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**Rural Industries Research and
Development Corporation**

Value for Money

Returns from Rural R&D into Olives, Oaten Hay and Rice

by Matthew Harding

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Foreword

Australia's rural industries make a fundamental contribution to the Australian economy and way of life. The Rural Industries Research and Development Corporation invests in many Australian rural industries on behalf of government and industry stakeholders. It is critical that this investment is properly evaluated for effectiveness in generating returns to rural industries and the wider community.

Through the Council of Rural Research and Development Corporation Chairs, a common evaluation framework for Rural Development Corporations has been developed. This process has been established to report on the overall returns from the Rural Development Corporations collectively to industry, along with public and spillover returns from the collective program. These spillover benefits strengthen the case for ongoing public support to the RDC's.

This report constitutes part of RIRDC's contribution to the across RDC evaluation process. It summarises three evaluations previously undertaken of successful projects that generated significant benefits. This research includes a number of olive projects, projects on new oat varieties and research into electromagnetic induction techniques in rice growing.

In total, the research evaluated in this report represents an investment of approximately \$5.9 million, with approximately half of this investment coming from RIRDC, with the remainder contributed by other agencies and industry. In net present value terms, the outcomes of the research evaluated in this report is estimated to have generated net benefits of between \$453 and \$757 million, including spillover benefits of \$162 million in the form of water savings. In terms of return on investment, benefit-cost ratios of between 22 and 101 were calculated with rates of return of between 29 and 79 per cent.

This project was funded from RIRDC Core Funds which are provided by the Australian Government.

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Peter O'Brien

Managing Director

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Executive Summary

Through the Council of Rural Research and Development Corporation Chairs (CRRDCC), ACIL Tasman has developed a common evaluation framework for use across rural RDCs. This evaluation process has been established to report on:

- overall returns from the RDCs collectively to industry;
- public and spillover returns from the collective program; and
- the public and spillover returns that are conditional on public contribution to the RDCs.

As part of the RRDC Guidelines, RIRDC is required to report on a small number of ‘successful’ (formerly hero) projects – with the motivation that return on these clusters of projects/programs justify the total expenditure across all programs. These projects should also demonstrate spillover benefits.

This report forms RIRDC’s contribution to the CRRDCC process for the first year, identifying ‘successful’ projects from past evaluations that best satisfy the requirements for the common RRDC evaluation process. Following a review of past evaluations, the CIE has identified three suitable projects to present for the first reporting year:

- olives (new plant products evaluation) published in 2004
- new oat varieties (fodder crops evaluation) published in 2005
- electromagnetic induction (rice evaluation) published in 2004.

In addition to its function as an input into CRRDCC process, this report is also beneficial as a summary of some of RIRDC’s more successful projects and programs. This information is useful as a feedback tool not only to government, but also to levy paying industries and other funding sources.

Details of investments

Table 1 shows the annual investment in each of the projects evaluated.

The olive evaluation looked at seven related projects where the investment totalled around \$2.4 million between 1997-98 and 2005-06. Of this investment, RIRDC contributed around 51 per cent with the remainder coming from other R&D organisations and industry. The new oat varieties evaluation was on three projects with investments totalling just over \$1.2 million between 1997-98 and 2003-04. Of this investment, RIRDC contributed 49 per cent with the remainder coming from other agencies and industry. The electromagnetic induction evaluation also included three projects, with a total investment of around \$2.3 million. RIRDC contributed half of this, with the remainder funded by other organisations and industry. This investment also included an estimate of in-kind costs associated with one of the projects run through the rice CRC.

1 Annual investment across evaluated projects (\$)

Year	Olives	New oat varieties	Electromagnetic induction
1993–94			129 409
1994–95			107 404
1995–96			111 209
1996–97			125 997
1997–98	539 081	114 258	210 562
1998–99	513 366	139 898	311 594
1999–00	579 210	140 876	26 678
2000–01	79 889	151 613	993 600 ^a
2001–02	119 769	98 270	
2002–03	258 431	288 859	330 000 ^a
2003–04	170 148	255 693	
2004–05	100 202		
2005–06	39 291		
Total	2 399 387	1 219 960	2 345 877
RIRDC contribution (%)	51	49	50

a. Estimated in-kind investment.

Source: : RIRDC (2005), RIRDC (2004a), RIRDC (2004b).

In total, the investment across the research evaluated was around \$5.9 million in nominal terms.

Key results

Table 2 summarises the results of the three evaluations.

2 Results summary

Evaluation	Net benefits (NPV)	BCR	IRR
	\$m	Ratio	%
Olives	86.1-390	22-96	29-44
New oat varieties	159.1	101	79
Electromagnetic induction	207.5	99	79

Note: Results generated using a discount rate of 5 per cent in 2007 dollar equivalents.

Source: RIRDC (2005), RIRDC (2004a), RIRDC (2004b), CIE calculations.

The olive evaluation included a range of benefits depending on the scenario used for olive oil quality. Allowing for this, the three evaluations report total net benefits of between \$453 million and \$757 million. The benefit cost ratios for each evaluation ranged between 22 and 101 with internal rates of return of between 29 and 79 per cent. This compares with total investment in projects across all RIRDC portfolios for 2006-07 of around \$23.7 million.

The benefits generated by the olive and new oat variety research have largely been captured by the relevant industry. However the electromagnetic induction generated significant spillover benefits in the form of water savings. In total, the water savings between 1999 and 2015 are estimated at 2.68 million megalitres. Assuming a discount rate of 5 per cent, the benefit of this water saving is estimated at \$162 million.

Sensitivity analysis was also undertaken for each evaluation around uncertain parameters. In each case, a significant positive net benefit was maintained, indicating robust results.

Introduction

Through the Council of Rural Research and Development Corporation Chairs (CRRDCC), ACIL Tasman has developed a common evaluation framework for use across rural RDCs. This evaluation process has been established to report on:

- overall returns from the RDCs collectively to industry;
- public and spillover returns from the collective program; and
- the public and spillover returns that are conditional on public contribution to the RDCs.

The RRDC Guidelines require RIRDC to report on:

- a small number of ‘successful’ (formerly hero) projects – with the motivation that return on these clusters of projects/programs justify the total expenditure. These should also demonstrate spillover benefits; and
- a randomly selected set of programs/projects to demonstrate, over time, the average returns to stakeholders (industry and government) from investments.

This report deals with the ‘successful’ project component of the guidelines — which is outlined further below.

This report

This report will form RIRDC’s contribution to the CRRDCC process for the first year, identifying ‘successful’ projects from past evaluations that best satisfy the requirements for the common RRDC evaluation process. The CIE is currently developing an evaluation framework for RIRDC, which will be used in the subsequent reporting years.

Following a review of past evaluations, the CIE has identified three suitable projects to present for the first reporting year:

- olives (new plant products evaluation) published in 2004
- new oat varieties (fodder crops evaluation) published in 2005
- electromagnetic induction (rice evaluation) published in 2004.

This summary will present a brief outline of each evaluation with key outputs and outcomes achieved along with summary results for each evaluation, modified and updated where necessary to meet the CRRDCC reporting requirements. Each of the original BCA documents is included as appendices to the summary. These documents provide more detailed results, which have been modified and from the original analysis with updated tables and information presented where applicable. They also provide a more detailed account of the project inputs, outputs and outcomes along with details on methodology. Whilst care has been taken to ensure that the results presented are as accurate and up-to-date as possible, it should be noted that the results presented in this report are based primarily on previous analysis undertaken for RIRDC by the CIE. It has not been possible to undertake any original analysis within the scope of this exercise.

1. Olive evaluation

As part of an evaluation of RIRDC's new plants program published in 2004, the CIE undertook an evaluation of R in the Australian olive industry (RIRDC 2004). Appendix A contains the full original evaluation document for reference.

The evaluation looked at seven projects, with R&D relating directly to the production of olive oil. The broad objective of this research was to move olive production from a boutique cottage industry to one that is import-replacing and export-creating. The program had the following goals.

1. Market and product development: development of export and quality standards, new market development, promotion of health benefits, collection and analysis of industry data, establishment of production and marketing networks.
2. Sustainable production: pest and disease control strategies and IPM guidelines, cost competitive harvest and production technologies, grove optimisation for best yield/quality, grower education and best practice guidelines.
3. Processing and product quality: a quality assurance program, world's best practice waste utilisation scheme, definition of oil quality standards, maximisation of health components.
4. Communication, coordination and training: training programs, curriculum development of Best Management Practices, coordination of industry bodies and extension delivery, for example, assisting Horticulture Australia Limited (HAL) with the development of a statutory levy funding process, (Olive Press and RIRDC, 2002).

Projects evaluated

The olive evaluation undertaken in the new plants program included the following projects.

- *UA-41A: Wild Olive selection for quality oil production*: This project was aimed at identifying wild olive varieties suited to a commercial olive industry in Australia.
- *UA-54A: Wild olive selection for quality oil production*: This project built on the identification and selection of suitable wild varieties in UA-41A.
- *UCS-19A: Olive oil: yield, quality and cultivar identification*: This project was aimed at developing information on DNA characteristics of olive varieties and a database on Australian olives.
- *UCS-33A: Quality enhancement of Australian extra-virgin olive oils*: The objective of this project was to determine the effects of processing conditions on olive oil quality.
- *BOG-1A: Gel-Pro Analyser software*: This project was for the purchase of software used in UA-41A.
- *BOG-2A: Benchtop Olive Oil Extraction Plant*: The objective of this project was to design a benchtop olive oil extraction plant to be produced for the 2001 harvest.
- *DAN-197A: Olive harvesting project – harvest timing for optimal oil quality*: The objective of this project was to determine the precise harvest time for optimal olive oil quantity through oil quality analysis, taking into account the effect of harvest parameters and irrigation, and to provide this data to the industry.

Investment

Table 1.1 shows the annual investment in the seven projects evaluated between 1998 and 2006.

1.1 Total funding of olive R&D

<i>FY end</i>	<i>RIRDC</i>	<i>Other R&D organisations</i>	<i>Industry</i>	<i>Total investment</i>	<i>Implementation costs</i>
1998	262 241	241 840	35 000	539 081	
1999	284 565	192 751	36 050	513 366	
2000	335 699	193 380	50 131	579 210	
2001	46 025	11 864	22 000	79 889	
2002	53 357	25 096	41 316	119 769	50 000
2003	101 387	58 059	98 985	258 431	25 000
2004	73 535	58 103	38 510	170 148	31 000
2005	45 128	43 726	11 348	100 202	33 000
2006	14 773	19 018	5 500	39 291	35 000
2007					65 000
2008					40 000
2009					40 000
TOTAL	1 216 710	843 837	338 840	2 399 387	319 000

Source: RIRDC (2004a).

The total investment across all seven projects was around \$2.4 million. This was split between RIRDC, who supplied around 51 per cent of the total, other R&D organisations (35 per cent) and industry (14 per cent). In addition, there was a further investment required in terms of implementation costs across the program out to 2009 totalling \$319 000.

Project outputs and outcomes

Chart 1.2 summarises the outputs and outcomes of the research along with the key impacts. Two projects (BOG –1A and UCS-19A) are inputs into the others and have no independent outcomes.

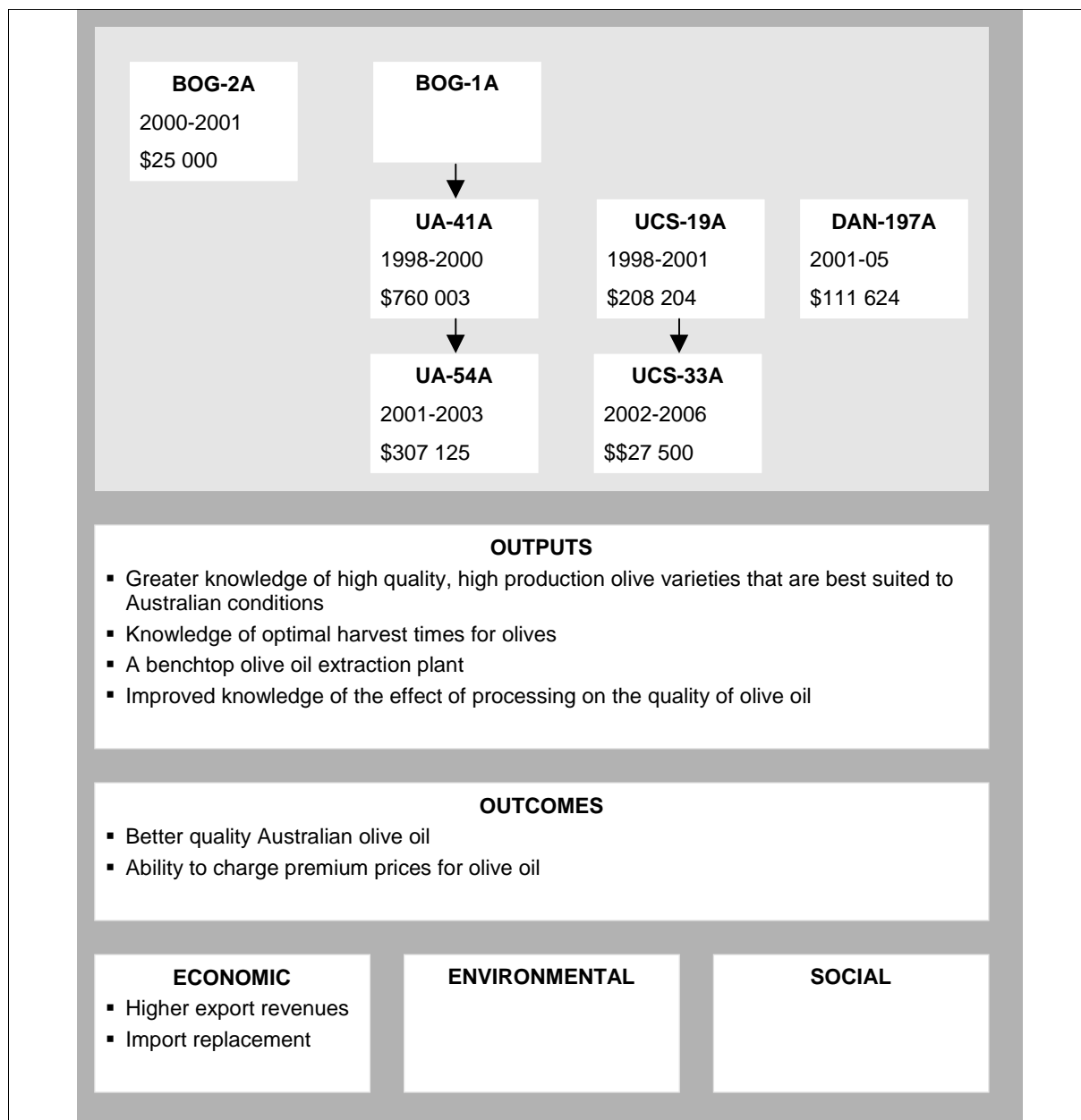
The major outcomes of the projects are better quality olive oil production and the associated ability to charge a premium price for this oil. The economic impacts of these outcomes are measured in terms of increased export revenue and import replacement. There have not been any environmental or social outcomes of significance arising from the projects.

Estimated benefits

The benefits of the projects were estimated using a range of potential quality improvements and associated price increases in response to these improvements. Due to the uncertainty around the level of potential quality increase resulting from the research, upper and lower bounds of the quality increases were estimated with the guidance of the researchers.

The quality scenarios used in the analysis are shown in table 1.3, while box 1.4 outlines other key assumptions.

1.2 Outputs, outcomes and benefits of olive R&D



Source: RIRDC (2004a).

1.3 Improvement in oil quality assumptions

	Lower bound quality increase	Upper bound quality increase	Year that quality improvement begins	Year that quality peaks	Initial adoption rate	Peak adoption rate
	%	%	year	year	%	%
Olive press enters market	0	0.05	2005	2008	0.1	20
Better knowledge of optimal harvest times	0.05	0.15	2006	2012	0.1	50
Improved varieties	0.05	0.25	2014	2020	0.1	6
Improved processing knowledge	0.05	0.2	2007	2013	0.1	50

Source: RIRDC (2004a).

1.4 Assumptions

Farm gate price extra virgin olive oil — range \$4 to \$6 a litre, most likely	\$5/litre
Percentage markup on farm gate price — range 20 to 100 per cent, most likely	90%
Australian production growth to 2010	43%/year
Australian production growth 2010 to 2012	1%/year
Australian production growth 2012 to 2014	0.5%/year
Price response to quality (elasticity) — range 0.5 to 1.5, most likely	1
Quality outcomes and adoption see table 4.7	

Source: RIRDC (2004a).

Table 1.5 outlines the key results from this evaluation in 2007 dollar equivalents.

1.5 Olive evaluation results

Discount rate	Project costs \$m	Benefits after production cost \$m	NPV \$m	BCR Ratio	IRR %
Lower quality					28.7
0 per cent	3.11	87.0	162.4	53.2	
5 per cent	4.11	47.4	86.1	22.0	
10 per cent	5.40	28.4	48.7	10.0	
Higher quality					44.0
0 per cent	2.95	381.4	721.6	232.8	
5 per cent	4.11	207.3	390.0	96.0	
10 per cent	5.40	123.9	230.1	43.6	

Source: RIRDC 2004a, CIE calculations.

Table 1.6 shows the results of the analysis over a range of time horizons, while chart 1.7 shows the undiscounted stream of net benefits for both quality scenarios.

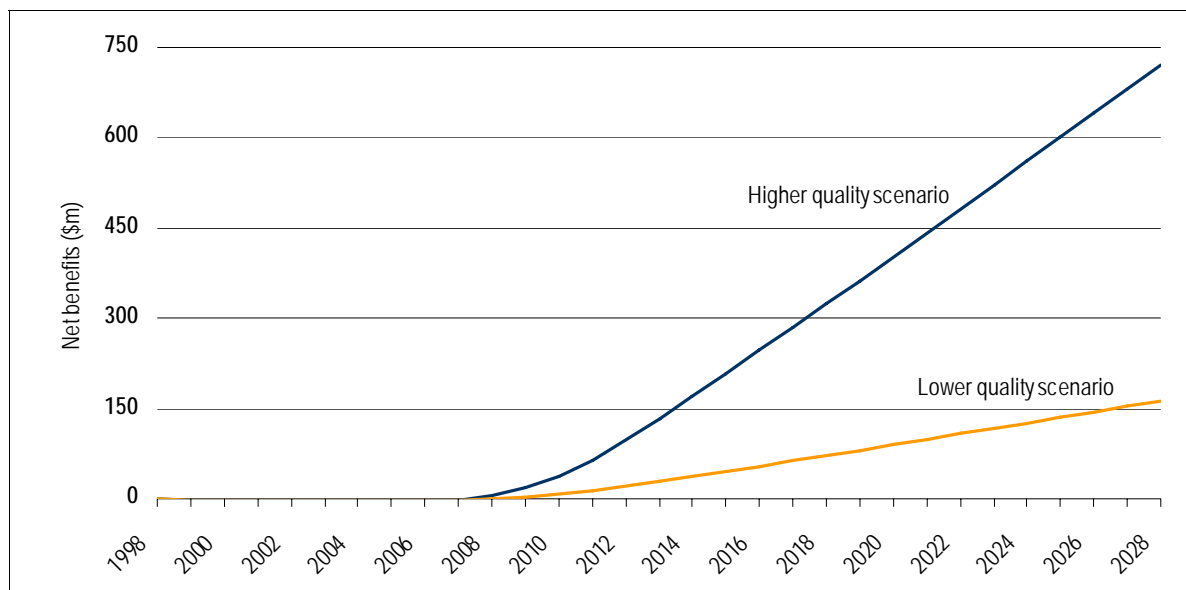
1.6 Results of the benefit-cost analysis across different time horizons

		5 years	10 years	20 years
Lower quality				
NPV costs	\$m	3.28	4.11	4.11
NPV benefits	\$m	0.00	0.37	46.38
NPV net benefits	\$m	-3.28	-3.73	42.27
Higher quality				
NPV costs	\$m	3.28	4.11	4.11
NPV benefits	\$m	0.00	1.29	201.24
NPV net benefits	\$m	-3.28	-2.81	197.13

Source: CIE calculations.

Notes: Using a 5 per cent discount rate, 2007 dollar equivalents.

1.7 Undiscounted stream of net benefits — olive evaluation



Data source: RIRDC 2004a, CIE calculations.

Sensitivity analysis

The ranges across the assumptions outlined in box 1.4 were used to undertake sensitivity analysis. The sensitivity analysis was undertaken using the software package @Risk. This package allows a range of assumptions to be specified, along with a distribution. In general, a triangular distribution would be specified, but other distributions such as normal are also possible.

The results of the sensitivity analysis are presented in table 1.8.

1.8 Sensitivity analysis for olive research

	NPV	BCR	IRR
Lower quality scenario	\$m	Ratio	%
Minimum	31.0	8.5	20.2
Maximum	147.8	37.0	33.9
90 per cent confidence interval	44.8-111.4	11.9-28.1	23.0-31.1
Higher quality scenario	\$m	Ratio	%
Minimum	149.5	37.4	33.7
Maximum	658.9	161.4	50.2
90 per cent confidence interval	209.5-500.2	52.0-122.8	37.1-46.9

Source: CIE calculations.

Notes: Using a 5 per cent discount rate, 2007 dollar equivalents.

2. New oat varieties evaluation

As part of an evaluation of RIRDC's fodder crop and pasture seeds program published in 2005, the CIE undertook an evaluation of R&D on new oat varieties (RIRDC 2005). Appendix B contains the full original evaluation document for reference.

The evaluation looked at three projects targeted at developing new oat varieties. They were the first projects funded by RIRDC that involved research into oats specifically for hay. Previously, research on oat breeding mainly focussed on its use for grains and for human consumption. The change in focus was recognition that oat breeding needed to be targeted for end-use.

Projects evaluated

The new oat varieties evaluation undertaken as part of the fodder crop and pasture seed evaluation included the following projects.

- *SAR-8A: Development of disease resistant, high yielding oat cultivar with enhanced quality for hay production:* The aim of this project was to improve oat varieties for hay end-use given characteristics prioritised by farmers and hay processors.
- *SAR-31A: Development of improved oat varieties for hay end-use:* This project built on the work undertaken in SAR-8A.
- *SAR-50A: Development of improved oat varieties for hay production: national program:* this project involved a coordinated breeding program for the development of improved oat varieties for hay production in southern Australia.

Investment

Table 2.1 shows the annual investment across each project. This investment includes all funding sources, including RIRDC, other research agencies and industry. The RIRDC share of the total funding for each project is also shown.

The total investment across all three projects was approximately \$1.2 million. In total, almost 50 per cent of the funding came from RIRDC, with the remainder coming from other agencies and industry. The final year of investment across the projects was 2003-04.

2.1 Annual research cost for new oat varieties (\$)

Year	SAR-8A	SAR-31A	SAR-50A	Total
1997-98	114 258			114 258
1998-99	139 898			139 898
1999-2000	140 876			140 876
2000-01	103 638	47 975		151 613
2001-02		98 270		98 270
2002-03		90 401	198 458	288 859
2003-04		47 251	208 442	255 693
Total	498 670	283 897	406 900	1 219 960
RIRDC contribution (%)	27	53	76	49

Source: RIRDC (2005).

Project outputs and outcomes

Chart 2.2 summarises the outputs and outcomes of the research along with the key impacts.

The outputs of the projects include:

- development of two advanced breeding lines, Wintaroo and Brusher for potential release as improved hay varieties (SAR-8A)
- Wintaroo and Brusher breeder seeds developed, necessary to commercialise the varieties (SAR-31A); and
- release of Wintaroo and Brusher oat varieties for commercial sale (SAR-50A).

The major outcomes and impacts are economic and include:

- improved hay yield — between 8 and 15 per cent higher than a comparable existing variety;
- increased resistance to disease, including cereal cyst nematode and stem rust nematode, which can negatively affect yields;
- improved leaf and stem colour performance (Wintaroo); and
- improved feeding quality (Brusher).

These outcomes translate to impacts on yield and the ability to attract a price premium. There have not been any significant environmental or social impacts as a result of the projects on new oat varieties.

Estimated benefits

Table 2.3 presents the key results for this evaluation across varying discount rates. In practice, the 5 per cent discount rate would be used as standard in accordance with the common RDC evaluation guidelines. The results are calculated over a time horizon of 29 years (1997-98 to 2026-27) and are real values in 2006-07 dollars.

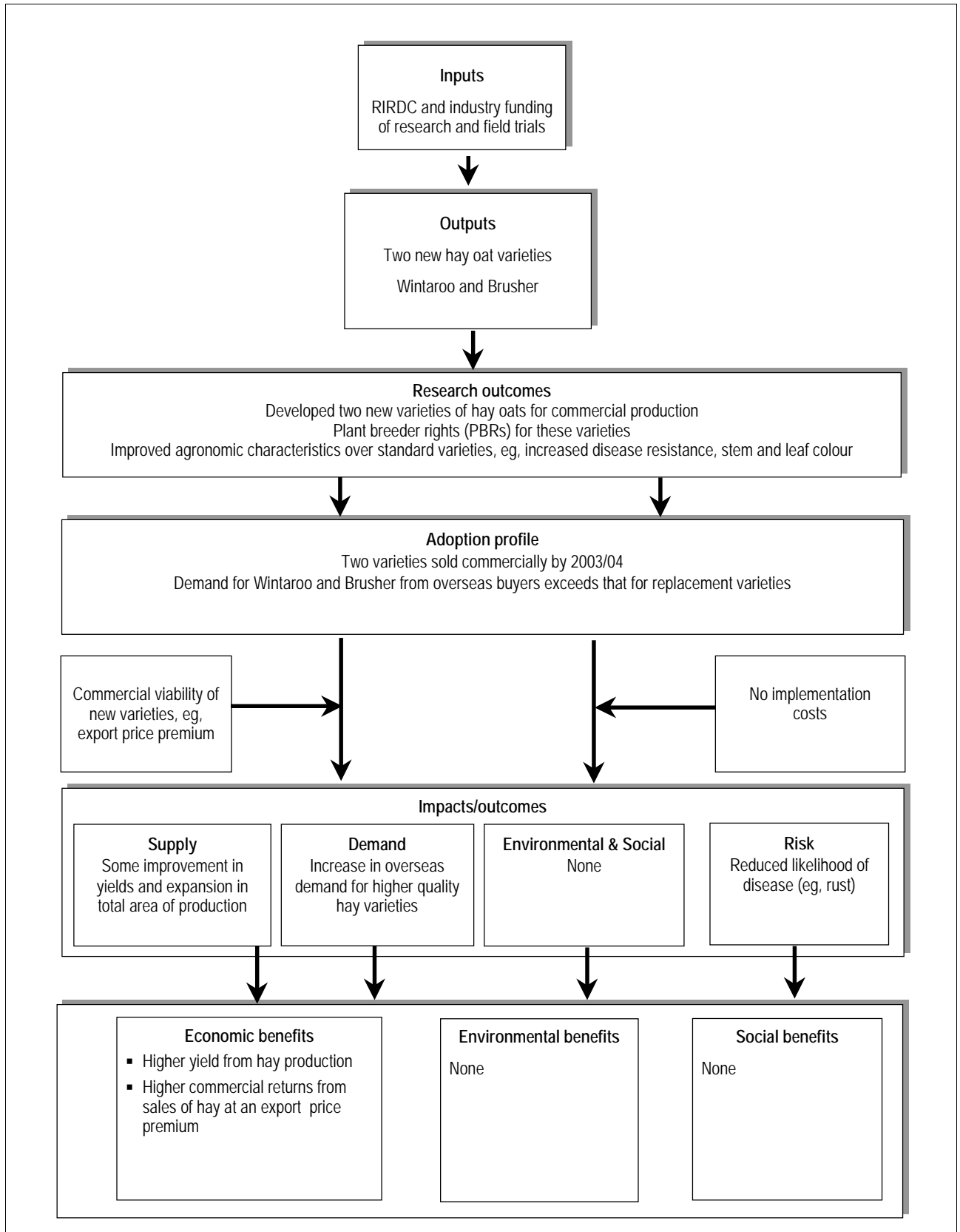
The research generated significant benefits relative to the research costs. At a discount rate of 5 per cent, the net present value of the net benefits was estimated at \$159 million, with a benefit-cost ratio of 101. The internal rate of return for the research (discount rate at which the net benefits equal zero) is estimated at 79 per cent.

The benefits accrue mostly to producers; however there was a small estimated benefit to researchers that was calculated in terms of projected royalties. At the 5 per cent discount rate, around \$159.9 million of the discounted benefits accrues to producers and around \$0.8 million to researchers.

The common RDC framework specifies that in addition to the time horizon chosen in any evaluation, other timeframes of 5, 10 and 20 years should be reported. Table 2.4 shows key results across these timeframes.

Chart 2.5 shows the net benefit stream of the projects over time (undiscounted), while table 2.6 shows the annual stream of benefits and costs calculated in the evaluation.

2.2 Potential benefits of new oat hay varieties



Data source: RIRDC (2005).

2.3 New oat varieties evaluation results

Discount rate	NPV R&D costs	NPV benefits	NPV net benefits	BCR	IRR
	\$m	\$m	\$m	Ratio	%
0 per cent	1.40	278.41	277.01	200	79
5 per cent	1.59	160.69	159.10	101	
10 per cent	1.82	103.89	102.07	57	

Source: RIRDC (2005), CIE calculations.

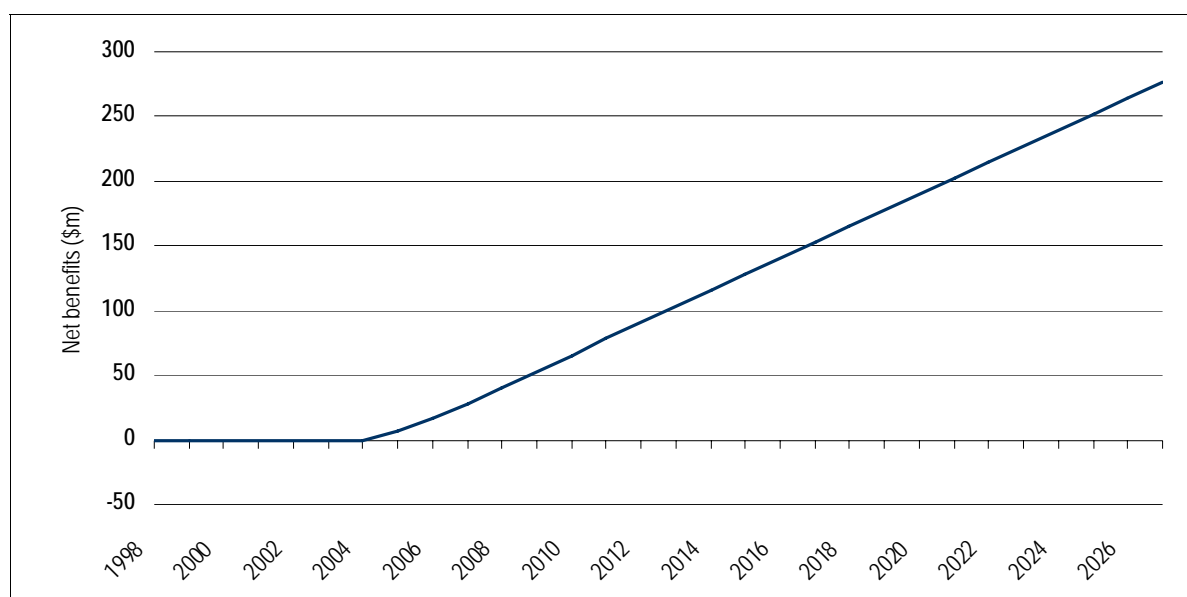
2.4 Results of the benefit-cost analysis across different time horizons

		5 years	10 years	20 years
NPV costs	\$m	0.97	1.59	1.59
NPV benefits	\$m	0.00	26.46	109.82
NPV net benefits	\$m	-0.97	24.87	108.24

Source: RIRDC (2005), CIE calculations.

Note: Using a 5 per cent discount rate.

2.5 Undiscounted stream of net benefits — new oat varieties



Data source: RIRDC (2005), CIE calculations.

Sensitivity analysis

Sensitivity analysis for the new oat varieties was undertaken using the @Risk software package. This tool allows a range and distribution to be specified across uncertain parameters. Using this approach, a 95 per cent confidence interval for the net benefits can be identified.

Table 2.6 outlines the ranges used across uncertain parameters in the analysis, whilst table 2.7 shows the results of the sensitivity analysis.

2.6 Values used to parameterise the probability distribution of each input variable

Input variable	Unit	Minimum	Maximum	Mean
Wintaroo average yield	t/ha	5	10	7.5
Brusher average yield	t/ha	4.5	9.5	7
Export price	\$/t	140	180	160
Domestic price	\$/t	80	100	90
Wintaroo peak production	t	-25%	+25%	250 000
Brusher peak production	t	-25%	+25%	50 000

Source: CIE estimates.

2.7 Results from sensitivity analysis ^a

	NPV	BCR	IRR
	\$m	Ratio	%
Minimum	0.9	1.5	12.5
Maximum	326.1	206.2	96.0
95% confidence interval	73.8-231.5	47.4-146.7	63.1-88.1

^a Assumes a 5 per cent discount rate.

Source: CIE estimates.

The range of results obtained in the sensitivity analysis is large, with the minimum estimate still showing a positive return. The 95 per cent confidence interval gives an estimate of the range of results that would be reasonably expected, with a range of NPV values of \$74 million to \$232 million and a rate of return of between 63 and 88 per cent indicating robust results overall.

3. Electromagnetic induction evaluation

As part of an evaluation of RIRDC’s rice program published in 2004, the CIE undertook an evaluation of R&D on the development of electromagnetic induction for rice production (RIRDC 2004). Appendix C contains the full original evaluation document for reference.

The evaluation looked at three projects aimed at developing an electromagnetic induction technique for determining soil suitability in terms of minimising groundwater recharge across the entire rice paddy area. Previously, measures of the amount and type of clay had been used to assess the suitability of rice farming. Soil samples were taken within each 200m grid (or every 4 hectares), which was a time consuming process and did not give a complete picture of the farming area. Groundwater recharge can be defined as water that seeps through the soil and continues to percolate deep into the soil until it reaches the groundwater supply. This is important in two respects: it is a major contributor to water loss and lower water use efficiency and it is a cause of rising water tables and increased salinity. The three projects lead to the development of EM31 and soil suitability testing.

Projects evaluated

The electromagnetic induction evaluation undertaken in 2004 included the following projects.

- *DAN 95A: Rice land suitability assessment:* The objective of this project was to develop a field survey and interpretation methods necessary to identify areas of high groundwater recharge by using the Geonics EM31 instrument.
- *DAN 145A: EM to estimate groundwater recharge from rice growing:* The objective of this project was to remove ‘leaky’ soils from rice farming to reduce groundwater recharge and eliminate the need for physical soil sampling and to develop an easy technique to measure soil composition and a simple indicator to determine groundwater recharge and the suitability of soil for rice growing.
- *CRC 1102: Better prediction of groundwater recharge from rice growing:* The objective of this project was to better predict rice farming impacts on water tables and further develop the rice land classification system by including landscape and physio-chemical properties.

Investment

Table 3.1 shows the annual investment across each project. This investment includes all funding sources, including RIRDC, other research agencies and industry

The total investment across all three projects was approximately \$2.3 million. In total, almost 50 per cent of the funding came from RIRDC, with the remainder coming from other agencies and industry. The final year of investment across the projects was 2003-04. CRC1102 included significant in-kind investments, however at the time of the evaluation being undertaken much of this investment was projected future investment. It has not been possible to update this information in this report, but at the time there was no scheduled direct RIRDC investment in this project, with the Rice CRC and NSW Agriculture sharing the funding. RIRDC’s contribution was limited to their block funding of the CRC.

3.1 Annual research cost for EM31

Year	DAN 95A	DAN 145A	CRC1102	TOTAL
	\$	\$	\$	\$

1993-94	129 409	-	-	129 409
1994-95	107 404	-	-	107 404
1995-96	111 209	-	-	111 209
1996-97	-	125 997	-	125 997
1997-98	-	128 385	82 177	210 562
1998-99	-	136 990	174 604	311 594
1999-2000	-	-	26 678	26 678
In kind to 12/2001	-	-	993 600	993 600
In kind to 06/2003	-	-	330 000	330 000
Total	347 446	391 372	1 607 059	2 345 877

Source: RIRDC (2004b).

Project outputs and outcomes

Chart 3.2 summarises the outputs and outcomes of the research along with the key impacts.

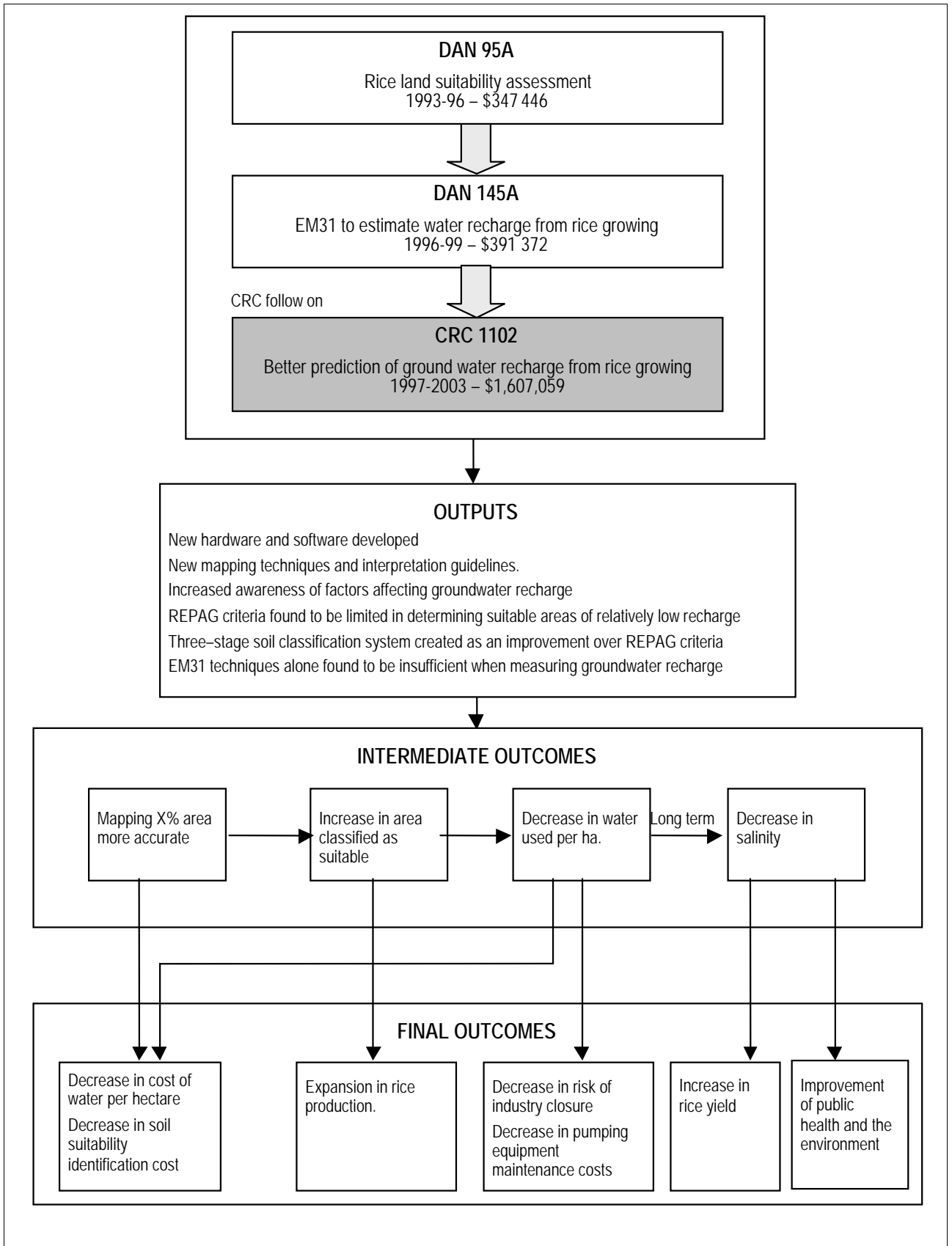
The major output of the projects was the development of development of EM31 and soil suitability testing. Associated outputs included:

- new mapping techniques to graphically illustrate detailed soil compositions over the entire measurement area;
- procedure established to guide EM31 users conducting measurements and interpreting results when determining rice land suitability;
- increased awareness of new technology and improved education on the factors determining the level of groundwater recharge;
- Rice Environmental Policy Advisory Group (REPAG) criteria for identifying rice soil suitability found to be limited as it only accounts for clay content. Preliminary relationship was developed between EM31 measurements and soil clay content;
- clay content alone was found to be a poor indicator of groundwater recharge;
- electromagnetic induction alone found to be an inadequate technique for measuring estimates of groundwater recharge as there was no single relationship established between the EM-31 values and recharge; and
- three-stage soil classification system for rice growing suitability developed as an improvement over the existing REPAG criteria.

The key economic outcomes included:

- reduction in water cost per hectare (as a result of using less 'leaky' soil for rice production);
- increase in efficient employment of land (as a result of better identification of suitable land for rice production and other activities); and
- additional water available for rice production (as a result of less water usage per hectare).

3.2 Flow chart detailing research inputs, outputs, and outcomes



Source: RIRDC (2004b).

Key environmental outcomes are:

- reduction in the leakiness of land used for rice production will reduce recharge and result in water tables being lower than would otherwise have been the case; and
- potentially, water saved could be released back to the environment as environmental flows (this depends on the amount of land allowable for rice growing and/or the approach to water allocation).

Social outcomes are difficult to define, but access to water is a highly contentious issue for irrigated crop producers. Uncertainty over future water allocations and the structure of the water market causes considerable pressures in rural communities. Any innovation that helps farmers save water lowers their adjustment cost and strengthens the long run position of the industry as a sustainable industry.

Estimated benefits

Quantifying the benefits from EM technology in the evaluation was limited to outcomes produced from DAN 95A. The primary economic benefits were identified as a reduction in water per hectare use and an increase in efficient land use. Both these benefits lead to an increase in production and an increase in water used for environmental purposes.

Environmental outcomes are twofold.

- Reduction in the leakiness of land used for rice production will reduce recharge and result in watertables being lower than would otherwise have been the case. Information on how much lower and where in the landscape the benefits would be felt was not available.
- Potentially, water saved could be released back to the environment as environmental flows. How large this benefit is depends on the amount of land allowable for rice growing and/or the approach to water allocation. It is uncertain that there would be any impact on environmental flows given the existing water allocation system and trading rights.

The analysis assumes that rice growers use the additional water up to the point that they reach their constraints on rice production. After this point the water saved could be sold to alternative uses including for return to the environment. The value of the water saved is proxied by the value that the water would have generated in the production of rice. Thus the value of the research is the same whether the water is used in rice production or delivered as environmental flows.

Benefits of water savings from expanding production

The result of reduced water use per hectare as a result of EM technology was that area planted to rice was able to be expanded where production would otherwise have been limited by water availability. This applied up to the point where production met its equivalent land constraint for each region (30 per cent). Table 3.3 shows the increases in production area by region used in the analysis.

3.3 Increase in rice growing area due to water savings

	1999	2000	2001	2002	2003	2004	2005	2006
	ha	ha	ha	ha	ha	ha	ha	ha
Coleambally Irrigation	-	-	-	-	932	-	-	-
Murrumbidgee Irrigation	-	-	-	-	499	1 708	-	-
East Murray Valley	440	759	-	1 550	507	1 809	2 888	-
West Murray Valley	300	474	-	1 230	376	1 403	2 291	211

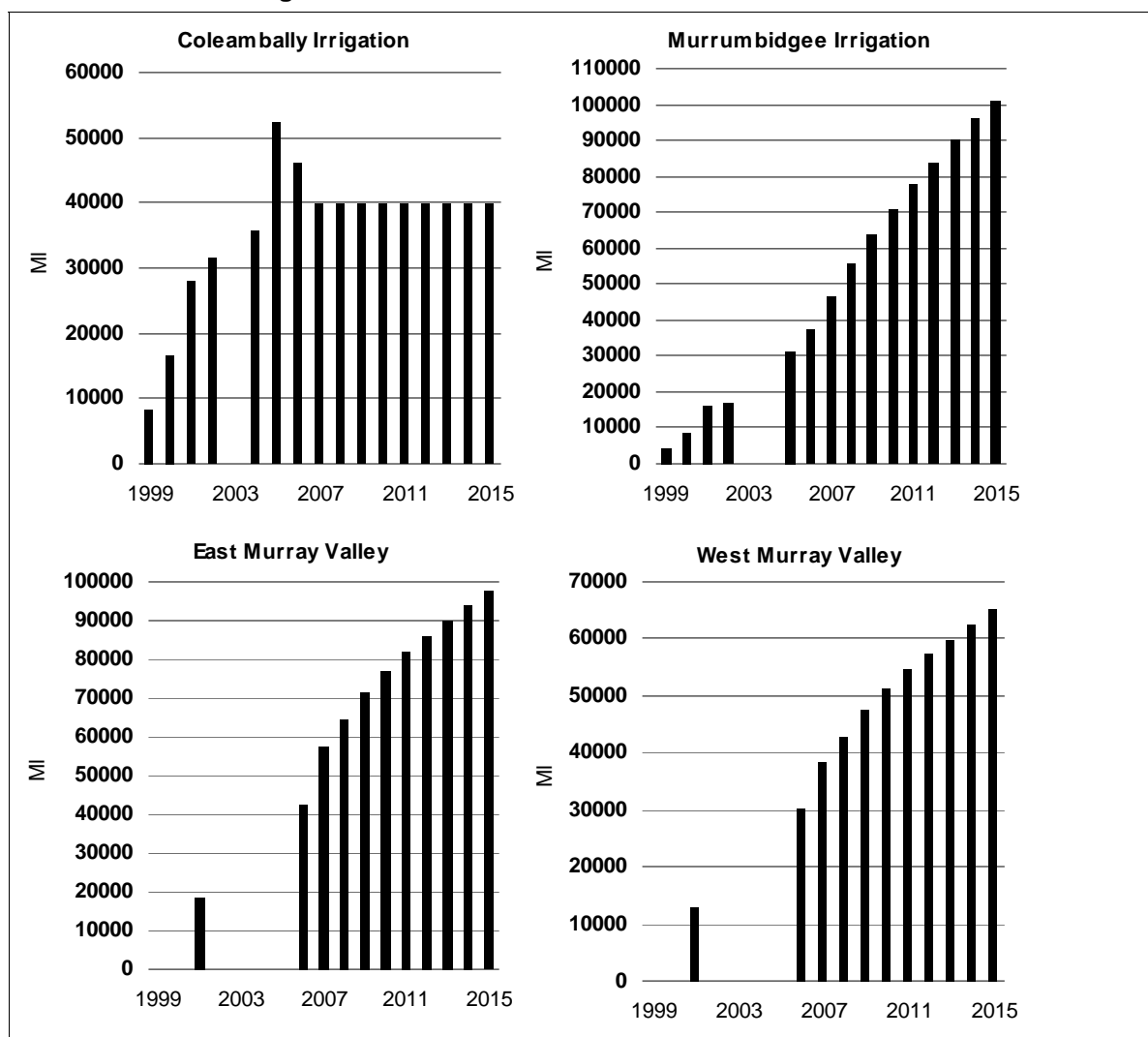
Source: RIRDC (2004b).

Assuming a discount rate of 5 per cent, the benefits to rice producers from the EM-31 technology is estimated at \$47.6 million in 2007 dollar equivalents.

Benefits of water savings

Water saved that has not been used to expand rice production due to land constraints could be used in a variety of ways. As noted earlier, this analysis values this water as the value it would have generated in the production of rice. Chart 3.4 shows the amount of water saved (not used to expand rice production) and released back to the environment between 1999 and 2015.

3.4 Water savings released back into the environment



Source: RIRDC (2004b).

In total, the water savings between 1999 and 2015 are estimated at 2.68 million megalitres. Assuming a discount rate of 5 per cent, the benefit of this water saving is estimated at \$162 million.

Total benefits

Table 3.5 shows the full results of the evaluation under varying discount rates in 2007 dollars. It includes research costs, along with implementation costs (cost of using the technology). Table 3.6 shows the results under a number of different time horizons, while chart 3.7 shows the undiscounted stream of net benefits.

3.5 Benefit from increasing rice area under various discount rates

<i>Discount rate</i>	<i>Research costs</i>	<i>Implementation costs</i>	<i>Benefits</i>	<i>Net benefits</i>	<i>BCR</i>	<i>IRR</i>
%	\$m	\$m	\$m	\$m	ratio	%
0	0.49	2.60	430.99	427.90	139.65	79
5	0.52	1.60	209.59	207.48	99.05	
10	0.54	1.06	109.17	107.57	68.26	

Source: RIRDC (2004b), CIE calculations.

At a discount rate of 5 per cent, the total net benefits of EM-31 technology are valued at \$207 million, with a benefit cost ratio of 99 and an internal rate of return of 79 per cent. Over 75 per cent of the benefits of the technology are the benefits of increased environmental flows, with the remainder accruing to rice producers. Of the benefits to rice producers, approximately 25 per cent comes from allowable expansion in production, with the remainder from reduced water costs for existing production.

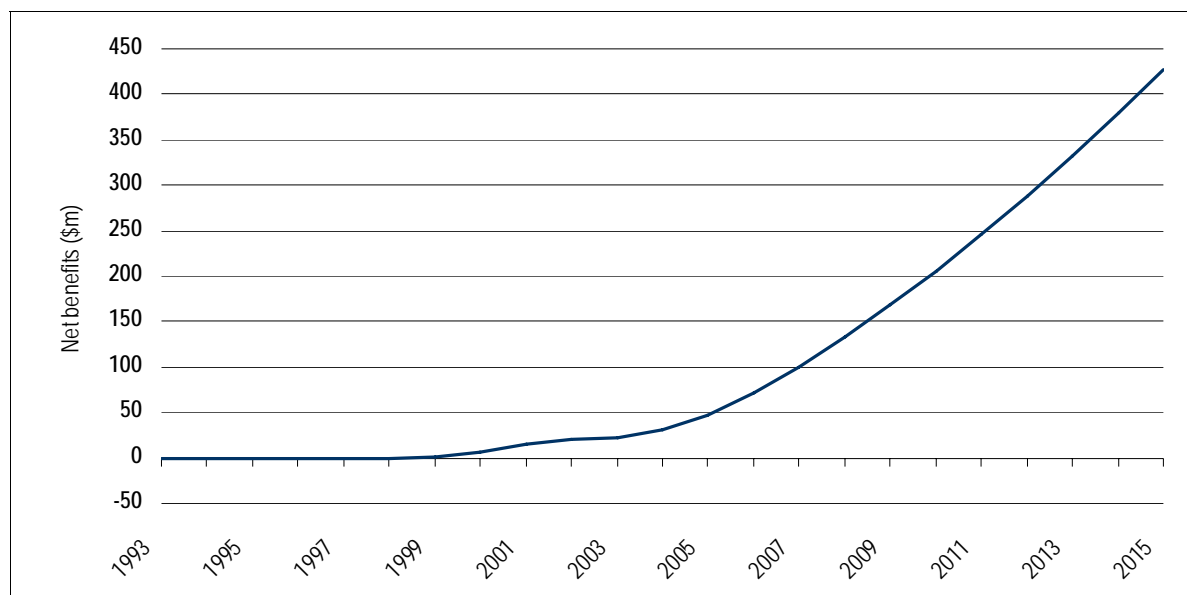
3.6 Results of the benefit-cost analysis across different time horizons

		5 years	10 years	20 years
NPV costs	\$m	0.52	1.29	2.01
NPV benefits	\$m	0.00	17.07	154.18
NPV net benefits	\$m	-0.52	15.78	152.16

Source: RIRDC (2004b), CIE calculations.

Notes: Using a 5 per cent discount rate, 2007 dollar equivalents.

3.7 Undiscounted stream of net benefits — EM-31



Source: RIRDC (2004b), CIE calculations.

Sensitivity analysis

The key assumption around which there was some uncertainty was the estimated water savings from using EM technology. The analysis presented above used an estimate of 2 megalitres per hectare as a best bet. The sensitivity analysis uses a range of between 0.5 megalitres per hectare to 3.5 megalitres

per hectare and the software package @RISK to estimate the sensitivity of the results to the water saving estimate.

Table 3.8 shows the results from the sensitivity analysis.

3.8 Results from sensitivity analysis^a

	NPV	BCR	IRR
	\$m	Ratio	%
Minimum	101.0	48.7	56.2
Maximum	324.4	154.3	92.5
95% confidence interval	121.7-298.2	58.5-141.9	62.2-89.9

^a Assumes a 5 per cent discount rate, 2007 dollar equivalents.

Source: CIE estimates.

The results of the sensitivity indicate that the NPV is expected to fall between \$101 million and \$324 million, with a benefit-cost ratio of between 49 and 154. The 95 per cent confidence interval gives an estimate of the range of results that would be reasonably expected, with a range of NPV values of \$122 million to \$298 million and a rate of return of between 62 and 90 per cent. These figures indicate robust results overall.

References

Rural Industries Research and Development Corporation (RIRDC) 2005, *Evaluation of the Fodder Crops and Pasture Seeds Programs: Benefit-Cost Evaluations — Stage 2*, report by Gordon J, Chou Y, Fisher S, Standing N, Hearne T and Gough R, RIRDC publication No 05/169.

—— 2004a, *Evaluation of the New Plant Products Program: Benefit-Cost Evaluations – Stage 2*, report by Gordon J, Cutler H, Hearne T, Sadlier P, Harding M and Bauer M, RIRDC publication No 04/161.

—— 2004b, *Evaluation of the Rice Program: Benefit-Cost Evaluations — Stage 2*, report by the Centre for International Economics, RIRDC publication No 04/94.

Appendix A: Olive evaluation

Background

Olives were first introduced into Australia in the early 1800s in Parramatta, Sydney (Olive Australia, 1997). They have been grown in all states in Australia at some stage of the country's history, although the industry has never been large. In a number of regions, olives have gone wild, resulting in a number of olive varieties.

Many areas of Australia have the Mediterranean climate suitable for the production of olives that is cold, wet winters and hot, dry summers. They can produce in other areas as long as they have a winter chill (temperatures varying from 1.5C to 18C, but not below -5C) and a long and hot enough summer to ripen the olives.

The current state of the olive industry

Production

Most Australian olive production is on a small-scale basis — 90 per cent of growers have 5 000 trees or less, and 37 per cent have less than 500 trees (AOA and RIRDC, 2002). Small producers target mainly local boutique markets, and there is little product differentiation.

Almost all oil produced in Australia is extra virgin olive oil, aiming for the higher end of the market.

Consumption

Increasing affluence and a greater concern for personal health has led to an increase in demand for olive oil. World consumption of olive oil has increased at 1.5 per cent per annum over the last 25 years.

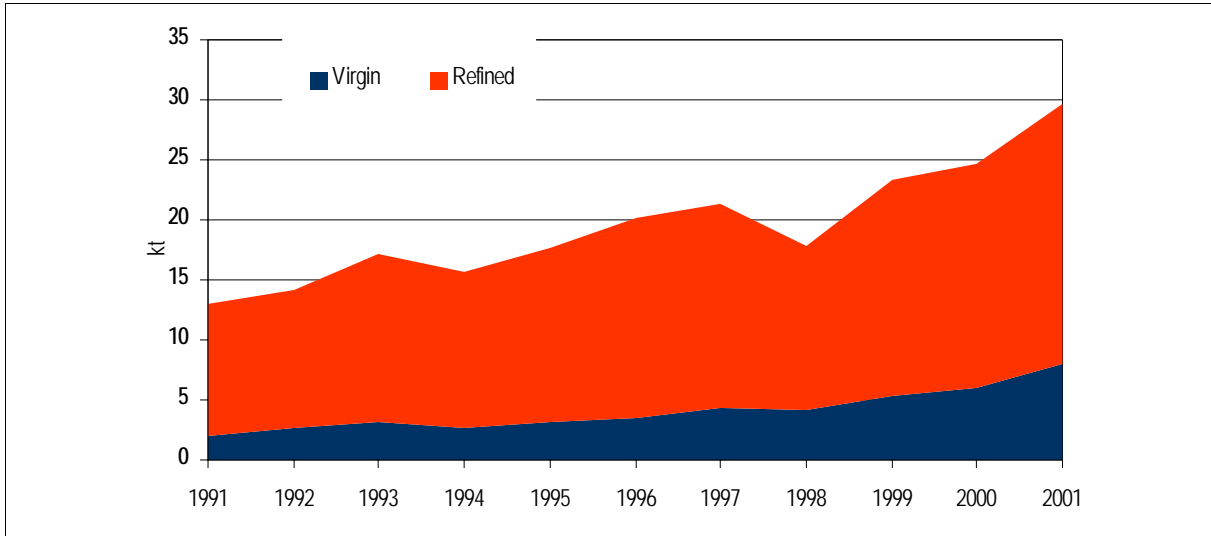
Domestic consumption of olive oil has increased considerably over the past decade. Over the ten years from 1992-93 to 2002-03, total Australian per annum consumption of olive oil almost doubled from 16 000 tonnes to 31 000 tonnes. The majority of this is imported (see chart A.1).

Over this period, there has also been an increase in preference for extra virgin olive oil. Extra virgin amounted for 19 per cent of olive oil imports in 1992. By 2001, this had increased to 26 per cent. When one considers that the local oil produced is all extra virgin oil, nearly 30 per cent of all olive oil consumed in Australia is extra virgin.

Exports

At present, a very limited number of growers export small quantities of extra virgin olive oil to boutique markets internationally. However, the amounts exported are too small to be picked up by measured by trade statistics.

A.1 Australian imports of olive oil



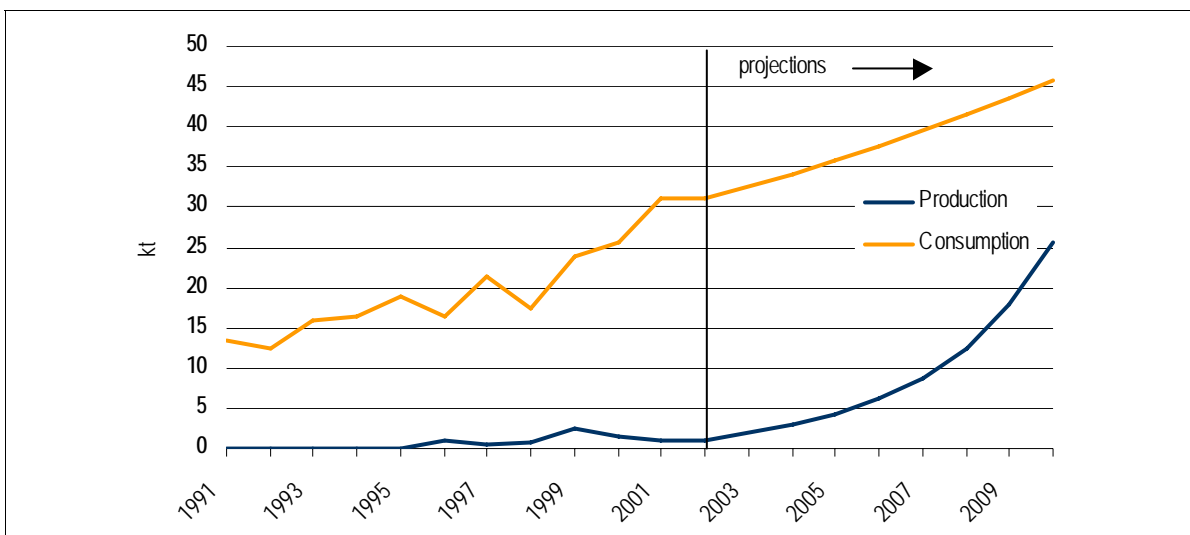
Data source: International Olive Oil Council (2004).

Projections of growth in the olive industry

Production

Olive production will increase rapidly over the next decade, as olive trees do not start to bear their maximum volume of fruit until they are ten years old. Local market supply of oil is expected to reach 25kt by 2010, most of which will be high quality extra virgin olive oil, although other oils may be produced as a by-product (chart A.2).

A.2 Australian olive oil production and consumption – actual and projected



Data source: International Olive Oil Council, Meyers 2001

Exports

The Australian Olive Association predicts that most Australian olive oil is destined for gourmet export markets. Through the wine industry, Australia has developed a reputation overseas for producing fine foods. The larger Australian olive oil companies are currently working on developing overseas export markets.

Japanese consumption of olive oil has increased more than six-fold from 5 tonnes in 1992-93 to 31.5 tonnes in 2002-03. South East Asian nations are starting to follow suit as their incomes rise. These markets are less likely to be romantically attached to European oil, and may be a fertile market to exploit. The recent signing of the US Free Trade Agreement will give Australian producers of all olive products duty free access to the US, giving them a significant advantage in this market over their European counterparts.

The research program

RIRDC has been funding R&D into olives since 1995. Since then they have completed three projects and undertaken eight others. This evaluation looks at seven of these projects, concentrating on the R&D that relates directly to olive oil production. Total investment in these projects was \$2.4 million from 1998 to 2006. Total RIRDC investment in these projects is \$1.2 million, as shown in table A.3.

A.3 Total funding of olive R&D

FY end	RIRDC	Other R&D organisations	Industry	Total
	\$	\$	\$	\$
1998	262 241	241 840	35 000	539 081
1999	284 565	192 751	36 050	513 366
2000	335 699	193 380	50 131	579 210
2001	46 025	11 864	22 000	79 889
2002	53 357	25 096	41 316	119 769
2003	101 387	58 059	98 985	258 431
2004	73 535	58 103	38 510	170 148
2005	45 128	43 726	11 348	100 202
2006	14 773	19 018	5 500	39 291
TOTAL	1 216 710	843 837	338 840	2 399 387

Source: RIRDC files

Research goals

The intention of this research was to move olive production from a boutique cottage industry to one that is import-replacing and export-creating. There has been a considerable increase in the volume of olives grown and the production of olive oil over the last five years. It is taken as given that olive oil production will continue to increase due to the huge upsurge in the number of olive trees planted since the late nineties. RIRDC has focused its research on ensuring the olives and olive oil produced are of the best possible quality, that the final product is competitive, and that markets exist for it.

RIRDC's olive program includes the following goals:

5. Market and product development: development of export and quality standards, new market development, promotion of health benefits, collection and analysis of industry data, establishment of production and marketing networks.
6. Sustainable production: pest and disease control strategies and IPM guidelines, cost competitive harvest and production technologies, grove optimization for best yield/quality, grower education and best practice guidelines.
7. Processing and product quality: a quality assurance program, world's best practice waste utilisation scheme, definition of oil quality standards, maximisation of health components.

8. Communication, coordination and training: training programs, curriculum development of Best Management Practices, coordination of industry bodies and extension delivery, for example assisting Horticulture Australia Limited (HAL) with the development of a statutory levy funding process, (Olive Press and RIRDC, 2002).

9.

The vision statement for the Australian Olive Industry, which RIRDC supports, is:

'By 2010 Australia will be globally acknowledged as a producer of high quality and price competitive olive products.'

RIRDC's R&D program aims to support this vision.

Description of the projects

There are seven projects with the main aim of improving the quality of olive oil produced in Australia.

UA-41A: Wild Olive selection for quality oil production

Objectives

Olives that escaped from early production have had more than 100 years to adapt themselves to Australian conditions, and some may be very suited to a commercial olive industry in Australia. The aim is to provide new varieties with improved yield and quality to domestic producers through selection, oil analysis, DNA fingerprinting, breeding and propagation of new improved oil cultivars based on wild southern Australian material.

Outputs

Collections were made of wild olive trees; 121 in 1997, 188 in 1998 and 95 in 1999, with plant material sent for analysis. Plants were measured for oil yield, composition of olive fruit and fatty acid content. The trees that showed superior oil quality and yield have been revisited to ensure reproducibility. In addition, a hybridisation program has commenced using these cultivars to establish the first Australian olive breeding program. The cultivars selected for further examination had yields and oil quality equal to, or better than, the varieties currently planted in Australia. However, they were not tested for other beneficial factors, such as ease of harvesting.

Further testing of the most promising varieties identified occurred in the later project, UA-54A.

UA-54A: Wild olive selection for quality oil production

Objectives

Selection of new improved oil cultivars from wild southern Australian material, based on oil analysis, DNA fingerprinting, propagation and field trials. This will improve yield and quality of olive oil for domestic and export markets, and provide quality assurance to the industry.

Outputs

The superior cultivars identified in UA-41A have been planted in trials at the Roseworthy campus of University of Adelaide. There is also a comparative trial of current olive varieties used in Australia at the same location. The trees will be tested for yield, oil quality and reliability, and their performance will be compared to that of existing varieties.

It is hoped that once this trial is completed, the best varieties can be tested under commercial trials. Such a trial would test the commercial viability of the plants by looking at factors such as growth times, fruit ripening times and ease of mechanical harvesting. University of Adelaide will apply for

plant breeder's rights for the best varieties. Further research is required before this can happen. Professor Margaret Sedgley of University of Adelaide believes it will be two years before they can approach the Plant Breeders Rights office, and then a three-year trial under commercial conditions will be necessary to register the varieties. It is expected that the commercial trial would cost around \$40 000 per year.

UCS-19A: Olive oil: yield, quality and cultivar identification

Objectives

To develop:

- family trees for olive cultivars by developing DNA identification procedures; and
- a database on Australian olives which can indicate the best time and place to plant different types, and the variability in quality according to oil content, fatty acids, polyphenols etc. based on IOOC standards.

Outputs

Olive groves at Wagga Wagga and Yanco were tested for fruit quality over a three year period to develop an understanding of cultivar and seasonal variation. Oil content and fatty acid profiles were developed from four harvest dates, and samples were taken on a fortnightly basis to study the oil and fatty acid development.

This development of nutritional profiles is intended to be a valuable genetic resource for the olive industry, as cultivars can be selected that produce nutritionally superior oil.

UCS-33A: Quality enhancement of Australian extra-virgin olive oils

Objectives

Top quality extra virgin olive oil can retail for up to \$75 a litre due to their flavour and finish, while cheaper oils, flat in aroma and flavour, retail for around \$5 a litre. These oils are around 95-98 per cent similar. The differences are due to the varieties used to make the oil and the method of processing. The objectives is to determine the effect of processing conditions on the levels of volatile compounds that contribute to the aroma and flavour of olive oil, and on the levels of phenolic antioxidants.

Outputs

The first trial has gone ahead, extraction methods have been refined, and samples have been analysed for phenolic and volatile components. The intention is that with a greater understanding of the effects of fruit chemicals and processing affect the quality of the olive oil, growers and processors can tell from examining their fruit and their processing plans the quality of their oil in terms of flavour and shelf life.

BOG-1A: Gel-Pro Analyser software

Outputs

This project was for the purchase of software used in UA-41A. RIRDC provided the \$3 500 to purchase the software.

BOG-2A: Benchtop Olive Oil Extraction Plant

Background

The recent rapid increase in the number of olive tree plantings means that a great deal of fruit will be entering the market for oil production. However, the industry still needs to develop the skill to determine which fruit will produce good oil, depending on oil varieties and harvest time. Most olive growers use European-developed colour guides to determine when their fruit is ready for harvest. These may not be accurate in Australian conditions due to higher levels of UV radiation in the Southern Hemisphere.

To use all the annual harvest to create oil and test the results will potentially result in a large quantity of poor quality oil. To run small batches through commercial presses is inefficient because of the clean-up times of large machines. There is an Italian-made benchtop olive processor on the market, but it is expensive (\$25 000) and must be altered to meet Australian occupational health and safety standards. There was a gap in the market for a small-scale olive processor to test the quality of olive oil that suited Australian requirements, and this project sought to fill it.

Objectives

To design a benchtop olive oil extraction plant to be produced for the 2001 harvest. The intention was to produce an inexpensive trial unit to be used by growers to assess the quality of the final product of their fruit. By having a ready unit that can efficiently press small quantities of oil, growers could experiment to find the optimal picking time for their fruit, and identify the fruit types and growing conditions that produced the best oil. It was intended to be light enough for one man to lift it and small enough to fit in the boot of a car, so smaller growers could share the use of a unit.

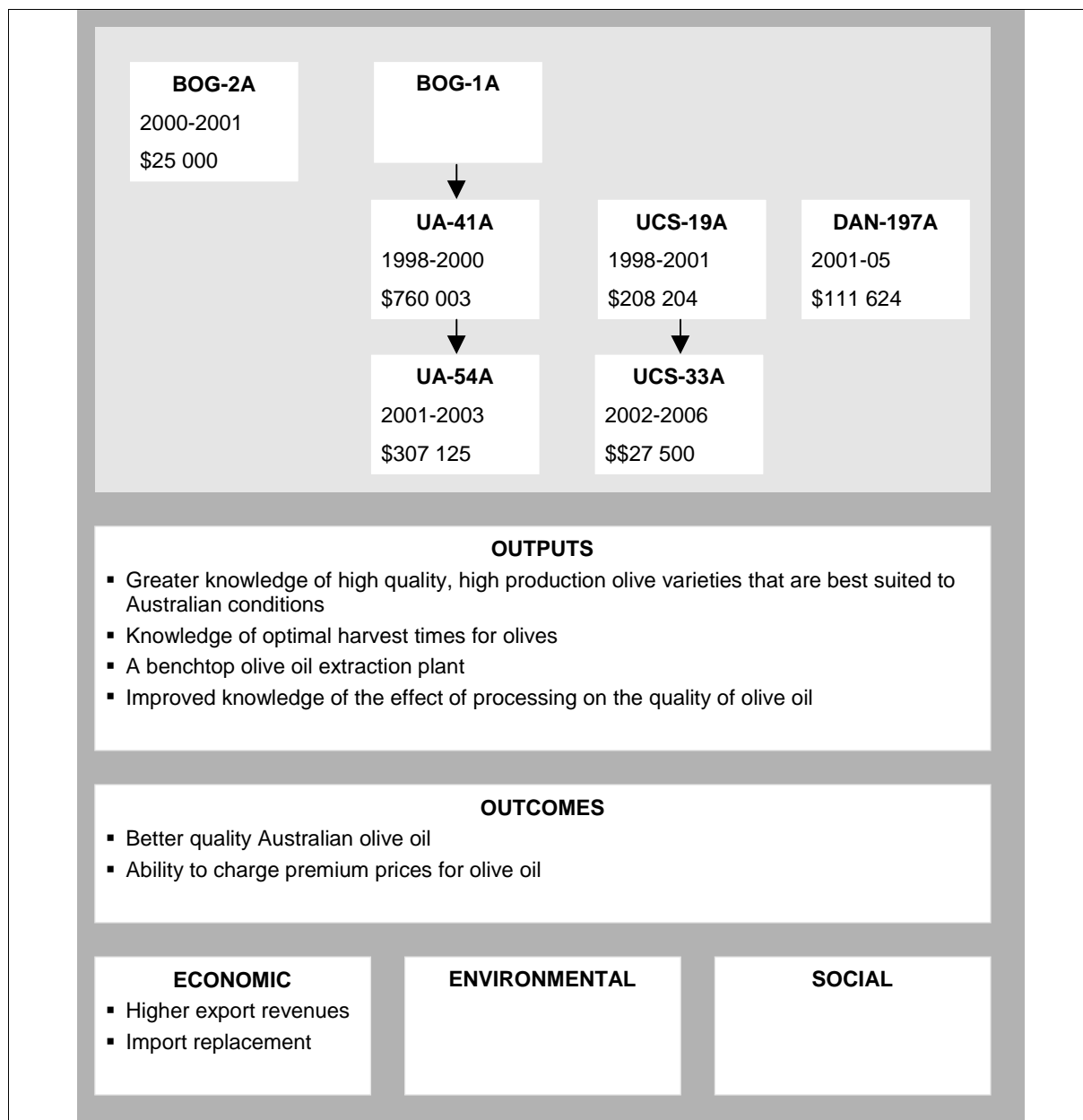
Outputs

The design was completed, and should be competitive with bottom of the range olive oil processors, doing 25kg/hr and costing \$13 000 plus GST. It would have cost around \$4 000 to \$5 000 to build. The intention was for units to be sold in 2001 for \$8 000 (promotional prices), after which they will be sold at the normal retail price. However, this has not gone according to plan.

To manufacture a commercially saleable product, Michael Burr, its designer, and John Brooke, an engineer, were encouraged to form a company to apply for a small business prize. They formed the company but did not receive the prize. They received a grant of \$25 000 from the South Australian Government, which was used by engineers to further develop the plant. John and Michael also invested their own money.

The plant ended up being developed into a more complex model than Michael intended, consisting of three modules, being very heavy and costing more than \$20 000 to build, and selling for around \$28 000. Its potential target markets are limited to heavier users, such as universities. Two demo models are being built, and it is hoped they will sell for \$28 000 to universities or large growers. Michael is investigating establishing a small manufacturing operation to produce the simple units he originally designed. He hopes to build around ten per year and start selling for the 2005 harvest. These expenses are included in the benefit cost calculations, but are not included in the costs of the project as listed in chart A.4, as they were not expenses of the project BOG-2A.

A.4 Outputs, outcomes and benefits of olive R&D



Data source: RIRDC files, CIE working, pers comms researchers etc.

DAN-197A: Olive harvesting project – harvest timing for optimal oil quality

Objectives

There are currently no objective guidelines on the optimal harvest time for olives. The objective is to determine the precise harvest time for optimal olive oil quantity through oil quality analysis, taking into account the effect of harvest parameters and irrigation, and to provide this data to the industry. Four olive varieties are being assessed: mission, leccino, paragon and corregiolla. The majority of growers have the mission variety, and the others are among the top major olive varieties. Many colour indexes that indicate when an olive is ripe enough to harvest were developed in Europe, and are often inappropriate for Australian conditions. It is hoped that the project will develop colour indexes for Australia that can be distributed to olive growers, along with information on how growers can assess the optimal time to harvest the olives.

Project outcomes

Two projects (BOG –1A and UCS-19A) are inputs into the others and have no independent outcomes.

Improvement in oil quality

All the projects contribute to an outcome of higher oil quality. UA-41A and UA-54A focused on achieving this by developing olive varieties that have high nutritional content and excellent flavour. Once these are planted and yielding fruit, they have the potential to increase the quality of olive oil produced in Australia. However it must be noted that most of the new varieties have reached the market very recently, or have not yet reached the market. Once they reach the market, there is at least a five year lag between when they are purchased and when they start bearing improved fruit. Thus it will be some years before the benefits of this research occur.

At present, the increase in quality from this research is unmeasurable, as the findings have not yet been applied to olive growing or processing. The extent to which the quality of oil produced will increase will depend on:

- the significance of the new varieties in improving in olive quality;
- the extent to which the processing and harvest timing methods improve olive oil quality;
- the extent to which farmers undertake to improve their oil quality through personal testing and experimenting with new varieties; and
- the time it takes for these new technologies to be made available to farmers.

Approach to evaluation

Assessing the market impact

This evaluation seeks to measure the improvement in quality and the resulting increase in price received as a result of RIRDC's research. The factors that have caused or are likely to cause an increase in the quality of olive oil produced are:

- the benchtop olive press (although it is possible this will not make it to market and thus not generate any benefits);
- better knowledge of optimal harvest times;
- improved tree varieties; and
- improved processing practices.

The extent to which the increase in oil quality will yield higher returns for the olive industry depend on the ability of domestic and overseas markets to absorb the increase in supply of Australian olive oil.

The most likely outcome is thought to be that Australia's oil will be absorbed by domestic and overseas markets with little or no effect on the price of quality oil. The improvement in flavour and health benefits from RIRDC's research should allow Australian growers to receive higher prices than they otherwise would have as they can sell most or all of their oil into the premium end of the market.

The domestic market outlook

The increase in consumption of all olive oils and the trend towards more extra virgin oil suggests that Australia's tastes are changing as more consumers become 'cuisine educated'. In addition to this, while most people were aware of the health and taste benefits of olive oil, they did not have any particular brand loyalty: consumers across all spectrums would switch to a different brand if it was cheaper and/or of better quality. And while all consumers surveyed by McEnvoy (1998) for a RIRDC report knew that olive oil was healthy, very few appeared to know why.

The survey suggested that the domestic market for quality Australian oil could expand with a good marketing campaign promoting the taste and health benefits of Australian oil. Such a campaign should promote Australia's oil as healthy, as good quality or better as Spanish or Italian oils and 'posh'. It should aim to appeal to current consumers of quality imports to try an Australian brand, and encourage 'non-aware' consumers to try their tastebuds and arteries on domestic oil.

Demand projections suggest that Australia will consume about 46kt of olive oil by 2010, of which at least 20kt could be extra virgin. With appropriate marketing, Australian oil could fulfil 30 per cent, or 6kt, of this market. However, this still leaves around 19kt of quality olive oil that needs to be exported.

The overseas market

The Australian Olive Association is confident that even with Australian oil production increasing, export markets will be found without a noticeable effect on the price received. The reasons for this are:

- the continually increasing demand for olive oil around the globe, especially Asia;
- 25 kt per annum is a tiny share of a market that will exceed 3 million tonnes by 2010;
- Australia's good reputation overseas for quality agricultural products, especially wine;
- the US Free Trade Agreement, which gives Australian oil a price advantage over European oil; and
- inefficient agricultural practices in subsidised European olive oil producing countries.

It seems to be the case that demand for olive oil is set to continue to increase, both domestically and internationally, with extra virgin olive oil experiencing an increase in favour. Based on these predictions, Australian oil should be absorbed into domestic and overseas markets with little effect on the price of oil, and that the increase in quality of oil from RIRDC research will result in higher prices than would otherwise be achieved.

The baseline data

Based on projections and figures from McEvoy (1998), Meyers (2001) and the Australian Olive Council, we have projected volumes of Australian production and consumption of olive oil.

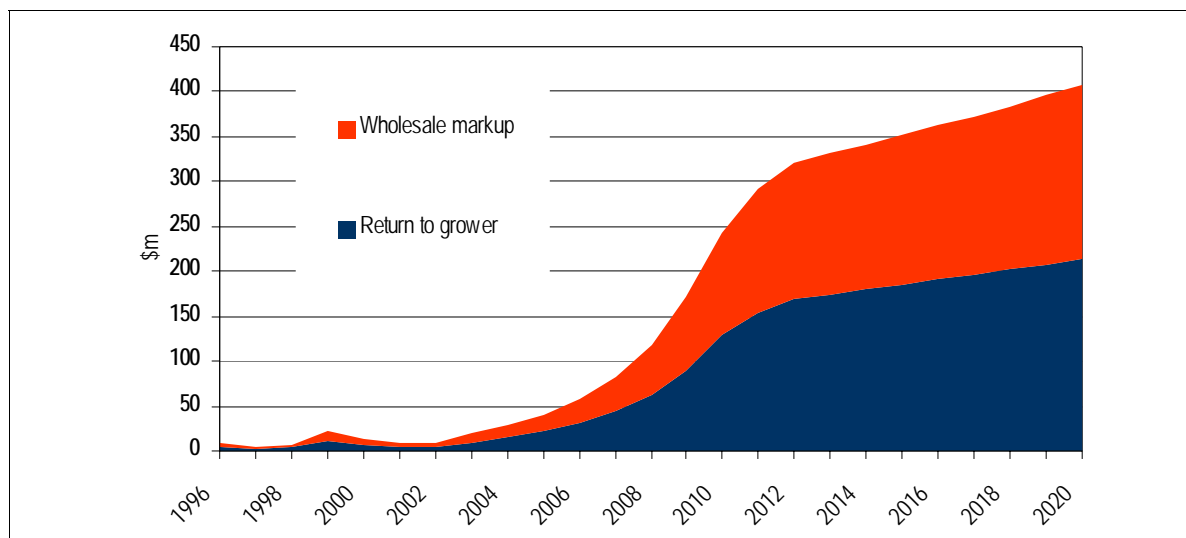
The farmgate or factory gate price of extra virgin oil is around \$5-6 a litre, and is expected to stay around this level for a while (Miller, AOC, pers comm). For this model, we have set the farmgate price of oil at \$5 a litre. The wholesale markup is around 90 percent (McEvoy, 1998), so the wholesale price of oil is around \$9.50 a litre, and it is approximately the amount paid by exporters and domestic retailers.

The 'without research' projection of olive oil revenues to 2020, based on these prices and production volumes, is shown in chart A.5.

Research impact

The research is expected to result in an increase in the price that growers receive for their olive oil. The improvement in quality should allow Australian oil to penetrate the higher price brackets more easily in domestic and overseas markets, and to establish market share in the growing world market for premium olive oil.

A.5 Olive oil production value projections



Data source: IOOC 2004, Meyers 2001, CIE projections.

It should be noted that the increases in quality would have little impact on prices if there were not strong marketing campaign for Australian olive oil. None of the projects evaluated here included such a marketing push. However, Paul Miller, the chairman of the Australian Olive Association, states that the Association is involved in export marketing campaigns of Australian olive oil, and is aware of private organisations undertaking their own marketing. We are assuming that the extent and quality of marketing is the same regardless of whether RIRDC undertook these research programs.

An improvement in the quality of Australian olive oil...

While the usual measure of an increase in quality is the increase in price people are willing to pay we take a two step approach to estimating this price impact. In order to map the time profile of potential quality improvements and adoption the researchers were asked to make an assessment of the impact of each of the technologies on oil quality and the expected adoption rate of the technology as a share of production.

Due to the uncertainty of the level of potential quality increase resulting from the research, we estimated upper and lower bounds of the quality increases with the guidance of the researchers. The adoption rate is calculated as the percentage of the olive oil market the research is expected to affect; estimated with the assistance of the researchers. The improvements in quality cannot be achieved until the research becomes publicly available, and may take some time to have an impact depending on the type of research outcome (for example, the improved olive varieties will take some time to have an impact on the quality of olive oil in the market as the trees will take some time to bear fruit). The year the quality improvement begins therefore depends on the expected time until the research is publicised, and the time it will take to have an impact after being released. These are shown in table A.6.

...leads to an increase in price...

The real measure of improvement in quality is the price premium people are willing to pay for the higher quality product. As quality assessments are subjective the most likely mapping is for people to associate a 10 per cent quality improvement with a 10 per cent price improvement, that is a price to quality elasticity of 1. While this is considered the most likely situation we use a range of elasticity values that imply that a 10 per cent quality improvement could result in a price being higher by between 5 and 15 per cent (elasticities of 0.5 to 1.5). Chart A.7 shows how a certain quality increase can result in a range of price increases depending on the quality elasticity of price. When the elasticity

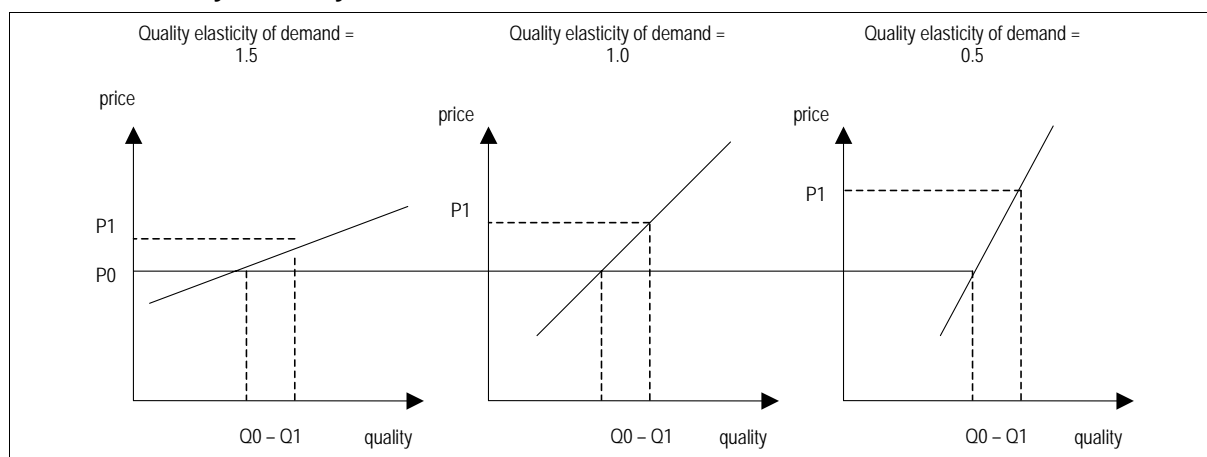
is relatively high, for example 1.5, an increase in quality results in a relatively small increase in price. However, when elasticity is relatively low, for example 0.5, an increase in quality results in a relatively large increase in price.

A.6 Improvement in oil quality

	Lower bound quality increase	Upper bound quality increase	Year that quality improvement begins	Year that quality improvement peaks	Initial adoption rate	Peak adoption rate
	%	%	year	year	%	%
Olive press enters market	0	0.05	2005	2008	0.1	20
Better knowledge of optimal harvest times	0.05	0.15	2006	2012	0.1	50
Improved varieties	0.05	0.25	2014	2020	0.1	6
Improved processing knowledge	0.05	0.2	2007	2013	0.1	50

Source: Personal communications, Paul Prenzler, Margaret Sedgley, Rod Mailer, Michael Burr.

A.7 Quality elasticity of demand

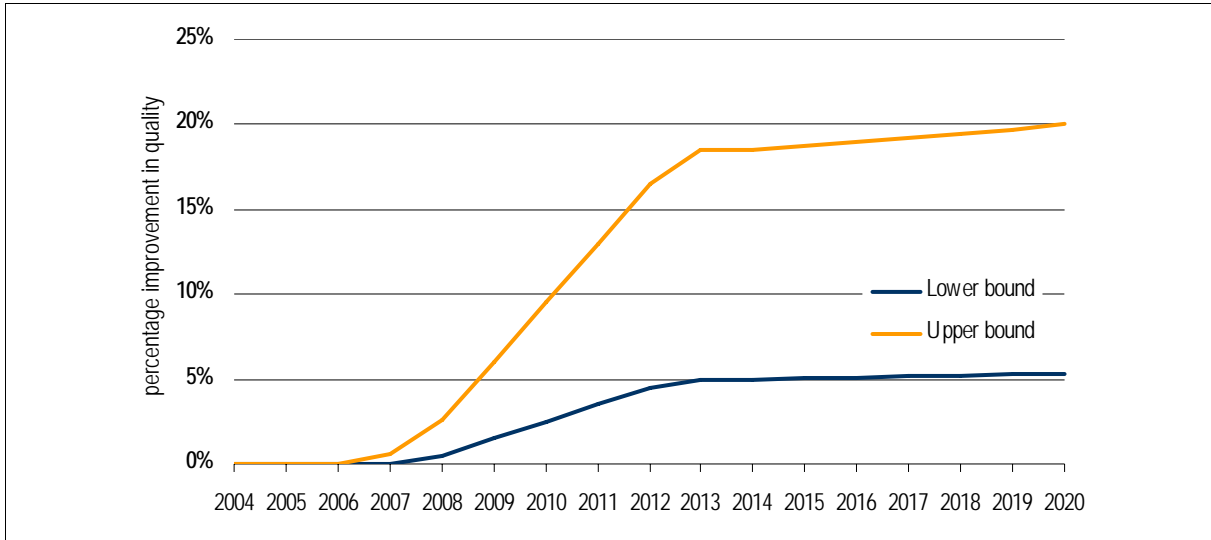


Based on this, we can calculate the upper and lower bounds of quality improvements in Australian olive oil from RIRDC research over time as the technologies are adopted. These are shown in chart A.8.

...which leads to an improvement in revenue for the Australian olive oil industry

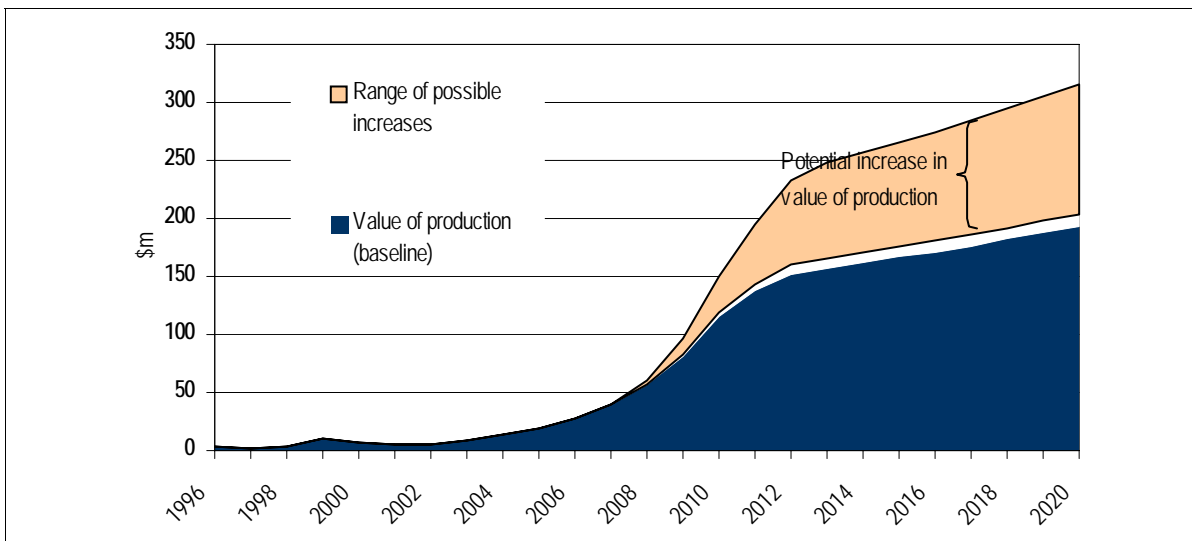
Chart A.9 shows the high and low possibilities for improved revenue resulting from RIRDC olive research. Price premiums for higher quality oil are highly dependent on the marketing strategy. The difference between the wholesale price of olive oil with the quality improvements and the wholesale price without any change in quality in chart 4.8 is the improvement in industry revenue, and thus the benefit, of RIRDC's research. The return to growers, based on a 90 per cent wholesale mark up, is 47 per cent of the total benefits.

A.8 Range of possible oil quality improvements



Data source: CIE calculations.

A.9 Range of possible values of production



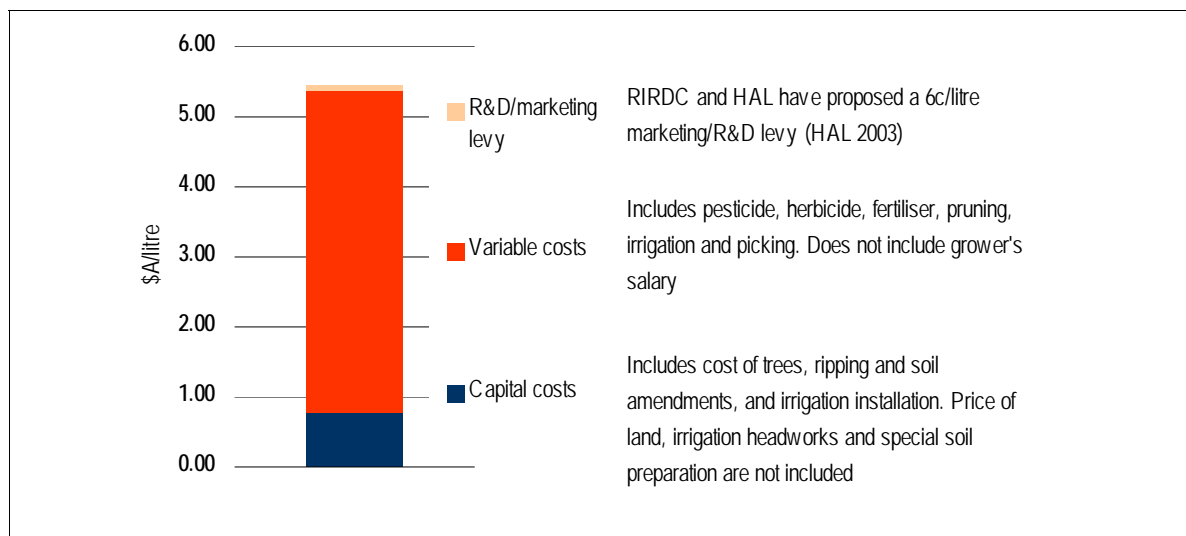
Data source: CIE calculations.

Changes to the quantity of olive oil produced due to the research

Without a very significant increase in the price of olive oil, it is unlikely that the quality increases in olive oil will result in an increase in production. The reason for this is the high establishment costs of an olive grove. These costs include purchasing and planting olive trees, preparing the soil and irrigation (\$3 000 to \$7 5000 per hectare) and the opportunity cost of the land before the olive trees bear fruit (estimated at \$2 000 per hectare per annum for the first five years). Variable costs range from \$6 000 to \$8 500 per hectare per year (Sweeney and Davies, 1998). In addition, there is a \$0.06/litre R&D/marketing levy proposed for olive oil (HAL 2003).

The expected cost of olive oil production per litre, including grove establishment costs, are shown in chart A.10. This is based on a 5 000 tree farm in its first 15 years of existence. These costs of production are not expected to increase noticeably for growers who adopt some of the technologies researched, as the costs of adoption of the research are likely to be minimal.

A.10 Annualised costs of production



Data source: Sweeney and Davies, 1998, HAL 2003, CIE calculations.

It should be noted that this cost of production diagram does not include the cost of land or the cost of labour by the owners. The capital costs of establishing an olive grove are significant enough that even with an increase in the farm gate price of oil to \$6.50/litre, a grower's average net profit would be \$52 000, which is not high considering salary and land costs must be paid out of this. However, if capital costs are treated as a sunk cost and the grove has reached full productive capacity, as they would be for a grower with an established olive farm, the grower can make around \$150 000 per year on their labour and investment.

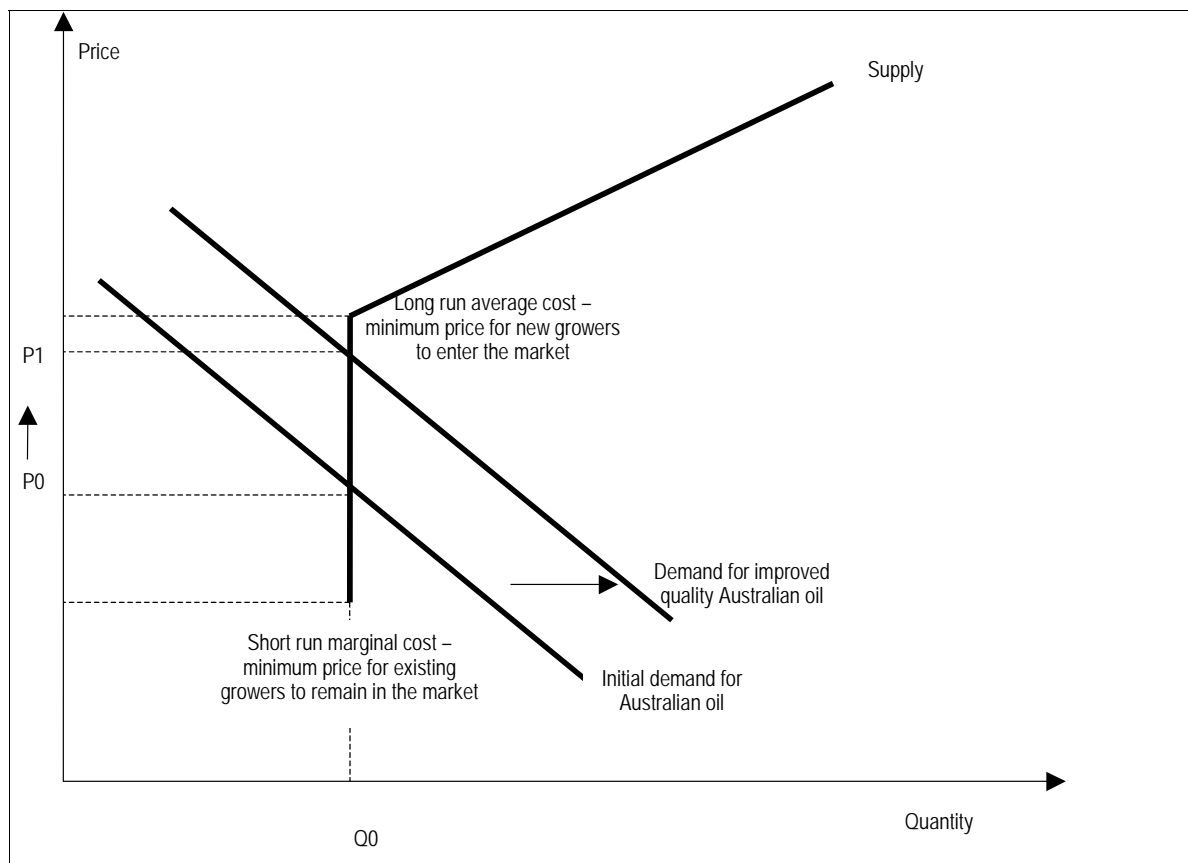
The long lag time between the establishment of an olive grove and a positive annual cash flow are a disincentive to entering the industry. Olive trees only start yielding their full capacity of fruit after about ten years (Meyers 2001) during which time the grower must maintain the trees and bear the opportunity cost from whatever would otherwise have been planted. If a potential grower wished to establish a 5000 tree farm, the expected internal rate of return would be -3 percent over 15 years at an farm gate oil price of \$5/litre, and 6 percent if the farm gate oil price was \$6.5/litre. This calculation does not take into account the tax treatment of the investment. If the capital cost can be offset against other income this would reduce the establishment costs raising the return on the investment considerably.

The evaluation assumes that the total production area is unlikely to grow further in response to the R&D given the uncertainty over the quality impacts and the price premium combined with the relatively low returns on investment (tax treatment aside). The production estimates used are based on the industry estimates.

Supply and demand changes

The supply and demand changes for olive oil as a result of the research are shown in chart A.11. There is little to no increase in the supply of olive oil as the increased price is still not enough to cover the long run costs; that is the costs of establishing a new grove. The price is enough to cover short run costs, or costs for established groves. This leads to a kinked supply curve; with the supply almost perfectly inelastic up until the point where price equals long run average cost, and then it becomes more elastic. The demand for Australian olive oil is expected to increase due to its quality improvements, thus the price increases for Australian olive oil.

A.11 Supply and demand changes due to research



Results

The assumptions used in this assessment are shown in box A.12.

A.12 Assumptions	
Farm gate price extra virgin olive oil — range \$4 to \$6 a litre, most likely	\$5/litre
Percentage markup on farm gate price — range 20 to 100 per cent, most likely	90%
Australian production growth to 2010	43%/year
Australian production growth 2010 to 2012	1%/year
Australian production growth 2012 to 2014	0.5%/year
Price response to quality (elasticity) — range 0.5 to 1.5, most likely	1
Quality outcomes and adoption see table 4.7	

Because of the very high level of uncertainty surrounding the quality outcomes in this project, upper and lower ‘best bet’ estimates are made. The range of results is shown in table A.13

At a 5 per cent discount rate the expected net present value of RIRDC’s olive research ranges from \$86 million to \$390 million. The benefit-cost ratio ranges from 22 to 96, and the internal rate of return from 29 percent to 44 percent.

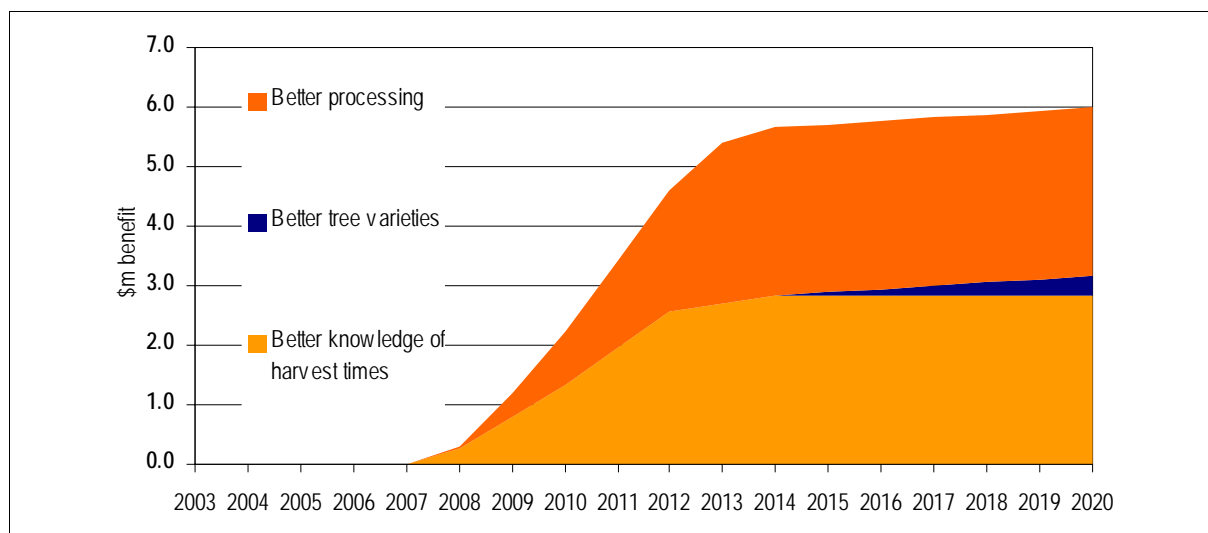
A.13 Olive evaluation results

Discount rate	Project costs \$m	Benefits after production cost \$m	NPV \$m	NBIR Ratio	IRR %
Lower quality					28.7
0 per cent	3.11	87.0	162.4	53.2	
5 per cent	4.11	47.4	86.1	22.0	
10 per cent	5.40	28.4	48.7	10.0	
Higher quality					44.0
0 per cent	2.95	381.4	721.6	232.8	
5 per cent	4.11	207.3	390.0	96.0	
10 per cent	5.40	123.9	230.1	43.6	

Source: CIE calculations.

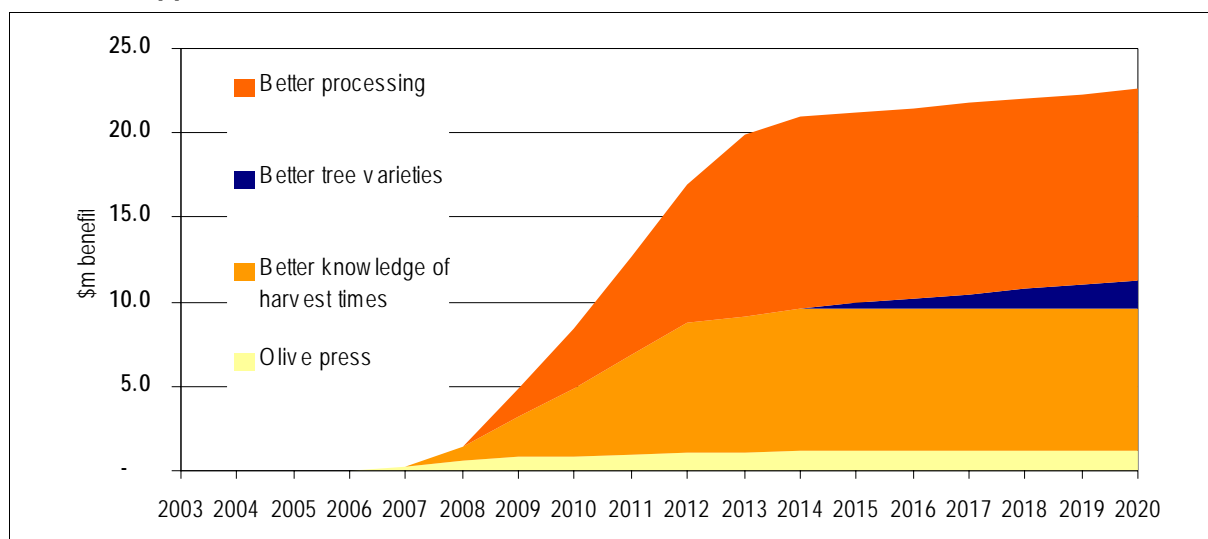
Charts A.14 and A.15 show the sources of the benefits. They map out from 2003 to 2012 the benefit flows from the four different areas of research. Chart A.14 shows the lower bound benefits and chart A.15 shows the upper bound benefits.

A.14 Lower bound benefits



Data source: CIE calculations.

A.15 Upper bound benefits



Data source: CIE calculations.

Sensitivity to the price of olive oil

The results reported in table A.13 make the assumption that the wholesale price of olive oil remains at \$9.50 a litre in current prices in the absence of any quality changes and that the price premium of a 10 per cent improvement in quality is \$0.95. A range of possible values for the key parameters are given above in box A.12. Using simulations, we estimate the probability distribution around the point estimates for the high and low quality outcome scenarios. These results are presented in table A.16. The key point is that even allowing for considerable uncertainty over future prices (both base price and in the premium achieved in response to oil quality) the internal rate of return is good even under the low quality outcome scenario. The 90 per cent confidence interval for the low quality outcome scenario internal rate of return is 23 per cent to 31 per cent while for the high quality outcome scenario it is 37 to 47 per cent. This suggests a very solid return to the R&D will be achieved.

A.16 Sensitivity analysis for olive research

	NPV	BCR	IRR
Lower quality scenario	\$m	Ratio	%
Minimum	31.0	8.5	20.2
Maximum	147.8	37.0	33.9
90 per cent confidence interval	44.8-111.4	11.9-28.1	23.0-31.1
Higher quality scenario	\$m	Ratio	%
Minimum	149.5	37.4	33.7
Maximum	658.9	161.4	50.2
90 per cent confidence interval	209.5-500.2	52.0-122.8	37.1-46.9

Source: CIE calculations.

Note: Using a 5 per cent discount rate.

Conclusion

The outcome of the olive oil research examined was an increase in the quality of olive oil. This was/will be achieved in a number of ways, namely improved olive varieties, better knowledge of optimal harvest times and processing methods, and a benchtop olive press available to olive growers. The net benefits of this research will depend on the quality improvement actually achieved in production and the associated price premium. The point estimated for the net present value of benefits range from \$86 million to \$390 million. The high returns reflect the scale of planting in the last decade and the very high levels of production expected to come on line in the next decade. The results, while sensitive to the price of premium olive oil, remain strong under significant variation in this price. These results hold regardless of the returns to the overall investment in the industry as long as the prices received mean that growers continue to harvest their fruit and make oil (at least cover variable costs). The results demonstrate the value of R&D that can improve market access and the prices achieved for an industry with a major sunk cost.

Appendix B: New oat varieties evaluation

Background

Fodder is defined as the wide range of crops and pasture species that are grown, harvested and lightly processed to facilitate both on farm use and domestic and export trade. The fodder industry has an estimated 20,000 producers on 46,000 properties across all states producing between 5.5 and 6.6 million tonnes of hay and around 3 million tonnes of silage per year. Fodder production is concentrated in Victoria and New South Wales, although Western Australia and South Australia are the major exporting states.

The gross value of production at the farm gate is estimated to be about \$1.2 billion a year — a 50 per cent increase over the past 10 years. The domestic market consists of the dairy industry (40 per cent), horse industry (25 per cent), feedlot industry (20 per cent) and others (15 per cent). Around 80 per cent of production is used on farm, mainly for dairy and beef the remaining 20 per cent is exported and sold as feed for dairy, beef and cattle feedlots and off-farm horses. Exports account for less than 10 per cent of the value with Japan being the major destination. Exports to East Asia and the feedlot industry in Australia provide the greatest potential. The East Asian animal feed industry is estimated to be \$US 10 billion per year. Australia's market share is less than half of one per cent and is derived mainly from Japan, where Australian production has around 15 per cent of the market (RIRDC 2004).

Description of the projects

The following projects on developing new oat varieties were the first time RIRDC provided funding on research into oats specifically for hay. During the 1970s research on oat breeding mainly focussed on its use for grains for feed and human consumption. More recently, researchers realised that oat breeding needed to be targeted for end-use. These projects were the first to focus on research targeting hay end-use, with particular attention to hay quality rather than yield and disease resistance. Some of the RIRDC funds for this research helped to finance part of the costs towards purchasing a forage harvester. The harvester allows researchers to cut a greater number of plots/varieties for evaluation and also allows them to evaluate earlier generation material to test for yield and quality. RIRDC and other research and industry organisations have funded three projects in this area.

Project summaries

Development of disease resistant, high yielding oat cultivars with enhanced quality for hay production (SAR-8A)

This project was conducted by South Australian Research and Development Institute (SARDI) over three years from 1998 to 2000. The aims of this project were to improve oat varieties for hay end-use given characters prioritised by farmers and hay processors by the year 2000. This project focussed on generating new populations and promoting advanced breeding lines being used currently in the program for oaten hay-end use. The stated objectives were as follows.

- Generate new oat populations and identify selections with improved hay end-use characters based on breeding priorities identified by farmers and hay processors by 2000.
- Promote F₅ (fifth generation) and F₆ (sixth generation) oat lines currently in the program to advanced trials.
- Review the most promising advanced breeding lines for variety releases.

Expanding the current domestic and overseas market for fodder is dependant on supplying first grade palatable hay. Producing hay with higher dry matter production, improved disease resistance, and enhanced quality assist in reducing the risk of producing first grade oaten hay and obtaining a higher economic return. This project strove to produce new varieties that would satisfy these needs.

The research

Parent material for the new varieties was selected based on characteristics that were prioritised by farmers and hay processors. These included agronomic characteristics of increased dry matter yield, improved early vigour to compete with weeds, thin to medium stem diameter, plant colour, and a wider range of plant maturities. Disease resistance and forage quality were also important in selecting parent material. Next, crosses were made with introduced germplasm that had desirable traits and adapted oat lines developed by SARDI.

This led to the development of advanced breeding lines. Advanced breeding lines were then evaluated in hay trials across South Australia, Victoria and Western Australia between 1998 and 2000. The breeding lines were evaluated based on their performance in disease resistance, agronomic characteristics, hay yield potential and forage quality. Data were summarised and used to identify improved oat varieties for hay end-use. The data on advanced breeding lines was compared to data on varieties already available. Those breeding lines that performed better than currently available varieties were considered for variety release by the Oaten Hay Industry Advisory Committee.

During this project, researchers identified Wintaroo and Brusher as improved new varieties for hay end-use. Researchers discussed the potential of these varieties with growers.

Development of improved oat varieties for hay end-use (SAR-31A)

This project ran over three years between 2001 and 2003. It continued on from the work undertaken in project SAR-8A. The objectives of this project were similar to that for the previous project as follows.

- To generate new oat populations and identify selections with improved hay end-use characters based on breeding priorities identified by growers and hay producers. Promote F₅ and F₆ oat lines currently in the program to advanced trials and make a decision about variety releases by 2003.

The research

Further trials of Wintaroo and Brusher were conducted in 2001 and 2002. Subsequent to the positive response received from growers regarding the potential of the new varieties in the previous project, researchers concentrated on moving towards commercialisation by developing breeder seed.

Development of improved oat varieties for hay production: national program (SAR-50A)

This project is still running and involves development of another new oat variety. SAR-50A is scheduled to run from 2002–03 to 2006–07. According to SARDI, some work on refining and commercialising the Wintaroo and Brusher varieties was carried out in this project during the years 2002–03 and 2002–04.

The objectives of this project are as follows.

- A coordinated breeding program for the development of improved oat varieties for hay production in southern Australia including Victoria, southern New South Wales, South Australia, and Western Australia.
- New oat varieties characterised in major hay producing regions.

- Rapid uptake of new varieties by industry and growers.
- Expansion of the breeding program to include late maturing oat populations.
- Evaluate stage 3 advanced breeding lines for disease resistance, dry matter production, and quality.

This evaluation will incorporate work performed in the two first years of this project, which relate to the development of the Wintaroo and Brusher new oat varieties.

Research and development costs

Total research and development costs were \$1.2 million (including only funding during 2002–04 for project SAR-50A). Table B.1 outlines the costs associated with the research and development of this project. RIRDC provided 49 per cent of the project funding with the remainder by the research organisation, SARDI, and the Western Australian Department of Agriculture.

B.1 Annual research cost for new oat varieties (\$)

Year	SAR-8A	SAR-31A	SAR-50A	Total
1997–98	114 258			114 258
1998–99	139 898			139 898
1999–2000	140 876			140 876
2000–01	103 638	47 975		151 613
2001–02		98 270		98 270
2002–03		90 401	198 458	288 859
2003–04		47 251	208 442	255 693
Total	498 670	283 897	406 900	1 219 960
RIRDC contribution (%)	27	53	76	49

Source: RIRDC database.

Project outputs

The outputs of the projects are as follows.

SAR–8A

- Development of two advanced breeding lines, SV88083-4 (Wintaroo) and SV87103-109 (Brusher) for potential release as improved hay varieties.

-

SAR–31A

- Wintaroo and Brusher breeder seeds developed, necessary to commercialise the varieties.

SAR–50A

- Release of Wintaroo and Brusher oat varieties for commercial sale.

Project outcomes

This group of projects has together produced a range of largely economic benefits as follows.

Economic

The economic outcomes of the projects include the following.

- Improved hay yield. Wintaroo has a better yield performance than a comparable variety Marloo. On average Wintaroo has a hay yield that is 15 per cent higher yield than Marloo. Brusher also has a relatively high hay yield. Brusher has an average hay yield that is 8 per cent higher than the comparable variety Wallaroo.
- Increased resistance to disease. Wintaroo is resistant and tolerant to cereal cyst nematode (CCN) and moderately tolerant to stem nematode. These diseases can negatively affect the yield of varieties. Brusher performs better than some varieties for stem and leaf rust resistance. However, it is resistant but moderately intolerant of CCN and is intolerant of stem nematode. As a result it is not suitable to be grown in certain areas where these nematodes are problematic.
- Wintaroo has an improved leaf and stem colour. It is more tolerant of brown-leaf tipping caused by hot, dry winds than Marloo.
- Improved feeding quality. Brusher has improved dry matter digestibility over all other varieties except for Glider (SARDI 2005).

The first and second outcomes increase the yield per unit input. The last three outcomes result in a price premium for the product if it allows the product to be sold on the export market. Hay with higher dry matter, improved disease resistance and higher quality is more likely to meet the demands of buyers on the export market. The achievement of these factors increases the probability of producing first grade export quality hay, which can receive an average price premium of around \$70 per tonne over hay sold on the domestic market.

Plant Breeder's Rights are attached to the Wintaroo and Brusher varieties. RIRDC and SARDI will receive royalties in return for their research and development of the varieties.

Environmental/social outcomes

There are no significant direct environmental or social outcomes from the release of these new varieties.

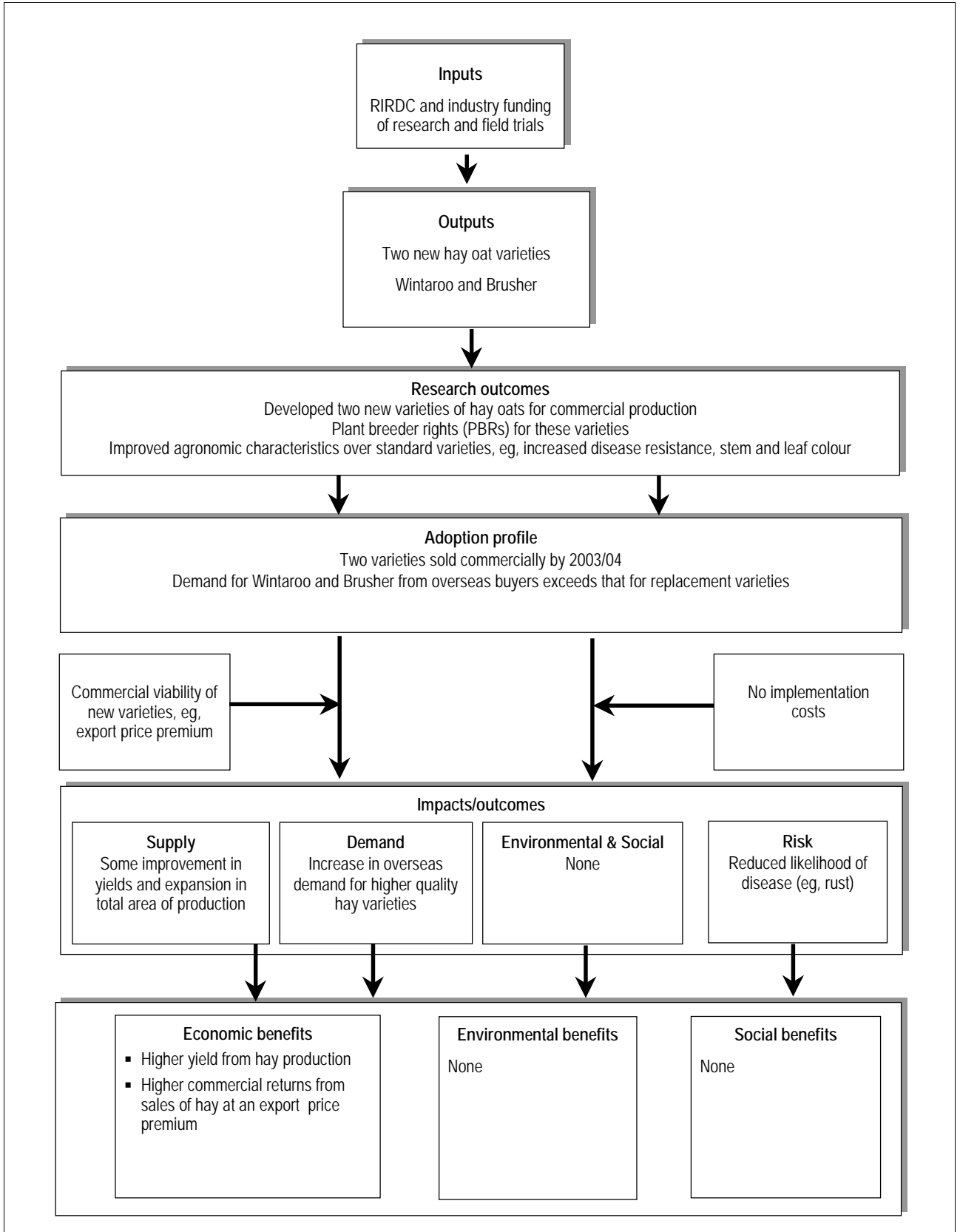
Benefits of the research projects are depicted in chart B.2.

Evaluation approach

The evaluation approach estimates the benefits to hay producers and researchers from the release of the new hay oat varieties.

The R&D phase of new varieties occurred between 1997 and 2004 and the new varieties were released for commercial sale in 2003 and 2004. Sales data for Brusher and Wintaroo is only available for 2003–04 and 2004–05. In 2004–05, around 107,000 tonnes of Wintaroo and 50,000 tonnes of Brusher were sold. Given the recent release of the varieties this evaluation is based on expected sales projections in both the export and domestic markets. The evaluation assumes that these new varieties replace the old varieties, achieve a higher yield, and sell a greater proportion of production to the higher value export market. Production costs rise only by the higher cost of the seed, much of which is returned as royalties to the developers.

B.2 Potential benefits of new oat hay varieties



Data source: CIE (2005).

Production of hay for export in Australia has been expanding over the last decade — and the new varieties are beginning to contribute to this. Growth in total hay production for export has been influenced by a downturn in grain prices and in the wool industry in the 1990s and early 2000. The higher probability of the new varieties reaching the export grades plus the wider regional adaptability of Wintaroo, in particular, have contributed to an expansion of production for export over the last two seasons (P. McCormack, SARDI, personal communication, 7 July 2005). Those producing more hay for export typically have had a combination of hay and grain crops or grazing on their land and are switching towards producing more of the new hay varieties. It is difficult to estimate any change in production costs to producers switching between these types of produce given a lack of detailed data available. According to SARDI, the costs of general sowing and management of hay compared to grains would be similar. Costs to process hay relative to grains could be more or less expensive depending on a number of variables such as whether producers do this themselves or contract this out. This evaluation does not include any potential change in costs to producers from switching from previous activities to new varieties. According to the researchers there is no difference in production costs from cultivating the new varieties over others.

The increase in production of hay for export is not expected to have any impact on the domestic hay market. A significant number of producers that traditionally supply hay for the domestic market are expected to continue doing so. In addition, domestic supply will also be maintained from hay intended for export that fails to meet overseas buyers' requirements. The evaluation assumes no change in the domestic price for hay.

The impacts of the R&D are measured over a 30-year period, commencing in 1997–98 when the research was first funded by RIRDC. Expected production and sales are based on estimates by SARDI (P. McCormack, SARDI, personal communication, 7 July 2005). Royalties payable to RIRDC and SARDI from their contribution to the R&D phase are also estimated.

Wintaroo and Brusher replace older varieties, in particular the Marloo and Wallaroo cultivars. Benefits to hay producers from selling Wintaroo variety on the domestic market are the value of the higher hay yield relative to Marloo. This is estimated as the yield difference multiplied by estimated sales and the domestic average price.

According to SARDI, Brusher is expected to target the export market. Due to its improved quality and other characteristics, Wintaroo is expected to have double the sales of Marloo on the export market. Whilst not as popular as Wintaroo, Brusher is expected to have higher export than Wallaroo. Producers selling Wintaroo and Brusher for export will benefit from the export price premium over domestic prices as well as the higher yields. The volume of exports is estimated as the higher share of Wintaroo exported relative to the base case sales of Marloo plus the higher share of Brusher exported relative to the base case sales of Wallaroo.

The new varieties tend to have a life cycle of around 5–10 years. After this time they are generally replaced by more advanced varieties. Expected sales will increase to an estimate peak at around 4–5 years after the initial release of the variety. Over the next three years there is a period of transition where growers tend to switch to the newer varieties, with sales of Wintaroo and Brusher declining during this period and then ceasing. The benefits from the varieties continue despite the expected replacement as new varieties have to perform better to be adopted. Royalty payments do decline, however, as they are based on sales.

The key assumptions in the BCA are outlined in box B.3.

B.3 Key assumptions in the BCA

- The time horizon for the evaluation is 1997-98 to 2020-21. Forecasts for sales and benefits apply from 2005–06 onwards.
- Wintaroo has an average yield improvement of 15 per cent over Marloo.
- Brusher has an average yield improvement of 8 per cent over Wallaroo.
- The average price per tonne for first grade export quality hay is \$160 and for lower grade domestic hay \$90 (2004–05 dollars) and is assumed to remain constant in real terms.
- Domestic sales of Wintaroo are anticipated to peak at 50,000 tonnes. Minimal domestic sales of Brusher are expected.
- At its peak, overseas demand for the old variety Marloo would reach 100,000 tonnes. Export demand for Wintaroo is expected to peak at 200,000 tonnes at least.
- At its peak, overseas sales of Wallaroo would have reached 20,000 tonnes. Sales of Brusher on the export market are expected to peak at 50,000 tonnes.
- No change in production costs as the new varieties replacing old ones have the same cost of production.
- Royalties are \$0.50 per tonne of total new hay varieties sold. Out of total royalties, RIRDC receives 30 per cent and SARDI receives 70 per cent.

Results

Benefits to producers

Table B.4 presents estimates of the benefits and costs from the new oat varieties research under a range of discount rates. The research produces benefits that are significantly greater than the costs of the research. This is due to the relatively low cost of the research and the assumption that there is no change in production costs to producers. At a discount rate of 5 per cent, the project generates net benefits of \$159 million with BCR of 101. This represents a return to the Australian economy of \$101 for every \$1 spent on the project. The positive result demonstrates the considerable benefits, particularly to growers from producing Wintaroo and Brusher varieties over the older varieties. The project's IRR, representing the interest rate at which the project would generate zero returns in net present value terms is high at 79 per cent.

2.3 New oat varieties evaluation results (2006-07 dollars)

Discount rate	NPV R&D costs	NPV benefits	NPV net benefits	BCR	IRR
	\$m	\$m	\$m	Ratio	%
0 per cent	1.40	278.41	277.01	200	79
5 per cent	1.59	160.69	159.10	101	
10 per cent	1.82	103.89	102.07	57	

Source: CIE calculations.

Benefits to the researchers

The costs of developing the new varieties exceed the estimated return from royalties generated by hay sales. The total R&D costs of developing new varieties of hay were \$1.13 million (at 5 per cent discount rate); the benefits (in the form of royalties) are estimated to be around \$0.82 million. Table B.5, summarises the benefit flows.

B.5 Royalty estimates

<i>Year</i>	<i>Sales Wintaroo</i>	<i>Sales Brusher</i>	<i>Royalties to RIRDC</i>	<i>Royalties to RIRDC</i>	<i>Total royalties</i>
	tonnes	tonnes	2004-05 (\$)	2004-05 (\$)	2004-05 (\$)
2003–04	9 960	57.4	1 503	3 506	5 009
2004–05	106 630	50 000	23 495	54 821	78 315
2005–06	200 000	50 000	37 500	87 500	125 000
2006–07	225 000	50 000	41 250	96 250	137 500
2007–08	250 000	50 000	45 000	105 000	150 000
2008–09	250 000	50 000	45 000	105 000	150 000
2009–10	250 000	50 000	45 000	105 000	150 000
2010–11	187 500	37 500	33 750	78 750	112 500
2011–12	125 000	25 000	22 500	52 500	75 000
2012–13	62 500	12 500	11 250	26 250	37 500

Source: CIE calculations.

The following sensitivity analysis explores the impact on the evaluation of benefits to producers from changing some of the key assumptions.

Sensitivity analysis

The base case results of the research are driven by various assumptions. To test the sensitivity of the results adjustments are made to some assumptions. A range of values is placed around four of the assumptions as outlined in table B.6.

B.6 Values used to parameterise the probability distribution of each input variable

<i>Input variable</i>	<i>Unit</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Mean</i>
Wintaroo average yield	t/ha	5	10	7.5
Brusher average yield	t/ha	4.5	9.5	7
Export price	\$/t	140	180	160
Domestic price	\$/t	80	100	90
Wintaroo peak production	t	-25%	+25%	250 000
Brusher peak production	t	-25%	+25%	50 000

Source: CIE estimates.

The sensitivity analysis indicates that despite changes to some of the key assumptions, the project is still likely to generate positive benefits. The results of the sensitivity analysis are contained in table B.7.

B.7 Results from sensitivity analysis ^a

	NPV	BCR	IRR
	\$m	Ratio	%
Minimum	0.9	1.5	12.5
Maximum	326.1	206.2	96.0
95% confidence interval	73.8-231.5	47.4-146.7	63.1-88.1

^a Assumes a 5 per cent discount rate.

Source: CIE estimates.

The evaluation and sensitivity analysis has assumed no change in costs to producers between the new and old varieties (or between switching from alternative products such as grain crops) based on estimates from researchers and available information. If producers did have to incur significant costs to produce the new varieties the benefits from this project would be lower.

Conclusion

The net benefits of the research into new hay oat varieties are estimated to be \$159 million (NPV, with a 5 per cent discount rate) due to higher yields and a higher share of total hay production reaching export quality. Only specialist hay producers are likely to adopt the new varieties who are targeting export markets. It is anticipated that the new varieties will make up around 30 per cent of the anticipated exports of 1 million tonnes by 2008. Development of these new varieties which have greater disease resistance, better leaf and stem colour and feeding quality improve the likelihood of producers selling their produce on the lucrative export market. The success of these new varieties is beginning to contribute to an expansion in the hay producing industry.

Appendix C: Electromagnetic induction evaluation

Background

Water is a critical input into rice production. Rice fields require permanent flooding with a depth of 300mm for up to 130-150 days. Between 60 to 70 per cent of all water used for irrigation in southern NSW is used by the rice growing industry. However it has been estimated that up to 35 per cent of the water applied to rice paddies bypasses the crop. This loss of water has been attributed to groundwater recharge.

Groundwater recharge can be defined as water that seeps through the soil and continues to percolate deep into the soil until it reaches the groundwater supply. It has a major impact on the rice growing industry of Southern New South Wales because the water loss is a continual cost to rice growers. Perhaps more critically, groundwater recharge causes rising water tables and can increase salinisation. To maintain a sustainable rice growing industry, ricegrowers need to be able to grow crops in paddies that minimise groundwater recharge, improving water use efficiency and limiting the rise of saline water tables.

Description of the projects

The amount of groundwater recharge can be directly linked to the watertable depth and the soil composition of the rice paddies. This includes clay, salt, sodicity, and water content. Previously measures of the amount and type of clay have been used to assess the suitability of soil for rice farming. Soil samples were taken within a 200 meter grid (or every 4 hectares). This was time consuming and did not give a complete picture of the farming area as growers were unable to identify localised sites that allowed high levels of groundwater recharge. Instead they were committed to removing the whole 4 hectares surrounding a leaky patch leading to an inefficient retirement of suitable rice growing areas.

The electromagnetic induction technique aims to rapidly map the entire rice paddy area enabling the farmer to test the soil suitability accurately and avoid growing in 'leaky' areas. It does this by measuring the apparent flow of electric current (ECa) through the soil. The level of electrical conductivity is affected by the soil's water content and the salinity of that water, the clay content, soil density, and temperature. Therefore the instrument can be used to measure one of these soil properties if the others are known or can be estimated.

Once the soil characteristic measurements are made, the soil is categorised into electrical conductivity classes. Using specially designed software, growers can generate contour maps to identify different physio-chemical properties and estimate groundwater recharge levels. This enables the grower to better target areas for drilling when testing soil suitability.

Three projects have led to the development of EM31 and soil suitability testing. The first two were funded by RIRDC and NSW Agriculture while the third was a follow on funded by the CRC for Sustainable Rice Production (CRC).

Project summaries

Rice land suitability assessment (DAN 95A)

The research was undertaken by NSW Agriculture and conducted over a three year period starting in July 1993 and finishing in June 1996.

The objective of this project was to develop a field survey and interpretation methods necessary to identify areas of high groundwater recharge using the Geonics EM31 instrument. The instrument would be used to identify soils that contain little clay within the first two metres or are well leached implying they may recharge the groundwater at high rates. Once identified, the grower can eliminate or ameliorate that patch of leaky soil instead of the 200 metre grid required under the previous identification method, thereby minimising land retirement.

In addition, DAN 95A set out to review the suitability of the Rice Environmental Policy Advisory Group (REPAG) criteria. This technique uses physical soil sampling (hand soil texturing) to measure the proportion of heavy/medium clay textured in the first 2-3 metres of the soil and gives an indication of how 'leaky' the soil is. The project sought to develop an improved measuring scale of soil suitability based on further soil properties by establishing an index of soil permeability and validated by field experiments to measure groundwater recharge beneath rice crops. (RIRDC final report DAN 95A)

The rice fields selected covered a variety of soil compositions, water conditions and farming history. Three were examined from the Murray Valley while eight were examined from the Murrumbidgee valley over a series of 21 experiments.

EM to estimate groundwater recharge from rice growing (DAN 145A)

Research was undertaken by NSW Agriculture and conducted over a three year period starting in July 1996 and finishing in June 1999. It was implemented to address some issues with soil testing discovered in DAN 95A and to expand on the research already undertaken.

The objective of this project was to remove 'leaky' soils from rice farming to reduce groundwater recharge and eliminate the need for physical soil sampling (Research and Development Project Agreement 1996, pp. 2). It was to develop an easy technique to measure soil composition and a simple indicator to determine groundwater recharge and the suitability of soil for rice growing. It was assumed that recharge was controlled primarily by the amount of clay in the soil and the research undertaken in DAN 95A found that there was a strong relationship between EM readings and the amount of clay in the soil profile. However relationships between clay index and EM were found to differ with the irrigation history of the field because of different levels of salt affecting the soils' EM value.

Therefore a universal index was sought which was to be achieved by using electromagnetic surveying and soil sodicity testing to generate a three-stage classification scheme of soil suitability to grow rice. The rice fields selected covered a variety of soil compositions, water conditions and rice growing history. Around 150 sites have been studied on 30 rice fields and all sites were within rice fields approved for rice growing and met existing soil suitability and rice water use criteria. The study area covered both the Murray valley and Murrumbidgee valley.

Better prediction of groundwater recharge from rice growing (CRC 1102)

The research commenced in September 1997 and completion is set for June 2003. It is being undertaken by NSW Agriculture and funded by Rice CRC and NSW Agriculture.

By expanding on previous research undertaken in DAN 95A and DAN 145A the objective of this project is to better predict rice farming impacts on water tables and further develop the rice land classification system by including landscape and physio-chemical properties. In particular, CRC 1102

hopes to complete the soil sodicity data set previously established in DAN 145A and measure physico-chemical and landscape properties to predict recharge. Surrogate measures or simple field tests will then be developed of those properties which are good but hard to measure predictors of groundwater recharge. (CRC 1102 R&D proposal 1997-98)

Research was conducted in the Murray and Murrumbidgee Valleys. Specifically, experiments were undertaken in Berriquin, Cadell, Denimein, Wakool, and Coleambally.

Research and Development Costs

Table C.1 sets out the costs attributed to DAN 95A, DAN 145A and CRC1102. The total present value cost of the research and development is \$3 044 444 discounted at 5 percent.

- Funding for both DAN 95A and DAN 145A was supplied by RIRDC and NSW Agriculture.
- Total funding over the project for DAN 95A was \$347 446 in current dollars. Of this, RIRDC contributed approximately 37 per cent while NSW Agriculture contributed approximately 63 percent.
- Total funding over the project for DAN 145A was \$391 372 in current dollars. Of this, RIRDC contributed approximately 43per cent while NSW Agriculture contributed approximately 57 percent.
- Total funding over the project for CRC 1102 was \$1 607 059 in current dollars. Of this total, \$283 459 has been in cash contributions while \$1 323 600 has been in kind. Based on funding presented in CRC's research and development proposal 1997-98, Rice CRC contributed approximately 47 per cent while NSW Agriculture contributed approximately 53 percent. There was no funding supplied by RIRDC for this project, except through their block funding of the CRC.

C.1 Annual research cost for EM31

Year	DAN 95A	DAN 145A	CRC1102	TOTAL
	\$	\$	\$	\$
1993-94	129 409	-	-	129 409
1994-95	107 404	-	-	107 404
1995-96	111 209	-	-	111 209
1996-97	-	125 997	-	125 997
1997-98	-	128 385	82 177	210 562
1998-99	-	136 990	174 604	311 594
1999-2000	-	-	26 678	26 678
In kind to 12/2001	-	-	993 600	993 600
In kind to 06/2003	-	-	330 000	330 000
TOTAL	347 446	391 372	1 607 059	2 345 877

Source: RIRDC Standard Research Agreement DAN 95A and DAN 145A, CRC 1102 Research and Development Proposal 1997-98.

Project outputs

DAN 95A

- Application of new technology and the development of hardware and software to link a real time differential global positioning system (dGPS) and the EM31 instrument.
- In conjunction with the use of global positioning systems, new mapping techniques have been developed to graphically illustrate detailed soil compositions over the entire measurement area.
- Procedure established to guide EM31 users conducting measurements and interpreting results when determining rice land suitability.

- Easy way to locate where soil suitability should be assessed instead of using the 200 metre grid system.
- Increased awareness of new technology and improved education on the factors determining the level of groundwater recharge.
- Rice Environmental Policy Advisory Group (REPAG) criteria for identifying rice soil suitability found to be limited as it only accounts for clay content. Preliminary relationship was developed between EM31 measurements and soil clay content.

DAN 145A

- Clay content alone was found to be a poor indicator of groundwater recharge. Although there are fields where clay content of the soil was a major factor in reducing recharge, these usually contained lighter soil. Once the clay content reached a critical level (around 40 to 45 per cent), the amount of clay within the soil had no relationship with recharge levels. Sites with high levels of clay classified as suitable under the REPAG criteria were found to have recharge levels well over the acceptable 2 MI/ha threshold. Other sites with little clay previously classified as unsuitable were found to have recharge levels suitable for rice growing.
- Electromagnetic induction alone was found to be an inadequate technique for measuring estimates of groundwater recharge as there was no single relationship established between the EM-31 values and recharge. The research was unable to eliminate the need for physical soil sampling and drilling is still required.
- Three-stage soil classification system for rice growing suitability developed as an improvement over the existing REPAG criteria. This involved the use of electromagnetic surveying in conjunction with sodicity measures obtained from drilling. In various experiments average recharge levels were reduced and very 'leaky' sites previously classified as suitable under the REPAG criteria were eliminated under the new criteria.

CRC 1102

Because research has not been completed, there is very little reported on research outputs. However, although CRC 1102 did not specifically set out to establish a relationship between EM values and sodicity, recent reports suggest EM31 survey results can be used to define classes of soil with different sodicity levels in areas containing constant irrigation and land use history. (Jinadasa 2001). This will reduce the current high cost of soil sodicity testing and therefore enable irrigators and growers to utilise research outputs from DAN 145A.

Project outcomes

The project outcomes are dependent on the adoption rate and the current restrictions on the amount of land allocated to rice growing. It is noted that the technology has been adopted more widely than for use on rice, and hence the focus on the benefits to the rice industry will understate the wider benefits. Adoption levels have been determined by surveying irrigators and the Department of Land and Water Conservation. Current adoption levels for EM technology is approximately 34 per cent of total area, however adoption in each rice growing area varies considerably as shown in table C.2. Although officially Murrumbidgee Irrigation has an adoption rate of around five per cent, true estimates are around twenty per cent. This is because growers in the Murrumbidgee area are reluctant to tell the irrigator they are using EM technology as any paddock found leaky will be removed without replacement by the irrigator.

C.2 Total adoption of EM31 technology as at March 2003

	Inception	Per cent
Murrumbidgee Irrigation area	2001	5-20

Coleambally Irrigation area	1999	70
East Murray Valley	1999	30
West Murray Valley	1999	25

Source: CIE survey of Murray, Murrumbidgee and Coleambally Irrigators and DLWC.

There has been virtually no adoption of the three stage soil classification test as yet and it is difficult to predict its uptake. The Department of Land and Water Conservation have estimated the new system has been used on 0.5 per cent of growers in the western part of the Murrumbidgee and Murray Irrigation is currently investigating its use. As a result we have excluded the potential benefits and research costs of this component of the R&D from the empirical estimates.

Economic outcomes

There are three primary economic outcomes from research into EM technology.

- Reduction in water cost per hectare — growers using EM technology typically use their less ‘leaky’ soils for rice production than growers that do not use the technology. It is a requirement set by irrigators and DLWC for rice growers exhibiting leaky paddocks to use EM technology to eliminate leaky patches.
- Increase in efficient employment of land — due to EM technology, a rice grower no longer needs to take out a 200 square metre patch of land to eliminate a leaky paddock. Instead they are able to examine their EM generated contour map and estimate likely patches where groundwater recharge is excessive. An increase in accuracy when measuring soil suitability has resulted in reducing the amount of suitable land removed from rice production. This expansion in choice of land to use for rice production would be reflected in higher yields available from being able to utilise more productive land. This outcome would be of particular value if suitable land is a constraint on the expansion of the industry. Currently expansion is restricted by regulations and not suitable land.
- Additional water available for rice production — reduced water use per hectare allows farmers facing a ceiling on water use per hectare to expand their production of rice if water is the limiting factor in their production decision.

Restrictions on water use and rice growing land

Currently rice growing is either restricted to approximately 30 per cent of the total rice suitable area or a water constraint of on average 4 ML/hectare (in the MV) that is equivalent to approximately 30 per cent of total growing area. As growers retain the right to use their allocation, any water saved can be used to either expand the rice production area, used in alternative crops, or sold to other users, including for environmental flows.

Environmental outcomes

Environmental outcomes are twofold.

- Reduction in the leakiness of land used for rice production will reduce recharge and result in watertables being lower than would otherwise have been the case. Information on how much lower and where in the landscape the benefits would be felt was not available.
- Potentially, water saved could be released back to the environment as environmental flows. How large this benefit is depends on the amount of land allowable for rice growing and/or the approach to water allocation. It is uncertain that there would be any impact on environmental flows given the existing water allocation system and trading rights.

The environmental benefits from such outcomes if they could be established would be:

- reduction in irrigation salinity of rice farms and the discharge of saline waters into nearby waterways resulting in the protection of soil micro-organisms essential for the breakdown of nutrients; and
- protection of bio-diversity, including protection of native vegetation along rivers and streams that further reduces bank erosion. Improvement in water quality in the rivers and streams helps protect aquatic bio-diversity. Other effects relate to the protection of habitat (for example, food, nesting sites) for native fauna such as birds.

In undertaking this evaluation it is lack of information the likely biophysical outcomes of adoption that forms the first barrier to evaluation. In addition the lack of information on the impacts of saline water tables on productivity would make impact estimates difficult.

Social outcomes

Access to water is a highly contentious issue for irrigated crop producers. The current uncertainty over future water allocations and the structure of the water market is causing considerable pressures in rural communities. Any innovation that helps farmers save water lowers their adjustment cost and strengthens the long run position of the industry as a sustainable industry. The use of EM-31 is also likely to feature in any environmental management system and accreditation that is likely to be adopted by the industry. As such EM-31 will contribute to reducing risk and reducing the communities' sense of vulnerability.

Further outcomes

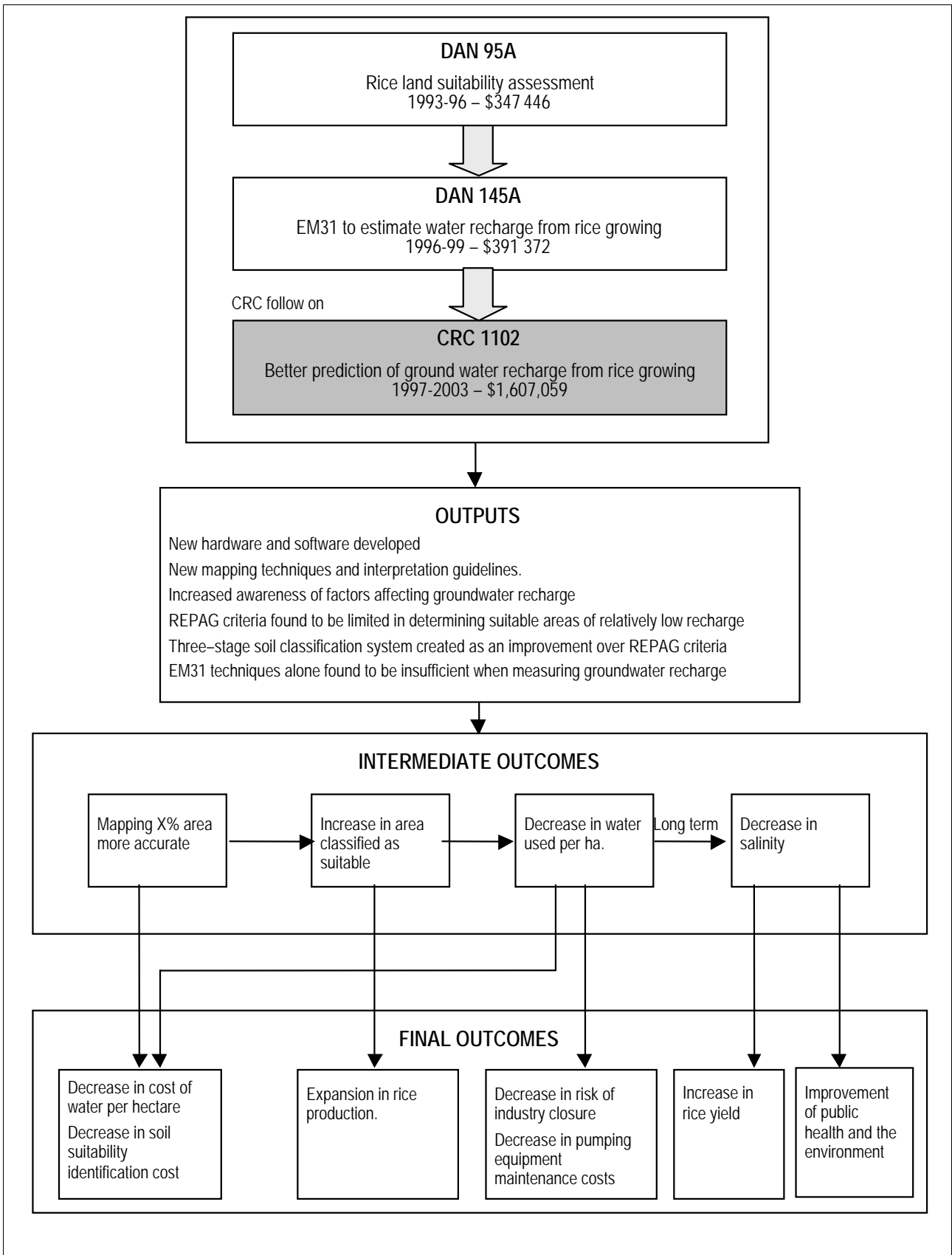
EM31 technology has also been used for agricultural resource management in applications other than rice. These applications pertain to water savings either in irrigation or water storage.

Reservoirs located randomly on a landscape have a significant chance of leaking. Assessing the soil texture alone does not provide sufficient information to predict how leaky the soil is. To get a better indication of water storage suitability, EM31 surveys and drilling selectively located test holes have been used.

The Macquarie Valley has adopted EM31 technology after discovering reservoirs in the same local area were exhibiting remarkably different seepage rates. Furthermore, some of the localities that contained a relatively high amount of clay had high seepage rates, while similar soil types in other landscapes had low seepage rates. The EM31 survey provides more detailed information about the pattern of leaky soil. By investigating the pattern of soil variation across the landscape, seepage rates can be estimated and the best locations for test holes used for ground truthing can be determined. These test holes can then be used to determine the correlation between EM31 readings and soil properties at the site investigated (Hulme 2001, pp. 160).

EM31 technology has also been used to identify irrigation channel seepage. As part of an ongoing study into channel seepage along the Waranga Western channel at Boort, an EM31 survey was undertaken in November 1998. Results indicated that EM31 technology was able to identify potential seepage areas where there were no visual signs of seepage. Other techniques used only gave a broad indication of potential seepage locations and often missed high seepage areas where there were no visual signs of seepage. By using EM31 surveying, the channel system was classified into three potential seepage categories that included high, mid and low ranges, and enabled the channel to be repaired through clay lining at a much lower cost (Heslop and Murphy 2001, pp. 142).

C.3 Flow chart detailing research inputs, outputs, and outcomes



EM technology has also been used to establish relative recharge rates across irrigated and dryland catchments. The rate and distribution of groundwater recharge are recognised as the main factors in the development of salinity problems in these catchments. Previously, very expensive estimation techniques over a large area have been used to estimate these parameters. However, EM31 is a relatively cheap and rapid technique for mapping salinity variation across large areas and can provide a robust relationship between estimated recharge and mapped electrical conductivity. By establishing relative differences in recharge rates, applications for grants for recharge control plantings on the plains can be assessed with greater accuracy (Trehwella 2001, pp.45).

EM surveys have also attempted to identify areas of high groundwater recharge under perennial pasture, where light soils contribute to high irrigation use. Initial findings indicate that the EM31 technique is valuable in identifying areas of high groundwater recharge under pasture and hence assisting in reducing water use through altering management practices to accommodate light soils, although further work is required to confirm these initial findings (Nicholson 2001, pp. 126). Finally, EM31 technology has been used to locate appropriate experimental sites when undertaking field experiments in the irrigated environment. By avoiding unsuitable areas, researchers can limit the presence of experimental error and reduce the probability of experimental failure. Thompson et al has listed a number of experiments where EM31 technology has been used (Thompson et al 2001, pp. 167).

Unfortunately the adoption rates or water savings that EM technology has had in these areas has not been measured. Much of the uses are still exploratory to establish the value of the investment in EM-31. As a result we do not quantify these additional benefits.

Evaluation approach

Quantifying the benefits from EM technology has been limited to outcomes produced from DAN 95A. The primary economic benefits have been identified as a reduction in water per hectare and an increase in efficient land use. Both these benefits will lead to an increase in production and an increase in water used for environmental purposes.

Although recent evidence suggests soil sodicity measures established in DAN 145A are useful in identifying leaky soils, there has been virtually no adoption. High costs in testing have been cited as the primary reason. However, Murray Irrigation is currently waiting on REPAG to endorse the criteria, and recent tests suggest the number of soils misclassified as suitable under the new criteria will be halved. This has yet to be confirmed and there is not information on the impact of reclassification on the planting pattern. Furthermore, benefits from CRC 1102 have not been calculated because results from the research have not been completed. These costs are excluded from the cost estimates.

Measuring net benefits requires an examination of the current water and land allocation rice growers face and likely restrictions in the future. Currently Coleambally Irrigation has reached its capacity in terms of the allowable rice growing area. Therefore, any water saved cannot be used to increase the production of rice. However, the Murray Valley and Murrumbidgee Irrigation areas are not under land constraints but under water constraints. Therefore any water saved can be used to increase the rice production area as long as the irrigator allows them to retain their water rights. Of course, expansion cannot continue indefinitely, and consultation with the rice industry suggests that the water constraint currently facing rice growers translates to an equivalent land constraint of approximately 30 per cent of available growing land. The Murrumbidgee is currently producing at its equivalent land capacity.

The approach to estimating the benefits

The analysis assumes that rice growers use the additional water up to the point that they reach their constraints on rice production. After this point the water saved could be sold to alternative uses including for return to the environment. The value of the water saved is proxied by the value that the water would have generated in the production of rice. Thus the value of the research is the same whether the water is used in rice production or delivered as environmental flows. What the approach identifies is the share of the benefits that flow to the rice producers compared to those that flow to the broader community in alternative uses of the water. The benefit to the rice producers has two components. The first is lower costs of production per hectare hence higher profit margin due to reduced water inputs, the second comes from the higher return on the production of rice relative to other crops as area is expanded up to the legal restrictions.

The use of the opportunity cost of water as a proxy for its value in alternative uses, such as to the environment, should be a lower bound. This value is the cost imposed on rice producers by the restrictions on their water use. If the policy is appropriate then the benefits of the additional water to other crops or in the rivers and streams should exceed this cost. Thus the benefit estimates may understate the real value of the water saved.

The analysis also understates the benefits to both rice producers and the environment in that it does not estimate the value of the reduced recharge to water tables. The net effect on recharge, despite an expansion in area, will be a significant reduction due to the removal of leaky areas from production. The other uses of EM31 also contribute to this outcome. It is however, very difficult to measure the effects of a decline in recharge on agricultural production and on the environment without detailed geophysical and hydrological models. This is because the impacts of salinity are determined by an array of geographical and soil properties, and different periods of time. Chapter 7, which discusses the SWAGMAN projects demonstrates the difficulties. Consequently, the CIE has not quantified the effects on water tables and on salinity levels either on or off farm and therefore, any estimates of benefits are likely to be biased downwards.

Each region was evaluated independently, recognising different water usage characteristics, amount of rice growing area, and EM technology adoption levels. The net benefits to rice producers were calculated as:

- the total profit from rice production (value of production less the costs of production (including costs of adopting EM-31 but lower levels of water use per hectare)) for the baseline plus enhanced allowable area of rice production, less;
- the opportunity cost of land that is now able to grow rice, estimated by the weighted average net revenue per hectare from wheat, barley and canola. These three crops were selected because they were recognised as the primary alternative crop to rice (Geoff Beecher, NSW Agriculture, 4 April 2003); compared to
- the total profit without adoption of EM-31 (value of production less costs with higher water use) for the baseline area of production.

Research costs were entered directly into the model in the years they occurred. The model has only accounted for research costs incurred throughout DAN 95A because it is only these benefits which are quantified. Including costs from DAN 145A and CRC 1102 is inappropriate because the model does not include their likely benefits.

Assumptions

The model has the following assumptions, which are summarised in table C.4.

- Water savings from undertaking EM surveys result in an average water saving of 2 megalitres applied to the remaining area. For example, if a 40 hectare field had an average water usage of 16 megalitres, then after EM surveying and removal of leaky sections the remaining area should

exhibit an average water usage of 14 megalitres. Estimated water savings figures range between 0.5 and 3.5 megalitres per hectare (Geoff Beecher, NSW Agriculture, 3 June 2003). An average of 2 megalitres per hectare is used in the estimation.

- Water used for rice production differs across regions and will also change as new varieties come into production. Water usage for growing rice has been projected to 2015 without the adoption of the EM technology. Water prices are also expected to rise over time. These assumptions are set out in chapter 2.
- Adoption of EM technology is expected to rise to 100 per cent for each rice growing region between by 2015 with the first adoption occurring in 1999. However, each region has a different adoption profile based on their current adoption rates. Adoption in the Murray and Murrumbidgee rice growing areas is assumed to grow in a relatively linear manner. This reflects the fact that the Murray is only undertaking EM surveys on new rice growing areas or paddocks considered leaky and the Murrumbidgee has a relatively low adoption rate because any paddocks found leaky are removed from production by the irrigator without replacement. The Coleambally area adoption rate is much higher with full adoption expected by 2005. This reflects the intentions of the irrigator to undertake EM surveys on 100 per cent of the rice growing area by the end of 2004 (Chris Shaw, Aran Tiwai and Rob Kelly pers. comm. April 2003). Each adoption curve is shown in chart C.5.
- Cost of using EM technology to survey a field is estimated to be \$17.50 per hectare, the mid point taken in the fifteen dollars to twenty dollars range quoted (Geoff Beecher, NSW Agriculture, 4 April 2003). Actual costs depend on how big the field is and how far the consultant has to travel.
- The opportunity cost of producing rice is calculated as \$156 per hectare. This represents the difference in gross margins obtained from growing wheat, barley, and canola, compared to rice given similar labour and capital inputs (ABS 7113.0 1999-2000 and CSIRO Research for Profitable and Sustainable Cropping 1994).

C.4 Assumptions

Water savings from removing leaky soils	2.0 Ml/ha
Adoption of EM technology between 1999-2015	100%
Mapping costs (per hectare)	\$17.50
Opportunity cost (per hectare)	\$156.00

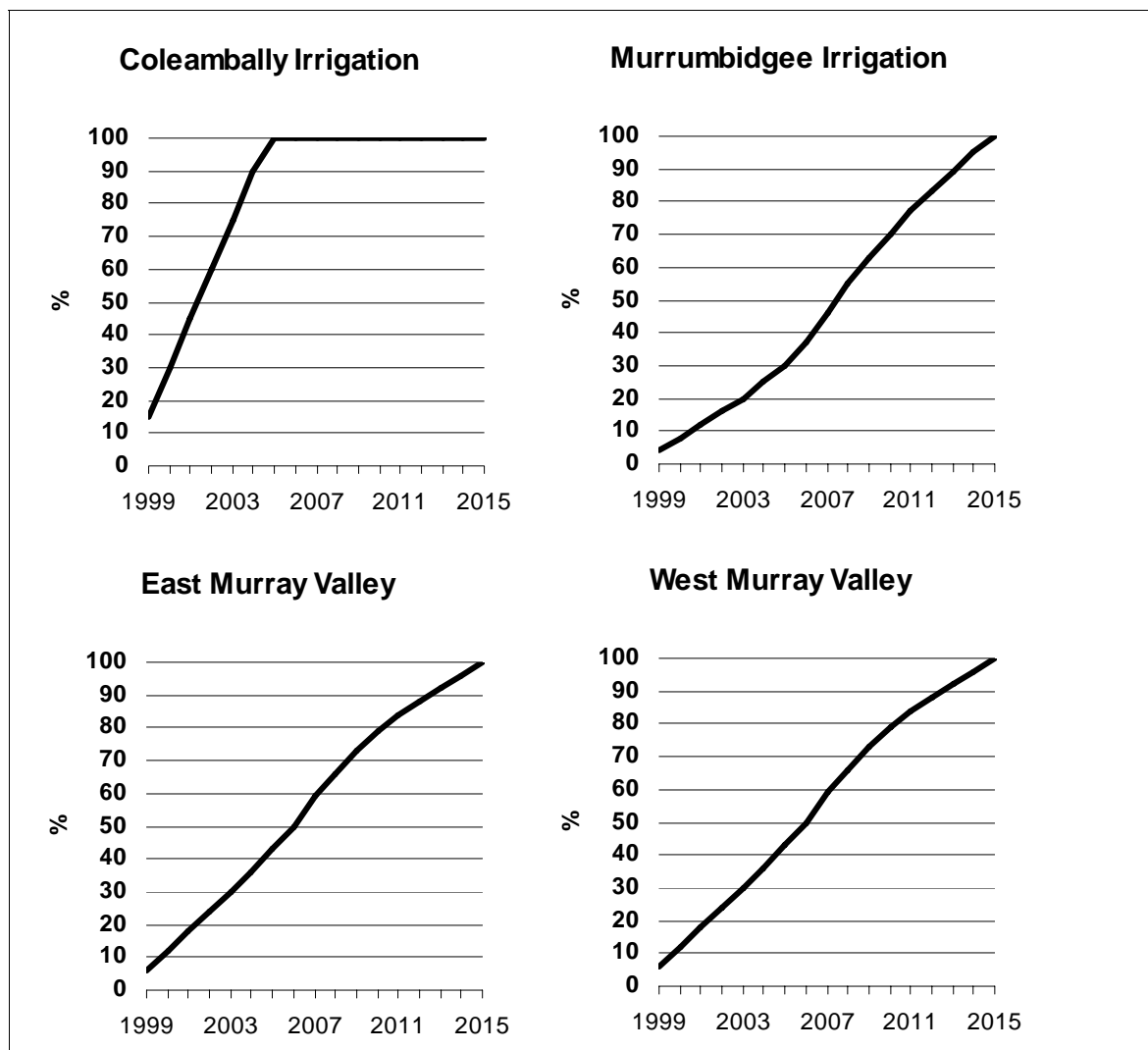
Source: CIE survey.

Results

Benefits of water savings from expanding production

In the first year of EM surveying (1999), water savings have been calculated to result in allowing the East Murray Valley to use 440 hectares and the West Murray Valley 300 hectares for growing rice that would have otherwise not been achievable. Because the Murray Valley is below its equivalent area constraint of 30 per cent, any water saved will be used to increase rice production. Except for 2001 when rice growing had met its equivalent land constraint, water savings contribute to the expansion of rice until 2005 for the West Murray Valley and 2006 for the East Murray Valley. At these points the equivalent constraints on growing rice are met and any additional water saved is not used to increase rice production. Whether the EM-31 technology will result in a change of policy on rice production is not known, and the estimates are based on the assumption that the restrictions are not relaxed. If they are then the distribution of benefits changes with greater benefits coming through expansion in the area of rice production.

C.5 Estimated adoption profiles of EM surveying



Data source: CIE estimates

Water savings have also allowed the Coleambally Irrigation and the Murrumbidgee Irrigation to produce more than otherwise, resulting in an additional 932 hectares and 499 hectares respectively in 2003. Although water constraints were faced by all growers in 2003 due to the drought, water savings since 1999 have effectively allowed them to produce more rice than would have been achievable if EM technology was not introduced. Table C.6 shows the effect of water savings on the rice growing area.

C.6 Increase in rice growing area due to water savings

	1999	2000	2001	2002	2003	2004	2005	2006
	ha	ha	ha	ha	ha	ha	ha	ha
Coleambally Irrigation	-	-	-	-	932	-	-	-
Murrumbidgee Irrigation	-	-	-	-	499	1 708	-	-
East Murray Valley	440	759	-	1 550	507	1 809	2 888	-
West Murray Valley	300	474	-	1 230	376	1 403	2 291	211

Source: CIE modelling

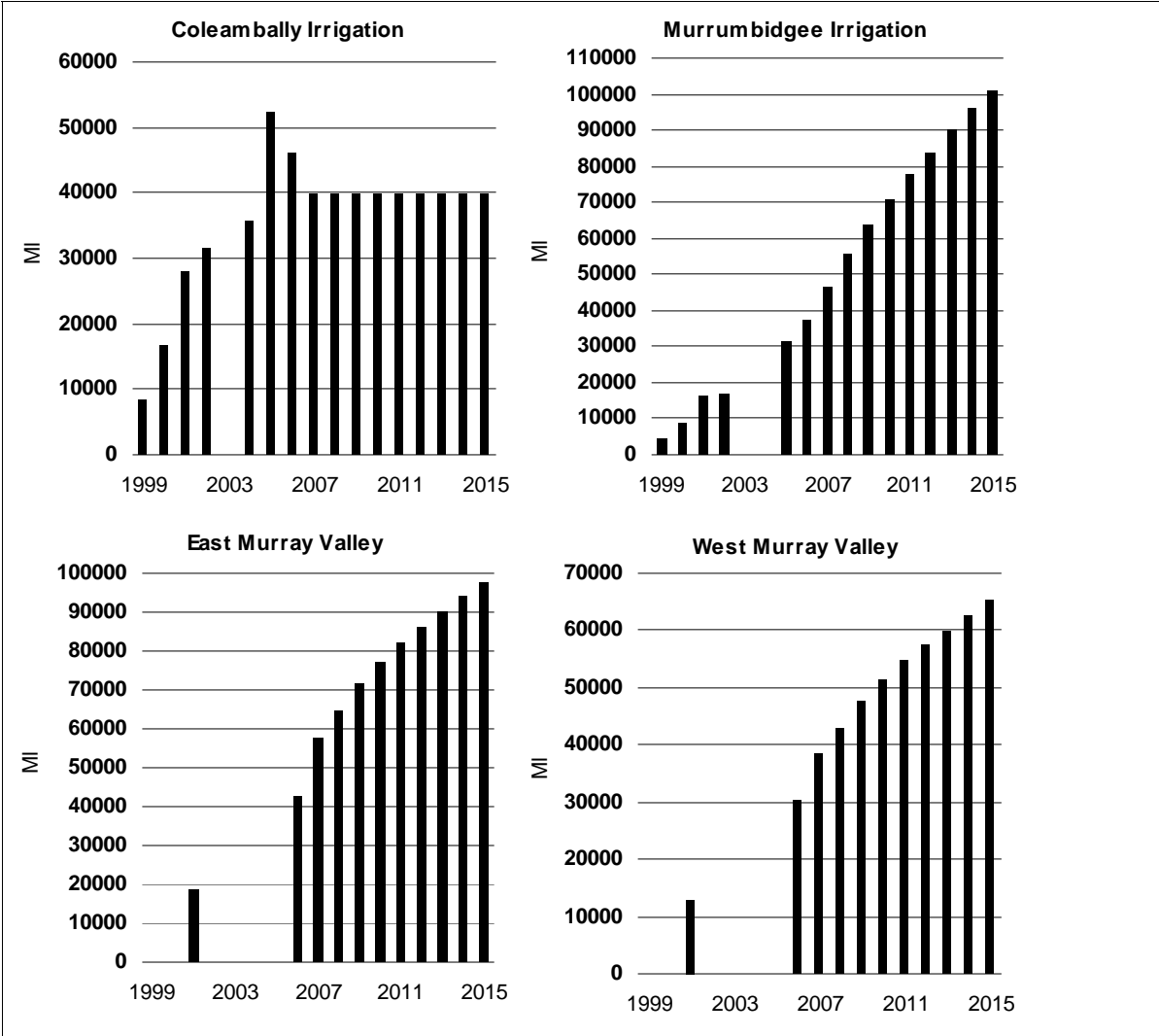
Assuming a discount rate of 5 per cent, the benefits to rice producers from the EM-31 technology is estimated at \$47.6 million. Of this \$36.6 million is due to the lower unit cost of production from the

saving of water. Note that this figure does not include research or implementation costs as these will be considered when total benefits are examined.

Benefits of water savings

Water that has not been used to increase the production of rice due to grower constraints could be used in a variety of ways. The amount of water saved from using EM technology over the period 1999-2015 is shown in chart C.7. Note the years which do not show any water saved correspond to those years where all water saved was used to increase rice production.

C.7 Water savings released back into the environment

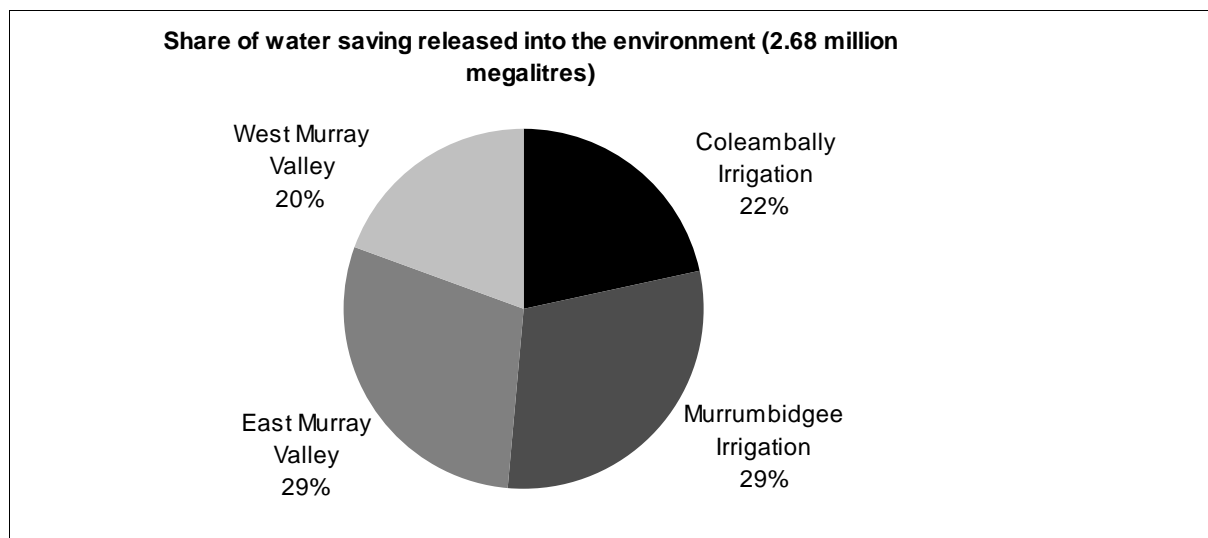


Data source: CIE modelling results.

Water savings for the period 1999-2015 total 2.68 million megalitres. The portion of water savings for each rice growing region is shown in chart C.8.

Assuming a discount rate of 5 per cent and a value of water given by its opportunity cost, the benefit from the water savings is approximately \$162 million.

C.8 Water saving by region



Data source: CIE modelling results.

Total benefits from EM technology

Assuming a discount rate of five per cent, the total benefit net of implementation costs and opportunity cost is approximately \$209.6 million. Of this rice growers receive around 24 per cent of the total benefits in cost saving and expansion in rice production. Research costs were around \$0.5 million and implementation costs \$1.5 million resulting in a net present value (net benefit) of \$207.5 million. A summary of results under different discount rates is shown in table C.9.

C.9 Benefit from increasing rice area under various discount rates

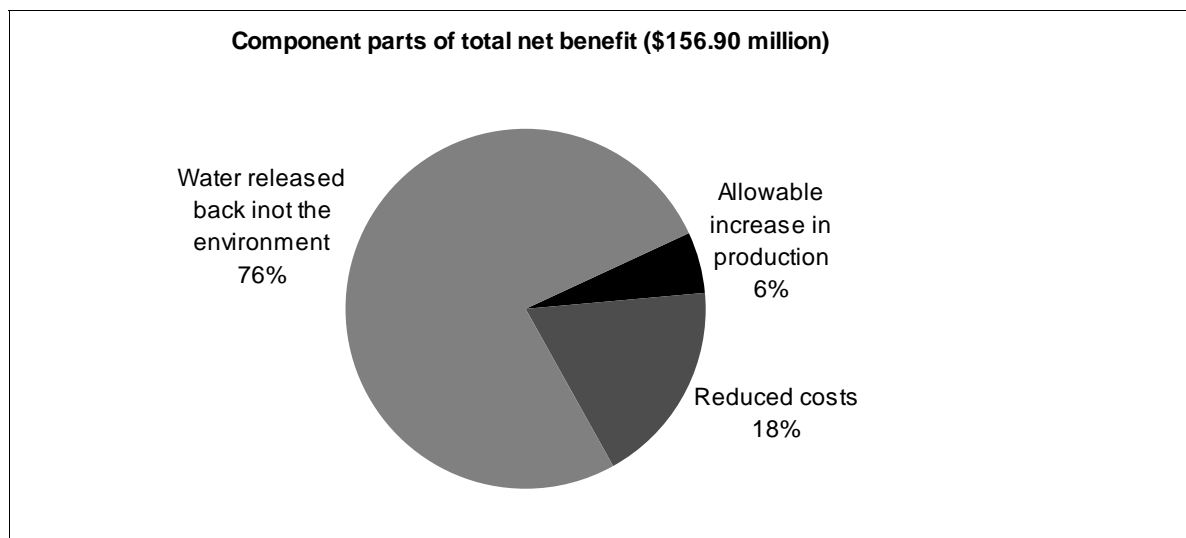
<i>Discount rate</i>	<i>Research costs</i>	<i>Implementation costs</i>	<i>Benefits</i>	<i>Net benefits</i>	<i>BCR</i>	<i>IRR</i>
%	\$m	\$m	\$m	\$m	ratio	%
0	0.49	2.60	430.99	427.90	139.65	79
5	0.52	1.60	209.59	207.48	99.05	
10	0.54	1.06	109.17	107.57	68.26	

Source: CIE calculations.

The BCR is 99 with a five per cent discount rate. The BCR is the ratio of the present value of the projects benefits, net of operating costs, to the total present value of its research and implementation costs. Therefore, for every one dollar spent on research and implementing EM technology, benefits distributed between the rice industry and the environment will be approximately \$99. Chart C.10 summarises how the benefits are distributed between the environment and rice producers. Note that the greatest gain for producers comes in the reduced cost of production with only 6 per cent of the total return coming from expansion of rice production area.

The internal rate of return (IRR) is approximately 79 per cent. The IRR is the discount rate that, if used to discount a project's costs and benefits, will just make the project's net present value equal to zero.

C.10 Allocation of benefits



Sensitivity analysis

Because of the inherent uncertainty surrounding the estimated water savings from using EM technology, a sensitivity analysis was conducted. This entailed varying the average amount of water within a prescribed range a grower can expect to save.

The sensitivity analysis simulates ten thousand different point estimates within an established range to determine a likely minimum and maximum NPV and to establish a confidence interval.

When undertaking the simulation, the probability distribution for the average amount of water savings per hectare was assumed to be triangular with a minimum point estimate of 0.5 megalitres per hectare and a maximum of 3.5 megalitres per hectare. This range was established in consultation with Geoff Beecher of NSW Agriculture (3 June 2003). Table C.11 shows the results of the sensitivity analysis.

C.11 Results from sensitivity analysis^a

	NPV	BCR	IRR
	\$m	Ratio	%
Minimum	101.0	48.7	56.2
Maximum	324.4	154.3	92.5
95% confidence interval	121.7-298.2	58.5-141.9	62.2-89.9

^a Assumes a 5 per cent discount rate.

Source: CIE estimates.

Assuming a five per cent discount, results from the sensitivity analysis establish an NPV range of \$101 million to \$324.4 million and a 95 per cent confidence interval of \$121.7 million to \$298.2 million. The large range represents the importance of water to the rice industry, as a reduction of two megalitres in water use represents a reduction in total water use of approximately 18 per cent.

Conclusion

Research into the use of EM technology is likely to produce many benefits, including economic and social benefits to the rice industry and environmental benefits to the wider growing community. Because water is a relatively scarce resource, these benefits will be derived from increased water use efficiency, expansion of rice production, and a reduction in water table recharge. Excluding the impact on recharge these benefits of adoption of EM-31 are estimated to be \$210 million over the period to 2015 for a research cost of \$0.5 million. Of these benefits only 24 per cent is a return on rice production due to the constraints on expanding the area of rice production. The benefit to rice growers will depend also on the use to which they can put the water saved.

These benefits are likely to be an underestimate as they do not take into account the expected reduction in the water table in rice growing areas which may bring both on and off farm benefits. These potential benefits are not included as we were unable to establish the biophysical impact on saline water tables in relation to the impact on production. More work is required to demonstrate and map these effects, which was beyond the scope of this evaluation.