Report to

National Program for Sustainable Irrigation

Economic Evaluation of Outcomes from Investment in the National Program for Sustainable Irrigation Phase 2

June 2012

BDA Group

Economics and Environment

BDA MELBOURNE
PO Box 6009
Hawthorn West, VIC 3122
Ph (03) 8684 9707

BDA CANBERRA
PO Box 4022
Manuka ACT 2603
Ph (02) 6282 1443

SUMMARY

The National Program for Sustainable Irrigation Phase 2 (NPSI II) is a partnership between a number of research agencies, irrigation industries, water management authorities and state and federal governments. Investment through NPSI II will conclude on 25th June 2012. BDA Group was commissioned to undertake an economic evaluation of NPSI II outcomes. Non-economic benefits such as improved soil and salinity management and increased human capacity were not quantified.

Project outcomes were described as either (1) direct economic benefits from the adoption of technologies (products, processes or information) developed through NPSI II and taken up by industry, (2) advancement of scientific knowledge and capability regarding irrigation systems or (3) increased efficiency in research and development (R&D) through leadership and coordination of effort across various R&D agencies. In total, 42% of funds were invested in projects that have increased knowledge, 37% that increased efficiency and 21% of invested funds have delivered a demonstrable industry economic impact.

The minimum pay off on funds invested through NPSI II was estimated using three projects that were deemed to have delivered a major economic benefit. These projects were:

- ***Fertigation Management in Citrus*** - a nutrition planning software (excel based) program was developed based on extensive R&D and extended to industry allowing citrus growers to achieve, on average, a $400 per ha saving in fertiliser costs. Total benefits were estimated at $3.4M in present value terms.
- ***Water Smart Cotton and Grains*** – the extension of best practice irrigation methods to 253 irrigators and 183 farm consultants and other industry members that assisted irrigators to achieve, on average, water use savings of up to 0.15 ML per hectare each year. Total benefits were estimated at $7.6m in present value terms.
- ***Water Management in Vegetables*** – the extension of the Vegetable Irrigation Scheduling System to 23 Western Australian vegetables growers to date that has enabled them to achieve water use savings of up to 40%. Total benefits were estimated at $2.7m in present value terms.

The economic pay off from NPSI II was estimated to deliver at least $13.7m (present value terms) to the Australian economy. Against a total NPSI II investment of $9.1m (present value terms) this represents a positive pay off on funds invested. The net present value was estimated at $4.6m which represents a return of $1.50 on every dollar invested in NPSI II. If benefits are only compared against the cost of projects that have delivered an economic benefit (21% of total costs) the return would be $7.20 for every dollar invested across those projects.

CONTENTS

1. CONSULTANCY BRIEF

The National Program for Sustainable Irrigation Phase 2 (NPSI II) is a partnership between a number of research agencies, irrigation industries, water management authorities and state and federal governments. As part of the final evaluation of the success, or otherwise, of the investment in NPSI II BDA Group was commissioned to undertake an economic evaluation of NPSI II outcomes.

Through NPSI II a number of case studies have been completed demonstrating the impact of NPSI II investment across irrigators, local communities and research partners. A detailed report based on a survey of irrigators and informed persons in the irrigation industry was also completed in May 2011 and demonstrated that NPSI II had[1]:

- Strengthened the wider industry support for the Australian irrigation sector by taking leadership for many cross sector issues facing the industry.
- Improved research and development cooperation, capacity and collaboration by engaging many stakeholder, industry and research groups to work together to address irrigation issues and research and development (R&D) across the country.
- Improved the capacity of irrigators to make decisions regarding the viability of irrigation practice change for their own circumstances based on the development and extension of best practice.
- Improved irrigation efficiency outcomes through the adoption of technologies (products, process and information) that increase water use efficiency.
- Improved environmental and social outcomes through more prosperous communities and a better understanding of the off-site impacts of nutrient migration and soil salinity.

The analysis completed here was based on the total investment in NPSI II and sought to quantify, where possible, and to describe otherwise, the following outcomes from NPSI II.

1. Benefits to Australia from adoption of developed technologies (products, processes or information). These benefits will provide a direct economic benefit to Australia and can be compared against the total investment in NPSI II to demonstrate the minimum “pay off” on funds invested.

2. Advancement in the collective understanding of science relating to irrigated agricultural practices in Australia. An aim of NPSI II was to provide research and development leadership across the many and diverse groups committed to the advancement of irrigated industries and their local communities to increase knowledge of irrigation systems. This also includes the building of human

[1] QualData (2011), NPSI Phase Two Impact Report 2011.

capacity which will enable the irrigation industry to better respond to the challenges of the future, including climate change and potential impacts on water scarcity.

3. Efficiency dividend to NPSI partners through participation in the collaborative program. Through enhanced collaboration across R&D agencies NPSI II sought to reduce duplication of effort and increase the effectiveness of investments made.

The approach taken in this evaluation was to focus on the whole NPSI II investment portfolio and identify individual projects that had a major contribution to each of the three outcomes noted above. Five projects were deemed to have had a major impact across these areas and were chosen for a more detailed review. Estimated economic benefits across those projects delivering a demonstrable industry impact were used to draw conclusions regarding the minimum economic pay off that could be attributed to the total investment in NPSI II.

In the following section the total investment in NPSI II is described. Section 3 provides a summary of project outcomes from individual NPSI II projects. Section 4 details the economic benefits that can be attributed to the three projects deemed to have had a major industry impact and provides a discussion of two further projects that demonstrates NPSI II leadership in R&D and the nature of efficiency dividends generated. The report concludes with an assessment of the economic return achieved on NPSI II investment funds.

2. INVESTMENT SUMMARY

NPSI II investment commenced in 2006/07 and will be finished at the end of 20011/12, with a total investment of $10.6m, or $9.1m in present value terms[2]. Sixteen different organisations have contributed nearly $5.0m to NPSI II operations including $1.5m from Land and Water Australia, $0.9m from Horticulture Australia Ltd, $0.8m from Goulburn Murray Rural Water Corporation, $0.5m from the Commonwealth Department of Environment and Water Resources and the rest from a number of research and development corporations and water management agencies across Australia. NPSI II funds are allocated to individual projects which have also been supported by third party funds totalling just over $6m. A breakdown of NPSI II funding by primary research agency is shown in Figure 1[3].

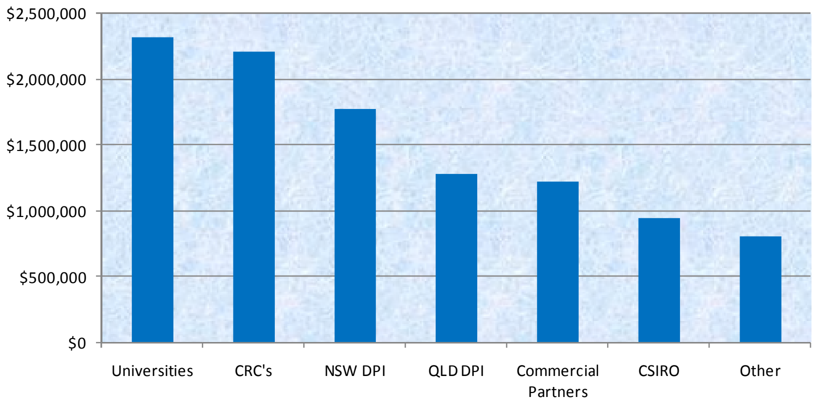
Project investment ranged from $1.3m (QPI5161) to $6,000 for a number of student scholarships. The largest 10 projects had an average investment of almost $0.8m each accounting for 75% of all funds invested in NPSI II. These top 10 projects involved a wide range of researchers from QLD DPI, NSW

[2] Based on a discount rate of 5%.

[3] Contributions were sourced from the 2007 Funding Agreement and funding by primary research provider was sourced from NPSI II budgets.

DPI, CSIRO Sustainable Ecosystems, Central Queensland University, CRC Polymers, CRC Irrigation Futures, University of NSW, University of Adelaide and Goulburn Murray Water.

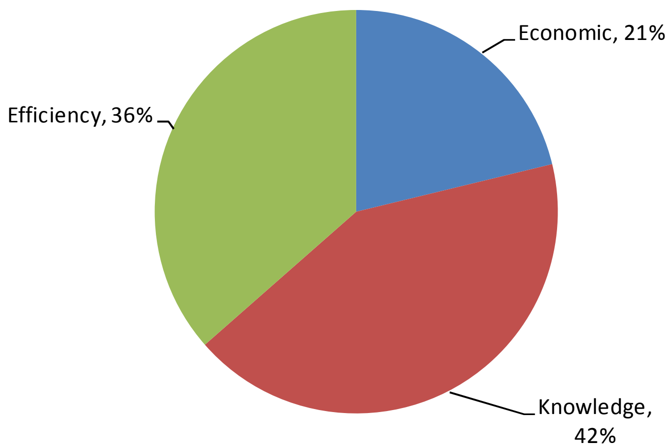
FIGURE 1: NPSI II FUNDING: BY PRIMARY RESEARCH AGENCY



3. OUTCOME SUMMARY

In consultation with the NPSI II Coordinator, all project outputs and outcomes were determined. These are summarised in the Appendix. While it was recognised that most projects would deliver against all the objectives of economic gain, building knowledge and R&D efficiency (see Section 1), each project was grouped in terms of the main objective that it was deemed to have delivered against. A breakdown of investment against the three objectives is shown in Figure 2. Most funds were deemed to have been delivered against the objective of increasing knowledge, although a substantial amount of funds have generated a direct economic return (21%).

FIGURE 2: NPSI II INVESTMENT OUTCOMES BY OBJECTIVE



4. SELECTED PROJECT BENEFITS

In this section a detailed evaluation of the selected projects is reported. These projects were selected in consultation with the NPSI II Coordinator to demonstrate how projects have delivered against the portfolio objectives of economic gain, building knowledge and R&D efficiency. The first three projects have delivered demonstrable (and quantifiable) economic gains to the irrigation industry, the fourth project delivered an increased knowledge of irrigation systems across the wider R&D community and the last project delivered an efficiency dividend across participating R&D agencies.

4.1 Fertigation Management in Citrus

This NPSI II project (DAN5027) was a collaborative effort involving NSW DPI and SARDI research and extension staff. It commenced in July 2008 and was completed by December 2011. Fertigation is the term used to describe the supply of nutrients to a plant via irrigation water. Drip irrigation has increasingly been taken up across the citrus industry in response to increased water supply costs. Delivering irrigation water using drip irrigation involves a higher level of management and frequency of application compared to other traditional irrigation methods. At the commencement of the project it was recognised that there was an opportunity to enhance the level of drip irrigation skills and knowledge to help growers optimise both the timing and rate of both water and nutrient supply to their orchards. This would help to improve orchard health, productivity and reduce fertiliser costs and nitrate pollution into ground and surface water systems. It is estimated that there are around 4,000 ha of citrus and almonds in the Riverland, Sunraysia and Riverina regions where drip irrigation and fertigation is used[4]. Investment in the project was substantial, totalling just over $0.8m over the course of the project.

NPSI Outcomes

One of the main outcomes from the project is that the use of a simple fertigation system with standard best practice conventional irrigation and nutrition management can deliver similar gains in productivity as compared to expensive high frequency irrigation and fertigation technologies that acidify irrigation water. This has implications for significant cost savings for growers adopting fertigation, but also highlights the potential of productivity gains that can be achieved by adopting best practice for conventional technologies. There is also a reduced need to use acid with

[4] Final Project Report

irrigation water with significantly reduces the occupational health and safety hazard associated with some of these advanced fertigation programs.

Another significant outcome from the project was the identification of strategies to reduce the risk of leaching of nutrients beyond the rootzone, especially nitrate. This can be minimised by[5]:

1. injecting nitrate in the middle of, or late in, an irrigation event;
2. avoiding excessive concentrations of nitrate in the soil solution (oversupplying nitrogen can also reduce fruit quality);
3. complete the nitrogen supply program by the end of summer /early Autumn to allow the depletion of nitrogen in the soil by winter; and
4. apply the correct amount of water, based on crop demand and expected rainfall.

The research also demonstrated that different rootstocks take up different amounts of nutrients, and that trees growing on those rootstocks may have different nutrient requirements as a result. Although fertiliser decisions are made on a regular basis throughout the growing season it was recommended that matching plant demand to nutrient supply should be based on a consideration of a range of factors rather than an assessment of how “trees look”. These factors include the previous season crop load, tree age, variety, rootstock, bud line, crop size management and current seasonal conditions. The use of soil solution sampling devices was also recommended as a semi-quantitative means of assessing the extent to which applied nitrogen was moving beyond the rootzone. A benchmark value for nitrate in soil solutions was also identified as a guide to assessing the efficacy of fertiliser programs.

A long term fertigation trial site has been established which will allow the impacts of fertigation to be investigated over the longer term. The site will also serve as a technology transfer site over the next twenty years. This capacity building activity is a unique in the world.

The project also had a significant extension component that enabled the research outputs to be effectively packaged into useable industry tools. Workshops were held with citrus growers to increase their awareness of nutrient management and the use of the developed tools to better match water and nutrient supply to plant needs. Good nutrient management involves monitoring the crop and using indicators such as tree health, tree vigour, leaf symptoms, leaf analysis and fruit quality yield and yield targets[6]. The two main tools developed included:

5 Guidelines for Fertigation of Citrus Orchard: Managing fertigation systems to achieve good productivity and avoiding fertiliser wastage and loss – NPSI project summary, page 5.

6 Dr Steven Falivene (NSW DPI) provided details of extension outcomes to BDA Group consultants.

(1) A nutrition planning spreadsheet (Excel based) that allows a growers to plan the rate and timing of different nutrients (including N, P, K and Ca) on a per hectare basis and the associated cost. The program allows rates and timing to be varied and the type of fertiliser applied in order to determine the most cost effective strategy. The program is being taken up by growers.

(2) An irrigation management and scheduling decision support program (E-Schedule) that integrates historical weather data and predictions and crop water demand to determine irrigation water demand over the next few days. The program's accuracy and stability is expected to be improved when the Bureau of Meteorology's predicative weather service is able to be linked into the software program. The program has potential application in all irrigated agriculture and further trials will be carried out outside of the NPSI funding period.

Benefits

This project was assessed as having had a major industry impact. The economic impact of the project outcomes was quantified in terms of reduced fertiliser costs across citrus growing enterprises.

A breakdown of citrus production by the major citrus producing states (NSW, SA and Vic) is provided in Table1. In 2009/10 there were 1,194 businesses with citrus orchards and the average area under citrus per business was 10 hectares.

TABLE 1: CITRUS PRODUCTION IN NSW, SA & VIC

State	Production (kt)	Businesses	Total Area (ha)
New South Wales	179	667	5,977
South Australia	113	346	3,753
Victoria	64	181	2,122
Total	**356**	**1,194**	**11,852**

Source: ABS Statistics Cat. 7121, 2008/09 & 2009/10. Note Production figures are a two year average. Area was estimated assuming an average production of 40 tonnes per ha with a 75% pack out.

Across the industry there is widespread use of drip irrigation as well as under tree sprinklers. Areas with sandy soil are more likely to use under tree sprinklers as irrigation water tends to move straight down the soil profile rather than laterally. Drip irrigation is gradually increasing in use as farms are being redeveloped. However drip irrigation requires different management techniques in both nutrition and irrigation as compared to sprinkler irrigation. To date there have been 50 growers through the nutrient management workshops and that are using the on-farm fertiliser tool.

Fertiliser savings have been estimated by NSW DPI at around $400 per ha[7]. This estimate was based on feedback received from the growers who participated in the workshops and are using the nutrient planning software to plan the timing of fertigation, nutrient rates and type of nutrient supplied. Lower costs are achieved through a combination of reduced amounts of nutrients supplied as well as shifting to lower cost products. At an average holding of 10 ha of citrus per business the total saving is estimated at $4,000 per business.

Adoption of the improved fertigation strategies has been achieved through grower participation at nutrient management workshops, and these are planned to continue over the coming years (at a cost of $0.1m a year). Better nutrient management has also been extended to farm consultants, and it is expected that further adoption of the strategies will be occur as a result. For the purpose of this evaluation it was assumed that there would be an additional 20 growers a year adopting the technology through participation at nutrient management workshops and an additional 10 growers a year through the service sector.

The counterfactual was considered in terms of how long it would otherwise have taken other parties to develop technologies delivering similar outcomes. Through NPSI II it was possible to bring together both the required science and practical application of the science for commercial citrus production. Without NPSI II support it is likely that work would have progressed in this area but at a much slower rate. A 7 year lag was assumed[8].

In Table 2 the estimated annual benefits attributable to the NPSI investment are detailed. Total benefits were estimated at $3.4m in present value terms[9].

7 Steven Falivene provided a series of simulations using the fertiliser spreadsheet on 6th June 2012.

8 In a review of Dairy Australia's Dairy Moving Forward program Malcolm, B. & Paine, M. (2005, A Social Benefit Cost Analysis of Dairy Moving Forward, A report prepared for Dairy Australia and the Faculty of Land & Food Resources, University of Melbourne, December) argued that a 3 year delay in benefit realisation would be appropriate for extension type activities. The use of a considerably longer lag is reasonable for NPSI II contribution in this evaluation because of the scientific skills that were required to determine plant demand as well as specialist skills required to develop industry specific tools.

9 Based on a 5% discount rate.

TABLE 2: ESTIMATED PROJECT BENEFITS THROUGH TIME ATTRIBUTED TO NPSI INVESTMENT

Year	Annual Adoption (businesses)	Cumulative Adoption (businesses)	Workshop Cost ($m)	Estimated Benefits ($m)
2009				0
2010	20	20		$0.1
2011	30	50		$0.2
2012	30	80	$0.1	$0.2
2013	30	110	$0.1	$0.3
2014	30	140	$0.1	$0.5
2015	30	170	$0.1	$0.6
2016	30	200	$0.1	$0.7
2017		180		$0.7
2018		150		$0.6
2019		120		$0.5
2020		90		$0.4
2021		60		$0.2
2022		30		$0.1

4.2 Water Smart Cotton & Grains

This NPSI II project (DAN5162) was undertaken by the NSW Department of Primary Industries. It commenced in November 2008 and was completed by November 2011. The project built on previous investments by state governments and the cotton and grains industry to improve their water use efficiency (WUE). It targeted continued adoption of best management practices in irrigation technologies and methods that have enabled irrigators to continually improve their WUE. The area covered by the project included cotton and grain production regions in NSW and Southern Queensland as well the Lachlan and Murrumbidgee irrigation areas. The project represented a significant investment under NPSI II with nearly $1m allocated over three years.

NPSI Outcomes

The project sought to increase the adoption of irrigation best management practices across cotton and grain irrigators and consultants. It was an extension program delivered to irrigators and service providers.

> "*Water Smart Cotton and Grains incorporated a comprehensive capacity building program including training workshops, technology demonstrations, consultant mentoring and dissemination of irrigation*

information to increase the knowledge and awareness of irrigation best practice, new irrigation technologies and to improve on-farm water management and irrigation efficiency within the Australian irrigated cotton and grains industries.[10]"

The program included a number of extension efforts.

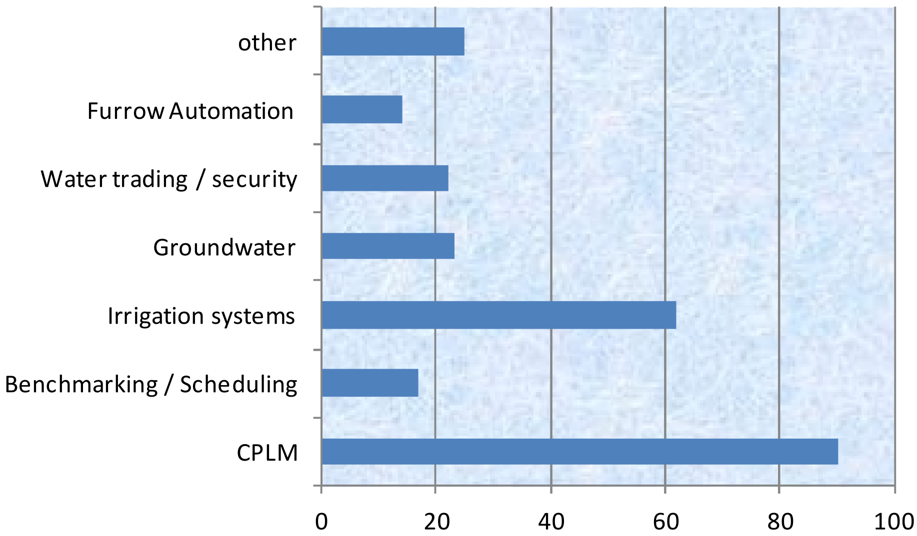
(1) Irrigation water use was benchmarked across 46 irrigated cotton farms and 24 irrigated wheat farms using Watertrack Rapid™. Results were distributed across the industry and will provide a baseline against which future industry gains in WUE can be assessed and individual growers can compare their own performance[11].
(2) Participatory Action Learning activities were undertaken with farm consultants and their clients to demonstrate water efficient technologies and their application on farms.
(3) Consultant mentoring to improve their skills in benchmarking WUE on a property.
(4) Industry round table to identify gaps and revisions required to upgrade the cotton and grains industries best practice manual WATERpak.
(5) Delivery of irrigation training to irrigators and consultants to increase their awareness of irrigation best practice. In total 35 training events were held involving 253 cotton and grain irrigators and 183 consultants, retailers and industry personnel. The most grower attended workshops covered the use of centre pivot and lateral move irrigation technologies (see Figure 3[12]).
(6) Coordinated and / or supported a number of field days and industry forums (24), industry meetings (39), technology demonstrations (4), publications (104) and conferences.

Overall, the aim of the project has been to assist irrigated cotton and grain growers to increase their WUE through adoption of best practice. For many years groups such as the Cotton Research and Development Corporation (CRDC) and the Grains Research and Development Corporation (GRDC) have led and supported state and federal government initiatives to increase WUE in their respective industries. This project was a large component of the extension effort in this area between 2008 and 2011. Feedback from Workshop participants suggests that the training was valuable to them and would lead to practice change on-farm[13].

[10] Project Final Report – page 2.
[11] Consultants did not take up Watertrack Rapid™.
[12] Final Project Report – Appendix 3.

[13] Final Project Report Appendix 4.

FIGURE 3: WORKSHOPS PARTICIPATION BY COTTON AND GRAIN GROWERS: NUMBER



Benefits

The main economic benefit that can be attributed to the project is the increase in WUE realised by growers that have changed practices as a result of their participation in training workshops. Other aspects of the project would support practice change, including increasing skills across farm consultants. Because no feedback has been obtained on the nature of changes made by growers an estimate was made based on past WUE improvements. In the decade up to 2008/09 a 40% improvement in WUE had been achieved across the cotton industry[14]. The baseline gain was therefore taken as a 3.8% annual (cumulative) gain, which equates to a 40% increase over 10 years. Using the average water use for irrigated cereals and cotton in 2009/10 of 3.8 ML per ha[15], this is equivalent to a 0.15 ML per ha gain in WUE each year. A range of factors would have contributed to this gain, and a 50% contribution from industry groups such as DPI was assumed[16].

The use of an average annual WUE gain understates the level of change for an individual farm as gains will tend to be much higher, but only achieved periodically rather than each year. For

[14] Project Final Report – page 40.

[15] Based on ABS Water Accounts Australia 2009/10 (Cat. 4610). Cotton water use was 5.6 ML per ha and cereals was 2.6 ML per ha.

[16] This was based on BDA Group's 2007 An Economic Analysis of Investment in Research to Improve Water Use Efficiency on Farms using Existing and New Infrastructure, New Tool and Technologies, report submitted to the Council of Rural Research and Development Corporations – prepared for the CRDC.

example, Hood and Hare (2009)[17] report savings from take up of best practice recommendations of between 0.13 ML and 0.7 ML per ha depending on the type of improvement made with pay back periods of less than 1 year. The value of a 1 ML water saving was estimated at $200[18].

The structure of the irrigated cotton and grain industry in NSW and Queensland is described in Table 3. Of the reported 521 cotton businesses operating in 2009/10 78% were irrigated, with an average of 376 ha under production. Of the reported 1,989 cereal growers operating in cotton growing areas only 10% were irrigated, with an average of 512 ha under production. Total water use was estimated at 1,368 ML[19] across 794 cotton and cereal farms with, on average 496 ha under irrigated production.

TABLE 3: COTTON AND CEREAL INDUSTRY STRUCTURE: 2009/10

State	Cotton		Cereal	
	Area ('000 ha)	Businesses	Area ('000 ha)	Businesses
NSW	109	234	1,220	1,968
QLD	87	287	769	1,915
total	196	521	1,989	3,883
irrigated	78%	407	10%	387

Source: ABS Water Account Australia 2009/10 (cat 4160) and ABS Agricultural Commodities Australia 2009/10 (cat 7121).

The NPSI II project involved 253 cotton and grain growers that attended 35 workshops as well as 183 farm consultants or other industry members. Benefits will be generated from cotton and grain growers making changes as a result of their participation at the workshops as well as those growers making changes from recommendations made by farm consultants. For the purpose of this study it was assumed that 253 irrigators have made changes, or nearly 32% of all irrigators. It was recognised that some irrigators may have attended two or more workshops, but this is likely

17 Hood, S. & Hare, J. 2009 Saving irrigation water, the environment and money, The Australian Cotton Grower, April - May 2009. NPSII II case study subject Robert Holmes, cotton consultant, also suggested that WUE gains could be achieved with minimal costs once major irrigation infrastructure was in place (March 2011).

18 Based on BDA Group (2007) evaluation of highly successful CRDC investments. The capital cost of water is around $1,500 per ML or $200 on an annualised basis.

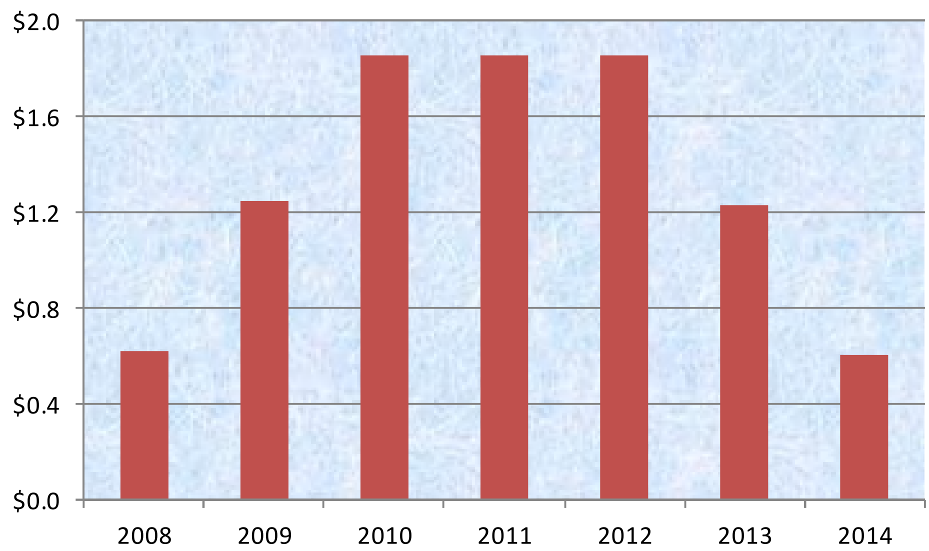
19 Derived from ABS Water Account Australia 2009 /10 Cat. 4610 where average annual water use across cereal and cotton farms from 2008/09 to 2009/10 was 3.9 ML per ha.

to be more than offset by irrigators who have made changes as a result of advice received from their farm consultants[20].

The counterfactual was considered in terms of how long it would otherwise have taken other parties to extend best practice knowledge and practice to industry. Extension work for irrigated cotton and grains has had a history of industry support for agencies such as the state departments of Agriculture and the CRC to develop best practice material and make it available to industry. The extension work through NPSI II was substantial, but involved increasing irrigator and farm consultant skills in irrigation best practice. Without NPSI support it is likely that work would have progressed in this area but at a much slower rate due to funding limitations, however a faster rate than that typically used for the extension of specific technologies is appropriate here as irrigation best practice involves a detailed understanding of a number of different technologies and the use of monitoring and scheduling irrigation events which can vary from farm to farm. A 5 year lag was assumed[21].

Total benefits (in present value terms) were estimated at $7.6m. Estimated annual benefits are shown in Figure 4.

FIGURE 4: ESTIMATED PROJECT BENEFITS THROUGH TIME: $M



[20] Janelle Montgomery (June 2012) suggested that farm consultants might have 10 clients and hence the reach of the extension program though farm consultants may indeed be significant and the use of only irrigators attending workshops to estimate benefits might understate the extent of change that has occurred.

[21] In a review of Dairy Australia's Dairy Moving Forward program Malcolm, B. & Paine, M. (2005, A Social Benefit Cost Analysis of Dairy Moving Forward, A report prepared for Dairy Australia and the Faculty of Land & Food Resources, University of Melbourne, December) argued that a 3 year delay in benefit realisation would be appropriate for extension of single technologies.

4.3 Water Management in Vegetables

This NPSI II project was undertaken by vegetablesWA. It was a short term project that started in April 2010 and was completed by December 2011. The primary aim of the project was to extend to the Western Australia vegetable industry the VISS (Vegetable Irrigation Scheduling System) technology that was developed by the Department of Agriculture and Food Western Australia (DAFWA). The VISS technology was designed to improve vegetable growing water use efficiency by better matching irrigation events to the specific needs of crops. VISS is a computer based decision support tool that uses real time weather data and crop factors to calculate both a minimum and maximum recommended daily irrigation requirement for specific vegetable crops.

Grower feedback in the past had indicated that the preferred means of extension was face-to-face and this was a service that could be provided through vegetablesWA. Extension efforts were supported with a series of grower workshops to increase their knowledge of irrigation management which was then followed up with individual farm visits to assist growers implement VISS for their own circumstances. The total cost of the project was $0.13m[22].

NPSI Outcomes

The main aim of the project was to help the WA vegetable industry improve its water use efficiency with a secondary aim of reducing the leaching of nutrients into groundwater systems. Specific outcomes included:

1. Improved vegetable industry irrigation knowledge. A range of information extension activities (including workshops, printed media, and face-to-face meetings) were undertaken with over 278 growers being reached.
2. Increased adoption of VISS. Some 23 growers have adopted the VISS technology and further adoption is expected in the future as continued extension work is undertaken by vegetablesWA.
3. Improved management of groundwater resources. Improved water use efficiency has resulted in more optimal groundwater extractions and reduced leaching of nutrients has been achieved through a reduction in over-watering.
4. Improved water use scheduling efficiency for WA vegetable growers through adoption of VISS.

[22] Information sourced from Project Final Report and WA Grower March 2011.

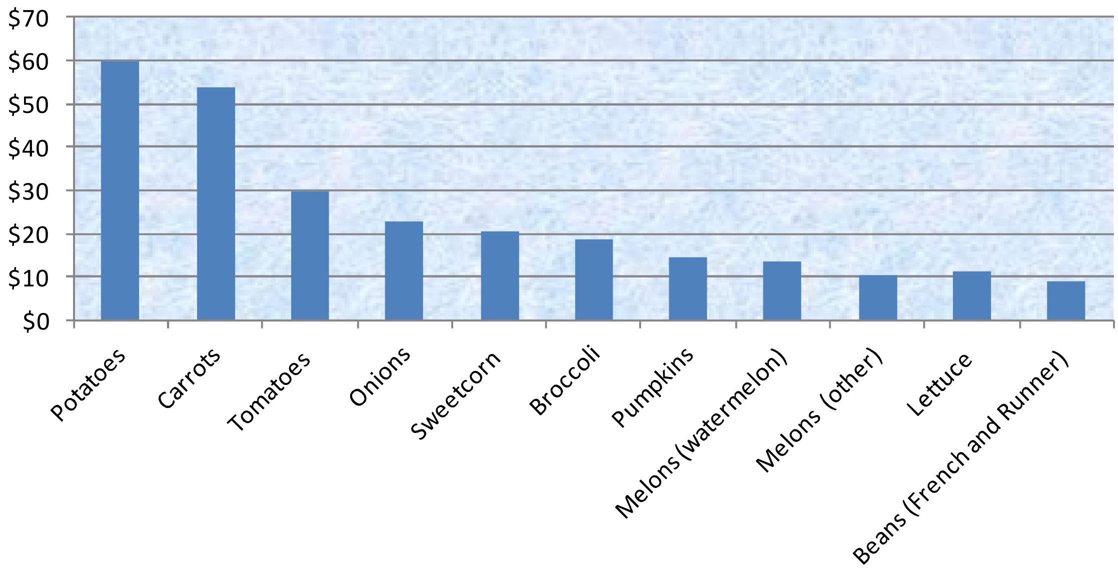
Benefits

This project was assessed as having a major impact. The economic impact can be described in terms of the value of water savings achieved through use of VISS[23]. It would also be expected that environmental benefits might have been realised though reduced leaching of nutrients into groundwater systems. However, the possible volume reduction is unknown, and therefore potential environmental benefits have not been quantified in this report.

The vegetable industry in WA contributes around $341m in terms of value of production. The top 11 crops by value are shown in Figure 5. Potatoes and carrots are the largest, both in value and area planted. The total area planted to vegetables in 2009/10 was 9,203 ha involving 598 businesses (ABS Cat. 7121).

Water used for irrigation will vary from year to year depending on seasonal conditions and the crop being watered. Use of the VISS has delivered water savings of 40% in trials carried out on tomato crops. Estimating the total water saving from use of VISS on a crop by crop basis is difficult as the average water use by crop could not be determined as part of this evaluation. Instead an average level of water use expressed on a per hectare basis was estimating using broad industry water consumption data. Water savings of up to 40% were considered in this evaluation[24].

FIGURE 5: VALUE OF VEGETABLE PRODUCTION IN WA: 2008/09: $M (ABS CAT.75030).



[23] The impact of the VISS technology was recognised by industry through the awarding of the prestigious Industry Impact Award at the national awards for excellence to Rohan Prince, the developer of the VISS from the DAFWA. Trials in tomatoes indicated that fertiliser cost savings might also be possible with the use of VISS but further trial work is required to prove this.

[24] Feedback from John Shannon, vegetablesWA, was that the trial proved a current demonstrated maximum..

In WA (2008/09) 58,439 ML were used in vegetable growing[25]. This represents an average of 6.4 ML per ha and hence a 40% water saving would be equivalent to 2.5 ML per ha.

The value of the water saved by using VISS will depend on the avoided pumping costs and the seasonal price of water. The value of saved water was estimated at $92 per ML.

- Pumping costs are estimated at $32 per ML based on pumping costs in the Murrumbidgee irrigation area[26].
- There is no seasonal price for water in WA, because water rights are not transferable. However, the water would still have an implicit value, given by the opportunity cost of the water in other enterprises. This value was estimated using average temporary water prices in the Murrumbidgee irrigation area (which was assumed to be more similar to WA irrigation conditions than other areas in the Murray Darling Basin). The long term average water price in seasons with an average allocation level and average rainfall was estimated at $60 per ML[27].

A total of 23 growers have taken up the VISS technology through activities funded by NPSI. While these growers only account for 4% of all WA vegetable growers they account for 20% of the area (1,840 ha) under vegetables[28]. On this basis, their average water use saving would be 200 ML a year with a corresponding saving of $18,400. The combined annual value of water saved across the 23 growers would be $423,200.

The counterfactual was considered in terms of how long it would otherwise have taken other parties to develop technologies delivering similar outcomes. The NPSI funded extension involved considerable work with individual famers which could be provided by private agents once they had built up their capability. The VISS technology was already available through DAFWA and the technology would have ultimately been delivered to industry through other channels. This is evident by the fact that further extension investment is planned by vegetablesWA. A 4 year lag was assumed[29].

[25] ABS Water Account Australia (Cat 4161).

[26] These costs were sourced from NSW DPI vegetable gross margins for 2009.

[27] These prices were derived from data provided to BDA Group as part of the evaluation of different trading portfolios for the Riverbank fund.

[28] Project Final Report.

[29] In a review of Dairy Australia's Dairy Moving Forward program Malcolm, B. & Paine, M. (2005, A Social Benefit Cost Analysis of Dairy Moving Forward, A report prepared for Dairy Australia and the Faculty of Land & Food Resources, University of Melbourne, December) argued that a 3 year delay in benefit realisation would be appropriate for extension type activities. The use of a slightly longer lag is reasonable for NPSI's contribution in this evaluation because the use of VISS requires a lot of knowledge to tailor it for individual grower circumstances.

Consideration also needs to be given to the increase in adoption of VISS in the future from the planned vegetableWA investment. For the purpose of this evaluation it was assumed that an annual investment of $50k would be made (based on funds contributed to the NPSI II project) and that 10 additional growers would take up VISS each year, each with 16 ha under vegetable production (the state average)[30].

In Table 4 the estimated annual benefits attributable to the NPSI II investment is detailed. Total benefits were estimated at $2.7m in present value terms[31].

TABLE 4: ESTIMATED PROJECT BENEFITS THROUGH TIME ATTRIBUTED TO NPSI INVESTMENT

Year	Total Area with NPSI II (ha)	Total Area without NPSI II (ha)	Area Attributed to NPSI II (ha)	Total Benefit ($m)
2011				
2012	1,840	0	1,840	$423,200
2013	2,000	0	2,000	$460,000
2014	2,160	0	2,160	$496,800
2015	2,320	0	2,320	$533,600
2016	2,480	1,840	640	$147,200
2017	2,640	2,000	640	$147,200
2018	2,800	2,160	640	$147,200
2019	2,960	2,320	640	$147,200
2020	3,120	2,480	640	$147,200
2021	3,280	2,640	640	$147,200
2022	3,440	2,800	640	$147,200
2023	3,600	2,960	640	$147,200
2024	3,760	3,120	640	$147,200
2025	3,920	3,280	640	$147,200
2026	4,080	3,440	640	$147,200
2027	4,240	3,600	640	$147,200
2028	4,400	3,760	640	$147,200
2029	4,560	3,920	640	$147,200
2030	4,720	4,080	640	$147,200

4.4 Aerated Irrigation Water in Horticulture

This NPSI II project was undertaken by researchers at Central Queensland University (CQU). It commenced in October 2008 and was completed in May 2012. It was known that plant roots and soil microbes require oxygen for respiration and that a problem with drip and subsurface drip irrigation systems was that soil oxygen is depleted around the emitters, often leading to sub-

[30] The Western Australian government has recently announced that it will support the development of VISS for other irrigated crops and provided some extension funding.

[31] Based on a 5% discount rate.

optimal plant growth. Aeration of the irrigation stream using a drip system is possible and is called oxygation. Being a recent innovation and one that offered the potential to increase the performance of drip irrigation systems in Australia, CQU researchers sought to increase the scientific understanding of the commercial benefits of oxygation techniques across a range of irrigated crops in Australia. Commercial oxygation systems are available and many growers have been experimenting with these systems[32].

NPSI Outcomes

The R&D largely involved field trials using commercially available oxygation equipment to assess the performance of different oxygation treatments across a number of irrigated industries. Preliminary crop information from the trials included:

- Pineapples - effects were notable with a 6% increase in crop yields.
- Cotton - higher yields were recorded (14%) in whole plots and sample harvest. Data has been collected over 7 seasons with yield impacts varying from year to year.
- Capsicum - yield increase of 4% with Mazzei air injector and small difference with oxycrop method.
- Lucerne - there were no significant yield benefits but water savings were realised (10%).
- Figs - plant biomass was increased but trial was affected by 2011 flooding.
- Grapes - one grape trial was terminated and the other suffered from wet weather, although a 5% increase in yield was recorded.
- Apricots - trial is still underway with first harvest data expected to be available in December this year.
- Winter vegetables – year one crop had a 4% increase in yield and the second year crop had no recording as it was exposed to wet weather.
- Sugarcane – trial works will continue past the NPSI II project.
- Watermelon – trial suffered from wet weather and is being rerun for the current crop.
- Chilli pepper – installed late in crop season with trial continuing.
- Strawberry – yield gain was recorded.
- Smart lawn – being a wet year there was low supplementary irrigation and the trial will continue.
- Tomato - new trial planned for 2012.

[32] Details were sourced from the Projects Final Report.

Benefits

The project has resulted in increased knowledge on the operation and commercial benefits from using oxygation systems in irrigated agricultural industries that employ drip irrigation methods for both the scientific community and industry to assist them in decisions regarding the adoption and use of oxygation technologies.

The Centre for Plant and Water Science (CPWS) at CQU, Australia has established itself as a key centre in oxygation research. Outcomes of the NPSI II project will support on-going research aimed at improving the efficiency and application of oxygation delivery systems in Australia.

Apart from increasing scientific knowledge about the role of soil oxygen in drip irrigation systems, project outcomes are also targeted at commercial growers, crop consultants, irrigation business and industries. These people have been engaged through project activities and project outcomes have been extended through a range of refereed international journals and industry magazines.

On-going R&D will be undertaken through CQU in collaboration with multi-disciplinary teams to support Australian irrigated industries to maximise potential benefits from available oxygation technologies.

4.5 Soil Management

This NPSI II project was undertaken by Soils Research Pty Ltd in partnership with CSIRO and industry. The project was funded under NPSI II second round of calls for project funding. It was well known that Australian soils deteriorate rapidly under irrigation, impacting crop yields and decreasing WUE. There have been significant changes in orchard soil management over the past 50 years and it was envisaged that the next phase would be a move to “super soils[33]” with yields two to three times that currently obtained in orchards. To achieve this, new systems of soil preparation and management in irrigated orchards were investigated that increase the level of stable soil organic matter through the incorporation of rhizosheaths formed on ryegrass roots. The project commenced in July 2008 and was concluded in May 2011 with a total investment of $0.44m.

NPSI Outcomes

The project involved the setting up of field trials (plots) and pot experiments with a variety of treatments to identify what treatments might change the typical Australian soil into a super soil. The major outcomes for the project include:

---

[33] This is a term used to describe the highly productive soils in California and the Yangtze delta.

- Demonstration that soil structure and irrigation penetration can be improved by following many of the best practice recommendations developed by Dr Cockcroft[34]. Links to research being carried out privately by orchardist have been established.
- Professor McCully and Dr Watt (CSIRO) have shown that the soil in the rhizosheath has a high amount of very fine grass roots as well as fungi, bacteria and other microbes. Together with a high level of organic matter and carbon turnover these soils are stable and have excellent soil structure.
- It is anticipated that from the range of plot and pot experiments carried out that a number will produce super soils, and if so, further research will be undertaken to better understand their formation and impact on orchard production.
- Simple trials in orchards have been established using best practice fertilser, irrigation, lime, gypsum and rye grass treatments. Soils will continue to measured for the degree of coalescence into the future.

Benefits

The key benefit of this project is the coordination that it brought to soil research in understanding the role of rhizosheaths (from rye grass) in improving soil condition. Research was not confined to organisations such as CSIRO, but involved many orchardists who were attempting to improve the condition of the soil on their orchards by following many of the practices advocated by Dr Cockcroft prior to the NPSI II project. These practices included the use of ryegrass, capillary irrigation, organic matter, reaggresing and lime and avoiding practices such as traffic compaction, clay contamination, powdering, use of ex-cropping or ex-pasture soil and poor drainage systems[35].

The value of coordinating soil research through the NPSI II project was recognised at the commencement of project where target outcomes sought were supported by the Canned Fruit Industry Council of Australia; forty leading fruit growers and tomato growers; board members of Australia's most prominent dairy processing companies; several leading dairy farmers and scientists at CSIRO Plant Industry, CSIRO Land and Water, Waite Agricultural Research Institute and Melbourne University's Faculty of Land and Environment[36].

[34] NPSI II Case Study on James Cornish's orchards in the Murray Valley, April 2011.
[35] NPSI 2007, Review of Dr Bruce Cockcroft's Work for Australian Irrigated Horticulture, R.S. Murray, April.
[36] Project Application 2008.

5. INVESTMENT PAYOFF

In this section the estimated pay off on the total investment in NPSI II is reported. The pay off on the NPSI II investment is based on a comparison of the total cost against the benefits generated from three projects that were deemed to have had a demonstrable industry impact that was able to be quantified. The pay off reported here is a minimum because many of the projects supported by NPSI II are likely to, with further investment by different agencies, deliver new technologies relevant to the productivity of Australian irrigated agriculture in the future. It should also be recognised that potential environmental benefits from reduced nutrient leaching in irrigated soils and practices to reduce soil salinisation were not able to be quantified from research outcomes achieved. Further, a key aim of the NPSI II program was to provide leadership and R&D coordination across R&D agencies more broadly, and these benefits have not been quantified in economic terms.

The economic pay off from NPSI II is reported in Table 5. It was estimated that the investment will deliver at least $13.7m (present value terms) to the Australian economy and represents a positive pay off on funds invested. The net present value was estimated at $4.6m which represents a return of $1.50 on every dollar invested in NPSI II. If benefits are only compared against the cost of projects that have delivered an economic benefit (21% of total costs) the return would be $7.20 for every dollar invested in these projects.

TABLE 5: ESTIMATED ECONOMIC PAY OFF FROM NPSI II

Measure	Value
Present Value of Benefits	$13.7m
Present Value of Costs	$9.1m
Net Present Value	$4.6m
Benefit Cost Ratio	1.5

ATTACHMENT – OUTCOME SUMMARY

Attachment Table 1: OUTPUTS AND OUTCOMES OF NPSI PROJECTS

Project	Outputs	Industry Outcomes	Outcome
ABARE	Research paper reporting result of an economic analysis of different water storage polices including current centralised systems, carry over systems and capacity sharing systems	No direct industry impact Analysis will support further economic and policy work in management of water storages.	Knowledge
CIF5121	Project has provided trial results on new vineyard floor management to reduce salt in grapes when using supplementary saline irrigation. Trend analysis for soil decline and salinity levels in soils and fruit. Developed a model of root zone salinisation and assessed salinity tolerance in rootstock.	No direct industry impact at this stage. It was found that re-distributing rain falling on the mid-row to under vine areas reduced root zone salinity. Further work is proposed to determine the viability of potential strategies. The work has increased scientific knowledge and improved models. One winery interested in piloting techniques developed to recycle saline water.	Knowledge
POL5067	Evaluated three different ultra thin chemical films (monolayers) effect on reducing evaporation from water storages Field trials of films in VIC, NSW & QLD	Films demonstrated ability to reduce evaporation. Large scale field trials have been carried out at St George and if successful further commercialisation investment required. No direct industry impact at this stage. Increased scientific knowledge.	Efficiency Dividend
CSE5029	Study of potential biodiversity impacts from changes in future farming practices and water management.	Recommended regional management should focus on areas of remnant vegetation. Possible changes in irrigation practices might impact how black box woodlands could be managed with surface flooding. No direct industry impact. Increased scientific knowledge to support future water management decisions	Knowledge

WVG1001	This investment was largely extension of irrigation scheduling methods for vegetable production in WA. Face to face meetings were held with 278 growers who received information relevant to their operations. 23 growers adopted the VISS system and were supported until they could use the system themselves.	Investment has had an industry impact. 278 vegetable growers have received information valuable to their operations and 23 growers have achieved water use savings through better irrigation scheduling.	Economic
NPSI6089 (GMW5034)	Field trials of monolayer products for reducing evaporation in irrigation channels. Undertook a cost comparison of different covers (capital cost only)	Identified need for further field trials, especially to look at methods to allow film product to move through submerged irrigation culverts. Information provided to support further work and possible commercialisation of technology.	Efficiency Dividend
CIF5032	Brought together information on dam management and updated a number of tools, such as the ready reckoner to assess costs and benefits of different dam management strategies. Extended information to farmers through workshops, field days and other communication media.	Increase rate of adoption of technologies (including monitoring evaporation and seepage) to reduce losses from farm dams.	Economic
GHD5207	Desk and field studies at Wilyabrup and Smith Creek WA) to better understand the nature of surface and ground water interactions. Provided a detailed report on linkage between surface and ground water and implications of harvesting ground water on base flows.	Increased scientific understanding of interactions between surface and ground water flows. Recommended that in fractured rock environments licences for surface and ground water be combined or considered as one resource. This would streamline processing as well as enabling the total resource to be better managed.	Knowledge
UAD25	Assessed the impact of poor soil structure on water uptake. Identified strategies to improve water use efficiency in areas of poor soil structure.	Problem is in knowing soil structure. In existing vineyards unlikely to get cost effective improvement, but can use strategies such as mulching and cover cops to improve WUE. In new vineyards with poor soil structure requires additional 1-2 years of work before planting to improve. Principles of soil management well known across industry. Limited industry impact at this stage.	Knowledge

QPI5161	Carried out scenario analysis on case study farms located in QLD, VIC and NSW to examine different farm based strategies in the face of reduced water availability in the future. For each farm a whole farm model was developed. Assessed the suitability of current risk management tools, including forecasting models and developed new tools that forecast river flows.	Provided irrigators with new insights into risk management under increased water scarcity and volatility in supply volumes (changing mix of rainfed and dryland enterprises). Further development of risk management tools and adoption by irrigators will better prepare the sector for potential climate change impacts. While no major no changes made by industry to date some participating growers have realised profit gains through the monitoring and analysis of moisture levels and better scheduling of irrigation.	Efficiency Dividend
DAN5162	Project involved benchmarking water use efficiency across cotton and grain growers in QLD and NSW. Existing best practice water use documents (WATERpak) were revised and extended to industry and support sectors through a range of different forums including workshops, training days and farm walks.	471 people participated in the various extension programs. These people would place a value on the programs accordingly and use the information to improve the profitability of their operations. The outcomes achieved under this project supported wider endeavours by a number of agencies to improve water use efficiency in grain and cotton enterprises.	Economic
RTS5115	Summary of irrigation research carried out over past two decades and summary of work undertaken through NPSI II, highlighting key findings and to promote wider understanding.	Information available in summary format.	Efficiency Dividend
BRO5191	Interviews were held with personnel in water basins where the UNESCO Health Environment Life Policy (HELP) program has been implemented to assess if it would be suitable for application in the Ord river basin to bring together a range of expertise to facilitate improvements in the management of water resources.	The submission to become a HELP basin was accepted and plans are being developed to obtain accreditation.	Efficiency Dividend
USQ5024	Desk review to summarise the current state of precision irrigation in Australia.	Information to assist potential development of precision irrigation systems in Australia.	Knowledge
SRD8	Funded under NPSI Phase 1		

CIF5033	Investigated using waste (salty) water for irrigation. Developed a prototype machine to measure soil salinity.	Generated scientific knowledge. No industry impact to date but improved soil monitoring technology will assist growers to better manage waste water applications in the future.	Knowledge
SRD 9	Economic analysis of the return on assets from shifting from conventional to open hydroponics for citrus production.	No direct industry impact. Information for growers to help make decisions regarding the viability of open hydroponics in their operations.	Knowledge
Travel Fellowships	Reports on visits / meeting (various)	Increased knowledge	Knowledge
DAN5027	Developed tools and strategies to assist citrus growers using drip irrigation / fertigation. An irrigation scheduling tool "E-Schedule" has been developed and will be further refined and transferred to industry. A fertiliser spreadsheet tool was developed and various extension activities were held with industry members. Long term fertigation trial site was established.	A direct industry impact has been realised. The main impact to date has been a reduction in fertilser costs (although fertigation requires capital investment in tanks). Future water use savings might be achieved with extension of E-Schedule to industry. Growers have also obtained value from information provided at the various extension activities. R&D capacity has been built to support future industry needs.	Economic
UNS5127	A tool was developed to measure water seepage from rivers and streams into groundwater storages.	No direct industry impact. Will increase knowledge and mapping of surface and groundwater interactions.	Efficiency Dividend
SRP5026	Research and extension of strategies to mitigate impacts of coalescence in orchards. Outputs extended work done on soil structure and impact practices such as irrigation and traffic compaction has on reducing soil structure.	Work in this area has been carried out for many years and NPSI II contribution has helped increase awareness among orchardists and use of practices such as planting rye grass between rows, capillary irrigation, reaggresizing and use of lime.	Efficiency Dividend
UCQ5070	Field trials across a number of crops to test potential benefits from oxygenating irrigation water. Results discussed with local and regional NRM groups and industry associations. Decision Support Systems developed including oxygenation calculator, manuals and flyers / factsheets.	Information largely of a scientific nature which will assist in focusing future work and on-going commercial trials. Commercial net benefit needs to be demonstrated. Six new areas of funding have been developed and submitted for funding support.	Knowledge

UCW5208	Information on proposed statutory changes to water law in Western Australia was summarised along with an assessment of the potential impacts of climate change. Information was provided to irrigators at workshops and made available on a CD.	Information will help irrigators to understand legislative changes and enable them to better incorporate proposed changes into their business decisions regarding water use and trading.	Knowledge
Management	Various investments including administration, reporting & planning	Part of NPSI II operation management providing overall leadership in this area.	

Note: The project outcomes that are shaded were selected for a more detailed evaluation.