jane Brook P/H	8	9.4	48.0	9.4	2015	16.5	5	34.4	5
Beernullah GW	9	7.6	49.2	7.6	2016	12.7	4	25.9	4
New Harvey Dam	10	57.0	51.0	40.0	2017	56.0	18	109.9	17
Wellesley PB	11	12.0	57.0	12.0	2024	14 .2	5	25.0	4
Brunswick R - Olive H	12	40.0	57.0	40.0	2026	35.4	11	62.0	10
Red Gully GW	13	7.0	56.5	7.0	2033	4.7	1	8.3	1
Victoria Plains	14	19.0	59.4	19.0	2035	11.0	3	18.6	3
Wellington Dam & Lower Collie	15	115.0	60.0	47.0	2039	15.4	5	25.7	4
Sussanah Brook P/H	16	3.4	61.0	3.4	2053	0.6	0	10.0	0
Breton Bay stage 1	17	13.2	63.5	13.2	2054	2.0	1	3.1	0
Breton Bay Stage II	18	16.6	63.1	16.6	2057	1.7	1	2.8	0
Wedge Is. Stage I	19	15.7	71.4	15.7	2061	1.2	0	1.6	0
Wedge Is. Stage II	20	21.0	72.2	21.0	2065	0.7	0	1.0	0
Preston PH	21	27.0	75.0	27.0	2070	0.1	0	0.1	0
Agaton	22	30.3	80.9	30.3	2073	0.0	0	0.0	0
Ferguson	23	16.0	82.0	16.0	2073	0.0	0	0.0	0
Eneaba	24	27.9	95.7	27.9	2073	0.0	0	0.0	0
Dandaragon	25	28.1	98.7	28.1	2073	0.0	0	0.0	0
Busselton GW	26	36.0	105.0	36.0	2073	0.0	0	0.0	0
Totals		633.3				316.1		646	

	NPV of Flow Demand	NPV of Flows (GL)	NPV of Costs ($ million)	c/kl
Costs with all Irrigation Water Available	646	646	270.9	41.9
** Costs for this Run **	646	646	316.1	48.9
MAINTAIN IRRIGATION ALL AREAS				
Cost for this run relative to complete closure of irrigation	0	0	45.2	7.0

The spreadsheet also shows the year in which each source is first used. Under the run shown the currently uncommitted water of the Wellington and New Lower Collie Reservoirs are not used until 2039 and not fully committed until 2053. Consequently water currently used for irrigation in the Collie District would not become a cheaper source until 2053. It's opportunity cost is therefore very small or zero in most cases. Therefore future source developments were only calculated for various combination of Waroona and Harvey District Options, given that no water was available from the Collie District.

Table 11 shows the volumes of water available from existing and potential sources in the Irrigation District regions for selected options. These figures formed the inputs to the future Source Development Spreadsheet to estimate the opportunity costs for the different options.

The results for Strategy 1 and the Current (Fixed Allocation) Water Charging Policy Options and Strategy 3 with a TWE market operating are shown in Tables 12 and 13.

Table 11 Water Volumes Available for use other than Irrigation from Existing and Potential Sources in 15 years time (millions of cubic metres per annum)

Source	Irrigation Options					
	Strategy 1 - High Water Demand - Current Water Charging Policy					
Area Option	A	B	C	D	E	Close Down
Waroona Reservoir	0.00	3.2	5.5	7.9	7.9	7.9
Sampson & Drakes Brook Reservoirs	0.0	0.0	0.0	5.6	5.6	9.8
Logue Brook Reservoir	0.0	12.0	12.0	12.0	12.0	12.0
Stirling Reservoir	0.0	0.0	6.4	11.8	33.4	39.0
Existing/New Harvey Reservoir	40.0	40.0	40.0	40.0	40.1	57.0
Wellington & New Lower Collie Reservoirs	47.0	53.2	67.1	67.1	67.1	115.0
	Strategy 2 - Low Water Demand with a TWE Market					
	A	B	C	D	E	Close Down
Waroona Reservoir	7.90	7.90	7.90	7.9	7.9	7.9
Sampson & Drakes Brook Reservoirs	0.9	0.9	0.9	6.3	6.3	9.8
Logue Brook Reservoir	12.0	12.0	12.0	12.0	12.0	12.0
Stirling Reservoir	27.0	27.0	27.0	27.0	27.0	27.0
Existing/New Harvey Reservoir	40.0	40.0	40.0	40.0	40.0	40.0
Wellington & New Lower Collie Reservoirs	82.3	82.3	82.3	82.3	82.3	82.3
	Strategy 3 - Low Water Demand with a TWE Market					
	A	B	C	D	H	P
Waroona Reservoir	7.9	7.9	7.9	7.9	6.93	7.9
Sampson Brook & Drakes Brook Reservoir	5.5	5.5	5.5	6.8	0.0	9.80
Logue Brooke Reservoir	12.0	12.0	12.0	12.0	12.0	12.0
Stirling Reservoir	39.0	39.0	39.0	39.0	30.8	39.0
Existing/New Harvey Dam	40.0	40.0	40.0	40.0	40.0	45.5
Wellington & New Lower Collie Reservoirs	94.4	94.4	94.4	94.4	115.0	115.0

Table 12 Opportunity Cost Values for Strategy 1 High Demand Cases with Fixed Rated Areas and with the Current Water Charging Policy ($millions in 1989/90 dollar terms at a 6% discount rate over 80 years)

Opportunity Costs for the combinations shown given Collie District Option A

Waroona District Options		A	B	C	D	E	Close Down
Harvey District Option	A	45.2	41.2	38.8	30.3	30.3	26.5
Harvey District Option	B		30.3	26.6	20.5	20.5	17.1
Harvey District Option	C			24.1	17.2	17.5	14.0
Harvey District Option	D				14.6	14.6	11.4
Harvey District Option	E					5.4	2.7
Harvey District Option	P						0.7
Harvey District Option	Close						0

Final Opportunity Cost Values for Irrigation Districts & Options

Options	Waroona	Harvey	Collie	Total
A	18.7	26.5	0.0	45.2
B	13.2	17.1	0.0	30.3
C	10.1	14.0	0.0	24.1
D	3.2	11.4	0.0	14.6
E	2.7	2.7	0.0	5.4
P	0.0	0.7	0.0	0.7
Close	0.0	0.0	0.0	0.0

Table 13 Opportunity Cost Values for Strategy 3 Options, Low Water Demand and with a TWE Market Operating ($millions in 1989/90 dollar terms at a 6% discount rate over 80 years)

Opportunity Costs for the Combinations shown given Collie District Option A

Waroona District Options		A	B	C	D	E	Close Down
Harvey District Option	A	3.7	3.7	3.7	2.9	8.2	1.0
Harvey District Option A	B		3.7	3.7	2.9	8.2	1.0
Harvey District Option A	C			3.7	2.9	8.2	1.0
Harvey District Option A	D				2.9	5.8	1.0
Harvey District Option A	H					11.2	3.8
Harvey District Option A	P						0.7
Harvey District Option A	Close						0

Final Opportunity Cost Values for Irrigation Districts & Options

Options	Waroona	Harvey	Collie	Total
A	2.7	1.0	0.0	3.7
B	2.7	1.0	0.0	3.7
C	2.7	1.0	0.0	3.7
D	1.9	1.0	0.0	2.9
H	7.4	3.8	0.0	11.2
P	0.0	0.7	0.0	0.7
Close	0.0	0.0	0.0	0.0

Table 12 shows the high opportunity cost of Waroona District Water ($18.7 million) in the Area Option A High Demand - Fixed Rated Area case. Per Cubic metre of water, the Waroona Opportunity Cost is about 2.7 higher than Harvey District. This is because of the relative closeness to Perth of the Waroona District Storages. The opportunity cost reduces as less water is committed to irrigation in the smaller Area Option cases.

Table 13 shows much lower opportunity costs than Table 12 as much smaller volumes of water are used for irrigation in the Strategy 3, Low Demand and with a TWE Market Operating.

All other options have opportunity costs values that fall between these extremes.

As the volume of water committed to irrigation decreases, the proportion of the headworks capital to be charged to irrigation also decreases. The cost for the dam safety upgrades must be funded, however. Therefore, the costs not incurred by irrigators should be included as an additional cost on future metropolitan source developments. This was included as a second component to the calculation of the opportunity cost.

Table 14 summarises these additional costs for the Strategy 1, High Water Demand case with both the Current Fixed Rated Policy and with a TWE Market Operating. Also shown is the Strategy 3, Low Water Demand case with a TWE Market Operating.

The table shows that the headworks costs to future metro consumers increase as the area served and volumes committed to irrigation decrease.

Table 14 Additional Metropolitan Source Costs ($ millions)

(a)	Strategy 1 High Demand Fixed Rating			Strategy 1 Low Demand With TWEs			Strategy 3 Low Demand With TWEs		
Options	W	H	C	W	H	C	W	H	C
A	0.0	0.0	0.0	1.77	2.43	0.1	3.2	3.0	0.3
B	0.6	0.8	0.0	1.77	2.43	0.1	3.3	3.0	0.3
C	1.4	1.2	0.0	1.77	2.43	0.1	3.3	3.0	0.3
D	3.8	1.6	0.0	3.88	2.43	0.1	3.8	3.0	0.3
E	3.8	3.1	0.0	3.88	3.1	0.0	-	-	-
H	1.3	2.4	0.3	-	-	-	-	-	-
P	5.9	3.5	0.3	-	-	-	-	-	-
Closedown	5.9	5.3	0.3	-	-	-	-	-	-

N.B. W - Waroona
H - Harvey
C - Collie

3.5 Areas Irrigated and Water Volumes Used

Table 15 summarises the areas irrigated and the water volumes allocated and supplied from the reservoir in Year 20, for all the options studied.

This year was taken as being a typical year following restructuring of the districts to achieve the particular option under evaluation.

Important points to note from the table are:

- the demand for irrigation land is only constrained by the size of the district in low demand Area Option D and E cases. That is, in the low demand scenarios all irrigation land can be provided in the relatively high productive (eastern portion) of the district.

- water volumes required to satisfy the area irrigated are well below the volumes allocated in the low demand cases. If fixed rating systems apply past the period of restructuring (15 years) then water would not be available for alternative uses. These effects are incorporated in the economic analysis through the opportunity cost estimates described in Section 3.4.

Under a low water demand scenario a service based on the high productive soils in the eastern region of the Irrigation Area would cover about 57% of the current area irrigated and use about 480% of the current water allocation (Area Option C Low Demand Strategy 1).

If the area was further reduced in size to minimise nutrient discharge to the Peel-Harvey Estuary, then the area irrigated would reduce to about 43% and use about 35% of the current water allocation (Area Option E Low Demand Strategy 1)

Table 15 Areas Irrigated and Volumes of Water Supplied at Year 20

AREA OPTION & WATER DEMAND SCENARIO	AREA SERVED		ACTUAL AREA IRRIGATED (PERMANENT PASTURES)				WATER VOLUMES ALLOCATED AND USED							
			Strategy 1 & 2		Strategy 3		Fixed Volume Allocated Strategy 1		Volumes Supplied From Reservoirs: Strategy 1		Strategy 2		Strategy 3	
	ha	% of Option A	ha	% of 89/90 Year	ha	% of 89/90 Year	(GLs)	% of Current Alloc.	(GLs)	% of Current Alloc.	(GLs)	% of Current Alloc.	(GLs)	% of Current Alloc.
Waroone District														
A High	1526	100%	1446	107%	1446	107%	16.6	100%	16.6	100%	14.9	90%	14.2	85%
A Low	1526	100%	950	70%	547	41%	16.6	100%	9.8	59%	8.9	54%	4.4	26%
B High	1331	87%	1331	99%	1331	99%	14.5	87%	14.5	87%	13.1	79%	12.4	75%
B Low	1331	87%	950	70%	529	39%	14.5	87%	9.8	59%	8.9	54%	4.2	25%
C High	1119	73%	1119	83%	1119	83%	12.2	73%	12.2	73%	11.0	66%	10.4	63%
C Low	1119	73%	950	70%	529	39%	12.2	73%	11.0	66%	10.0	60%	4.2	25%
D High	385	25%	385	29%	385	29%	4.2	25%	4.2	25%	3.8	23%	3.6	22%
D Low	385	25%	385	29%	385	29%	4.2	25%	3.9	23%	3.6	22%	3.1	19%
E High	385	25%	385	29%	-	-	4.2	25%	4.2	25%	3.8	23%	-	-
E Low	385	25%	385	29%	-	-	4.2	25%	3.9	23%	3.6	22%	-	-
H	1135	74%	-	-	1135	84%	10.7	64%	-	0%	-	0%	10.7	64%
P														
Harvey District														
A High	5820	100%	4716	103%	4653	102%	67.6	100%	67.5	100%	60.8	90%	51.5	76%
A Low	5820	100%	2750	60%	1921	42%	67.6	100%	32.6	48%	29.8	44%	15.8	23%
B High	4744	82%	4744	104%	4622	101%	55.5	82%	55.5	82%	50.0	74%	42.3	63%
B Low	4744	82%	2749	60%	1921	42%	55.5	82%	32.6	48%	29.8	44%	15.8	23%
C High	4223	73%	4223	92%	4223	92%	49.6	73%	49.6	73%	44.6	66%	33.7	50%
C Low	4223	73%	2750	60%	1921	42%	49.6	73%	32.6	48%	29.8	44%	15.8	23%
D High	3751	64%	3751	82%	3751	82%	44.2	65%	49.6	73%	44.6	66%	33.7	50%
D Low	3751	64%	2750	60%	1921	42%	44.2	65%	32.6	48%	29.8	44%	15.8	23%
E High	1889	32%	1889	41%	-	-	22.2	33%	22.2	33%	20.0	30%	-	-
E Low	1889	32%	1889	41%	-	-	22.2	33%	21.9	32%	20.0	30%	-	-
H	2661	46%	-	0%	2661	58%	-	-	-	-	-	0%	24.8	37%
P	1259	22%	-	0%	1259	27%	-	-	-	-	-	0%	10.8	16%
Collie District														
A High	5132	100%	4169	99%	4169	99%	61.1	100%	61.1	100%	55.0	90%	47.2	77%
A Low	5132	100%	2090	50%	1460	35%	61.1	100%	26.0	43%	23.7	39%	13.5	22%
B High	4663	91%	4169	99%	4169	99%	55.5	91%	55.5	91%	50.0	82%	42.9	70%
B Low	4663	91%	2090	50%	1512	36%	55.5	91%	26.0	43%	23.7	39%	13.6	22%
C High	3613	70%	3613	86%	3614	86%	43.1	71%	43.1	71%	38.8	64%	33.2	54%
C Low	3613	70%	2090	50%	1548	37%	43.1	71%	26.0	43%	23.7	39%	13.6	22%
D High	3613	70%	3613	86%	3614	86%	43.1	71%	43.1	71%	38.8	64%	33.2	54%
D Low	3613	70%	2090	50%	1548	37%	43.1	71%	26.0	43%	23.7	39%	13.6	22%
E High	3613	70%	3613	86%	-	-	43.1	71%	43.1	71%	38.8	64%	-	-
E Low	3613	70%	2090	50%	-	-	43.1	71%	26.0	43%	23.7	39%	-	-
H														
P														
Total of Districts														
A High	12478	100%	10331	102%	10268	101%	145.3	100%	145.2	100%	130.7	90%	112.9	78%
A Low	12478	100%	5790	57%	3928	39%	145.3	100%	68.4	47%	62.4	43%	33.7	23%
B High	10738	86%	10244	101%	10122	100%	125.5	86%	125.5	86%	113.1	78%	97.6	67%
B Low	10738	86%	5789	57%	3962	39%	125.5	86%	68.4	47%	62.4	43%	33.6	23%
C High	8954	72%	8955	88%	8956	88%	104.8	72%	104.9	72%	94.4	65%	77.3	53%
C Low	8954	72%	5790	57%	3998	39%	104.8	72%	69.6	48%	63.5	44%	33.6	23%
D High	7749	62%	7749	76%	7750	76%	91.5	63%	96.9	67%	87.2	60%	70.5	49%
D Low	7749	62%	5225	52%	3854	38%	91.5	63%	62.5	43%	57.1	39%	32.5	22%
E High	5887	47%	5887	58%	0	0%	69.4	48%	69.5	48%	62.6	43%	0.0	0%
E Low	5887	47%	4364	43%	0	0%	69.4	48%	51.8	36%	47.3	33%	0.0	0%
H	3796	30%	0	0%	3796	37%	10.7	7%	0.0	0%	0.0	0%	35.5	24%
P	1259	10%	0	0%	1259	12%	0.0	0%	0.0	0%	0.0	0%	10.8	7%

3.6 Overall Benefit/Cost Results

The tables in Section 3.6 summarise the results of the overall economic analyses conducted for the 45 options evaluated in Phase 2.

The tables show the results for the total South-West Irrigation Area and for each of the Waroona, Harvey and Collie Districts.

Each option in the Tables 16 to 19 is described by 4 factors.

e.g.	A2L TWE	A	designates the Area to be irrigated
		2	designates the On-farm Irrigation Practice and Engineering Scheme Strategy for salinity mitigation (Strategies 1, 2 or 3)
		L	designates the water demand scenario, in this case the low demand scenario (H for high, or L for low)
		TWE	designates the applicable water charging policy adopted. In this case the introduction of TWEs and a volumetric charge per megalitre (Current or TWE).

Values in these tables are expressed in net present values (NPV's) and in;

- millions of dollars;
- 1989/90 dollar values terms;
- with a discount rate of 6 per cent; and,
- measured over 80 years.

3.6.1 Explanation of Terms Used in Results Summary

Agricultural Benefits

Net Agricultural Returns (NAR)

- this is the sum of the value of agricultural output from permanent irrigated land, early germinated annual pasture and dryland for the designated option less the variable costs (excluding water costs), and the additional overhead costs needed to obtain that output.
- the NAR represents the amount available to pay water costs, service farm capital costs and provide a return on capital invested.

Extra on farm stock water costs due to reduction in the irrigation service

- covers the cost of providing stock water to paddocks and to dairy sheds previously serviced from irrigation channels.

Net Agricultural Benefit - net agricultural return less extra on-farm costs of providing stock water.

Net Agricultural Benefit Relative to Close Down - the net agricultural benefit of the option less the net agricultural benefit of the Close Down option.

Water Costs

- Headworks

  Operating Costs - the operating costs of maintaining and rehabilitating the dams and dam offtakes.

  Capital Costs - the capital costs of dam upgrades and maintenance. This mainly involves works to ensure the ongoing safety of the dams.

- Distribution Costs - all costs associated with the maintenance and rehabilitation of the channels and water control structures up to and including metering devices (Dethridge Wheels) onto farms. There are also divided into capital and operating costs.

- Close Down Costs - costs to the Water Authority if parts of the distribution system are closed down. These mainly include staff redundancy costs and costs associated with the removal of water control structures, bridges and the filling in of dangerous channels.

Opportunity Costs

- Costs to Metro Consumers - this represents the additional costs to metropolitan consumers of not being able to use water from irrigation storages when it becomes the cheapest water to use for Perth, Mandurah and the Goldfields Water Supply Scheme.

  - the opportunity cost falls as the area irrigated shrinks reflecting that the irrigaiton water that is no longer needed is freed up and available for metropolitan consumption.

- Contribution of metro consumers to headworks - this is an offset amount against the opportunity cost of water and represents the share of the headworks cost the metropolitan consumers would have to pay if water used for irrigation was to be made available for metropolitan consumption.

Net Benefit to the State - The net agricultural benefits less water costs and less opportunity costs.

Net Benefit Relative to Close Down - The net benefit to the State of the option less the net benefit to the State of the Close Down Option.

Table 16

TOTAL COST BENEFIT

ECONOMIC ANALYSIS

(All units $million unless specified)

SCENARIO	A1 H	A2H	A3H	A1L	A1L	A2L	A2L	A3L	A3L
Water Charging Policy	Current	Current	Current	Current	TWE's	Current	TWE's	Current	TWE's
NET AGRICULTURAL RETURNS	103.4	106.3	107.3	97.5	97.5	100.4	100.4	99.0	99.0
Extra on farm stock water costs due to reduction in irrigation service									
NET AGRICULTURAL BENEFIT	103.4	106.3	107.3	97.5	97.5	100.4	100.4	99.0	99.0
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	35.9	38.9	39.8	30.0	30.0	32.9	32.9	31.5	31.5
WATER COSTS									
Headworks	1.0	1.0	1.0	0.7	0.4	1.0	0.4	1.0	0.6
Operating costs	10.5	10.5	10.7	10.5	6.5	10.5	6.5	10.7	4.8
Capital costs	11.5	11.5	11.7	11.1	6.9	11.5	6.9	11.7	5.3
Distribution									
Operating costs	36.1	36.1	30.7	31.9	32.5	31.9	32.5	25.4	25.8
Capital costs	15.4	15.4	77.3	14.5	13.8	14.5	13.8	77.2	51.2
Total distribution costs	51.5	51.5	108.0	46.4	46.3	46.4	46.3	102.6	77.1
Close down costs									
TOTAL WATER COSTS	63.0	63.0	119.7	57.6	53.2	57.9	53.2	114.3	82.4
AG. BENEFITS LESS WATER COSTS	40.4	43.3	-12.4	39.9	44.3	42.5	47.2	-15.3	16.6
OPPORTUNITY COST (Includes $11.55m spillway cost)									
Contribution of metro consumers to headworks	-11.6	-11.6	-11.6	-11.6	-7.2	-11.6	-7.2	-11.6	-5.0
Cost to metro consumers	45.2	35.1	27.2	45.2	13.2	35.1	11.3	27.2	3.7
TOTAL OPPORTUNITY COST	33.7	23.6	15.7	33.7	6.0	23.6	4.1	15.7	-1.3
NET BENEFIT TO THE STATE	6.8	19.8	-28.1	6.3	38.4	19.0	43.1	-31.0	17.9
NET BENEFIT RELATIVE TO CLOSE DOWN	-40.0	-26.9	-74.8	-40.4	-8.4	-27.8	-3.6	-77.7	-28.8

SCENARIO	B1H	B2H	B3H	B1L	B1L	B2L	B2L	B3L	B3L
Water Charging Policy	Current	Current	Current	Current	TWE's	Current	TWE's	Current	TWE's
NET AGRICULTURAL RETURNS	103.2	106.6	108.6	97.5	97.5	100.4	100.4	99.1	99.1
Extra on farm stock water costs due to reduction in irrigation service	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36	0.36
NET AGRICULTURAL BENEFIT	102.9	106.2	108.2	97.2	97.2	100	100	98.7	98.7
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	35.4	38.7	40.7	29.7	29.7	32.6	32.6	31.2	31.2
WATER COSTS									
Headworks	0.9	0.9	0.9	0.9	0.4	0.9	0.4	0.9	0.5
Operating costs	9.1	9.1	9.3	9.1	6.5	9.1	6.5	9.3	4.7
Capital costs	10.1	10.1	10.2	10.1	6.9	10.1	6.9	10.2	5.2
Distribution									
Operating costs	33.8	33.8	29.4	30.3	30.9	30.3	30.9	25.2	25.6
Capital costs	14.6	14.6	55.7	13.9	13.5	13.9	13.5	55.6	38.9
Total distribution costs	48.4	48.4	85.1	44.2	44.3	44.2	44.3	80.8	64.5
Close down costs	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
TOTAL WATER COSTS	58.8	58.8	95.7	54.6	51.6	54.6	51.6	91.4	70.1
AG. BENEFITS LESS WATER COSTS	44.1	47.4	12.5	42.6	45.6	45.5	48.5	7.3	28.6
OPPORTUNITY COST (Includes $11.55m spillway cost)									
Contribution of metro consumers to headworks	-10.1	-10.1	-10.0	-10.2	-7.2	-10.2	-7.2	-10.1	-5.0
Cost to metro consumers	30.3	25.3	20.5	30.3	13.2	25.6	11.3	20.5	3.7
TOTAL OPPORTUNITY COST	20.2	15.2	10.5	20.2	6.0	15.5	4.1	10.5	-1.3
NET BENEFIT TO THE STATE	23.9	32.2	2.1	22.4	39.6	30.0	44.4	-3.1	29.9
NET BENEFIT RELATIVE TO CLOSE DOWN	-22.8	-14.5	-44.7	-24.3	-7.1	-16.7	-2.3	-49.8	-16.8

SCENARIO	C1 H	C2H	C3H	C1L	C1L	C2L	C2L	C3L	C3L
Water Charging Policy	Current	Current	Current	Current	TWE's	Current	TWE's	Current	TWE's
NET AGRICULTURAL RETURNS	101.3	104.7	106.4	97.5	97.5	100.4	100.4	99.1	99.1
Extra on farm stock water costs due to reduction in irrigation service	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75
NET AGRICULTURAL BENEFIT	100.5	104	105.7	96.8	96.8	99.7	99.7	98.3	98.3
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	33.0	36.5	38.2	29.3	29.3	32.2	32.2	30.8	30.8
WATER COSTS									
Headworks	0.8	0.8	0.8	0.8	0.3	0.8	0.3	0.8	0.5
Operating costs	8.1	8.1	8.2	8.1	6.5	8.1	6.5	8.2	4.7
Capital costs	8.9	8.9	9.0	8.9	6.9	8.9	6.9	9.0	5.2
Distribution									
Operating costs	31.0	31.0	25.8	28.2	28.7	28.2	28.7	22.8	23.1
Capital costs	13.5	13.5	44.2	13.1	12.9	13.1	12.9	44.1	32.8
Total distribution costs	44.5	44.5	70.0	41.3	41.5	41.3	41.5	66.9	55.9
Close down costs	0.56	0.56	0.56	0.56	0.56	0.56	0.56	0.57	0.57
TOTAL WATER COSTS	54.0	54.0	79.6	50.8	49.0	50.8	49.0	76.5	61.7
AG. BENEFITS LESS WATER COSTS	46.6	50.0	26.1	46.0	47.8	48.9	50.7	21.9	36.7
OPPORTUNITY COST (Includes $11.55m spillway cost)									
Contribution of metro consumers to headworks	-8.9	-8.9	-8.8	-9.0	-7.2	-9.0	-7.2	-8.8	-5.0
Cost to metro consumers	24.1	20.3	16.4	24.1	13.2	20.3	11.3	16.4	3.7
TOTAL OPPORTUNITY COST	15.2	11.4	7.6	15.2	6.0	11.4	4.1	7.6	-1.3
NET BENEFIT TO THE STATE	31.4	38.6	18.6	30.9	41.8	37.5	46.6	14.3	37.9
NET BENEFIT RELATIVE TO CLOSE DOWN	-15.4	-8.1	-28.2	-15.9	-4.9	-9.2	-0.1	-32.5	-8.8

SCENARIO	D1 H	D2H	D3H	D1L	D1L	D2L	D2L	D3L	D3L
Water Charging Policy	Current	Current	Current	Current	TWE's	Current	TWE's	Current	TWE's
AGRICULTURAL BENEFITS									
NET AGRICULTURAL RETURNS	99.3	102.7	104.5	97.4	97.4	100.3	100.3	99.1	99.1
Extra on farm stock water costs due to reduction in irrigation service	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
NET AGRICULTURAL BENEFIT	98.4	101.7	103.6	96.4	96.4	99.3	99.3	98.2	98.2
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	30.9	34.2	36.1	28.9	28.9	31.8	31.8	30.7	30.7
WATER COSTS									
Headworks									
Operating costs	0.8	0.8	0.8	0.8	0.3	0.8	0.3	0.8	0.5
Capital costs	5.5	5.5	5.6	5.5	4.7	5.5	4.7	5.6	4.2
Total headworks	6.3	6.3	6.4	6.3	5.1	6.3	5.1	6.4	4.7
Distribution									
Operating costs	29.0	29.0	24.2	27.0	27.4	27.0	27.3	21.8	22.1
Capital costs	13.9	13.9	35.9	13.7	13.5	13.7	13.5	36.1	28.6
Total distribution costs	42.8	42.8	60.1	40.6	40.8	40.6	40.8	57.9	50.7
Close down costs	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
TOTAL WATER COSTS	49.8	49.8	67.1	47.6	46.6	47.6	46.5	64.9	56.0
AG. BENEFITS LESS WATER COSTS	48.6	5.0	36.5	48.9	49.9	51.8	52.9	33.3	42.2
OPPORTUNITY COST (Includes $11.55m spillway cost)									
Contribution of metro consumers to headworks	-6.2	-6.2	-6.0	-6.2	-5.2	-6.2	-5.2	-6.0	-4.4
Cost to metro consumers	14.6	12.3	9.1	14.6	9.0	12.3	7.5	9.1	2.9
TOTAL OPPORTUNITY COST	8.4	6.1	3.1	8.5	3.9	6.2	2.4	3.1	-1.5
NET BENEFIT TO THE STATE	40.2	45.8	33.4	40.4	46.0	45.6	50.5	30.2	43.7
NET BENEFIT RELATIVE TO CLOSE DOWN	-6.6	-0.9	-13.3	-6.3	-0.7	-1.1	3.8	-16.5	-3.0

SCENARIO	E1 H	E2H	E1L	E1L	E2L	E2L	H	P	Close down
Water Charging Policy	Current	Current	Current	TWE's	Current	TWE's	TWE's	Current	Current
AGRICULTURAL BENEFITS									
NET AGRICULTURAL RETURNS	96.1	99.1	95.7	95.7	98.5	98.5	102.6	85.5	70.2
Extra on farm stock water costs due to reduction in irrigation service	1.33	1.33	1.33	1.33	1.33	1.33	2.06	2.41	2.69
NET AGRICULTURAL BENEFIT	94.7	97.8	94.3	94.3	97.2	97.2	100.5	83.1	67.5
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	27.2	30.3	26.8	26.8	29.7	29.7	33.0	15.6	
WATER COSTS									
Headworks									
Operating costs	0.7	0.7	0.7	0.3	0.7	0.3	0.3	0.5	0.5
Capital costs	4.2	4.2	4.2	4.1	4.2	4.1	6.7	1.6	
Total headworks	4.8	4.8	4.8	4.5	4.8	4.5	7.0	2.1	0.5
Distribution									
Operating costs	27.2	27.2	25.5	25.9	25.5	25.8	19.0	17.8	17.1
Capital costs	11.8	11.8	11.6	11.6	11.6	11.6	8.9	2.1	1.9
Total distribution costs	39.0	39.0	37.1	37.4	37.1	37.4	27.9	19.8	19.0
Close down costs	0.79	0.79	0.79	0.79	0.79	0.79	1.14	1.29	1.37
TOTAL WATER COSTS	44.6	44.6	42.7	42.7	42.7	42.6	36.0	23.3	20.8
AG. BENEFITS LESS WATER COSTS	50.1	53.2	51.6	51.6	54.5	54.6	64.5	59.8	46.7
OPPORTUNITY COST (Includes $11.55m spillway cost)									
Contribution of metro consumers to headworks	-4.7	-4.7	-4.7	-4.5	-4.7	-4.5	-7.5	-1.8	
Cost to metro consumers	5.4	4.3	5.4	5.1	4.3	4.1	11.1	0.7	
TOTAL OPPORTUNITY COST	0.8	-0.4	0.8	0.6	-0.4	-0.4	3.6	-1.1	
NET BENEFIT TO THE STATE	49.4	53.5	50.9	51.0	54.8	55.0	60.9	60.9	46.7
NET BENEFIT RELATIVE TO CLOSE DOWN	2.7	6.8	4.2	4.3	8.1	8.2	14.2	14.2	

NPV @ 6% over 80 years: Units $ million (1989/90): 15 June 1992

COLLIE COST BENEFIT

Table 17

ECONOMIC ANALYSIS

(All units $million unless specified)

SCENARIO	A1 H	A2H	A3H	A1L	A1L	A2L	A2L	A3L	A3L	B1H	B2H	B3H	B1L	B1L	B2L	B2L	B3L	B3L
Water Charging Policy	Current	Current	Current	Current	TWE's	Current	TWE's	Current	TWE's	Current	Current	Current	Current	TWE's	Current	TWE's	Current	TWE's
NET AGRICULTURAL RETURNS	40.1	41.5	42.1	37.2	37.2	38.5	38.5	38.3	38.3	40.2	41.7	42.8	37.2	37.2	38.5	38.5	38.4	38.4
Extra on farm stock water costs due to reduction in irrigation service										0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
NET AGRICULTURAL BENEFIT	40.1	41.5	42.1	37.2	37.2	38.5	38.5	38.3	38.3	40.1	41.6	42.6	37.1	37.1	38.4	38.4	38.3	38.3
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	11.5	12.9	13.5	8.7	8.7	9.9	9.9	9.8	9.8	11.5	13	14.1	8.5	8.5	9.8	9.8	9.7	9.7
WATER COSTS																		
Headworks	0.3	0.3	0.3	0.3	0.1	0.3	0.1	0.3	0.2	0.3	0.3	0.3	0.3	0.1	0.3	0.1	0.3	0.2
Operating costs	0.4	0.4	0.6	0.4	0.2	0.4	0.2	0.6	0.2	0.4	0.4	0.5	0.4	0.2	0.4	0.2	0.5	0.2
Capital costs	0.7	0.7	0.9	0.7	0.4	0.7	0.4	0.9	0.4	0.7	0.7	0.9	0.7	0.4	0.7	0.4	0.9	0.4
Distribution																		
Operating costs	13.7	13.7	11.0	12.1	12.3	12.1	12.3	9.5	9.6	12.9	12.9	10.3	11.4	11.6	11.4	11.6	8.9	9.0
Capital costs	4.8	4.8	30.0	4.4	4.4	4.4	4.4	29.9	20.0	4.6	4.6	22.9	4.2	4.3	4.2	4.3	22.8	15.9
Total distribution costs	18.5	18.5	41.0	16.5	16.6	16.5	16.6	39.4	29.6	17.5	17.5	33.1	15.6	15.8	15.6	15.8	31.6	24.9
Close down costs										0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
TOTAL WATER COSTS	19.2	19.2	41.9	17.2	17.0	17.2	17.0	40.3	30.0	18.3	18.3	34.1	16.4	16.3	16.4	16.3	32.6	25.4
AG. BENEFITS LESS WATER COSTS	20.9	22.3	0.2	20.0	20.2	21.3	21.5	-2.0	8.3	21.9	23.3	8.6	20.8	20.9	22.1	22.2	5.8	13.0
OPPORTUNITY COST (Includes $0.29m spillway cost)																		
Contribution of metro consumers to headworks	-0.29	-0.29	-0.29	-0.29	-0.18	-0.29	-0.18	-0.29	0.02	-0.29	-0.29	-0.25	-0.29	-0.18	-0.29	-0.18	-0.25	0.02
Cost to metro consumers																		
TOTAL OPPORTUNITY COST	-0.3	-0.3	-0.3	-0.3	-0.2	-0.3	-0.2	-0.3	0.0	-0.3	-0.3	-0.3	-0.3	-0.2	-0.3	-0.2	-0.3	0.0
NET BENEFIT TO THE STATE	21.2	22.5	0.5	20.3	20.4	21.6	21.7	-1.7	8.3	22.2	23.6	8.8	21.1	21.0	22.3	22.3	6.0	12.9
NET BENEFIT RELATIVE TO CLOSE DOWN	0.8	2.2	-19.9	-0.1	0.0	1.2	1.3	-22.1	-12.1	1.8	3.2	-11.6	0.7	0.7	1.9	1.9	-14.4	-7.5

SCENARIO	C1 H	C2H	C3H	C1L	C1L	C2L	C2L	C3L	C3L
Water Charging Policy	Current	Current	Current	Current	TWE's	Current	TWE's	Current	TWE's
NET AGRICULTURAL RETURNS	39.2	40.7	41.6	37.2	37.2	38.5	38.5	38.4	38.4
Extra on farm stock water costs due to reduction in irrigation service	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38
NET AGRICULTURAL BENEFIT	38.8	40.3	41.2	36.9	36.9	38.1	38.1	38.0	38.0
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	10.2	11.8	12.6	8.3	8.3	9.6	9.6	9.5	9.5
WATER COSTS									
Headworks	0.3	0.3	0.3	0.3	0.1	0.3	0.1	0.3	0.2
Operating costs	0.3	0.3	0.4	0.3	0.2	0.3	0.2	0.4	0.2
Capital costs	0.6	0.6	0.7	0.6	0.4	0.6	0.4	0.7	0.4
Distribution									
Operating costs	11.5	11.5	9.6	10.4	10.6	10.4	10.6	8.5	8.6
Capital costs	4.2	4.2	16.6	4.0	4.0	4.0	4.0	16.5	12.5
Total distribution costs	15.7	15.7	26.2	14.4	14.6	14.4	14.6	25	21.1
Close down costs	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
TOTAL WATER COSTS	16.5	16.5	27.1	15.2	15.1	15.2	15.1	25.9	21.7
AG. BENEFITS LESS WATER COSTS	22.3	23.9	14.1	21.7	21.8	23	23.1	12.2	16.4
OPPORTUNITY COST (Includes $0.29m spillway cost)									
Contribution of metro consumers to headworks	-0.29	-0.29	-0.16	-0.29	-0.18	-0.29	-0.18	-0.16	0.02
Cost to metro consumers									
TOTAL OPPORTUNITY COST	-0.3	-0.3	-0.2	-0.3	-0.2	-0.3	-0.2	-0.2	0.0
NET BENEFIT TO THE STATE	22.6	24.1	14.3	22.0	22.0	23.3	23.2	12.3	16.3
NET BENEFIT RELATIVE TO CLOSE DOWN	2.2	3.8	-6.1	1.6	1.6	2.9	2.8	-8.1	-4.1

SCENARIO	D1 H	D2H	D3H	D1L	D1L	D2L	D2L	D3L	D3L	E1 H	E2H	E1L	E1L	E2L	E2L	H	P	Close down
Water Charging Policy	Current	Current	Current	Current	TWE's	Current	TWE's	Current	TWE's	Current	Current	Current	TWE's	Current	TWE's	TWE's	Current	Current
AGRICULTURAL BENEFITS																		
NET AGRICULTURAL RETURNS	39.2	40.7	41.6	38.1	38.1	39.4	39.4	38.7	38.7	39.2	40.7	38.1	38.1	39.4	39.4	29.9	29.9	29.9
Extra on farm stock water costs due to reduction in irrigation service	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	0.38	1.3	1.3	1.3
NET AGRICULTURAL BENEFIT	38.8	40.4	41.2	37.7	37.7	39.0	39.0	38.4	38.4	38.8	40.4	37.7	37.7	39.0	39.0	28.6	28.6	28.6
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	10.2	11.8	12.6	9.1	9.1	10.4	10.4	9.8	9.8	10.2	11.8	9.1	9.1	10.4	10.4			
WATER COSTS																		
Headworks																		
Operating costs	0.3	0.3	0.3	0.3	0.1	0.3	0.1	0.3	0.2	0.3	0.3	0.3	0.1	0.3	0.1	0.2	0.2	0.2
Capital costs	0.3	0.3	0.4	0.3	0.3	0.3	0.3	0.4	0.2	0.3	0.3	0.3	0.3	0.3	0.3			
Total headworks	0.6	0.6	0.7	0.6	0.4	0.6	0.4	0.7	0.4	0.6	0.6	0.6	0.4	0.6	0.4	0.2	0.2	0.2
Distribution																		
Operating costs	11.5	11.5	9.6	10.7	10.9	10.7	10.9	8.5	8.6	11.5	11.5	10.7	10.9	10.7	10.9	6.5	6.5	6.5
Capital costs	4.2	4.2	16.6	4.1	4.0	4.1	4.0	16.5	12.5	4.2	4.2	4.1	4.0	4.1	4.0	1.0	1.0	1.0
Total distribution costs	15.7	15.7	26.2	14.8	14.9	14.8	14.9	25	21.1	15.7	15.7	14.8	14.9	14.8	14.9	7.5	7.5	7.5
Close down costs	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.59	0.59	0.59
TOTAL WATER COSTS	16.5	16.5	27.1	15.6	15.5	15.6	15.5	25.9	21.7	16.5	16.5	15.6	15.5	15.6	15.5	8.2	8.2	8.2
AG. BENEFITS LESS WATER COSTS	22.3	23.9	14.1	22.1	22.2	23.4	23.5	12.5	16.7	22.3	23.9	22.1	22.2	23.4	23.5	20.4	20.4	20.4
OPPORTUNITY COST (Includes $0.29m spillway cost)																		
Contribution of metro consumers to headworks	-0.29	-0.29	-0.16	-0.29	-0.2	-0.29	-0.2	-0.16	0.02	-0.29	-0.29	-0.29	-0.2	-0.29	-0.2			
Cost to metro consumers																		
TOTAL OPPORTUNITY COST	-0.3	-0.3	-0.2	-0.3	-0.2	-0.3	-0.2	-0.2	0.0	-0.3	-0.3	-0.3	-0.2	-0.3	-0.2			
NET BENEFIT TO THE STATE	22.6	24.2	14.3	22.4	22.4	23.7	23.7	12.6	16.7	22.6	24.2	22.4	22.4	23.7	23.7	20.4	20.4	20.4
NET BENEFIT RELATIVE TO CLOSE DOWN	2.2	3.8	-6.1	2.0	2.0	3.3	3.3	-7.8	-3.7	2.2	3.8	2.0	2.0	3.3	3.3			

NPV @ 6% over 80 years: Units $ million (1989/90): 15 June 1992

Table 18

WAROONA COST BENEFIT

ECONOMIC ANALYSIS

(All units $million unless specified)

SCENARIO / Water Charging Policy	A1 H Current	A2H Current	A3H Current	A1L Current	A1L TWE's	A2L Current	A2L TWE's	A3L Current	A3L TWE's
NET AGRICULTURAL RETURNS	18.0	18.2	18.2	17.6	17.6	17.9	17.9	17.4	17.4
Extra on farm stock water costs due to reduction in irrigation service									
NET AGRICULTURAL BENEFIT	18.0	18.2	18.2	17.6	17.6	17.9	17.9	17.4	17.4
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	9.0	9.2	9.2	8.6	8.6	8.8	8.8	8.4	8.4
WATER COSTS									
Headworks	0.3	0.3	0.3	0.3	0.1	0.3	0.1	0.3	0.2
Operating costs	5.2	5.2	5.2	5.2	3.7	5.2	3.7	5.2	2.4
Capital costs	5.6	5.6	5.6	5.6	3.8	5.6	3.8	5.6	2.6
Distribution									
Operating costs	3.8	3.8	5.9	3.2	3.4	3.2	3.4	3.8	3.9
Capital costs	3.2	3.2	12.2	3.1	2.8	3.1	2.8	12.2	8.2
Total distribution costs	6.9	6.9	18	6.2	6.2	6.2	6.2	15.9	12.1
Close down costs									
TOTAL WATER COSTS	12.5	12.5	23.6	11.8	9.9	11.8	9.9	21.5	14.7
AG. BENEFITS LESS WATER COSTS	5.5	5.7	-5.4	5.8	7.7	6.1	8.0	-4.1	2.7
OPPORTUNITY COST (Includes $5.93m spillway cost)									
Contribution of metro consumers to headworks	-5.9	-5.9	-5.9	-5.9	-4.2	-5.9	-4.2	-5.9	-2.7
Cost to metro consumers	18.7	15.0	12.4	18.7	6.8	15.0	6.1	12.4	2.7
TOTAL OPPORTUNITY COST	12.8	9.1	6.5	12.8	2.6	9.1	1.9	6.5	
NET BENEFIT TO THE STATE	-7.3	-3.4	-11.9	-7.0	5.1	-3.0	6.0	-10.6	2.7
NET BENEFIT RELATIVE TO CLOSE DOWN	-13.7	-9.8	-18.3	-13.4	-1.4	-9.5	-0.4	-17	-3.7

SCENARIO / Water Charging Policy	B1H Current	B2H Current	B3H Current	B1L Current	B1L TWE's	B2L Current	B2L TWE's	B3L Current	B3L TWE's
NET AGRICULTURAL RETURNS	17.9	18.2	18.4	17.6	17.6	17.9	17.9	17.4	17.4
Extra on farm stock water costs due to reduction in irrigation service	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
NET AGRICULTURAL BENEFIT	17.9	18.1	18.3	17.6	17.6	17.8	17.8	17.4	17.4
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	8.8	9.1	9.3	8.6	8.6	8.8	8.8	8.3	8.3
WATER COSTS									
Headworks	0.3	0.3	0.3	0.3	0.1	0.3	0.1	0.3	0.2
Operating costs	4.7	4.7	4.7	4.7	3.7	4.7	3.7	4.7	2.4
Capital costs	5.0	5.0	5.0	5.0	3.7	5.0	3.7	5.0	2.5
Distribution									
Operating costs	3.6	3.6	4.4	3.1	3.3	3.1	3.3	3.2	3.3
Capital costs	3.0	3.0	9.6	3.0	2.8	3.0	2.8	9.6	6.7
Total distribution costs	6.5	6.5	13.9	6.0	6.1	6.0	6.1	12.7	10.0
Close down costs	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
TOTAL WATER COSTS	11.5	11.5	18.9	11.0	9.8	11.0	9.8	17.7	12.5
AG. BENEFITS LESS WATER COSTS	6.3	6.6	-0.6	6.5	7.7	6.8	8.0	-0.4	4.8
OPPORTUNITY COST (Includes $5.93m spillway cost)									
Contribution of metro consumers to headworks	-5.3	-5.3	-5.3	-5.3	-4.2	-5.3	-4.2	-5.3	-2.7
Cost to metro consumers	13.2	10.9	9.9	13.2	6.8	11.2	6.1	9.9	2.7
TOTAL OPPORTUNITY COST	7.9	5.6	4.6	7.8	2.6	5.9	1.9	4.6	0.1
NET BENEFIT TO THE STATE	-1.5	1.0	-5.2	-1.3	5.1	0.9	6.1	-5.0	4.8
NET BENEFIT RELATIVE TO CLOSE DOWN	-8.0	-5.4	-11.6	-7.8	-1.3	-5.5	-0.4	-11.4	-1.7

SCENARIO / Water Charging Policy	C1 H Current	C2H Current	C3H Current	C1L Current	C1L TWE's	C2L Current	C2L TWE's	C3L Current	C3L TWE's
NET AGRICULTURAL RETURNS	17.7	17.9	18.2	17.6	17.6	17.9	17.9	17.4	17.4
Extra on farm stock water costs due to reduction in irrigation service	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
NET AGRICULTURAL BENEFIT	17.6	17.9	18.1	17.5	17.5	17.8	17.8	17.3	17.3
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	8.6	8.9	9.1	8.5	8.5	8.8	8.8	8.3	8.3
WATER COSTS									
Headworks	0.3	0.3	0.3	0.3	0.1	0.3	0.1	0.3	0.2
Operating costs	4.0	4.0	4.0	4.0	3.7	4.0	3.7	4.0	2.4
Capital costs	4.3	4.3	4.3	4.3	3.7	4.3	3.7	4.3	2.5
Distribution									
Operating costs	3.4	3.4	3.5	3.0	3.2	3.0	3.2	2.9	3.0
Capital costs	2.8	2.8	8.2	2.8	2.8	2.8	2.8	8.2	6.1
Total distribution costs	6.2	6.2	11.7	5.8	6.0	5.8	6.0	11.1	9.1
Close down costs	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
TOTAL WATER COSTS	10.5	10.5	16.0	10.1	9.7	10.1	9.7	15.4	11.6
AG. BENEFITS LESS WATER COSTS	7.1	7.3	2.1	7.4	7.8	7.7	8.1	1.9	5.7
OPPORTUNITY COST (Includes $5.93m spillway cost)									
Contribution of metro consumers to headworks	-4.5	-4.5	-4.6	-4.5	-4.2	-4.5	-4.2	-4.6	-2.7
Cost to metro consumers	10.1	8.6	7.7	10.1	6.8	8.6	6.1	7.7	2.7
TOTAL OPPORTUNITY COST	5.6	4.1	3.1	5.6	2.6	4.1	1.9	3.1	0.1
NET BENEFIT TO THE STATE	1.5	3.3	-1.1	1.8	5.2	3.6	6.1	-1.3	5.6
NET BENEFIT RELATIVE TO CLOSE DOWN	-5.0	-3.2	-7.5	-4.6	-1.3	-2.9	-0.3	-7.7	-0.8

SCENARIO / Water Charging Policy	D1 H Current	D2H Current	D3H Current	D1L Current	D1L TWE's	D2L Current	D2L TWE's	D3L Current	D3L TWE's
AGRICULTURAL BENEFITS									
NET AGRICULTURAL RETURNS	16.4	16.6	16.9	16.6	16.6	16.9	16.9	17.1	17.1
Extra on farm stock water costs due to reduction in irrigation service	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16
NET AGRICULTURAL BENEFIT	16.2	16.5	16.8	16.5	16.5	16.7	16.7	17.0	17.0
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	7.2	7.5	7.8	7.4	7.4	7.7	7.7	8.0	8.0
WATER COSTS									
Headworks									
Operating costs	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.2	0.1
Capital costs	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.9
Total headworks	2.0	2.0	2.0	2.0	1.9	2.0	1.9	2.0	2.0
Distribution									
Operating costs	2.7	2.7	2.6	2.4	2.5	2.4	2.4	2.4	2.5
Capital costs	2.2	2.2	3.3	2.2	2.2	2.2	2.2	3.2	3.2
Total distribution costs	4.9	4.9	5.9	4.6	4.7	4.6	4.6	5.6	5.6
Close down costs	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
TOTAL WATER COSTS	7.0	7.0	8.0	6.7	6.7	6.7	6.6	7.7	7.7
AG. BENEFITS LESS WATER COSTS	9.2	9.5	8.8	9.7	9.7	10	10.1	9.3	9.3
OPPORTUNITY COST (Includes $5.93m spillway cost)									
Contribution of metro consumers to headworks	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1
Cost to metro consumers	3.2	2.7	2.1	3.2	2.6	2.7	2.3	2.1	1.9
TOTAL OPPORTUNITY COST	1.1	0.6	0.0	1.1	0.6	0.6	0.3	0.0	-0.2
NET BENEFIT TO THE STATE	8.1	8.9	8.7	8.7	9.2	9.4	9.8	9.2	9.4
NET BENEFIT RELATIVE TO CLOSE DOWN	1.7	2.5	2.3	2.2	2.7	3.0	3.4	2.8	3.0

SCENARIO / Water Charging Policy	E1 H Current	E2H Current	E1L Current	E1L TWE's	E2L Current	E2L TWE's	H TWE's	P Current	Close down Current
AGRICULTURAL BENEFITS									
NET AGRICULTURAL RETURNS	16.4	16.6	16.6	16.6	16.9	16.9	24.3	9.2	9.2
Extra on farm stock water costs due to reduction in irrigation service	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.21	0.21
NET AGRICULTURAL BENEFIT	16.2	16.5	16.5	16.5	16.8	16.8	24.1	9.0	9.0
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	7.2	7.5	7.5	7.5	7.7	7.7	15.1		
WATER COSTS									
Headworks									
Operating costs	0.2	0.2	0.2	0.1	0.2	0.1	0.1	0.2	0.2
Capital costs	1.8	1.8	1.8	1.8	1.8	1.8	4.1		
Total headworks	2.0	2.0	2.0	1.9	2.0	1.9	4.2	0.2	0.2
Distribution									
Operating costs	2.7	2.7	2.4	2.5	2.4	2.4	2.5	1.8	1.8
Capital costs	2.2	2.2	2.2	2.2	2.2	2.2	3.7	0.5	0.5
Total distribution costs	4.9	4.9	4.6	4.7	4.6	4.6	6.2	2.3	2.3
Close down costs	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.17	0.17
TOTAL WATER COSTS	7.0	7.0	6.7	6.7	6.7	6.6	10.5	2.6	2.6
AG. BENEFITS LESS WATER COSTS	9.2	9.5	9.8	9.8	10	10.1	13.6	6.4	6.4
OPPORTUNITY COST (Includes $5.93m spillway cost)									
Contribution of metro consumers to headworks	-2.1	-2.1	-2.1	-2.1	-2.1	-2.1	-4.6		
Cost to metro consumers	2.7	2.3	2.7	2.5	2.3	2.2	7.4		
TOTAL OPPORTUNITY COST	0.6	0.2	0.6	0.5	0.2	0.2	2.8		
NET BENEFIT TO THE STATE	8.6	9.3	9.2	9.3	9.9	10.0	10.8	6.4	6.4
NET BENEFIT RELATIVE TO CLOSE DOWN	2.2	2.9	2.8	2.9	3.4	3.5	4.4		

NPV @ 6% over 60 years: Units $ million (1989/90): 15 June 1992

HARVEY COST BENEFIT

Table 19

ECONOMIC ANALYSIS

(All units $million unless specified)

SCENARIO	A1 H	A2H	A3H	A1L	A1L	A2L	A2L	A3L	A3L
Water Charging Policy	Current	Current	Current	Current	TWE's	Current	TWE's	Current	TWE's
NET AGRICULTURAL RETURNS	45.3	46.7	46.9	42.7	42.7	44.0	44.0	43.2	43.2
Extra on farm stock water costs due to reduction in irrigation service									
NET AGRICULTURAL BENEFIT	45.3	46.7	46.9	42.7	42.7	44.0	44.0	43.2	43.2
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	15.4	16.8	17.0	12.8	12.8	14.1	14.1	13.3	13.3
WATER COSTS									
Headworks	0.3	0.3	0.3		0.2	0.3	0.2	0.3	0.2
Operating costs	4.9	4.9	4.9	4.9	2.6	4.9	2.6	4.9	2.1
Capital costs	5.2	5.2	5.2	4.9	2.8	5.2	2.8	5.2	2.3
Distribution									
Operating costs	18.7	18.7	13.9	16.7	16.9	16.7	16.9	12.2	12.3
Capital costs	7.5	7.5	35.2	7.1	6.7	7.1	6.7	35.2	23.1
Total distribution costs	26.1	26.1	49.0	23.7	23.5	23.7	23.5	47.3	35.4
Close down costs									
TOTAL WATER COSTS	31.3	31.3	54.2	28.6	26.3	28.9	26.3	52.5	37.7
AG. BENEFITS LESS WATER COSTS	14.0	15.4	-7.3	14.1	16.4	15.1	17.7	-9.3	5.5
OPPORTUNITY COST (Includes $5.33m spillway cost)									
Contribution of metro consumers to headworks	-5.3	-5.3	-5.3	-5.3	-2.9	-5.3	-2.9	-5.3	-2.3
Cost to metro consumers	26.5	20.1	14.8	26.5	6.4	20.1	5.2	14.8	1.0
TOTAL OPPORTUNITY COST	21.2	14.8	9.5	21.2	3.5	14.8	2.3	9.5	-1.3
NET BENEFIT TO THE STATE	-7.1	0.6	-16.7	-7.1	12.9	0.4	15.4	-18.7	6.9
NET BENEFIT RELATIVE TO CLOSE DOWN	-27	-19.2	-36.6	-26.9	-7.0	-19.5	-4.5	-38.6	-13

SCENARIO	B1H	B2H	B3H	B1L	B1L	B2L	B2L	B3L	B3L
Water Charging Policy	Current	Current	Current	Current	TWE's	Current	TWE's	Current	TWE's
NET AGRICULTURAL RETURNS	45.1	46.7	47.4	42.7	42.7	44.0	44.0	43.3	43.3
Extra on farm stock water costs due to reduction in irrigation service	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21	0.21
NET AGRICULTURAL BENEFIT	44.9	46.5	47.2	42.5	42.5	43.8	43.8	43.1	43.1
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	15.0	16.6	17.3	12.6	12.6	13.9	13.9	13.2	13.2
WATER COSTS									
Headworks	0.3	0.3	0.3	0.3	0.1	0.3	0.1	0.3	0.2
Operating costs	4.1	4.1	4.1	4.1	2.6	4.1	2.6	4.1	2.1
Capital costs	4.4	4.4	4.4	4.4	2.8	4.4	2.8	4.4	2.3
Distribution									
Operating costs	17.3	17.3	14.7	15.8	16	15.8	16	13.1	13.2
Capital costs	7.0	7.0	23.3	6.7	6.5	6.7	6.5	23.3	16.4
Total distribution costs	24.3	24.3	38.0	22.5	22.4	22.5	22.4	36.4	29.6
Close down costs	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
TOTAL WATER COSTS	29.0	29.0	42.7	27.2	25.5	27.2	25.5	41.1	32.2
AG. BENEFITS LESS WATER COSTS	15.9	17.5	4.5	15.3	17.0	16.6	18.3	1.9	10.8
OPPORTUNITY COST (Includes $5.33m spillway cost)									
Contribution of metro consumers to headworks	-4.5	-4.5	-4.5	-4.5	-2.9	-4.5	-2.9	-4.5	-2.3
Cost to metro consumers	17.1	14.4	10.6	17.1	6.4	14.4	5.2	10.6	1.0
TOTAL OPPORTUNITY COST	12.6	9.9	6.1	12.6	3.5	9.9	2.3	6.1	-1.3
NET BENEFIT TO THE STATE	3.3	7.6	-1.6	2.7	13.5	6.7	16.0	-4.1	12.2
NET BENEFIT RELATIVE TO CLOSE DOWN	-16.6	-12.3	-21.5	-17.2	-6.4	-13.1	-3.9	-24.0	-7.7

SCENARIO	C1 H	C2H	C3H	C1L	C1L	C2L	C2L	C3L	C3L
Water Charging Policy	Current	Current	Current	Current	TWE's	Current	TWE's	Current	TWE's
NET AGRICULTURAL RETURNS	44.4	46.1	46.7	42.7	42.7	44	44	43.3	43.3
Extra on farm stock water costs due to reduction in irrigation service	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31
NET AGRICULTURAL BENEFIT	44.1	45.7	46.4	42.4	42.4	43.7	43.7	43	43
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	14.2	15.8	16.5	12.5	12.5	13.8	13.8	13.1	13.1
WATER COSTS									
Headworks	0.3	0.3	0.3	0.3	0.1	0.3	0.1	0.3	0.2
Operating costs	3.7	3.7	3.7	3.7	2.6	3.7	2.6	3.7	2.1
Capital costs	4	4	4	4	2.8	4	2.8	4	2.3
Distribution									
Operating costs	16	16	12.6	14.7	14.9	14.7	14.9	11.3	11.4
Capital costs	6.6	6.6	19.5	6.4	6.2	6.4	6.2	19.5	14.3
Total distribution costs	22.6	22.6	32.1	21.1	21	21.1	21	30.8	25.7
Close down costs	0.34	0.34	0.34	0.34	0.34	0.34	0.34	0.35	0.35
TOTAL WATER COSTS	26.9	26.9	36.4	25.4	24.1	25.4	24.1	35.2	28.4
AG. BENEFITS LESS WATER COSTS	17.2	18.8	10	16.9	18.2	18.3	19.6	7.8	14.6
OPPORTUNITY COST (Includes $5.33m spillway cost)									
Contribution of metro consumers to headworks	-4.1	-4.1	-4.1	-4.1	-2.9	-4.1	-2.9	-4.1	-2.3
Cost to metro consumers	14	11.7	8.7	14	6.4	11.7	5.2	8.7	1
TOTAL OPPORTUNITY COST	9.9	7.6	4.6	9.9	3.5	7.6	2.3	4.6	-1.3
NET BENEFIT TO THE STATE	7.3	11.2	5.4	7.1	14.7	10.7	17.3	3.2	15.9
NET BENEFIT RELATIVE TO CLOSE DOWN	-12.6	-8.7	-14.5	-12.8	-5.2	-9.2	-2.6	-16.7	-4

SCENARIO	D1 H	D2H	D3H	D1L	D1L	D2L	D2L	D3L	D3L
Water Charging Policy	Current	Current	Current	Current	TWE's	Current	TWE's	Current	TWE's
AGRICULTURAL BENEFITS									
NET AGRICULTURAL RETURNS	43.7	45.3	46.0	42.7	42.7	44.0	44.0	43.3	43.3
Extra on farm stock water costs due to reduction in irrigation service	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41	0.41
NET AGRICULTURAL BENEFIT	43.3	44.9	45.6	42.3	42.3	43.6	43.6	42.9	42.9
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	13.4	15.0	15.7	12.4	12.4	13.7	13.7	13.0	13.0
WATER COSTS									
Headworks									
Operating costs	0.3	0.3	0.3	0.3	0.1	0.3	0.1	0.3	0.2
Capital costs	3.4	3.4	3.4	3.4	2.6	3.4	2.6	3.4	2.1
Total headworks	3.7	3.7	3.7	3.7	2.8	3.7	2.8	3.7	2.3
Distribution									
Operating costs	14.7	14.7	11.9	13.8	14.0	13.8	14.0	10.8	11.0
Capital costs	7.5	7.5	16.0	7.4	7.3	7.4	7.3	16.4	13.0
Total distribution costs	22.2	22.2	27.9	21.2	21.2	21.2	21.2	27.2	23.9
Close down costs	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37	0.37
TOTAL WATER COSTS	26.3	26.3	32	25.3	24.4	25.3	24.4	31.3	26.6
AG. BENEFITS LESS WATER COSTS	17.0	18.6	13.6	17.0	17.9	18.4	19.3	11.6	16.3
OPPORTUNITY COST (Includes $5.33m spillway cost)									
Contribution of metro consumers to headworks	-3.7	-3.7	-3.7	-3.7	-2.9	-3.7	-2.9	-3.7	-2.3
Cost to metro consumers	11.4	9.6	7.0	11.4	6.4	9.6	5.2	7.0	1.0
TOTAL OPPORTUNITY COST	7.7	5.9	3.3	7.7	3.5	5.9	2.3	3.3	-1.3
NET BENEFIT TO THE STATE	9.4	12.8	10.4	9.3	14.4	12.5	17.0	8.3	17.6
NET BENEFIT RELATIVE TO CLOSE DOWN	-10.5	-7.1	-9.5	-10.6	-5.5	-7.4	-2.9	-11.6	-2.3

SCENARIO	E1 H	E2H	E1L	E1L	E2L	E2L	H	P	Close down
Water Charging Policy	Current	Current	Current	TWE's	Current	TWE's	TWE's	Current	Current
AGRICULTURAL BENEFITS									
NET AGRICULTURAL RETURNS	40.5	41.7	40.9	40.9	42.2	42.2	48.4	46.4	31.1
Extra on farm stock water costs due to reduction in irrigation service	0.79	0.79	0.79	0.79	0.79	0.79	0.6	0.9	1.18
NET AGRICULTURAL BENEFIT	39.7	40.9	40.1	40.1	41.4	41.4	47.8	45.5	29.9
NET AG. BENEFIT RELATIVE TO CLOSE DOWN	9.8	11.0	10.2	10.2	11.5	11.5	17.9	15.6	
WATER COSTS									
Headworks									
Operating costs	0.2	0.2	0.2	0.1	0.2	0.1	0.1	0.2	0.2
Capital costs	2.0	2.0	2.0	2.0	2.0	2.0	2.6	1.6	
Total headworks	2.2	2.2	2.2	2.2	2.2	2.2	2.7	1.8	0.2
Distribution									
Operating costs	13.0	13.0	12.4	12.5	12.4	12.5	10.0	9.6	8.9
Capital costs	5.4	5.4	5.3	5.4	5.3	5.4	4.2	0.6	0.4
Total distribution costs	18.4	18.4	17.7	17.8	17.7	17.8	14.2	10.2	9.3
Close down costs	0.49	0.49	0.49	0.49	0.49	0.49	0.43	0.53	0.61
TOTAL WATER COSTS	21.1	21.1	20.4	20.5	20.4	20.5	17.3	12.5	10.0
AG. BENEFITS LESS WATER COSTS	18.6	19.8	19.8	19.7	21	20.9	30.5	33	19.9
OPPORTUNITY COST (Includes $5.33m spillway cost)									
Contribution of metro consumers to headworks	-2.2	-2.2	-2.2	-2.2	-2.2	-2.2	-2.9	-1.8	
Cost to metro consumers	2.7	2.0	2.7	2.6	2.0	1.9	3.7	0.7	
TOTAL OPPORTUNITY COST	0.5	-0.2	0.5	0.4	-0.2	-0.3	0.8	-1.1	
NET BENEFIT TO THE STATE	18.1	20.1	19.3	19.3	21.3	21.3	29.7	34.1	19.9
NET BENEFIT RELATIVE TO CLOSE DOWN	-1.8	0.2	-0.6	-0.6	1.4	1.4	9.8	14.2	

NPV @ 6% over 80 years: Units $ million (1989/90): 15 June 1992

4. THE FINANCIAL EVALUATION OF THE OPTIONS

4.1 Introduction

The financial analysis is a related, but separate, evaluation to the economic assessment. It's purpose is to provide an indication of the cost of each option to the Water Authority and Irrigation users.

The capital components of each option were calculated using a variation of a "renewals" accounting approach. The main difference between conventional accounting and renewals accounting is that instead of accounting for the cost of an asset over it's expected life through an annual depreciation charge, renewals accounting brings the full cost of asset replacement to account in the year in which it occurs. Renewals accounting then accounts for the past investment in assets through a rate of return on the full initial cost of the assets.

The objective of this approach is to avoid the uncertainty involved in estimating asset lives and replacement values for annual depreciation and works well for an industry in a "steady state" where maintenance and replacement are fairly consistent from year to year. Renewals accounting is used in a number of privatised water companies, particularly in the United Kingdom.

The objective of using a renewal based approach for the Strategy, however, was to calculate the cost of continuing to operate the irrigation districts under each of the options examined rather than to calculate the full cost of providing the irrigation service, including the past capital expenditure. For the Strategy, the return on existing assets has been set to zero, effectively writing-off past investment. With a zero rate of return, only future expenditure is taken into account and therefore provides the cost of continuing to operate the service.

Projected replacement expenditure for the South-West Irrigation Districts will vary considerably from year to year. To avoid the need for large fluctuations in prices, the renewal accounting approach was modified by projecting the expenditure required for the next 80 years and discounting it back to a NPV. The prices were then calculated to ensure future revenue recovered costs with constant real prices.

The results from this approach do not give the full cost of providing the service as the cost of interest and depreciation on past investment are ignored. The conventional financial accounts that include operating expenses, depreciation and interest provide the total cost which must be funded, and the Water Authority must recover this amount either from the irrigators, through cross-subsidy from other customers or through government grants. The renewals approach provides the minimum cost to be recovered to make it financially worth while continuing to operate the irrigation districts but charges at this level will not avoid the need to continue to subsidise the districts.

Water costs for each option can be divided into operating costs, capital costs for the irrigation distribution system and capital costs for the headworks. 85% of the cost for the headworks (dams) has been considered in calculating the required irrigation water price. The remaining 15% has been allocated to other beneficiaries - recreational use of the reservoirs and the Harvey town water supply drawn from the Harvey Reservoir.

The financial impact of the adoption of the different options on the Water Authority and irrigation farmers is designed to identify the cost to the Water Authority of the various options compared to current revenue and the likely cost to irrigators from the adoption of the options.

4.2 Methodology

The financial impact on the State and/or Water Authority and farmers is reported in four ways:

- an annual net deficit between revenue required and expected revenue (at 1989/90 water prices);
- a multiple by which water charges would need to increase by Year 11 to meet full cost recovery for the irrigation service on a "beneficiaries pay" principle;
- the additional financial benefit to a farmer over dryland farming after taking into account the full cost of water; and,
- profit and loss statements of the Water Authority's Irrigation Service for a 4% return on assets.

The methodology for calculating the financial results is described in more detail below.

4.2.1 Annual Net Deficit

This represents the annual equivalent deficit to the State or Water Authority (in 1989/90 dollar terms) from operating the Irrigation Service.

The annual equivalent net deficit is calculated by converting to an annuity the difference in the NPV's of expected and required revenue for the particular option.

Expected revenue is obtained by multiplying the expected demand for water under each option by the current real price of water.

The required revenue is obtained by calculating the cash flow of future costs for each option over the next 80 years. The costs included are:

- 100% of the operational cost;
- 100% of the capital costs of the distribution system; and,
- 85% of the capital costs of the headworks.

This represents a full "beneficiaries" or "user" pays approach to recovering costs from the irrigators. The remaining 15% of headworks cost is legitimately charged to other users of the reservoirs (i.e. recreators - see Supplementary Paper No. 1).

4.2.2 Water Prices Required to Recover Full Costs

If a full cost recovery policy was to be applied to irrigation water the current water price would need to rise. This is shown here as a multiple by which water charges would need to increase by the Year 2000 to achieve full cost recovery for each of the options evaluated. It is assumed the price of irrigation water services would rise in 10 annual increments to the year 2000 to reach the required multiple.

4.2.3 The Additional Benefit to the Farmer from Irrigation

The objective of this measure is to show the additional financial benefit to an average irrigation farm over dryland production under the different Phase 2 options evaluated. This measure assumes irrigators are required to pay full cost recovery rates.

A positive result indicates irrigation of the average farm pays. A negative result implies that it would not pay the average farm to irrigate if it was required to pay full cost recovery rates.

Four sets of results were provided for each low demand option. High demand options were not analysed because these automatically assume the current (real) price paid for water would continue and so, by definition, all existing irrigation would continue.

The four situations for which results were provided for each low demand option were:

- Irrigation farm returns compared to dryland farm returns with all farms in the area being dry. This regional dryland situation incorporates expected improvements in pasture productivity of 25 per cent for medium productivity (marginally salt affected) land and 50 per cent for low productivity (salt affected) land.

- Irrigation farm returns compared to dryland farm returns for the (individual) farm (this assumes only the farm in question reverts to dryland production and there are no regional productivity improvements).

and each of the above for two time periods

- 80 years - assumes the continued operation of the farm as an irrigation farm

- 15 years - enables the relative return from continuing with irrigation for 15 years prior to phase out of irrigation activities on the farm to be estimated.

4.2.4 Water Authority Profit and Loss Statements

The objective of this measure was to present the implications of different pricing policies on the Water Authority's financial statements on its Irrigation Service. Values are quoted for a 4% and 0% rate of return on assets for selected options in the Collie District. Values are quoted for years 5, 10, 20 and 30. The Profit and Loss Statements include the following:

- Revenue (given the necessary price increase)
- Operating Costs
- Depreciation
- Asset Write Off
- % return on Assets

Profit (Loss)

These profit and loss statements do not included interest payments on past capital borrowings or take into account an allowance for the statutory levy the Water Authority pays the State Government. This levy was 3% on the previous years revenue in 1989/90 and has increased to 4% in 1990/91.

4.3 The Results

Table 22 to 28 provide summaries of the financial analysis of all options.

The following points can be made based on the financial analysis results.

The tables show the price increases necessary to meet the requirements of the particular option and water charging approach. Figures are quoted in dollars per megalitre and have been partitioned into a headworks and distribution charge. Also shown are the necessary increases relative the charges in the 1989/90 season.

4.3.1 Effect of Area on Water Price

In all the high water demand cases a factor of 1.0 times the 1989/90 price is shown. This is of course a consequence of one of the major assumptions of the high demand case, that being that the charge for water would not increase relative to inflation. In these cases the Net Deficit (Annual Equivalent) represents the ongoing loss of the service in a "Renewals Accounting" sense.

In the low demand cases the increases in water prices indicated are set to cover the net annual deficit. That is, if these price increases were introduced over a ten year period the service would be self funding in a Renewals Accounting sense. This implies that the past debt is considered as "sunk", a zero return on assets could be achieved and sufficient money would be generated to ensure that the irrigation service is adequately maintained.

As the area reduces the overall cost of maintaining the system, relative to the water sold, reduces. This occurs no matter which water charging approach is used. This is shown in the following table.

Table 20 Average Water Prices Per Megalitre in Low Demand Cases for Different Water Charging Approaches (Total Area Cases)

Option	Current Approach (Fixed Allocation)	Possible TWE Approach (Variable Water Allocation)
A1L	$64.3	$59.7
B1L	$59.7	$56.9
C1L	$55.2	$53.6
D1L	$51.4	$50.4

4.3.2 Effect of Water Charging Policy on Water Price

The table also shows that the total cost per megalitre is less in the TWE (or variable water allocation) approach than in the current charging approach. This is because the headworks component of the costs are lower in the TWE charging approach than under the Current (Fixed Allocation) approach. Less water would be allocated to irrigation if farmers decide to reduce their water usage and sell some of their Water Entitlement. As this occurs the costs associated with running and maintaining the headworks for the Irrigation Service reduces.

The increases in charging components and increases per megalitre relative to those in 1989/90 are shown in Table 21.

Table 21 Water Price Increases Required in Low Demand Cases for Different Water Charging Approaches (Total Area Cases)

Option	Current Approach (Fixed Allocation)		Possible TWE Approach (Variable Water Allocation)
	Current Rates & Volumetric Charge Components	Equivalent Volumetric Charge	Volumetric Charge Only
	Increase in Rates & Volumetric Charge Components over 89/90	Increase in Average Charge megalitre over 89/90	Increase in Average Charge per megalitre over 89/90
A1L	2.1	2.6	2.5
B1L	2.0	2.5	2.4
C1L	1.9	2.3	2.2
D1L	1.8	2.1	2.1

Table 21 shows that if the current water charging system were maintained the rates and volumetric components would increase between 1.8 to 2.1 times for the Low Demand Options shown. The equivalent increases when expressed as an average charge per megalitre range from 2.1 to 2.6. This simply reflects that, currently, the smaller users effectively pay a higher per megalitre price and that this effect will be increased as water use declines.

The table also shows that with a TWE market operating in which a volumetric charge only was applied, the price increases per megalitre would range from 2.1 to 2.5. These increases are less than the equivalent volumetric charge increases for the current two component charging approach.

Under a fully volumetric charging approach both small and large water users would pay the same amount per megalitre. With the establishment of a TWE market a farmer who reduced his Water Entitlement and used less water would be contributing a smaller component of the overall costs than currently. If he sold all his entitlement (i.e. had no effective allocation of irrigation water) he would pay no costs even though an irrigation service would be available to him.

A dual charging structure (fixed and volumetric) could be devised that would have a similar pricing outcome to the current charging structure when a TWE market was operating. Such alternative structures could and should be considered during Phase 3 and 4. Alternatives that reflect the fixed costs of maintaining the distribution system within the area served have merit. There are real fixed costs that need to be recovered each year if small quantities of water are sold. The dilemma with this approach is that a farmer who has sold his entitlement would still be asked to pay a fixed cost each year for remaining in the irrigation district even when he had decided to stop irrigating.

4.3.3 Effect of Water Price on Average Farm Profitability

Analysis of the additional benefits from irrigation for the average farm shows that irrigated dairying was more profitable than dryland dairy farming for most options with Strategy 2 options yielding the highest returns.

However, on average irrigated grazing properties would not be more profitable than dryland farms if they were required to pay full costs for water.

If a full cost recovery water pricing policy was instituted (for the average sized property):

Horticulture	-	Horticulture would continue to be profitable.
Dairy	-	Irrigated dairy farms should be more profitable than dryland farms on high productivity land.
	-	Irrigated dairy farms should be more profitable than dryland farms on medium productivity land, but only if Strategy 2 on-farm irrigation productivity improvements were adopted.
	-	Irrigated fairy farms should be less profitable than dryland dairy farms on low (salt affected) productivity land.
	-	The adoption of Strategy 3 would not be profitable for dairy farms, compared to dryland dairy farming at a regional level.

However, if the majority of the area continued to be irrigated it would pay the individual to irrigate medium productivity land.

Grazing - Irrigation for grazing enterprises would be less profitable than dryland farming. Income would have to be above average or the individual farm enterprise able to capture considerable out of season market premiums for livestock before irrigation was more profitable than dryland grazing.

4.3.5 Water Authority Profit and Loss

Table 28 summarises the Water Authority profit and loss statements for selected options of the future Collie District Irrigation Service.

The financial profit and loss statements indicate that, for the most economically viable district, Collie, even with the "renewals" accounting price increases (Low Water demand cases) the Water Authority would not be able to achieve a 4% return on its irrigation assets. However, following the ten years of price increases in the low demand cases a zero return on assets is achieved.

Note that if interest on past borrowings were also included in the profit and loss statements then rates of return would remain negative.

Water prices would have to increase substantially (more than shown in the financial analysis tables) if irrigators were asked to pay the full interest bill on past debt as well as covering the full future costs.

Currently, under Option A1, Low Demand for the total area and considering the fixed water charging policy, water prices would have to increase by 2.1 times by the year 2000 to meet future user pays costs. If users also had to pay the full interest on past debt then price increases would need to exceed 3.5 times current levels.

This price increase would be necessary to avoid cross-subsidies between irrigation users and other Water Authority customers if the State Government required the Water Authority to pay the full interest on past debt.

TOTAL COST BENEFIT

FINANCIAL ANALYSIS

(All units $million unless specified)

SCENARIO / Water Charging Policy	A1H Current	A2H Current	A3H Current	A1L Current	A1L TWE's	A2L Current	A2L TWE's	A3L Current	A3L TWE's	B1H Current	B2H Current	B3H Current	B1L Current	B1L TWE's	B2L Current	B2L TWE's	B3L Current	B3L TWE's	C1H Current	C2H Current	C3H Current	C1L Current	C1L TWE's	C2L Current	C2L TWE's	C3L Current	C3L TWE's
• EXPECTED REVENUE (at 1989/90 prices)	36.6	36.6	36.3	30.0	24.1	30.0	24.1	28.1	21.3	35.3	35.3	35.3	29.2	24.1	29.2	24.1	27.0	21.2	32.7	32.7	32.6	28.2	24.1	28.2	24.1	26.2	21.2
• REQUIRED REVENUE TO MEET WATER COSTS	61.1	61.1	117.8	56.1	52.1	56.1	52.1	112.4	81.6	56.8	56.8	93.7	52.7	50.1	52.7	50.1	89.5	68.9	52.0	52.0	77.5	48.9	47.3	48.9	47.3	74.4	60.2

(Operating costs + Distribution capital costs + 85% of head works capital costs)
"(Allowance for capital costs based on "renewals" accounting principle with existing capital values written off)"

	A1H Current	A2H Current	A3H Current	A1L Current	A1L TWE's	A2L Current	A2L TWE's	A3L Current	A3L TWE's	B1H Current	B2H Current	B3H Current	B1L Current	B1L TWE's	B2L Current	B2L TWE's	B3L Current	B3L TWE's	C1H Current	C2H Current	C3H Current	C1L Current	C1L TWE's	C2L Current	C2L TWE's	C3L Current	C3L TWE's
• NET DEFICIT (NPV)	24.6	24.6	81.5	26.1	28.1	26.1	28.1	84.3	60.3	21.5	21.5	58.5	23.5	26.0	23.5	26.0	62.5	47.7	19.3	19.3	44.9	20.7	23.3	20.7	23.3	48.2	39.0
• NET DEFICIT (ANNUAL EQUIVALENT) $'000	1488	1488	4938	1579	1700	1579	1700	5107	3651	1304	1304	3540	1421	1577	1421	1577	3783	2891	1171	1171	2718	1251	1409	1251	1409	2918	2365

WATER COSTS

• REQUIRED WATER CHARGE TO MEET ACTUAL COSTS BY YEAR 11
(Assuming 100% volumetric charge)

	A1H Current	A2H Current	A3H Current	A1L Current	A1L TWE's	A2L Current	A2L TWE's	A3L Current	A3L TWE's	B1H Current	B2H Current	B3H Current	B1L Current	B1L TWE's	B2L Current	B2L TWE's	B3L Current	B3L TWE's	C1H Current	C2H Current	C3H Current	C1L Current	C1L TWE's	C2L Current	C2L TWE's	C3L Current	C3L TWE's
Headworks ($ per megalitre)				11.8	7.1	11.8	7.1	15.6	7.1				10.3	7.1	10.3	7.1	13.3	6.8				9.1	7.1	9.1	7.1	11.7	6.7
Distribution ($ per megalitre)				52.5	52.6	55.5	55.6	163.7	123.1				49.4	49.8	52.4	52.7	123.4	98.9				46.0	46.5	48.8	49.2	100.2	83.7
TOTAL ($ per megalitre)				64.3	59.7	67.3	62.7	179.3	130.1				59.7	56.9	62.6	59.7	136.7	105.7				55.2	53.6	57.9	56.3	111.9	90.4
• INCREASE OVER 1989/90 PRICE (Current mix of rates & volume charges)	1.0	1.0	1.0	2.1		2.1		4.8		1.0	1.0	1.0	2.0		2.0		3.9		1.0	1.0	1.0	1.9		1.9		3.3	
• INCREASE OVER 1989/90 PRICE (Volume charge only)				2.6	2.5	2.8	2.6	7.4	5.4				2.5	2.4	2.6	2.4	5.6	4.4				2.3	2.2	2.4	2.3	4.6	3.7
NPV of FLOWS - Volume sold - megalitres																											

SCENARIO / Water Charging Policy	D1H Current	D2H Current	D3H Current	D1L Current	D1L TWE's	D2L Current	D2L TWE's	D3L Current	D3L TWE's	E1H Current	E2H Current	E1L Current	E1L TWE's	E2L Current	E2L TWE's	H TWE's	P Current	Close down Current
• EXPECTED REVENUE (at 1989/90 prices)	30.5	30.5	30.5	27.7	24.1	27.7	24.1	25.4	21.1	27.3	27.3	25.8	22.9	25.8	22.9	21.9	19.0	16.9
• REQUIRED REVENUE TO MEET WATER COSTS	30.5	30.5	30.5	27.7	24.1	27.7	24.1	25.4	21.1	27.3	27.3	25.8	22.9	25.8	22.9	21.9	19.0	16.9

(Operating costs + Distribution capital costs +85% of head works capital costs)
"(Allowance for capital costs based on "renewals" accounting principle with existing capital values written off)"

	D1H Current	D2H Current	D3H Current	D1L Current	D1L TWE's	D2L Current	D2L TWE's	D3L Current	D3L TWE's	E1H Current	E2H Current	E1L Current	E1L TWE's	E2L Current	E2L TWE's	H TWE's	P Current	Close down Current
• NET DEFICIT (NPV)	1849	1849	1850	1680	1459	1680	1459	1539	1278	1654	1654	1565	1387	1565	1387	1326	1153	1022
• NET DEFICIT (ANNUAL EQUIVALENT) $'000																		

WATER COSTS

• REQUIRED WATER CHARGE TO MEET ACTUAL COSTS BY YEAR 11
(Assuming 100% volumetric charge)

	D1H Current	D2H Current	D3H Current	D1L Current	D1L TWE's	D2L Current	D2L TWE's	D3L Current	D3L TWE's	E1H Current	E2H Current	E1L Current	E1L TWE's	E2L Current	E2L TWE's	H TWE's	P Current	Close down Current
Headworks ($ per megalitre)				6.4	5.2	6.4	5.2	8.1	6.0			5.2	4.8	5.2	4.8	8.4	3.1	
Distribution ($ per megalitre)				45.0	45.2	47.7	47.8	85.1	74.4			43.8	46.2	46.1	46.2	32.0	27.9	
TOTAL ($ per megalitre)				51.4	50.4	54.1	52.9	93.2	80.3			48.9	51.0	51.3	51.0	40.4	31.0	
• INCREASE OVER 1989/90 PRICE (Current mix of rates & volume charges)	1.0	1.0	1.0	1.8		1.8		2.9		1.0	1.0	1.8		1.8			1.2	1.0
• INCREASE OVER 1989/90 PRICE (Volume charge only)				2.1	2.1	2.2	2.2	3.8	3.3			2.0	2.0	2.1	2.1	1.7	1.3	
NPV of FLOWS - Volume sold - megalitres																		

NPV @ 6% over 80 years: Units $ million (1989/90): 15 June 1992

COLLIE COST BENEFIT

FINANCIAL ANALYSIS

(All units $million unless specified)

SCENARIO / Water Charging Policy		A1 H Current	A2H Current	A3H Current	A1L Current	A1L TWE's	A2L Current	A2L TWE's	A3L Current	A3L TWE's	B1H Current	B2H Current	B3H Current	B1L Current	B1L TWE's	B2L Current	B2L TWE's	B3L Current	B3L TWE's
• EXPECTED REVENUE (at 1989/90 prices)		15.2	15.2	15.2	12.1	9.4	12.1	9.4	11.5	8.6	14.9	14.9	14.9	11.9	9.4	11.9	9.4	11.2	8.6
• REQUIRED REVENUE TO MEET WATER COSTS		19.2	19.2	41.8	17.1	16.9	17.1	16.9	40.1	30.0	18.1	18.1	34	16.3	16.2	16.3	16.2	32.4	25.2
(Operating costs - Distribution capital costs + 85% of head works capital costs) "(Allowance for capital costs based on "renewals" accounting principle with existing capital values written off)"																			
• NET DEFICIT (NPV)		4.0	4.0	26.6	5.0	7.5	5.0	7.5	28.6	21.4	3.2	3.2	19.0	4.4	6.7	4.4	6.7	21.2	16.6
• NET DEFICIT (ANNUAL EQUIVALENT)	$'000	241	241	1614	302	454	302	454	1732	1293	192	192	1151	267	408	267	408	1286	1008
WATER COSTS																			
• REQUIRED WATER CHARGE TO MEET ACTUAL COSTS BY YEAR 11 (Assuming 100% volumetric charge)																			
Headworks	($ per megalitre)				1.9	1.0	1.9	1.0	3.0	1.4				1.8	0.9	1.8	0.9	2.6	1.3
Distribution	($ per megalitre)				42.0	44.7	44.1	44.7	145.6	109.6				39.6	40.1	41.6	42.0	111.8	88.4
TOTAL	($ per megalitre)				43.9	45.7	46.0	45.7	148.5	111.0				41.4	41.0	43.4	42.9	114.5	89.6
• INCREASE OVER 1989/90 PRICE (Current mix of rates & volume charges)		1.0	1.0	1.0	1.5		1.5		4.1		1.0	1.0	1.0	1.4		1.4		3.3	
• INCREASE OVER 1989/90 PRICE (Volume charge only)					1.8	1.8	1.9	1.9	6.1	4.6				1.7	1.7	1.8	1.8	4.7	3.7
NPV of FLOWS - Volume sold - megalitres		637.0	637.0	600.6	434.0	414.0	434.0	414.0	374.9	375.0	637.9	637.9	601.4	434.0	414.0	434.0	414.0	375.5	376.0

SCENARIO / Water Charging Policy		C1 H Current	C2H Current	C3H Current	C1L Current	C1L TWE's	C2L Current	C2L TWE's	C3L Current	C3L TWE's
• EXPECTED REVENUE (at 1989/90 prices)		13.5	13.5	13.5	11.3	9.4	11.3	9.4	10.7	8.6
• REQUIRED REVENUE TO MEET WATER COSTS		16.3	16.3	26.8	15.0	14.9	15.0	14.9	25.6	21.5
• NET DEFICIT (NPV)		2.8	2.8	13.3	3.7	5.5	3.7	5.5	14.9	12.9
• NET DEFICIT (ANNUAL EQUIVALENT)	$'000	168	168	807	224	331	224	331	904	778
Headworks	($ per megalitre)				1.5	0.9	1.5	0.9	2.2	1.3
Distribution	($ per megalitre)				36.4	36.8	38.2	38.6	86.0	72.5
TOTAL	($ per megalitre)				37.9	37.8	39.6	39.6	88.2	73.7
• INCREASE OVER 1989/90 PRICE (Current mix of rates & volume charges)		1.0	1.0	1.0	1.4		1.4		2.7	
• INCREASE OVER 1989/90 PRICE (Volume charge only)					1.6	1.6	1.6	1.6	3.6	3.0
NPV of FLOWS - Volume sold - megalitres		580.3	580.3	548.8	434.0	414.0	434.0	414.0	375.5	376.0

SCENARIO / Water Charging Policy		D1 H Current	D2H Current	D3H Current	D1L Current	D1L TWE's	D2L Current	D2L TWE's	D3L Current	D3L TWE's	E1 H Current	E2H Current	E1L Current	E1L TWE's	E2L Current	E2L TWE's	H TWE's	P Current	Close down Current
• EXPECTED REVENUE (at 1989/90 prices)		13.5	13.5	13.5	12.1	10.4	12.1	10.4	10.7	8.6	13.5	13.5	12.1	10.4	12.1	10.4	6.9	6.9	6.9
• REQUIRED REVENUE TO MEET WATER COSTS		16.3	16.3	26.8	15.3	15.3	15.3	15.3	25.6	21.5	16.3	16.3	15.3	15.3	15.3	15.3	7.6	7.6	7.6
(Operating costs + Distribution capital costs +85% of head works capital costs) "(Allowance for capital costs based on "renewals" accounting principle with existing capital values written off)"																			
• NET DEFICIT (NPV)		2.8	2.8	13.3	3.2	4.9	3.2	4.9	14.9	12.9	2.8	2.8	3.2	4.9	3.2	4.9	0.7	0.7	0.7
• NET DEFICIT (ANNUAL EQUIVALENT)	$'000	169	169	807	193	294	193	294	904	778	169	169	193	294	193	294	44	44	44
WATER COSTS																			
• REQUIRED WATER CHARGE TO MEET ACTUAL COSTS BY YEAR 11 (Assuming 100% volumetric charge)																			
Headworks	($ per megalitre)				1.4	0.8	1.4	0.8	2.2	1.3			1.4	0.8	1.4	0.8			
Distribution	($ per megalitre)				33.6	33.8	35.4	35.5	86.0	72.5			33.6	33.8	35.4	35.5			
TOTAL	($ per megalitre)				34.9	34.6	36.7	36.4	88.2	73.7			34.9	34.6	36.7	36.4			
• INCREASE OVER 1989/90 PRICE (Current mix of rates & volume charges)		1.0	1.0	1.0	1.3		1.3		2.7		1.0	1.0	1.3		1.3		1.0	1.0	1.0
• INCREASE OVER 1989/90 PRICE (Volume charge only)					1.4	1.4	1.5	1.5	3.6	3.0			1.4	1.4	1.5	1.5			
NPV of FLOWS - Volume sold - megalitres		580.2	580.2	548.8	483.5	460.0	483.5	460.0	375.5	376.0	580.2	580.2	483.5	460.0	483.5	460.0	270.1	270.1	270.1

NPV @ 6% over 80 years: Units $ million (1989/90): 15 June 1992

Table 24

HARVEY COST BENEFIT

FINANCIAL ANALYSIS

(All units $million unless specified)

SCENARIO / Water Charging Policy	A1 H Current	A2H Current	A3H Current	A1L Current	A1L TWE's	A2L Current	A2L TWE's	A3L Current	A3L TWE's	B1H Current	B2H Current	B3H Current	B1L Current	B1L TWE's
• EXPECTED REVENUE (at 1989/90 prices)	16.8	16.8	16.5	14.0	11.3	14.0	11.3	13.1	10.0	16.0	16.0	16.0	13.5	11.3
• REQUIRED REVENUE TO MEET WATER COSTS	30.4	30.4	53.3	28.1	25.9	28.1	25.9	51.7	37.3	27.9	27.9	41.7	26.2	24.7
• NET DEFICIT (NPV)	13.7	13.7	36.8	14.1	14.6	14.1	14.6	38.6	27.3	12.0	12.0	25.7	12.7	13.4
• NET DEFICIT (ANNUAL EQUIVALENT) $'000	828	828	2228	854	883	854	883	2336	1656	724	724	1558	768	813

SCENARIO / Water Charging Policy	B2L Current	B2L TWE's	B3L Current	B3L TWE's	C1 H Current	C2H Current	C3H Current	C1L Current	C1L TWE's	C2L Current	C2L TWE's	C3L Current	C3L TWE's
• EXPECTED REVENUE (at 1989/90 prices)	13.5	11.3	12.5	10.0	15.2	15.2	15.2	13.2	11.3	13.2	11.3	12.3	10.0
• REQUIRED REVENUE TO MEET WATER COSTS	26.2	24.7	40.1	31.5	25.9	25.9	35.4	24.5	23.4	24.5	23.4	34.1	27.7
• NET DEFICIT (NPV)	12.7	13.4	27.6	21.5	10.7	10.7	20.2	11.3	12.1	11.3	12.1	21.8	17.7
• NET DEFICIT (ANNUAL EQUIVALENT) $'000	768	813	1669	1304	649	649	1226	683	732	683	732	1322	1069

(Operating costs + Distribution capital costs + 85% of head works capital costs)
"(Allowance for capital costs based on "renewals" accounting principle with existing capital values written off)"

WATER COSTS

• REQUIRED WATER CHARGE TO MEET ACTUAL COSTS BY YEAR 11
(Assuming 100% volumetric charge)

SCENARIO / Water Charging Policy	A1 H Current	A2H Current	A3H Current	A1L Current	A1L TWE's	A2L Current	A2L TWE's	A3L Current	A3L TWE's	B1H Current	B2H Current	B3H Current	B1L Current	B1L TWE's
Headworks ($ per megalitre)				12.3	6.7	12.6	6.7	15.3	6.8				10.6	6.7
Distribution ($ per megalitre)				60.0	59.9	63.4	63.4	166.6	124.3				56.2	56.2
TOTAL ($ per megalitre)				72.3	66.7	76.0	70.1	181.9	131.2				66.8	62.9
• INCREASE OVER 1989/90 PRICE (Current mix of rates & volume charges)	1.0	1.0	1.0	2.3		2.3		4.7		1.0	1.0	1.0	2.2	
• INCREASE OVER 1989/90 PRICE (Volume charge only)				3.0	2.8	3.1	2.9	7.5	5.4				2.7	2.6
NPV of FLOWS - Volume sold - megalitres	670.6	670.6	616.4	488.3	465.0	488.3	465.0	405.9	406.0	654.2	654.2	616.4	488.2	465.0

SCENARIO / Water Charging Policy	B2L Current	B2L TWE's	B3L Current	B3L TWE's	C1 H Current	C2H Current	C3H Current	C1L Current	C1L TWE's	C2L Current	C2L TWE's	C3L Current	C3L TWE's
Headworks ($ per megalitre)	10.6	6.7	12.6	6.6				9.6	6.7	9.6	6.7	11.5	6.5
Distribution ($ per megalitre)	59.5	59.5	122.9	100.0				52.3	52.5	55.5	55.6	101.5	84.8
TOTAL ($ per megalitre)	70.1	66.1	135.6	106.6				61.8	59.1	65.1	62.3	113.0	91.3
• INCREASE OVER 1989/90 PRICE (Current mix of rates & volume charges)	2.2		3.7		1.0	1.0	1.0	2.1		2.1		3.2	
• INCREASE OVER 1989/90 PRICE (Volume charge only)	2.9	2.7	5.6	4.4				2.5	2.4	2.7	2.6	4.6	3.8
NPV of FLOWS - Volume sold - megalitres	488.2	465.0	405.9	406.0	617.9	617.9	582.7	488.3	465.0	488.3	465.0	405.9	406.0

SCENARIO / Water Charging Policy	D1 H Current	D2H Current	D3H Current	D1L Current	D1L TWE's	D2L Current	D2L TWE's	D3L Current	D3L TWE's	E1 H Current	E2H Current	E1L Current	E1L TWE's	E2L Current	E2L TWE's	H TWE's	P Current	Close down Current
• EXPECTED REVENUE (at 1989/90 prices)	14.3	14.3	14.3	13.0	11.3	13.0	11.3	12.0	10.0	11.1	11.1	11.1	10.1	11.1	10.1	11.3	10.0	7.8
• REQUIRED REVENUE TO MEET WATER COSTS	25.3	25.3	31.0	24.3	23.5	24.3	23.5	30.3	25.8	20.3	20.3	19.6	19.6	19.6	19.6	16.4	11.7	9.3
• NET DEFICIT (NPV)	11.0	11.0	16.7	11.3	12.2	11.3	12.2	18.3	15.6	9.2	9.2	8.5	9.5	8.5	9.5	5.1	1.7	1.5
• NET DEFICIT (ANNUAL EQUIVALENT) $'000	666	666	1012	684	741	684	741	1111	956	556	556	515	578	515	578	310	102	92

(Operating costs + Distribution capital costs +85% of head works capital costs)
"(Allowance for capital costs based on "renewals" accounting principle with existing capital values written off)"

WATER COSTS

• REQUIRED WATER CHARGE TO MEET ACTUAL COSTS BY YEAR 11
(Assuming 100% volumetric charge)

SCENARIO / Water Charging Policy	D1 H Current	D2H Current	D3H Current	D1L Current	D1L TWE's	D2L Current	D2L TWE's	D3L Current	D3L TWE's	E1 H Current	E2H Current	E1L Current	E1L TWE's	E2L Current	E2L TWE's	H TWE's	P Current	Close down Current
Headworks ($ per megalitre)				8.9	6.6	8.9	6.6	10.3	6.4			6.1	5.9	6.1	5.9	6.3	5.1	
Distribution ($ per megalitre)				53.4	53.5	56.5	56.7	87.9	77.2			51.4	51.5	54.0	54.0	34.5	29.2	
TOTAL ($ per megalitre)				62.3	60.1	65.4	63.3	98.2	83.6			57.5	57.4	60.1	60	40.8	34.3	
• INCREASE OVER 1989/90 PRICE (Current mix of rates & volume charges)	1.0	1.0	1.0	2.1		2.1		2.9		1.0	1.0	2.0		2.0			1.2	1.0
• INCREASE OVER 1989/90 PRICE (Volume charge only)				2.6	2.5	2.7	2.6	4.0	3.4			2.4	2.4	2.5	2.5	1.7	1.4	
NPV of FLOWS - Volume sold - megalitres	578.5	578.5	547.4	488.3	465	488.3	465.0	405.9	406.0	429.6	429.6	429.6	411.0	429.6	411.0	463.0	375.9	277.3

NPV @ 6% over 80 years: Units $ million (1989/90): 15 June 1992

WAROONA COST BENEFIT

FINANCIAL ANALYSIS

(All units $million unless specified)

SCENARIO / Water Charging Policy	A1 H Current	A2H Current	A3H Current	A1L Current	A1L TWE's	A2L Current	A2L TWE's	A3L Current	A3L TWE's	B1H Current	B2H Current	B3H Current	B1L Current	B1L TWE's	B2L Current	B2L TWE's	B3L Current	B3L TWE's
• EXPECTED REVENUE (at 1989/90 prices)	4.6	4.6	4.6	3.9	3.3	3.9	3.3	3.5	2.7	4.4	4.4	4.4	3.8	3.3	3.8	3.3	3.3	2.6
• REQUIRED REVENUE TO MEET WATER COSTS	11.6	11.6	22.7	10.9	9.3	10.9	9.3	20.7	14.3	10.8	10.8	18.1	10.2	9.2	10.2	9.2	17.0	12.2
• NET DEFICIT (NPV)	6.9	6.9	18.1	7.0	6.0	7.0	6.0	17.2	11.6	6.4	6.4	13.7	6.4	5.9	6.4	5.9	13.7	9.6
• NET DEFICIT (ANNUAL EQUIVALENT) $'000	419	419	1096	422	363	422	363	1039	701	388	388	831	386	357	386	357	827	578

SCENARIO / Water Charging Policy	C1 H Current	C2H Current	C3H Current	C1L Current	C1L TWE's	C2L Current	C2L TWE's	C3L Current	C3L TWE's
• EXPECTED REVENUE (at 1989/90 prices)	4.0	4.0	4.0	3.7	3.3	3.7	3.3	3.2	2.6
• REQUIRED REVENUE TO MEET WATER COSTS	9.8	9.8	15.3	9.4	9.0	9.4	9.0	14.6	11.1
• NET DEFICIT (NPV)	5.8	5.8	11.3	5.7	5.7	5.7	5.7	11.4	8.5
• NET DEFICIT (ANNUAL EQUIVALENT) $'000	353	353	684	344	346	344	346	693	517

(Operating costs + Distribution capital costs + 85% of head works capital costs)
"(Allowance for capital costs based on "renewals" accounting principle with existing capital values written off)"

WATER COSTS

- REQUIRED WATER CHARGE TO MEET ACTUAL COSTS BY YEAR 11
  (Assuming 100% volumetric charge)

	A1 H Current	A2H Current	A3H Current	A1L Current	A1L TWE's	A2L Current	A2L TWE's	A3L Current	A3L TWE's	B1H Current	B2H Current	B3H Current	B1L Current	B1L TWE's	B2L Current	B2L TWE's	B3L Current	B3L TWE's
Headworks ($ per megalitre)				44.6	30.2	44.6	30.2	59.7	27.7				39.6	30.0	39.6	30.0	52.2	26.4
Distribution ($ per megalitre)				51.9	52.6	57.3	57.1	212.7	160.8				50.3	51.5	55.2	56.0	164.8	128.3
TOTAL ($ per megalitre)				96.5	82.7	101.9	87.3	272.4	188.5				90.0	81.5	94.8	86.0	217.0	154.7
• INCREASE OVER 1989/90 PRICE (Current mix of rates & volume charges)	1.0	1.0	1.0	3.2		3.2		7.3		1.0	1.0	1.0	3.1		3.1		6.2	
• INCREASE OVER 1989/90 PRICE (Volume charge only)				4.0	3.4	4.2	3.6	11.2	7.8				3.7	3.4	3.9	3.5	8.9	6.4
NPV of FLOWS - Volume sold - megalitres	199.1	199.1	187.4	153.1	145.0	153.1	145.0	115.7	116.0	187.7	187.7	177.1	153.1	145.0	153.1	145.0	114.4	114.0

	C1 H Current	C2H Current	C3H Current	C1L Current	C1L TWE's	C2L Current	C2L TWE's	C3L Current	C3L TWE's
Headworks ($ per megalitre)				34.5	30.0	34.5	30.0	45.3	26 1
Distribution ($ per megalitre)				48.7	50.0	53.2	54.3	141.5	114.2
TOTAL ($ per megalitre)				83.1	80.0	87.7	84.3	186.8	140.2
• INCREASE OVER 1989/90 PRICE (Current mix of rates & volume charges)	1.0	1.0	1.0	2.9		2.9		5.5	
• INCREASE OVER 1989/90 PRICE (Volume charge only)				3.4	3.3	3.6	3.5	7.7	5 8
NPV of FLOWS - Volume sold - megalitres	170.8	170.8	161.7	153.1	145.0	153.1	145.0	114.4	114.0

SCENARIO / Water Charging Policy	D1 H Current	D2H Current	D3H Current	D1L Current	D1L TWE's	D2L Current	D2L TWE's	D3L Current	D3L TWE's	E1 H Current	E2H Current	E1L Current	E1L TWE's	E2L Current	E2L TWE's	H TWE's	P Current	Close down Current
• EXPECTED REVENUE (at 1989/90 prices)	2.7	2.7	2.7	2.6	2.4	2.6	2.4	2.7	2.5	2.7	2.7	2.6	2.4	2.6	2.4	3.7	2.2	2.2
• REQUIRED REVENUE TO MEET WATER COSTS	6.6	6.6	7.6	6.3	6.2	6.3	6.2	7.3	7.3	6.6	6.6	6.3	6.2	6.3	6.2	9.7	2.4	2.4
• NET DEFICIT (NPV)	3.8	3.8	4.8	3.6	3.9	3.6	3.9	4.6	4.8	3.8	3.8	3.6	3.9	3.6	3.9	6.0	0.3	0.3
• NET DEFICIT (ANNUAL EQUIVALENT) $'000	233	233	294	220	233	220	233	279	288	233	233	220	233	220	233	360	17	16

(Operating costs + Distribution capital costs +85% of head works capital costs)
"(Allowance for capital costs based on "renewals" accounting principle with existing capital values written off)"

WATER COSTS

- REQUIRED WATER CHARGE TO MEET ACTUAL COSTS BY YEAR 11
  (Assuming 100% volumetric charge)

	D1 H Current	D2H Current	D3H Current	D1L Current	D1L TWE's	D2L Current	D2L TWE's	D3L Current	D3L TWE's	E1 H Current	E2H Current	E1L Current	E1L TWE's	E2L Current	E2L TWE's	H TWE's	P Current	Close down Current
Headworks ($ per megalitre)				22.8	21.9	22.8	21.9	21.5	21.4			22.8	21.9	22.8	21.9	30.7		
Distribution ($ per megalitre)				55.8	56.7	59.1	59.8	71.9	71.2			55.8	56.7	59.1	59.8	52.3		
TOTAL ($ per megalitre)				78.6	78.6	82.0	81.6	93.4	92.6			78.6	78.6	82.0	81.6	83.0		
• INCREASE OVER 1989/90 PRICE (Current mix of rates & volume charges)	1.0	1.0	1.0	3.3		2.8		3.2		1.0	1.0	3.3		2.8			1.0	1.0
• INCREASE OVER 1989/90 PRICE (Volume charge only)				3.2	2.8	3.4	3.4	3.8	3.8			3.2	2.8	3.4	3.4	3.4		
NPV of FLOWS - Volume sold - megalitres	112.7	112.7	108.6	107.3	103.0	107.3	103.0	108.6	109.0	112.7	112.7	107.3	103.0	107.3	103.0	159.0	89.8	89.8

NPV @ 6% over 80 years: Units $ million (1989/90): 15 June 1992

Table 26

INCREMENTAL BENEFITS OF AN IRRIGATED DAIRY FARM OVER DRYLAND FARM OF SAME SIZE

(After paying full cost of water)

Option Description

1. IRRIGATED DAIRY FARM VERSUS DRYLAND FARM - TOTAL REGIONAL SHUTDOWN OF IRRIGATION

Over 80 Years (Improved productivity of dryland: +25% for marginal and +50% for salinity affected dryland)

Area	A	A	B	B	C	C	D	D	E	E
Water Charging Policy	Current	TWEs	Current	TWEs	Current	TWEs	Current	TWEs	Current	TWEs
Strategy 1										
High	7,727	4,258	8,595	5,125	9,462	6,860	10,330	7,727	10,330	8,595
Medium	-10,645	-14,114	-9,777	-13,247						
Low	-22,405	-25,874								
Strategy 2										
High	14,450	10,547	15,231	12,108	16,011	12,889	16,792	13,669	16,792	14,450
Medium	3,589	-314	4,370	1,247						
Low	-8,303	-12,206								
Strategy 3										
High	-10,968	-15,652	-3,942	-7,846						
Medium	-14,164	-18,848	-7,138	-11,042						
Low	-24,092	-28,776								

2. IRRIGATED DAIRY FARM VERSUS DRYLAND FARM - TOTAL REGIONAL SHUTDOWN OF IRRIGATION

Over 15 Years (Improved productivity of dryland: +25% for marginal and +50% for salinity affected dryland)

Area	A	A	B	B	C	C	D	D	E	E
Water Charging Policy	Current	TWEs	Current	TWEs	Current	TWEs	Current	TWEs	Current	TWEs
Strategy 1										
High	7,727	4,258	8,595	5,125	9,462	6,860	10,330	7,727	10,330	8,595
Medium	-10,645	-14,114	-9,777	-13,247						
Low	-22,405	-25,874								
Strategy 2										
High	14,326	10,423	15,107	11,984	15,887	12,765	16,668	13,545	16,668	14,326
Medium	3,465	-438	4,246	1,123						
Low	-8,427	-12,330								
Strategy 3										
High	-14,449	-19,133	-7,423	-11,327						
Medium	-17,644	-22,328	-10,618	-14,522						
Low	-27,572	-32,256								

3. IRRIGATED DAIRY FARM VERSUS DRYLAND FARM - THE MARGINAL FARM (i.e. Other farms in the area remain irrigated)

Over 80 Years (No improved productivity of dryland)

Area	A	A	B	B	C	C	D	D	E	E
Water Charging Policy	Current	TWEs	Current	TWEs	Current	TWEs	Current	TWEs	Current	TWEs
Strategy 1										
High	7,727	4,258	8,595	5,125	9,462	6,860	10,330	7,727	10,330	8,595
Medium	2,799	-670	3,667	197						
Low	2,232	-1,237								
Strategy 2										
High	14,450	10,547	15,231	12,108	16,011	12,889	16,792	13,669	16,792	14,450
Medium	17,033	13,130	17,814	14,691						
Low	16,334	12,431								
Strategy 3										
High	-10,968	-15,652	-3,942	-7,846						
Medium	-720	-5,404	6,306	2,402						
Low	545	-4,139								

4. IRRIGATED DAIRY FARM VERSUS DRYLAND FARM - THE MARGINAL FARM (i.e. Other farms in the area remain irrigated)

Over 15 Years (No improved productivity of dryland)

Area	A	A	B	B	C	C	D	D	E	E
Water Charging Policy	Current	TWEs	Current	TWEs	Current	TWEs	Current	TWEs	Current	TWEs
Strategy 1										
High	7,727	4,258	8,595	5,125	9,462	6,860	10,330	7,727	10,330	8,595
Medium	2,799	-670	3,667	197						
Low	2,232	-1,237								
Strategy 2										
High	14,326	10,423	15,107	11,984	15,887	12,765	16,668	13,545	16,668	14,326
Medium	16,909	13,006	17,690	14,567						
Low	16,210	12,307								
Strategy 3										
High	-14,449	-19,133	-7,423	-11,327						
Medium	-4,200	-8,884	2,826	-1,078						
Low	-2,935	-7,619								

KEY: Strategy - refers to the on-farm and Scheme salinity mitigation and engineering strategy adopted

: High, Medium and Low refers to the land productivity type

INCREMENTAL BENEFITS OF AN IRRIGATED BEEF FARM OVER DRYLAND FARM OF SAME SIZE

(After paying the full cost of water)

Option Description

Area	A	A	B	B	C	C	D	D	E	E
Water Charging Policy	Current	TWEs	Current	TWEs	Current	TWEs	Current	TWEs	Current	TWEs

1. IRRIGATED BEEF FARM VERSUS DRYLAND FARM - TOTAL REGIONAL SHUTDOWN OF IRRIGATION
Over 80 Years (Improved productivity of dryland: +25% for marginal and +50% for salinity affected dryland)

	A Current	A TWEs	B Current	B TWEs	C Current	C TWEs	D Current	D TWEs	E Current	E TWEs
Strategy 1										
High	-7,110	-9,131	-6,605	-8,626	-6,100	-7,615	-5,594	-7,110	-5,594	-6,605
Medium	-21,532	-23,553	-21,027	-23,048						
Low	-24,349	-26,370								
Strategy 2										
High	-5,322	-7,596	-4,867	-6,686	-4,413	-6,232	-3,958	-5,777	-3,958	-5,322
Medium	-15,633	-17,907	-15,178	-16,997						
Low	-18,100	-20,374								
Strategy 3										
High	-19,631	-22,359	-15,538	-17,812						
Medium	-28,840	-31,568	-24,747	-27,021						
Low	-31,408	-34,136								

2. IRRIGATED BEEF FARM VERSUS DRYLAND FARM - TOTAL REGIONAL SHUTDOWN OF IRRIGATION
Over 15 Years (Improved productivity of dryland: +25% for marginal and +50% for salinity affected dryland)

	A Current	A TWEs	B Current	B TWEs	C Current	C TWEs	D Current	D TWEs	E Current	E TWEs
Strategy 1										
High	-7,110	-9,131	-6,605	-8,626	-6,100	-7,615	-5,594	-7,110	-5,594	-6,605
Medium	-21,532	-23,553	-21,027	-23,048						
Low	-24,349	-26,370								
Strategy 2										
High	-5,394	-7,668	-4,939	-6,758	-4,485	-6,304	-4,030	-5,849	-4,030	-5,394
Medium	-15,705	-17,979	-15,250	-17,069						
Low	-18,173	-20,447								
Strategy 3										
High	-21,661	-24,389	-17,568	-19,842						
Medium	-30,870	-33,598	-26,777	-29,051						
Low	-33,438	-36,166								

3. IRRIGATED BEEF FARM VERSUS DRYLAND FARM - THE MARGINAL FARM (i.e. Other farms in the area remain irrigated)
Over 80 Years (No improved productivity of dryland)

	A Current	A TWEs	B Current	B TWEs	C Current	C TWEs	D Current	D TWEs	E Current	E TWEs
Strategy 1										
High	-7,110	-9,131	-6,605	-8,626	-6,100	-7,615	-5,594	-7,110	-5,594	-6,605
Medium	-8,965	-10,986	-8,460	-10,481						
Low	-9,865	-11,886								
Strategy 2										
High	-5,322	-7,596	-4,867	-6,686	-4,413	-6,232	-3,958	-5,777	-3,958	-5,322
Medium	-3,066	-5,340	-2,611	-4,430						
Low	-3,616	-5,890								
Strategy 3										
High	-19,631	-22,359	-15,538	-17,812						
Medium	-16,273	-19,001	-12,180	-14,454						
Low	-16,924	-19,652								

4. IRRIGATED BEEF FARM VERSUS DRYLAND FARM - THE MARGINAL FARM (i.e. Other farms in the area remain irrigated)
Over 15 Years (No improved productivity of dryland)

	A Current	A TWEs	B Current	B TWEs	C Current	C TWEs	D Current	D TWEs	E Current	E TWEs
Strategy 1										
High	-7,110	-9,131	-6,605	-8,626	-6,100	-7,615	-5,594	-7,110	-5,594	-6,605
Medium	-8,965	-10,986	-8,460	-10,481						
Low	-9,865	-11,886								
Strategy 2										
High	-5,394	-7,668	-4,939	-6,758	-4,485	-6,304	-4,030	-5,849	-4,030	-5,394
Medium	-3,138	-5,412	-2,683	-4,502						
Low	-3,689	-5,963								
Strategy 3										
High	-21,661	-24,389	-17,568	-19,842						
Medium	-18,303	-21,031	-14,210	-16,484						
Low	-18,954	-21,682								

KEY: Strategy - refers to the on-farm and Scheme salinity mitigation and engineering strategy adopted
: High, Medium and Low refers to the land productivity type

Table 28 (a) Water Authority Profit and Loss Statements for 4% Return on Assets on the Collie Irrigation District (Values in $millions)

Year of Profit & Loss Statement	A1H Fixed	AIL De-rate	A3H Fixed	A3L De-rate	D1H Fixed	D1L De-Rate	D3H Fixed	D3L De-Rate
Year 5	-1.9	-1.7	-1.9	-1.0	-1.9	-1.8	-1.9	-1.4
Year 10	-1.8	-1.6	-1.8	-0.7	-1.9	-1.7	-1.8	-1.7
Year 20	-1.3	-1.0	-3.3	-2.2	-0.9	-0.7	-1.9	-1.4
Year 30	-1.3	-1.0	-3.0	-1.9	-0.9	-0.7	-1.7	-1.2
Price increase by Year 11	1.0	1.9	1.0	4.1	1.0	1.7	1.0	2.8

Table 28 (b) Water Authority Profit and Loss Statements for a zero% Return on Assets for Collie District (Values are in $millions)

Year of Profit & Loss Statement	A1H Fixed	AIL De-rate	B3H Fixed	B3L De-rate	C1H Fixed	C1L De-Rate	D1H Fixed	D1L De-Rate
Year 5	-0.5	-0.2	-0.6	-0.2	-0.6	-0.2	-0.6	-0.2
Year 10	-0.5	-0.3	-0.6	-0.3	-0.7	-0.2	-0.7	-0.2
Year 20	-0.3	0.1	-0.2	0.1	-0.2	0.1	-0.2	0.1
Year 30	-0.3	0.0	-0.2	0.0	-0.2	0.1	-0.2	0.1
Price increase by Year 11	1.0	1.9	1.0	1.8	1.0	1.7	1.0	1.4

4.4 The Impact on Individual Farmers

All the options, other than Area Option A with a high demand scenario, will have a financial impact on the farm businesses of the Area. In the Low Demand Scenario cases all farm businesses will be affected. In the High Demand Scenario Cases only those outside the boundary of the future service area will be affected.

The financial burden of water price increases, if they are adopted, can be minimised by the way in which the price increases are introduced and other aspects that may be included in the overall strategy (e.g. the introduction of TWEs).

Once an agreed South-West Irrigation Area Strategy is decided each irrigator will need to evaluate their farm operations and plan how much, if any, irrigation water they will continue to purchase and the extent of their irrigated agricultural enterprises.

For some existing farmers this planning may mean the cessation of farming operations in the South-West Irrigation Area, moving to another area, and or out of agriculture altogether. However, it is expected that the majority will simply adjust farm operations to take account of changed water prices and distribution arrangements. Depending on the final strategy adopted many farmers may elect to cease irrigating and continue dryland production from the same land.

Also, the financial impact of the options has been calculated on the average sized enterprise in the Irrigation Area. The impact may vary greatly depending on the size of the enterprise. The impact of a doubling of water prices would be expected to have a larger financial impact on smaller irrigators.

Little is known about the distribution of enterprise size for the horticulture and grazing properties in the Irrigation Area. However, a survey conducted by the Western Australian Farmers Federation in 1990 showed the distribution of dairy farmers by size of home farm area and area permanently irrigated. The distribution is shown in Figures 12 and 13 on the following pages. A summary of the results is also given on the next page in Table 30.

The irrigation committee of WAFF conducted a survey with the assistance of members, to gain information on the details of farms within the irrigation district. This information was collected in August 1990 to assist the Consultative Committee in its Irrigation Strategy Study.

A summary of the results are as follows:

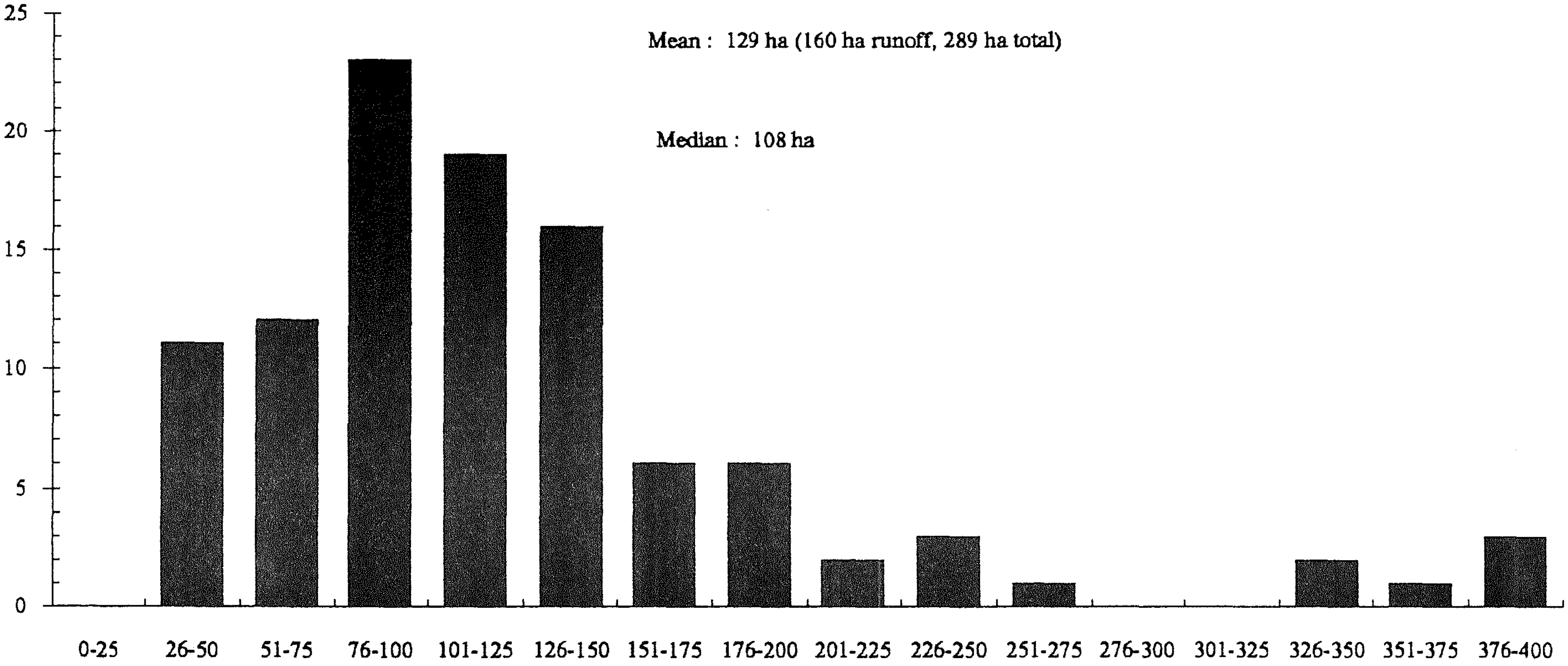
Table 29 Survey of Irrigation Dairy Farms by WAFF

IRRIGATION ON-FARM SURVEY - AUGUST 1990

Area class (ha)	Average	<100	100-150	150-300	>300
Number of farms	107	9	28	45	25
% of farms		8.4	26.2	42.1	23.4
Total farm area (ha)	228	67	134	221	405
Irrigation farm area (ha)	121	52	88	119	188
Runoff farm area (ha)	105	17	45	99	220
Perm past irrig area (ha)	38	19	34	33	51
Early germ irrig area (ha)	12	4	11	12	16
Total irrigated (ha)	50	23	45	45	67
Dairy irrig area (ha)	33	19	30	30	46
Dairy early germ area (ha)	12	4	10	11	16
Dairy annual past area (ha)	88	36	60	82	148
Total dairy area (ha)	133	59	100	123	210
Cows calved	134	78	109	135	181
TOTAL STOCK NUMBERS					
Cows	134	86	128	122	180
Replacements	98	39	82	92	147
Steers	64	15	26	58	131
Total milk prodn ('000 L/yr)	611	364	473	603	881
Avge milk prodn (L/cow/year)	4,560	4,667	4,339	4,467	4,867
HAY					
Area from farm (ha)	29	16	20	28	47
Area runoff (ha)	18	5	9	20	28
Total hay area (ha)	47	21	29	48	75
Dairy Hay requd (t)	172	97	135	163	258
Hay storage (t)	148	60	127	142	206
Grain used (t)	75	72	68	75	91
No. silos	1.1	1.2	1.1	1.23	1.69
Runoff block with irrigation area Yes:		3	11	14	4
No:		6	17	31	21

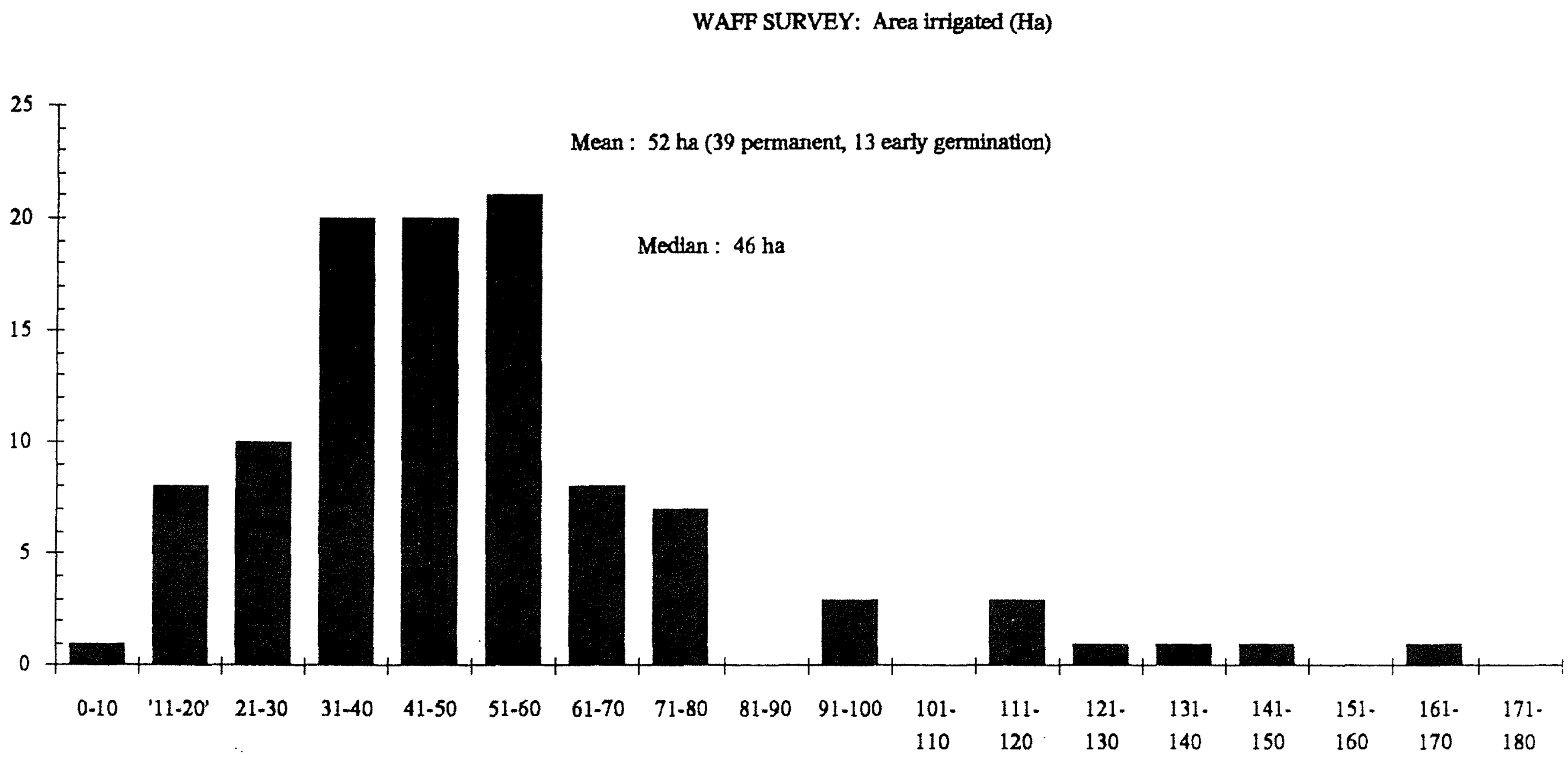
Figure 12

WAFF SURVEY: Area of home farm (Ha)



Source: G Olney, Department of Agriculture, Analysis of WAFF Survey 1990 :7/31/92

Figure 13



Source: G Olney, Department of Agriculture, Analysis of WAFF Survey 1990: 7/31/92

4.5 Extending the Irrigation Services

During the Phase 2 workshops the question was asked whether it would be profitable to extend the current irrigation service to the Myalup Sands to the West of the main Irrigation Area and the foothills of the Darling Scarp (East of the South West Highway).

Two sub options were developed to evaluate these ideas. These sub-options were subjected to the same financial cost/benefit analysis as the main options.

- Myalup Sands

  The Myalup sub-option involved pumping water from the Main Harvey Drain to an area of approximately 600 hectares on the Myalup Sands, west of Harvey. This required the release of extra quantities of water down the drain to ensure a sufficient supply for pumping through a piped scheme servicing fifteen 40 hectare blocks. In total 506 hectares of useable land would be available for permanent irrigation. The value of the net agricultural benefits for horticulture dairying and grazing activities were calculated.

  The costs of supplying water to 15 supply points was then calculated.

  As it was a new irrigation scheme an additional capital cost (5 per cent return on capital) was included in calculating the cost of water to service this area. This is in accordance with the suggested guidelines for new irrigation projects in the Industries Commission's 1992 report entitled "Water Resources and Waste Water Disposal", Report No. 26, July 1992.

- The Foothills

  The pumping of water from existing irrigation channels into farm storage dams on foothills properties with suitable soils adjacent to the channels was also examined. This sub-option required pumping of water every 7 days into the storage dam and then gravity irrigation of the additional permanent irrigated area.

4.5.1 Calculating the Agricultural Benefits

Gross margins were supplied by Peter Eckersley of the Department of Agriculture for horticulure enterprises on the Myalup Sands and the Foothills. These were compared with net agricultural returns for other enterprises using the agricultural net benefits model used to evaluate the main options.

Table 30 shows the net difference in agricultural return per hectare for various enterprise activities compared to dryland beef production.

Table 30 Additional Agricultural Return for Irrigation Compared to dryland Beef Grazing

Use of Land		$/ha
Horticulture	Foothills	1,348
	Myalup	1,560
Irrigation Dairy		397
Early Germination Dairy		279
Dryland Dairy		206
Irrigated Beef		84
Early Germination Beef		36

Source: P. Eckersley, Department of Agriculture for Horticulture Gross Margins for Foothills and Myalup

4.5.2 Engineering Costs

Supply to Myalup Sands involves:

- Construction of 90 megalitre/day pumping station for peak requirements.
- 6 kilometres pipeline (in 6 sections) with offtakes approximately every 200 metres.
- Volume pumped on average 5.26 GL/per annum

  (Based on 13 mL/ha for actual area planted - 80% of area irrigable at any one time - assumes an average of 10.4 GL/a for whole area serviced - 506 ha)

(a) Capital Costs

	$ million
Pipe Costs	2.56
Pump Station (with replacement of Mechanical/Electric Components)	1.79
Contingencies (15%)	0.65
Overheads (5%)	0.22
	5.22

(b) Operating Costs

The operating costs are governed by the head loss through the pipes which in turn is affected by the peak or average nature of the water demand.

If pumping was a uniform rate over the irrigation season basic pump costs would be $54,000 per annum. If peak rates of pumping over 8 hours per day are assumed pumping costs could be $100,000 per annum.

	$
Basic Pumping Cost	85,000
Additional operational costs	5,000
- maintenance	
- meter reading	
Overheads 35%	31,500
Total Operating Costs	121,500

4.5.3 Costs and Charges for Water Provided to Horticultural Farms at Myalup

The following factors need to be considered in setting a water price for water delivered to the Myalup region.:

- capital and operational costs of new distribution (including return on assets).
- component for headworks costs.

In addition the consideration of an allowance for the opportunity costs of the water is also required when considering if it is economic for the State to provide the supply.

The following table summarises the costs which would ensure at least a 5% return on new assets employed, cover the operational costs of the new distribution system and cover the future capital and operating costs of the headworks.

Table 31   Total Cost of Water Supplied to Myalup

	Annual Costs $000's	A1 High Current	C2 Low TWE	E1 Low TWE
		$ per megalitre		
New Capital Costs (at 6% over 80 years)	316.2	60.1	60.1	60.1
Operating Cost	121.5	23.1	23.1	23.1
Headwork Cost (Harvey District)	-	7.7	6.0	5.3
Total		90.9	89.2	88.5

Opportunity costs should be calculated to determine the value of the additional irrigation area to the State's economy. These have been estimated in terms of dollars per megalitre for the selected options in the above table. The opportunity costs of Myalup Irrigation Water range between $120 and $136 per megalitre.

These costs are high and if incorporated in the charge for water would significantly impact on the development of irrigation in the area. However, if the water entitlement was purchased in a market in which all potential alternative users could compete, then this cost would not need to be included in the price of water purchased. The respective economic values would be resolved through the market place.

4.5.4 Summary of Results

- The cost/benefit analysis undertaken in Phase 2 showed that the development of these options would be profitable for horticulture but not for dairying or grazing enterprises.

- Both these sub options would require the movement of water resources from existing users. The most efficient way for this to happen would be through a transferable water entitlement system.

- The development of these areas for horticulture had a positive net economic benefit, even after taking into account full cost recovery and an additional charge of 5% return on capital for new irrigation schemes (as recommended by the Industries Commission). The further investigation of these sub options on a case by case basis is therefore warranted.

5. THE SOCIAL IMPACT OF THE OPTIONS

5.1 Overview

The main social impact from the adoption of options with reduced demand for irrigation water is expected to be a decline in the number of farm businesses and density of irrigated farms as the area of irrigation falls and irrigation farms are replaced by dryland farms.

As the demand for the irrigation water shrinks the number of irrigation farm households and hence farm population will fall. However, most irrigation farm enterprises will be replaced by dryland farm enterprises albeit with larger average areas and hence fewer people.

The decline in the number of people on farms as irrigation farms convert to dryland enterprises is likely to be offset to some extent by an increase in the number of horticultural enterprises which tend to be more labour intensive and a general trend to increased populations in the three irrigation shires due to the growth in other industry.

5.2 Estimating the Changes in the Number of Farm Enterprises

Using the future area estimates generated for each option a set of results were generated to show the number of farm enterprises expected in Year 30 (Table 33).

These calculations were based on the current average size of irrigated farm operations and assuming the current ratio of permanent irrigation to dryland area. Average farm sizes used in these calculations are shown below.

Table 32 Average Farm Sizes (hectares)

Horticulture*	20 hectares		
		Irrigated	Dryland
Dairy	36	Permanent Irrigation	
	14	Early Germination	
	180	Dryland	302
	230		302
Beef	21	Permanent Irrigation	
	8	Early Germinated	
	255	Dryland	284
	284		284

*For the intensive horticulture options (Options H and P) an average property size of 40 hectares was assumed.

The number of people engaged in horticulture is expected to grow under all the Phase 2 options.

As irrigation land is relinquished by grazing and dairy enterprises the number of people engaged in these enterprises in the Irrigation Area may fall.

It is more difficult to predict what will happen to the number of part time and hobby farm operators. It is likely that the number of these (139 in 1989/90) will continue to increase as the population of the region increases whether or not the Irrigation Area shrinks in size. Much of the Irrigation Area is in close proximity to Bunbury and there is every indication that industry in the region will continue to grow. This will continue to fuel the demand for blocks for part-time and hobby farm activities.

Table 33 shows the expected impact of the various options on the number of farm enterprises in the Irrigation Area in 30 years time.

TABLE 33 IMPACT OF OPTIONS ON NUMBER OF ENTERPRISES (BY YEAR 30)

	89/90	A 1,2,3H	A 1,2 L	A 3 L	B 1,2,3H	B 1,2 L	B 3 L	C 1,2,3H	C 1,2 L	C 3 L	D 1,2,3H	D 1,2 L	D 3 L	E 1,2,3H	E 1,2 L	E 3 L	H	P	CD
DAIRY																			
Waroona	9	9	6	5	9	6	5	9	6	5	5	6	5	5	6	5	3	3	3
Harvey	80	76	48	43	77	48	43	77	48	43	70	48	43	40	45	43	22	22	22
Collie	80	78	48	43	78	48	43	79	48	43	79	48	43	80	51	43	21	21	21
Total	169	163	102	91	164	102	91	165	102	91	154	102	91	125	102	91	46	46	46
GRAZING																			
Waroona	16	15	16	16	15	16	16	15	16	16	16	16	16	16	16	16	12	18	18
Harvey	45	41	54	55	43	54	55	43	54	55	46	54	55	54	56	56	45	56	67
Collie	57	57	67	68	57	67	68	58	67	68	58	67	68	57	66	76	76	76	76
Total	118	113	137	139	115	137	139	116	137	139	120	137	139	127	138	140	133	150	161
HORTICULTURE																			
Waroona	4	13	8	8	13	8	8	13	8	8	13	8	8	13	8	8	29	0	0
Harvey	12	41	25	25	41	25	25	41	25	25	41	25	25	41	25	25	67	32	0
Collie	3	9	5	5	9	5	5	9	5	5	9	5	5	9	5	5	0	0	0
Total	19	63	38	38	63	38	38	63	38	38	63	38	38	63	38	38	96	32	0
TOTAL COMMERCIAL FARMS																			
Waroona	29	37	30	29	37	30	29	37	30	29	34	30	29	34	30	29	44	21	21
Harvey	137	158	127	123	161	127	123	161	127	123	157	127	123	135	126	124	134	110	89
Collie	140	144	120	116	144	120	116	146	120	116	146	120	116	146	122	116	97	97	97
Total	306	339	277	268	342	277	268	344	277	268	337	277	268	315	278	269	275	228	207

PARTI/TIME HOBBY

Waroon	26
Harvey	72
Collie	41
Total	139

5.3 Population Movements in the South-West Irrigation Area

An analysis of recent population trends shown in Table 34 for the three shires incorporating the Irrigation Area shows that over the last decade to 1991 the population grew by 42 per cent whilst the area irrigated fell by 18 per cent.

Table 34 Recent Changes in Population in the Irrigation Area

	Area Irrigated (ha)	Population (3 Irrigation Shires)	Irrigation Area Total Population	Irrigation Area Population	Irrigation Area Employment in Total	(excluding towns)
1981	14,690	14,375	8,934	3,608	934	755
1986	12,851	17,359	9,247	3,763	853	717
1991	12,100	20,471	NA	NA	NA	NA

Notes: (1) NA - Not Available
(2) Detailed data for Collector Areas from the 1991 Census is not expected to be available until late in 1992 to enable this table to be completely updated.
(3) The Irrigation Area comprises Collector Areas 0615, 0616, 0617 and 0503.

The impact of the reduction of commercial irrigated farming businesses on reductions in the number of people in the South-West Irrigation Area is likely to be masked by the general increase in the population of the South-West Irrigation Area. Any drop in resident farm population due to the decline in the number of commercial irrigated farm enterprise is expected to be more than offset by increases in population flowing on from increased retirement settlement and increased resource processing, industrial activity in the Perth to Bunbury strip resulting in more employment options in the region. Whilst the nature of the population mix may well change (in terms of occupation and age) the region is expected to undergo further increases in population regardless of which irrigation option is adopted.

During the Phase 1 survey of irrigators a number of people expressed a concern about the negative effects of population increase in the area due to urban encroachment and industrial development. However, it was ranked as the seventh issue of concern along with other concerns such as the increasing price of land, pressure from the environment movement and the problem of having to maintain productivity increases.

Farmers in the South-West Irrigation Area are fearful that farming will be 'over run' by other industry. Whilst farmers are divided in their opinion on whether increasing population due to urban development or industry is a problem the commonly expressed concerns are:

- downgrading of the agricultural importance of the area;
- possible loss of jobs;
- wasting of highly productive agricultural land; and,
- the loss of tourist and aesthetic value of green fields in summer.

It was concluded that the major social impact changes on the Irrigation Area will continue to be due to factors other than the Irrigation Strategy adopted. Planners should be mindful of the concerns expressed by farmers and in particular about the impact of urban and industrial encroachment onto high productivity land.

5.4 The Impact on Individual Farmers

All options other than Area Option A with a high demand, will produce a financial impact on some or all individual farm businesses. This has been described in Section 4.4 of this report. This in turn will produce a social impact on individual farm households.

There may be significant disruptions to households from decisions to cease irrigation activities and revert to dryland production (in some cases the social consequences could well be positive as less out of hours work activities would be required). In some cases the financial assessment of the outcome of the strategy may lead to the decision to relocate to another district or leave farming altogether.

It is recognised there will be considerable social impact on individual farm families from the adoption of different options. The final strategy can, however, significantly affect the social impact. For example, long lead times could be given to enable individuals to plan their futures and continue to provide advisory and social support services to assist farmers to make these adjustments with minimal impact on their families and themselves. These aspects need to be further developed in Phase 3 and 4 of the Study.

6. ENVIRONMENTAL EVALUATION I - NUTRIENT DISCHARGE

6.1 Introduction

The shallow, poorly flushed estuaries and wetlands of the South-West of Western Australia are very susceptible to major algae blooms when their streamflow input is enriched by nutrients.

The process of nutrient enrichment (eutrophication) has become a major problem in most of the western and southern coastal estuaries where sandy coastal soils have been cleared for agricultural development.

The worst example is the Peel/Harvey Estuary. However, real concerns also exist about the eutrophic state of the Leschenault Inlet.

All of the Waroona District and 50% of the Harvey District drain to the Peel/Harvey Estuary. All of the Collie District and 35% of the Harvey District drains into the Leschenault Inlet. Consequently nutrient discharge from the irrigation districts is a major environmental factor to be considered in the future of the irrigation service.

Investigations into the cause of eutrophication of the Peel/Harvey estuary commenced over 15 years ago. The final outcome has been the adoption of a major Government restoration program to significantly reduce the frequency of algal blooms in the estuary.

It has two components. The first is the construction of the Dawesville cut; a new channel between the ocean and the estuary to promote increased flushing of nutrients from the estuary each tidal cycle. The second is a catchment management program aimed at reducing nutrients discharge from the coastal plain catchment to the estuary by 50%. Both components are necessary if algal blooms in the estuary are to be controlled.

Investigations into the sources of nutrients commenced in the late 1970s and showed that Phosphorous was the limiting nutrient for algal growth.

Subsequent sampling and analysis has concentrated on this nutrient. The annual load of total phosphorus to an estuary, relative to the estuary's surface area, is the most critical parameter affecting its eutrophic status. The annual nutrient load is essentially a product of the annual average total phosphorus nutrient concentration with the average annual streamflow. The highest concentrates of dissolved phosphorus in the coastal plain areas are recorded on the Bassenden Sands to the west of the current irrigation districts (Ref 1).

Initial catchment management actions were centred on reducing nutrient loads from these areas. However as studies progressed through the 1980's there has been a growing realisation that high nutrient loads also occur from irrigated areas. High water yields, combined with moderate concentrations of total phosphorus in streamflow, produce a total phosphorous discharge loads that are similar to those from the Bassenden soils. In addition irrigated dairying is now seen as a significant contributor to phosphorus input into coast estuaries (Ref 2).

A reduction of 50% in the overall nutrient load to the Peel/Harvey Estuary will be difficult to achieve. In establishing this target Government has argued that, for equity reasons, all parts of the catchment should seek to reduce their contribution by 50%.

While this approach can be considered to apply at a sub catchment or individual farm scale, it has been taken here to apply to that portion of the current irrigation area which drains into the Peel/Harvey Estuary.

Major improvements in nutrient discharge management of irrigated lands will be required to achieve the 50% target. In this analysis estimates are made of the effect of future options for the irrigation service.

These have been prepared to highlight the relative impact of different scales of irrigation and roughly compare them with other nutrient management methods which are likely to be introduced over the next 15 plus years.

6.2 Phosphorous Export

6.2.1 General Approach

While considerable nutrient monitoring has been carried out at large catchment scales and for detailed small catchments with sandy soils, it has only been in the last one or two years that monitoring of irrigated dairying areas has commenced.

However, data from two catchments, one with reliable flow data and the other with reliable nutrient concentration, data are available to estimating average nutrient export rates from irrigated land. This is supplemented by additional sampling data from north of the irrigation district by the Department of Agriculture (Ref. 3). This information, together with related estimates from the literature enabled estimates of average rates of total phosphorous export per cleared per hectare to be made for a range of soil types, farm enterprise types and types of irrigation.

Nutrient loads contributing to the three catchments of the Peel/Harvey, Leschenault Inlet and the Harvey Diversions Drain were calculated in the following way. Areas of enterprise type, irrigation type were estimated from the Agriculture Economics Model. Existing mapping defined the known soil and catchment boundaries. Simplifications of soil types into the two categories were adopted - Dardanup loams and Pinjarra plains clays. Small areas of Serpentine River and Southern River soils were assumed to have the same phosphorous export rate per ha as the Guildford Formation or Pinjarra plain clays.

While known to be a simplification, the areas of these soils within the irrigated districts were relatively small. Drainage boundaries were defined from mapping of the drainage network through the area. Digital computation of the intersection of drainage boundaries with soil boundaries were performed to estimate the areas of agricultural land in each soil type within each catchment for each Irrigation Strategy Option.

The resultant areas were simply multiplied by their respective annual average total phosphorus export rate and summed over each catchment to estimate the annual total phosphorus discharge for each catchment.

6.2.2 Total Phosphorous Annual discharge rates

(a) Irrigated and Dryland Beef Grazing

Irrigated beef grazing is the main land use within the Sampson Brook North Catchment in the Waroona Irrigation District.

Reliable phosphorous concentrations have been estimated since 1983. However water yields are unreliable as the definition of the catchment is unclear. An adopted figure of 350mm, taken from Vindictive Drain Catchment (Phase 2 Supplementary Paper 4) has been adopted. The annual total phosphorous concentration between 1983 and 1988 was 0.376 mg/L.

The resultant total phosphorous discharge for the catchment is $3500m^3/ha \times 0.376 \times 10^{-3} kg/m^3 = 1.31$ kg/ha of total phosphorous export per annum.

Sampling in the Mundijong/Serpentine area in 1991 by the Department of Agriculture suggests that dryland beef grazing nutrient discharge could range from 0.4 kg/ha to about 1.0 kg/ha.

A figure of 0.6 kg/ha has been adopted here as representative of discharge from the heavier clay soils of the Pinjarra Plain. On the basis that 30% of the North Sampson Brook Catchment was irrigated then the nutrient land for the irrigated paddocks would be approximately 3.0 kg/ha.

Discharge from the Dardanup loam soils has been taken as 40% of discharge from the heavier Pinjarra Plain clays. This is based on the current estimates being used by the Department of Agriculture in their Decision Support System Model of nutrient discharge from coastal plain.

(b) Dairying

The stocking rates assumed for beef grazing and dairying are similar. Therefore the general paddock grazing contribution to nutrient discharge are likely to be similar for a beef or a dairy herd. However the dairy and associated holding paddocks and feeding areas on a dairy farm significantly add to the nutrient export of a dairy farm overall. It is common practice for dairies to discharge washdown waters into nearby surface drains. These discharges contain faeces and waste milk accumulated from the milking sheds. In addition the twice daily washdown, commonly involves the use of phosphate based detergent cleaners and phosphoric acid as a sterilising solution. The Department of Agriculture has estimated a Phosphorous export rate of about 3.3kg/cow per annum from one large dairy and associated feeding area in the district. This translates to about 350kg/yr per average 107 cow herd. For the average irrigated dairy farm of 230 ha, this represents a unit area load of 1.53 kg/ha per annum.

For a larger scale dryland farm it represents 1.17 kg/ha but was rounded down to 1.0 kg/ha because of lower likelihood of waterlogging and direct discharge to drainage on a dryland farm.

To be useful in the context of the predicted areas of farm enterprises produced from the Agricultural Economic Model of the options, the additional nutrient load from the dairy and associated yards must be distributed between the irrigated perennial pastures, the irrigated annual pastures and the dryland pastures. This was done using the average proportions of each as determined from the WAFF dairy farm survey.

The resultant nutrient loads were added to the previous beef grazing values to obtain the final estimates for the dairy enterprises. Note that the irrigated annual pastures were assumed to discharge at the same rate as dryland pastures plus 20% of the difference between irrigated perennial and dryland pastures. This is proportional to the water application rates for irrigated annual pasture relative to irrigated perennial pastures.

The additional nutrient discharge from dairies and the associated yards was not varied between soil types. The resultant figures are summarised in Table 35.

Table 35 Total Phosphorous Annual Export Rates per Unit Area

		SOIL TYPE	
IRRIGATION TYPE	FARM ENTERPRISE	DARDANUP LOAMS (kg/ha)	PINJARRA PLAIN SOILS (kg/ha)
Horticulture	Fruit	1.00	-
	Vegetables	1.00	-
Irr. Perennial	Dairying	5.20	7.00
	Grazing	1.20	3.00
Irr. Annual	Dairying	2.03	2.68
	Grazing	0.41	1.10
Dryland	Dairying	1.24	1.60
	Grazing	0.24	0.60

Table 36 summarises the areas of agricultural land of high, medium and low productivity within the 2 soil types and three catchment areas in the Harvey Irrigation District. Also shown are the different catchment areas for Option D where the drainage has been altered.

Table 36 Areas of Agricultural Land by Catchment Area in the Harvey Irrigation District (hectares)

CATCHMENTS	Peel/Harvey Catchment		Leschenault Catchment		Harvey Diversion Drain Catchment	
SOIL TYPE	Dardanup Loams	Pinjarra Plain Clays	Dardanup Loams	Pinjarra Plain Clays	Dardanup Loams	Pinjarra Plain Clays
With current Drainage						
High	815	4584	1502	669	1347	643
Moderate	72	673	4	480	37	194
Low	63	1028	0	2446	0	94
With modification to drainage for Option D						
High	0	1705	2152	3712	1347	643
Moderate	0	291	76	862	37	194
Low	0	759	63	2715	0	94

Depending on the Agricultural Economic Model, each option results in a different mix of farm Enterprises within each productivity zone. The product of those areas with the Table 37 unit area discharge rates are summed across each catchment to provide the final total phosphorous export for each option.

6.2.3 Phosphorous Export Estimates for the Strategy 1 Options

Tables 37 and 38 summarise the total annual tonnes of phosphors exported to the three catchment outlets from the study area for the Strategy 1 options at year 30 for the high and low water demand cases.

with the exception of Option D1H in the Leschenault Catchment and B1H in the Peel Harvey Catchment all options result in reduced nutrient export loads relative to maintenance of the current situation (Option A1H).

Table 37 Strategy 1 Phosphorus Export Totals for the High Water Demand Case at Year 30 (Tonnes of Total Phosphorus per Year)

Option and District		Peel/Harvey Catchment	Leschenault Catchment	Harvey Diversion Drain Catchment
A1H	- Waroona	6.79	-	-
	- Harvey	19.41	12.16	5.06
	- Collie	-	36.40	-
	Total	26.20	48.56	5.06
B1H	- Waroona	6.54	-	-
	- Harvey	20.07	9.65	5.49
	- Collie		36.30	-
	Total	26.61	45.95	5.49
C1H	- Waroona	5.86	-	-
	- Harvey	19.49	9.06	5.32
	- Collie		34.27	-
	Total	25.35	43.33	5.32
D1H	- Waroona	3.81	-	-
	- Harvey	6.55	19.87	4.89
	- Collie	-	34.27	-
	Total	10.36	54.14	4.89
E1H	- Waroona	3.81	-	-
	- Harvey	11.38	6.27	3.15
	- Collie	-	35.29	-
	Total	15.19	41.56	3.15
P	- Waroona	2.82	-	-
	- Harvey	7.72	5.02	2.22
	- Collie	-	15.74	-
	Total	10.54	20.76	2.22

Table 38 Strategy 1 Phosphorous Export Totals for the Low Water Demand Case at Year 30 (Tonnes of Phosphorus Per Year)

Option and District		Peel/Harvey Catchment	Leschenault Inlet Catchment	Harvey Diversion Drain Catchment
A1L	- Waroona	4.99	-	-
	- Harvey	13.80	7.05	3.85
	- Collie	-	24.45	-
	Total	18.79	31.50	3.85
B1L	- Waroona	4.99	-	-
	- Harvey	13.80	7.05	3.85
	- Collie	-	24.45	-
	Total	18.79	31.50	3.85
C1L	- Waroona	4.99	-	-
	- Harvey	13.80	7.05	3.85
	- Collie	-	24.45	-
	Total	18.79	31.50	3.85
D1L	- Waroona	4.06	-	-
	- Harvey	4.89	17.15	3.85
	- Collie	-	25.72	-
	Total	8.95	42.87	3.83
E1L	- Waroona	4.25		-
	- Harvey	12.26	6.57	3.45
	- Collie		26.34	-
	Total	16.51	32.91	3.45
CD	- Waroona	2.82		-
	- Harvey	7.25	4.83	1.93
	- Collie	-	15.74	-
	Total	10.07	20.57	1.93
H	- Waroona	3.68		-
	- Harvey	8.37	5.09	2.51
	- Collie		15.74	-
	Total	12.05	20.83	2.51

In the most critical catchment of the Peel/Harvey, however, a target of a 50% reduction has already been set by Government.

Under a high demand scenario cases, Options D1H, P and H and Closedown would achieve the 50% reduction target if no other management actions were taken. The small increases in nutrient discharge in the B1H case is caused by an increase in dairying in the Harvey Districts.

The higher nutrient export to the Leschenault Inlet catchment in Option D1H (11.5%) is a result of the proposed extensions to the Mangosteen Drain which redirects approximately 5,100 ha from the Peel/Harvey Catchment to the Leschenault catchment. There is scope to modify the current siphon at the Mangosteen Drain - Harvey Division Drain intersection so that some of the flow can be diverted down the Harvey Division Channel. This will not be able to occur at times of high flow in the Harvey Diversion Channel as backwater effect could potentially exacerbate flooding along the Mangosteen Drain. Consequently the relative amount of the nutrient discharge which could be diverted into the Harvey Diversion Channel is uncertain at this stage. It is likely, however, that a system could be developed so that the overall nutrient input to the Leschenault Catchment (given the extension of Mangosteen Drain as proposed in Option D, was not increased. Further detailed investigations would be required and additional costs over those estimated in Option D would be required.

Under the low water demand scenario nutrient export is likely to reduce to at least 72% of current levels without additional nutrient management improvement in all cases. However, again only options D1L, P and H and Close Down achieve a 50% reduction in nutrient exports if no other management actions were taken. Note also that in the Low Demand Case nutrient export to the Leschenault Inlet is not increased in Option D relative to current discharge.

6.2.4 Phosphorous Export Estimates for Series 2 Options and Additional Nutrient Management Strategies

The Strategy 2 Options improve water application and efficiency rates by about 20 to 25% each watering. However, twice the waterings are proposed and an overall 10% reduction of on-farm water needs has been assumed in the other components of the study.

In the nutrient calculations context a 15% reduction in nutrient export has been adopted. A reduction in proportion to the water efficiency improvement would be the first simple estimate. However, the redesign of bays, table drains and head-ditches proposed under Strategy 2 provides scope to improve the nutrient retention potential if specifically considered in the redesign. A higher reduction than 15% is clearly possible but further development and demonstration of the effectiveness of other techniques is required before a higher figure could be adopted.

The high nutrient discharge from the dairies and associated yards has already been targeted as a major area for improved management.

The Department of Agriculture has been working with selected farmers to build holding ponds to minimise nutrient discharge from such areas. Reductions of order 50% and higher are considered possible.

Annual export rates per unit area for a range of improved management measures are summarised in Table 39. They include the 15% reduction estimated from the introduction of Strategy 2 and a range of reductions from different degrees of control of dairy effluent.

Table 40 summarises the resultant nutrient export rates to the Peel-Harvey Estuary from the Irrigation Area for selected options.

Table 39 Total Phosphorous Annual Export Rates per Unit Area given improved Nutrient Management

		DEGREE OF 'DAIRY EFFLUENT' CONTROL					
		50%		75%		90%	
IRRIGATION TYPE	FARM ENTERPRISE	Dard. Loams	Pinjarra P.Clays	Dard. Loams	Pinjarra P.Clays	Dard. Loams	Pinjarra P.Clays
Horticulture	Fruit	1.0	-	1.0	-	1.0	-
	Vegetables	1.0	-	1.0	-	1.0	-
Irr. Perennial	Dairying	3.02	4.55	2.02	3.55	1.42	2.95
	Grazing	1.02	2.55	1.02	2.55	1.02	2.55
Irr. Annual	Dairying	1.17	1.72	0.77	1.32	0.53	1.08
	Grazing	0.35	0.94	0.35	0.94	0.35	0.94
Dryland	Dairying	0.70	1.01	0.45	0.85	0.30	0.61
	Grazing	0.20	0.51	0.20	0.51	0.20	0.51

Note: Assumes that a 15% reduction occurs in nutrient export from irrigated and dryland paddocks due to the adoption of Strategy 2 improved on-farm practices.

Table 40 Total Phosphors Annual Export Totals Given Improved Nutrient Management for the Peel/Harvey Catchment

Option and District		Zero Dairy Effluent Reduction	50% Dairy Effluent Reduction	75% Dairy Effluent Reduction	90% Dairy Effluent Reduction
A2H	- Waroona		5.02	4.47	4.13
	- Harvey		13.20	10.49	8.98
	Total		18.22	14.96	13.11
E2H	- Waroona	3.49	2.84		
	- Harvey	10.57	7.97		
	Total	14.06	10.81		
E1H	- Waroona	3.81	3.11		
	- Harvey	11.38	8.53		
	Total	15.19	11.64		
C2H	- Waroona			3.67	3.34
	- Harvey			10.22	8.63
	Total			13.89	12.97
A2L	- Waroona		3.76	3.32	
	- Harvey		9.57	7.63	
	Total		13.33	10.95	
C2L	- Waroona		3.76	3.32	
	- Harvey		9.57	7.63	
	Total		13.33	10.95	

Table 40 (Continued)
Total Phosphors Annual Export Totals Given Improved Nutrient Management for the Peel/Harvey Catchment (Continued)

Option and District	Zero Dairy Effluent Reduction	50% Dairy Effluent Reduction	75% Dairy Effluent Reduction	90% Dairy Effluent Reduction
D2L - Waroona		2.96		
- Harvey		3.40		
Total		6.36		
E2L - Waroona		2.96		
- Harvey		8.49		
Total		11.45		

Table 40 shows that very high levels of control of effluent from dairies throughout the region will be required if the 50% reduction target from the irrigated area is to be achieved. This is particularly the case if demand for irrigated land remains high.

The degree or percentage of dairy effluent reduction necessary to achieve a 50% reduction in nutrient discharge from Irrigation Area draining to the Peel/Harvey catchment has been estimated from Tables 37 and 41 and summarised in Table 41. Table 41 shows the effect of Area Options, the High and Low Demand scenarios and the effect of the two on-farm nutrient management strategies.

The table demonstrates that it will be virtually impossible to achieve a 50% reduction in total nutrient export form the irrigated area if no other action, other than controlling dairy effluent takes place.

If demand for a irrigated agricultural land remains high, then the application of improved watering and improved fertiliser practices on paddocks together with dairy effluent control, will be a high priority for nutrient management.

Table 41 Percentage of Dairy Effluent Control Necessary to Achieve 50% Reduction in Nutrient Discharge to Peel/Harvey Estuary

Area Option	Strategy 1 High Water Demand	Strategy 1 Low Water Demand	Strategy 2 High Water Demand	Strategy 2 Low Water Demand
A	100 +	65	90	52
B	100 +	65	90 +	52
C	90 +	65	84	52
D	0	0	0	0
E	30	40	15	20
H	0	-	0	-
P	0	0	0	-

Note: Based on Table 36 and Table 40 together with some additional runs not included in either table.

6.3 Conclusions

- A trend the towards conversion of irrigated agriculture to dryland grazing will reduce nutrient inputs to the Peel/Harvey and Leschenault Estuaries from the South-West Irrigation Area.

- Given a high demand for irrigation land and no other nutrient management control measures, the irrigation areas would have to reduce to only 25% of their current size in Waroona District (Option D) and less than 32% (Option E) in the Harvey Districts to achieve a 50% reduction in the nutrient load to the Peel/Harvey Estuary.

- The extension of Mangosteen Drain (Option D in Harvey) reduces nutrient loads from the Irrigation Districts by over 50% and maintains about 65% of the original irrigation district.

- Given a low demand for irrigation land, and no other nutrient control measures, then nutrient loads from the current irrigation are likely to reduce to at least 72% of current levels (options A1 Low to C1 Low).

- If a high water demand occurs then over a 90% reduction in nutrient discharge from farm dairies and associated holding areas, and a 15% reduction of nutrient discharge from farm grazing paddocks, would be required to achieve the overall 50% reduction in nutrient export.

- If a low water demand occurs, then about a 65% reduction in nutrient discharge from farm dairies and associated holding areas, would be required to achieve the overall 50% reduction area nutrient export. If improved water practices and associated other measures are introduced which reduce nutrient discharge from paddocks by 15% (Strategy 2), then dairy discharge would only have to be reduced by about 50%.

- Option E, which restricts irrigation to the Dardanup Loams in the Peel Harvey Catchment, would required about a 30 to 40% reduction in nutrient discharge from dairies and associated holding areas to achieve the overall 50% reduction in nutrient export. If improved watering practices and other nutrient controls were introduced (Strategy 2), then dairy discharge would only need to be reduced by 15 to 20%.

- Options D, H and P could achieve a 50% reduction in overall nutrient export without additional on-farm nutrient management measures being taken.

7. ENVIRONMENTAL EVALUATION II - WATER LOGGING, SALINITY AND PASTURE PRODUCTIVITY

7.1 Introduction

The Phase 1 report highlighted the significance of a salinity mitigation strategy to the long term future of the irrigation districts. In that preliminary analysis a comprehensive salinity mitigation strategy was costed at over $51 million (NPV over 30 years).

The economic analyses indicated that, if such a program was required to maintain current pasture productivity levels, then the overall irrigation scheme would be uneconomic. The need for a much more detailed investigation of the salinity issue in Phase 2 was clearly highlighted.

The following section summarises the investigations carried out to better define the regional and local hydrogeological settings of the salinity problem, and to determine the most appropriate salinity mitigation strategies to evaluate in detail.

7.2 Hydrogeological Investigations

Two new studies were commissioned to build on and update the Department of Agriculture's work on salinity on the coastal plain. They were designed to assist in the development of the most appropriate range of salinity mitigation strategies to be costed in the Phase 2 studies.

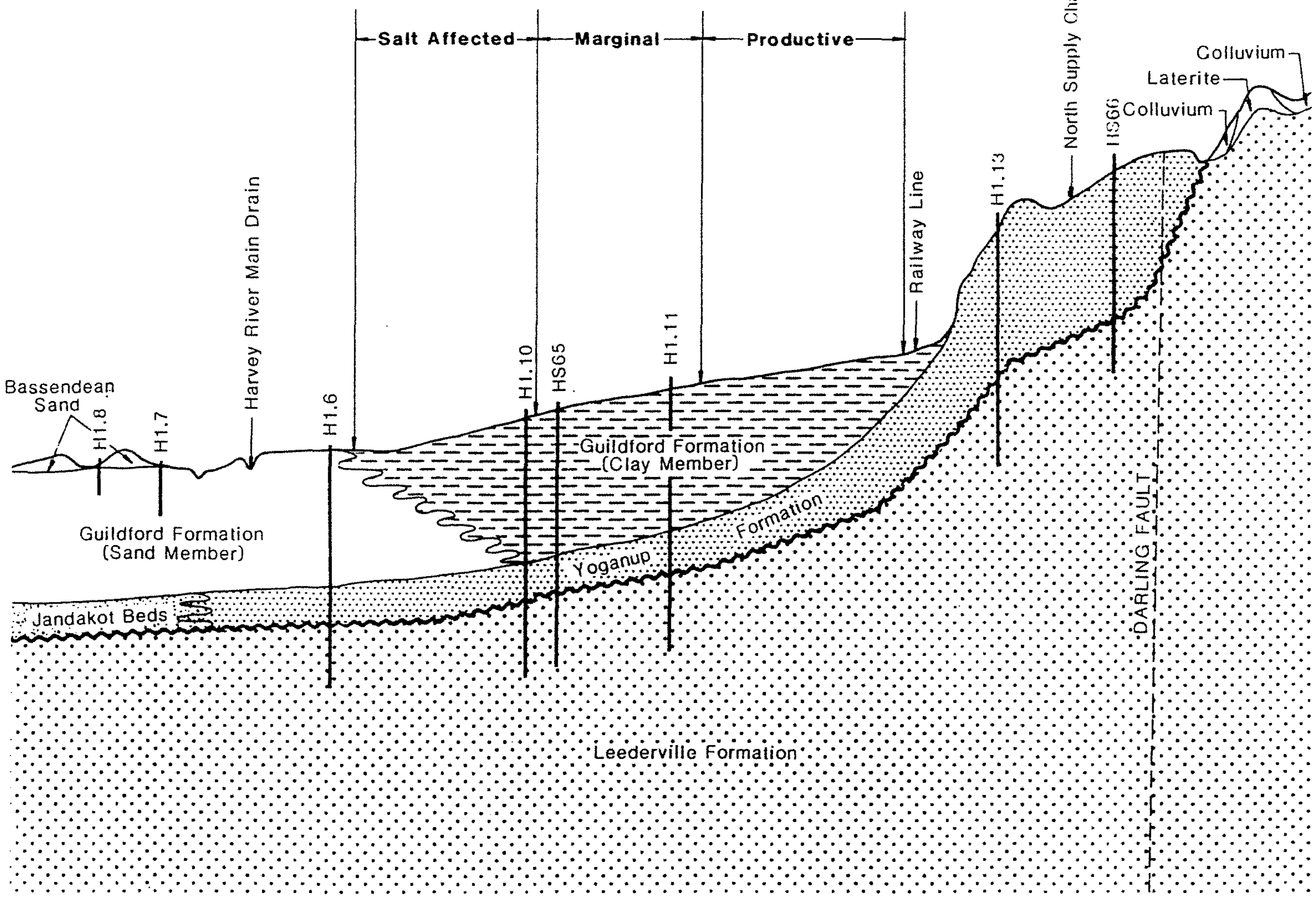
Mackie Martin & Associates were engaged to integrate the collective hydrological knowledge of the area and the effect of irrigation on regional groundwater flow systems. A groundwater model of 2 cross-sections of the coastal plain was calibrated against known groundwater monitoring data and available knowledge on hydraulic properties of the aquifer systems. Figure 14 shows the Harvey (Cookernup) cross-section and Figure 15 shows the simulated steady state distribution of salinities at the Cookernup cross-section. Estimates were made of groundwater recharge from both upslope and within the irrigation district and model runs carried out to evaluate the regional impact of different salinity strategies. The drain spacings necessary to achieve a 1.5 metre reduction in regional water tables was also studied using drainage theory and outputs from the model. The results are included as in Attachment 6.

To ensure the best possible input data to the modelling, estimates of channel leakage and groundwater recharge were reviewed and upgraded. Water and salt balances of a small (200 ha) irrigated catchment on the coastal plain near Dardanup (Vindictive Drain) were completed for a ten year period to 1987/88, updating earlier work by the Department of Agriculture. These are summarised in Supplementary Paper Number 4. Channel leakage estimated were also made at a number of points through the districts and channel losses distributed through the districts.

The main conclusions from the hydrogeological investigations are discussed below.

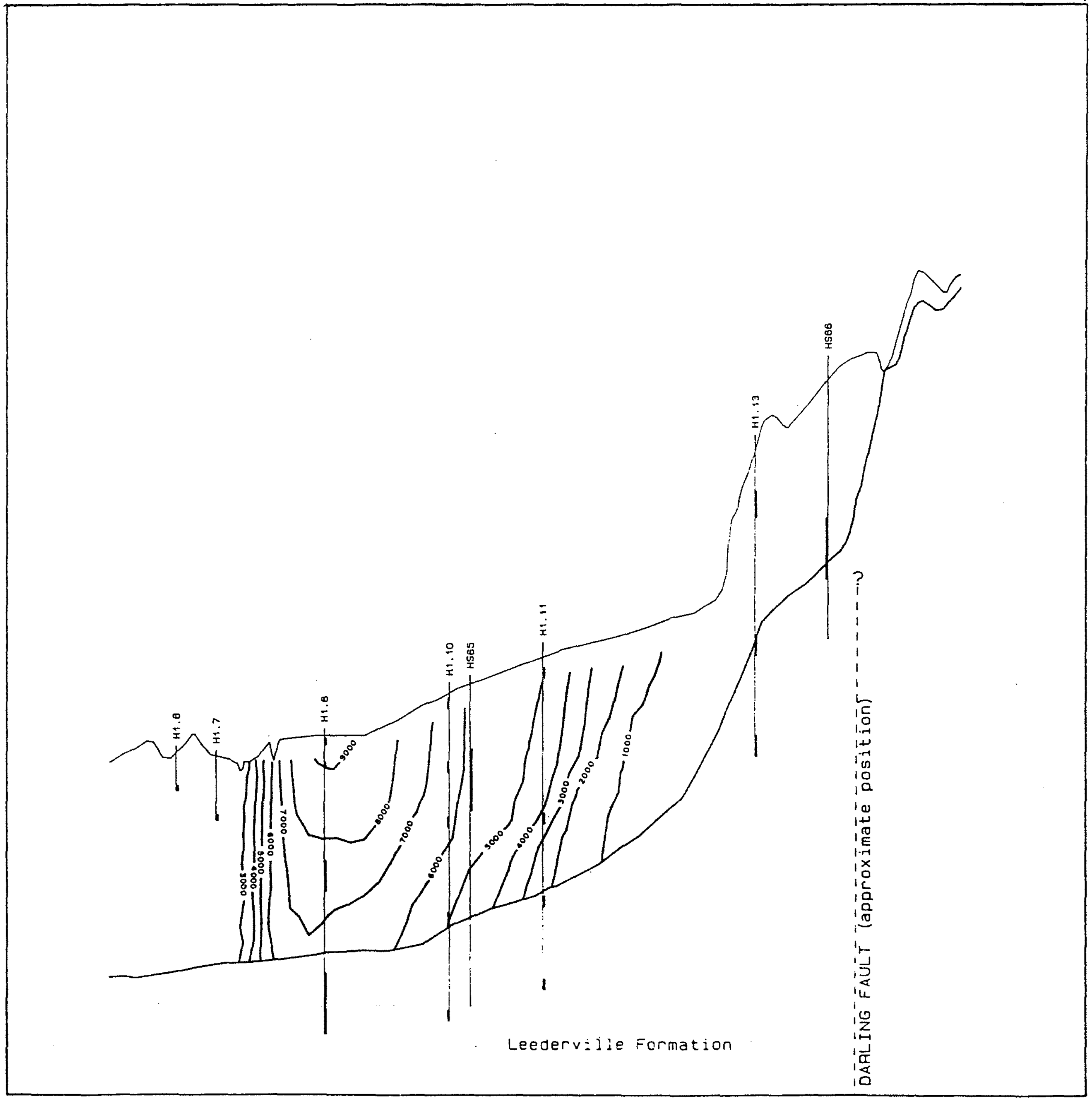
Figure 14

COOKERNUP GEOLOGICAL CROSS-SECTION



Horizontal Scale 1:40000
Vertical to Horizontal 1:50

Mackie Martin & Associates PTY. LTD.
GROUNDWATER ENGINEERS & EARTH SCIENTISTS



WATER AUTHORITY OF W.A.
GROUNDWATER INVESTIGATIONS
for the
IRRIGATION STRATEGY STUDY
SOUTH-WEST WESTERN AUSTRALIA

LEGEND:

- ——— Base of Superficial Formations
- - - - - Darling Fault
- H1.7 Borehole
- ——— Screened Interval
- ——— Concentration Contour (TSS)

NOTES:

Vertical exaggeration: 100x.
Data compiled from bores completed by the Agricultural Department.

0 500 1000 1500 2000 2500 M

ORIGINAL SCALE 1: 40000

SIMULATED SEASONALLY AVERAGED TSS
COOKERNUP

Mackie Martin & Associates
GROUNDWATER ENGINEERS

Figure 15

The control of recharge upslope from the irrigation district has only a small effect on the groundwater levels in the critical western and central regions of the irrigation district. The effect is to mainly reduce recharge to and pressure heads in the underlying Leederville aquifer. This has only an indirect benefit by enabling a greater downward flow from the superficial formations. Some benefits of improved salt flushing from the shallow soils will occur. However, spending large sums of money to reduce recharge form either channel leakage or upslope cleared areas would not be very cost effective from a salinity perspective.

There is scope for lowering water tables by improving irrigation watering practices. A 50% reduction in groundwater recharge throughout the region could lower regional water tables at the end of summer by about 0.3 of a metre.

The phasing out of irrigation in the saline western portion of the current districts could reduce regional water tables in that area by 0.6 to 0.7 metres. The impact of recharge control is effectively limited to the region over which the control occurs.

While seen as relatively minor by effects on the regional water table by Mackie Martin and Associates these changes have potential to positively impact pasture productivity.

The salt balance calculation of Vindictive Drain Catchment (Supplementary Paper Number 4) indicated that salts accumulate over the summer months in the shallow soils of the catchment and are leached from the catchment each winter. However, net winter leaching is insufficient to remove the summer accumulation and a net annual salt accumulation of 500 kg/ha/annum results.

Lower estimates of accumulation would be occurring in the shallow soils of the Harvey district. Mackie Martin (Supplementary Paper 3) used these shallow soil accumulations rates, together with other input from channel leakage and computed fluxes from their modelling, to calculate regional hydrogeological salt balances for the Cookernup and Waterloo cross-sections.

From this regional perspective the results suggest that the Harvey Irrigation Area is close to equilibrium with respect to salt inputs and outputs. Much of the shallow soil, salt accumulation and salt from channel leakage appears to recharge the Leederville Groundwater System in the eastern productive portions of the Harvey district.

In the Collie area, a net accumulation of salt was calculated, with the highest accumulation rate in the western (salt affected region). Higher supply water salinities and lower rates of Leederville leakage are the main reasons for the difference between net salt balance in the two cases.

However, only gradual increases with salinities in the Collie District over the next thirty years are expected.

Review of the groundwater hydrograph data in the irrigation districts indicates that water table levels are controlled by existing surface drains and evaporation from the water table. Significant increases in the level of shallow water tables are not expected in the Harvey district. Some increases are still occurring (Phase 1 Background Paper 6) in the Collie Districts. However, overall future productivities from agriculture will be governed by the slow increases in groundwater salinities in the Collie District more than anything else.

The overall picture then is that pasture productivity is already affected by high saline groundwaters in the western portions of the irrigation district, but that the situation will not deteriorate greatly, particularly in the Harvey District.

Table 42 summarises the estimated utilisable tonnes of dry matter/ha with current levels of salinity and current practices. Although a minor decline is likely in the Collie District these figures have been used as the basis of scaling the gross margins across the districts for the Strategy 1 Options. Details of the approach used are given in Section 3.2.1.

Table 42 Current Pasture Productivity Levels (Utilisable Tonnes of Dry Matter/ha)

Pasture Type	High Productive Land	Medium (Marginally salt affected)	Low (Salt affected)
Irrigated perennial	7.6	5.7	3.8
Early germination	6.0	4.8	3.0
Annual	4.4	3.8	2.2

7.3 Possible Salinity Mitigation Strategies

Means of improving pasture productivity cost effectively is crucial if the industry is to survive and prosper. This section describes the range of measures considered in formulating the Strategy 2 and Strategy 3 options.

7.3.1 Groundwater Control Options

(a) Drainage

The model developed by Mackie Martin was used to simulate the regional impact of different drainage strategies. Different uniform extraction rates were applied at the top node of the model and the impact of predicted water levels noted. Drainage theory was applied to then determine the necessary spacing of drains to achieve that volume abstraction, given the calibrated hydraulic conductive used in the model.

They conclude that water tables could be lowered to a minimum depth of 1.2 metres with 2 metre deep drains spaced at between 50 and 100 metres.

However, following review by the Technical Working Group it was decided that the hydraulic conductivity appropriate for regional scale modelling were not appropriate for the local shallow drain scale spacing design.

Construction difficulties in the heavy clays of much of the western salt affected area suggest that horizontal hydraulic conductivities would be at least 1 order of magnitude lower that those used in the regional model. The drainage theory developed in Supplementary Paper No 3 was re-applied using a local hydraulic conductivity. A value 10 times less permeable than the model calibration figure was used to develop appropriate drainage spacings. Sample calculations and cost estimates are given in Attachment 6.

(b) Aquifer Dewatering

Mackie Martin also argued that deeper drains that lowered the water table on a regional basis would be more effective in exporting salt than shallow drains which intercept largely transient shallow flow. While this is true, practical difficulties and increased costs are associated with construction of drains at depths greater than 2.5 metres. Moreover, shallow drains can be effective at reducing transient local high and saline water tables caused by irrigation applications.

The deeper drainage approach was considered in the context of regional dewatering of the Yoganup Formation. This is the most conductive hydrogeological formation of the coastal plains superficial aquifiers. It overlies the Leederville Formation and underlies the Guildford Formation (see Figure 14) and if dewatered would lower water table levels at the surface. Simulations based on drawings $0.5m^3/m$ from a line of bores in the Western Region of the Cookernup Section resulted in reductions in watertable elevations of 1.1 metres. The costs of this approach are also summarised in Attachment 6.

7.3.2 Improved On-Farm Water and Pasture Management

The Phase 1 study highlighted the scope to improve pasture productivity by better surface water management and pasture management practices (Phase 1 Background Paper 5).

Many farmers are implementing more frequent watering, laser levelling and surface ripping/mole draining to improve their pasture productivity.

These approaches have three main benefits. Firstly they minimise water logging and promote pasture growth. Secondly they promote uniform watering and enable better control of drainage over flow. Thirdly they minimise recharge to the underlying groundwater.

The Technical Working Group developed a set of measures including:

- whole farm planning;
- bay length and slope reforming, head ditch and tail drain reforming; and,
- surface ripping/mole drainage to existing surface drainage; and,
- 6 to 8 day waterings.

to cost and evaluate their effectiveness.

7.3.3 Other Approaches

Methods of controlling channel leakage and improving agricultural production by tree planting was also evaluated. Papers by CALM and Department of Agriculture offices (Refs 5 and 6) were prepared which showed that although commercial returns from trees planted on the heavy soils would be doubtful (Ref 5), their value for stock shade and shelter was significant. Trees will have some small value in reducing groundwater recharge from channels and drains at little cost. Their agricultural benefits would cover their costs of establishment.

7.4 Formulation of Strategy 2 and Strategy 3 Options

This section discusses the development and adoption of the two salinity mitigation strategies used in the Phase 2 economic and financial analysis. They are a mix of the possible control measures described in the previous section. The following section (Section 7.5) summarises their likely productivity improvements.

7.4.1 Strategy 2

At the November 1990 workshop it was proposed to develop an enhanced mitigation strategy which aimed to reduced recharge from channels by 50% and which would reduce by 50% the area over which groundwater was closer than 1 metre to the surface.

As investigations of the hydrogeological setting, regional salt balances and drainage layout designs developed, the Strategy 2 salinity control approach evolved. The task became one of developing a suite of practices that would be practical and affordable to the farmer and would improve overall productivity.

Three approaches were considered and are briefly discussed in turn:

(a) On-farm redesign to improve water and pasture management.

plus

10% tree plantings adjacent to channels and drains.

As discussed in Section 7.3.2 above, and in more detail in background paper 5 of Phase 1, higher pasture productivities are possible from improved surface water and pasture management. The suite of measures proposed in Section 7.3.2 were included in all proposed mitigation strategies as they were assessed as highly cost effective to the irrigators.

The concept of 10% tree cover arose primarily from the significant agricultural benefits that shade and shelter provide livestock production. Trees are known to both reduced groundwater recharge and lower water tables, although usually only within the immediate area of the tree plantings. The tree plantings were proposed to be adjacent to channels and drains to maximise their hydrologic effect. However, they need to be carefully placed so as not to increase the maintenance costs and access difficulties to the channels and drains.

(b) On-farm redesign to improve water and pasture management

plus

Sub-surface drainage of irrigated land in the western and central regions with the following conditions.

- 50 metre spacing
- 2.3 metre depth
- cost $2,100/ha

Drainage at 50 metre spacings, while being affordable at $2,100/ha, is only being fully effective for 15 metres either side of the drain. Productivity improvements of only 30% of a comprehensive drainage program were assessed.

(c) On-farm redesign for improved water and pasture management.

plus

Piping of feeder and lateral channels (rather than main supply channels) to control on-farm recharge and improve watering operations.

The productivity gains from piping feeder channels were small (20% of the low pasture productivity figure of the western areas) relative to the high capital cost. Only small reductions in the recharge to groundwater from tree planting were assessed but their other benefits to agricultural production makes it a low cost strategy.

Follow up review of the likely costs and potential benefits by the Technical Working group indicated that the most likely cost effective strategy of the three was Case (a). This was adopted as the most appropriate Strategy 2 approach. Many uncertainties remain about the most appropriate mix of pasture improvement strategies. Further investigations of the appropriate mix of sub-surface drainage and mole drainage is warranted.

7.4.2 Strategy 3

The Strategy 3 case represents the "Rolls Royce" approach to salinity mitigation. It includes full piping of the distribution system, a comprehensive program of water table control in the western and central portions of the districts and the best practices of surface water and pasture management throughout the area.

As noted earlier piping of the irrigation distribution systems, particularly the main supply channels will have limited benefit for salinity control. However, the water saved could be used for other purposes. Piping also reduces operating costs substantially and was specifically asked to be evaluated by the farming community.

The comprehensive control program involves either regional pumping from Yoganup Bores or a drainage program on irrigated paddocks based on 15 metre spacings and a depth of 2.3 metres. Both approaches are costly and have practical difficulties in implementation. The cheapest and most effective approach will be implemented over time if either are shown to be economic. An average cost of $4,500/ha was adopted for the analysis on the basis of a 50% mix of approaches.

In addition there are benefits that occur to dryland farming if irrigated agriculture is phased out of a whole region (Supplementary Paper 3). These were considered when reviewing the financial effects of the various strategies from the farmers perspective.

7.5 Estimation of Productivity Gains from Strategies 1, 2 and 3

7.5.1 Approach

The overall assessment of the impact of the three strategies on the pasture productivity of the three separate productivity regions was made in the following way.

The improved surface water and pasture management (Strategy 2) were based on reaching 80% of the pasture productivities achieve on Kyabram Research Station in Victoria in the high productive region. Lower levels of production were adopted for central and western regions. As these figures are averaged for whole regions it was not considered realistic to achieve values equal to research station results.

The productivity gains from water table changes caused by Strategies 2 and 3 were developed by

- adopting a 50% reduction in the on-farm summer accessions to the water table by introducing Strategy 2 (N.B. a larger improvement than assumed in the Shepparton Study)

- adopting a 100% reduction in the current summer accession to the water table from channels if they were replaced by pipes (Strategy 3)

- determining the combined accession reduction for each productivity region and accessing the net summer recharge after allowance was made for a decreased net evaporation from the water table

- converting this change in net summer recharge into a regional decline in water tables based on Supplementary Paper 3 - Phase 2

- assessing the change in pasture productivity from this decline based on experience/knowledge of regional salinities and pasture yield declines as a function of depth to saline water.

The impact of Strategy 1 (maintaining current practice) was based on knowledge summarised in Background Paper 6 - Phase 1 and the salt balances of Supplementary Papers 1 and 3.

The productivity improvements from surface water management and from regional water table decline were simply added to obtain an overall productivity improvement for each region.

As noted above the Harvey and Waroona district do not appear to be accumulating salts and water table levels appear relatively stable. No change in the productivity in the eastern areas of these districts are likely. It is also unlikely that significant change will occur in the average productivity of the central or western regional although decline in some individual paddocks is probable.

Increases in salinity and level of groundwater are expected in the Western and Central regions of the Collie District. A decline of 10% in overall productivity in the western region was considered possible by Year 30. A higher average productivity decline of 15% was considered possible in the central region as the areal extent of shallow saline water tables were likely to increase more so in this region than in the western region.

Relative to the uncertainty in estimations the expected gradual decline in pasture productivity in the Collie District was considered small. For simplicity it was not specifically modelled in the economic and financial analysis of the Collie District.

The economic benefits from the Collie District are therefore slight over estimates.

7.5.2 Strategy 2

The pasture productivity improvements for the improved surface water and pasture management were estimated to be as follows:

	Improvement in Productivity of Permanent Irrigation Pastures		
Strategy 2	Western Region	Central Region	Eastern Region
Improved surface water and pasture management	15%	20%	25%
Improvement due to less Groundwater Recharge	20%	10%	0%
Total Improvement	35%	30%	25%

These improvements are greater than the possible decline in productivity levels that are considered likely in the Collie District over the next 30 years.

It is therefore concluded that no significant decline in pasture productivity levels is expected in the Collie District provided improved on-farm irrigation practices are introduced.

7.5.3 Strategy 3

The extensive drainage and/or regional pumpage of Strategy 3 was designed to have a major impact on the productivity of the western and central regions. Lowering water tables by 1.5 metres should ensure that productivity gains approached those of the eastern productive areas affected by salinity.

The adopted improvement levels for permanent irrigation pasture are shown below.

	Improvement in Productivity of Permanent Irrigation Pastures		
Strategy 3	Western Region	Central Region	Eastern Region
Improved surface water and pasture management	15%	20%	25%
Improvement due to Groundwater Table Control	100%	100%	0%
Total Improvement	115%	120%	25%

The drainage and pumpage works of Strategy 3 also have a benefit on the adjacent early germination and dryland pasture. The estimated improvements are listed below.

	Early Germination and Annual Pasture Productivity Improvements		
Strategy 3	Western Region	Central Region	Eastern Region
Improved surface water and pasture management	0%	0%	0%
Improvement due to Groundwater Tabe Control	25%	15%	5%
Total 5%	25%	15%	5%

In practice the improved watering and pasture management would increase the productivity of early germination pastures. This effect was considered small and not specifically modelled in the economic and financial analysis.

7.5.4 Adoption Rates

The adoption of new farm management strategies often take many years to achieve. This is particularly the case where costs are high and benefits are uncertain. Optimistic adoption rates of the proposed practices were used in this analysis to ensure that the effects of the different approaches were apparent in the economic analysis.

The figures used were:

Year Number	Adoption Rate
1	3%
5	10%
15	55%
30	90%

Linear interpolation was used between years up to year 30 after which the adoption rat e was set at 90%.

7.6 Agricultural Gross Margins and Financial Effectiveness of Strategies to Farmers

The overall productivity improvement and cost of implementing the management strategies on-farm are summarised in Table 8, Section 2.2.

The final agricultural gross margin for each option was determined by multiplying each enterprise gross margin by its application area, the productivity increases and by the adoption rate to determine a year by year agricultural return. Net present values for each option were then determined for the 80 year sequence. Results are presented in Attachment 4 and incorporated into the overall cost/benefit in Section 3.5.

The implication for the individual farmer are discussed here. Table 43 summarises the net annual benefit (or loss) of irrigation to the Dairy Farmer for the three strategies in the high, marginal and low productive areas for selected Low Water Demand Options. No high demand cases are presented as all were financially attractive to the farmer. They would not have been adopted as appropriate strategies if they were not.

Effectively the table shows whether it is cost effective for the farmer to continue irrigating as prices rise to cover the full "beneficiaries pays" costs for the particular option.

Results are presented for the cases where there is a regional shutdown of irrigation and where other farms in the area remain.

The differences arise from effects on the regional water table if all farms in an area go dry. Higher productivity from dryland pastures should develop as regional water tables decline following cessation of irrigation in the western portion of the districts (Supplementary Paper 3).

Table 43

INCREMENTAL BENEFITS OF AN IRRIGATED DAIRY FARM OVER DRYLAND FARM OF SAME SIZE

(After paying full cost of water)

Option Description

Area Water Charging Policy	A Current	A TWEs	B Current	B TWEs	C Current	C TWEs	D Current	D TWEs	E Current	E TWEs
1. IRRIGATED DAIRY FARM VERSUS DRYLAND FARM - TOTAL REGIONAL SHUTDOWN OF IRRIGATION Over 80 Years (Improved productivity of dryland: +25% for marginal and +50% for salinity affected dryland)										
Strategy 1										
High	7,727	4,258	8,595	5,125	9,462	6,860	10,330	7,727	10,330	8,595
Medium	-10,645	-14,114	-9,777	-13,247						
Low	-22,405	-25,874								
Strategy 2										
High	14,450	10,547	15,231	12,108	16,011	12,889	16,792	13,669	16,792	14,450
Medium	3,589	-314	4,370	1,247						
Low	-8,303	-12,206								
Strategy 3										
High	-10,968	-15,652	-3,942	-7,846						
Medium	-14,164	-18,848	-7,138	-11,042						
Low	-24,092	-28,776								
2. IRRIGATED DAIRY FARM VERSUS DRYLAND FARM - TOTAL REGIONAL SHUTDOWN OF IRRIGATION Over 15 Years (Improved productivity of dryland: +25% for marginal and +50% for salinity affected dryland)										
Strategy 1										
High	7,727	4,258	8,595	5,125	9,462	6,860	10,330	7,727	10,330	8,595
Medium	-10,645	-14,114	-9,777	-13,247						
Low	-22,405	-25,874								
Strategy 2										
High	14,326	10,423	15,107	11,984	15,887	12,765	16,668	13,545	16,668	14,326
Medium	3,465	-438	4,246	1,123						
Low	-8,427	-12,330								
Strategy 3										
High	-14,449	-19,133	-7,423	-11,327						
Medium	-17,644	-22,328	-10,618	-14,522						
Low	-27,572	-32,256								
3. IRRIGATED DAIRY FARM VERSUS DRYLAND FARM - THE MARGINAL FARM (i.e. Other farms in the area remain irrigated) Over 80 Years (No improved productivity of dryland)										
Strategy 1										
High	7,727	4,258	8,595	5,125	9,462	6,860	10,330	7,727	10,330	8,595
Medium	2,799	-670	3,667	197						
Low	2,232	-1,237								
Strategy 2										
High	14,450	10,547	15,231	12,108	16,011	12,889	16,792	13,669	16,792	14,450
Medium	17,033	13,130	17,814	14,691						
Low	16,334	12,431								
Strategy 3										
High	-10,968	-15,652	-3,942	-7,846						
Medium	-720	-5,404	6,306	2,402						
Low	545	-4,139								
4. IRRIGATED DAIRY FARM VERSUS DRYLAND FARM - THE MARGINAL FARM (i.e. Other farms in the area remain irrigated) Over 15 Years (No improved productivity of dryland)										
Strategy 1										
High	7,727	4,258	8,595	5,125	9,462	6,860	10,330	7,727	10,330	8,595
Medium	2,799	-670	3,667	197						
Low	2,232	-1,237								
Strategy 2										
High	14,326	10,423	15,107	11,984	15,887	12,765	16,668	13,545	16,668	14,326
Medium	16,909	13,006	17,690	14,567						
Low	16,210	12,307								
Strategy 3										
High	-14,449	-19,133	-7,423	-11,327						
Medium	-4,200	-8,884	2,826	-1,078						
Low	-2,935	-7,619								

KEY: Strategy - refers to the on-farm and Scheme salinity mitigation and engineering strategy adopted

: High, Medium and Low refers to the land productivity type

The table shows that it remains profitable to the dairy farmers to continue to irrigate with current methods but only in the high productive areas. However, it is more profitable to introduce the improved management practices of Strategy 2.

On the medium productivity land it is only profitable to continue irrigating if Strategy 2 is implemented. Alternatively the productivity gains from Strategy 2 are critical to the dairy enterprise in offsetting the water price increases from the Low Demand Cases.

If dairy farmers have to pay the full cost of water then Strategy 3 is financially unattractive.

Table 44 shows a similar analysis for a beef grazing enterprise. The conclusion is, that if beef graziers had to pay full costs for the water, then it would not be financially attractive for them to continue irrigating under any of the three on-farm strategies.

7.7 Discussion and Implications for Future Study

All irrigation development and groundwater control strategies are expensive to the farmer. They are nonetheless economically attractive in all cases if water prices do not increase further. The less costly approaches are very important in improving productivity. However, the practicalities and appropriateness of constructing expensive drainage (at 15 metres spacings to depths of 2 to 2.5 metres) in the western saline area must be questioned until there is very clear evidence that the productivity gains estimated can, in fact, be obtained.

Similarly, with the irrigation development proposals (Strategic 2 and 3) significant productivity gains were assumed. These need to be thoroughly researched and further refined before the most appropriate details of redevelopment can be formulated.

For example mole drainage, designed in conjunction with affordable subsurface drainage may be a much more efficient combined strategy that achieves higher productivity gains at comparable costs. The best combination technique awaits a comprehensive research and investigation program. The Wellesley Land Conservation District, in conjunction with the Department of Agriculture, is developing such a program. The need for such investigation and research are supported by this analysis.

INCREMENTAL BENEFITS OF AN IRRIGATED BEEF FARM OVER DRYLAND FARM OF SAME SIZE

(After paying the full cost of water)

Option Description

Area / Water Charging Policy	A Current	A TWEs	B Current	B TWEs	C Current	C TWEs	D Current	D TWEs	E Current	E TWEs
1. IRRIGATED BEEF FARM VERSUS DRYLAND FARM - TOTAL REGIONAL SHUTDOWN OF IRRIGATION Over 80 Years (Improved productivity of dryland: +25% for marginal and +50% for salinity affected dryland)										
Strategy 1										
High	-7,110	-9,131	-6,605	-8,626	-6,100	-7,615	-5,594	-7,110	-5,594	-6,605
Medium	-21,532	-23,553	-21,027	-23,048						
Low	-24,349	-26,370								
Strategy 2										
High	-5,322	-7,596	-4,867	-6,686	-4,413	-6,232	-3,958	-5,777	-3,958	-5,322
Medium	-15,633	-17,907	-15,178	-16,997						
Low	-18,100	-20,374								
Strategy 3										
High	-19,631	-22,359	-15,538	-17,812						
Medium	-28,840	-31,568	-24,747	-27,021						
Low	-31,408	-34,136								
2. IRRIGATED BEEF FARM VERSUS DRYLAND FARM - TOTAL REGIONAL SHUTDOWN OF IRRIGATION Over 15 Years (Improved productivity of dryland: +25% for marginal and +50% for salinity affected dryland)										
Strategy 1										
High	-7,110	-9,131	-6,605	-8,626	-6,100	-7,615	-5,594	-7,110	-5,594	-6,605
Medium	-21,532	-23,553	-21,027	-23,048						
Low	-24,349	-26,370								
Strategy 2										
High	-5,394	-7,668	-4,939	-6,758	-4,485	-6,304	-4,030	-5,849	-4,030	-5,394
Medium	-15,705	-17,979	-15,250	-17,069						
Low	-18,173	-20,447								
Strategy 3										
High	-21,661	-24,389	-17,568	-19,842						
Medium	-30,870	-33,598	-26,777	-29,051						
Low	-33,438	-36,166								
3. IRRIGATED BEEF FARM VERSUS DRYLAND FARM - THE MARGINAL FARM (i.e. Other farms in the area remain irrigated) Over 80 Years (No improved productivity of dryland)										
Strategy 1										
High	-7,110	-9,131	-6,605	-8,626	-6,100	-7,615	-5,594	-7,110	-5,594	-6,605
Medium	-8,965	-10,986	-8,460	-10,481						
Low	-9,865	-11,886								
Strategy 2										
High	-5,322	-7,596	-4,867	-6,686	-4,413	-6,232	-3,958	-5,777	-3,958	-5,322
Medium	-3,066	-5,340	-2,611	-4,430						
Low	-3,616	-5,890								
Strategy 3										
High	-19,631	-22,359	-15,538	-17,812						
Medium	-16,273	-19,001	-12,180	-14,454						
Low	-16,924	-19,652								
4. IRRIGATED BEEF FARM VERSUS DRYLAND FARM - THE MARGINAL FARM (i.e. Other farms in the area remain irrigated) Over 15 Years (No improved productivity of dryland)										
Strategy 1										
High	-7,110	-9,131	-6,605	-8,626	-6,100	-7,615	-5,594	-7,110	-5,594	-6,605
Medium	-8,965	-10,986	-8,460	-10,481						
Low	-9,865	-11,886								
Strategy 2										
High	-5,394	-7,668	-4,939	-6,758	-4,485	-6,304	-4,030	-5,849	-4,030	-5,394
Medium	-3,138	-5,412	-2,683	-4,502						
Low	-3,689	-5,963								
Strategy 3										
High	-21,661	-24,389	-17,568	-19,842						
Medium	-18,303	-21,031	-14,210	-16,484						
Low	-18,954	-21,682								

KEY: Strategy - refers to the on-farm and Scheme salinity mitigation and engineering strategy adopted

: High, Medium and Low refers to the land productivity type

8. MANAGEMENT OF THE FUTURE IRRIGATION SERVICE

8.1 Introduction

At the July/August 1990 workshops the farming community clearly stated their wish to have a greater input to management of the scheme, particularly if they are asked to pay a higher contribution to the total costs of irrigation water.

Some farmers expressed concern about Water Authority efficiency and believed that farmer labour could be used to reduce some of the maintenance costs.

In contrast, at the workshop for Water Authority operational staff they saw the Water Authority as continuing to operate the scheme, albeit with improved efficiency.

Water Authority regional and senior management is open to the idea of a more co-operative approach which involved additional farmer input in the planning and running of the maintenance of the Irrigation scheme.

A wide range of administrative structures to manage the future irrigation scheme have been proposed (Ref 8.1) and are discussed below.

8.2 Kinhill Engineers "Management Alternatives Study"

To provide background for further discussion of management options Kinhill Engineers were commissioned to:

- review recent trends in irrigation management in Australia;
- review Water Authority irrigation management and cost efficiencies since 1985;
- compare Water Authority costs with other private and public irrigation schemes in Australia; and,
- propose alternative management arrangements for further discussion and evaluation in Phase 3 and Phase 4.

The main findings from the Kinhill review (Supplementary Paper Number 5) are summarised below.

- With the exception of Queensland, there is an Australia wide move to greater farmer involvement in irrigation management and/or greater financial responsibility for the operation and maintenance of the distribution systems.

- Comparisons of costs of self management of individual districts with costs of continued Government management indicated that costs would not necessarily be lower (based on South Australian experience).

- Pressures are on government water agencies providing irrigation services to improve their financial performance. Major changes are being introduced in Victoria by the Rural Water Commission of Victoria. By July 1993 six regional should be managed by separate boards operating as discrete businesses - setting prices, determining levels of services, operating their own system including relevant headworks, and taking initiatives to control costs.

Kinhill also reviewed the Water Authority's management and financial performance and compared it with other public and private irrigation agencies. The following conclusions were drawn:

- The Water Authority's direct operational and maintenance costs have dropped $400,000 in real terms between 1985/86 and 1989/90. This represents a decrease of 20% or a 5% improvement in efficiency per annum. The combined salary and administrative costs have declined $18,000 or 0.8% over the same period.

- Further improvements in efficiency have been implemented through centralising the management of the irrigation service at the Harvey office. Additional efficiencies of between 10 to 15% have been proposed. However, these savings would be accompanied by some reductions in the levels of service provided.

- Comparison of performance indicators between irrigation agencies in Australia proved inconclusive. The Water Authority compared well on some measures and poorly on others. Large differences in the characteristics of irrigation system make such comparisons fraught with difficulty.

- Regardless of the management structure proposed the large number of dams, the high gradients on channels and the long length of drainage channels are cost burdens that are unavoidable in the South-West Irrigation Districts.

- The integration of drainage of non-irrigated land, town water supply and sewerage means that the share of regional overheads assigned to the Irrigation Service is lower than it would otherwise be.

- Water Authority salary staff and administration overheads do not appear to be in excess of those that would be incurred if the operation were being managed by a private board.

- However, scope exists to improve the allocation of salaries between the different irrigation regions in the State with the development of regional profit and loss statements.

8.3 Alternative Management Options

While the Kinhill review was relatively favourable to the current management by the Water Authority, farmers have a different perception. At the July/August 1990 workshops many expressed strong views in favour of private Water Boards running the irrigation service. The advantages and disadvantages of the possible options are discussed fully in Supplementary Paper 5.

A brief summary of the management options is provided here.

8.3.1. Private Irrigation Boards

A private Irrigation Board would be fully responsible for

- the operation, maintenance and long term refurbishment of all channels and drains in the irrigation districts
- the financial viability of the enterprise (including paying for bulk water and drainage costs)
- satisfying environmental responsibility associated with the irrigation service.

The Water Authority would continue to operate and maintain dams and raise charges to the irrigation board for water delivered to the irrigation district boundary.

The Water Authority would also remain responsible for operating and maintaining the non-irrigated land drainage outside the irrigation districts.

Likely costs for the bulk water charges are summarised in Table 44 for the Engineering Strategy 2 (the minimum maintenance strategy).

If averaged over the three districts bulk water charges would be between 18% (E2 De-Rated) and 31% (A2 Fixed) of current charges depending on what portion of the reservoir yields were taken. Note the high bulk water charge for the Waroona District. Also Option H has a high bulk water charge (72% of the current charge) as the Waroona Headworks costs are a significant component of the total costs in this option.

The Engineering Strategy 3 options have bulk water charges that range between 22% and 32% of current levels.

The adoption of a user pays principle would imply that the Water Authority should also charge the irrigation board for conveying the winter drainage flows from the irrigation districts to the estuaries, and for the increased cost of maintaining the drains that convey irrigation water in summer.

Additional analysis would be required to determine appropriate drainage charges. As current drainage rates are not meeting operation, maintenance, salaries and administration costs in the Harvey District it is apparent that a private board would have to raise a higher drainage charge than the existing Water Authority rate.

8.3.2 Increased User Input by a Management Board with Farmer Majority

This option involves the creation of a management board consisting mainly of irrigation farmers with power to make recommendation or decisions on standards of service, maintenance and capital expenditure, and water charges. The recommendations/decisions would have to conform with cost recovery guidelines established by Government. The Water Authority would continue to provide the staff and run the irrigation districts as at present.

This approach is a significant extension of the current Advisory Committee role. It would allow farmers a say in the formulation of capital expenditure programmes of their district, the level of maintenance carried out and the service provided. This is not on a day to day basis but rather through considerable input into developing the districts annual operation and financial plan each year.

This approach would allow farmers to gain an appreciation of the physical and financial factors involved in running an irrigation district and would put then in a better position to judge the future merits of privatising all or part of the operation at some later date. At the same time this option maintains the expertise of the Water Authority and its technical backup.

8.3.3 Maintaining Current Water Authority Management

Under this options the management by Water Authority would be much the same as at present with the advisory committee having a role in water distribution policy but not other management issues. In recent years there has been a move to involve the advisory committee in scheme maintenance and other policy issues. However, decision making power remains with the Water Authority.

8.4 Comparison of the Alternatives

Supplementary Paper No. 5 outlines the advantage and disadvantages of the management alternatives and implies that no one approach is clearly preferable.

The interested reader is referred to Section 4 of that report for a detailed discussion of the arguments.

Table 45 Possible Bulk Water Charges to a Private Water Board

Option	District						Averaged over Three Districts	
	Waroona		Harvey		Collie		Total Area	
High Water Demand and Fixed Rating	$/ML	% of 89/90 Charge	$/ML	% of 89/90 Charge	$/ML	% of 89/90 Charge	$/ML	% of 89/90 Charge
A2	27.9	115	7.7	32	1.1	5	7.6	31
B2	26.4	109	6.7	28	1.1	4	6.8	28
C2	25.2	104	6.5	27	1.0	4	6.5	27
D2	18.0	74	6.3	26	1.0	4	4.9	20
E2	18.0	74	5.2	21	1.0	4	4.3	18
H	26.3	108	5.9	24	0.6	2	17.5	72
P	-	-	4.7	19	-	-	-	-
Low Water Demand Derated								
A2	25.9	106	6.0	25	0.9	4	6.4	26
B2	25.8	106	6.0	25	0.9	4	6.4	26
C2	25.8	106	6.0	24	0.9	4	6.4	26
D2	18.8	77	5.9	24	0.8	3	4.7	19
E2	18.8	77	5.3	22	0.8	3	4.4	18
P	-	-	4.4	18	-	-	-	-

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4. Water Authority of WA: 1990 Future Options for the Irrigation Service - Outcomes from Workshop Discussions - The Irrigation Strategy Study Technical Working Group, Water Authority of Western Australia, Water Resources Planning Branch, September, 1990.

5. Ellis, G. (1991) Alternative Land Uses for Previously Irrigated Land: Eucalyptus Globulus Growth on the Pinjarra Plain Soils. Draft Report of Conservation and Land Management, Manjimup.

6. George, R.J. (1991) Conservation and Production from Trees on the Coastal Plain. Department of Agriculture, Bunbury, WA 6230.

7. Transferable Water Entitlements in Western Australia, Western Australian Water Resources Council, March 1989.

8. Transferability of Water Entitlements, Centre for Water Policy Research, University of New England, Armidale, July 1990.

PHASE 2 SUPPLEMENTARY PAPERS

The following papers were prepared as part of the technical research during the Phase 2 analysis. Copies of these background reports are available on enquiry to I. Loh, Study Manager, Water Authority of Western Australia.

1. An Estimation of the Economic Benefits of Recreation Activities occurring at Waroona and Logue Brook Reservoirs, S. Lucas, Water Authority of Western Australia, May 1991.

2. The Dairy Industry in the South West Irrigation Area, J. Connell, Dairy Industry Authority, July 1991.

3. Groundwater Investigations for the Irrigation Strategy Study, Mackie Martin and Associates, June 1991.

4. Water and Salt Balances for an Irrigated Coastal Plain Catchment near Bunbury, Western Australia, C.G. Jeevaraj, Report No. WS81, Water Authority of Western Australia, April 1991.

5. Management Alternatives Study, Kinhill Engineers, June 1991.

6. Agricultural Gross Margins Used in Phase 2 Analysis, P. Eckersley, June 1992.

7. Future Options for the Irrigation Service: Outcomes from Workshop Discussions, Irrigation strategy Study, September 1990.

8. Options for Analysis in Phase 2, Background for November 28th Workshop, Technical Working Group, Irrigation Strategy Study, Water Authority of Western Australia, November 1990.

THE CONSULTATIVE COMMITTEE FOR PHASES 1 AND 2

The Water Authority of Western Australia was responsible for project management for Phase 1 and 2 of the Strategy Study. A Consultative Committee was formed to guide the direction of the study through these early stages. Members of the Committee were as follows:

Mr B. Sadler	-	Chairman and Director, Water Resources, Water Authority of Western Australia
Sir D. Eckersley	-	South-West Development Authority
Mr D. Norton	-	Irrigation Farmer, Benger and Western Australian Water Resources Council Member
Mr C. Rigg	-	Irrigation Farmer (Dairying) - Wokalup
Mr G. Edwards	-	Irrigation Farmer (Dairying) - Waterloo
Mr C. Capogreco	-	Irrigation Farmer (Horticulture) - Harvey
Mr L. Snell	-	Irrigation Farmer (Beef) - Waroona
Mr G. Luke	-	Resource Management Division - Department of Agriculture of Western Australia
Mr G. de Chaneet	-	Bunbury Region, Department of Agriculture of Western Australia
Mr R. Harvey/H. Ventriss	-	Manager, Water Resource Planning, Water Authority of Western Australia (replaced Mr R. Harvey Acting Manager Water Resource Planning in November 1991)
Mr C. Elliott	-	Regional Manager, South-West, Water Authority of Western Australia
Mr G. Holtfreter	-	Senior Irrigation Officer, Water Authority of Western Australia
Mr I. Loh	-	Project Manager for the Irrigation Study, Water Authority of Western Australia
Mr I. Longson	-	ACIL, Australia - Agricultural Economic Consultants
cc	-	Office of Cabinet

THE TECHNICAL WORKING GROUP

A Technical Working Group (TWG) was formed to analyse the options and assist the Consultative Committee. A large number of people served on the TWG for part or all of its activities. The Consultative Committee would like to thank and acknowledge the assistance of the following people:

Department of Agriculture

Mr P. Arkell
Mr R. Doyle
Mr P. Eckersley
Mr Richard George
Mr Ross George
Mr G. Luke
Mr D. Maughan
Dr D. Morrison
Mr G. Olney
Mr W. Russell

Water Authority of Western Australia

Mr D. Bostock
Mr S. Eccleston
Mr R. Dubekin
Mr G. Holtfreter
Mr C. Jeevaraj
Mr I. Loh
Mr S. Lucas
Mr D. Nabbs
Mr K. Wearne
Mr L. Werner

Dairy Industry Authority of Western Australia

Mr J. Connell

CALM

Mr G. Ellis

ACIL Australia

Mr I. Longson
Mr P. Jacob

Kinhill Engineers

Mr J. Abbott

Mackie Martin & Associates

Mr S. Nield

The contribution from other staff in the Department of Agriculture and the Water Authority of Western Australia and support staff from ACIL Australia, Kinhill Engineers and Mackie Martin & Associates are also greatfully acknowledged.

THE CALCULATION OF THE AGRICULTURAL NET BENEFITS FOR PHASE 2 OPTIONS

1. Summary of Results

2. Conversion Costs

   - Land Development
   - Livestock Capital
   - Land Development and Livestock Capita Costs

The Calculation of the Agricultural Net Benefits for Phase 2 Options

The following notes are designed to help interpret summary sheets for the calculation of the Agricultural Benefits.

Agriculture Gross Margins - the 80 year NPV of the product of the areas involved under the different options times the gross margins per hectare.

Fixed Costs - the 80 year NPV of the product of the areas involved under the different options times the fixed costs per hectare as shown in Table 7 on P33.

Livestock and Development Costs - the 80 year NPV of the product of the change in areas times the sum of the conversion costs associated with land development and livestock capital changes

e.g. Converting high productivity land from dryland beef to irrigated perennial dairy pasture required $500/ha in land development costs (laser levelling, pasture seeding, head and tail ditch farming) - as per Page A4 plus $562/ha (1125 - 563) for additional livestock capital - as per Page A4.8.

This gives a total of $1,062/ha for livestock and development costs to convert a hectare of high productivity land from dryland beef into irrigated perennial dairy pasture.

Vegetable Development Costs - the 80 year NPV of the capital costs associated with developing vegetable cropping land based on the capital costs as set out in the Gross Margins for Vegetable enterprises contained in Supplementary Paper 6.

Citrus Development Costs - the 80 year NPV of the capital costs associated with developing citrus cropping land based on the capital costs as set out in the Gross Margins for Citrus enterprises contained in Supplementary Paper 6.

On-farm irrigation development - the 80 year NPV of the capital and operating costs of the applicable on-farm strategies for irrigation and drainage each option management for as per Table 8 on P35.

On-farm salinity control costs - the 80 year NPV of the capital and operating costs of the on-farm salinity mitigation Strategy 3 to the applicable options - as per Table 8 on P35.

AREA

ALL IRRIGATION AREA

SCENARIO	A1 H	A2 H	A3 H	A1 L	A2 L	A3 L	B1 H	B2 H	B3 H	B1 L	B2 L	B3 L	C1 H	C2 H	C3 H	C1 L	C2 L	C3 L
ECONOMIC ANALYSIS																		
AGRICULTURE GROSS MARGIN	223,182,938	232,879,252	240,683,767	204,204,192	210,954,581	208,349,047	224,014,658	234,152,136	239,914,209	204,204,192	210,954,581	208,427,132	222,114,398	231,672,059	234,287,022	204,204,192	210,954,581	208,427,132
COSTS																		
Fixed costs	108,484,865	108,484,865	108,484,865	100,898,137	100,898,137	99,859,866	108,313,857	108,313,857	108,313,857	100,898,137	100,898,137	99,861,850	107,895,385	107,895,385	107,895,385	100,898,137	100,898,137	99,861,850
Livestock & Development	49,106	49,106	49,106	722,339	722,339	845,110	1,240,909	1,240,909	1,240,909	722,402	721,736	844,710	1,722,000	1,722,000	1,722,000	722,298	722,298	844,751
Veg. development costs	7,599,188	7,599,188	7,599,188	3,241,407	3,241,407	3,241,407	7,599,188	7,599,188	7,599,188	3,241,407	3,241,407	3,241,407	7,599,188	7,599,188	7,599,188	3,241,407	3,241,407	3,241,407
Citrus development costs	3,637,677	3,637,677	3,637,677	1,826,795	1,826,795	1,826,795	3,637,677	3,637,677	3,637,677	1,826,795	1,826,795	1,826,795	3,637,677	3,637,677	3,637,677	1,826,795	1,826,795	1,826,795
On farm irigation dev. costs		6,761,270	6,761,270		3,858,835	2,730,724		6,809,264	6,809,264		3,858,835	2,730,725		6,106,894	6,106,894		3,858,835	2,730,725
On farm salinity control costs			6,893,881			849,796			3,749,101			849,796			876,794			849,796
TOTAL AGRICULTURAL COSTS	119,770,836	126,532,106	133,425,987	106,688,678	110,547,513	109,353,698	120,791,631	127,600,895	131,349,996	106,688,741	110,546,910	109,355,283	120,854,250	126,961,144	127,837,938	106,688,637	110,547,472	109,355,324
NET AGRICULTURAL BENEFIT	103,412,102	106,347,146	107,257,780	97,515,514	100,407,068	98,995,349	103,223,027	106,551,241	108,564,213	97,515,451	100,407,671	99,071,849	101,260,148	104,710,915	106,449,084	97,515,555	100,407,109	99,071,808
COMPARED TO CLOSE DOWN	33,230,593	36,165,637	37,076,271	27,334,005	30,225,559	28,813,840	33,041,518	36,369,732	38,382,704	27,333,942	30,226,162	28,890,340	31,078,639	34,529,406	36,267,575	27,334,046	30,225,600	28,890,299
FINANCIAL ANALYSIS																		
AGRICULTURE GROSS MARGIN	285,683,631	299,563,219	310,666,477	260,155,965	269,647,470	264,663,134	287,408,003	301,916,474	310,085,775	260,155,965	269,647,470	264,774,708	285,613,705	299,633,297	303,107,663	260,155,965	269,647,470	264,774,708
AG COSTS	119,770,836	126,532,106	133,425,987	106,688,678	110,547,513	109,353,698	120,791,631	127,600,895	131,349,996	106,688,741	110,546,910	109,355,283	120,854,250	126,961,144	127,837,938	106,688,637	110,547,472	109,355,324
NET AGRICULTURE BENEFIT	165,912,795	173,031,113	177,240,490	153,467,287	159,099,957	155,309,436	166,616,372	174,315,579	178,735,779	153,467,224	159,100,560	155,419,425	164,759,455	172,672,153	175,269,725	153,467,328	159,099,998	155,419,384
COMPARED TO CLOSE DOWN	48,806,199	55,924,517	60,133,894	36,360,691	41,993,361	38,202,840	49,509,776	57,208,983	61,629,183	36,360,628	41,993,964	38,312,829	47,652,859	55,565,557	58,163,129	36,360,732	41,993,402	38,312,788

	D1 H	D2 H	D3 H	D1 L	D2 L	D3 L	E1H	E2H	E3H	E1L	E2L	E3L	H	P	CD
ECONOMIC ANALYSIS															
AGRICULTURE GROSS MARGIN	219,411,444	227,993,605	230,705,199	204,277,330	211,027,719	208,513,614	214,604,985	221,491,515	224,369,444	202,083,111	208,211,212	208,067,048	275,772,175	202,618,962	163,386,872
COSTS															
Fixed costs	107,363,303	107,363,303	107,363,303	100,893,963	100,893,963	99,862,584	106,054,955	106,054,955	106,054,955	100,362,030	100,362,030	99,761,751	112,777,064	97,252,276	89,735,650
Livestock & Development	1,488,347	1,488,347	1,488,347	925,339	925,339	859,300	1,252,864	1,252,864	1,252,864	988,988	988,988	855,906	762,308	1,058,192	1,311,277
Veg. development costs	7,599,188	7,599,188	7,599,188	3,241,407	3,241,407	3,241,407	7,599,188	7,599,188	7,599,188	3,241,407	3,241,407	3,241,407	42,874,958	13,909,986	1,260,875
Citrus development costs	3,637,677	3,637,677	3,637,677	1,826,795	1,826,795	1,826,795	3,637,677	3,637,677	3,637,677	1,826,795	1,826,795	1,826,795	16,764,973	4,891,921	897,561
On farm irigation dev. costs		5,223,586	5,223,586		3,858,835	2,730,724		3,850,814	3,850,814		3,289,940	2,677,129			
On farm salinity control costs			876,794			849,796			876,794			849,796			
TOTAL AGRICULTURAL COSTS	120,088,515	125,312,101	126,188,895	106,887,504	110,746,339	109,370,606	118,544,684	122,395,498	123,272,292	106,419,220	109,709,160	109,212,784	173,179,303	117,112,375	93,205,363
NET AGRICULTURAL BENEFIT	99,322,929	102,681,504	104,516,304	97,389,826	100,281,380	99,143,008	96,060,301	99,096,017	101,097,152	95,663,891	98,502,052	98,854,264	102,592,872	85,506,587	70,181,509
COMPARED TO CLOSE DOWN	29,141,420	32,499,995	34,334,795	27,208,317	30,099,871	28,961,499	25,878,792	28,914,508	30,915,643	25,482,382	28,320,543	28,672,755	32,411,363	15,325,078	
FINANCIAL ANALYSIS															
AGRICULTURE GROSS MARGIN	281,788,651	294,576,531	298,154,489	260,232,238	269,723,743	264,861,190	272,758,819	282,872,080	286,660,341	256,877,040	265,594,731	264,153,820	322,697,263	249,544,050	210,311,959
AG COSTS	120,088,515	125,312,101	126,188,895	106,887,504	110,746,339	109,370,606	118,544,684	122,395,498	123,272,292	106,419,220	109,709,160	109,212,784	173,179,303	117,112,375	93,205,363
NET AGRICULTURE BENEFIT	161,700,136	169,264,430	171,965,594	153,344,734	158,977,404	155,490,584	154,214,135	160,476,582	163,388,049	150,457,819	155,885,571	154,941,036	149,517,960	132,431,675	117,106,596
COMPARED TO CLOSE DOWN	44,593,540	52,157,834	54,858,998	36,238,138	41,870,808	38,383,988	37,107,539	43,369,986	46,281,453	33,351,223	38,778,975	37,834,440	32,411,364	15,325,079	

AREA

COLLIE

SCENARIO	A1 H	A2 H	A3 H	A1 L	A2 L	A3 L	B1 H	B2 H	B3 H	B1 L	B2 L	B3 L	C1 H	C2 H	C3 H	C1 L	C2 L	C3 L
ECONOMIC ANALYSIS																		
AGRICULTURE GROSS MARGIN	84,674,128	88,925,990	92,623,448	79,421,983	82,195,258	81,721,478	85,315,133	89,761,593	92,892,316	79,421,983	82,195,258	81,820,133	84,303,939	88,521,387	89,756,982	79,421,983	82,195,258	81,820,133
COSTS																		
Fixed costs	43,101,633	43,101,633	43,101,633	41,187,877	41,187,877	40,834,653	43,154,001	43,154,001	43,154,001	41,187,877	41,187,877	40,839,729	42,922,977	42,922,977	42,922,977	41,187,877	41,187,877	40,839,729
Livestock & Development	19,555	19,555	19,555	333,278	333,278	351,599	465,136	465,136	465,136	333,341	333,341	350,788	757,467	757,467	757,467	333,237	333,237	350,777
Veg. development costs	557,929	557,929	557,929	252,476	252,476	252,476	557,929	557,929	557,929	252,476	252,476	252,476	557,929	557,929	557,929	252,476	252,476	252,476
Citrus development costs	892,877	892,877	892,877	412,904	412,904	412,904	892,877	892,877	892,877	412,904	412,904	412,904	892,877	892,877	892,877	412,904	412,904	412,904
On farm irigation dev. costs	0	2,896,893	2,896,893	0	1,488,292	1,173,019	0	2,971,712	2,971,712	0	1,488,292	1,178,917	0	2,677,036	2,677,036	0	1,488,292	1,178,917
On farm salinity control costs	0	0	3,041,353	0	0	363,831	0	0	2,092,051	0	0	363,831	0	0	387,401	0	0	363,831
TOTAL AGRICULTURAL COSTS	44,571,994	47,468,887	50,510,240	42,186,535	43,674,827	43,388,482	45,069,943	48,041,655	50,133,706	42,186,598	43,674,890	43,398,645	45,131,250	47,808,286	48,195,687	42,186,494	43,674,786	43,398,634
NET AGRICULTURAL BENEFIT	40,102,134	41,457,103	42,113,208	37,235,448	38,520,431	38,332,996	40,245,190	41,719,938	42,758,610	37,235,385	38,520,368	38,421,488	39,172,689	40,713,101	41,561,295	37,235,489	38,520,472	38,421,499
COMPARED TO CLOSE DOWN	10,219,680	11,574,649	12,230,754	7,352,994	8,637,977	8,450,542	10,362,736	11,837,484	12,876,156	7,352,931	8,637,914	8,539,034	9,290,235	10,830,647	11,678,841	7,353,035	8,638,018	8,539,045
FINANCIAL ANALYSIS																		
AGRICULTURE GROSS MARGIN	113,870,284	120,046,070	125,365,048	105,453,072	109,465,237	107,897,831	114,962,669	121,395,369	125,889,309	105,453,072	109,465,237	108,029,975	113,970,504	120,223,416	121,873,968	105,453,072	109,465,237	108,029,975
AG COSTS	44,571,994	47,468,887	50,510,240	42,186,535	43,674,827	43,388,482	45,069,943	48,041,655	50,133,706	42,186,598	43,674,890	43,398,645	45,131,250	47,808,286	48,195,687	42,186,494	43,674,786	43,398,634
NET AGRICULTURE BENEFIT	69,298,290	72,577,183	74,854,808	63,266,537	65,790,410	64,509,349	69,892,726	73,353,714	75,755,603	63,266,474	65,790,347	64,631,330	68,839,254	72,415,130	73,678,281	63,266,578	65,790,451	64,631,341
COMPARED TO CLOSE DOWN	17,502,701	20,781,594	23,059,219	11,470,948	13,994,821	12,713,760	18,097,137	21,558,125	23,960,014	11,470,885	13,994,758	12,835,741	17,043,665	20,619,541	21,882,692	11,470,989	13,994,862	12,835,752

	D1 H	D2 H	D3 H	D1 L	D2 L	D3 L	E1H	E2H	E3H	E1L	E2L	E3L	H	P	CD
ECONOMIC ANALYSIS															
AGRICULTURE GROSS MARGIN	84,301,121	88,517,433	89,753,160	80,661,392	83,849,857	82,319,054	84,301,121	88,517,433	89,753,160	80,661,392	83,849,857	82,319,054	69,371,938	69,371,938	69,371,938
COSTS															
Fixed costs	42,922,355	42,922,355	42,922,355	41,450,100	41,450,100	40,910,324	42,922,355	42,922,355	42,922,355	41,450,100	41,450,100	40,910,324	38,770,829	38,770,829	38,770,829
Livestock & Development	730,788	730,788	730,788	458,003	458,003	345,647	730,788	730,788	730,788	458,003	458,003	345,647	463,272	463,272	463,272
Veg. development costs	557,929	557,929	557,929	252,476	252,476	252,476	557,929	557,929	557,929	252,476	252,476	252,476	96,990	96,990	96,990
Citrus development costs	892,877	892,877	892,877	412,904	412,904	412,904	892,877	892,877	892,877	412,904	412,904	412,904	158,393	158,393	158,393
On farm irigation dev. costs	0	2,676,016	2,676,016	0	1,902,512	1,293,665	0	2,676,016	2,676,016	0	1,902,512	1,293,665	0	0	0
On farm salinity control costs	0	0	387,401	0	0	363,831	0	0	387,401	0	0	363,831	0	0	0
TOTAL AGRICULTURAL COSTS	45,103,949	47,779,965	48,167,366	42,573,483	44,475,995	43,578,847	45,103,949	47,779,965	48,167,366	42,573,483	44,475,995	43,578,847	39,489,484	39,489,484	39,489,484
NET AGRICULTURAL BENEFIT	39,197,172	40,737,468	41,585,794	38,087,909	39,373,862	38,740,207	39,197,172	40,737,468	41,585,794	38,087,909	39,373,862	38,740,207	29,882,454	29,882,454	29,882,454
COMPARED TO CLOSE DOWN	9,314,718	10,855,014	11,703,340	8,205,455	9,491,408	8,857,753	9,314,718	10,855,014	11,703,340	8,205,455	9,491,408	8,857,753	0	0	0
FINANCIAL ANALYSIS															
AGRICULTURE GROSS MARGIN	113,967,089	120,218,549	121,869,269	106,692,482	111,119,837	108,528,896	113,967,089	120,218,549	121,869,269	106,692,482	111,119,837	108,528,896	91,285,073	91,285,073	91,285,073
AG COSTS	45,103,949	47,779,965	48,167,366	42,573,483	44,475,995	43,578,847	45,103,949	47,779,965	48,167,366	42,573,483	44,475,995	43,578,847	39,489,484	39,489,484	39,489,484
NET AGRICULTURE BENEFIT	68,863,140	72,438,584	73,701,903	64,118,999	66,643,842	64,950,049	68,863,140	72,438,584	73,701,903	64,118,999	66,643,842	64,950,049	51,795,589	51,795,589	51,795,589
COMPARED TO CLOSE DOWN	17,067,551	20,642,995	21,906,314	12,323,410	14,848,253	13,154,460	17,067,551	20,642,995	21,906,314	12,323,410	14,848,253	13,154,460	0	0	

AREA

HARVEY

SCENARIO	A1 H	A2 H	A3 H	A1 L	A2 L	A3 L	B1 H	B2 H	B3 H	B1 L	B2 L	B3 L	C1 H	C2 H	C3 H	C1 L	C2 L	C3 L
ECONOMIC ANALYSIS																		
AGRICULTURE GROSS MARGIN	103,068,005	107,383,454	110,668,694	92,440,107	95,534,386	94,190,521	103,360,386	107,948,912	109,991,002	92,440,107	95,534,386	94,220,426	102,752,970	107,108,463	108,158,958	92,440,107	95,534,386	94,220,426
COSTS																		
Fixed costs	50,273,047	50,273,047	50,273,047	46,000,412	46,000,412	45,515,416	50,158,937	50,158,937	50,158,937	46,000,412	46,000,412	45,521,476	50,037,891	50,037,891	50,037,891	46,000,412	46,000,412	45,521,476
Livestock & Development	29,953	29,953	29,953	305,436	305,436	362,447	695,112	695,112	695,112	305,436	304,770	360,335	868,168	868,168	868,168	305,436	305,436	360,387
Veg. development costs	5,624,240	5,624,240	5,624,240	2,614,575	2,614,575	2,614,575	5,624,240	5,624,240	5,624,240	2,614,575	2,614,575	2,614,575	5,624,240	5,624,240	5,624,240	2,614,575	2,614,575	2,614,575
Citrus development costs	1,792,494	1,792,494	1,792,494	832,717	832,717	832,717	1,792,494	1,792,494	1,792,494	832,717	832,717	832,717	1,792,494	1,792,494	1,792,494	832,717	832,717	832,717
On farm irigation dev. costs	0	2,953,278	2,953,278	0	1,747,587	1,220,950	0	3,007,218	3,007,218	0	1,747,587	1,228,323	0	2,729,602	2,729,602	0	1,747,587	1,228,323
On farm salinity control costs	0	0	3,067,532	0	0	395,457	0	0	1,285,403	0	0	395,457	0	0	389,029	0	0	395,457
TOTAL AGRICULTURAL COSTS	57,719,734	60,673,012	63,740,544	49,753,140	51,500,727	50,941,562	58,270,783	61,278,001	62,563,404	49,753,140	51,500,061	50,952,883	58,322,793	61,052,395	61,441,424	49,753,140	51,500,727	50,952,935
NET AGRICULTURAL BENEFIT	45,348,271	46,710,442	46,928,150	42,686,967	44,033,659	43,248,959	45,089,603	46,670,911	47,427,598	42,686,967	44,034,325	43,267,543	44,430,177	46,056,068	46,717,534	42,686,967	44,033,659	43,267,491
COMPARED TO CLOSE DOWN	14,268,566	15,630,737	15,848,445	11,607,262	12,953,954	12,169,254	14,009,898	15,591,206	16,347,893	11,607,262	12,954,620	12,187,838	13,350,472	14,976,363	15,637,829	11,607,262	12,953,954	12,187,786
FINANCIAL ANALYSIS																		
AGRICULTURE GROSS MARGIN	132,625,320	138,981,934	143,784,018	118,943,350	123,390,995	120,892,865	133,310,719	140,059,242	143,015,755	118,943,350	123,390,995	120,922,770	132,751,350	139,304,741	140,744,033	118,943,350	123,390,995	120,922,770
AG COSTS	57,719,734	60,673,012	63,740,544	49,753,140	51,500,727	50,941,562	58,270,783	61,278,001	62,563,404	49,753,140	51,500,061	50,952,883	58,322,793	61,052,395	61,441,424	49,753,140	51,500,727	50,952,935
NET AGRICULTURE BENEFIT	74,905,586	78,308,922	80,043,474	69,190,210	71,890,268	69,951,303	75,039,936	78,781,241	80,452,351	69,190,210	71,890,934	69,969,887	74,428,557	78,252,346	79,302,609	69,190,210	71,890,268	69,969,835
COMPARED TO CLOSE DOWN	21,715,045	25,118,381	26,852,933	15,999,669	18,699,727	16,760,762	21,849,395	25,590,700	27,261,810	15,999,669	18,700,393	16,779,346	21,238,016	25,061,805	26,112,068	15,999,669	18,699,727	16,779,294

	D1 H	D2 H	D3 H	D1 L	D2 L	D3 L	E1H	E2H	E3H	E1L	E2L	E3L	H	P	CD
ECONOMIC ANALYSIS															
AGRICULTURE GROSS MARGIN	101,610,062	105,564,311	106,652,986	92,440,107	95,534,386	94,220,426	96,803,603	99,062,221	100,317,231	90,203,324	92,667,387	93,773,860	145,030,143	111,401,471	72,169,381
COSTS															
Fixed costs	49,868,798	49,868,798	49,868,798	46,000,412	46,000,412	45,521,476	48,560,450	48,560,450	48,560,450	45,455,099	45,455,099	45,420,643	55,373,705	46,738,276	39,221,650
Livestock & Development	597,853	597,853	597,853	305,436	305,436	361,018	362,370	362,370	362,370	368,458	368,458	357,624	227,354	360,581	613,666
Veg. development costs	5,624,240	5,624,240	5,624,240	2,614,575	2,614,575	2,614,575	5,624,240	5,624,240	5,624,240	2,614,575	2,614,575	2,614,575	28,766,931	13,586,685	937,574
Citrus development costs	1,792,494	1,792,494	1,792,494	832,717	832,717	832,717	1,792,494	1,792,494	1,792,494	832,717	832,717	832,717	12,240,168	4,311,146	316,786
On farm irigation dev. costs	0	2,381,617	2,381,617	0	1,747,587	1,228,323	0	1,008,845	1,008,845	0	1,178,408	1,174,728	0	0	0
On farm salinity control costs	0	0	389,029	0	0	395,457	0		389,029	0	0	395,457	0	0	0
TOTAL AGRICULTURAL COSTS	57,883,385	60,265,002	60,654,031	49,753,140	51,500,727	50,953,566	56,339,554	57,348,399	57,737,428	49,270,849	50,449,257	50,795,744	96,608,158	64,996,688	41,089,676
NET AGRICULTURAL BENEFIT	43,726,677	45,299,309	45,998,955	42,686,967	44,033,659	43,266,860	40,464,049	41,713,822	42,579,803	40,932,475	42,218,130	42,978,116	48,421,985	46,404,783	31,079,705
COMPARED TO CLOSE DOWN	12,646,972	14,219,604	14,919,250	11,607,262	12,953,954	12,187,155	9,384,344	10,634,117	11,500,098	9,852,770	11,138,425	11,898,411	17,342,280	15,325,078	
FINANCIAL ANALYSIS															
AGRICULTURE GROSS MARGIN	130,896,760	136,888,211	138,369,263	118,943,350	123,390,995	120,922,770	121,866,928	125,183,760	126,875,115	115,437,805	119,080,343	120,215,400	167,140,979	133,512,308	94,280,217
AG COSTS	57,883,385	60,265,002	60,654,031	49,753,140	51,500,727	50,953,566	56,339,554	57,348,399	57,737,428	49,270,849	50,449,257	50,795,744	96,608,158	64,996,688	41,089,676
NET AGRICULTURE BENEFIT	73,013,375	76,623,209	77,715,232	69,190,210	71,890,268	69,969,204	65,527,374	67,835,361	69,137,687	66,166,956	68,631,086	69,419,656	70,532,821	68,515,620	53,190,541
COMPARED TO CLOSE DOWN	19,822,834	23,432,668	24,524,691	15,999,669	18,699,727	16,778,663	12,336,833	14,644,820	15,947,146	12,976,415	15,440,545	16,229,115	17,342,280	15,325,079	

AREA

WAROONA

SCENARIO	A1 H	A2 H	A3 H	A1 L	A2 L	A3 L	B1 H	B2 H	B3 H	B1 L	B2 L	B3 L	C1 H	C2 H	C3 H	C1 L	C2 L	C3 L
ECONOMIC ANALYSIS																		
AGRICULTURE GROSS MARGIN	35,440,805	36,569,808	37,391,625	32,342,102	33,224,937	32,437,048	35,339,139	36,441,631	37,030,891	32,342,102	33,224,937	32,386,573	35,057,489	36,042,209	36,371,082	32,342,102	33,224,937	32,386,573
COSTS																		
Fixed costs	15,110,185	15,110,185	15,110,185	13,709,848	13,709,848	13,509,797	15,000,919	15,000,919	15,000,919	13,709,848	13,709,848	13,500,645	14,934,517	14,934,517	14,934,517	13,709,848	13,709,848	13,500,645
Livestock & Development	-402	-402	-402	83,625	83,625	131,064	80,661	80,661	80,661	83,625	83,625	133,587	96,365	96,365	96,365	83,625	83,625	133,587
Veg. development costs	1,417,019	1,417,019	1,417,019	374,356	374,356	374,356	1,417,019	1,417,019	1,417,019	374,356	374,356	374,356	1,417,019	1,417,019	1,417,019	374,356	374,356	374,356
Citrus development costs	952,306	952,306	952,306	581,174	581,174	581,174	952,306	952,306	952,306	581,174	581,174	581,174	952,306	952,306	952,306	581,174	581,174	581,174
On farm irigation dev. costs	0	911,099	911,099	0	622,956	336,755	0	830,334	830,334	0	622,956	323,485	0	700,256	700,256	0	622,956	323,485
On farm salinity control costs	0	0	784,996	0	0	90,508	0	0	371,647	0	0	90,508	0	0	100,364	0	0	90,508
TOTAL AGRICULTURAL COSTS	17,479,108	18,390,207	19,175,203	14,749,003	15,371,959	15,023,654	17,450,905	18,281,239	18,652,886	14,749,003	15,371,959	15,003,755	17,400,207	18,100,463	18,200,827	14,749,003	15,371,959	15,003,755
NET AGRICULTURAL BENEFIT	17,961,697	18,179,601	18,216,422	17,593,099	17,852,978	17,413,394	17,888,234	18,160,392	18,378,005	17,593,099	17,852,978	17,382,818	17,657,282	17,941,746	18,170,255	17,593,099	17,852,978	17,382,818
COMPARED TO CLOSE DOWN	8,742,347	8,960,251	8,997,072	8,373,749	8,633,628	8,194,044	8,668,884	8,941,042	9,158,655	8,373,749	8,633,628	8,163,468	8,437,932	8,722,396	8,950,905	8,373,749	8,633,628	8,163,468

FINANCIAL ANALYSIS

	A1 H	A2 H	A3 H	A1 L	A2 L	A3 L	B1 H	B2 H	B3 H	B1 L	B2 L	B3 L	C1 H	C2 H	C3 H	C1 L	C2 L	C3 L
AGRICULTURE GROSS MARGIN	139,188,027	40,535,215	41,517,411	35,759,543	36,791,238	35,872,438	39,134,615	40,461,863	41,180,711	35,759,543	36,791,238	35,821,963	38,891,851	40,105,140	40,489,662	35,759,543	36,791,238	35,821,963
AG COSTS	17,479,108	18,390,207	19,175,203	14,749,003	15,371,959	15,023,654	17,450,905	18,281,239	18,652,886	14,749,003	15,371,959	15,003,755	17,400,207	18,100,463	18,200,827	14,749,003	15,371,959	15,003,755
NET AGRICULTURE BENEFIT	21,708,919	22,145,008	22,342,208	21,010,540	21,419,279	20,848,784	21,683,710	22,180,624	22,527,825	21,010,540	21,419,279	20,818,208	21,491,644	22,004,677	22,288,835	21,010,540	21,419,279	20,818,208
COMPARED TO CLOSE DOWN	9,588,453	10,024,542	10,221,742	8,890,074	9,298,813	8,728,318	9,563,244	10,060,158	10,407,359	8,890,074	9,298,813	8,697,742	9,371,178	9,884,211	10,168,369	8,890,074	9,298,813	8,697,742

	D1 H	D2 H	D3 H	D1 L	D2 L	D3 L	E1H	E2H	E3H	E1L	E2L	E3L	H	P	CD
ECONOMIC ANALYSIS															
AGRICULTURE GROSS MARGIN	33,500,261	33,911,861	34,299,053	31,175,831	31,643,476	31,974,134	33,500,261	33,911,861	34,299,053	31,218,395	31,693,968	31,974,134	61,370,094	21,845,553	21,845,553
COSTS															
Fixed costs	14,572,150	14,572,150	14,572,150	13,443,451	13,443,451	13,430,784	14,572,150	14,572,150	14,572,150	13,456,831	13,456,831	13,430,784	18,632,530	11,743,171	11,743,171
Livestock & Development	159,706	159,706	159,706	161,900	161,900	152,635	159,706	159,706	159,706	162,527	162,527	152,635	71,682	234,339	234,339
Veg. development costs	1,417,019	1,417,019	1,417,019	374,356	374,356	374,356	1,417,019	1,417,019	1,417,019	374,356	374,356	374,356	14,011,037	226,311	226,311
Citrus development cost	952,306	952,306	952,306	581,174	581,174	581,174	952,306	952,306	952,306	581,174	581,174	581,174	4,366,412	422,382	422,382
On farm irigation dev. costs	0	165,953	165,953	0	208,736	208,736	0	165,953	165,953	0	209,020	208,736	0	0	0
On farm salinity control costs	0	0	100,364	0	0	90,508	0	0	100,364	0	0	90,508	0	0	0
TOTAL AGRICULTURAL COSTS	17,101,181	17,267,134	17,367,498	14,560,881	14,769,617	14,838,193	17,101,181	17,267,134	17,367,498	14,574,888	14,783,908	14,838,193	37,081,661	12,626,203	12,626,203
NET AGRICULTURAL BENEFIT	16,399,080	16,644,727	16,931,555	16,614,950	16,873,859	17,135,941	16,399,080	16,644,727	16,931,555	16,643,507	16,910,060	17,135,941	24,288,433	9,219,350	9,219,350
COMPARED TO CLOSE DOWN	7,179,730	7,425,377	7,712,205	7,395,600	7,654,509	7,916,591	7,179,730	7,425,377	7,712,205	7,424,157	7,690,710	7,916,591	15,069,083	0	

FINANCIAL ANALYSIS

	D1 H	D2 H	D3 H	D1 L	D2 L	D3 L	E1H	E2H	E3H	E1L	E2L	E3L	H	P	CD
AGRICULTURE GROSS MARGIN	36,924,802	37,469,771	37,915,957	34,596,406	35,212,911	35,409,524	36,924,802	37,469,771	37,915,957	34,746,753	35,394,551	35,409,524	64,271,211	24,746,669	24,746,669
AG COSTS	17,101,181	17,267,134	17,367,498	14,560,881	14,769,617	14,838,193	17,101,181	17,267,134	17,367,498	14,574,888	14,783,908	14,838,193	37,081,661	12,626,203	12,626,203
NET AGRICULTURE BENEFIT	19,823,621	20,202,637	20,548,459	20,035,525	20,443,294	20,571,331	19,823,621	20,202,637	20,548,459	20,171,864	20,610,643	20,571,331	27,189,550	12,120,466	12,120,466
COMPARED TO CLOSE DOWN	7,703,155	8,082,171	8,427,993	7,915,059	8,322,828	8,450,865	7,703,155	8,082,171	8,427,993	8,051,398	8,490,177	8,450,865	15,069,084	0	

CONVERSION COSTS

LAND DEVELOPMENT COSTS ($/HA)

	Horticulture	Irrigated Perennial Dairy	Irrigated Perrenial Beef	Irrigated Annual Dairy	Irrigated Annual Beef	Dryland Dairy	Dryland Beef
Horticulture	0	800	800	500	500	300	300
Irrigated Perennial Dairy	1,000	0	0	600	600	600	600
Irrigated Perrenial Beef	1,000	0	0	600	600	600	600
Irrigated Annual Dairy	500	400	400	0	0	200	200
Irrigated Annual Beef	500	400	400	0	0	200	200
Dryland Dairy	500	500	500	400	400	0	0
Dryland Beef	500	500	500	400	400	0	0

CONVERSION COSTS CONTINUED

LIVESTOCK CAPITAL ($/HA)

Based on dairy 1 DSE = $45
beef 1 DSE = $37.50

Land Productivity	Dryland	Early Germination	Permanent Irrigation
High			
Dairy	675	900	1125
Beef	563	750	938
Medium			
Dairy	585	720	855
Beef	488	600	713
Low			
Dairy	315	450	585
Beef	263	375	488

HIGH PRODUCTIVITY CONVERSION COSTS per HECTARE

FROM: \ TO:	Horticulture	Perrenial Dairy	Perrenial Beef	Annual Dairy	Annual Beef	Dryland Dairy	Dryland Beef
Horticulture	$0 /ha	$1,925 /ha	$1,738 /ha	$1,400 /ha	$1,250 /ha	$975 /ha	$863 /ha
Perrenial Dairy	-$125 /ha	$0 /ha	-$187 /ha	$375 /ha	$225 /ha	$150 /ha	$38 /ha
Perrenial Beef	$62 /ha	$187 /ha	$0 /ha	$562 /ha	$412 /ha	$337 /ha	$225 /ha
Annual Dairy	-$400 /ha	$625 /ha	$438 /ha	$0 /ha	-$150 /ha	-$25 /ha	-$137 /ha
Annual Beef	-$250 /ha	$775 /ha	$588 /ha	$150 /ha	$0 /ha	$125 /ha	$13 /ha
Dryland Dairy	-$175 /ha	$950 /ha	$763 /ha	$625 /ha	$475 /ha	$0 /ha	-$112 /ha
Dryland Beef	-$63 /ha	$1,062 /ha	$875 /ha	$737 /ha	$587 /ha	$112 /ha	$0 /ha

MEDIUM PRODUCTIVITY CONVERSION COSTS per HECTARE

FROM: \ TO:	Horticulture	Perrenial Dairy	Perrenial Beef	Annual Dairy	Annual Beef	Dryland Dairy	Dryland Beef
Horticulture	$0 /ha	$1,655 /ha	$1,513 /ha	$1,220 /ha	$1,100 /ha	$885 /ha	$788 /ha
Perrenial Dairy	$145 /ha	$0 /ha	-$142 /ha	$465 /ha	$345 /ha	$330 /ha	$233 /ha
Perrenial Beef	$287 /ha	$142 /ha	$0 /ha	$607 /ha	$487 /ha	$472 /ha	$375 /ha
Annual Dairy	-$220 /ha	$535 /ha	$393 /ha	$0 /ha	-$120 /ha	$65 /ha	-$32 /ha
Annual Beef	-$100 /ha	$655 /ha	$513 /ha	$120 /ha	$0 /ha	$185 /ha	$88 /ha
Dryland Dairy	-$85 /ha	$770 /ha	$628 /ha	$535 /ha	$415 /ha	$0 /ha	-$97 /ha
Dryland Beef	$12 /ha	$867 /ha	$725 /ha	$632 /ha	$512 /ha	$97 /ha	$0 /ha

LOW PRODUCTIVITY CONVERSION COSTS per HECTARE

FROM: \ TO:	Horticulture	Perrenial Dairy	Perrenial Beef	Annual Dairy	Annual Beef	Dryland Dairy	Dryland Beef
Horticulture	$0 /ha	$1,385 /ha	$1,288 /ha	$950 /ha	$875 /ha	$615 /ha	$563 /ha
Perrenial Dairy	$415 /ha	$0 /ha	-$97 /ha	$465 /ha	$390 /ha	$330 /ha	$278 /ha
Perrenial Beef	$512 /ha	$97 /ha	$0 /ha	$562 /ha	$487 /ha	$427 /ha	$375 /ha
Annual Dairy	$50 /ha	$535 /ha	$438 /ha	$0 /ha	-$75 /ha	$65 /ha	$13 /ha
Annual Beef	$125 /ha	$610 /ha	$513 /ha	$75 /ha	$0 /ha	$140 /ha	$88 /ha
Dryland Dairy	$185 /ha	$770 /ha	$673 /ha	$535 /ha	$460 /ha	$0 /ha	-$52 /ha
Dryland Beef	$237 /ha	$822 /ha	$725 /ha	$587 /ha	$512 /ha	$52 /ha	$0 /ha

DISTRIBUTION SYSTEM MAINTENANCE AND RENEWAL COST ESTIMATES

1. INTRODUCTION

This attachment provides details of the assumption made and examples of the cost calculated for the Strategy 1 and Strategy 3 approaches to maintaining and renewing the Irrigation Distribution Scheme.

Initially the costs were estimated over a 30 year period. However, they were extended to an 80 year period to improve the consistency of comparison between the high capital intensive Strategy 3 with the high operation costs of Strategy 1.

Please note that the operating costs evaluated in this option were based on data from the financial year 1989/90. They pre-date the changes introduced in centralising operations at Harvey and recently proposed short term options for the improved operation and management of the South-West Irrigation Service as a result of the September 1992 Value Management Study.

2. STRATEGY 1 - MINIMUM MAINTENANCE OF THE EXISTING CHANNEL SYSTEM

These pages provide an introduction into the costings and assumptions associated with maintaining the current channel system for Option A. They do not cover the details of all options. Costs peculiar to particular options (particularly the drainage costs of Option D) are detailed in spreadsheets for that particular option.

The components of the costings for Option A are similar for all options and provide an introduction to all the spreadsheets. The costs components have been grouped into capital and operating as detailed below.

Capital - Channel Patchup Costs

As small sections of lined channel "fail" they are currently patched up on a job by job basis. While each job is relatively costly because of its small scale this "patchup" approach avoids a major capital refurbishment program. However, as the channels age the frequency of "failures" increase and greater expenditure on replacement patchup is required.

It is difficult to reliably estimate such expenditure. However estimates are possible by considering the age of channel lining and the replacement costs based on past operational experience. This approach is considered preferable to adopting a general depreciation allowance based on standard accounting procedures.

An increased "patchup" programme run by the existing maintenance gangs (or contracted out by the Region as appropriate) was costed in the following way.

An effective life for lined channels of 60 to 80 years adopted. This is based on their ability to maintain channel stability and hydraulic capacity (not leakage control) (see background paper number 2 Phase 1). A maximum patchup/replacement yearly expenditure was set sufficient to ensure that at least 50% of the lined lengths of a district would be replaced in a 20 year period once the average age reached 60 years. An average replacement cost (without overheads) as listed below was adopted.

Channel Capacity M^3/sec	Adopted Unit Costs (Dec 1990) $/metre
0 - 0.5	$100
0.5 - 1.0	$120
1.0 - 2.0	$170
2.0 - 3.0	$220
> 3.0	$275

For the Collie and Harvey District average replacement costs were about $170 to $175 per metre. As the Waroona District has smaller channel capacities average costs were $110 per metre.

The start year at which the maximum yearly expenditure on patchup was taken when the average age reached about 55 years. A 5 to 10 year gradual increase to this level was adopted.

The following table summarises the channel patchup estimates.

Timing and Expenditure on Channel Patchup

District	Average Current Age of Lining (Years)	Start Time for Maximum Replacement Expenditure (Year No.)	Nominal Average Length Replaced Each Year (km)	Adopted[1] Maximum (Direct Costs only) $1000's
Waroona	49	5	0.7	75
Harvey	44	11	2.0	340
Collie	25	21	1.1	194
Total	-	-	3.8	609

Notes: [1] Overall expenditure would replace all lining in about 40 years. It would take about 20 years in Waroona, about 35 years in Harvey and 50 years in Collie.

An allowance was made of $70,000 for capital upgrade of earth channels over the three districts. While ongoing maintenance should ensure that the channels are maintained, episodic problems requiring specific upgrading costs will increase as the earth channels age.

Capital - Waterway Structures and Distribution Outlet Works

Over the next 10 years preliminary expenditure on automation of distribution outlet works and automatic controls at major bifuration points in the distribution system are planned to evaluate the cost effectiveness of further automation. The expenditure is expected to save the equivalent wages of 2 watermen over the ten year period.

The distribution outlets marks proposed are as follows:

		$000's
Year 1	Wellington	70
Year 2	Samson & Waroona	150
Year 3	Drakesbrook	50
	Burekup & North Supply Offtake (Collie District)	100
Year 4	Logue Brook	80
	Waroona Major Bifurcation	50
	North Supply - High Level (Collie District)	50
Year 5	Stirling	70
	Uduc Channel Offtake	30

Within the channel system one automatic gate installation was planned in each district in Year 1. Three additional auto-gate installations each year at bifurcations are planned between years 2 and 5 in the Collie District to complete a particular channel sub-system. Three are planned in Waroona in year 6 and three in years 7 to 10 in Harvey. Each auto-gate installation is estimated at $16,000.

After year 10 replacement and upgrading of bifurcation and flow control structures will continue throughout the distribution system but without automation and at cost of $10,000 each. Automation would be extended only if the experience in the first 10 years showed that automation was cost effective.

The average effective life for a Dethridge wheel is about 20 years. Allowance has been made for replacement of most wheels over the next 10 years. Wheel replacement costs return to zero by year 11, but commence again in year 21 when the first wheels replaced in year 1 need to be replaced again.

Capital - Minor Works Overheads

The patching up of channels, replacement of flow control structures and installation of new Dethridge Wheels are works to be carried out within the South-West region. They would incur the average salary and administration overheads of 35%.

Operating - Water Delivery Costs

The cost of water delivery is based on the operating figures for 1989/90. These have been modified for future years in the following ways.

As the new automatic control gear is introduced increases in electrical maintenance costs are incurred. These grow by about $2,000 per year per district as the equipment is installed. In year 5 (Collie District) and year 10 (Harvey District) the labour of one waterman is saved. Past year 10 the water delivery costs remain constant.

Operating - Channel Maintenance and Additional Drainage Operation and Maintenance

Channel maintenance is that cost involved in the routine weed control, cleaning and minor maintenance tasks to ensure the routine operation of the channel system. Cost estimates do not change with time under this minimum maintenance strategy.

Similarly, the additional drainage costs are those additional costs incurred in operating the drainage in the irrigation areas relative to the cost of operating the drainage in nearby dryland drainage areas. It is a fixed cost (for Option A) based on operating costs in 1989/90.

Operating - Salary and Administration Overhead Costs

As detailed in the Kinhill Alternatives Management Paper (Phase 2 Paper Supplementary Paper Number 5) an appropriate long term overhead charge for the salary and administrative costs of the South-West Irrigation service is 35%. This additional (real) operating cost is included as a separate item.

Strategy 1 Spreadsheet Examples

The following 3 pages list the actual costs for the Waroona, Harvey and Collie Districts for Option A and the current water charging policy.

The distribution costs described above are listed together with the areas irrigated for the High Demand Case, the Headworks costs involved and estimates of water sold and revenue received.

****** OPTION A1 ******** WAROONA

Current Max Perm Irr Area	1526 ha	Max Irr Area (IPP+IAP+V+F)	1896 ha	
Max Perm Irr Area - Year 15	1526 ha	Rated Area for Water Alloc. at Yr 15	1499 ha	Max Early Germination Area at Yr 15 370 ha

Year '89/90 +	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	30-80	Total $mill	NPV at 6% $mill
AREA LIMITS ON IRRIGATION																																	
Max area of Permanent Irr. Land	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	24049		
Max area Irr. (+ Early Germin)	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	29878		
Rated Area for Water Allocation	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	23629		
High Water Demand - Permanent Irr Land	1350	1359	1369	1378	1387	1389	1392	1394	1397	1399	1401	1404	1406	1409	1411	1418	1425	1432	1439	1446	1453	1460	1467	1474	1481	1488	1495	1502	1509	1516	23895		
High Water Demand - Early Germin. Land	477	476	475	474	474	474	474	474	474	474	473	473	473	473	473	467	461	454	448	442	436	430	423	417	411	405	399	392	386	380	5990		
CAPITAL COSTS ($ 000's)																																	
Headworks																																	
Structures	0	0	0	0	2300	2300	2700	0	0	300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1243	7.6	5.507
Major Contract O/Heads	0	0	0	0	184	184	216	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	99	0.6	0.441
Total with O/H	0	0	0	0	2484	2484	2916	0	0	324	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1342	8.2	5.948
Extra Metro Source Cost ***																																	-0.016
Headworks- Outlets	0	150	50	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.215
Distribition System																																	
Lined Channel Patch Up or replace	0	0	0	25	50	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	914	2.0	0.924
Unlined Channel Patch Up	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	158	0.3	0.164
Pipe Network Const.																																	
(a) Irrig. System	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.000
Drain Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.000
Flow control -																																	
Structures	16	0	0	0	0	48	0	0	0	0	28	28	28	28	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	16	248	0.4	0.214
Wheel replace.	10	10	10	10	10	10	10	10	10	10	0	0	0	0	0	0	0	0	0	0	10	10	10	10	10	10	10	10	10	10	159	0.2	0.123
Sub Total (Irrig.)	36	170	70	95	70	143	95	95	95	95	113	113	113	113	101	101	101	101	101	101	111	111	111	111	111	111	111	111	111	111	1479	3.1	1.640
Minor Works O/H	13	60	25	33	25	50	33	33	33	33	40	40	40	40	35	35	35	35	35	35	39	39	39	39	39	39	39	39	39	39	518	1.1	0.574
Sub Total with O/H	49	230	95	128	95	193	128	128	128	128	153	153	153	153	136	136	136	136	136	136	150	150	150	150	150	150	150	150	150	150	1996	4.2	2.214
CAPITAL TOTAL (Inc. O/H)	49	230	95	128	2579	2677	3044	128	128	452	153	153	153	153	136	136	136	136	136	136	150	150	150	150	150	150	150	150	150	150	3339	12.4	8.162
OPERATION COSTS																																	
Water Delivery Costs (Waterman & M & E Costs)	55	56	57	57	58	59	59	60	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	61	967	1.8	0.979
Maintenance of Irrig Supply System	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	1221	2.3	1.267
Add. Drainage O & M	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	529	1.0	0.549
TOTAL (without O/H)	166	167	168	168	169	170	170	171	172	172	172	172	172	172	172	172	172	172	172	172	172	172	172	172	172	172	172	172	172	172	2718	5.1	2.795
Admin- O/H Costs	58	58	59	59	59	59	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	951	1.8	0.978
TOTAL DIST (with O/H)	225	226	227	227	228	229	230	231	232	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	3669	6.9	3.774
Headworks OP (with O/H)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	319	0.6	0.331
OPS TOTAL (with O/H)	245	246	247	248	249	249	250	251	252	253	253	253	253	253	253	253	253	253	253	253	253	253	253	253	253	253	253	253	253	253	3988	7.6	4.105
********Grand Tot. NPV - 80 yrs @ 6%=																																	12.267
GRAND TOTALS - $ 000's	294	476	341	376	2827	2927	3295	380	380	706	406	406	406	406	389	389	389	389	389	389	403	403	403	403	403	403	403	403	403	403	7327	20.0	11.37
NPV Costs - 85% H/works + dist. + deprec. on old assets																																	11.48
Revenue(Rates and charges)	275	276	277	278	279	279	280	280	280	281	281	281	281	282	282	283	283	284	285	285	286	287	288	288	289	290	290	291	292	292	4609	8.5	4.629
Cost(Inc. Deprec. of old Assets)/Current Income																																	2.480
Cost(Excl. Deprec. of old Assets)/Current Income																																	2.457

NPV Flows	199.11
$/mL	23.25
$/mL	57.13
$/Ha	366.93

Dam Replace. $mill	0.2027

****** OPTION A1 ******** HARVEY				
Current Max Perm Irr Area	5820 ha	Max Irr Area (IPP+IAP+V+F)	6960 ha	
Max Perm Irr Area - Year 15	5820 ha	Rated Area for Water Alloc. at Yr 15	5431 ha	Max Early Germination Area at Yr 15: 954

Year '89/90 +	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	30-80	Total $millions	NPV at 6% $millions
AREA LIMITS ON IRRIGATION																																	
Max area of Permanent Irr. Land	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	91726		
Max area Irr. (+ Early Germin)	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	6773	106755		
Rated Area for Water Allocation	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	85601		
High Water Demand - Permanent Irr Land	4582	4561	4541	4520	4499	4510	4521	4531	4542	4553	4564	4575	4585	4596	4607	4629	4651	4672	4694	4716	4738	4760	4781	4803	4825	4847	4869	4890	4912	4934	77769		
High Water Demand - Early Germin. Land	1379	1366	1352	1339	1325	1324	1323	1321	1320	1319	1318	1317	1315	1314	1313	1313	1312	1312	1311	1311	1311	1310	1310	1309	1309	1309	1308	1308	1307	1307	20601		
CAPITAL COSTS ($ 000's)																																	
Headworks																																	
Structures	0	0	0	2600	1000	0	0	2000	600	0	0	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0	0	0	0	0	1243	7.2	0.3
Major Contract O/Heads	0	0	0	208	80	0	0	160	48	0	0	0	0	0	0	0	0	0	0	80	0	0	0	0	0	0	0	0	0	0	99	0.6	0.0
Total with O/H	0	0	0	2808	1080	0	0	2160	648	0	0	0	0	0	0	0	0	0	0	1080	0	0	0	0	0	0	0	0	0	0	1342	7.8	0.3
Extra Metro Source Cost ***																																	-0.0
Headworks- Outlets	0	0	0	50	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.2
Distribition System																																	
Lined Channel Patch Up or replace	10	10	10	10	10	40	100	160	220	280	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	340	4143	7.7	1.7
Unlined Channel Patch Up	10	10	10	10	10	20	20	20	20	20	20	20	20	20	20	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	473	0.7	0.6
Pipe Network Const.																																	
(a) Irrig. System	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
Drain Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
Flow control -																																	
Structures	16	0	0	0	0	0	48	48	48	48	51	51	51	51	63	63	63	63	63	63	63	63	51	51	51	51	51	51	51	51	804	1.3	0.7
Wheel replace.	33	33	33	33	33	33	33	33	33	33	0	0	0	0	0	0	0	0	0	0	33	33	33	33	33	33	33	33	33	33	514	0.7	0.4
Sub Total (Irrig.)	69	53	53	103	153	93	201	261	321	381	411	411	411	411	423	433	433	433	433	433	466	466	454	454	454	454	454	454	454	454	5934	10.5	3.5
Minor Works O/H	24	18	18	36	53	32	70	91	112	133	144	144	144	144	148	152	152	152	152	152	163	163	159	159	159	159	159	159	159	159	2077	3.7	1.2
Sub Total with O/H	93	71	71	139	206	125	271	352	433	514	555	555	555	555	571	585	585	585	585	585	629	629	612	612	612	612	612	612	612	612	8011	14.1	4.7
CAPITAL TOTAL (Inc. O/H)	93	71	71	2947	1286	125	271	2512	1081	514	555	555	555	555	571	585	585	585	585	1665	629	629	612	612	612	612	612	612	612	612	9354	21.9	5.0
OPERATION COSTS ($ 000's)																																	
Water Delivery Costs (Waterman & M & E Costs)	194	196	199	201	203	206	208	210	213	215	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	189	2980	5.8	2.7
Maintenance of Irrig Supply System	426	426	426	426	426	426	426	426	426	426	426	426	426	426	426	426	426	426	426	426	426	426	426	426	426	426	426	426	426	426	6719	12.8	6.1
Add. Drainage O & M	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	3522	5.7	1.4
TOTAL (without O/H)	844	846	849	851	853	856	858	860	863	865	839	839	839	839	839	839	839	839	839	839	839	839	839	839	839	839	839	839	839	839	13222	25.3	10.2
Admin- O/H Costs	295	296	297	298	299	299	300	301	302	303	294	294	294	294	294	294	294	294	294	294	294	294	294	294	294	294	294	294	294	294	4628	8.9	3.6
TOTAL DIST (with O/H)	1139	1142	1146	1149	1152	1155	1158	1161	1164	1168	1132	1132	1132	1132	1132	1132	1132	1132	1132	1132	1132	1132	1132	1132	1132	1132	1132	1132	1132	1132	17849	34.2	13.7
Headworks OP (with O/H)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	319	0.6	0.3
OPS TOTAL (with O/H)	1160	1163	1166	1169	1172	1175	1178	1182	1185	1188	1153	1153	1153	1153	1153	1153	1153	1153	1153	1153	1153	1153	1153	1153	1153	1153	1153	1153	1153	1153	18168	34.8	14.0
*******Grand Tot. NPV - 80 yrs @ 6%=																																	19.0
GRAND TOTALS - $ 000's	1252	1234	1237	4116	2458	1300	1449	3693	2266	1702	1708	1708	1708	1708	1724	1737	1737	1737	1737	2817	1781	1781	1765	1765	1765	1765	1765	1765	1765	1765	27522	56.7	19.0
NPV Costs - 85% H/works + dist. + deprec. on old assets																																	19.2
REVENUE (Rates & Vol. Charges)	1016	1013	1010	1007	1004	1006	1007	1008	1009	1011	1012	1013	1015	1016	1017	1020	1023	1026	1028	1031	1034	1036	1039	1042	1044	1047	1050	1053	1055	1058	16677	30.8	15.2
Cost(Inc. Deprec. of old Assets)/Current Income																																	1.3
Cost(Excl. Deprec. of old Assets)/Current Income																																	1.3

NPV Flows	637
$/mL	23.8
$/mL	29.8
$/Ha	183.918

Dam Replace. $mill	0.19271

****** OPTION A1 ******** COLLIE

Current Max Perm Irr Area	5132 ha	Max Irr Area (IPP+IAP+V+F)	6320 ha		
Max Perm Irr Area - Year 15	5132 ha	Rated Area for Water Alloc. at Yr 15	4977 ha	Max Early Germination Area at Yr 15	1188 ha

Year '89/90 +	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
AREA LIMITS ON IRRIGATION																
Max area of Permanent Irr. Land	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132
Max area Irr. (+ Early Germin)	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320
Rated Area for Water Allocation	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977
High Water Demand - Permanent Irr Land	4200	4184	4168	4151	4135	4136	4137	4139	4140	4141	4142	4143	4145	4146	4147	4151
High Water Demand - Early Germin. Land	1499	1491	1484	1476	1468	1467	1467	1466	1465	1465	1464	1463	1462	1462	1461	1461
CAPITAL COSTS ($ 000's)																
Headworks																
Structures	0	300	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Major Contract O/Heads	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total with O/H	0	324	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Headworks- Outlets	70	0	100	50	0	0	0	0	0	0	0	0	0	0	0	0
Distribition System																
Lined Channel Patch Up or replace	60	60	60	60	60	60	60	60	60	60	80	80	80	80	80	116
Unlined Channel Patch Up	20	20	20	20	20	40	40	40	40	40	40	40	40	40	40	40
Pipe Network Const.																
(a) Irrig. System	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Drain Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flow control -																
Structures	16	48	48	48	48	0	0	0	0	0	65	65	65	65	65	65
Wheel replace.	34	34	34	34	34	34	34	34	34	34	0	0	0	0	0	0
Sub Total (Irrig.)	200	162	262	212	162	134	134	134	134	134	185	185	185	185	185	221
Minor Works O/H	70	57	92	74	57	47	47	47	47	47	65	65	65	65	65	78
Sub Total with O/H	270	219	354	286	219	181	181	181	181	181	250	250	250	250	250	299
CAPITAL TOTAL (Inc. O/H)	270	543	354	286	219	181	181	181	181	181	250	250	250	250	250	299
OPERATION COSTS																
Water Delivery Costs (Waterman & M & E Costs)	168	170	172	174	176	152	154	156	158	160	160	160	160	160	160	160
Maintenance of Irrig Supply System	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374	374
Add. Drainage O & M	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
TOTAL (without O/H)	627	629	631	633	635	610	612	614	616	618	618	618	618	618	618	618
Admin- O/H Costs	219	220	221	221	222	214	214	215	216	216	216	216	216	216	216	216
TOTAL DIST (with O/H)	846	849	851	854	857	824	827	830	832	835	835	835	835	835	835	835
Headworks OP (with O/H)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
OPS TOTAL (with O/H)	866	869	872	874	877	844	847	850	852	855	855	855	855	855	855	855
GRAND TOTALS - $ 000's	1136	1412	1225	1161	1096	1025	1028	1031	1033	1036	1105	1105	1105	1105	1106	1154
REVENUE (Rates & Vol. Charges)	933	931	928	926	924	924	924	924	924	924	925	926	925	925	925	926

Year '89/90 +	17	18	19	20	21	22	23	24	25	26	27	28	29	30	30-80	Total $millions	NPV at 6% $millions
AREA LIMITS ON IRRIGATION																	
Max area of Permanent Irr. Land	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	80890		
Max area Irr. (+ Early Germin)	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	99621		
Rated Area for Water Allocation	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	78447		
High Water Demand - Permanent Irr Land	4156	4160	4165	4169	4173	4178	4182	4187	4191	4195	4200	4204	4209	4213	66405		
High Water Demand - Early Germin. Land	1461	1460	1460	1460	1460	1460	1459	1459	1459	1459	1459	1458	1458	1458	22981		
CAPITAL COSTS ($ 000's)																	
Headworks																	
Structures	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.3
Major Contract O/Heads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
Total with O/H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.3
Extra Metro Source Cost '''																	-0.0
Headworks- Outlets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.2
Distribition System																	
Lined Channel Patch Up or replace	116	116	116	116	194	194	194	194	194	194	194	194	194	194	2360	3.5	1.7
Unlined Channel Patch Up	40	40	40	40	40	40	40	40	40	40	40	40	40	40	630	1.1	0.6
Pipe Network Const.																	
(a) Irrig. System	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
Drain Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
Flow control -																	
Structures	65	65	65	65	65	53	53	53	53	53	53	53	53	53	649	1.4	0.7
Wheel replace.	0	0	0	0	34	34	34	34	34	34	34	34	34	34	415	0.7	0.4
Sub Total (Irrig.)	221	221	221	221	333	321	321	321	321	321	321	321	321	321	4055	6.9	3.5
Minor Works O/H	78	78	78	78	117	112	112	112	112	112	112	112	112	112	1419	2.4	1.2
Sub Total with O/H	299	299	299	299	450	433	433	433	433	433	433	433	433	433	5474	9.3	4.7
CAPITAL TOTAL (Inc. O/H)	299	299	299	299	450	433	433	433	433	433	433	433	433	433	5474	9.7	5.0
OPERATION COSTS																	
Water Delivery Costs (Waterman & M & E Costs)	160	160	160	160	160	160	160	160	160	160	160	160	160	160	2524	4.8	2.7
Maintenance of Irrig Supply System	374	374	374	374	374	374	374	374	374	374	374	374	374	374	5888	11.2	6.1
Add. Drainage O & M	85	85	85	85	85	85	85	85	85	85	85	85	85	85	1336	2.5	1.4
TOTAL (without O/H)	618	618	618	618	618	618	618	618	618	618	618	618	618	618	9748	18.6	10.2
Admin- O/H Costs	216	216	216	216	216	216	216	216	216	216	216	216	216	216	3412	6.5	3.6
TOTAL DIST (with O/H)	835	835	835	835	835	835	835	835	835	835	835	835	835	835	13160	25.1	13.7
Headworks OP (with O/H)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	319	0.6	0.3
OPS TOTAL (with O/H)	855	855	855	855	855	855	855	855	855	855	855	855	855	855	13480	25.7	14.0
********Grand Tot. NPV - 80 yrs @ 6%=																	19.0
GRAND TOTALS - $ 000's	1154	1154	1154	1154	1306	1289	1289	1289	1289	1289	1289	1289	1289	1289	18954	35.4	19.0
NPV Costs - 85% H/works + dist. + deprec. on old assets																	19.2
REVENUE (Rates & Vol. Charges)	926	927	927	928	929	929	930	930	931	931	932	933	933	934	14716	27.8	15.2
Cost(Inc. Deprec. of old Assets)/Current Income																	1.3
Cost(Excl. Deprec. of old Assets)/Current Income																	1.3

NPV Flows	733
NPV Flows	637
$'mL	23.8
$'mL	29.8
$'Ha	183.818
Dam Replace. $mill	0.18271

3. STRATEGY 3 - FULLY PIPE DISTRIBUTION SYSTEM

A major planning preliminary design exercise was undertaken to evaluate the cost of piping the distribution system to serve the various different areas and demand rates. A number of old channel systems have been upgraded with pipe networks over the last 15 years in Australia. The cost of such upgrades are high on capital but reduce operating costs significantly and reduce water loss substantially. The costings carried out here were designed to explicitly evaluate the full capital and operational costs of the different options and to evaluate the savings in water from construction of a piped network.

Capital Costs - High Demand Cases

The following general approach to the pipe network design for Area Option A to D was adopted.

The general layout of the current channel system was used as the basis for the pipe network. For each area option (in the Harvey and Waroona districts) a peak design flow rate case was determined. This involved the identification of the number of supply points that currently operate at any one time. The rated area being served down stream of each point in the network was the determined and a peak flow rate based on this rated area assessed.

These peak flow rates and the associated heads (and minimum head requirement of 3 metres at each supply point) formed the basis for input into an optimising pipe network design package called "Optnet". This program performs the necessary hydraulic calculations to optimise the size of the pipework required to meet the head and flow demands throughout the network. Pipe purchase costs were updated to January 1991 dollars and laying costs estimated from experience in the Harvey area.

A full pipe network analysis was not carried out for Option E. The capital cost estimates for the Collie District were scaled on the basis of the relative channel length and sizes from the Harvey District preliminary design study.

In the case of the Horticultural Options a minimum flow rate of 35 litres per second (per 20 ha area) was adopted throughout the distribution system. No scheduling would be required and farmers would be able to water their average crop requirements in about 8 to 10 hours per day. In one day in 20 during January - February they may need to water the full 24 hours. Flow restrictors would be installed to limit usage to the maximum of 35 litres per second per 20 hectares. Those wishing additional security could construct onsite storage. Water would be provided at a low three metre head. Individual irrigators would then establish their own means of pressurising their farm distribution system to their own requirements.

Output from the design program gives a listing of the pipe sizes in the network, their cost in the ground (without overheads), and a graphical presentation of the overall network layout. Ten percent contingency costs and supply point costs were added to the capital cost of the pipe network as provided by water supply design branch.

A major pipe network construction program would be placed out to tender. The Water Authority would carry out the detailed design and supervise the construction. Salary and administration costs for such large projects range between 5% and 10% of the capital costs. A figure of 8% was adopted in this case.

Capital expenditures (with 8% salary and administration overheads) exceed $60 million for the large networks for Option A in the Collie and Harvey districts. Construction time in these cases were spread over a 5 year period (years 11 to 15) for both practical construction and financial reasons. Maximum yearly capital expenditures of about $12 to $13 million were adopted in any one year. Construciton time was spread over 3 years in the smaller distribution system options (e.g. Years 13 to 15 for the Horticulture Option).

It should be stressed that the costings provided, while realistic for planning purposes do not constitute detailed designs or accurately reflect construction costs. More detailed design and construction cost estimation would be required in 5 to 8 years time, prior to any decision to proceed with a fully piped system.

Operating Costs for the Pipe Networks

While pipe networks are very capital intensive they are low on operation costs. The experience of operating the Harvey Pipe network served as the basis for estimating the future operating costs.

Water delivery costs only involve labour costs associated with scheduling users and in reading metres for charging purposes.

Two operations were assessed as being able to run the 3 districts or Area Option A. Other options were costed in proportion to the number of sampling points remaining in operation.

Other maintenance costs were assessed as proportional to the length of the pipe network and consisted of :

Mechanical & Electrical Maintenance	$50/km/a
Routine Maintenance	$50/km/a
One off bursts	$50/km/a

Replacement/renewal of constant flow rate supply points were assessed at $1,400 per supply point and required every 15 years. A replacement program of 10% per year over a 10 year period was included.

Capital Costs - Low Water Demand Cases

The capital costs of the designed networks were based on providing the current watered area with sufficient water to meet peak operating demand in February each year. However as demand reduces as price rises the same sized pipe network is not required. The capital costs of the networks for the low demand cases were appropriately scaled to take this effect into account.

The following 3 pages detail the capital and operating costs for the high and low demand Strategy 3 case for Area Option A.

****** OPTION A3 ******** WAROONA

Current Max Perm Irr Area	1526 ha	Max Irr Area (IPP+IAP+V+F)	1896 ha
Max Perm Irr Area - Year 15	1526 ha	Rated Area for Water Alloc. at Yr 15	1499 ha
Max Early Germination Area at Yr 15	370 ha		

Year '89/90 +	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	30-80	Total $millions	NPV at 6% $millions
AREA LIMITS ON IRRIGATION																																	
Max area of Permanent Irr. Land	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	1526	24049		
Max area Irr. (+ Early Germin)	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	1896	29878		
Rated Area for Water Allocation	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	1499	23629		
High Water Demand - Permanent Irr Land	1350	1359	1369	1378	1387	1389	1392	1394	1397	1399	1401	1404	1406	1409	1411	1418	1425	1432	1439	1446	1453	1460	1467	1474	1481	1488	1495	1502	1509	1516	23895		
High Water Demand - Early Germin. Land	477	476	476	475	474	474	474	474	474	474	473	473	473	473	473	467	461	454	448	442	436	430	423	417	411	405	399	392	385	380	5990		
CAPITAL COSTS ($ 000's)																																	
Headworks																																	
Structures	0	0	0	0	2300	2300	2700	0	0	300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1243	7.6	5.507
Major Contract O/Heads	0	0	0	0	184	184	216	0	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	99	0.6	0.441
Total with O/H	0	0	0	0	2484	2484	2916	0	0	324	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1342	8.2	5.948
Extra Metro Source Cost ***																																	0.000
Headworks- Outlets	0	150	50	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0.215
Distribibution System																																	
Lined Channel Patch Up or replace	0	0	25	25	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.078
Unlined Channel Patch Up	10	10	10	10	10	5	5	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.052
Pipe Network Const.																																	
(a) Irrig. System	0	0	0	0	0	0	0	0	0.00	0.00	0.00	5.90	5.90	7.47	4.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.5	10.746
Drain Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.000
Flow control -																																	
Structures	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.015
Wheel replace.	10	10	10	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.042
Sub Total (Irrig.)	36	170	95	95	70	5	5	5	0	0	0	5900	5900	7470	4180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	23.9	11.149
Minor Works O/H	13	60	33	33	25	2	2	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.141
Sub Total with O/H	49	230	128	128	95	7	7	7	0	0	0	5900	5900	7470	4180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	24.1	11.290
CAPITAL TOTAL (Inc. O/H)	49	230	128	128	2579	2491	2923	7	0	324	0	5900	5900	7470	4180	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1342	32.3	17.238
OPERATION COSTS																																	
Water Delivery Costs (Waterman & M & E Costs)	55	56	57	57	58	59	59	60	61	61	61	61	61	61	327	327	327	327	327	327	327	327	327	327	327	327	327	327	327	327	5154	6.1	2.854
Maintenance of Irrig Supply System	77	77	77	77	77	77	77	77	77	77	77	77	77	77	23	23	23	23	23	23	23	23	23	38	38	38	38	38	38	38	601	1.6	0.944
Add. Drainage O & M	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	529	1.0	0.549
TOTAL (without O/H)	166	167	168	168	169	170	170	171	172	172	172	172	172	172	384	384	384	384	384	384	364	384	384	399	399	399	399	399	399	399	6284	8.6	4.346
Admin- O/H Costs	58	58	59	59	59	59	60	60	60	60	60	60	60	60	134	134	134	134	134	134	134	134	134	140	140	140	140	140	140	140	2199	3.0	1.522
TOTAL DIST (with O/H)	225	226	227	227	228	229	230	231	232	233	233	233	233	233	518	518	518	518	518	518	518	518	518	538	538	538	538	538	538	538	8483	11.6	5.869
Headworks OP (with O/H)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	319	0.6	0.331
OPS TOTAL (with O/H)	245	246	247	248	249	249	250	251	252	253	253	253	253	253	538	538	538	538	538	538	538	538	538	558	558	558	558	558	558	558	8802	12.3	6.201
*******Grand Tot. NPV - 80 yrs @ 6%=																																	23.439
GRAND TOTALS - $ 000's	294	475	375	376	2827	2740	3173	258	252	577	253	6153	6153	7723	4716	538	538	538	538	538	538	538	538	558	558	558	558	558	558	558	10145	44.6	22.55
NPV Costs - 85% H/works + dist. + deprec. on old assets																																	22.65
Revenue(Rates and charges)	275	276	277	278	279	279	280	280	280	281	281	281	281	282	282	283	283	284	285	285	286	287	288	288	289	290	290	291	292	292	4609	8.5	4.629
Cost(Inc. Deprec. of old Assets)/Current Income																																	4.894
Cost(Excl. Deprec. of old Assets)/Current Income																																	4.871

NPV Flows	199.11
$/mL	23.25
$/mL	113.24
$/Ha	727.31

Dam Replace. $mill	0.2027

****** OPTION A3 ******** HARVEY	Current Max Perm Irr Area	5820 ha	Max Irr Area (IPP+IAP+V+F)	6960 ha		
	Max Perm Irr Area - Year 15	5820 ha	Rated Area for Water Alloc. at Yr 15	5431 ha	Max Early Germination Area at Yr 15	712 ha

Year '89/90 +	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	30-80	Total $millions	NPV at 6% $millions
AREA LIMITS ON IRRIGATION																																	
Max area of Permanent Irr. Land	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820	5820			
Max area Irr. (+ Early Germin)	6773	6773	6773	6773	6773	6761	6749	6737	6725	6713	6676	6640	6604	6568	6531	6531	6531	6531	6531	6531	6531	6531	6531	6531	6531	6531	6531	6531	6531	6531			
Rated Area for Water Allocation	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431	5431			
High Water Demand - Permanent Irr Land (ha)	4582	4561	4541	4520	4499	4510	4521	4532	4543	4554	4564	4575	4586	4597	4608	4617	4626	4635	4644	4653	4662	4671	4681	4690	4699	4708	4717	4726	4735	4744			
High Water Demand - Early Germin. Land (ha)	1379	1366	1352	1339	1325	1264	1202	1141	1079	1018	956.6	895.2	833.8	772	711	711	711	711	711	711	711	711	711	711	711	711	711	711	711	711			
CAPITAL COSTS ($ 000's)																																	
Headworks																																	
Structures	0	0	0	2600	1000	0	0	2000	600	0	0	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0	0	0	0	0	1243	7.2	4.933
Major Contract O/Heads	0	0	0	208	80	0	0	160	48	0	0	0	0	0	0	0	0	0	0	80	0	0	0	0	0	0	0	0	0	0	99	0.6	0.395
Total with O/H	0	0	0	2808	1080	0	0	2160	648	0	0	0	0	0	0	0	0	0	0	1080	0	0	0	0	0	0	0	0	0	0	1342	7.8	5.327
Extra Metro Source Cost ***																																	0.000
Headworks- Outlets	0	0	0	50	100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.114
Distribution System																																	
Lined Channel Patch Up or replace	10	10	10	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.042
Unlined Channel Patch Up	10	10	10	10	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.042
Pipe Network Const.																																	
(a) Irrig. System - $ Millions	0	0	0	0	0	0	0	0	6.4	12.3	11.8	12.1	12.6	6.72	5.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		67.2	34.0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		0.0	0.000
Flow control -																																	
Structures	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.015
Wheel replace.	4	4	4	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.014
Sub Total (Irrig.)	40	24	24	74	120	0	0	0	6400	12300	11800	12100	12600	6720	5300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67.5	34.2
Minor Works O/H	14	8	8	26	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.080
Sub Total with O/H	54	32	32	100	162	0	0	0	6400	12300	11800	12100	12600	6720	5300	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	67.6	34.3
CAPITAL TOTAL (Inc. O/H) - $Millions **	0.05	0.03	0.03	2.91	1.24	0.00	0.00	2.16	7.05	12.3	11.8	12.1	12.6	6.7	5.30	0.00	0.00	0.00	0.00	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.34	75.4	39.6
OPERATION COSTS ($ 000's)																																	
Water Delivery Costs (Waterman & M & E Costs)	194	196	199	201	203	206	208	210	213	215	189	189	189	189	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6	30.6	482.31	3.3	2.080
Maintenance of Irrig	426	426	426	426	426	426	426	426	426	426	426	426	426	426	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	39.3	620.07	6.6	4.240
Supply System	0	0	23	23	23	23	23	23	23	23	23	23	0	0	0	0	0	0	0	0	0	0	0	48	48	48	48	48	48	48	296		
Add. Drainage O & M	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	223	3522.1	6.7	3.654
TOTAL (without O/H)	844	846	872	874	876	879	881	883	886	888	862	862	839	839	293	293	293	293	293	293	293	293	293	341	341	341	341	341	341	341	4920	17.2	10.2
Admin- O/H Costs	295	296	305	306	307	307	308	309	310	311	302	302	294	294	103	103	103	103	103	103	103	103	103	119	119	119	119	119	119	119	1722	6.0	3.585
TOTAL DIST (with O/H)	1139	1142	1177	1180	1183	1186	1189	1192	1195	1199	1163	1163	1132	1132	396	396	396	396	396	396	396	396	396	460	460	460	460	460	460	460	6642	23.2	13.8
Headworks OP (with O/H)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	319	0.6	0.331
OPS TOTAL (with O/H)	1160	1163	1197	1200	1203	1206	1209	1213	1216	1219	1184	1184	1153	1153	416	416	416	416	416	416	416	416	416	481	481	481	481	481	481	481	6961	23.8	14.2
****** Grand Tot. NPV - 80 yrs @ 6%=																																	53.8
GRAND TOTALS - $ Millions	1.21	1.20	1.23	4.11	2.45	1.21	1.21	3.37	8.26	13.52	12.98	13.3	13.8	7.9	6.72	0.42	0.42	0.42	0.42	1.50	0.42	0.42	0.42	0.48	0.48	0.48	0.48	0.48	0.48	0.48	8.3		52.97
NPV Costs - 85% H/works + dist. + deprec. on old assets																																	53.26
REVENUE (Rates & Vol. Charges)	1016	1013	1010	1007	1004	1004	1004	1004	1004	1003	1003	1003	1003	1003	1002	1004	1005	1006	1007	1008	1009	1010	1012	1013	1014	1015	1016	1017	1018	1019	16068	30.3	16.5
Cost(Inc. Deprec. of old Assets)/Current Income																																	3.226
Cost(Excl. Deprec. of old Assets)/Current Income																																	3.209

NPV Flows	660.5
$/ML	24.99
$/ML	80.20
$/Ha	487.489
Dam Replace. $mill	0.38275

****** OPTION A3 ******** COLLIE			
Current Max Perm Irr Area	5132 ha	Max Irr Area (IPP+(AP+V+F)	6320 ha
Max Perm Irr Area - Year 15	5132 ha	Rated Area for Water Alloc. at Yr 15	4977 ha
Max Early Germination Area at Yr 15	1188 ha		

Year '89/90 +	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
AREA LIMITS ON IRRIGATION															
Max area of Permanent Irr. Land	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132
Max area Irr. (+ Early Germin)	6631	6631	6631	6631	6631	6615	6600	6584	6569	6553	6507	6460	6414	6367	6320
Rated Area for Water Allocation	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977
High Water Demand - Permanent Irr Land	4200	4184	4168	4151	4135	4136	4137	4139	4140	4141	4142	4143	4145	4146	4147
High Water Demand - Early Germin. Land	1499	1491	1484	1476	1468	1467	1467	1466	1465	1465	1464	1463	1462	1462	1461
CAPITAL COSTS ($ 000's)															
Headworks															
Structures	0	300	0	0	0	0	0	0	0	0	0	0	0	0	0
Major Contract O/Heads	0	24	0	0	0	0	0	0	0	0	0	0	0	0	0
Total with O/H	0	324	0	0	0	0	0	0	0	0	0	0	0	0	0
Headworks- Outlets	70	0	100	50	0	0	0	0	0	0	0	0	0	0	0
Distribition System															
Lined Channel Patch Up or replace	60	40	20	0	0	0	0	0	0	0	0	0	0	0	0
Unlined Channel Patch Up	20	20	20	20	20	0	0	0	0	0	0	0	0	0	0
Pipe Network Const.															
(a) Irrig. System - Millions	0	0	0	0	0	0	0	0	0.00	0.00	11.8	12.3	12.6	12.6	10.9
Drain Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flow control -															
Structures	16	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wheel replace.	34	34	0	0	0	0	0	0	0	0	0	0	0	0	0
Sub Total (Irrig.)	200	94	140	70	20	0	0	0	0	0	*******	*******	*******	*******	*******
Minor Works O/H	70	33	49	25	7	0	0	0	0	0	0	0	0	0	0
Sub Total with O/H	270	127	189	95	27	0	0	0	0	0	*******	*******	*******	*******	*******
CAPITAL TOTAL (Inc. O/H)	270	451	189	95	27	0	0	0	0	0	*******	*******	*******	*******	*******
OPERATION COSTS ($ 000's)															
Water Delivery Costs (Waterman & M & E Costs)	168	170	172	174	176	152	154	156	158	160	160	160	160	160	31.7
Maintenance of Irrig Supply System	374	374	374	374	374	374	374	374	374	374	374	374	374	374	33.8
Add. Drainage O & M	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85
TOTAL (without O/H)	627	629	631	633	635	610	612	614	616	618	618	618	618	618	150
Admin- O/H Costs	219	220	221	221	222	214	214	215	216	216	216	216	216	216	53
TOTAL DIST (with O/H)	846	849	851	854	857	824	827	830	832	835	835	835	835	835	203
Headworks OP (with O/H)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
OPS TOTAL (with O/H)	866	869	872	874	877	844	847	850	852	855	855	855	855	855	223
GRAND TOTALS - $ 000's	1136	1320	1061	969	904	844	847	850	852	855	*******	*******	*******	*******	*******
REVENUE (Rates & Vol. Charges)	933	931	929	926	924	924	924	924	924	925	925	925	925	925	925

Year '89/90 +	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	30-80	Total $millions	NPV at 6% $millions
AREA LIMITS ON IRRIGATION																		
Max area of Permanent Irr. Land	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	5132	80890		
Max area Irr. (+ Early Germin)	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	6320	99621		
Rated Area for Water Allocation	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	4977	78447		
High Water Demand - Permanent Irr Land	4151	4156	4160	4165	4169	4173	4178	4182	4187	4191	4195	4200	4204	4209	4213	66405		
High Water Demand - Early Germin. Land	1461	1461	1460	1460	1460	1460	1460	1459	1459	1459	1459	1459	1458	1458	1458	22981		
CAPITAL COSTS ($ 000's)																		
Headworks																		
Structures	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1243	0.3	0.5
Major Contract O/Heads	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	99	0.0	0.0
Total with O/H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1342	0.3	0.5
Extra Metro Source Cost ***																		0.0
Headworks- Outlets	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0.2
Distribition System																		
Lined Channel Patch Up or replace	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2360	0.1	0.5
Unlined Channel Patch Up	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	630	0.1	0.2
Pipe Network Const.																		
(a) Irrig. System - Millions	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	60.2	28.3
Drain Construction	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0
Flow control -																		
Structures	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	839	0.0	0.2
Wheel replace.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	537	0.1	0.2
Sub Total (Irrig.)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4367	60.7	29.5
Minor Works O/H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1529	0.2	0.4
Sub Total with O/H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5896	60.9	29.9
CAPITAL TOTAL (Inc. O/H)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7238	61.2	30.4
OPERATION COSTS ($ 000's)																		
Water Delivery Costs (Waterman & M & E Costs)	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	31.7	2524	2.8	2.1
Maintenance of Irrig Supply System	33.8	33.8	33.8	33.8	33.8	33.8	33.8	33.8	83.5	83.5	83.5	83.5	83.5	83.5	83.5	5888	6.1	4.7
Add. Drainage O & M	85	85	85	85	85	85	85	85	85	85	85	85	85	85	85	1336	2.5	1.4
TOTAL (without O/H)	150	150	150	150	150	150	150	150	200	200	200	200	200	200	200	9748	11.5	8.1
Admin- O/H Costs	53	53	53	53	53	53	53	53	70	70	70	70	70	70	70	3412	4.0	2.8
TOTAL DIST (with O/H)	203	203	203	203	203	203	203	203	270	270	270	270	270	270	270	13160	15.5	11.0
Headworks OP (with O/H)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	319	0.6	0.3
OPS TOTAL (with O/H)	223	223	223	223	223	223	223	223	290	290	290	290	290	290	290	13480	16.1	11.3
******* Grand Tot. NPV - 80 yrs @ 6%=																		41.7
GRAND TOTALS - $ 000's	223	223	223	223	223	223	223	223	290	290	290	290	290	290	290	20718		41.7
NPV Costs - 85% H/works + dist. + deprec. on old assets																		41.9
REVENUE (Rates & Vol. Charges)	926	926	927	928	928	929	929	930	930	931	932	932	933	933	934	14720	27.8	15.2

Cost(Inc. Deprec. of old Assets)/Current Income	2.8
Cost(Excl. Deprec. of old Assets)/Current Income	2.7

NPV Flows	637
$/mL	23.8
$/mL	65.4
$/Ha	394.078

Dam Replace. $mill	0.18269

COMPUTATIONS OF SPACING AND COSTS OF SHALLOW DRAINAGE

1. INTRODUCTION

This appendix summarises the calculations to determine the most appropriate drainage strategy to lower water tables 1.5 metres in the salt prone western portions of the irrigation areas. It should return productivity levels to values similar to those in the productive eastern portion of the irrigation districts.

2. SUMMER RE-CHARGE ESTIMATE FOR DRAINAGE DESIGN - (Collie District)

(a) Net Re-charge calibrated from regional model

= 0.1mm per day (Phase 2 Supplementary Paper 3)

(b) Gross Re-charge from shallow soils (averaged over whole farm)

= 0.2mm per day (Phase 2 Supplementary Paper 4)

Gross Re-charge from channels (Western portion of Collie district)

= 0. 1mm per day (estimated from channel density through district and average channel losses)

(c) Required average evaporation from water table to match net re-charge = 0.22mm/day.

(d) For the Vindictive Drain Catchment where 28% of catchment is irrigated the re-charge rates would be distributed as follows:

	Area Averaged (mm/d)	Irrigated Portion (mm/d)	Dryland Portion (mm/d)
Gross Re-charge to Water Table	0.3	0.9	0.1
Evaporation from Water Table	0.2	0.4	0.1
Net Re-charge to Water Table	0.1	0.4	0

Therefore adopt 0.4 mm/day as the design re-charge rate for drainage over irrigation paddocks. That is R = 0.4mm/day.

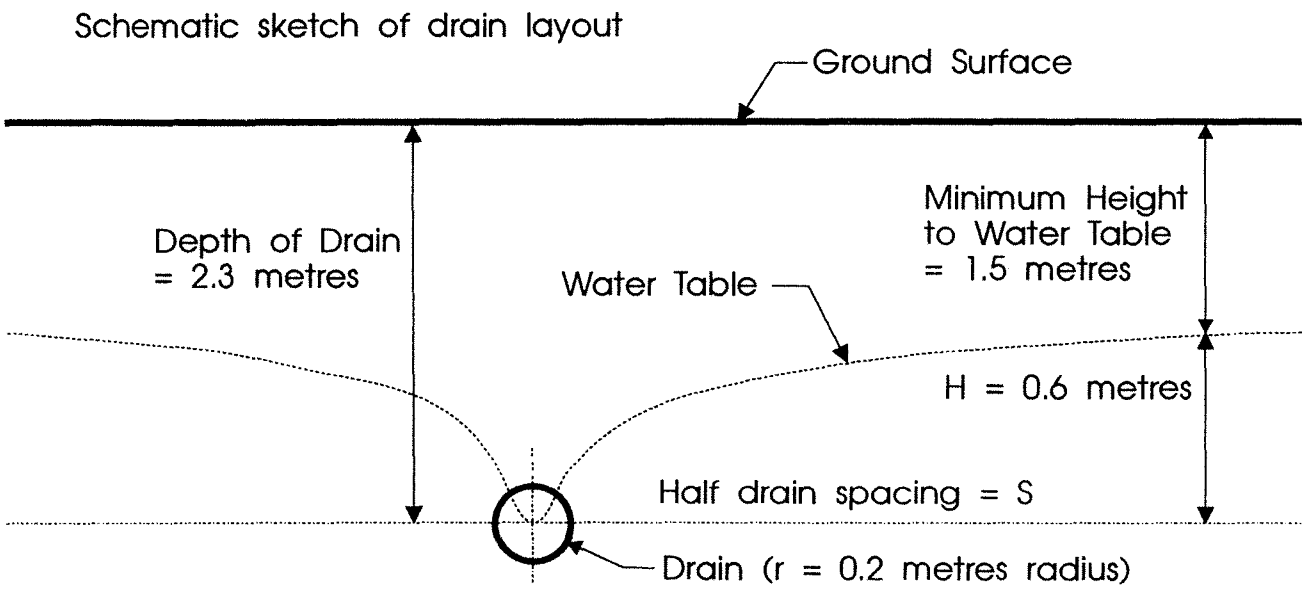
2. SPACING COMPUTATIONS

(a) Adopted Conductivities

K_V = .001 m/d (Supplementary Paper 3)

K_H = 0.1 m/d (10 times less permeable than Supplementary Paper 3)

(b) Geometric Layout



The maximum practical depth for construction was taken as 2.5 metres (mid depth of 2.3 metres).

To ensure that virtually no salt would rise to the surface a depth of 1.5 metres below the surface was adopted as the desired minimum depth.

This implies that a maximum mid drain height about the drains would be 0.6 metres from Supplementary Paper No ?

$$C_1 = \frac{H (K_V K_H)^{0.5}}{rR}$$

$$= \frac{0.6 (.001 \times 0.1)^{0.5}}{0.2 * 0.0004}$$

$$= 75$$

From Figure 29 S/r = 38

Therefore required spacing is 15 metres.

3. DRAIN LAYOUT AND COSTINGS

Estimates of the length of drains per irrigated hectare were made on a typical 4 hectare paddock with a 200 metre bay length. Allowance was made for an additional 500 metres of drain to an outlet surface drain.

Length required	- 13.3 rows - say 14 x 200 metres
	- link to outlet - 500 metres
	- 3,500 metres total per 4 ha
	- 875 metres/ha

Costs are a function of the scale of the operation and the depth of the construction.

Automated trenching machines can reduce unit of drainage. However large scale projects need to be arranged for these lower contract prices to be obtained. Quotes from Victorian drainage contractors indicate costs of about $4.50 to $4.80 for drains to depths up to 2.5 metres if large areas are carried out.

Allowing for 20% contingencies a figure of $5.50 per metre was adopted.

Final cost per hectare	= $5.5 x 875/ha
	= $4,700/ha

COSTS OF REGIONAL PUMPING

INTRODUCTION

The regional groundwater modelling indicated that water tables could be lowered by over 1 metre by a "line sink" abstraction rate of $0.5m^3$/day/m across the 3 km of the western portion of the Collie district. This appendix estimates the cost of such a pumping strategy.

APPROACH

The original transect modelling needs to be converted into a number of bores per hectare.

The original "line sink" suggests a row of bores 100 metres apart and space in two lines 1,500 metres apart (one bore per 15 hectares). The actual location of the bores could be modified to suit irrigation paddocks, facilitate disposal of effluent and close to power. An alternative spacing may be 200 x 750 metres.

COSTINGS

Assume maximum pumping rate 100 m^3/day for 250 days per year.

- Drilling Costs	- $5,000 per hole
	- if only ⅓ successful cost of hole $15,000
	- $3,000 SEC power connection
	- $2,000 bore equipment
- Bore Capital	- $20,000
- Life	- 20 years
- Replacement Cost	- $6,250
- Operating Cost	- $25 x 10^2 x (20/0.6) x .0272/yr
	- $2,266.0/yr
	- $151/ha/yr

Capitalised Operating over 80 years - $37,400

<u>Summary of Costs</u>

1 Bore at	$20,000
Replacement at 20, 40 and 60 years	$ 7,800
Capitalised Energy Cost	$34,400
	$65,200

Cost per hectare	$ 4,350