An Assessment of the Economic, Environmental and Social Impacts of NSW Agriculture's Advisory Programs in Water Use Efficiency

J. Crean, A Shaw, R. Singh, and J. Mullen

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NSW DEPARTMENT OF
PRIMARY INDUSTRIES

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Abstract

An assessment of the economic, environmental and social impacts of extension activities by NSW Agriculture related to water use efficiency is reported. The main vehicle for these extension activities has been a four day vocational course delivered to about 4,400 irrigators under the auspices of the WaterWise on the Farm Initiative (WWF). We focused on four industry/regional complexes – the cotton industry in northern NSW, the lucerne industry in central and northern NSW, the cherry industry and the viticulture industry in southern NSW – where WWF was known to have had an impact. Generally the impact of WWF was to advance the adoption of water use efficient technologies by several years. The investment by NSW Agriculture in year 2002 dollars is likely to be about $19.8m and the benefit-cost ratio is estimated to be 4.5:1

Keywords: Water use efficiency; benefit cost analysis; WaterWise

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We would particularly like to acknowledge the contribution of Stephen Elliott to this Evaluation. Stephen in his position as Coordinator, Irrigation Industry Assistance has managed the WWF Initiative and devoted many hours to assembling the data we required and to providing insights into the course and its impact on irrigated agriculture and into the water reform process more generally.

Executive Summary

This publication reports an assessment of the economic, social and environmental impacts of the former NSW Agriculture's advisory programs in water use efficiency[1]. Since 1998 the principal vehicle for this advisory work has been the WaterWise on the Farm (WWF) Initiative.

Description of WaterWise on the Farm

WWF is an initiative of the former NSW Agriculture's Water Management Subprogram and operates as an extension program as part of the NSW Water Reform Structural Adjustment Program (WRSAP). The WRSAP is an integrated package of extension, education and financial products and services designed to assist NSW irrigators to improve the efficiency of their use of irrigation water to offset the reduction in average long term irrigation extractions arising from the implementation of reforms in regulated and unregulated rivers and groundwater systems.

WWF is an extension program for informing and assisting NSW irrigators to improve the efficiency and effectiveness of irrigation water use, to minimise the negative environmental impacts of irrigation water use, and to improve the sustainability of the irrigated agriculture farm sector. Since 1999 the Water Management Subprogram has received budget enhancements of around $2.8 million annually to deliver WWF.

Through WWF, the Water Management sub-program has developed and delivered introductory vocational based training to just under 4,400 irrigators at June 30, 2003; conducted issue specific field and group events; developed, refined and implemented the statewide irrigation and drainage management planning framework; conducted communication campaigns through electronic and print media; and supported capacity building activities within the irrigation industry.

The core training provided by the WWF Initiative is the four day 'Introduction to Irrigation Management Course' (IIMC) which focuses on planning and implementing best practice irrigation and drainage management on farms. The course aims to promote the concept of Best Irrigation Management Practice (BIMP) and Technologies through "Right Amount - Right Time - Right Place" as an overarching guiding principle in using water. Technical staff also provide ongoing advice about efficient irrigation technologies to those who undertake the course and other irrigators.

Scope of this evaluation

The scope of this evaluation is confined to the extension activities of the Water Management Subprogram, most notably the WWF Initiative, related to greater efficiency in the on-farm use of irrigation water. The evaluation does not consider other aspects of WRSAP including the provision of financial services. In particular, the water reform process in NSW and Australia has an objective of improving river health by diverting some water from irrigated agriculture

[1] This work was done prior to the formation of the NSW Department of Primary Industries (on July 1, 2004) through an amalgamation of NSW Agriculture, NSW Fisheries, State Forests of NSW and the NSW Department of Mineral Resources.

with significant economic, social and environmental benefits and costs. No attempt has been made here to consider the impact of the broader water reform process. Our objective has been to relate the economic, social and environmental benefits from the adoption of water efficient technologies being promoted by WWF and the Water Management Subprogram to the investment by the NSW Government in WWF.

We have evaluated WWF as an extension program attempting to hasten the adoption of technologies and practices related to improving water use efficiency. The economic effects of the WWF initiative include water savings, product yield or quality improvements, and reductions in costs that may arise from the adoption of water management technologies recommended in WWF related activities. We have made some assessment of environmental and social impacts of these productivity gains but this is necessarily qualitative rather than quantitative.

Approach to evaluation

The WWF Initiative has attempted to reach irrigators in many industries across NSW. This was a deliberate choice to ensure that all industries affected, not just the large industries, had access to some assistance in adjusting to change occasioned by the Water Reform process. The promotion of different sets of technologies and best management practices across multiple industries and locations made a comprehensive evaluation of the program difficult. Given limited resources for this evaluation, we decided to focus on those regional/industry complexes where program management felt that WWF had been most effective, in the expectation that the benefits from these selected areas would more than cover the total costs of the Initiative. The complexes selected for evaluation included:

i) Lucerne industry in Central and Northern NSW;

ii) Cotton industry in Northern NSW

iii) Cherry industry around Orange and Young; and

iv) Viticulture industry in Southern NSW

To the extent that we have not attempted to assess the benefits of WWF in other catchments and industries, the evaluation represents a conservative estimate of the value of the Initiative. This evaluation required about 60 days of professional time and our judgment was that little would be served by extending the analysis to other complexes.

In each of the four evaluations, we have characterized the impact of the WWF Initiative as bringing forward the adoption of either new technology or best management practices by a certain number of years rather than influencing the maximum level of adoption. The Lucerne industry case study was the only exception, where the lack of industry structures suggested that WWF would actually increase the maximum level of adoption as well as influencing its rate.

A mixture of technologies and best management practices was evaluated across the case studies. In the case of lucerne and cotton, the WWF Initiative promoted better scheduling of irrigation applications involving more frequent but lower volumes of water which had the effect of reducing groundwater accessions and evaporation whilst reducing yield losses associated with both under and over watering. Better irrigation scheduling is principally a management change although normally some relatively minor infrastructure changes (reducing the length of runs, increasing the size of outlets etc) are also required. In the case of

viticulture, the principal change promoted by WWF involved the conversion from furrow or spray based systems to drip irrigation systems. Changing to more efficient drip irrigation systems reduced crop water use and groundwater accessions whilst also providing yield and quality gains. More efficient water use in the cherry industry involved increasing the number of drippers per tree to allow faster and more targeted irrigation reducing watertable accessions and increasing fruit size.

Economic, social and environmental effects

The economic benefits from WWF were estimated to be approximately $88.0 million (in 2002 dollars), exceeding estimated total expenditure on the Initiative from 1999 to 2005 of $19.8 million (also in 2002 dollars). Hence the net present value from this investment is estimated to be $68.2m, the benefit-cost ratio is 4.45 and the internal rate of return is 49 per cent. Investments by the Initiative in the lucerne and cotton industries generated the greatest benefits in absolute terms. Details of the economic impacts of WWF in the four industries can be found in Table 1.

It should be noted that these economic benefits are shared by irrigators, agribusiness and consumers in the form of increased income and have important social consequences for regional communities. In addition, the skills developed by irrigation communities through the *Waterwise* initiative have added to regional social capital allowing more effective participation in the water reform process and greater capacity to adjust to reduced access to water. These potential benefits of increased social capital were not quantified in this report. The social impacts of the water reform process were considered to be outside the scope of this evaluation.

These estimates of economic impacts also reflect at least some of the on-farm environmental impacts of changes in water use efficiency. Changes in water use were valued at market prices. In addition technologies to improve water use efficiency can have positive environmental outcomes through reduced groundwater accessions and lower levels of irrigation salinity. These impacts were identified but not valued. Improved river health arising from the water reform process was attributed to the broader reform process and was not valued in this report.

Funders and Beneficiaries

The costs of WWF have been primarily met by the NSW Government with a minor contribution from the Australian Government through the Natural Heritage Trust (NHT). The NSW Government contribution has been through the Department's Consolidated Revenue Funds and through a budget enhancement. Irrigators incur opportunity costs in attending the training courses offered but these costs have not been valued in the financial analysis reported here.

Irrigators are clearly the principal beneficiaries of WWF. However, WWF was established to assist irrigators adjust to water reforms. Many of these impacts, primarily reduced access to irrigation water, were imposed early in the reform process whereas benefits accrue as improved practice is implemented. Governments have regularly intervened to assist adjustment processes particularly those arising from changes in government policy. Hence there are legitimate grounds for WWF to be publicly funded even though many of the benefits of increased water use efficiency are captured by irrigators. Funding for the Initiative is scheduled to cease in 2005. Were WWF to continue then industry might be expected to meet a share of the costs unless there are further changes in irrigators' entitlements to water.

Table 1: Summary of key parameters and results across the case study evaluations

	Cotton	Lucerne	Cherries	Grapes
Technology	Scheduling	Scheduling	Modified drip	Drip&Scheduling
Industry Area (ha)	204,200	75,035	900	4,800
Net Benefits: ($/ha)				
Yield	357	137	0	2091
Quality	0	276	519	0
Water Savings	37	-23	100	300
Labour savings	-32	-34	0	293
Establishment costs	-166	-160	-170	-416
Annual Costs	-46	-53	-20	-50
Total Net Benefits:$/ha	*150*	*143*	*429*	*2218*
Adoption				
Year to Max. W/O	2008	2008	2009	2009
Year to Max. With	2007	2008	2004	2004
Max. Adoption W/O	80%	25%	40%	75%
Max. Adoption: With	80%	50%	40%	75%
Program start/end				
Waterwise starts	1999	1999	1999	1999
Waterwise ends	2005	2005	2005	2005
Contribution to benefits ($m)	12.21	61.85	0.29	13.64
Summary results				
PV of Benefits ($m)	$88.0			
PV of Costs ($m)	$19.8			
NPV ($m)	$68.2			
BC Ratio	4.45			
Internal rate of return	49%			

1. Introduction

There has been a long history within the now former NSW Agriculture[2] of evaluating the returns from investment in specific research and development (R&D) projects. These evaluations were often used to support industry funding submissions and focused on the economic benefits from changes in farm productivity.

In 2003 NSW Agriculture began a more systematic process of evaluating the economic, social and environmental impacts of major programs of investment in research, extension and education. Five areas of investment were selected for evaluation of their economic, environmental and social impacts in 2003:

- an assessment of NSW Agriculture's wheat breeding program;
- an assessment of NSW Agriculture's advisory programs in water use efficiency;
- an assessment of net feed efficiency breeding research in beef cattle;
- an assessment of research and extension in conservation farming;
- an assessment of research and extension in annual weeds (*Vulpia*) in pastures.

This report presents the results of one of these initial evaluations conducted in 2003.

NSW Agriculture has been investing about $100m per year in research, extension and education activities making it the largest provider of research and development services within the NSW government sector. The opportunity cost of this investment is the benefit to the people of NSW were these resources used in other areas such as health and education. Hence it is important that NSW Agriculture can demonstrate that it uses these resources in ways that enhance the welfare of the people of NSW.

This suite of evaluations is designed to assess the economic, social and environmental impacts of some key areas of investment by NSW Agriculture. It is anticipated that each year another set of investment areas will be evaluated, so that a significant proportion of the Department's portfolio will be evaluated on a regular basis.

This evaluation process serves a number of purposes. The first is an external requirement for accountability in the way NSW Agriculture uses the scientific resources in its care. This evaluation process can also be used within NSW Agriculture to assist in allocating resources to areas likely to have high payoffs and to assist in designing research and extension projects that have clearly defined objectives consistent with the role of a public institution like NSW Agriculture. Working through this formal benefit cost framework gives those involved – economists, research and advisory officers and program managers - a greater appreciation of the paths by which, and the extent to which, research and extension activities are likely to have an impact at the farm level and hence lead to better projects. Part of this process is a greater understanding of other trends in the industry and of the extent to which "the market" is failing to deliver outcomes sought by the industry or by the community.

We would like to be able to value all economic, environmental and social impacts and relate these to the investments made, but generally we are only successful in valuing some of these impacts because of:

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[2] This work was done prior to the formation of the NSW Department of Primary Industries (on July 1, 2004) through an amalgamation of NSW Agriculture, NSW Fisheries, State Forests of NSW and the NSW Department of Mineral Resources.

- uncertainty about the technology on farm production both now and in the future;
- uncertainty about environmental and social impacts both now and in the future;
- uncertainty about the value of environmental and social resources both now and in the future;
- limited resources to undertake these evaluations.

Our approach has been to first describe qualitatively the economic, social and environmental impacts of the actual or proposed investment. We also describe the rationale for government investment from a market failure viewpoint which seeks to identify the characteristics of the investment resulting in farmers individually or collectively under-investing in the areas under consideration. We examine the share of public and private funding in the investment and compare this to a qualitative assessment of whether the benefits from the investment flow largely to farmers or largely to the community.

We then attempt to quantify as many impacts as practicable to arrive at the common measures of economic performance such as a benefit cost ratio. There are insights to be gained from persevering with an empirical benefit cost analysis even under uncertain scenarios. A key step is to identify not only the expected impact on an industry of the investment, the "with technology" scenario, but just as importantly, how the industry would continue to develop without the investment by NSW Agriculture, the "without technology" scenario. Rarely is the "without technology" scenario a no-change scenario because there are usually other sources of similar technologies leading to ongoing productivity growth. This quantitative approach also gives an indication of the relative importance of key parameters such as the rate and extent of adoption of technology, the on-farm impacts, and the size of the investment and its time path.

In assessing the "with" and "without" technology scenarios, key outputs from research and extension activities and communication strategies used are described to give credence to claims about the contribution of NSW Agriculture and to assumptions about the rate and extent of adoption of the technology.

In the case of water use efficiency, we evaluated extension activities related to greater efficiency in the on-farm use of irrigation water. The key 'instrument' in these activities has been WaterWise on the Farm (WWF) and its four day course. This package of extension activities has been viewed as an element of the Water Reform process delivered by government as part compensation to assist irrigators adjust to the reduction in their access to surface and groundwater flows.

2. Irrigated Agriculture and Water Reforms in NSW

2.1 Irrigated agriculture in NSW

The irrigation sector in NSW relies principally on surface water from regulated rivers and groundwater with smaller volumes of water being used from unregulated streams and farm dams and only small amounts, often on high value production, from potable supplies. Regulated water supplies underpin the majority of irrigated agriculture in the State. There are 16 major dams and other storages on major rivers providing regulated flows in NSW. The combined storage capacity of these storages is over 14 million ML (DLWC, 1999).

The majority of rainfall in NSW occurs on the Great Dividing Range and the narrow coastal plain along the East Coast. Rainfall is lower and more variable to the west of the mountains (400 to 650 mm per annum in the main cropping zone) and evaporation is higher (2,000 to 2,500 mm per annum). As a result, irrigation development has focused on the major inland river systems. Around 80 per cent of total water use occurs in inland NSW and approximately 90 per cent of this is used for irrigation.

NSW has a large and productive irrigation sector growing a mixture of broad-acre crops (rice, cotton and winter cereals), annual and perennial horticulture (grapes and fruit) and pastures to support livestock enterprises. According to data from the Australian Bureau of Statistics, the annual value of irrigated production in NSW in 2000-01 was in excess of $2.7 billion, or 30.7 per cent of the value of total agricultural production in NSW (NSW Irrigators Council, 2003). The irrigation industry in NSW is a major contributor to regional economies in rural NSW and accounts for around a quarter of the total value of irrigated production in Australia.

There are significant variations in the types of enterprises grown across different catchments, differences in the types of irrigation systems used (from surface irrigation to high technology drip systems), wide variations in irrigation demands driven by climatic variability and differing levels of water reliability.

There are also key differences in the nature of irrigated farming systems in the northern and southern parts of the State. Rainfall is winter dominant in southern NSW meaning that summer cropping irrigation demands are reasonably predictable. Reliable irrigation supplies are received from a number of large storages, some of which are supplemented with diversions from the Snowy Mountains Scheme. Irrigation has been long established in these areas and rice is the most significant irrigated crop. Within the Murrumbidgee Irrigation Areas and between Swan Hill and the South Australian border are significant areas of permanent (stone fruit and wine grapes) and annual horticulture (vegetables).

This situation can be contrasted with that of Northern NSW which has summer dominant rainfall, creating variable summer water demands. Irrigation supplies are also much more uncertain in the north of the State because of a lower overall level of river regulation and more variable climatic conditions. These conditions have made water a relatively scarcer resource in northern NSW and have led to higher levels of on-farm investment in water storages and floodplain water harvesting technologies. Cotton is by far the most significant irrigated crop in the region.

Private irrigation development on the NSW tablelands (northern, central and southern) and the coastal sub tropical and temperate areas consists of smaller centres of aggregation (for example, Mudgee, Orange, Batlow, Bega, Sydney Basin), and much less homogeneity in enterprise types within any one area. Coastal and tableland irrigation development produces high valued commodities with water sourced principally from rainfed farm dams, potable supplies, unregulated rivers and streams, and groundwater. Notably, the regulated Hunter River is a significant source of irrigated supplies on coastal NSW.

2.2 NSW Water reforms

Publicly funded irrigation development in NSW became commonplace from the early twentieth century. Irrigation development was closely associated with closer settlement (including soldier settlers) policies which involved the allocation of small agricultural holdings, complete with water supply and drainage facilities, to new settlers. Such irrigation schemes were seen as an appropriate public investment to overcome climatic limitations associated with dryland agricultural production and to populate the inland of the continent, particularly north of the Murray River.

By the late 1960s, however, most of the highest yielding and more cost efficient water storage sites had been utilised. Continuing public investment in irrigation infrastructure came under increasing scrutiny, particularly by economists (Davidson 1969) as schemes failed to recover the full cost of water supply. Subsidised water supplies encouraged inefficient water use which, in turn, led to increasing problems with waterlogging, salinisation, and soil structural decline in major irrigation areas. By the 1980s, questions also started to be raised about the ability of rivers to support further levels of development, as environmental concerns began to emerge (DLWC, 1999).

Water management in NSW has been under constant review since the mid 1980's. Between 1984 and 1995 there were 10 major reports into the NSW water industry. Most of these independent inquiries were established by the Government (DLWC, 1999). These reviews have been complemented by a large number of inquiries undertaken at a Commonwealth level as well as reports undertaken by joint State and Commonwealth institutions including the Murray Darling Basin Commission. The pace of water policy reform increased in the mid 1990's following agreement by the Commonwealth and all state governments to the Council of Australian Governments (COAG) water reform framework. NSW is in the process of implementing this framework which includes fundamental changes to the way in which water is priced, allocated (environmental flows) and traded.

The implementation of many aspects of the COAG framework poses more difficulties for water users in NSW relative to other States. This is because NSW has historically adopted a less conservative approach to the allocation of water resources to foster economic and social development in inland NSW. Many surface and groundwater systems have been over-committed compared to sustainable resource limits (National Land and Water Resources Audit Advisory Council 2001). The over-commitment of water resources has led to environmental degradation and to conflict, not only between irrigators and other sectors of the community but also between different irrigator groups, about who should bear the burden of reduced access to water. Key features of water reforms implemented in NSW include:

- The introduction of a "Cap" on water diversions in the Murray Darling Basin

(which includes most inland rivers in NSW) based on 1993-94 levels of irrigation development;

- The allocation of up to 10 percent of average annual diversions back to the environment in all inland regulated catchments;
- A reduction in irrigator access to low flows in unregulated streams in order to minimise environmental impacts at times of natural environmental stress (low flows are also the time of peak irrigation demand);
- Management of groundwater reserves on a sustainable yield basis to protect users from further declines in groundwater quantity and quality, to ensure the sustainability of groundwater dependant ecosystems and to avoid the possibility of aquifer collapse;
- Water prices have been put on a path towards full cost recovery resulting in price increases across the State;
- Water markets are being further expanded to encourage more efficient use and allow transfer from low to high value uses.
- Public education and consultation about water use and the implementation of water reforms.

The water reform process in NSW developed in three phases. First, the NSW Government initiated institutional reforms to divest itself of the ownership of irrigation assets. Between 1995 and 1998 Government owned irrigation districts and areas were privatised or corporatised. These reforms were accompanied by Governmental assistance for the development and implementation of Land & Water Management Plans to address resource sustainability issues associated with rising watertables and increasing salinity and nutrient loads being exported from the irrigation areas.

During the second phase commencing in August 1997, the NSW Government committed itself to an extensive 5 year $117million water reform program which involved legislative and institutional reform, water management planning, community involvement in setting water quality objectives, revision of property rights, introduction of environmental water rights, the introduction of trading rules and provision for structural adjustment services to the irrigated agricultural community.

Critical components of the 1997 reforms were the Government decisions to immediately reduce average long-term irrigation extractions within each of the regulated river valleys; to reduce access for irrigators during low flow periods on unregulated streams; and to define sustainable groundwater extraction limits. Each of these actions imposed costs upon the irrigated farm sector that acted to reduce the availability of extractive water for agricultural production. To reduce the impact of these decisions the Government provided education, extension and financial services to build the industry's capacity to adjust by improving on-farm water use efficiency and agricultural productivity.

NSW Agriculture was given responsibility to deliver the Water Reform Structural Adjustment Program (WRASP) involving some $33.4 million over 5 years. WRSAP consisted of the following three components.

- NSW Agriculture extension-education services (WWF)

- Financial assistance measures funded by NSW for irrigation redevelopment (Irrigated Agricultural Water Use Efficiency Incentive Scheme and the Special Conservation Scheme – Irrigation), and
- Commonwealth exit assistance available through the Commonwealth Advancing Agriculture Australia package.

The NSW Government passed its Water Management Act 2000 and committed itself to the implementation of the new Act, the third phase of reform. During this phase, continued services were deemed to be required to meet the on-going need for adjustment within the irrigated farm sector and the WWF Initiative was extended to 30 June 2005.

2.3 Structural adjustment and water reforms

Some agricultural extension programs facilitate adjustment but few programs have specific roles to play in respect to easing adjustment pressures created by policy change as is the case with WWF. This section provides some background on agricultural adjustment and why government might concern itself with structural adjustment problems. Some understanding of these issues is required when comparing the relative merits of WWF and other more traditional productivity orientated extension programs.

Structural adjustment results from pressure for industries and communities to change the way they behave, the way they do business, their combination of inputs and outputs, the types of activities they undertake, the types of employment opportunities available to community members and community demographics. In a market-based economy, structural change and adjustment are an integral part of the process of economic growth and development.

Australian agriculture, like other industries, faces continuous adjustment pressure from a mixture of market and government related influences including:

- Commodity prices and input costs;
- Seasonal conditions - Australia's natural climate is highly variable with extreme events (droughts and floods) posing adjustment issues for agricultural pursuits;
- Technologies - the adoption of farm technologies has provided both the opportunity and necessity to improve productivity growth and has been underpinned by significant public funded R&D;
- Government policies – a wide range of policies affect the farm sector including market deregulation, micro-economic reform, macro-economic policy, trade policy, land use regulations and taxation policy; and
- Changes in resource quality - a deterioration in the quality of the natural resource base in some regions as well as increasing community awareness of the quality and value of a wide range of natural resources.

While there are a wide variety of adjustment pressures confronting the agricultural sector, there is particular concern about the impact of natural resource management policies on landholders, with water reforms being an example. Treating policy based changes differently from market orientated changes is justified on the basis that policy changes are in effect changes that the community, through its elected representatives, chooses to impose on itself. Market changes on

the other hand (including factors which affect markets like seasonal conditions) are not directly attributable to anyone specifically and are generally accepted as part of the normal operating environment.

In general terms, the provision of government assistance to ease adjustment pressures is based on either efficiency or equity reasons. On **economic efficiency** grounds, the nature of change needs to be considered from the perspective of whether changes go beyond the scope of market participants' autonomous adjustment capacity (the existence of an adjustment problem). At an extreme end, this might involve farmers being trapped in the sector with insufficient resources to remain viable in farming but at the same time being unable or unwilling to leave agriculture. A less extreme case is when the expected rate of adjustment to a particular change is slower than desirable.

Principles for considering assistance on efficiency grounds include:

1. the magnitude and timing of change - is the policy likely to impose significant costs on affected individuals and will it be implemented in the short term?
2. the ability of stakeholders to foresee the change - is the change unexpected or does it break long standing traditions about resource access (where moral rights are strong)?
3. the availability of adjustment options - are there limited adjustment options available for individuals to implement on the basis of their own resources?
4. evidence that inappropriate adjustment may occur in the absence of government intervention

If there is a case on efficiency grounds, will the benefits of government intervention to facilitate adjustment exceed the costs? This involves identifying the impediments to adjustment and how governments could efficiently overcome them. In some instances, an adjustment problem may be recognized but there will also be questions over whether government can effectively address the problem given the wide variety of other adjustment pressures operating at the time.

A case for government assistance can also be mounted on **'equity'** and **'fairness'** grounds. Equity is normally concerned with the distribution of benefits and costs, while fairness is a subjective concept that will mean different things to different people. The case for government assistance because policy change is unfair or inequitable is strengthened when such change:

1. imposes costs on a relatively disadvantaged group of society (i.e. has a regressive distributional effect) or provides large gains to a well advantaged group;
2. involves losses which are concentrated on a minority of individuals, or a particular sector or region and when the broader community is the principal beneficiary;
3. can be directly related to financial losses (a clear linkage exists between a policy change and its effect);
4. does not relate to the removal of a set of privileges or conditions which may have previously imposed costs on the rest of society (eg cross subsidies, externalities) or is in breach of the duty of care principle.

3. NSW Agriculture's WWF Initiative

3.1 Description

WWF is an initiative of NSW Agriculture's Water Management Subprogram. It is an extension program within the NSW Water Reform Structural Adjustment Program (WRSAP). The WRSAP is an integrated package of extension, education and financial products and services designed to provide a sequential pathway that delivers behavioural change outcomes within the irrigated agricultural sector. The overall aims of WRSAP is to assist NSW irrigators to improve the efficiency of their use of irrigation water to offset the reduction in average long term irrigation extractions arising from the implementation of reforms in regulated and unregulated rivers and groundwater systems.

A 1998 Communications Survey revealed that many licensed irrigators did not have any formal training in irrigation management, were unable to define what their current water use efficiency was, and had no clear or consistent understanding of water use efficiency. Few used any objective form of measuring and monitoring plant available water, less than 50% of irrigators belonged to irrigation related organizations or associations, and the diversity of preferred methods for acquiring knowledge, skills and information were as varied as the industry.

WWF is an extension program for informing and assisting NSW irrigators to improve the efficiency and effectiveness of irrigation water use, to minimise the negative environmental impacts of irrigation water use, and to improve the sustainability of the irrigated agriculture farm sector. Through WWF, the Water Management Subprogram has developed and delivered introductory vocational based training, conducted issue specific field and group events, developed, refined and implemented the state-wide irrigation and drainage management planning framework, conducted communication campaigns through electronic and print media and provided support for capacity building activities within the irrigation industry.

The core training provided by the WWF is the four day 'Introduction to Irrigation Management Course' (IIMC) which focuses on planning and implementing best practice irrigation and drainage management on farms. The course aims to promote the concept of Best Irrigation Management Practice (BIMP) and Technologies through "Right Amount - Right Time - Right Place" as an overarching guiding principle in using water. The intent of the course is to provide introductory skills training for owner/managers of irrigated enterprises to assist them in enhancing efficiency of their operations. From August 1998 to 30 June 2003 there have been just under 4,400 irrigators trained in irrigation and drainage management. This has involved the running of some 335 IIMCs across the State. In addition to delivering the course, technical staff also provide ongoing advice about efficient irrigation technologies to those who undertake the course and other irrigators.

Other courses developed to assist irrigators include a two day pump efficiency course and a two day water security options course. In addition to these courses, the WWF Initiative produces a range of information products ranging from static displays to an 'Update' series of newsletters, production of technical information sheets and guidelines such the Irrigation and Drainage Management Guidelines. WWF staff are also involved in a range of activities other than the training course including:

- Participation in field days

- On farm technical advice
- Industry based support programs and group based extension
- Media Campaigns
- Farm based trials
- Facilitating access to financial assistance information
- Publications

A list of publications can be found in an Appendix.

In light of the previous discussion on structural adjustment, it appears that WWF has both efficiency and equity rationales. In respect to efficiency, WWF has an objective of facilitating agricultural industry adjustment to lower water availability arising out of implementation of water reforms in NSW. That is, it attempts to increase the rate of industry adjustment from the old to the new water management regime through improving awareness of water as a finite resource and the need for sustainable development, the knowledge and skills to adopt best irrigation management practices and technologies to achieve a higher level of irrigated water use efficiency and to reduce the irrigation induced negative impacts upon the environment.

There also appears to be some equity rationale for the program. Water reform imposes up front costs on the irrigation sector whilst the environmental benefits are shared generally throughout the community. Given the distribution of these benefits, government may feel obliged to provide assistance to the industry on equity grounds. Indeed, governments have commonly provided assistance packages to wide range of industries when these circumstances exist. It could also be argued that industry assistance given on equity grounds eases the political resistance to reform and facilitates change in the broader public interest. However, in the context of the WWF program, it is not possible to identify what reforms would have been implemented in the absence of the Initiative.

It is also worth noting that one of key elements of the over arching COAG water reform agreement is public education about water use and consultation in implementing the reforms. These are important considerations in evaluating the merits of the WWF program.

3.2 Sources of Funding

The WWF initiative commenced with the procurement by the Water Management Subprogram of National Landcare Program funding and the subsequent recruitment of a State Coordinator WWF. This initial investment commenced on 1 July 1996.

The initiative received further support as part of the Government's water reform agenda, particularly as part of WRSAP. This resulted in a 5-year $8.4 million investment by government via an enhancement to NSW Agriculture for the development and delivery of services from July 1998 to June 2003. WRSAP was instituted to aid farmers to adjust to pressures arising out of the NSW water reforms. These services were badged as WWF. In addition to the enhancement funds, considerable resources from Consolidated Revenue are also used within the Initiative.

The WWF Initiative was further extended and enhanced as part of the 5-year Water Management Act Implementation Budget Enhancement. This funding stream commenced in July 2000 and is due to cease on 30 June 2005. The balance of unspent funds and forecast Treasury commitments from the 1998-2003 program were effectively 'rolled' into this new enhancement. No action was deemed necessary at that time to alter operational activities within the new phase, as program tasks were consistent with the new framework.

3.3 Resources

Overall, the WWF initiative utilises 21 CRF staff and 22 temporary (enhancement) staff providing a range of information, coordination and technical education/extension services to the NSW irrigator community. The overall budget for the Initiative has averaged $2.8 million annually. This is comprised of existing CRF commitments (CRF salaries and operation) averaging $1 million and a government enhancement averaging $1.8 million per annum. Additional funding support has been received by NSW Agriculture from Natural Heritage Trust funds for the specific purpose of conducting water use efficiency benchmarking on focus farms.

The costs of WWF includes the direct costs of employing program staff including Regional Facilitators and the State Coordinator for WWF, Water Use Efficiency Officers, an Education Officer – Irrigation, and a Communication Support unit (media, publications and graphic design). It also includes the costs of Irrigation Officers who have played an important role in extension in water use efficiency and the IIMC more specifically. Expenditure on this group amounts to about $2.8m per year covering salary and operating expenses. We have excluded the costs of the Water Use Efficiency Unit in Dubbo as it has been largely involved in other work. Other staff within NSW Agriculture such as District Agronomists in irrigation areas have no doubt reinforced the extension program related to water use efficiency (WUE) but we have not placed a cost on these activities partly because they are performed in course of their normal activities.

Details of the annual costs of the WWF Initiative can be found in Table 2.Costs prior to 2002 were inflated to 2002 dollars using the GDP deflator. To allow costs to be summed across years, costs prior to 2002 were compounded forward and those after 2002 discounted back at a rate of 4 percent. Hence the cost of the Initiative from 1998 to 2005 in year 2002 dollars was estimated to be $19.8m. Similar adjustments were made to revenue streams so that all costs and benefits were expressed in year 2002 dollars.

The capacity of the WWF initiative to deliver services and products up to 30 June 2005 is likely to be increasingly influenced by the impending loss of government enhancement support. Beyond 2005, under present CRF support, the delivery of products and services will be severely reduced. In view of the changing support for funding water reform structural adjustment programs, growing emphasis by governments on the use of market based instruments and the establishment of Catchment Management Authorities to achieve natural resources outcomes, restructuring the WWF requires further consideration.

Table 2: Investment in WWF Initiative

	$,000 nominal	$,000 real	$,000 compound
1999	2,250	2,464	2,772
2000	2,418	2,593	2,804
2001	2,700	2,768	2,878
2002	2,943	2,943	2,943
2003	3,024	3,024	2,908
2004	3,024	3,024	2,796
2005	3,024	3,024	2,688
	Total		19,789

4. Approach to the Evaluation of WWF

4.1 Scope

Our approach has been to regard the WWF Initiative as an extension program implemented by government to assist adjustment by irrigators to the water reform process. As such the gains to irrigators from the adoption of more efficient water use technologies are coincident with the benefits to society from an advance in the rate at which resources shift to more efficient uses, the gains from an assistance program. Hence it seems reasonable to evaluate the WWF Initiative as part of the advisory activities of the Water Management Subprogram using an approach that one would use to evaluate standard extension programs.

The scope of this evaluation is confined to the extension activities of the Water Management Subprogram, most notably the WWF Initiative, and is related to achieving greater efficiency in the on-farm use of irrigation water. The evaluation does not consider other aspects of WRSAP including the provision of financial services. In particular, while the water reform process in NSW and Australia has an objective of improving river health by diverting some water from irrigated agriculture with significant economic, social and environmental benefits and costs, no attempt has been made here to consider the impact of the broader water reform process. Our objective has been to relate the economic, social and environmental benefits from the adoption of water efficient technologies being promoted by WWF and the Water Management Subprogram to the investment by the NSW Government in WWF.

The economic effects of the WWF initiative include water savings, product yield or quality improvements, and reductions in costs that may arise from the adoption of water management technologies recommended in WWF related activities. These farm level productivity gains are then aggregated to an industry or regional level requiring judgments about the extent of the industry to which the technology is applicable and the speed at which the technology is taken up.

These economic benefits may have important social consequences as they are shared by producers, processors and consumers in each of the industry/region complexes. Given the nature of the markets in these industries we expect producers to be able to capture the larger share of the benefits. In addition, an intensive educational program such as WWF may build up the problem solving skills of farmers in a way that benefits themselves and their community (social capital) in tackling other problems related to the water reform process and to change in general.

More efficient use of water promoted by WWF may also have environmental consequences. Change in water use in each of the industry/region complexes was valued at market prices. However improved water efficiency may also reduce accessions to groundwater with consequent implications for salinity. At the same time, improving irrigation efficiency has the potential to reduce return flows to the river and reduce river flow levels if it is not accompanied by any change in property rights. We did not attempt to value these impacts.

Because of WWF's role in structural adjustment, it is perhaps unreasonable to subject the Initiative to an analysis of its economic benefits and costs in isolation of the broader water reform process. The Initiative might be seen as a necessary cost of achieving water reform.

Nevertheless it is instructive to analyse the efficiency with which resources have been used by WWF.

4.2 Case study industries/regions

The WWF Initiative has attempted to reach irrigators in many industries across NSW. The promotion of different sets of technologies and best management practices across multiple industries and locations made a comprehensive evaluation of WWF difficult. To address this, advice was sought from leaders of the Water Management Subprogram about the selection of a number of regional/industry complexes where WWF has been active. The complexes selected for evaluation included the:

i) Lucerne industry in Central and Northern NSW[3];

ii) Cotton industry in Northern NSW

iii) Cherry industry in Central and Southern Tablelands; and

iv) Viticulture industry in Southern NSW

The evaluation focused on areas where WWF has delivered significant benefits and assessed these against the total costs of the Initiative. There will be benefits in other catchments and industries but for reasons explained in section 5.4, often related to the size of the industries, we chose not to attempt to quantify these benefits. Consequently, the evaluation represents a conservative estimate of the value of WWF.

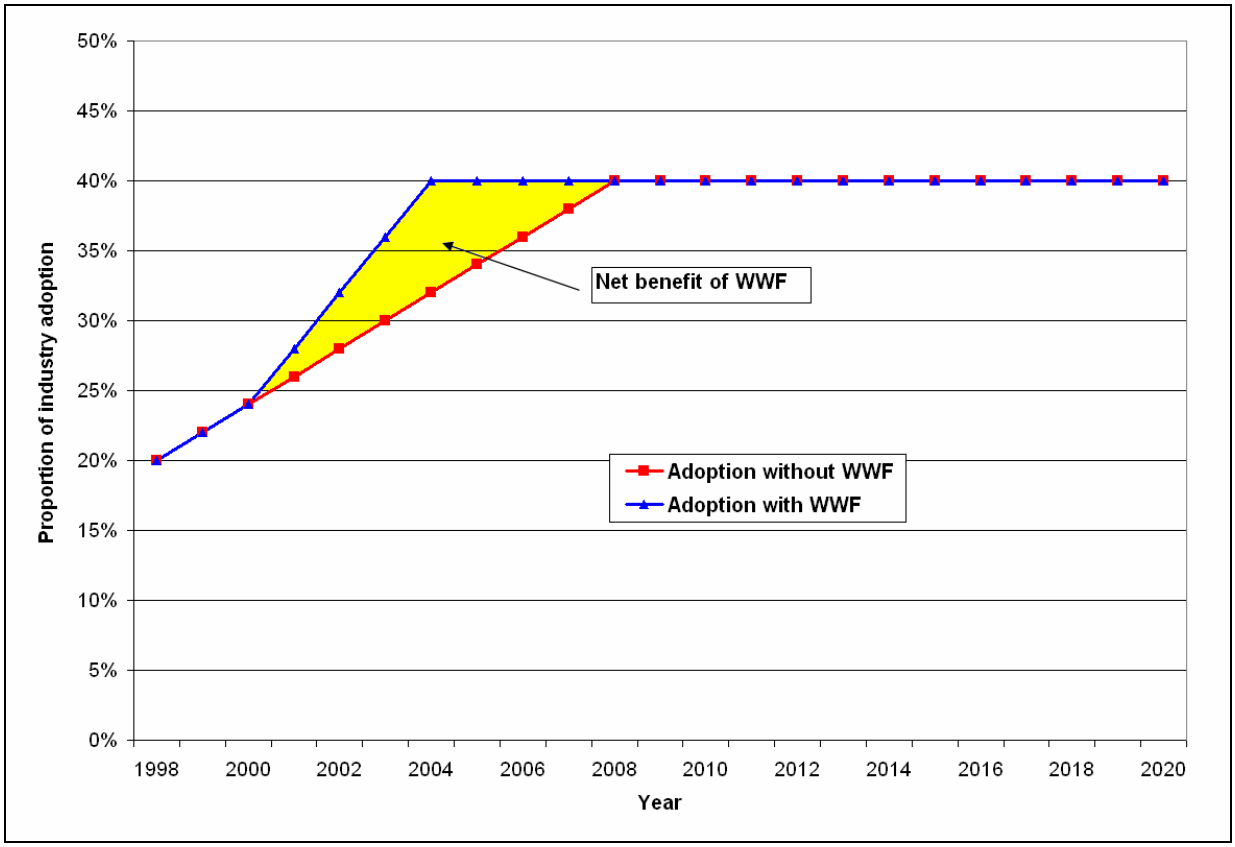
4.3 Defining the 'with' and 'without' WWF scenarios

In each of the evaluations (with the exception of lucerne), we have characterized the impact of the WWF Initiative as bringing forward the adoption of either new technology or best management practices by a certain number of years rather than influencing the maximum level of adoption. That is, our starting point for the case studies has been to assume that the maximum level of adoption of a technology or management practice is the same in the 'with' and 'without' WWF scenarios but that adoption occurs earlier in the 'with' scenario. This approach is illustrated in Figure 1 using hypothetical adoption rates.

This is perhaps a conservative approach and thought needs to be given as to whether an extension program like WWF might result in a higher maximum level of adoption unlike the assumption generally made for less focused programs. It is also possible that irrigators who undertake the course pick up skills that would take them much longer to acquire if ever and hence earn a higher rate of return from the same technologies than those who don't undertake the course. We moved away from the standard approach for the Lucerne industry case study where the lack of industry structures suggested that WWF would actually increase the maximum level of adoption as well as influencing its rate.

[3] The Lachlan Valley is used as a case study region to estimate the impacts of WWF on lucerne production in Central and Northern NSW.

Figure 1: Estimation of benefits from adoption of more efficient technologies and practices



A mixture of technologies and best management practices were evaluated across the case studies. In the case of lucerne and cotton, WWF promoted better scheduling of irrigation applications involving more frequent but lower volumes of water which had the effect of reducing groundwater accessions and evaporation whilst reducing yield losses associated with both under and over watering. Better irrigation scheduling is principally a management change although normally some relatively minor infrastructure changes (reducing the length of runs, increasing the size of outlets, changing nozzle size etc) are also required. In the case of both cherries and viticulture, the principal change promoted by WWF involved the conversion from furrow or spray based systems to drip irrigation systems. Changing to more efficient drip irrigation systems reduced crop water use and groundwater accessions whilst also providing yield and quality gains.

The net benefits (per hectare) of the changes promoted by WWF were estimated using conventional farm budgets to represent the production system pre and post change. Economic benefits valued in the analysis varied across the different case studies but involved either increases in yield and/or product quality, reduced water use and savings in labour costs. The net benefits of the changes were then incorporated into the analysis based on how WWF had been projected to influence adoption of these practices and technologies.

Where water savings do arise from the adoption of irrigation technologies or practices, farmers face a number of choices. One option is to sell any water saved. However, farmers may also choose to use the water in expanding existing or new irrigation enterprises. In the evaluations

below we have valued any water saved at the price it could be sold for. We take this approach for the pragmatic reason that we haven't the resources to model how farmers might use this water on-farm. However the approach is a reasonable one since the opportunity cost of using 'saved' water on-farm is its value in the market to other irrigators.

4.4 Collection of data

The investigation into the impact of WWF on water use efficiency was completed mainly through interviews with people employed under the Initiative. It was very difficult to collect reliable data on water use across industries and catchments and how these may change with the adoption of different technologies and management practices. Many staff contacted in the course of the evaluation were reluctant to provide estimates of how WWF had changed adoption profiles in selected industries. This reluctance may apply more generally to the extension activities of the Department.

The collection of benchmarking data across industries and geographical regions specifically in terms of water usage and crop production under different irrigation systems would be of great assistance in undertaking any further evaluations. Despite some focus by WWF on this area there appears to be little data of this nature currently available.

Following the completion of a draft report on the impact of WWF, some preliminary data became available on the influence of the WWF program on selected agricultural industries. Data were provided by Rural Enablers Pty Ltd who were commissioned to undertake an external review of the Program. As part of this review, a state-wide telephone survey of irrigators was completed to establish if the practice changes made by the respondents had any effect on yield, quality (reflected in product prices) and labour requirements.

The preliminary data from the survey were reviewed for potential application to the defined case studies reported here. With the exception of the lucerne case study, low survey numbers (particularly in the group who did not do the course) precluded the use of the data to revise assumed adoption rates or yield, quality and labour parameters.

In following sections we attempt to identify and value the economic impact of WWF in the four industry complexes.

5. WWF Case Study Evaluations

5.1 Lucerne industry in Central and Northern NSW

The Lachlan Valley is used as a case study region to estimate the impacts of WWF on lucerne production in Central and Northern NSW. The benefits of WWF in the Lachlan catchment are extended to Lucerne production in Central and Northern NSW through the use of state wide survey results on the effect of WWF and statistical data on the extent of lucerne production in selected catchments.

Description of the area/industry

The Lachlan catchment has a diverse range of irrigated crops, from pasture, cereals and oilseeds grown on the alluvial soils of the riverine plain to vegetables, wine grapes and stone fruit grown on the riverine plain and the tableland region. Pasture (summer and winter) and lucerne are the predominant irrigated crops, followed by cereals. Smaller irrigated areas of cherries are grown around Young and wine grapes are grown around Cowra. Cotton is a relatively new crop grown in the lower part of the catchment around Hillston. (Water Use Efficiency Unit, 2003)

There are approximately 72,000 ha of irrigated crops and pasture in the Lachlan catchment. Around 20 per cent of the area (14,500 ha) is under irrigated lucerne production. Lucerne is grown on sandy and clay loam soils. Eighty percent of lucerne is produced using surface irrigation, with spray irrigation being the other major method used. In recent years there has been increasing interest in drip irrigation. (pers. comm. I. Smith, NSW Agriculture) The area of irrigated lucerne in Central and Northern NSW has been estimated from ABS statistics to be 75,000 hectares.

Operation of WWF

The advantages of surface irrigation are low development and operating costs, coupled with a minimal labour requirement. The disadvantage is that unless the soils and slope are compatible with the flow rate and the system type, there will be an inefficient use of water. There is also a high risk of waterlogging and salt accumulation, with high water losses due to evaporation and seepage.

Waterlogging occurs when the soil profile becomes saturated. This causes an oxygen deficiency in the soil which inhibits the plant's ability to absorb nutrients (WWF Training Manual, 2002). Once the soil profile is full, water is lost through either accessions to the watertable with the potential to increase salinity or through evaporation from the field surface. Traditionally, farmers were applying a single large irrigation per lucerne cut. However, too much water was being applied in this single irrigation causing water logging as well as crop water stress outside this irrigation period.

WWF promoted the concept of applying two smaller irrigations per cut. This reduced crop waterlogging during the irrigation period and water wastage through groundwater accessions and evaporation. Yields also improved as the crop was not exposed to periods of water stress or waterlogging. While a greater amount of water is used, irrigators are able to achieve one more cut per season and hence water use efficiency increases. (pers. comm. I. Smith, NSW Agriculture) Emphasis was also given to determining appropriate farm strategies to alter

crop management due to the associated labour costs of increasing the frequency of irrigation[4].

Better irrigation scheduling has sometimes required minor infrastructure changes to the irrigation lay out to improve flow rates across the field. WWF also advocated the adoption of soil moisture monitoring systems to aid with irrigation scheduling decisions. Soil moisture monitoring provides the irrigator with information concerning the moisture levels of the soil, and when crop stress is occurring. With this data, the irrigator can accurately schedule irrigation rather than using guess work.

WWF also runs courses on spray irrigation systems. In the opinion of the irrigation officer, there was limited change in the rate of adoption of spray irrigation systems. In light of this there seems to have been a minimal impact on the adoption rates of technologies more efficient in delivering water than the flood systems used predominantly in lucerne production.

The following NSW Agriculture staff were involved in WWF in the Lachlan Region:

- Mike Robbins, Irrigation Officer, Orange Agricultural Institute
- Richard Etherington, Regional Facilitator, Orange Agricultural Institute
- David Coleman, Water Use Efficiency Officer, Orange Agricultural Institute
- David Wilson, Irrigation Officer, Forbes
- Ian Smith, Irrigation Officer, Forbes
- Megan Rogers, Regional Facilitator, Forbes
- Michael Grabham, Irrigation Officer, Hilston

The WWF Initiative seems to have been highly successful in reaching a large proportion of Lachlan Valley lucerne growers. Just over 1,000 people attended the course and it is estimated that 80% of the attendees were lucerne growers. (pers. comm. I. Smith, NSW Agriculture)

'With' and 'Without' WWF scenarios

The adoption of dual irrigations per lucerne cut increases water usage per hectare by an estimated 7 per cent (an increase from 8.3 to 8.9 ML/ha). However, the improvement in scheduling led to an improvement in product yield and quality. The state-wide survey results for the lucerne industry reported that 45 per cent of WWF participants recorded an improved yield with an average increase reported of 24 per cent. Weighted across participants adopting scheduling, this implies an 11 per cent average improvement in yield. The State wide survey also reported that 63 per cent of WWF participants recorded an improvement in product price (as a consequence of better quality) with an average increase reported of 32 per cent. Weighted across participants adopting scheduling, this implies a 20 per cent average increase in price.

The financial gains of the WWF Initiative were quantified in gross margin terms. The total per hectare net benefits of adoption of these recommended practices was $143/ha. Adoption and production parameters used in the evaluation are given in Table 3.

[4] These techniques included cutting or grazing the stand to reduce crop demand on available soil root zone moisture during periods of low water availability or when labour input costs governed by the irrigation technology (hand shift systems) made increasing irrigation frequency uneconomic.

Table 3: Lucerne case study – adoption and production parameters

	Without WWF	With WWF
Adoption parameters		
Year when max. adoption occurs	2008	2008
Start level of adoption (1999)	10%	10%
Max. adoption level	25%	50%
Annual adoption rate	1.5%	4.0%
Years until max. adoption	10	10
Production parameters		
Yield (t/ha)	8.3	9.2
Price ($/t)	150	180
Water Use (Ml/ha)	8.3	8.9
Water Cost ($/ha)	114	137
Labour Cost ($/ha)	40	74
Gross Margin ($/ha)	303	607
Annual Establishment Cost ($/ha)		160
Net Return ($/ha)	303	447
Net benefits of Change ($/ha)		143

We have not tried to identify who developed this improved scheduling management in lucerne nor when it was developed. The key philosophy of this evaluation is that the contribution of WWF has been to increase the rate of adoption of this management strategy.

Under the 'with WWF' scenario, we have assumed that the maximum level of adoption of scheduling in the lucerne industry will peak at 50 per cent and that this is achieved over a 10 year period. According to the state-wide survey undertaken by Rural Enablers Pty Ltd, 50 per cent of WWF participants involved in the lucerne production indicated that they had either adopted scheduling or were planning to in the future.

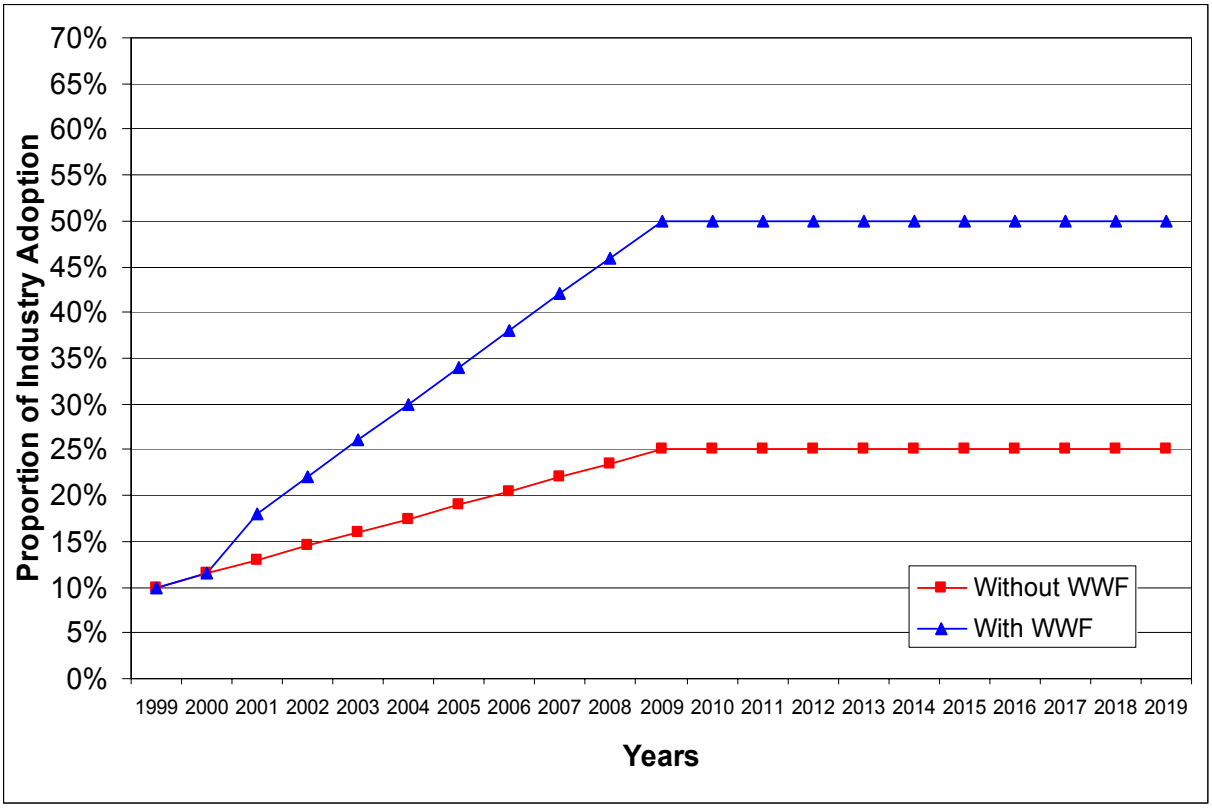
Under the 'without WWF' scenario, we assumed that industry adoption of scheduling scenario would peak at 25 per cent, just half of the maximum rate in the 'with WWF' scenario. Whilst the survey indicated that only 10 per cent of irrigators in the non-participant group indicated current or future adoption of scheduling, we assumed that this rate would increase over time as growers learn about these practices by observing their neighbours, from industry irrigation advisers or from media outlets.

Increasing the rate and level of adoption is the financial benefit from the WWF investment. Details of the adoption profiles 'with' and 'without WWF' are given in graphically in Figure 2. The area between the two adoption profiles represents the benefits from the WWF Initiative. In

any year the benefit is the product of the difference in the level of adoption, the area of lucerne and the gains per hectare from water use efficient technologies and management techniques. The sum of these benefits is derived by discounting the stream of annual benefits to 2020 at a discount rate of 4 percent and summing them.

While WWF began in 1998, there is some lag in adoption related to the development of WWF activities and uptake of improved scheduling practices by farmers. Prior to WWF, the major extension resource available to lucerne farmers focused on irrigation lay-out and design. (pers. comm. I. Smith, NSW Agriculture) This was provided by the Department of Agriculture. There were also some short courses run through the TAFE Outreach program, upon request of farmers. The IIMC course offered through WWF was the first formal program available to farmers which provided training in scheduling and soil/water relationships. Without the WWF Initiative the industry would not reach as high a level of adoption and the annual adoption rate would be slower.

Figure 2: Lucerne - Adoption curves 'with and without' WWF



Economic outcomes

The economic impact of the WWF Initiative has been significant with increases in yield and improvements in quality outweighing increased costs associated with higher overall water use, labour costs and infrastructure costs. The WWF Initiative has had strong demand and filled a gap in formal irrigation training of lucerne irrigators. The Initiative is likely to have played a useful role in facilitating adjustment to much lower water availability in catchments in Central and Northern NSW.

The WWF Initiative in Central and Northern NSW had a net present value of $61.9 million at an industry level (excluding WWF Initiative costs). These economic benefits in the lucerne industry are shared by producers, processors, input suppliers and consumers, some of whom are non-residents of Australia. Generally we assume that Australia is a price taker on world markets and hence few of these benefits flow to overseas consumers and processors. Generally we assume that the distribution and processing sector in Australia is competitive and that the inputs used in these sectors are readily available. Under these circumstances, most of the benefits valued above are retained by lucerne producers.

Social outcomes

These economic benefits have positive social consequences, largely through their contribution to the incomes of farmers and those who handle and process lucerne in regional NSW. Most lucerne growers already have the irrigation infrastructure to be able to adopt these scheduling technologies. Hence the technology seems neutral in its impact, not favouring large growers over small growers.

As already noted an intensive educational program such as WWF may build up the problem solving skills of farmers in a way that benefits themselves and their community (social capital) in tackling other problems related to change. For example as a result of WWF, catchment based irrigation communities were better able to articulate the impacts of water reforms upon their enterprises and communities, the service sector's capacity to provide integrated management planning services consistent with the technical requirements of Irrigation & Drainage Management Planning improved, and representational bodies such as the Irrigation Association of Australia were better able to construct products and services that are consistent with industry awareness, knowledge and capacity to engage in activities which are consistent with WWF and overall water reforms. No attempt was made to value these benefits.

Environmental outcomes

Some environmental impacts will occur on-farm and be reflected in the costs and returns of the producers and hence in the estimate of economic benefits. The increased water use has already been valued. However there may also be environmental outcomes that impact on the broader community. With improved WUE, there will be less waterlogging and in turn reduced accessions to the watertable. This will be beneficial in inhibiting salinity problems in catchments in Central and Northern NSW. There may be broader environmental benefits if WWF is seen as an integral part of the NSW water reforms.

5.2 Northern NSW Cotton Industry

Description of the area/industry

The Northern NSW cotton industry includes the production areas of the Gwydir, Namoi and McIntyre Valleys. The scale of the industry and regions are given in Table 4.

Table 4: Characteristics of the Northern NSW Cotton Industry (2000-01 Statistics)

Catchment	*Cotton Area (ha)*	*Total ML used*	*Avg. ML/Ha*	*Prod' bales*	*Avg. Yield bales/ha*
Namoi	74164	574000	8.25	538113	7.15
Gwyder	90000	49700	8.25	690597	7.67
MacIntyre	40033	49700	8.25	309591	7.73
Sub total	204197	673400	8.25	1538301	7.52

**based on data obtained from irrigation profiles and Cotton Australia.*

Irrigated cotton in northern NSW accounts for 70% of the total area of irrigated cotton in NSW. Other major agricultural industries include grain crops, and sheep and cattle grazing. Cotton is generally grown on the riverine plains in these catchments where the cracking clay soils dominate. Around 95 per cent of cotton is based on furrow irrigation using siphons. (Water Use Efficiency Unit, 2003)

Operation of WWF

The WWF Initiative focused on improving the efficiency of furrow irrigation in cotton rather than the promotion of other systems like drip. The Initiative also focused on tail water return systems. The program team has encouraged irrigators to focus on the precision of their application of water. (pers. comm. S. Bray, NSW Agriculture) The advantages of furrow irrigation are that there are low development and annual operating costs. However, if there is poor slope or incompatible soils, there will be an inefficient use of water and lower yields. (WWF Training Manual, 2002)

The major changes which were being promoted were increased flow rates across the fields, and less water applied per application, with an increased number of applications. Scheduling tools were promoted so growers could determine when and how much water to apply, and so deliver to the root zone exactly what the crop requires. Flow rate measurements were also advocated so growers could minimise run-off from the fields and drainage losses beyond the root zone, thus reducing groundwater accessions and reducing the risk of salinity. Other practices included: (pers. comm. P. Smith, NSW Agriculture)

- Matching soil types to irrigation system design.
- Land forming for improved bay lengths and channel capacity.
- More siphons to increase flow rates onto bays
- Laser levelling to improve the slope of the bay.

While the WWF Initiative advocates the use of soil moisture monitoring there has been no change in the rate of adoption of this practice. Soil moisture monitoring is already common throughout the cotton industry. There is a WWF course component for spray irrigation but it was not a focus in the cotton industry although some large growers have increased their use of this technology.

The following staff were involved in WWF in the cotton industry in Northern NSW:

- Lew Hyson, Technical Assistant, Tamworth
- Raelene Greensleigh, ex-Water Use Efficiency Officer, Gunnedah
- Stuart Bray, Regional Facilitator – WWF, Gunnedah
- Peter Smith, Irrigation Officer, Tamworth

The WWF course has been attended by 128 cotton irrigators, 9 of whom have gone onto complete IDMPs. The courses were held in Bonshaw, Bourke, Croppa Creek, Curlewis, Maules Creek, Moree, Mullaley, Walgett, Wee Waa, Narrabri, and Gunnedah. It is believed that 20% of the attendees have made changes since attending the course in terms of irrigation scheduling changes and minor infrastructure investments in siphons and land forming. (pers. comm. S. Bray, NSW Agriculture)

'With and without' WWF

Water use efficiency is being promoted by several organisations within the cotton industry. Regional staff believe that any improvements in WUE would have largely occurred if there was no WWF Initiative. The principal effect of WWF has been to marginally increase the rate of adoption of these technologies.

The adoption of increased frequency of irrigations by the cotton industry using smaller effective amounts of water is expected to reduce water use by around 10 per cent (a decrease from 8.0 to 7.2 ML/ha) and improve yield by the same amount (an increase from 7.43 to 8.17 bales/ha) (pers. comm. J. Purcell, Aquatech Consulting) The financial gains from WWF were quantified in gross margin terms The total per hectare net benefits of adoption of these recommended practices is $150/ha**.** Changes in key parameters are given in Table 5.

We have not tried to identify who developed this improved scheduling management in cotton nor when it was developed. The key philosophy of this evaluation is to evaluate the contribution of WWF to the rate of adoption of the better management practices rather than their development. Without WWF our assessment is that the maximum level of adoption will peak at 80 per cent and that this will be achieved over a 10 year period. (pers. comm. P. Smith, NSW Agriculture) Cotton irrigators would have learnt about this technology by observing their neighbours, from industry irrigation advisers or from media outlets.

We have assumed that the WWF course and subsequent contact with WWF staff will not effect the maximum level of adoption but will bring forward adoption by 1 year. This may appear to be somewhat conservative but advice from the industry and program staff suggested that adoption of these practices would have occurred at a similar rate had there been no WWF Initiative. The cotton industry itself provides a lot of educational programs for farmers and has a very strong base of service providers. The cotton industry is also supported by the cotton CRC and benefits from substantial investment by Queensland Department of Primary Industries (QDPI). It is this inherent strength of the industry in research, development and education that makes most uncertain the share of benefits that can be attributed to the WWF Initiative. Combining strong industry structures with long term scarcity of water resources in Northern NSW further explains why WWF has only had a limited impact on the adoption of more efficient practices. Details of the adoption profiles with and without WWF are given.

Table 5: Cotton case study – adoption and production parameters.

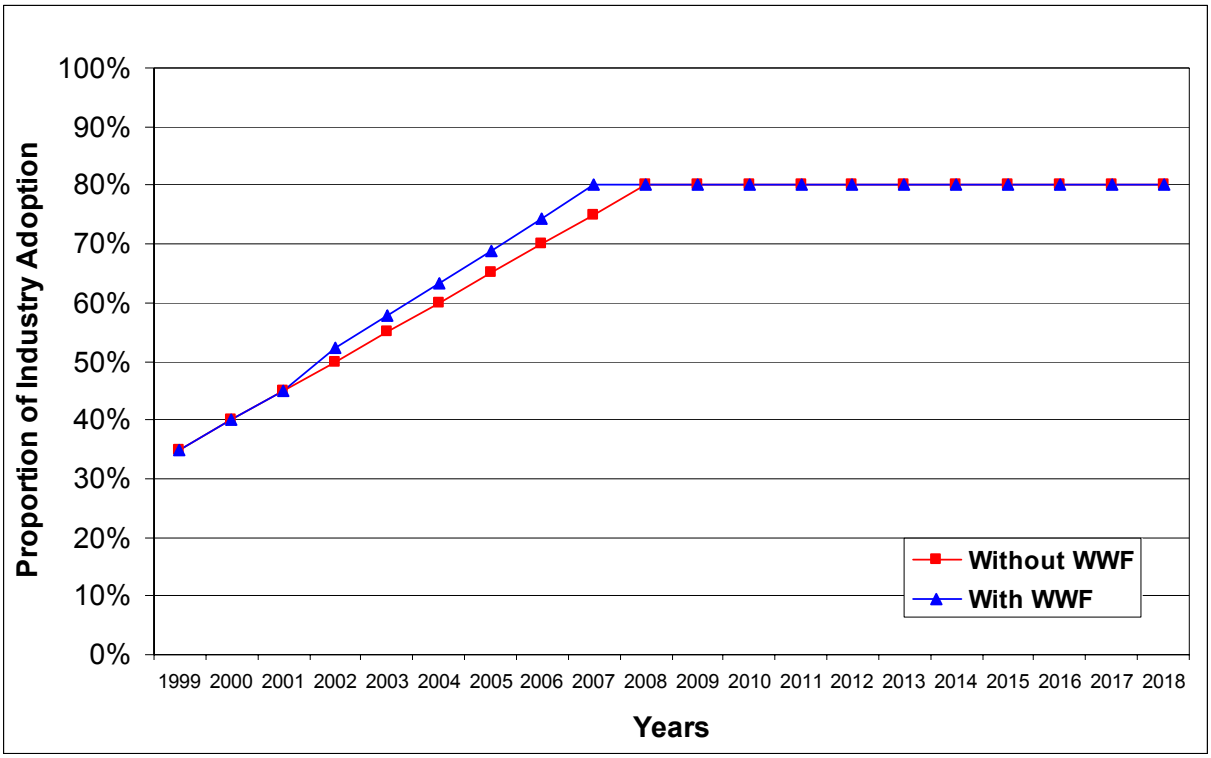
	Without WWF	With WWF
Adoption parameters		
Year when max. adoption occurs	2008	2007
Start level of adoption (1999)	35%	35%
Max. adoption level	80%	80%
Annual adoption rate	8%	9%
Years until max. adoption	10	9
Production parameters		
Yield (bales/ha)	7.43	8.17
Price ($/bales)	480	480
Water Use (Ml/ha)	8	7.2
Water Cost ($/ha)	110	99
Labour Cost ($/ha)	80	112
Gross Margin ($/ha)	998	1,314
Annual Establishment Cost ($/ha)		166
Net Return ($/ha)	998	1,148
Net benefits of Change ($/ha)		150

WWF training was not implemented in cotton areas until 2001-02. On average it took farmers one year to implement the changes so the economic benefits of the WWF Initiative are assumed to not begin until 2003 (pers. comm. P. Smith, NSW Agriculture).

Economic outcomes

The difficulty of attributing a large share of advances in water use efficiency by cotton growers to WWF has already been noted. However due to the sheer size of the industry (204,200 ha), the economic gains from the minor changes in adoption rates attributed to WWF are large. The WWF Initiative has an estimated net present value of $12.21 million at an industry level (excluding WWF Initiative costs).

Figure 3: Cotton - Adoption curves 'with and without' WWF



These economic benefits in the cotton industry are shared by producers, processors, input suppliers and consumers, some of whom are non-residents of Australia. Generally we assume that Australia is a price taker on world markets and hence few of these benefits flow to overseas consumers and processors. Generally we assume that the distribution and processing sector in Australia is competitive and that the inputs used in these sectors are readily available. Under these circumstances, most of the benefits valued above are retained by cotton producers.

Social outcomes

These economic benefits have positive social consequences, largely through their contribution to the incomes of farmers and those who handle and process cotton in regional NSW. Most cotton growers already have the irrigation infrastructure to be able to adopt these scheduling technologies. Hence the technology seems neutral in its impact, not favouring large growers over small growers.

As already noted an intensive educational program such as WWF may build up the problem solving skills of farmers in a way that benefits themselves and their community (social capital) in tackling other problems related to change. The WWF Initiative has created an additional forum for farmers to network and communicate on issues associated with water management. There has been a link formed between the Department of Agriculture, farmers and industry groups which has made some contribution to institutional participation and awareness within the irrigation community

Environmental outcomes

Some environmental impacts will occur on-farm and be reflected in the costs and returns of the producers and hence in the estimate of economic benefits. The water savings have already been valued. However there may also be environmental outcomes that impact on the broader community through lower groundwater accessions and reduced risk of salinity. There may be broader environmental benefits if WWF is seen as an integral part of the NSW water reforms.

5.3 Cherry Industry in Central and Southern Tablelands

Description of the area / industry

NSW produces 50 – 70% of Australia's cherry production with Young and Orange being the main cherry growing districts in the state (Cherries: An Investment Option, 1996).

Cherries are a high value crop. They are suited to areas with cool to cold winters and warm, dry summers with well drained soils. Winter and spring rainfall is usually satisfactory for the early season water requirements of cherry trees but without follow up rains, this soil moisture is depleted by early October. Because of this and the growing of cover crops in the orchards, 80 – 90 percent of farmers have installed drip irrigation systems to meet the irrigation needs of the tree during the latter stages of fruit growth and in the post harvest growth periods (pers. com. M. Robbins, NSW Agriculture).

Some 70 percent of the existing drip irrigation systems have a single drip line with two drippers to a tree. Soil investigations have shown that on lighter soils where the majority of the cherry trees are grown, two emitters per tree do not deliver enough water to the root zone to meet the daily water requirements of the plants. Farmers were applying water for as long as 24 hours per week. The crop was being stressed leading to small fruit because much of the water after 4 hours of irrigation was not used by the trees but was lost into the deeper profile.

Operation of WWF Initiative

The WWF Initiative sought to improve water use efficiency on cherry farms by promoting an improved drip irrigation system that includes two drip lines with drippers every 0.5 metre supplying water to the root zone of each tree via 14 drippers This system increases the root volume receiving water considerably while not altering the hourly volume of 16 litres of water supplied to each tree. It leads to an improvement in quality of the fruit if operated correctly. The improved drip irrigation also helps to save 1ML of irrigation water (pers. com. M. Robbins, NSW Agriculture).

With and without WWF Scenario

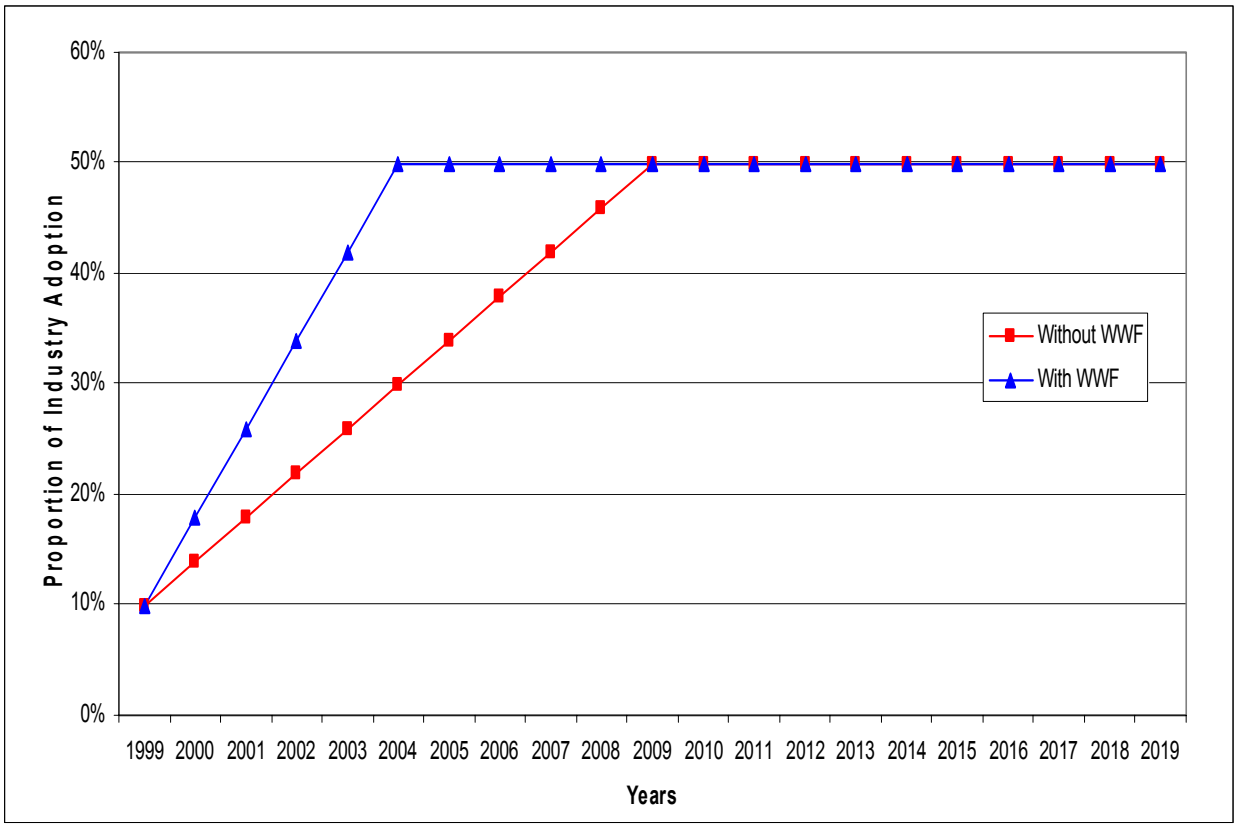
The better irrigation management is expected to lead to a 5% shift of fruit from the small size category to the large size category. Large size fruit (24/26 size) attracts premium prices over small size fruit (22/24 size). The improved irrigation system would also help to save some water. Since farmers are already using a drip irrigation system, there will not be any additional labour savings with the modified drip system. In this evaluation, the financial benefits of WWF are measured in terms of the increased value of fruit production and income from sale of saved water. Key adoption and production parameters are provided in Table 6.

Table 6: Cherry case study – adoption and production parameters

	Without WWF	With WWF
Adoption parameters		
Year when max. adoption occurs	2009	2004
Start level of adoption (1999)	10%	10%
Max. adoption level	50%	50%
Annual adoption rate	4.0%	8.0%
Years until max. adoption	10	5
Production parameters		
Marketable Yield (t/ha)		
Size 22/24	3.10	2.95
Size 24/26	8.90	9.05
Total	12.00	12.00
% Pack-out Yield (t/ha)		
Size 22/24	20.36	9.34
Size 24/26	58.35	69.37
Total	78.71	78.71
Price ($/t)		
Size 22/24	3,066	3,066
Size 24/26	6,427	6,427
Water Use (Ml/ha)	3.50	2.50
Value of Water ($/ha)	350	250
Gross Margin ($/ha)	66,753	67,272
Annual Establishment Cost ($/ha)		170
Net benefits of Change ($/ha)		449

The WWF Initiative began in 1999. Prior to the WWF Initiative, with the support from the extension staff of the NSW Agriculture, 10 percent of the area had already changed to more efficient drip irrigation system. With WWF training, specifically aimed at improving water use efficiency on the cherry farms, the rate of adoption of the technology was advanced. With WWF, 50 percent of the area would be under improved drip irrigation system in five years time i.e. 2004. Without WWF, it would take 10 years to reach the maximum adoption level of 50 percent.

Figure 4: Cherries - Adoption curves 'with and without' WWF



Economic Outcomes

The WWF Initiative, by promoting better irrigation management has lead to an increase in profits from cherry production through improvement in the size of the fruit and some savings in water use. A detailed breakdown of costs and benefits can be found in Table 6. The value of better quality fruit is estimated to be $519/ha with water savings of $100/ha. The annualised capital costs of installing more drippers are about $170 /ha. Hence the net gains from the improved drip system are $449/ha.

It is expected that the level of adoption of the technology will increase from 10% in 1999 to 50% of the industry. This increased level of adoption of 40% is worth $132,902 per year ($449/ha times 296 hectares). The impact of WWF has been to advance the rate of adoption by 5 years as illustrated in Figure 4.

These economic benefits from better quality cherries and water savings are shared within the cherry industry by producers, processors, input suppliers and consumers, some of whom are non-residents of Australia. Generally we assume that Australia is a price taker on world markets and hence few of these benefits flow to overseas consumers and processors. Generally we assume that the distribution and processing sector in Australia is competitive and that the inputs used in these sectors are readily available. Under these circumstances, most of the benefits valued above are retained by cherry producers.

Social outcomes

These economic benefits have positive social consequences, largely through their contribution to the incomes of farmers and those who handle and process cherries in regional NSW. Most cherry growers already have the irrigation infrastructure to be able to adopt this new drip irrigation technology. Hence the technology seems neutral in its impact, not favouring large growers over small growers.

As already noted an intensive educational program such as WWF may build up the problem solving skills of farmers in a way that benefits them and their community (social capital) in tackling other problems related to change. This is likely to apply to the cherry industries in Orange and Young but we have not identified specific instances of increased social capital.

Environmental Outcomes

Some environmental impacts will occur on-farm and be reflected in the costs and returns of the producers and hence in the estimate of economic benefits. The water savings from the improved drip irrigation technology have already been valued. However there may also be environmental outcomes that impact on the broader community from reductions in deep drainage, accessions to the watertable and soil salinity. We have not attempted to estimate and value this reduction in deep drainage.

5.4 Viticulture industry in Southern NSW

Description of the area

Viticulture is one of the most important industries in the Lower Murray and Murrumbidgee Irrigation Area (MIA) of NSW. Three types of viticulture enterprises exist in the area; wine grapes, table grapes and dried fruit. Wine grapes, both red and white, account for 70 percent of the area, dried fruit around 20 percent and table grapes around 10 percent.

There is around 2,800 ha of viticulture in the Lower Murray Land and Water Management Plan area. This area includes the districts of Curlwaa, Coomealla, Gol Gol, Mourquong and Buronga. Another 2,000 ha is under viticulture in the Intensive Irrigation Area (outside the L&WMP area) which includes the districts of Boeill Creek, Ellerslie, Euston, Menindee, Monak, Paringi, Trentham Cliffs, Pomona and all other scattered horticultural properties on Murray and Darling Rivers.

There is around 12,000 ha of viticulture in the MIA. Viticulture accounts for approximately 60 percent of total area under different horticultural industries in the region. More than 90 percent of the total area under viticulture is under wine grapes. The whole industry in the MIA is covered by the MIA L&WMP.

Prior to WWF, furrow irrigation and overhead sprinkler systems were the main irrigation systems on vineyards in the Lower Murray and MIA. Management of furrow irrigation is labour intensive with high fuel and tractor costs. The rate of water infiltration is very high especially on light textured sandy soils, and this leads to problems of rising watertables and soil salinity. Furrows also limit the timeliness of different operations especially application of fertilizers and chemical sprays (J. Giddings, NSW Agriculture, Irrigation Management Manual

Part 2).

Sprinkler systems are considered to be more water efficient than furrow irrigation because irrigation can be matched to crop requirements better than with furrow systems with less water wasted to drainage. Sprinkler systems involve less maintenance and labour costs but have high pumping costs due to high pumping pressure requirements. They also provide better frost control in grapes. Wetting patterns are distorted especially during windy conditions and there are greater levels of disease infection, particularly downy and powdery mildew, under warm and humid conditions.

Operation of WWF Initiative

WWF through its extension and training activities has focussed on the adoption of more efficient irrigation systems and Best Irrigation Management Practices (BIMPs) in viticulture. In particular, in the Lower Murray irrigation areas the focus of efforts has been on encouraging conversion to drip/under-vine sprinkler systems from furrow/overhead irrigation systems accompanied by greater use of irrigation scheduling technologies. Whereas the aim of the program in the MIA was to encourage the growers to shift from the existing furrow irrigation to more efficient drip irrigation along with the adoption of BIMPs.

WWF commenced in 1999 and its impact in the form of the adoption of new technology and BIMPs started in year 2000. As for most of the other case studies evaluated in this report, we have assumed that the impact of the WWF Initiative has been to speed up the rates of adoption of more efficient irrigation technologies.

'With and Without' WWF

Lower Murray Irrigation Area

In the Lower Murray Irrigation area, prior to WWF, 70 percent of the area was under furrow or overhead sprinklers and only 30 percent of the area was under more efficient under-vine sprinklers or drip irrigation (pers. comm. J. Giddings, NSW Agriculture). We estimate that the maximum level of adoption of these more efficient irrigation systems in the future will reach a peak of 75 per cent under both the with and without WWF scenarios. However, we expect WWF to double the rate of adoption so that peak adoption will occur in just 5 years rather than 10. The 45 per cent additional area under more efficient irrigation systems reflects the conversion of 30 percent of the area from furrow and 15 percent of the area from overhead sprinkler systems. Key production and adoption parameters of moving from furrow to drip and from overhead to drip systems in the Lower Murray Irrigation Area are given in Table 7 and Figure 5.

The conversion to drip/under vine sprinkler systems and scheduling technologies from the existing furrow irrigation systems is expected to lead to yield increases of about 13 percent, labour savings of about 35 percent and a 33 percent reduction in the use of irrigation water. The value of the increased yield, reduced labour costs and water savings amount to $2,091/ha, $293/ha, and $300/ha when shifting from furrow irrigation to drip irrigation. The annualised cost of converting from furrow to drip irrigation systems has been estimated to be $416/ha. Annual maintenance costs were estimated to be $50/ha. The annual net gain from this switch in technologies is estimated to be $2,218/ha.

Changing from overhead to drip irrigation in this area would lead to a yield increase of 5 percent, water savings of 17 percent and labour savings of 25 percent. The value of these changes is $836/ha, $111/ha, and $200/ha from yield improvement, water savings and labour savings, respectively. The annualised capital and maintenance costs are estimated to be $300/ha and $50/ha respectively. The net benefit of change in technologies is $797/ha.

Murrumbidgee Irrigation Area

In the MIA, prior to extension and training initiatives, 95 per cent of the viticulture area was under furrow irrigation and just 5 per cent under drip irrigation (pers. comm. I. Quarisa, NSW Agriculture). Significant shifts from furrow to drip irrigation are expected in the MIA as a consequence of the MIA L&WMP's own irrigation training program known as 'FarmWise'. However, 'FarmWise' has been adapted from the WWF program and the staff of the WWF Initiative are involved in providing training for two of the six modules of the FarmWise training program. For the purposes of this analysis we have assumed that 20 percent of the total benefits from the adoption of drip and BIMPs in the MIA can be attributed to the WWF Initiative (pers. comm. I. Quarisa, NSW Agriculture).

To appropriate these benefits, we firstly need to assess the total benefits flowing from adoption of drip systems in the MIA. We estimate that the maximum level of adoption of drip systems in viticulture in the MIA in the future will reach a peak of 50 per cent[5] under both the with and without Farmwise scenarios. However, we expect Farmwise to double the rate of adoption so that peak adoption will occur in just 5 years rather than 10 (see Figure 1). For the purposes of this analysis, the production benefits are assumed to be the same as those estimated for the Lower Murray reported above (a net change of $2,218/ha).

Economic Benefits

The WWF Initiative in the Lower Murray provided extension and training activities to increase the adoption of drip irrigation and water scheduling technologies by all growers including those in the L&WMP area. Therefore we have assumed that all benefits from the adoption of the technologies described above can be attributed to the contributions made by the WWF program.

In the MIA, the L&WMP has its own irrigation training program known as 'FarmWise'. However, the FarmWise course has been adapted from the WWF program. We have attributed 20 percent of the total benefits ($2684/ha) from the adoption of drip and BIMPs to WWF.

In both the Lower Murray and the MIA, WWF and the related Farmwise course, has brought forward the adoption of more efficient under-vine sprinklers or drip irrigation systems. The benefits from switching from furrow and overhead systems to drip were calculated separately. The value of this advance in adoption rate to the viticulture industry of southern NSW is estimated to have a net present value of benefits of $13.64 million (excluding WWF Initiative costs) using a discount rate of 4 percent

[5] In the MIA the adoption of drip irrigation would increase significantly after the main supply channels are converted to underground pipe supply channels by 2010. This would help to ensure regular supply of water and reduce the capital cost of the storage system required for drip irrigation (pers. comm. I. Quarisa, NSW Agriculture).

Table 7: Viticulture case study - adoption and production parameters for the Lower Murray Irrigation Area

		Without WWF	With WWF
Adoption parameters			
Year when max. adoption occurs		2009	2004
Start level of adoption (1999)		30%	30%
Max. adoption level		75%	75%
Annual adoption rate		4.5%	9.0%
Years until max. adoption		10	5
	Furrow	**Overhead**	**Drip**
Production parameters			
Average yield (t/ha)	25.0	26.9	28.2
Water use (Ml/ha)	9.0	8.0	6.0
Labour used for Irrigation (hrs/ha)	65	51	42.5
Gross margins ($/ha)	12,698	13,950	14,790
Benefits from shift to drip			
Productivity benefits ($/ha)	2,091	836	-
Irrigation water savings ($/ha)	300	200	-
Labour savings ($/ha)	293	111	-
Total benefits ($/ha)	2,684	1,147	-
Annualised capital costs ($/ha)	416	300	-
Annual maintenance costs ($/ha)	50	50	
Net benefits of change ($/ha)	**2,218**	**797**	-

These economic benefits from new technologies at the farm level are shared within the viticulture industry by producers, processors, input suppliers and consumers, some of whom are non-residents of Australia. Generally we assume that Australia is a price taker on world markets and hence few of these benefits flow to overseas consumers and processors. Generally we assume that the distribution and processing sector in Australia is competitive and that the inputs used in these sectors are readily available. Under these circumstances, most of the benefits valued above are retained by grape producers.

Figure 5: Viticulture – Adoption curves of switching to Drip Irrigation Systems - 'with and without' WWF in the Lower Murray Irrigation Area.

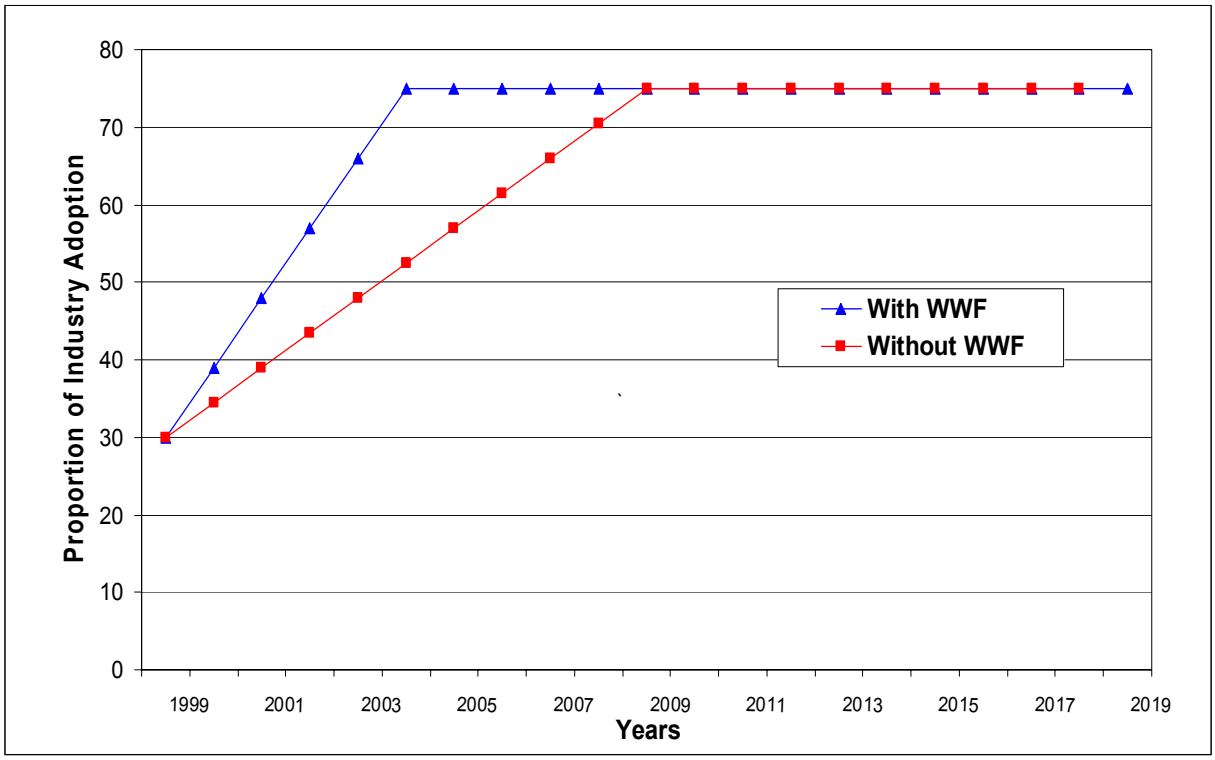
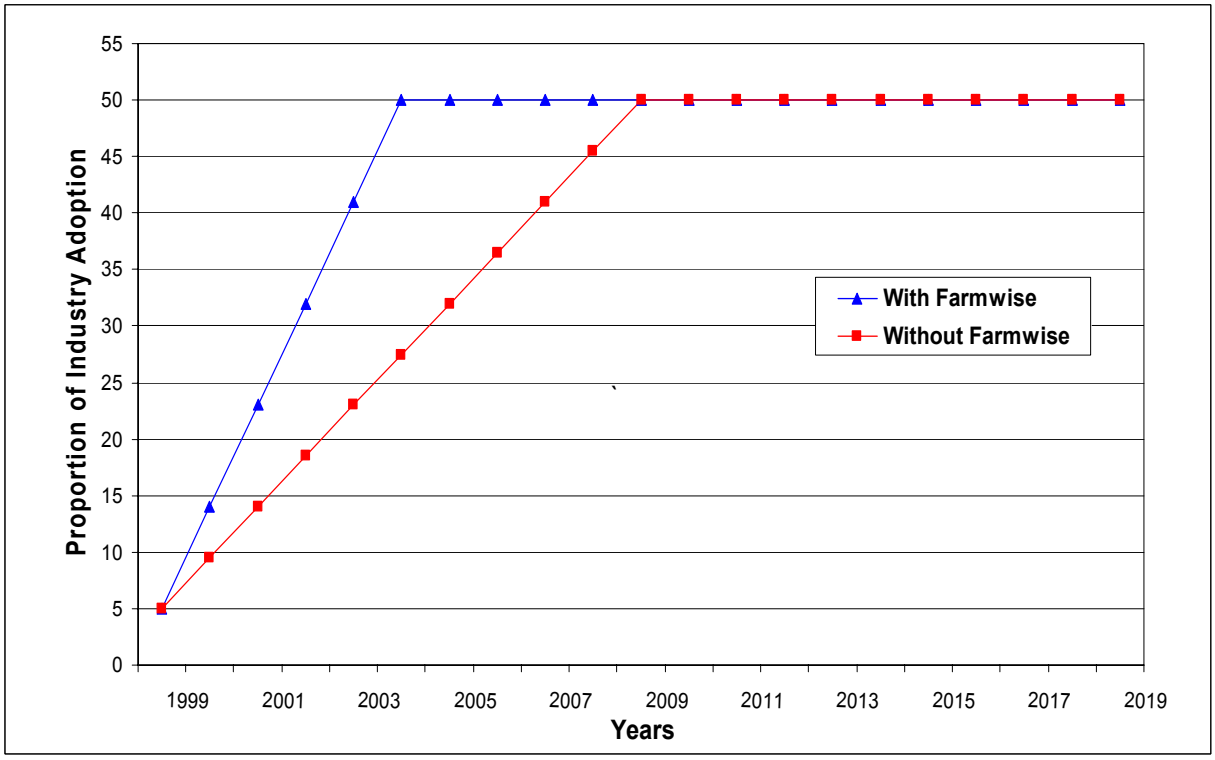


Figure 6: Viticulture – Adoption curves of switching to Drip Irrigation Systems - 'with and without' Farmwise in the Murrumbidgee Irrigation Area



Social outcomes

These economic benefits have positive social consequences, largely through their contribution to the incomes of farmers and those who handle and process grapes in regional NSW. The capital costs of moving from furrow to drip irrigation systems are quite high and hence there is a danger that the larger producers will be in a better position to adopt this technology than smaller growers, an adverse social impact if publicly funded.

As already noted an intensive educational program such as WWF may build up the problem solving skills of farmers in a way that benefits them and their community (social capital) in tackling other problems related to change. This is likely to apply to the viticulture industry in southern NSW but we have not identified specific instances of increased social capital.

Environmental Outcomes

Some environmental impacts will occur on-farm and be reflected in the costs and returns of the producers and hence in the estimate of economic benefits. The water savings from the improved drip irrigation technology has already been valued. However there may also be environmental outcomes that impact on the broader community. There may be benefits from a reduction in deep drainage, accessions to the watertable and soil salinity. We have not attempted to estimate and value this reduction in deep drainage.

5.5 The impact of WWF in other industries

Rice in Land and Water Management Areas (LWMP) Areas

As one of the major water using industries in NSW, consideration was given to assessing the impact of WWF on the rice industry. Approximately 85 per cent of the total area of rice is grown in Land and Water Management Plan (LWMP) areas in the Murrumbidgee and Murray Valleys. The implementing authorities, Murrumbidgee Irrigation, Coleambally Irrigation and Murray Irrigation Limited, provide their own extension and training services to irrigators in accordance with their own economic and environmental sustainability objectives.

The MIA and Jemalong are the only LWMP areas which have utilised the WWF training course. It is estimated that 45% of the IIMC has been adopted by the LWMP Farmwise course (pers. comm. I.Quarisa, 2003). Initially 40 rice growers from the MIA attended the WWF course and 75 attended the Farmwise course. The WWF course was used in its entirety until 2002 prior to the introduction of Farmwise.

Despite some spillovers of course material between WWF and Farmwise, advice from program staff suggested that WWF had a limited effect on the adoption of more efficient irrigation practices in the rice industry due to the irrigation system involved. The rice industry appears to be already well serviced by a number of programs which provide some training and advice on water management. These include programs like 'RiceCheck' and MaNage Rice. These have been running for a number of years and have been providing rice growers with WUE information. So the information provided by WWF delivered to farmers via Farmwise reiterated the technologies and BIMPs that were available. In light of this, we took a view that WWF has been largely overshadowed by alternative extension programs provided to farmers by the Department of Agriculture, LWMP's and the industry itself. Consequently, an economic evaluation of the contribution of WWF was not undertaken for the rice industry.

Dairy Industry

There was qualitative research undertaken to assess the extent of WUE savings in the dairy industry as a result of WWF. Based on reports by NSW Agriculture staff it was decided that an economic analysis would not be worthwhile. There may have been beneficial effects of WWF on dairy farms in the Wagga region. The dairy industry is expanding in this region due to an exodus of dairy farmers from coastal regions to areas of cheaper land. WWF is thought to have an impact on the adoption of best management practices but the small scale of the industry could not justify an evaluation.

Low Chill Stone Fruit

Consideration was given to evaluating the impact of WWF in the low Chill Stone Fruit Industry given the high per ML returns involved with water use. However, due to the small size of the industry (estimated at 500 Ha) it was concluded that the quantity of water saved would not be significant enough to justify an in-depth evaluation.

Apple industry in the Batlow Region

An evaluation of the impact of WWF in the Batlow region was also considered. Benefits had been reported from WWF principally through improved water scheduling to control fruit size. Given time constraints and the contribution of other industry programs related to fruit size, there was no evaluation of the economic benefits of WWF undertaken.

6. Results and Conclusions

In the four evaluations, we have characterized the impact of WWF as bringing forward the adoption of either new technology or best management practices by a certain number of years rather than influencing the maximum level of adoption, except in the case of lucerne. The lucerne industry case study was the only exception, where the lack of industry structures suggested that WWF would actually increase the maximum level of adoption as well as influencing its rate.

A mixture of technologies and best management practices were evaluated across the case studies. In the case of lucerne and cotton, the WWF Initiative promoted better scheduling of irrigation applications involving more frequent but lower volumes of water which had the effect of reducing groundwater accessions and evaporation whilst reducing yield losses associated with both under and over watering. Better irrigation scheduling is principally a management change although normally some relatively minor infrastructure changes (reducing the length of runs, increasing the size of outlets etc) are also required. In the case of viticulture, the principal change promoted by WWF involved the conversion from furrow or spray based systems to drip irrigation systems. Changing to more efficient drip irrigation systems reduced crop water use and groundwater accessions whilst also providing yield and quality gains. More efficient water use in the cherry industry involved increasing the number of drippers per tree to allow faster and more targeted irrigation reducing watertable accessions and increasing fruit size.

The per hectare net benefits of the changes promoted by WWF were estimated using conventional farm budgets to represent the production system pre and post change. Economic benefits valued in the analysis varied across the case studies but involved increases in yield and/or product quality, reduced water use and savings in labour costs. The net benefits of the changes at the farm level were then aggregated to an industry or regional level based on the size of the industry or region and how WWF had been projected to influence adoption of these practices and technologies.

The economic benefits experienced in the four regional/industry complexes from the WWF Initiative were estimated to be approximately $88 million. The costs of the WWF Initiative incurred between 1998 and 2005 were estimated to be $19.8 million in year 2002 dollars. Hence the net present value from this investment is $68.2m, the benefit-cost ratio is 4.45 and the internal rate of return is 49 per cent. Nominal revenue and costs streams prior to 2002 were expressed in year 2002 dollars using the GDP deflator. Expenditures and revenue from 2002 were assumed to be in real terms. Revenue and expenditure flows were expressed in present value terms by either compounding forward or discounting back to 2002 at a rate of four percent.

Investments by the Initiative in the lucerne and cotton industries generated the greatest benefits in absolute terms. Ironically, while WWF is widely thought to have only a very minor effect in the cotton industry, bringing forward the adoption of best management practices by just one year generates large absolute benefits due the large scale of the cotton industry (just over 200,000 ha in Northern NSW). Details of the economic impacts of WWF in the four industries can be found in Table 8.

These economic benefits may have important social consequences as they are shared by producers, processors and consumers in each of the industry/region complexes. Given the nature of the markets in these industries we expect producers to be able to capture the larger share of the benefits. In addition, an intensive educational program such as WWF may build up the problem solving skills of farmers in a way that benefits themselves and their community (social capital) in tackling other problems related to the water reform process and to change in general.

More efficient use of water promoted by WWF may also have environmental consequences. Change in water use in each of the industry/region complexes was valued at market prices. However improved water efficiency may also reduce accessions to groundwater with consequent implications for salinity. At the same time, improving irrigation efficiency has the potential to reduce return flows to the river and reduce river flow levels if it is not accompanied by any change in property rights. We did not attempt to value these impacts.

Some caution should be exercised in interpreting the results above. First because we focussed on only four industry/region complexes it is likely that we have underestimated the benefits from the WWF Initiative. Extending the analysis to a range of other much smaller complexes was seen as an inefficient use of resources. Second it is important to reiterate that our objective has been to evaluate the extension activities related to water use efficiency within the Water Management Subprogram of NSW Agriculture, where the principal component has been the WWF Initiative. In adopting this approach we have not attempted to value the impacts on farmers and the community of the transfer of water from agricultural to environmental purposes that is associated with the water reform process currently occurring in NSW and Australia. We see these impacts as being attributable to the broader water reform process and hence beyond the scope of this analysis.

The costs of WWF have been fully met by the NSW Government. The broad availability of the Initiative across the State and agricultural industries suggests that it is mainly a program about facilitating broad agricultural adjustment to water reforms rather than a program focused on industry benefits. Taking this view it could be argued that WWF has assisted the implementation of the NSW water reforms which are primarily about the delivery of public benefits like improved river health. The NSW community is the principal beneficiary of such environmental improvements and hence the WWF should be funded by the community. Funding for the Initiative is scheduled to cease in 2005. Were funding to continue then industry might be expected to meet a share of the costs as a more significant share of the benefits from promoting more efficient irrigation technologies become private in nature.

Table 8: Summary of key parameters and results across the case study evaluations

	Cotton	Lucerne	Cherries	Grapes[6]
Technology	Scheduling	Scheduling	Modified drip	Drip&Scheduling
Industry Area (ha)	204,200	75,035	900	4,800
Net Benefits: ($/ha)				
Yield	357	137	0	2091
Quality	0	276	519	0
Water Savings	37	-23	100	300
Labour savings	-32	-34	0	293
Establishment costs	-166	-160	-170	-416
Annual Costs	-46	-53	-20	-50
Total Net Benefits:$/ha	*150*	*143*	*429*	*2218*
Adoption				
Year to Max. W/O	2008	2008	2009	2009
Year to Max. With	2007	2008	2004	2004
Max. Adoption W/O	80%	25%	40%	75%
Max. Adoption: With	80%	50%	40%	75%
Program start/end				
Waterwise starts	1999	1999	1999	1999
Waterwise ends	2005	2005	2005	2005
Contribution to benefits ($m)	12.21	61.85	0.29	13.64
Summary results				
PV of Benefits ($m)	$88.0			
PV of Costs ($m)	$19.8			
NPV ($m)	$68.2			
BC Ratio	4.45			
Internal rate of return	49%			

[6] The reported benefits for grapes are based on a shift from furrow to drip systems in Southern NSW. We have also evaluated the returns of a shift from overhead sprinklers to drip systems and this is reflected in the results of the economic evaluation.

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- 70 extension publications available at http://www.agric.nsw.gov.au/waterwise;
- 60 posters available from Water Management Subprogram;
- 30 printed brochures and publications.

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