Return on Investment for National Vegetable Research and Development Levy

VG07089

FINAL REPORT

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Executive Summary

Background

At a time of an increasingly globalised and highly competitive vegetable sector, research and development (R&D) expenditure has a vital role to play in assisting Australian vegetable growers to remain competitive in domestic and export markets. Given the finite nature of available R&D funding and a range of competing priorities, it is essential the outcomes from the research be reviewed to ensure a positive return to those contributing funding and to inform future funding decisions.

A centrally co-ordinated approach to R&D expenditure is needed because it is unlikely growers would undertake this investment independently (Productivity Commission 2007). Further, as some of the benefits of vegetable industry R&D spill over to the wider public, the Productivity Commission (2007) argue it is equitable for the public to contribute towards the costs of R&D expenditure.

Vegetable industry R&D is currently funded through a combination of a compulsory member levy with matched funding from the Australian Government. The funds are managed by Horticulture Australia Limited (HAL), which co-ordinates total vegetable R&D expenditure of approximately $14 million per annum ($2008). Given limited available R&D funding, it is essential that expenditures are used to maximum effect by targeting priority areas to provide the greatest return on investment and that HAL is able to demonstrate the return from this investment.

Why is Assessing Return on Investment Important?

The Productivity Commission (2007) highlighted Government concerns about the lack of evidence supporting a positive return on R&D investment across all Rural Development Corporations (RDCs). The report also questioned the alignment between the division of private and public funding of R&D (both explicit and implicit[1]) and the distribution of benefits.

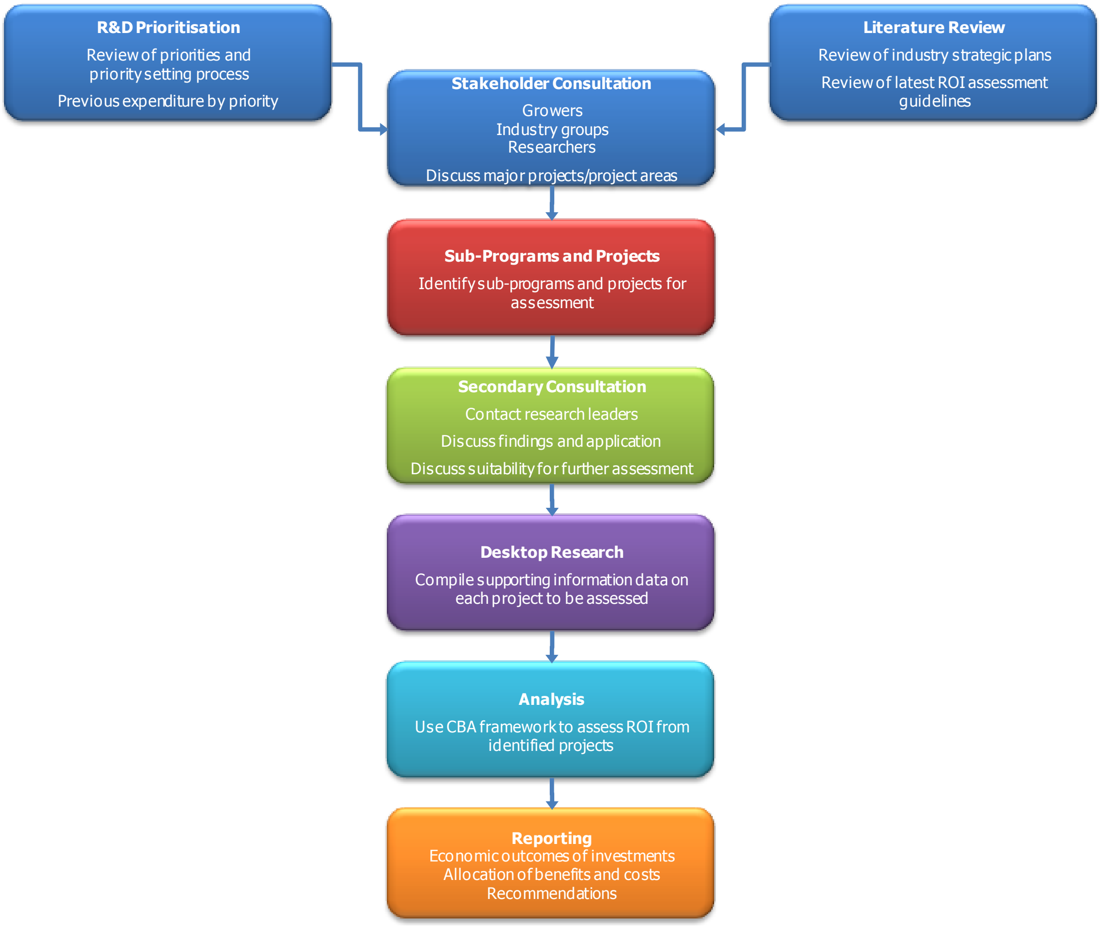
In May 2007, the Council of Rural Research and Development Corporation Chairs (CRRDCC) produced guidelines to assist the review process for RDCs in response to the Productivity Commission (2007). The guidelines include sections on appropriate sampling methods, reporting requirements and cost-benefit methodology. Land and Water Australia (LWA) has also produced a methodology for evaluating return on investment for natural resource management R&D. These guidelines are to be used to enable all RDCs to assess the return on investment from R&D expenditure.

Approach Used

The following figure summarises the key stages and actions undertaken in the conduct of this study.

[1] Explicit public funding is provided by governments direct to co-ordinating bodies (including HAL) to fund R&D activity, implicit support is provided through government support for the organisations which undertake the research (for example universities and government departments).

Figure ES.1. Project Methodology Overview



Note: This project undertook a ten-year review as the first step in establishing a rolling three-year review program as outlined in the CRRDCC Guidelines, and used a targeted sampling approach due to the large number of projects to be assessed over the ten-year period. A random sampling approach will be used for the ongoing three-year rolling reviews.
Source: AEC*group*

Assessment Methodology

A standard project assessment methodology was developed to ensure all projects were assessed on an equal basis and to simplify final reporting, each project assessment uses a consistent set of headings as set out in the following table.

Table ES.1. Stages in Project Assessment Methodology

Project Stage	Description
Project Description	• Provides an overview of the project, including: project rationale, aims and objectives, commodity/s affected, related projects and geographic extent of the project.
Project Deliverables	• Describes what the investment in each project actually produced, what HAL (and through HAL the levy payers) received for their investment.
Project Adoption	• Establishes the anticipated adoption scenario for each assessment in terms of the total area of production that could potentially adopt the findings, the maximum proportion of the potential area expected to adopt the project findings and the length of time to maximum adoption.
Identification of Impacts	• Identifies the tangible outcomes (benefits and costs) associated with each project. Impacts are classified as economic, social or environmental, quantitatively or qualitatively assessed and whether the impact applies to levy payers, the public or both.
Counterfactual Case	• A counterfactual case was developed for each project to isolate the impacts of the R&D expenditure from changes likely to have occurred irrespective of each project.
Cost Benefit Analysis	• Quantifies the relative costs and benefits of a project or proposal and converts available data into manageable and comparable information units.
Sensitivity Analysis	• Tests the sensitivity of the outcomes of the CBA to combinations of the variables used.
Confidence Rating	• A confidence rating has been applied based on a review of the risks associated with the figures used. The confidence ratings are high, medium and low.

Results Analysis

Each cost and benefit is identified in a table stating the cost per unit (including per tonne, year or hectare) and the present value of the cash flows over the twenty year assessment period. The discount rate set out by the CRRDCC (2007) guidelines for assessment of R&D expenditure is the benchmark rate used in present value calculations. Results under alternative discount rates are also reported.

The CBA outcomes are also presented to demonstrate the division of cost and benefits over time (five, ten and twenty years) and between levy payers (direct impacts) and the public (indirect impacts).

Reporting

This report represents the confidential reporting component, including the methodology that has been used, the outcomes of the assessment of the identified projects and sub-programs and recommendations on potential development of the management of the vegetable R&D program. A summary of this report will be available to the general public, highlighting the overall return to levy payers and the general public from the Vegetable Levy R&D program.

Selected Sub-Programs and Projects for Assessment

In all, nine sub-programs were identified based on stakeholder consultations, however not all were suitable for assessment at this stage. The sub-programs selected for review are introduced below and the subsequent table summarises the CBA outcomes for each project assessed within the selected sub-programs.

A. Minor Use Chemical Registration

The sub-program allows Australian vegetable growers to use chemicals on crops other than those stated on the product label. To do this HAL funds the collection of residue data which is then used to support an application to the Australian Pest and Veterinary Medicine Association (APVMA). Once approved a minor use registration certificate is issued allowing use within guidelines which are also established as part of the HAL funded work.

The case studies examined within this sub-program returned approximately $29.43 for every dollar invested, comprising $30.62 dollars for every dollar invested by growers and $17.63 dollars for every dollar invested by the broader public.

Key benefits identified included:

- Providing growers with a means of controlling significant pest and disease threats where in many cases there were no effective alternative controls available;
- Providing growers with access to effective chemical controls, which were not registered for legal use on specific commodities in Australia and which the chemical producers would not have registered for use in Australia; and
- Reducing environmental impacts on growers, the public and the wider environment associated with chemical application by facilitating the continuing transition from calendar based application of broad spectrum pesticides to more targeted approach with fewer non-target impacts.

B. Production Efficiencies

In an increasingly competitive vegetable market Australian growers need to continually seek ways to reduce operating costs to defend market share and exploit opportunities. Efficiencies can come in a variety of formats from reduced operating costs from a better understanding of input requirements to increased yields as a result of better targeted use of chemical control measures.

The case studies examined within this sub-program returned approximately $31.65 for every dollar invested, comprising $33.43 dollars for every dollar invested by growers and $18.41 dollars for every dollar invested by the broader public.

Key benefits identified included:

- Improved competitiveness of Australian production by reducing input costs without compromising quality;

- Allows growers an opportunity to increase the productivity without buying, leasing to renting additional land; and
- Provides a potential opportunity to develop the technology and export.

C. Integrated Pest Management

Over the last decade there has been a gradual shift from traditional pest and disease management techniques reliant on chemical control measures towards more holistic approaches which combine biological, physical and cultural control measures with chemical controls to manage pests and diseases.

The case studies examined within this sub-program returned approximately $7.31 for every dollar invested, comprising $7.59 dollars for every dollar invested by growers and $6.94 dollars for every dollar invested by the broader public.

Key benefits identified included:

- Development of an effective pest management which reduces reliance on chemicals as the sole control mechanism;
- Reduced environmental impacts from the application of broad spectrum chemicals and the recognition of the potential role for beneficial species; and
- Establishment of a long-term management structure which has the potential to be applied across multiple commodities with specific component targeted to the pest/ commodity in question.

D. Environmental Management

For a variety of reasons (including regulatory controls and public awareness) growers now have to be much more aware of their environmental impacts and how they affect their immediate surrounds and the wider environment. This can be daunting for some growers and this work helps to overcome some of these issues while establishing appropriate environmental management practices and recognising good practice.

The case studies examined within this sub-program returned approximately $5.99 for every dollar invested, comprising $8.96 dollars for every dollar invested by growers and $3.01 dollars for every dollar invested by the broader public.

Key benefits identified included:

- Demonstration to growers that environmental management need not be an expensive and time consuming process and recognition of existing practices which demonstrate sound environmental management;
- Improved public perception of grower practices, especially as consumers become increasing environmentally conscious; and
- Preparing growers for likely increased scrutiny for their environmental impacts through legislation and consumer pressure.

E. Soil Borne Diseases

Soil borne diseases are often impossible to detect until a grower has incurred the site preparation, planting management and harvesting costs of a crop. It is not clear the crop must be discarded before harvesting occurs. In many cases no soil test was available and it was not possible to detect infected areas and growers would suffer repeated losses, in some cases even replanting having ploughed in diseased crops.

The case studies examined within this sub-program returned approximately $10.19 for every dollar invested, comprising $22.55 dollars for every dollar invested by growers and $8.94 dollars for every dollar invested by the broader public.

Key benefits identified included:

- The ability to detect soil borne diseases, avoiding continued losses due to a lack of information about the presence of the disease;
- Increased understanding of the lifecycle and potential host crops for the diseases; and

- Development of a whole of production cycle management approach (clubroot) integrating disease control measures throughout the production process.

F. <u>Grower Education and Development and Collaboration</u>

As well as reactive R&D which has an immediate application it is also important industry continues to provide opportunities for growers to experience other management techniques and to interact with others who may have examples of best practice. This is especially important in the vegetable industry which is inherently solitary with limited opportunity for interaction. It is important the sector continues to invest in projects which provide a bridge between R&D findings and their practical application in order to achieve maximum extension of R&D benefits. The benefits from these projects are likely to accrue through increased adoption of other R&D outcomes and so to avoid double counting have not been assessed quantitatively. However, stakeholders considered these projects very important to both the short-term dissemination of findings and the longer-term development of the industry and its participants.

Key benefits identified include:

- Communication of project findings is a format that was easily understood and described the actions that were needed in order to implement on the ground;
- The provision of opportunities to learn from other growers and to assess the impacts that R&D outcomes have had on working properties;
- Access to overseas production and processing facilities and the opportunity to establish networks with other growers; and
- The opportunity to identify and develop the next generation of industry leaders.

Return on Investment

Quantitative Assessment

The following table shows the present value of the costs and benefits of each of the projects assessed. The case study programs assessed in this review and presented in the table below approximated $20.0 million ($2008) in direct R&D expenditure (i.e. does not include additional grower costs of implementing the findings). Projects in this assessment comprised 13.5 percent of the total R&D allocation for the period (11.5 percent are assessed quantitatively).

Table ES.2. Return on Investment from Assessed Projects ($ million)

Project/s	NPV			BCR		
	Grower	Public	Total	Grower	Public	Total
Minor Use Chemical Registration	**$979.4**	**$55.5**	**$1,035.0**	**30.62**	**17.63**	**29.43**
Lettuce Aphid	$362.6	$25.9	$388.5	25.88	39.59	26.48
WFT	$616.9	$29.6	$646.5	34.35	12.11	31.55
Productivity Increases	**$105.3**	**$7.4**	**$112.6**	**33.43**	**18.14**	**31.65**
Harvest	$105.3	$7.4	$112.6	33.43	18.14	31.65
Integrated Pest Management	**$275.1**	**$38.7**	**$313.9**	**7.41**	**6.65**	**7.31**
DBM	$169.6	$17.1	$186.7	7.73	6.49	7.59
Sweet Corn	$105.5	$21.6	$127.1	6.97	6.79	6.94
Environmental Management	**$12.3**	**$3.1**	**$15.4**	**8.96**	**3.01**	**5.99**
EnviroVeg	$12.3	$3.1	$15.4	8.96	3.01	5.99
Soil Borne Diseases	**$243.1**	**$66.6**	**$309.7**	**8.94**	**22.55**	**10.19**
Beans	$11.6	$1.6	$13.2	35.94	5.80	20.87
Clubroot	$143.9	$33.3	$177.2	5.95	22.93	6.80
Carrots	$87.6	$31.7	$119.3	71.63	26.56	49.09
Total	**$1,615.2**	**$171.3**	**$1,786.5**	**15.50**	**12.23**	**15.11**

Notes: Totals may not sum due to rounding
Source: AEC*group*

The assessed projects are estimated to have produced a total net present value of $1,786.5 million, of which 90.4 percent is estimated to accrue to growers, with the remaining 9.6 percent accruing to the public.

These figures include the additional investments made by growers in order to adopt project findings in addition to their levy payments. The BCR for growers and the public offer an assessment of the return relative to the size of the investment made. This indicates growers received approximately $15.50 for every dollar invested and the public received $12.23 for every dollar they invested, a much closer outcome.

These case studies are recognised to include several strong performing examples of the return from HAL supported vegetable levy R&D investment and as a result cannot be used to estimate a return on the whole program expenditure. However, over the last ten years, HAL has funded approximately $14 million ($2008) of R&D expenditure per year, the annual average NPV over the 20 year period studied is approximately $89.3 million ($2008), indicating the indicative return on investment from the projects assessed is considerably greater than the total R&D investment.

Qualitative Assessment

The majority of quantified economic benefits accrue to growers. Grower benefits are more readily quantified as they tend to be either cost or market impacts and subsequently have a dollar value attached to them. Public benefits are more likely to be intangible, especially environmental and social outcomes. In the majority of cases the impact of individual projects are limited. However, in aggregate the overall impact of the Vegetable Levy R&D program is significant.

The majority of the impacts assessed using a qualitative approach fall under the social category, reflecting difficulties in quantifying these impacts. However, it is important that these are considered in any review of return from R&D expenditure. Significant benefits, which have been assessed qualitatively, include the contribution of R&D outcomes towards:

- **Regional and national economies**: Direct expenditure by growers can be significant and supports employment in a wide range of related industries. The flow on impacts of grower expenditure (as it passes through the rest of the economy) also provide additional economic benefits.
- **Sustaining a competitive Australian vegetable sector:** A sustainable Australian vegetable sector is likely to increase grower confidence about the long-term future of their business, encouraging investment in new technology and other production improvements. For the wider community, the benefit is in the form of increased choice, lower environmental impacts and in some cases lower prices.
- **Sustaining regional communities:** Growers and their families make a significant contribution to regional communities through their participation in the community and by contributing to the population mass needed to secure the continuation of critical services including school and health facilities. Without R&D, it is likely some growers would leave the industry (and regional areas) reducing the sustainability of some communities.
- **Supporting research and development positions:** The Australian Government has identified science and innovation as a key priority which will contribute to the nation’s long-term development and prosperity. By funding approximately $14 million ($2008) of R&D expenditure each year the program makes a significant contribution to the maintenance of a vibrant research community, which is appropriately skilled and experienced. R&D skills developed on HAL projects are often applicable across multiple agriculture sectors.
- **Avoided environmental impacts associated with transporting and storing imported products:** Commodities which could no longer be grown competitively in Australia would either need to be replaced by imports or would no longer be available. Imported commodities are likely to have significant environmental impacts associated with the additional transport and storage required relative to domestic production.

Confidence Rating

The heterogeneous nature of vegetable growers, their operations and properties mean that any overall analysis must rely on a series of assumptions and estimates informed through the best available information. This assessment utilises a high, medium and low confidence rating framework, as developed by Land and Water Australia (LWA, 2007), to assess the relative confidence of the input data used in the assessment. The detailed knowledge of individual researchers and the extensive nature of the stakeholder consultation undertaken resulted in a high overall level of confidence in the data and assumptions utilised in this assessment.

Assessment Outcomes

Assessment Outcomes for the Levy Payer

- The HAL managed Vegetable Levy R&D expenditure has resulted in a clear benefit to growers. The projects examined in these case studies identified:
  - A total NPV of $1,615.2 million to growers, representing a BCR of 15.5.
- The assessment of the returns to growers includes their contributions to the levy and the implementation costs associated with some projects;
- In addition to the quantifiable benefits to growers, R&D funded work has also contributed to several benefits which have been assessed qualitatively including:
  - Improved sustainability of the Australian vegetable production sector; and
  - Reduced risks to grower health.

R&D Alignment to Priorities

- It is considered that the overall vegetable R&D program reflects Government and grower priorities and provides a positive return on investment. Through their input to the Industry Advisory Committee through industry groups and other methods, growers have the opportunity to communicate their priorities for the R&D program. Consultations suggest that the primary areas of grower focus are in pest and disease management (supported by the findings of the 2005-06 ABARE survey, ABARE 2007) and this is reflected in the observed distribution of expenditure. Growers also expressed the high value they place on project expenditure which facilitates the adoption of project findings and provides opportunities for grower development, even where these projects may not provide an obvious short-term return.

Assessment Outcomes for the Public

- The HAL managed Vegetable Levy R&D expenditure has also produced a clear benefit to the public. The projects examined in these case studies identified:
  - A total NPV of $171.3 million to the public, representing a BCR of 12.2.
- The assessment of the returns to the public only includes their contribution to the cost of the R&D activities;
- In addition to the quantifiable benefits to the public, R&D funded work has also contributed to the several benefits which have been assessed qualitatively including:
  - Maintenance of regional communities;
  - Increased consumer choice;
  - The maintenance of a vibrant R&D sector; and
  - Reduced environmental impacts associated with the importation of vegetables.

Market Impacts of R&D Expenditure

- Very few of the projects assessed had a direct focus on market expansion. In many cases, the work undertaken was critical to defending market share (domestic and export) in the face of significant increased production and competitiveness from lower cost producing countries such as China;
- The R&D program must be seen within the context of multiple external factors. The emergence of China as a major competitor in export markets, in particular, where price is a differentiating factor has significantly eroded the market for Australian vegetable exports, especially in South-East Asian markets. As a result, few projects have had any discernable impacts on the expansion of export markets for Australian vegetables. However, many projects have resulted in the maintenance of export

markets against competition from lower cost producers, quite often through a quality differential; and

- Several projects did establish the opportunity to expand into new export markets, for example by allowing growers to produce crops to the standards required. However there are overwhelming macro-economic factors that ultimately impact the success of these markets, such as cost pressures from other countries, climate production windows and trade restrictions. Continued R&D is expected to contribute to the maintenance and potentially the development and/or expansion of export and domestic markets for Australian vegetable production.

Distribution of R&D Benefits

- Throughout the supply chain, the majority of benefits have accrued to growers in the form of avoided crop losses and efficiency increases although as many growers do not recognise their own time as an input cost, some benefits may have been overlooked;
- The other major supply chain beneficiary identified was the consumer. The retail sector has exerted price pressures on growers and generated efficiencies in procurement and supply chains and the major supermarkets in particular have been able to access significant benefits in terms of the profitability of their vegetable produce. It is likely these benefits have been shared between the retail sector and the consumer;
- The distribution of benefits to various supply chain stakeholders has been limited by the shortage of projects for review relating to the processing and transportation sectors;
- Although the aggregate return on investment is greater to growers, this is largely due to the additional investments which growers make on top of the levy contributions in order to access the full quantifiable benefits of the R&D. Comparing BCRs, which assess returns relative to investment, indicates a much more equitable outcome and subsequent return on investment; and
- The projects have provided a range of economic, social and environmental benefits to both growers and the public including:
    - Reduced crop losses;
    - Reduced externalities as a result of the use of pesticides and other chemicals;
    - Avoidance of vegetable imports;
    - Reduced grower operating costs; and
    - Strengthening of rural communities.

Summary

- In all, the projects examined quantitatively totaled an estimated vegetable R&D expenditure of $17.1 million ($2008) and were assessed as producing an average BCR of 15.1 over the ten years 1998-99 to 2007-08, which implies a return of $15.11 for every dollar invested; and
- Despite these returns, it is considered unlikely any other organisation would fund these types of projects due to the relatively small size of the Australian vegetable sector (on a global scale) and the difficulties in finding an appropriate and effective cost recovery process (other than a levy).

Project Learning

Key points of learning from the project include:

- A standardised assessment methodology has been developed to assess the identified projects/groups of projects. This follows the majority of the guidelines issued by the CRRDCC (2007) and where these have not been practical the reasoning behind the different approach has been included in **Appendix B**;
- In some instances, it is apparent there are data gaps and although a series of assumptions have been adopted in their place, this does increase the margin of error

in the results. A conservative (and precautionary) approach has been used throughout the assessments. It is likely that as a result the assessed outcomes represent the minimum likely return from the projects;

- In many cases, little information was available surrounding the anticipated detrimental or beneficial impacts associated with the R&D project outcomes prior to research being undertaken. This raises questions about the identification of key issues prior to funding allocations and the way in which projects are nominated and approved;
- In many cases, while there is some information on the extension activities that were undertaken, there is little, if any published or officially recorded information surrounding subsequent uptake of project findings;
- Some projects were not assessed due to a lack of available data. This does not mean they failed, just that there was insufficient information recorded in order to undertake an informed and accurate assessment. In the majority of such cases this was due to the length of time since the project had been completed;
- In many cases, the environmental and social outcomes were not quantified as the volume of benefits could not be identified. In other cases, this was further confounded by a lack of available and appropriate values in order to quantify the identified impacts;
- In many cases, the reports focus on reporting activity (e.g. number of trials completed, cultivars tested) rather than outcomes achieved (e.g. percentage crop loss reductions);
- The HAL work program continues to address a wide range of vegetable R&D priorities including reactive management of pest and disease outbreaks as well as broader strategic industry development. The program also addresses the broader goals of the Australian Government R&D program;
- There is a need for some researchers to consider the impacts of their work and how findings will be adopted by growers, including key data relating to costs and benefits. This data is essential for any future program evaluation. During interviews, some researchers had little or no idea about the extent of adoption or the impact of their work when it was put into practical application. To address this it is recommended:
  - A set of measures are agreed before each project is funded;
  - The measures are specific and quantifiable; and
  - The measures provide the information necessary to undertake a return on investment review.

  This approach would allow easier and more transparent assessment of all projects funded (it is not recommended that every project is assessed but this approach would increase the available choice);
- Projects should be assigned to a sub-program at the time of approval. This would assist in the management of the R&D program by allowing HAL to assess the alignment between stated priorities and expenditure. This facility would also be very useful when subsequent reviews of R&D expenditure are undertaken allowing easy identification of the pool of projects from which the random sample of projects for review will be chosen. New sub-programs could be added as required;
- Many of the outcomes of current projects will be used to develop future research which could not take place without these 'building blocks' or 'frameworks' which makes 'discrete' return on investment analyses difficult. (For example, the Integrated Pest Management principles will remain in place even though the chemical controls used will eventually need to be replaced);
- Growers identified the minor use chemical registration and Industry Development Officer programs as having the greatest benefit for their business. However, in some instances there was limited understanding of the full suite of research and subsequent impacts and benefits, indicating that many growers' comments were related to what they see and hear;

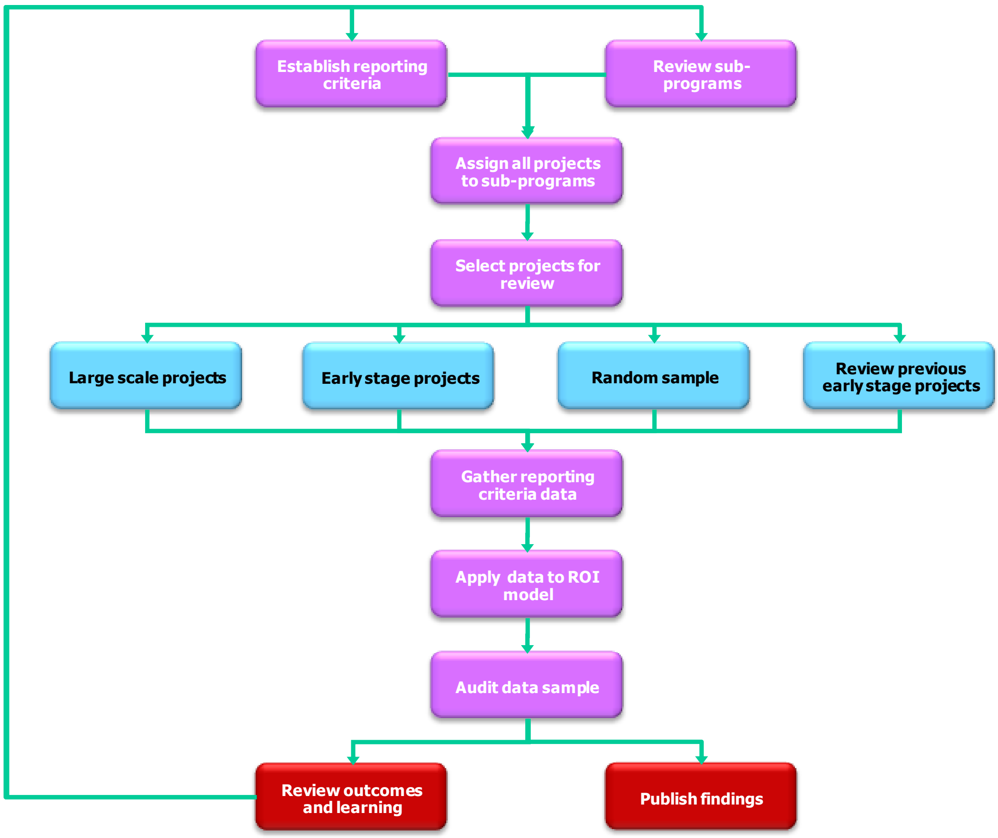
- Although grower development projects may appear expensive given the number of attendees, the findings are often disseminated over a much wider audience after the event with growers more likely to be open to findings communicated by another grower than through other mechanisms. Projects that support the long-term development of grower capabilities are very important as they provide opportunities that may not otherwise be available to the vast majority of growers and help to drive a continual improvement process;
- It is important to recognise the social impacts of projects, which despite being challenging to evaluate have the potential to provide significant benefits to growers and the public;
- There is a need to address the disconnection experienced by some growers between project findings and their practical application. This is apparent through the importance that growers place on the Industry Development Officer network and the success of projects such as the Integrated Pest Management for brassica crops DVD; and
- The HAL vegetable R&D program makes a significant contribution to maintaining and developing the skills of research practitioners throughout Australia, this benefits the vegetable sector and other related sectors which can benefit from this skill and experience in the research community.

Recommended Structure for Future Assessments

Having completed this initial review of the return from Vegetable Levy R&D expenditure between 1998-99 and 2007-08, HAL now has a basis from which to establish a rolling review program. Although the review program should be tailored to meet the needs of HAL, it should also follow the review guidelines as established by CRRDCC (2007).

The following diagram outlines one potential review process although the chosen approach should also consider links between the reviews of other HAL R&D programs.

Figure ES.2. Potential Rolling R&D Review Structure



Source: AEC*group*

The two principle changes between the above assessment structure and the one used in completing this study are the selection process for projects to be assessed and the method of data collection:

Sub-Program and Project Selection

Having completed this initial ten-year review, a rolling program should be established with a project selection mechanism which meets all of the requirements of the CRRDCC guidelines (2007). However, before any projects can be selected, a review of the sub-programs being assessed should be undertaken to ensure they are still appropriate.

Outcome Reporting Framework

The most difficult element of the review has been establishing data on the impact of the projects on the ground. Some researchers have found it challenging to describe the effect a project is likely to have had at either an industry wide or individual grower level. The assessment process above is based on the adoption of the recommendation that for every project as well as the media and technical summary, every final report must report on a set of agreed measures. This would make assessing the return on investment (and the distribution of the return between levy payers and the public) much simpler and more transparent as well as improving the researcher's focus on delivering projects with practical applications. The types of measures which could be recorded include:

- Percentage of growing area over which the findings can be applied;
- Percentage of growers likely to adopt the findings (and how quickly);
- Likely price and/or quality impacts; and
- Likely demand impacts.

These measures could easily be tailored to each project. At the end of the project the final report would include an *ex ante* assessment of each measure to provide some guidance and context surrounding the expected returns that may result from the extension of the R&D findings. This data could be used as inputs to the three-year rolling review, with data capture focusing on validating information and assumptions rather than primary data collection. It is important that researchers realise the need to capture 'with R&D' data estimates and the counterfactual 'without R&D' data estimates.

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1. Introduction

1.1 Background

At a time of an increasingly globalised and highly competitive vegetable sector, research and development (R&D) expenditure has a vital role to play in assisting Australian vegetable growers to remain competitive in domestic and export markets. Given the finite nature of available funding and a range of competing priorities, it is essential the outcomes from the R&D be reviewed to ensure a positive return to those contributing funding and to inform future funding decisions.

In Australia, the vegetable industry is characterised by a small number of large scale producers who account for the majority of production and many more small scale growers who account for a low proportion of total output. A centrally co-ordinated approach to R&D expenditure is needed because it is unlikely growers would undertake this investment independently (Productivity Commission 2007). Further, as some of the benefits of vegetable industry R&D spill over to the wider public the Productivity Commission (2007) argue it is equitable for the public to contribute towards the costs of R&D expenditure.

A funding model has emerged where vegetable industry R&D is funded through a combination of a compulsory member levy with matched funding from the Australian Government. The funds collected are managed by Horticulture Australia Limited (HAL), an industry-owned Rural Development Corporation (RDC) which co-ordinates R&D and promotional programmes on behalf of Australia's horticulture sector, including the National Vegetable Levy.

HAL co-ordinates total vegetable R&D expenditure of approximately $14 million ($2008) per annum and in the ten years between 1997-98 and 2007-08, HAL has overseen the expenditure of approximately $131.4 million on vegetable industry R&D, which is equivalent to approximately $148.4 million in 2008 dollar terms. Given limited available R&D funding, it is essential that expenditures are used to maximum effect by targeting priority areas to provide the greatest return on investment and that HAL is able to demonstrate the returns from this investment.

1.2 Need for this Study

HAL commissioned this study to assess the return on investment from the vegetable R&D expenditure over the last ten years to 2007-08. In so doing, the research should demonstrate the return to growers and other stakeholders from the investment of Vegetable Levy and public funds and meet the requirement for increased scrutiny of RDC managed R&D expenditure.

The accurate quantification of the benefits from R&D expenditure is complex. Considerable debate surrounds the specific benefits directly attributable to R&D expenditure, benefits which would have been likely to occur without the R&D and the length of time over which benefits can be claimed.

The Productivity Commission (2007) highlighted Government concerns about the lack of evidence supporting a positive return on R&D investment across all RDCs. The report also questioned the alignment between the division of public funding of R&D (explicit and implicit[2]) and the distribution of benefits.

In May 2007, the Council of Rural Research and Development Corporation Chairs (CRRDCC) produced guidelines to assist the review process for RDCs in response to the Productivity Commission report (2007). The guidelines include sections on appropriate sampling methods, reporting requirements and cost-benefit methodology. Land and Water Australia (LWA) has also produced a methodology for evaluating the return on investment for natural resource management R&D. These guidelines are to be used to enable all RDCs to assess the return on investment from R&D expenditure.

[2] Explicit public funding is provided by governments direct to co-ordinating bodies (including HAL) to fund R&D activity, implicit support is provided through government support for the organisations which undertake the research (for example universities and government departments).

1.3 Terms of Reference

The following table sets out the terms of reference for the study and how each requirement has been addressed.

Table 1.1. VG07089 Project Objectives and Scope of Works

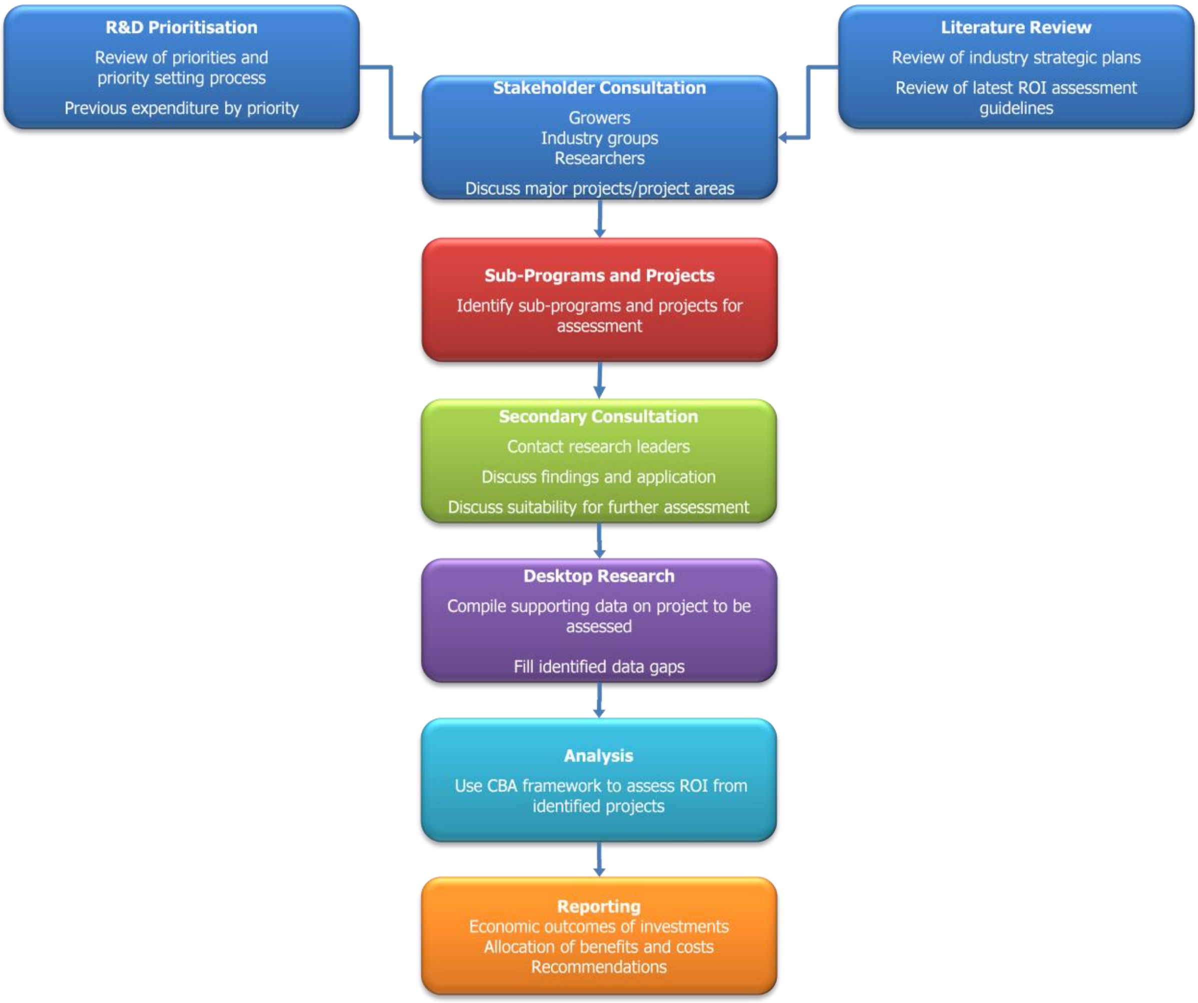
Project Objectives and Scope of Works	How Addressed
1. Assess the benefits the levy has delivered to various stakeholders, in particular to growers and industry. This will include: • Analysis of programs that have been undertaken, through specific return on investment information for the whole program; • Identification of the quantifiable benefit the vegetable levy has had on the domestic and export market; and • Identification of where in the supply chain the benefits of the project have been received and where the end results can be identified.	• A series of sub-programs were identified through stakeholder consultations and analysis of historical expenditure; • Within each sub-program, project/s were identified for quantitative and qualitative assessment; • Using a standard set of measurable outcomes, sub-program assessments were undertaken; and • Each project assessment considered the distribution of project benefits and costs.
2. Assess how well levy payer interests have been served by the vegetable levy R&D investments. This will include an assessment of how well each project aligns with HAL R&D priorities and identification of the benefits (and costs) received by levy payers.	• A review was undertaken of the R&D investment prioritisation process; • Each of the costs and benefits of the reviewed projects were assessed to determine which of the identified measurable outcomes it contributed towards; • Each project assessment identified which benefits and costs were incurred by or benefited levy payers; and • For each assessed project, a return on investment and benefit cost ratio to growers was established.
3. Identify any public benefit that has been created as a result of the vegetable levy R&D. This includes: • Environmental outcomes (such as enhanced ecosystem function, reduced ecosystem damage resulting from vegetable industry practices, etc.); • Social outcomes to the greater community (such as additional employment opportunities, income, etc.); and • Economic outcomes to the greater community (such as enhanced regional economic output, technology transfer, etc.).	• Each project assessment identified public costs and benefits; • Costs and benefits were broken down by economic, social and environmental benefits as well as by measurable outcome; • Each assessment identified and discussed the return on investment to the public and the benefit cost ratio; • Assessments included testing key assumptions over a series of scenarios to determine the range of potential outcomes; and • Costs and benefits which could not be quantified were assessed using a risk based (likelihood and consequence) qualitative assessment framework.
4. Make recommendations to improve future investments. These recommendations can be strategic (i.e. allocation of funding targeting strategic industry development) or technical (i.e. improvement in extension and operational efficiencies) in nature.	• The project assessment concludes with a series of recommendations based on both stakeholder consultations and the key project outcomes; and • The final report identifies key learning outcomes and makes recommendations regarding the future vegetable levy funded R&D program.

Source: HAL and AEC*group*

1.4 Approach Used

The following figure summarises the key stages and actions undertaken in the conduct of this study. Additional detail and explanation is included for each element below.

Figure 1.1. Project Methodology Overview



Note: This project undertook a ten-year review as the first step in establishing a rolling three-year review program as outlined in the CRRDCC Guidelines, and used a targeted sampling approach due to the large number of projects to be assessed over the ten-year period. A random sampling approach will be used for the ongoing three-year rolling reviews.
Source: AEC*group*

- **R&D Prioritisation Review -** a review was undertaken of the way in which vegetable R&D priorities were established. This analysis traces the R&D priorities from the broad Australian Government R&D priorities to individual projects. The review identifies the key processes and how they relate to the Vegetable Levy as well as reviewing historical Vegetable Levy funding allocation between identified priorities.
- **Stakeholder Consultation Exercise** – growers, representatives from a range of industry bodies, researchers and other related service providers were each contacted to discuss key areas of research (sub-programs) and projects which had produced successful outcomes.
- **Literature Review –** the two main elements of the literature review included:
  - Assessment of the existing guidelines and recommendations regarding the appropriate assessment methodology to be used in assessing ROI from R&D expenditure including Council for Rural Research and Development Corporation Chairs (CRRDCC 2007) and Land and Water Australia (LWA, 2007) reports.

- Assessment of relevant background material including industry strategic plans (including VegVision 2020 (2006) and Future Focus (2008) and external documents pertaining to the vegetable growing sector such as the ABARE (2007) report on their 2005-06 economic survey of the Australian vegetable growing industry.

- **Identification of Sub-programs and Projects for Review –** using the outcomes of the three previous sections, a set of sub-programs was developed to cover principle areas of vegetable R&D work funded by HAL over the preceding ten year period. Within each sub-program project/s were identified that might be suitable for in-depth review and ROI assessment.
- **Secondary Consultation –** for each of the identified projects, the lead consultant was contacted to discuss the suitability of the project for detailed assessment, the availability of data to inform the analysis and the extent to which the project had delivered tangible benefits. Following this consultation exercise, further revisions were made to the sub-program and project listing to develop a final list for detailed assessment.
- **Desktop Research –** for each of the identified projects, further research was undertaken to identify the required data to inform and be tested in the analysis. This data was sourced from a range of publically available sources.
- **Analysis –** a cost benefit analysis (CBA) was undertaken for each of the identified projects, following a standard assessment process, which included the comparison of the benefits and costs of a counterfactual 'without R&D' case against the 'with R&D' outcomes. Where costs and benefits could not be quantified, a qualitative assessment was used to assess the project impacts and inform the analysis.
- **Reporting –** the final project report summarised the impacts of the assessed projects (sometimes this was actually groups of projects which had worked towards a common outcome) and sub-programs, demonstrating the overall return on investment over the ten years covered by the study to levy payers and any public benefit that was created. The final report set out a series of key learning points and recommendations identifying potential improvements to the R&D impact assessment process. The recommendations established a potential framework for future reviews of return on investment from R&D expenditure as part of a rolling process.

2. Research Expenditure and Strategic Priorities

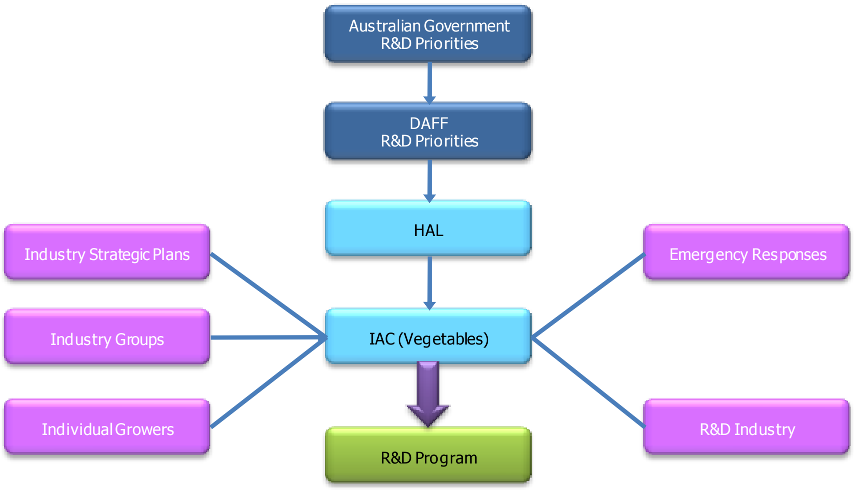
This section provides an overview of the current strategic priorities and priority setting process and introduces a series of measurable outcomes, which are used to structure the quantification of the identified impacts resulting from the R&D projects. The chapter concludes with a review of historical vegetable R&D expenditure by research area and measurable outcomes.

2.1 The Research & Development Priority Setting Process

Several organisations have input into determining the direction of National Vegetable Levy R&D expenditure. The scope of this input ranges from setting National Research objectives (as in the case of the Australian Government), to an industry consultation and advocacy role (as in the case of AusVeg) (**See Appendix A** for more details of roles and responsibilities). However, it is important to recognise that the final decision on the expenditure of levy funds is made by HAL.

The following figure provides an overview of the priority setting process.

Figure 2.1. Overview of the Vegetable Levy R&D Priority Setting Process



Source: AEC*group*

HAL, through its Industry Advisory Committee (IAC), must recognise the priorities of a range of stakeholders. These include top down priorities from the Australian Government and the Department of Agriculture, Fisheries and Forestry (DAFF) as well as bottom up priorities from industry groups and individual growers. The priorities also need to balance responses to unforeseen emergency situations and the requirement to develop the industry as established in the published strategic planning documents.

2.1.1 Australian Government R&D Priorities

The Australian Government research priorities were launched in 2002 and updated in 2003 and apply to all Government sponsored R&D initiatives. They aim to highlight areas of particular social, economic and environmental importance to Australia.

The Department of Agriculture, Fisheries and Forestry (DAFF) also produce priorities for R&D expenditure undertaken by the RDCs. The following table demonstrates the alignment between national R&D priorities and the DAFF R&D priorities (DAFF 2008).

Figure 2.2. Alignment of National and DAFF Research & Development Priorities

National Research Priorities	DAFF Rural R&D Priorities
Promoting & Maintaining Good Health Through strengthening Australia's social and economic fabric and preventative healthcare (healthy food and production)	Productivity & Value Adding Improve the productivity and profitability of existing industries and support the development of viable new industries
	Supply Chain & Markets Better understand and respond to domestic and international market and consumer requirements and improve the flow of such information through the whole supply chain, including to consumers
An Environmentally Sustainable Australia	Natural Resource Management Support effective management of Australia's natural resources to ensure primary industries are both economically and environmentally sustainable
	Climate Variability & Climate Change Build resilience to climate variability and adapted to and mitigate the effects of climate change
Safeguarding Australia	Biosecurity Protect Australia's community, primary industries and environment from biosecurity threats
Supporting the Rural Research & Development Priorities	
Frontier Technologies for building and Transforming Australian Industries	Innovation Skills Improve the skills to undertake research and apply its findings
	Technology Promote the development of new and existing technologies

Source: DAFF (2008)

2.1.2 Industry Advisory Committee R&D Priorities

For each of the commodities which HAL manages, an Industry Advisory Committee (IAC) provides recommendations to the HAL Board about which projects they consider to be the most appropriate to receive funding. However, the final decision to approve funding for projects supported by the IAC rests with the HAL Program Manager. Each IAC develops its own more detailed priorities, which inform the assessment of potential projects. The IAC priorities must recognise a wide range of sometimes competing factors including balancing short, medium and long-term goals.

The views of levy payers are communicated to HAL directly by growers and through industry groups (some of whom also have their own published R&D priorities). VegVision 2020 was produced by the Australian Vegetable Industry Development Group and establishes a strategic plan for the industry between 2006 and 2020. The strategic imperatives identified are:

- Delivering to changing consumer preferences and increasing demand;
- Market recognition of Australian quality, safety, reliable supply and innovation in products and services;
- Internationally competitive Australian vegetable supply chains;
- Advanced industry data and information systems to meet future needs; and
- Visionary leadership and change management.

Peak Industry Bodies (PIBs) work with their members to develop R&D priorities, which becomes the basis for discussion with the relevant IAC who have the final decision on which projects to recommend for support.

2.2 Measurable Outcomes

Although there are differences in the wording and scope of the priorities, a series of common underlying themes can be identified. This enables the likely outputs from each R&D priority to be assessed using six measurable outcomes, which makes it possible to identify:

1. The benefits Vegetable Levy R&D expenditure has delivered to various stakeholders, in particular to growers and industry;
2. How well levy payer interests have been served by the Vegetable Levy R&D investments; and
3. Any public benefit that has been created as a result of the Vegetable Levy R&D.

The six measurable outcomes identified are:

- **Increased production –** R&D expenditure that aims to increase the productive output from each unit of input, for example in the growing sector, this could be achieved through the development of higher yielding varieties and improved irrigation practices or through new growing techniques. This outcome could include indirect activities like disseminating best practice advice to growers that may increase productivity in the longer-term or reduce wastage;
- **Reduced operating costs –** R&D expenditure that aims to reduce the costs of producing, processing, packaging and selling vegetables. This covers all operating costs throughout the production supply chain, including on farm costs as well as all other supply chain elements such as logistics and storage;
- **Market development –** R&D expenditure that aims to develop domestic and overseas markets, including developing markets for new products, developing new markets for existing products and increasing market share in existing markets;
- **Increased quality differential –** R&D expenditure that aims to improve vegetable quality, or the perception of quality in the consumer's eyes to generate a price premium or to maintain/ grow market share and can be used to differentiate the Australian product in the market place. This includes expenditure on projects to improve the quality of the product at harvest and expenditure on projects to better maintain the quality of the product during transportation and when presented to the consumer;
- **Reduced environmental and/or social impact –** R&D expenditure that aims to reduce the environmental impact of the vegetable growing industry. This includes expenditure on farm activities including regulating discharges to water courses and better managing fertilizer and other chemical inputs as well as off farm activities including reducing the impacts incurred in transporting materials to and from the consumer; and
- **Management/Administration –** R&D expenditure that aims to improve the efficiency with which information is captured, stored and disseminated to industry. This outcome includes projects relating to the management of the R&D programme, attending conferences and investigation of the effectiveness of the R&D programme. These projects rarely produce a direct impact on industry, but are important foundation and capacity building tasks for industry.

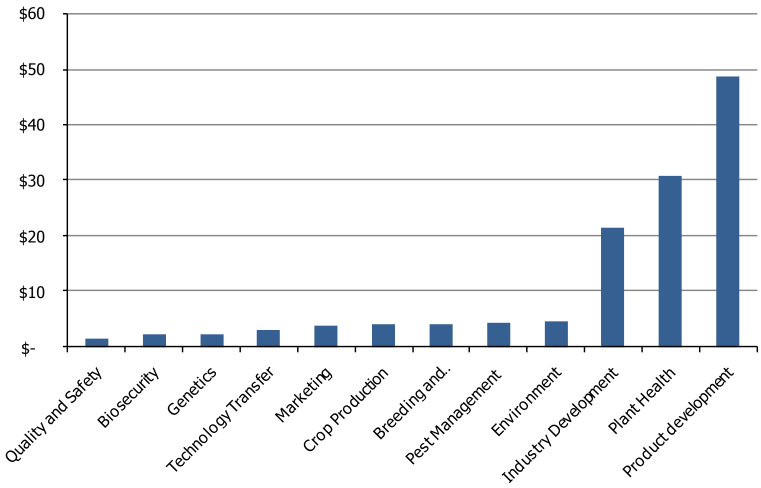
2.3 Alignment Between Expenditure, Priorities and Outcomes

HAL funded projects are not currently required to be coded to vegetable industry or Australian Government research priorities. Therefore, assessing the alignment of expenditure and these priorities is not always straightforward. HAL projects have been consistently coded against Research Areas and this has been used to retrospectively assign projects to priorities.

2.3.1 Expenditure by Research Area

Assigning projects to Research Areas was done to aid internal assessment rather than as a means of strategic analysis. However, these data are still a useful way to review the allocation of expenditure. The following figure shows the total Vegetable Levy R&D expenditure by Research Area between 1997 and 2008.

Figure 2.3. Expenditure by Research Area 1997-2008 ($2008 million)



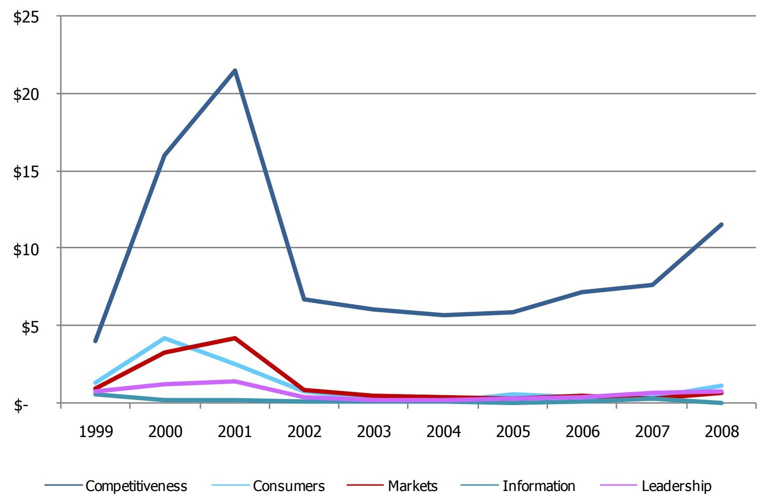
Note: The above diagram represents total expenditure over the ten-year assessment process and includes Research Areas no longer in the Strategic Plan. In a number of cases the R&D project, and subsequently the funding, contribute to more than one Research Area, which may result in under representation of funding to smaller and/ or discontinued Research Areas.
Source: HAL (Unpublished)

Historically, the majority (76.9 percent) of Vegetable Levy R&D expenditure has been allocated to industry development, plant health and product development priority areas whilst the other nine research areas received comparatively low (23.1 percent) levels of funding. Over the past three years funding has been focussed on plant health and industry development. It is likely that the analysis under represents that actual contribution to some smaller Research Areas as each project could only be assigned to one priority even where the outcomes may have delivered against several priorities (for example marketing is identified as a separate priority but it is likely that some marketing expenditure is also coded under industry and product development work).

2.3.2 Expenditure by Vegetable Industry Priority

The following analysis is based on an initial assessment of the Vegetable Levy R&D projects undertaken between 1998-99 and 2007-08. The figure below shows Vegetable Levy R&D expenditure assigned to the current vegetable industry priorities.

Figure 2.4. Expenditure by Vegetable Industry Priority 1998-99 to 2007-08 ($2008 million)



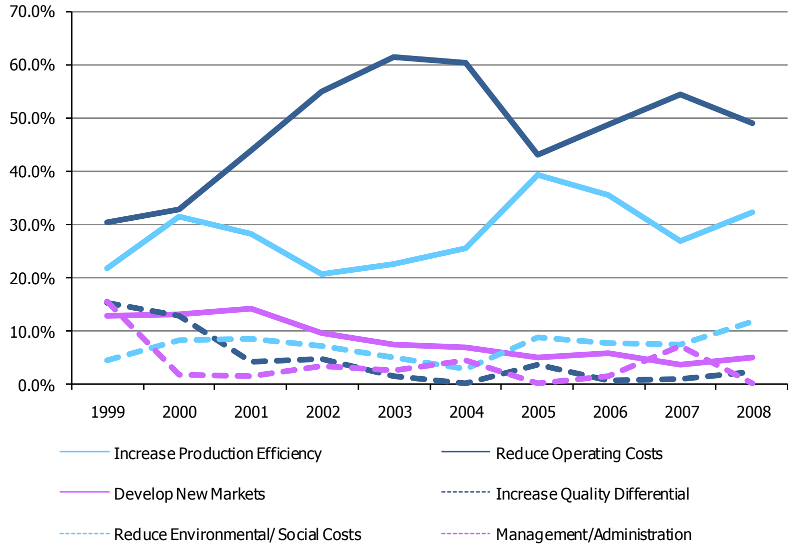
Source: HAL (Unpublished), AEC*group*

Significant investment was made in enhancing the competitiveness of Australian vegetable production between 2000 and 2002, since then this has remained the largest single research priority, although the level of funding has fallen significantly since that period. This may be explained by the fact that improving competitiveness is a very broad topic heading and this may account for its dominance over other categories, which are more narrowly defined.

2.3.3 Expenditure by Measurable Outcome

The following figure shows the distribution of R&D expenditure by measurable outcome.

Figure 2.5. Distribution of Expenditure by Measurable Outcome 1998-99 to 2007-08 ($2008)



Source: HAL (Unpublished), AEC*group*

Since 1999-00, National Vegetable Levy R&D expenditure has focussed on reducing operating costs and increasing productive efficiency. It appears that the two priorities may be inversely related with any changes in expenditure on one outcome having the opposite effect on the other. However, no basis for this relationship has been identified. On average, between 1998-99 and 2007-08, these two outcomes have accounted for 75.1 percent of all R&D expenditure.

On average from 1999 to 2008, there has been a 19.0 percent annual average decline in the proportion of total expenditure on 'increasing differential quality', 'developing new markets' (10.2 percent) and 'management/administration' (10.0 percent) whilst there has been a slight (11.2 percent) increase in the proportion of available funding allocated to work on 'reducing environmental/social costs'.

The following table demonstrates the co-relation between expenditure by measurable outcome and by sub-program. As projects are not currently coded to either of these measures, projects have been coded based on the project title. Ideally projects would be coded to sub-programs at the time of approval. Therefore the following data should be treated with caution.

Table 2.1. HAL R&D Expenditure by Measurable Outcome and Sub-Program 1998-99 to 2007-08 ($ million 2008)

	Production Efficiency	Reduced Operating Costs	New Markets	Increase Quality Differential	Environmental/ Social Impact	Management	Total	%
MCS	$0.0	$8.9	$0.1	$0.2	$0.0	-	**$9.1**	6.2%
Productivity	$1.5	$1.1	$2.3	$2.0	$1.7	-	**$8.6**	5.8%
IPM	$2.4	$37.6	$1.8	$0.6	$0.8	-	**$43.3**	29.2%
Environment	$1.1	$0.1	-	$0.2	$2.8	-	**$4.2**	2.8%
Soils	$6.0	$11.8	$0.3	$1.1	$2.3	-	**$21.5**	14.5%
Education	$30.8	$4.6	$10.7	$4.5	$0.2	$2.2	**$53.2**	35.8%
Management	-	-	-	-	-	$2.3	**$2.3**	1.5%
Supply Chain	$1.2	$0.2	$0.1	-	-	-	**$1.6**	1.0%
Water	$0.2	$0.6	-	$0.5	$3.3	-	**$4.6**	3.1%
Total	**$43.2**	**$64.9**	**$15.3**	**$9.2**	**$11.2**	**$4.5**	**$148.4**	**100.0%**
%	30.0%	45.1%	10.6%	6.4%	7.8%	3.1%	**100.0%**	

Notes: Table does not sum due to rounding
Source: AEC*group*

The distributions of projects and vegetable R&D investments are likely to be further complicated by the fact most projects will deliver against more than one category. However, the assessment does indicate the likely order of magnitude and relative distribution of expenditure over the last ten years.

2.4 Identified Issues and Learning

Historically, project expenditure has not been directly linked to stated vegetable R&D priorities. Whilst it is important to be able to link expenditure to research areas, it would also be useful to have an explicit link between project expenditure and stated priorities of R&D allowing clear annual reporting to levy payers and other stakeholders, establishing how expenditure on the ground had been targeted to delivering the agreed priorities.

Consultation with growers and the outcomes of the 2007 ABARE grower survey, suggest that for growers the highest priority for R&D is pest and disease management followed by higher yielding varieties, farm productivity and market development.

3. Methodology

Although HAL has funded work to assess the economic returns from some individual projects, it has not previously assessed the impact of its entire R&D program. The following methodology used in this report is informed by the guidelines produced by the CRRDCC (2007) and the Land and Water Australia (LWA) (2007) methodologies. A review of the key CRRDCC Guidelines (2007) and the steps taken in the development of this project to address their key points, as well as the reasoning for any variations from their methodology is included at **Appendix B**.

3.1 Methodology Process

3.1.1 Data Gathering and Review

The initial stages of the project involved a project inception meeting, literature review and data collection exercise. This work set the context for the study and established why the project was needed. The review included the Productivity Commission Report (2007) into returns from R&D activity and the CRRDC guidelines (2007) on completing ROI assessments of R&D expenditure and the latest industry strategic plans including VegVision 2020 (2006) and Future Focus (2008).

An assessment of the way in which R&D priorities are established and how Vegetable Levy R&D expenditure has been allocated to HAL Research Areas and stated vegetable industry priorities was then completed.

3.1.2 Initial Stakeholder Consultation and Sub-Program Selection

A consultation exercise was conducted with over 100 industry stakeholders to determine the sub-programs and projects they considered had produced the greatest returns to growers and the public over the last ten years.

Since 1998-99, HAL has managed over 581 projects for vegetables many of which have run over multiple years. It was not practical to review all of these projects in sufficient detail to evaluate the return on investment and so a targeted sampling technique was required. Due to the wide scope of projects undertaken in the last decade, it was appropriate to obtain stakeholder views on the sub-programs and individual projects, which they felt had provided the greatest return to levy payers.

The CRRDC guidelines suggest using a random sampling approach to select projects for review and then aggregating the outcomes to produce a sub-program and eventually a whole of portfolio assessment. However, the guidelines also recognise the need for a pragmatic approach. Given that this review covers a ten-year period, it was agreed with the Steering Committee that it was not appropriate to review sufficient numbers of projects in each of the ten years to record a statistically significant result to aggregate up to a total portfolio return. Instead projects have been selected to demonstrate a positive return on total R&D expenditure from even a modest selection of projects. It is expected a rolling three-year review process will follow on from this initial review and use a random sampling approach.

The sampling approach used in this study is similar to that used in the LWA (2007) methodology (2007), which states:

'When commencing a portfolio ROI assessment, it is sensible to attempt to evaluate the highest-performing investments first, as these will contribute the most to the final ROI figures.'

The LWA (2007) methodology also notes:

'In 2006, the [previous] selection process was replaced with a pragmatic approach to the selection of projects, innovations and programs, based primarily on timing of completing programs, but also corporate knowledge availability, topicality and emergence of new information and methods …'

HAL provided details of more than 100 stakeholders, all were contacted up to four times, initially by HAL via email to introduce the project and then followed up by phone. In all, 45 stakeholders were interviewed, with most interviews lasting between 30 minutes and one hour. The interviews included a discussion of the HAL projects the stakeholder had either been directly involved in or were aware of, the project outcomes, successful aspects of each project and areas that could be improved. A summary of the stakeholders contacted and their comments is included at **Appendix C**. At the end of the consultation, an initial set of sub-programs and suggested projects for further review had been identified.

3.1.3 Identified Sub-Programs

Growers in particular consistently identified similar research areas as the most successful. The identified sub-programs are:

- Minor use chemical scheme;
- Integrated pest management;
- Productivity improvements;
- Environmental management;
- Supply chain management;
- Water use management;
- Soil borne diseases;
- Grower education, development and collaboration; and
- Management and administration;

Following consultation with growers and other key stakeholders who were able to identify specific projects, fifty projects (across all sub-programs) were identified as having the potential for further investigation. These projects had run for a combined total of 176 years (the longest running project had run for seven years) and together accounted for approximately 25 percent of all vegetable R&D expenditure since 1998-99. However, on further investigation, some projects were not appropriate for assessment due to:

- Incomplete findings (for projects that had started recently and not yet reached final conclusions);
- The original researchers were no longer contactable or willing to assist;
- Some project reports had insufficient information to allow desktop assessment of the return on investment; and
- The project had not yet resulted in a benefit, either because it was still in the very early stages of adoption or where the findings would be used to inform future work rather than to be rolled out to growers.

From the original list, 39 projects were identified for analysis. Several projects are continuations or extensions of previous work and have effectively been delivered as one continuous project with the final report of earlier projects effectively a milestone or progress report on the overarching project. These related projects have been analysed as one overarching project.

Not all sub-programs have been assessed due to a lack of projects which could provide suitable information to inform the analysis. In some cases, i.e. management and administration, this expenditure is purely to support other projects. In other cases, projects had been completed by researchers who could not be contacted to provide comment or who were unable or unwilling to assist in the review process. The sub-programs which have not been assessed are water quality management and supply chain management. It is anticipated work in these areas is likely to increase in the short to medium term and projects in these sub-programs should be reviewed during future reviews of R&D expenditure. However, it was not possible to identify projects with sufficient data for assessment at this stage.

3.2 Key Assumptions and Data Sources

Some key assumptions have been used throughout the analyses. To avoid duplicating these for each assessment they are set out below. Where any project varies from these assumptions, the variance and the revised assumption are stated within the case study.

- All values are expressed in 2008 dollars unless otherwise stated;
- In accordance with the CRRDCC Guidelines (2007), a common discount rate has been adopted for all CBAs. For projects whose main output is private (levy payers), the rate is 7.15 percent (calculated as the long-term bond rate[3] plus 3 percent). For those projects whose main benefits accrue to the public, a 4.15 percent discount rate is used (calculated as the long-term bond rate);
- The economic planning period is 20 years from first project expenditure because the impact of discounting beyond this time scale makes the value of any cash flows beyond this time very small. To ensure a conservative assessment, the analysis does not include a salvage value at the end of the period as rates of technological change and innovation are likely to erode project benefits beyond 20 years and including a salvage value may overstate the benefits;
- Unless otherwise stated, assumptions have been based on information contained within research reports, augmented by the views of a range of stakeholders acquired throughout the consultation process;
- For each project assessed, an ongoing maintenance cost has been estimated, which reflects the ongoing expenditure required to maintain the benefits of the projects findings (e.g. additional extension and education activity, further research or the registration of newer chemical control mechanisms);
- Lower domestic production is likely to lead to a combination of substitution by imports, price increases and consumers buying substitute goods, some of which would be within the vegetable sector and some of which would be within the other food sector. Where relevant, details of these assumptions are stated prior to the CBA;
- Where growers who chose not to adopt the R&D findings are forced to grow other crops, it has been assumed the value of the crop is ten percent lower than the original crop value;
- Many of the pests and diseases that are the subject of these projects have emerged over the last ten years. Although there are likely to be new pests and diseases that emerge in the next ten years, growers will still rely on the control techniques developed through these projects, and many of the benefits that have been identified will continue throughout the period under assessment;
- A 'no change' scenario has also been developed along with the counterfactual and 'with R&D' scenarios. The 'no change' scenario assumes that all vegetable outputs increase by the forecast rate of national population increase to 2028 in line with ABARE (2007), which stated that:

  'Trends in per person [vegetable] consumption in both Australia and other developed countries suggest that per person consumption of vegetables is unlikely to increase significantly in the short term to medium term. This implies that the rate of population growth in Australia will be a major factor, influencing demand for vegetables.'

- The 'no change' scenario also assumes that there is no change to the growing area for each commodity (reflecting increased productivity over time) and that commodity prices increase in line with the mid-point of the Reserve Bank of Australia's inflation target of 2.5 percent per annum;
- Adopting new growing techniques and management practices often also allows growers to reduce the absolute volume of chemicals applied as well as the toxicity of those chemicals to non-target species. The value of this benefit has been assessed using an Environmental Impact Quotient (EIQ) (details are available at **Appendix E**);

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[3] Long-term bond rate - Treasury Fixed Coupon Bonds maturing May 2021 released 28th January 2009

- A standard EIQ has been used for 'old style' chemicals such as synthetic pyrethroids and organo-phosphates based on the broad spectrum chemical with the lowest EIQ; and
- A standard EIQ has been used for 'new style' chemicals such as Spinosad, Success, Gemstar and BT sprays based on the new chemical with the highest EIQ.

3.3 Assessment Methodology

A standard project assessment methodology was developed, to ensure all projects were assessed on an equal basis and to simplify final reporting. Each project assessment uses a consistent set of headings as set out in the following table.

Table 3.1. Stages in Project Assessment Methodology

Project Stage	Description
Project Description	• This section provides a succinct introduction to provide an overview of the project, including as appropriate: o The project rationale - explaining the reason the work was needed; o The aims and objectives of the research; o The commodity/s that were likely to be affected; o Any previous related projects; and o The geographic significance of the project – where was it undertaken and the growing regions where its results are likely to be relevant.
Project Deliverables	• This section describes what the investment in each project actually produced on completion. In other words, what HAL (and through HAL the levy payers) received for their investment.
Project Adoption	• This section establishes the anticipated adoption scenario for each assessment in terms of the total area of production that could potentially adopt the findings, the maximum proportion of the potential area expected to adopt the project findings and the length of time to maximum adoption. • An 'S-shaped' adoption curve was used unless otherwise stated.
Identification of Impacts	• This section identifies the tangible outcomes (benefits and costs) associated with each project. • Each impact is classified according to whether it was predominantly economic, social or environmental and classified as being either quantitatively or qualitatively assessed and whether the impact applies to levy payers, the public or both. • Where it was not possible to quantify costs and benefits in dollar terms a qualitative impact assessment framework has been applied to provide an objective measure of these impacts • Qualitative impact assessment frameworks are well recognised as an appropriate approach for assessing economic, social and environmental impacts. In the assessment, impacts on growers are assessed as the impact on all levy payers not only those immediately affected by a project and impacts on the public are assessed as the impact on the whole of the Australian public.
Counterfactual Case	• A counterfactual case was developed for each project to isolate the impacts of the R&D expenditure from changes likely to have occurred irrespective of each project. The counterfactual case considered: o What benefits would have been lost had the project not been funded? o Would the project have happened without the funding provided by HAL? o Has the project produced any benefits that may not otherwise have emerged? o Would the same outcomes have emerged from overseas research and how long would the lag-time have been? o Are other groups working on substitute technologies which might make the project findings obsolete? o Without the input of HAL, would other groups have supported the project? o Has the involvement of HAL increased adoption rates? • Not all aspects of the counterfactual case are relevant to every project, however, these points provide a framework around which the counterfactual cases were developed.

Project Stage	Description

Cost Benefit Analysis	• Cost benefit analysis (CBA) is an analytical tool used to aid decision-makers in the efficient allocation of resources. It identifies and attempts to quantify the relative costs and benefits of a project or proposal and converts available data into manageable and comparable information units. The strength of the method is that it provides a framework for analysing complex and sometimes confusing data in a logical and consistent way.
	• CBA assesses the impact of a situation by comparing the "with" and "without" (counterfactual) scenarios, and helps decision makers answer questions such as:
	  o Does the proposed project provide a net financial benefit?
	  o Should the proposed action, be implemented?
	• The key decision criteria that are investigated in the CBA are:
	  o Net present value (NPV): Represents the present value of all benefits minus the present value of all costs. If the net present value is positive, (i.e. present value of benefits is greater than the present value of costs) then the option or project is considered economically desirable and will provide net benefit; and
	  o Benefit cost ratio (BCR): Is the present value of benefits divided by the present value of the costs. If the resulting BCR is greater than one (1) then the option or project is considered economically desirable and will provide net benefit. The higher the BCR the greater the quantified economic benefits compared to the quantified economic losses.
	• Where the results of the analysis meets these decision criteria, expenditure on the project under review is considered to have produced a net benefit.

Sensitivity Analysis	• The CBA calculations are based on a series of variables, in some instances these variables are based on estimations and assumptions, made using the best available information. It is important that some analysis of the outcomes of CBA exercise is undertaken to test out the sensitivity to the key variables used. A sensitivity analysis has been undertaken for each CBA to demonstrate the impact of a range of scenarios on the overall CBA outcomes.

Confidence Rating	• There are limitations on the data used and after each project assessment, a confidence rating has been applied based on a review of the risks associated with the figures used. The confidence ratings are high, medium and low and are defined as:
	  o **High -** Good coverage of benefits or reasonable confidence in the assumption made.
	  o **Medium -** Reasonable coverage of benefits and/or some significant uncertainties in assumptions.
	  o **Low -** Poor coverage of benefits or many uncertainties in assumptions.

Results Analysis

Each cost and benefit is identified in a table stating the cost per unit (including per tonne, year or hectare) and the present value of the cash flows over the twenty year assessment period. The discount rate set out by the CRRDCC (2007) guidelines for assessment of R&D expenditure is the benchmark rate used in present value calculations. Results under alternative discount rates are also reported.

The CBA outcomes are also presented to demonstrate the division of cost and benefits over time (five, ten and twenty years) and between levy payers (direct impacts) and the public (indirect impacts).

Reporting

This report represents the confidential reporting component, including the methodology that has been used, the outcomes of the assessment of the identified projects and sub-programs and recommendations on potential development of the management of the vegetable R&D program. A summary of this report will be available to the general public, highlighting the overall return to levy payers and the general public from the Vegetable Levy R&D program.

3.4 Data Limitations

The variable nature of the vegetable sector, with many growers operating a wide range of production systems and multiple growing areas and timings mean that it is inevitable there will be some data limitations. Where these issues have been identified, a range of techniques have been used to fill any gaps.

3.4.1 Vegetable Growing Area, Production and Prices

The assessments utilise data from a range of sources including the 2004 Australian Horticulture Statistics Handbook, AusVeg statistics, ABARE and grower information. Where data gaps exist, Australian Bureau of Statistics (ABS) published data on historical crop area, production and value has been used to fill these gaps. The ABS notes the estimates used are based on information obtained from respondents to the Agricultural Census (2006) and because not all selected units responded, the estimates may differ from those that would have been produced if all farms had responded.

The ABS does note that the number of growers included in the Agricultural Census is increasing and whilst it does not contain all agricultural businesses in Australia, it is expected to provide better coverage than the previous Agricultural Surveys.

It is difficult to assess the likely reliability of these data and some stakeholders have suggested that the published ABS data is considerably different to actual performance. For example, ABS data suggests sweet corn production decreased by 39.7 percent between 2005 and 2006, whilst stakeholders suggest that in fact production increased between these years.

In some instances, the collection frequency of these data is inconsistent, with gaps of a few years between published figures. Missing data has been estimated by assuming a linear interpolation between the missing data points. Although it is unlikely that this mirrors the reality, it does allow assessment of commodities where records have not been maintained and is unlikely to be a significant misrepresentation.

3.4.2 Growing Area, Production and Prices in Future

In order to review the likely impact of research findings into the future, it is necessary to estimate future production and productivity. In line with the ABARE forecasts, it has been estimated that counterfactual production will increase at the same rate as the forecast growth in the Australian population over the same period using the medium series projections (and that the growing area for each commodity will remain constant). In this way the counterfactual case will reflect the anticipated productivity gains which are expected to occur irrespective of R&D expenditure as a result of general technological improvements.

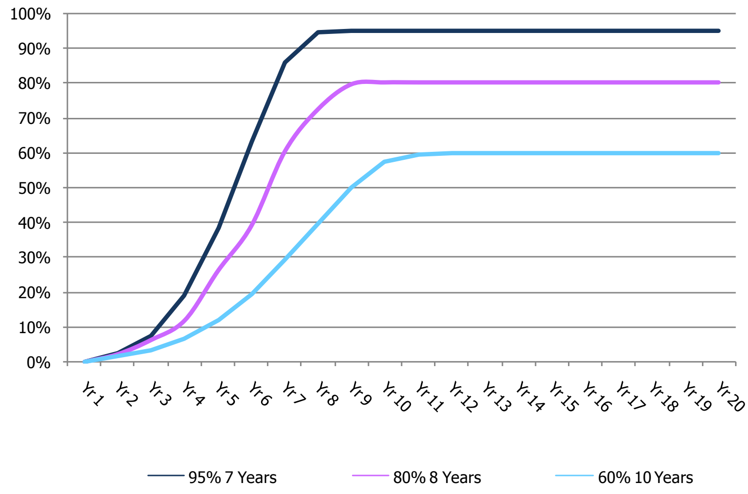
3.4.3 Grower Adoption Rates

Consultation with growers often raised issues about a shortage of education and extension activity at the end of projects and equally researchers often raised the issue of insufficient project funding to finance significant extension exercises. This issue is an inherent part of R&D. Researchers must balance the need for rigorous research and analysis against the need to communicate findings to growers. One outcome of this is that there is very little funding available for follow up reviews to gauge the extent to which growers have adopted the findings of a particular project.

In the following analysis adoption rates are based on information provided by stakeholders (growers and researchers). Given their experience in the relevant commodities these are considered to be reasonably accurate (with +/- 10%).

In assessing the rate of adoption, the CBA model uses an adoption curve to reflect the likely rate of uptake from the commencement of extension activities to the maximum achievable adoption. Each adoption scenario notes both the maximum adoption level and the length of time over which this maximum adoption is achieved. The following figure highlights three examples of potential adoption curves.

Figure 3.1. Example Project Adoption Rate Curves



Source: AEC*group*

The curves reflect the likely early adoption scenario as some growers are likely to start implementing findings as soon as they are published. For example, where a trial has taken place on their/neighbouring properties. The next wave of adoption is likely to follow the project extension and education phases, leading to a sharp increase in the proportion of growers that have adopted the findings. Finally, less formal communications including industry development officers, agronomists and word of mouth leads to further increases. Very few projects will achieve 100 percent of the total potential adoption rate due to a range of factors including:

- Fragmented nature of the industry, which means there are a lot of growers to convince;
- Change resistance (especially given the grower age profile which might dissuade some levy payers from committing to capital investments); and
- The effect of natural variables which may make some findings impractical in some areas/industries.

3.4.4 Useful Life Estimations

The period over which R&D findings are effective is influenced by a range of factors including the speed at which new technology becomes available, the emergence of new pressures (e.g. a new pest or disease) as well as the underlying economic conditions. Each of these factors represents a significant unknown in assessing the period of time over which a project outcome would continue to provide benefits. It would be anticipated that some benefits will be eroded gradually over a significant period of time, while other benefits may disappear almost instantly.

An assumption is required about the actual length of the useful life of the benefit of the R&D projects. In this assessment, it is assumed that growers receive full project benefits for ten years from the start of project extension activities. At the end of that period the benefits decline at a rate based on the project in question. These assumptions are stated in each benefit identification table.

3.5 Identified Issues and Learning

In preparing and applying this methodology several issues and learning points have emerged:

- A standardised assessment methodology has been developed to assess the identified projects/groups of projects. This follows the majority of the guidelines issued by the CRRDCC (2007) and where these have not been practical the reasoning behind the different approach has been included in **Appendix B**.

- In some instances, it is apparent there are data gaps and although a series of assumptions have been adopted in their place, this does increase the margin of error in the results. A conservative (and precautionary) approach has been used throughout the assessments. It is likely that as a result the assessed outcomes represent the minimum likely return from the projects.
- In many cases, little information was available surrounding the anticipated detrimental or beneficial impacts associated with the R&D project outcomes prior to research being undertaken. This raises questions about the identification of key issues prior to funding allocations and the way in which projects are nominated and approved.
- In many cases, while there is some information on the extension activities that were undertaken, there is little, if any published or officially recorded information surrounding subsequent uptake of project findings.
- Some projects were not assessed due to a lack of available data. This does not mean they failed, just that there was insufficient information recorded in order to undertake an informed and accurate assessment. In the majority of such cases this was due to the length of time since the project had been completed.
- In many cases, the environmental and social outcomes were not quantified as the volume of benefits could not be identified. In other cases, this was further confounded by a lack of available and appropriate values in order to quantify the identified impacts.
- In many cases, the reports focus on reporting activity (number of trials completed, cultivars tested) rather than outcomes achieved (percentage crop loss reductions).

4. Review of Sub-Programs

4.1 Introduction

This chapter provides a brief introduction to each of the assessed sub-programs and summarises the outcomes of the analysis of the projects selected for review. Details of the assessments, including all identified project impacts, assumptions used in the modelling and the qualitative assessments are included in subsequent chapters nominated A-E.

4.2 Minor Use Chemical Scheme

4.2.1 Introduction

The minor use chemical registration scheme projects gather the data required to gain approval from the Australian Pesticides and Veterinary Medicines Authority (APVMA) for chemicals to be used on crops other than those stated on the product label. This research is needed because large chemical companies are focused on gaining approval for the use of the chemical in question in the major commodities in major producing nations where they can recover their costs from large sales volumes. Relative to overseas horticultural production (and production of other commodities such as grains), Australian horticultural output is considered too low for many of the major chemical companies to accept the necessary licensing costs.

The minor use chemical registration scheme provides growers with a means of legally accessing the available chemical control options, which would not otherwise be available. Any product found with traces of a chemical which does not have the necessary registration would be destroyed and the producer liable to fines. Further, breaches of insecticide approvals are likely to have a detrimental impact on consumer demand.

The minor use chemical registration scheme was the most frequently cited example of successful project work funded through the Vegetable Levy. In the opinion of many of the growers consulted (across multiple commodities and growing regions), their businesses and those of other growers would be unsustainable without this work. Since 1999, HAL has funded $9.1 million ($2008) of project expenditure on minor use chemical registrations for the vegetable sector.

The philosophy of plant pest control has evolved over the past ten years, with a greater understanding of pest dynamics and the development of alternative control measures beyond pesticides. Despite problems associated with insecticide resistance and public concern over the direct and indirect impacts of chemical usage in agriculture, chemical control measures remain an integral part of the vast majority of vegetable growing systems.

The following projects have been identified as examples where the minor use registration scheme had made a significant impact. In both cases, the chemicals were registered to support broader pest and disease management strategies including physical, cultural and biological management mechanisms. The following assessments concentrate on the chemical control aspects although all costs of the related projects are also included in the analysis. It is recognised the achieved outcomes are the result of combinations of control mechanisms of which chemical control is an integral part and the full costs of developing the control mechanisms have been included in the analysis.

4.2.2 Projects Assessed

Two clusters of projects have been chosen for assessment under this sub-program, the first relates to work to combat losses as a result of Lettuce Aphid, the second work to combat losses as a result of Western Flower Thrips. Other clusters of projects which were considered for assessment include Silver Leaf White Fly, Brassica Leafy Vegetables and White Blister. In each case, this work related to activities required to register chemical control mechanisms which would not otherwise have been legally available to growers, as part of overarching integrated pest and disease management strategies.

4.2.3 Sub-Program Summary

The minor use registration scheme is an integral component of the vegetable growing industry in Australia and has produced significant benefits to growers and the public. The benefits fall into two principle categories, the first relates to providing growers with access to the most effective disease and pest management tools and the second relates to aiding the transition from broad spectrum chemicals to better targeted products which are less environmentally damaging.

By registering newer less harmful chemicals, the scheme ensures that Australian growers are able to have access to the latest chemical technologies allowing them to control pests, respond rapidly to new infestations, maintain yields and reduce environmental impacts.

For the wider community, the scheme ensures that chemical use is properly regulated and that the chemicals used are appropriate to the commodity in question and appropriate withholding periods are observed. Without the scheme, it is almost certain that vegetables would be more expensive, imports would increase and varietal choice would decrease. Where broad spectrum insecticides were still in use the detrimental environmental and public health impacts would also be more severe. The following table summarises the quantifiable impacts of the two projects assessed under this sub-program since 1998.

Table 4.1. Minor Use Chemical Registration Sub-Program Summary ($2008 million)

	PV Costs		PV Benefits		NPV		BCR	
	Private	Public	Private	Public	Private	Public	Private	Public
Lettuce Aphid	$14.6	$0.7	$377.1	$26.6	$362.6	$25.9	25.9	39.6
WFT	$18.5	$2.7	$635.4	$32.3	$616.9	$29.6	34.4	12.1
Total	**$33.1**	**$3.3**	**$1,012.5**	**$58.9**	**$979.4**	**$55.5**	**30.6**	**17.6**

Notes: Totals may not sum due to rounding
Source: AEC*group*

The assessment of the projects estimates the combined NPV to be $1,035.0 million. This equates to an overall project BCR of 29.4 (where the total BCR is calculated as the sum of public and private benefits divided by the sum of public and private costs), which suggests that for every dollar invested, these projects returned an average of $29.43. The BCR for levy payer's investment is 30.6 and 17.6 for the public, offering both investor groups significant returns on their investments in these projects.

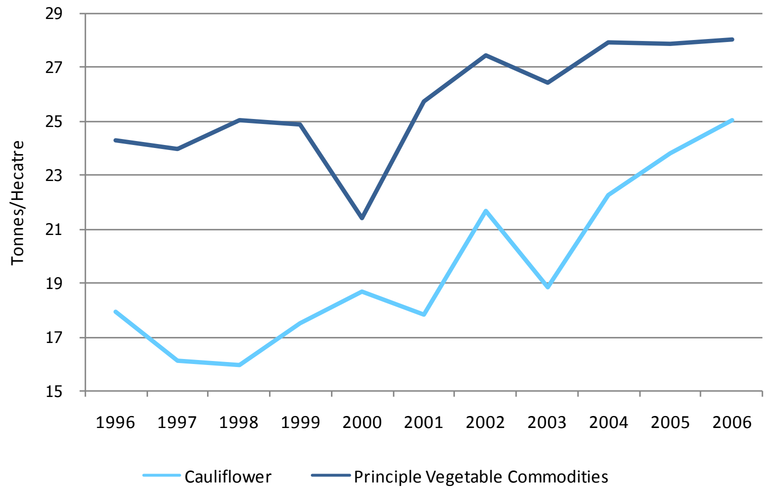
It is estimated that over the period in question, HAL has funded approximately $9.1 million ($2008) of projects in this sub-program. However, it is recognised this assessment cannot be used to project an overall sub-program return as the projects assessed were selected from suggested highlights rather than from a random sample.

4.3 Productivity Increases

4.3.1 Introduction

The following figure demonstrates the average increase in principle vegetable commodities and cauliflower yields per hectare over the last ten years. In common with vegetable production in other countries, production efficiency has increased steadily over this period and growers must continue to increase their productivity by at least similar levels to their competitors in order to maintain their current position. Only by finding new means of increasing faster than this trend can growers develop a competitive advantage.

Figure 4.1. Principle Commodities and Cauliflower Production Increases 1996-2006



ABS (Various Years)

Whilst it is technologically possible to increase yields beyond their current levels, these gains must be offset against the economic (as well as social and environmental) costs of achieving them. Growers will only adapt their current operations when there is a clear net gain resulting from the adoption of a new management technique or investing in new equipment.

4.3.2 Project Assessed

The project chosen for assessment relates to work on developing techniques to allow the harvesting of brassica crops using fewer passes. Harvesting accounts for a significant proportion of grower variable costs including direct and indirect costs of additional labour requirements. Further, as the project relies on accurate application of inputs in order to manage the timing of crop maturity, growers are able to benefit from reduced inputs costs.

4.3.3 Sub-Program Summary

The following table summarises the impact of the projects assessed under this sub-program. Productivity increases are important in maintaining the competitiveness of the Australian vegetable sector both in terms of defending domestic market share against overseas production and in trying to increase vegetable exports.

Table 4.2. Productivity Increases Sub-Program Summary ($2008 million)

	PV Costs		PV Benefits		NPV		BCR	
	Private	Public	Private	Public	Private	Public	Private	Public
Crop Maturity	$3.2	$0.4	$108.5	$7.8	$105.3	$7.4	33.4	18.1
Total	**$3.2**	**$0.4**	**$108.5**	**$7.8**	**$105.3**	**$7.4**	**33.4**	**18.1**

Notes: Totals may not sum due to rounding
Source: AEC*group*

The assessment of this project estimates the total NPV is $112.6 million. This equates to an overall project BCR of 31.7 (where the total BCR is calculated as the sum of public and private benefits divided by the sum of public and private costs), which suggests that for every dollar invested, these projects returned an average of $31.65. It is estimated growers would receive benefits with an NPV of $105.3 million and the public would receive benefits with an NPV of $7.4 million. The quantified return to growers is estimated to result in a BCR of 33.4 and 18.1 to the public.

It is estimated that over the period in question, HAL has funded approximately $8.6 million ($2008) of projects in this sub-program. However, it is recognised this assessment cannot be used to project an overall sub-program return as the projects assessed were selected from suggested highlights rather than from a random sample.

4.4 Integrated Pest Management

4.4.1 Introduction

Integrated pest management (IPM) describes a holistic approach to crop management, which attempts to provide growers with a range of complimentary tools to control pest activity. This represents a significant shift from what might be described as 'traditional methods', which relied on the timed application of broad spectrum insecticides (including organo-phosphates and synthetic pyrethroids). The timed or 'calendar spraying' approach to pest management was very widely adopted in Australia and other developed countries where the increasing mechanisation of agriculture and the development of highly effective chemical control measures allowed growers to achieve significant reductions in labour and other input costs.

From around the late 1980s, three main factors emerged to reduce the effectiveness of this approach:

- Increased government regulation of the use of chemical control measures;
- Growing consumer awareness of health and environmental impacts associated with some chemicals; and
- Increasing pest resistance to some chemicals, especially where one product had been used repeatedly as the sole means of pest control.

IPM strategies can be different for each crop and between growing regions, however, they all seek to integrate cultural, biological, physical and chemical control methods. Growers can choose the extent to which they adopt IPM strategies and in many cases significant variations in the management activities undertaken by two growers can be observed.

4.4.2 Projects Assessed

The two projects assessed in the IPM sub-program include a significant cluster of projects around control of the Diamond Backed Moth (DBM) and its impacts on brassica crops and the control of Heliothis damage in the sweet corn sector which was faced with the threat of collapse due to insecticide resistance in the registered chemicals. In both cases, a holistic approach has been developed to the management of pest activity which incorporates biological, chemical, physical and cultural practices. As well as addressing the immediate pest issue at hand both projects have developed techniques with additional benefits for other projects. In the case of DBM work the development of the 'two-window' spraying strategy is likely to have increased the effective life of the chemicals used by limiting resistance build up, in the case of sweet corn the identification of the additional effectiveness of boom sprayers with droppers in targeting the chemicals applied has highlighted the need for more sophisticated application techniques.

4.4.3 Sub-Program Summary

The following table summarises the impacts of the projects assessed under this sub-program. It is widely acknowledged by almost all stakeholders that IPM is a central component of the sustainable future of the vegetable industry. Better understanding of pest populations and how they fit into their ecosystem has facilitated the development of the type of holistic pest management systems outlined above.

In each case, chemical control measures remain an important component of the overall management approach but are no longer the sole control measures. This reduces immediate risks to growers, maintains their ability to supply domestic markets, keeping domestic process lower. This approach also encourages the use of less harmful chemical measures with significantly reduced impacts for non-target species, water ways and other habitats as well as growers and others living nearby the area being sprayed.

IPM is likely to continue to play a key role in vegetable production in the medium to longer term. However, it is important to recognise that as yet there is no price premium to growers who have adopted IPM. Growers will typically only adopt this style of management where it can provide an improved financial return. This usually happens when the scale of losses incurred using older style broad spectrum insecticides is greater than the additional costs of the adopting IPM.

Table 4.3. Integrated Pest Management Sub-Program Summary ($2008 million)

	PV Costs		PV Benefits		NPV		BCR	
	Grower	Public	Grower	Public	Grower	Public	Grower	Public
DBM	$25.2	$3.1	$194.8	$20.2	$169.6	$17.1	7.7	6.5
Sweet Corn	$17.7	$3.7	$123.2	$25.4	$105.5	$21.6	7.0	6.8
Total	**$42.9**	**$6.8**	**$318.0**	**$45.6**	**$275.1**	**$38.7**	**7.4**	**6.7**

Notes: Totals may not sum due to rounding
Source: AEC*group*

Assessment of both projects estimates the combined return on investment as $313.9 million. This equates to a BCR of 7.3 (where the total BCR is calculated as the sum of public and private benefits divided by the sum of public and private costs), which suggests that for every dollar invested, these projects returned an average of $7.31. Of the total return on investment, it is anticipated that 87.7 percent ($275.1 million) would accrue to growers with the remaining 12.3 percent ($38.7 million) accruing to the public. However, these benefit distributions include the return on funds invested only by growers. The project BCRs indicate a much closer distribution of funds, recognising that much of the return to grower is the result of additional investment which the public does not make.

It is estimated that over the period in question, HAL has funded approximately $43.3 million ($2008) of projects in this sub-program. However, it is recognised this assessment cannot be used to project an overall sub-program return as the projects assessed were selected from suggested highlights rather than from a random sample.

4.5 Environmental Management

4.5.1 Introduction

At a time of growing awareness of environmental issues in general and in particular the effects of human activities, growers need to be increasingly aware of their environmental impacts for a variety of reasons including:

- Increasing scarcity and cost of water (both irrigation and non-irrigation);
- Cost of non-compliance with environmental control regulations;
- Potential future impacts of a carbon pollution reduction scheme;
- Consumer perceptions of the vegetable growing industry;
- Duty of environmental care requirements; and
- Securing the long-term sustainability of the vegetable growing sector.

A first step towards greater awareness of environmental issues is for growers to assess their current actions using an objective and systematic approach. For some growers, although environmental management can appear complex and time consuming it is likely that they are already carrying out many of the actions that would be prescribed under an environmental farm management plan (pers. comm. H Whitman 13th Nov 2008). Another reason why some growers might be slow to adopt formalised environmental management is a perception that it will incur significant additional costs with a low direct return. While larger operators might consider a two percent saving in water consumption per annum as representing a significant cost saving, for smaller growers a two percent saving in water consumption might be an insufficient return to justify the initial outlay required. However, while reducing one grower's water use by two percent is a small benefit, from the perspective of the environmental impact of Australian horticulture, reducing total water consumption by two percent would represent a significant saving.

It is important that growers are supported through the process of assessing the current environmental impact of their operations, preparing environmental management plans to address areas of concern and to highlight examples of good practice. It is also important to communicate growers' efforts to consumers and the wider community, which might perceive the industry to be environmentally harmful, especially as result of media stories about the use of insecticides. Communication of growers' environmental efforts will ensure appropriate recognition of the programs vegetable and horticultural producers have in place.

4.5.2 Projects Assessed

The cluster of projects assessed under this sub-program relate to the EnviroVeg program. This cluster is identified as one of the early stage projects which have the potential to deliver significant benefits going forward. It is likely the program would continue to be developed and might potentially lead to the establishment of an independently audited and accredited environmental quality management system.

4.5.3 Project Summary

The following table summarises the impact of the projects assessed under this sub-program. Environmental compliance is an increasingly important issue for growers who must respond to legislative and consumer pressure to operate in less environmentally damaging ways and to demonstrate these changes. There are also potential savings to growers and the public from growers adopting techniques and practices that reduce input wastage. For many growers the costs of employing a consultant to advise on environmental management is too expensive and so EnviroVeg is an opportunity to assist these growers in assessing their current operations and identifying areas for improvement.

Table 4.4. Environmental Management Sub-Program Summary ($2008 million)

	PV Costs		PV Benefits		NPV		BCR	
	Grower	Public	Grower	Public	Grower	Public	Grower	Public
EnviroVeg	**$1.5**	**$1.5**	**$13.8**	**$4.6**	**$12.3**	**$3.1**	**9.0**	**3.0**

Notes: Totals may not sum due to rounding
Source: AEC*group*

The assessment of this project estimates that the total project NPV is $15.4 million. This produces an overall BCR of 6.0 (where the total BCR is calculated as the sum of public and private benefits divided by the sum of public and private costs), which suggests that for every dollar invested, these projects returned an average of $6.12. Quantifiable benefits to growers ($12.3 million BCR 9.2) are higher than those to the public ($3.1 million BCR 3.0) however, the project has the potential to develop over time to provide greater public benefits through adoption of more detailed environmental controls and subsequent reduction in externalities. There are also significant qualitative benefits associated with the project, which are assessed in the benefit identification table.

In the longer term, it is likely this project will continue to develop as growers become increasingly aware of the need to control their environmental impacts and demonstrate to legislators and consumers that they have appropriate environmental management controls in place. It is also likely any response to the potential carbon reduction scheme would need to be co-ordinated through a similar scheme which would help individual growers assess their carbon impact and what steps they could take to reduce this.

It is estimated that over the period in question, HAL has funded approximately $4.2 million ($2008) of projects in this sub-program. However, it is recognised this assessment cannot be used to project an overall sub-program return as the projects assessed were selected from suggested highlights rather than from a random sample.

4.6 Soil Borne Diseases

4.6.1 Introduction

Soil borne diseases are a significant threat to several vegetable commodity groups in Australia. In the projects described below, growers faced considerable uncertainty due to the scarcity of information regarding the diseases in question as well as the direct threat of the disease itself. Unlike many insect problems, where the pest and the damage it causes can be easily observed, in the case of soil borne pathogens (especially where this is no soil test available) growers may be unaware of the presence of the disease, incur all of the costs of preparing, planting, managing and harvesting the crop only to discover that it has been destroyed and must be discarded. Unless a grower can correctly identify the disease, they may even plough in a diseased crop or plant an alternative host crop, inadvertently increasing the concentration of the pathogen in the soil before replanting in the following season and repeating the cycle.

4.6.2 Projects Assessed

Three projects have been assessed under this sub-program. The first relates to a cluster of projects undertaken to develop management controls for Clubroot in brassica crops. This involved the establishment of a whole system approach from seed nursery to harvest. As well as the outcomes relating to Clubroot, the work also led to the development of an incorporator which has made significant improvements to crop production and grower profitability. The second project relates to managing root and stem diseases in beans. This project has been identified as an early stage project with the potential to generate significant future returns. The work already completed is likely to be the foundation for future research into these diseases and the development of additional control mechanisms. The final project in this sub-program relates to the control of Pythium disease in carrots. Carrots are Australia's largest vegetable export crop (AusVeg 2009) and the control of Pythiums which can impact the cosmetic appearance of the crop (and thereby make it unacceptable for export and some domestic markets) has significant consequences for the horticulture sector.

4.6.3 Sub-Program Summary

The following table summarises the impacts of the projects assessed under this sub-program. Soil borne diseases are a significant threat to a range of vegetable crops, and losses are often compounded by inadvertent spread of the diseases and difficulties in recognising and managing the diseases once they have been identified. At the same time, soil management techniques are attempting to adopt more integrated approaches which do not rely on soil fumigants as the only method of control.

The following table summarises the CBA outcomes of the three projects assessed.

Table 4.5. Soil Borne Diseases Sub-Program Summary ($2008 million)

	PV Costs		PV Benefits		NPV		BCR	
	Grower	Public	Grower	Public	Grower	Public	Grower	Public
Beans	$0.3	$0.3	$11.9	$1.9	$11.6	$1.6	35.9	5.8
Clubroot	$29.0	$1.5	$172.9	$34.8	$143.9	$33.3	6.0	22.9
Carrots	$1.2	$1.2	$88.9	$33.0	$87.6	$31.7	71.6	26.6
Total	**$30.6**	**$3.1**	**$273.7**	**$69.7**	**$243.1**	**$66.6**	**8.9**	**22.5**

Notes: Tables may not sum due to rounding.
Source: AEC*group*

Assessment of the three projects estimates the NPV of both investments to be approximately $309.7 million, with a combined BCR of 10.2 (where the total BCR is calculated as the sum of public and private benefits divided by the sum of public and private costs). It is estimated that 78.5 percent of the NPV ($243.1 million) would accrue to growers, with the remaining 21.5 percent ($66.6 million) accruing to the public. As in previous sub-programs, the assessed projects provide growers with a greater aggregate return ($243.1 million) compared to the return to growers (NPV 66.6 million). However, as a factor of the investment required it appears that the public receive a greater return relative to the size of their investment. The overall BCR for the three projects assessed is 8.9 for growers but 22.5 for the public.

It is important to remember these benefits only represent the quantifiable impacts of the project. There are several other project impacts, which would be expected to provide benefits to growers and the public, which have been assessed qualitatively in the benefit identification table of each project.

It is estimated that over the period in question, HAL has funded approximately $21.5 million ($2008) of projects in this sub-program. However, it is recognised this assessment cannot be used to project an overall sub-program return as the projects assessed were selected from suggested highlights rather than from a random sample.

4.7 Grower Education & Development

4.7.1 Introduction

The primary focus of R&D supported through the Vegetable Levy and Government matched funding has been on work with a set of explicit outcomes, which can then be adopted to provide a tangible benefit to growers and the broader community. However, R&D expenditure is also assigned to projects which are focussed on longer term development of the industry and its participants. Although these types of projects tend to have longer payback periods and have less readily quantified benefits than some other projects, they contribute to the overall development of the sector. Consultation with levy payers suggested these types of project are considered an essential component of the overall R&D program.

4.7.2 Sub-Program Summary

The benefits of these projects are found throughout all of the other assessments and so a quantitative assessment has not been undertaken to avoid double counting. However, it is essential that the contribution these projects make to the overall success of the R&D program and the wider industry is recognised. Grower consultations rated these case study projects particularly highly and in particular the work of the Industry Development Officers (IDOs).

5. Summary of Findings

5.1 Return on Investment

5.1.1 Quantitative Assessment

The following table shows the present value of the costs and benefits of each of the projects assessed. The case study programs assessed in this review and presented in the table below approximated $20.0 million ($2008) in direct R&D expenditure (i.e. does not include additional grower costs of implementing the findings). Projects in this assessment comprised 13.5 percent of the total R&D allocation for the period (11.5 percent are assessed quantitatively).

Table 5.1. Return on Investment from Assessed Projects ($2008 million)

Project/s	NPV			BCR		
	Grower	Public	Total	Grower	Public	Total
Minor Use Chemical Registration	**$979.4**	**$55.5**	**$1,035.0**	**30.62**	**17.63**	**29.43**
Lettuce Aphid	$362.6	$25.9	$388.5	25.88	39.59	26.48
WFT	$616.9	$29.6	$646.5	34.35	12.11	31.55
Productivity Increases	**$105.3**	**$7.4**	**$112.6**	**33.43**	**18.14**	**31.65**
Harvest	$105.3	$7.4	$112.6	33.43	18.14	31.65
Integrated Pest Management	**$275.1**	**$38.7**	**$313.9**	**7.41**	**6.65**	**7.31**
DBM	$169.6	$17.1	$186.7	7.73	6.49	7.59
Sweet Corn	$105.5	$21.6	$127.1	6.97	6.79	6.94
Environmental Management	**$12.3**	**$3.1**	**$15.4**	**8.96**	**3.01**	**5.99**
EnviroVeg	$12.3	$3.1	$15.4	8.96	3.01	5.99
Soil Borne Diseases	**$243.1**	**$66.6**	**$309.7**	**8.94**	**22.55**	**10.19**
Beans	$11.6	$1.6	$13.2	35.94	5.80	20.87
Clubroot	$143.9	$33.3	$177.2	5.95	22.93	6.80
Carrots	$87.6	$31.7	$119.3	71.63	26.56	49.09
Total	**$1,615.2**	**$171.3**	**$1,786.5**	**15.50**	**12.23**	**15.11**

Notes: Totals may not sum due to rounding
Source: AEC*group*

The assessed projects are estimated to have produced a total net present value of $1,786.5 million, of which 90.4 percent is estimated to accrue to growers, with the remaining 9.6 percent accruing to the public.

These figures include the additional investments made by growers in order to adopt project findings in addition to their levy payments. The BCR for growers and the public offer an assessment of the return relative to the size of the investment made. This indicates growers received approximately $15.50 for every dollar invested and the public received $12.23 for every dollar they invested, a much closer outcome.

These case studies are recognised to include several strong performing examples of the return from HAL supported vegetable levy R&D investment and as a result cannot be used to estimate a return on the whole program expenditure. However, over the last ten years, HAL has funded approximately $14 million ($2008) of R&D expenditure per year, the annual average NPV over the 20 year period studied is approximately $89.3 million ($2008), indicating the indicative return on investment from the projects assessed is considerably greater than the total R&D investment.

5.1.2 Qualitative Assessment

The majority of quantified economic benefits accrue to growers. Grower benefits are more readily quantified as they tend to be either cost or market impacts and subsequently have a dollar value attached to them. Public benefits are more likely to be intangible, especially environmental and social outcomes. In the majority of cases the impact of individual projects are limited. However, in aggregate the overall impact of the Vegetable Levy R&D program is significant.

The majority of the impacts assessed using a qualitative approach fall under the social category, reflecting difficulties in quantifying these impacts. However, it is important that these are considered in any review of return from R&D expenditure. Significant benefits, which have been assessed qualitatively, include the contribution of R&D outcomes towards:

- **Regional and national economies**: Direct expenditure by growers can be significant and supports employment in a wide range of related industries. The flow on impacts of grower expenditure (as it passes through the rest of the economy) also provide additional economic benefits.
- **Sustaining a competitive Australian vegetable sector:** A sustainable Australian vegetable sector is likely to increase grower confidence about the long-term future of their business, encouraging investment in new technology and other production improvements. For the wider community, the benefit is in the form of increased choice, lower environmental impacts and in some case lower prices.
- **Sustaining regional communities:** Growers and their families make a significant contribution to regional communities both through their participation in the community and by contributing to the population mass needed to secure the continuation of critical services including school and health facilities. Without R&D, it is likely some growers would leave the industry (and regional areas) reducing the sustainability of some communities.
- **Supporting research and development positions:** The Australian Government has identified science and innovation as a key priority which will contribute to the nation's long-term development and prosperity. By funding approximately $14 million ($2008) of R&D expenditure each year the program makes a significant contribution to the maintenance of a vibrant research community, which is appropriately skilled and experienced. R&D skills developed on HAL projects are often applicable across multiple agriculture sectors.
- **Avoided environmental impacts associated with transporting and storing imported products:** Commodities which could no longer be grown competitively in Australia would either need to be replaced by imports or would no longer be available. Imported commodities are likely to have significant environmental impacts associated with the additional transport and storage required relative to domestic production.

5.1.3 Confidence Rating

The heterogeneous nature of vegetable growers, their operations and properties mean that any overall analysis must rely on a series of assumptions and estimates informed through the best available information. However, the detailed knowledge of individual researchers and the extensive nature of the stakeholder consultation undertaken mean that confidence in the data and assumptions utilised in the development of this assessment and the subsequent results is high.

5.2 Assessment Outcomes

Assessment Outcomes for the Levy Payer

- The HAL managed Vegetable Levy R&D expenditure has resulted in a clear benefit to growers. The projects examined in these case studies identified:
  - A total NPV of $1,615.2 million to growers, representing a BCR of 15.5.
- The assessment of the returns to growers includes their contributions to the levy and the implementation costs associated with some projects;
- In addition to the quantifiable benefits to growers, R&D funded work has also contributed to the benefits which have been assessed qualitatively including:
  - Improved sustainability of the Australian vegetable production sector; and
  - Reduced risks to grower health.

R&D Alignment to Priorities

- It is considered that the overall vegetable R&D program reflects Government and grower priorities and provides a positive return on investment. Through their input to the Industry Advisory Committee through industry groups and other methods, growers have the opportunity to communicate their priorities for the R&D program. Consultations suggest that the primary areas of grower focus are in pest and disease management (supported by the findings of the 2005-06 ABARE survey, ABARE 2007) and this is reflected in the observed distribution of expenditure; and
- Growers expressed the high value they place on project expenditure which facilitates the adoption of project findings and provides opportunities for grower development, even where these projects may not provide an obvious short-term return.

Assessment Outcomes for the Public

- The HAL managed Vegetable Levy R&D expenditure has also produced a clear benefit to the public. The projects examined in these case studies identified:
  - A total NPV of $171.3 million to the public, representing a BCR of 12.2.
- The assessment of the returns to the public only includes their contribution to the cost of the R&D activities;
- In addition to the quantifiable benefits to the public, R&D funded work has also contributed to the several benefits which have been assessed qualitatively including:
  - Maintenance of regional communities;
  - Increased consumer choice;
  - The maintenance of a vibrant R&D sector; and
  - Reduced environmental impacts associated with the importation of vegetables.

Market Impacts of R&D Expenditure

- Very few of the projects assessed had a direct focus on market expansion. In many cases, the work undertaken was critical to defending market share (domestic and export) in the face of significant increased production and competitiveness from lower cost producing countries such as China;
- The R&D program must be seen within the context of multiple external factors. The emergence of China as a major competitor in export markets, in particular, where price is a differentiating factor has significantly eroded the market for Australian vegetable exports, especially in South-East Asian markets. As a result, few projects have had any discernable impacts on the expansion of export markets for Australian vegetables. However, many projects have resulted in the maintenance of export markets against competition from lower cost producers, quite often through a quality differential; and

- Several projects did establish the opportunity to expand into new export markets, for example by allowing growers to produce crops to the standards required. However there are overwhelming macro-economic factors that ultimately impact the success of these markets, such as cost pressures from other countries, climate production windows and trade restrictions. Continued R&D is expected to contribute to the maintenance and potentially the development and/or expansion of export and domestic markets for Australian vegetable production.

Distribution of R&D Benefits

- Throughout the supply chain, the majority of benefits have accrued to growers in the form of avoided crop losses and efficiency increases. Although, as many growers do not recognise their own time as an input cost, some benefits may have been overlooked;
- The other major identified supply chain beneficiary was the consumer. The retail sector has exerted price pressures on growers and generated efficiencies in procurement and supply chains and the major supermarkets in particular have been able to access significant benefits in terms of the profitability of their vegetable produce. It is likely these benefits have been shared between the retail sector and the consumer;
- The distribution of benefits to various supply chain stakeholders has been limited by the shortage of projects for review relating to the processing and transportation sectors;
- Although the aggregate return on investment is greater to growers, this is largely due to the additional investments growers make on top of the levy contributions in order to access the full quantifiable benefits of the R&D. Comparing BCRs, which assess returns relative to investment, produces a more equitable outcome and subsequent return on investment; and
- The projects have provided a range of economic, social and environmental benefits to both growers and the public including:
    - Reduced crop losses;
    - Reduced externalities as a result of the use of pesticides and other chemicals;
    - Avoidance of vegetable imports;
    - Reduced grower operating costs; and
    - Strengthening of rural communities.

Summary

- In all, the projects examined quantitatively totaled an estimated vegetable R&D expenditure of $17.1 million ($2008) and were assessed as producing an average BCR of 15.1 on over the ten years 1998-99 to 2007-08, which implies a return of $15.11 for every dollar invested; and
- Despite these returns, it is considered unlikely any other organisation would fund these types of projects due to the relatively small size of the Australian horticultural sector (on a global scale) and the difficulties in finding an appropriate and effective cost recovery process (other than a levy).

5.3 Project Learning

Key points of learning from the project include:

- A standardised assessment methodology has been developed to assess the identified projects/groups of projects. This follows the majority of the guidelines issued by the CRRDCC (2007) and where these have not been practical the reasoning behind the different approach has been included in **Appendix B**;
- In some instances, it is apparent there are data gaps and although a series of assumptions have been adopted in their place, this does increase the margin of error in the results. A conservative (and precautionary) approach has been used

throughout the assessments. It is likely that as a result the assessed outcomes represent the minimum likely return from the projects;

- In many cases, little information was available surrounding the anticipated detrimental or beneficial impacts associated with the R&D project outcomes prior to research being undertaken. This raises questions about the identification of key issues prior to funding allocations and the way in which projects are nominated and approved;
- In many cases, while there is some information on the extension activities that were undertaken, there is little, if any published or officially recorded information surrounding subsequent uptake of project findings;
- Some projects were not assessed due to a lack of available data. This does not mean they failed, just that there was insufficient information recorded in order to undertake an informed and accurate assessment. In the majority of such cases this was due to the length of time since the project had been completed;
- In many cases, the environmental and social outcomes were not quantified as the volume of benefits could not be identified. In other cases, this was further confounded by a lack of available and appropriate values in order to quantify the identified impacts;
- In many cases, the reports focus on reporting activity (e.g. number of trials completed, cultivars tested) rather than outcomes achieved (e.g. percentage crop loss reductions);
- The HAL work program continues to address a wide range of vegetable R&D priorities including reactive management of pest and disease outbreaks as well as broader strategic industry development. The program also addresses the broader goals of the Australian Government R&D program;
- There is a need for some researchers to consider the impacts of their work and how findings will be adopted by growers, including key data relating to costs and benefits. This data is essential for any future program evaluation. During interviews, some researchers had little or no idea about the extent of adoption or the impact of their work when it was put into practical application. To address this it is recommended:
    - A set of measures are agreed before each project is funded;
    - The measures are specific and quantifiable; and
    - The measures provide the information necessary to undertake a return on investment review.

  This approach would allow easier and more transparent assessment of all projects funded (it is not recommended that every project is assessed but this approach would increase the available choice);
- Projects should be assigned to a sub-program at the time of approval. This would assist in the management of the R&D program by allowing HAL to assess the alignment between stated priorities and expenditure. This facility would also be very useful when subsequent reviews of R&D expenditure are undertaken allowing easy identification of the pool of projects from which the random sample of projects for review will be chosen. New sub-programs could be added as required;
- Many of the outcomes of current projects will be used to develop future research which could not take place without these 'building blocks' or 'frameworks' which makes 'discrete' return on investment analyses difficult. (For example, the Integrated Pest Management principles will remain in place even though the chemical controls used will eventually need to be replaced);
- Growers identified the minor use chemical registration and Industry Development Officer programs as having the greatest benefit for their business. However, in some instances there was limited understanding of the full suite of research and subsequent impacts and benefits, indicating that many growers' comments were related to what they see and hear;
- Although grower development projects may appear expensive given the number of attendees, the findings are often disseminated over a much wider audience after the

event with growers more likely to be open to findings communicated by another grower than through other mechanisms. Projects that support the long-term development of grower capabilities are very important as they provide opportunities that may not otherwise be available to the vast majority of growers and help to drive a continual improvement process;

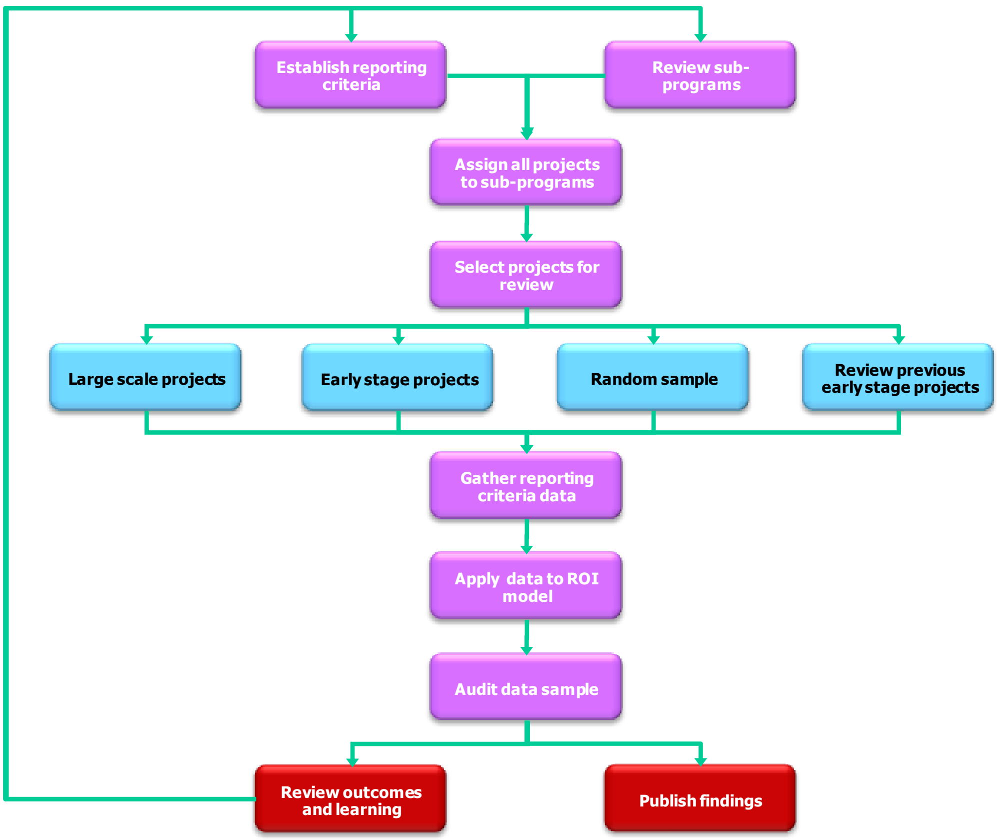
- It is important to recognise the social impacts of projects, which despite being challenging to evaluate have the potential to provide significant benefits to growers and the public;
- There is a need to address the disconnection experienced by some growers between project findings and their practical application. This is apparent through the importance that growers place on the Industry Development Officer network and the success of projects like the Integrated Pest Management for brassica crops DVD; and
- The HAL vegetable R&D program makes a significant contribution to maintaining and developing the skills of research practitioners throughout Australia, this not only benefits the vegetable sector, but also other related sectors which can benefit from this skill and experience in the research community.

5.4 Recommended Structure for Future Assessments

Having completed this initial review of the return from vegetable R&D expenditure between 1998-99 and 2007-08, HAL now has basis from which to establish a rolling review program. Although the review program should be tailored to meet the needs of HAL, it should also follow the review guidelines as established by CRRDCC (2007).

The following diagram outlines one potential review process although the chosen approach should also consider links between the reviews of other HAL R&D programs.

Figure 5.1. Potential Rolling R&D Review Structure



Source: AEC*group*

In essence this revised structure uses the same cost and benefit identification and assessment techniques as this study. The two principle changes between the above assessment structure and the one used in completing this study are the selection process for projects to be assessed and the method of data collection:

Sub-Program and Project Selection

Having completed this initial ten-year review, a rolling program should be established with a random sampling project selection mechanism which meets all of the requirements of the CRRDCC guidelines (2007). However, before any projects can be selected, a review of the sub-programs should be undertaken to ensure they are still appropriate. For example, earlier grower consultation suggested hydroponics as a potential sub-program area, however, closer assessment found this group of projects was yet to deliver significant benefits. This sub-program may become more important in later assessments.

Outcome Reporting Framework

The most difficult element of the review has been establishing data on the impact of the projects on the ground. Some researchers have found it challenging to describe the effect a project is likely to have had at either the level of the individual grower or the commodity sector as a whole. The assessment process above is based on the adoption of the recommendation that for every project as well as the media and technical summary, every final report must report on a set of agreed measures. This would make assessing the return on investment (and the distribution of the return between levy payers and the public) simpler and more transparent as well as improving the researchers' goals on delivering projects with practical applications. The types of measures which could be recorded include:

- Percentage of growing area over which the findings can be applied;
- Percentage of growers likely to adopt the findings (and how quickly);
- Likely price and quality impacts; and
- Likely demand impacts.

These measures could easily be tailored to each project. At the end of the project the final report would include an *ex ante* assessment of each measure to provide some guidance and context surrounding the expected returns that my result from the extension of the R&D findings. This data could be used as inputs to the three-year rolling review, with data capture focusing on validating information and assumptions rather than primary data collection. It is important that researchers realise the need to capture 'with R&D' data estimates and the counterfactual 'without R&D' data estimates.

6. Assessment User Guide

The following chapters detail the assessment of each project and have a uniform structure. This chapter provides the reader with a guide to each stage of the assessment structure, establishing the tasks and outcomes associated with each stage. This aims to guide the reader through each of the case study assessments which compromise the sub-program assessment.

Figure 6.1. Assessment Stages, Tasks and Outcomes

Assessment Stage	Tasks	Outcome
Project Description	Briefly introduce the project/s included in the assessment, the original need for the project and other relevant contextual information	Provides background to the project/s and commodity affected
Project Deliverables	Describe the principle project outputs	Summarises what was delivered following the investment
Adoption Rates	Establish the quantum and rate of change including: •Area over which R&D findings are applicable •Maximum area and rate of R&D adoption •Growing area maintained in production (by non-adopters) •Growing area taken out of production (by non-adopters) •Rate at which R&D findings are eroded •Price impacts	Establishes impact scenarios that describe what happened and when as a result of the R&D outputs
Identification of Impacts	Identify and categorise each impact by: •Cost/benefit •Economic/social/environmental •Quantitative/qualitative •Grower/public	Identifies the project impacts and then assesses each one to determine what difference they make
Counterfactual, No Change and With R&D Scenarios	Establish three scenarios: Counterfactual Scenario – what would happen without the R&D findings No Change Scenario - what would happen according to long-term growth trends With R&D Scenario – what would happen according to the identified assumptions	Establishes three scenarios to provide a context against which to asses the identified impacts
Cost Benefit Analysis	Conduct a CBA of R&D outcomes to determine the present value of all quantifiable costs and benefits to growers and the public Identify project NPV and BCR	Values the cost and benefits to arrive at a net position for the project/s
Sensitivity	Assess the impact of combinations of changes to the critical assumptions used in the CBA on the CBA outcomes	Assesses the extent to which the project net position is reliant on key variables
Confidence	Assess the degree of confidence in the findings based on consultations and comparison with alternative data sources	Assesses the degree of uncertainty around the data used in the CBA

Source: AEC*group*

Each of the following assessments follows this structure, allowing easier comparison between the projects being assessed and over time. On completion the outputs are used to inform the sub-program summary.

A. Minor Use Chemical Scheme

A.1 Minor Use Registration for Control of Lettuce Aphid in Head Lettuce Varieties

A.1.1 Project Description

Lettuce Aphid destroys head lettuce by burrowing into the head causing losses of up to 100 percent of an affected crop. In 2006-07, head lettuce was grown in significant volumes in Queensland, New South Wales, Victoria, Tasmania, South Australia and Western Australia and had a gross value of production of approximately $152.3 million (ABS 2008).

Lettuce Aphid was identified as a pest in New Zealand lettuce in 2002, before arriving in Tasmania in January 2004 (and subsequently spreading throughout the rest of Australia over the ensuing twelve months). The only totally effective way to test for Lettuce Aphid was to cut each lettuce open. This is impractical in the fresh market, increasing the risk of consumers purchasing a diseased lettuce and only discovering it is diseased as the lettuce was about to be consumed. This could potentially have had a significant negative impact on demand and repeat instances are unacceptable to consumers and therefore also retailers and consumers.

Project VG04068 *(Generation of efficacy and residue data for Confidor (imidacloprid) in leafy and head lettuce for control of lettuce aphid (Nosanovia ribis-nigri))* aimed to develop data to support the registration of Imidacloprid (Confidor™), which had been found to be an effective chemical control for Lettuce Aphid but which was not registered for use on head lettuce in Australia. This chemical control could then be used support other (non-chemical) management techniques developed through the related projects:

- VG04039 *(Allocation for Lettuce Aphid R&D)*;
- VG04067 (*Integrating Currant Lettuce Aphid into IPM for lettuce: a commercial trial)*; and
- VG05044 *(Further developing integrated pest management for lettuce).*

While the chemical registration was not intended to provide the sole control mechanism, it was needed to allow growers to maintain their production (and market share) before being included as one component of an integrated approach.

A.1.2 Project Deliverables

Once Lettuce Aphid was discovered in New Zealand, the Australian lettuce industry recognised there was a significant risk it would spread to Australia. It was also known that the source populations had developed resistance to the available chemical controls in the USA and that the insecticides that were registered for use in Australia would be ineffective.

Having identified the serious risk to the head lettuce sector, HAL provided funding for the required registrations to ensure the appropriate chemicals were available for use should the Lettuce Aphid spread to Australia. When Lettuce Aphid was first identified in Tasmania in January 2004, the necessary permit registration data had been developed and an emergency minor-use permit was prepared and issued within two days. This effectively prevented the collapse of the Tasmanian lettuce industry (pers. comm. P Dal Santo Director AgAware Consulting Pty 11th February 2009). Minor use permits were then issued for all states as the pest spread throughout lettuce growing regions. The protocols for Lettuce Aphid control in lettuce with Imidacloprid (Confidor™) are still in place and operating today (pers. comm. P Dal Santo 11th February 2009).

A.1.3 Project Adoption

Lettuce Aphid is a potential pest in all head lettuce growing regions, and it has been assumed that the project findings are applicable across 100 percent of Australian production. In the following CBA it assumed:

In the following CBA it is assumed:

- 90 percent of total head lettuce production was grown using the outputs of this work within three years of minor use registration in 2004;
- Of the remaining growing area (10 percent):
  - 50 percent was used to grow the same crops, sustaining enduring 20 percent losses; and
  - 50 percent was switched to alternative (less profitable) crops.

A.1.4 Impact Identification

The following table introduces the identified project impacts and introduces the basis of the calculations used in the CBA. Where it has not been possible to assign a dollar value to an impact, a qualitative assessment has been used, the details of which are included in the table.

Table A.2. Impact Identification Table

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
	Economic Costs		
Project and Related Expenditure	**Project costs:** • The four projects associated with this project had combined costs of $717,708, equivalent to $749,559 ($2008).	Quantitative	Both
	Ongoing maintenance costs: • Annual ongoing maintenance costs are estimated to be $50,000 per annum ($2008).	Quantitative	Both
Project Implementation Costs	**Increased chemical costs:** • Chemical costs are based on nine applications per crop with average costs of $250 per hectare for broad spectrum insecticides and $907 per hectare for the newly registered chemical control measures. • The older chemicals are less expensive as in many cases the patent protection has expired. • It could be argued that these additional costs should not be included as the high levels of resistance in Lettuce Aphid mean they would be much less effective than the newer chemical controls. However, a conservative approach has been adopted, recognising the additional costs of the new chemistry and assuming the same number of applications per crop. • To reflect the declining efficacy of older chemicals, their costs are assumed to reduce by ten percent per annum after the initial extension activities begin. The scale of benefits received (in the form of reduced externalities) is reduced by the same factor.	Quantitative	Grower
	Economic Benefits		
Avoided Loss	**Avoided crop losses:** • It is assumed crop losses of 20 percent per annum are experienced on properties that continue to operate without adopting the project findings. • Ten years after the minor use registration, the average loss experienced by non-adopters is assumed to reduce by two percent per annum (reaching zero after a further ten years), reflecting the adoption of other chemical control measures and alternative technologies in the future. • The value of avoided crop losses has been calculated as the annual loss rate multiplied by the total output of growers that have adopted the project findings.	Quantitative	Grower
	Avoided lost revenues: • For non- adopters (following crop losses of 20 percent) it is assumed that within five years of the project extension activities 50 percent of growers would switch production to the next most profitable crops. • Alternative crops are assumed to be ten percent less profitable than growing head lettuce. • As the benefits of the R&D diminish over time, growers would be expected to return to growing head lettuce.	Quantitative	Grower

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted

Avoided Price Increase	**Avoided higher priced imports:**
	• Although the project is not considered to have developed any new markets, it is likely to have protected the domestic market from overseas competition. It is anticipated that if growers sustained repeated heavy crop losses, with no effective means of controlling the pest and there had been repeated incidents of consumers purchasing a diseased product, domestic market share would have eroded by overseas production and that:
	  ○ Head lettuce prices would be 5 percent higher than under the 'no change scenario' due to scarcity of supply
	  ○ Higher prices would encourage consumers to purchase substitute goods
	  ○ Domestic demand would be lower with 10 percent of production losses replaced by imports
	• This avoided additional cost (under the R&D adoption scenario) is included as a benefit to the consumer and is calculated as the cost of substituting 10 percent of the reduction in head lettuce production with imported products which are 5 percent more expensive.
		Quantitative	Public

Economic Contribution	**Contribution to regional and national economies[a]:** • In 2006-07, the head lettuce sector has a gross value of production of $152.3 million (ABS 2008) and was grown on 351 properties in almost every state and territory. Direct grower expenditure contributes to regional economies in the lettuce growing regions and to the national economy and there are also likely to be flow-on benefits associated with this additional economic activity. It is **likely** (will probably occur in most circumstances) that this group of projects has prevented a reduction in the economic contribution of the head lettuce growing sector, resulting in a **negligible** (unlikely to be measurable against benchmarks) public benefit. Resulting in a **low** impact score.	Qualitative	Public
	Social Benefits		
Reduced Social Impact	**Reduced risks to physical and mental health:** • Growers (and their families) affected by Lettuce Aphid would be expected to experience considerable stress relating to the short-term viability of their business and its long-term prospects. The projects undertaken to control Lettuce Aphid provide growers with control mechanisms, which whilst not infallible do give growers far greater control. It is thought **almost certain** (expected to occur in most circumstances) that this provides a **negligible** (unlikely to be measurable against benchmarks) social benefit to growers. Resulting in a **low** impact score.	Qualitative	Grower
	Strengthening regional communities: • Growers contribute to their local communities in a wide range of ways including their participation in community activities as well as the contribution they make to retain the critical population mass needed to sustain other rural sector businesses and community services including schools and health care facilities. It is **almost certain** (expected to occur in most circumstances) that head lettuce growers provide a **negligible** (unlikely to be measurable against benchmarks) social benefit to regional communities. Resulting in a **low** impact score.	Qualitative	Public
	Increasing the sustainability of the Australian vegetable sector: • This project has provided growers with tools to manage Lettuce Aphid and has helped to ensure the continuation of a viable head lettuce sector in Australia. In doing so, the project has contributed to the sustainability of the vegetable sector as a whole, which encourages growers to make investments in equipment and other technology as well as giving them re-assurance about their own positions and the likelihood of being able to pass on a viable operation to the next generation of their family. This is **likely** (will probably occur in most circumstances) to provide a **minor** (small relative to the wider context of the population/area being affected) benefit to growers. Resulting in a **medium** impact score.	Qualitative	Grower

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
	Skill and knowledge development: • In developing the data necessary for the minor use registration application, researchers have continued to develop their skills including the adoption of the Good Laboratory Practice Guidelines. The knowledge gained in developing this permit application can be used to better inform work in other vegetable and non-vegetable sectors in future. • These projects have also contributed to the development and retention of R&D posts in Australia as well as developing researchers' knowledge and skills. This helps to retain researcher skills within Australia and has the potential to lead to benefits in other related fields. • This is considered **almost certain** (expected to occur in most circumstances) to provide a **negligible** (unlikely to be measurable against benchmarks) benefit to growers and a **negligible** (unlikely to be measurable against benchmarks) public benefit. Resulting in **low** impact scores.	Qualitative	Both
Environmental Benefits			
Reduced Environmental Impact	**Reduced environmental impacts of grower activity:** • The externalities of the chemicals registered through the minor use schemes are estimated to be approximately $1.39 per application per hectare (Leach and Mumford 2008), significantly lower than externalities associated with older chemicals (approximately $22.09 per application per hectare) (Leach and Mumford 2008). • In the analysis, it is assumed there are nine chemical applications per crop using both the old and new chemicals. This is a conservative assumption as during periods of intense pest activity growers using 'older style' insecticides may be forced to spray on a more frequent basis, especially where resistance levels are significant. • The benefits of adopting the new chemicals are allocated between growers and the public based on the average allocation of externalities for all chemicals studied by Leach and Mumford (2008). The total benefit is calculated as the difference in externalities per hectare per application between applying the old and new chemicals, multiplied by the number of applications and the area adopting the R&D findings.	Quantitative	Both
	Reduced indirect environmental impacts: • If domestic production had collapsed, it would be expected that demand would fall as higher prices encouraged consumers to switch to lower cost alternative products. Remaining demand would be met from overseas production with associated environmental impacts as a result of the additional transportation and storage. It is **almost certain** (expected to occur in most circumstances) that avoiding these additional transport costs has produced a **negligible** (unlikely to be measurable against benchmarks) public benefit. Resulting in a **low** impact.	Qualitative	Public

Notes: (a) Should the flow on impacts be quantified in dollar terms they should not be incorporated into the CBA, as per Australian Treasury Guidelines (Australian Government, 2006).
Source: AEC*group*

A.1.5 Counterfactual Case

A.1.5.1 What are the main benefits that would have eluded growers without this project?

The principle benefit is the ability to control losses to Lettuce Aphid. This not only saves on wasted input costs, it increases yields, maintains and/or develops consumer confidence in the product quality, maintains the competitiveness and subsequently market share of the sector against international competitors and keeps prices lower for consumers. Without this project it is likely that the head lettuce sector would not have been viable to survive in Australia and 30-60 percent of all head lettuce grown would need to be discarded (pers. comm. P. Dal Santo 11th February 2009).

Losses on this scale would incur significant additional growing, harvesting, handling and processing costs across the remaining saleable crop as there would be no cost recovery for the diseased lettuce. In some cases, the remaining saleable crop might not be worth harvesting, because the cost per hectare may exceed the potential revenues.

It is likely that without this group of projects the head lettuce industry would have become unviable within a few years given the rapid rate at which insecticide resistance develops in Lettuce Aphid as observed overseas and the fact that when the pest arrived in Australia it had already developed a significant degree of resistance to existing chemical control mechanisms. If the domestic industry had become unviable, significant price increases would be expected, which would subsequently reduce domestic demand with consumers switching to alternative food groups and remaining domestic demand likely met from higher priced overseas production.

A.1.5.2 Would the project have happened without the funding provided by HAL?

It is unlikely major chemical companies would undertake or fund the research needed to register a chemical for minor use in the majority of horticulture crops in Australia (pers. comm. P Dal Santo 11th February 2009). Whilst some companies might be willing to assist minor use registrations by providing data developed overseas (the company will have this data if the chemical has been approved for use on the same or similar commodities in other jurisdictions), manufacturers generally focus on developing and registering new products, not adding new crops to old products.

In some instances, companies are also concerned that possible over use in one (smaller) industry or market will breed resistance reducing the effectiveness of the chemical in a larger (and therefore more lucrative) industry or market. For example, in the sweet corn sector, chemical companies were reluctant to permit the minor use registration of narrow spectrum insecticides for use in sweet corn in case over use developed resistance in a pest which also affected cotton crops.

A.1.5.3 Has the project brought forward any benefits that may not otherwise have emerged?

Without these project findings and the registration of new chemical controls, growers would either have had to take land out of production or try to find alternative crops to grow that were suited to their property and had a viable market. Where such a viable market existed, it is likely the returns from the alternative crop would have been lower than for head lettuce, as otherwise an economically rational grower would have planted the alternative crop in the first instance.

In addition to the potential crop losses, outcomes of not funding the minor-use program could include:

- If a grower's crops were threatened by pest insects, growers may take the risk of using product off-label. This could lead to rejection of the produce if discovered;
- The variety of crops produced would decline as growers were forced to focus on crops and cropping systems with lesser plant pest issues, thereby reducing availability and increasing prices;
- Growers would be forced to only use the available registered pesticides, which would likely result in their overuse and the rapid and/or increased development of resistance; and

- Growers would be forced to rely on biological control systems, which are not currently adequate as a sole management method.

A.1.5.4 Would the same outcomes have emerged from overseas research and how long would the lag-time have been?

As discussed above, the chemical control measures are usually developed overseas for use in major commodities. However, without the HAL funding, it is unlikely that these chemicals would be registered for use in Australian horticulture.

A.1.5.5 Are other groups working on substitute technologies which might make the project findings obsolete?

Over the last ten years, there has been a shift away from calendar based insecticide spraying programs towards more integrated management approaches which make use of a range of techniques (including chemical control) to manage pest populations. If a successful biological control measure could provide the same level of control as applying chemicals at a lower cost it is likely growers would adopt that technique in place of chemical controls. However, other than for the organic sector, chemical controls remain an integral component of all Integrated Pest Management strategies and it is unlikely that this will change in the short to medium term.

A.1.5.6 Has the involvement of HAL increased adoption rates?

HAL's grower support network and information dissemination structures are likely to have increased adoption of the project findings, however, given the risks facing the industry it is likely in this instance growers would be aware of the project and they would have had sufficient incentive to adopt the project findings.

A.1.6 Cost Benefit Analysis Results

The following table summarises the economic cost impacts used in the CBA (no social or environmental costs were identified as being associated with the project).

Table A.2. Present Value of Project Costs

Costs	Cost ($2008)	Present Value ($M)		
		6.00%	7.15%	9.00%
Project cost	$717,708	$0.9	**$0.9**	$1.0
Ongoing costs (per annum)	$50,000	$0.8	**$0.8**	$0.7
Increased chemical cost	$657[(a)]	$13.8	**$13.9**	$14.1
Total		**$15.5**	**$15.6**	**$15.8**

Notes: Totals may not sum due to rounding (a) per hectare per crop
Source: AEC*group*

The present values of the economic costs of the projects are estimated to be $15.6 million. Total project costs and ongoing costs would be split equally between levy payers and the public, however, growers alone would be faced with the higher chemical costs.

The following table summarises the economic benefits from the project.

Table A.3. Present Value of Project Benefits

Benefits	Benefits ($2008)	Present Value ($M)		
		6.00%	7.15%	9.00%
Avoided crop losses	$18.92/tonne	$371.1	**$359.6**	$343.5
Avoided lost revenues due to switching crops	$9.46/tonne)	$18.1	**$17.4**	$16.5
Import savings	$4.73/tonne)	$27.0	**$26.1**	$24.8
Reduced risks to physical and mental health	$2.79[(a)]	$0.1	**$0.1**	$0.1
Reduced environmental impact of grower activities	$20.70[(a)]	$0.5	**$0.5**	$0.5
Total		**$416.7**	**$403.7**	**$385.4**

Notes: Totals may not sum due to rounding (a) per hectare, per application.
Source: AEC*group*

The total present value of the stream of benefits from the projects is estimated to be $403.7 million over a twenty year period to 2021. The majority of this benefit is associated with the avoided crop losses that would have been expected as a result of Lettuce Aphid without these projects. However, significant benefits are also observed to flow to consumer from avoided price increases from imports. The table below outlines the distribution of costs, benefits and net present value between levy payers and the public.

Table A.4. CBA Outcomes ($2008 million)

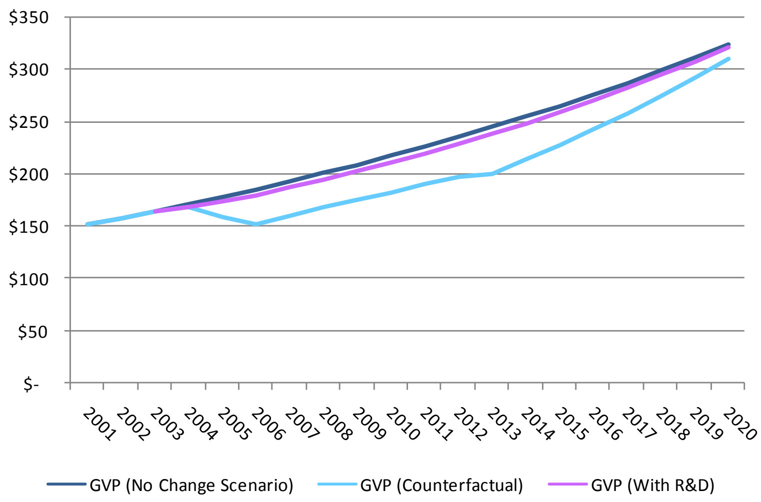
Discount Rate	PV Costs		PV Benefits		NPV		BCR	
	Grower	Public	Grower	Public	Grower	Public	Grower	Public
6.00%	$14.6	$0.8	$389.2	$27.5	$374.6	$26.6	26.6	32.7
7.15%	**$14.7**	**$0.8**	**$377.1**	**$26.6**	**$362.4**	**$25.7**	**25.6**	**31.5**
9.00%	$15.0	$0.9	$360.1	$25.3	$345.1	$24.5	24.1	29.6

Notes: Totals may not sum due to rounding
Source: AEC*group*

The above table demonstrates that this work produces a positive return on investment to both growers ($362.4 million) and the public ($25.7 million). Benefits to growers are principally related to avoided crop losses, reduced externalities associated with chemical use and avoided reductions in profitability. Benefits to the public relate to the significantly lower environmental externalities associated with the newer chemical controls and avoiding price increases above the rate of inflation a result of reduced domestic supply.

The following figure compares the gross value of production (GVP) between the no change, counter factual and with R&D adoption. The 'with R&D' case includes output from growers adopting the project findings, those that continue to grow head lettuce despite incurring significant losses and those that transfer production to alternative crops.

Figure A.2. Gross Value of Production Comparison ($ million)



Notes: Relative change in GVP is not equal to total project NPV as it does not include all project costs and benefits
Source: AEC*group*

It can be seen from the chart that:

- As soon as the losses are experienced, the GVP of the counterfactual case decreases significantly;
- Due to the pre-emptive nature of the research project and its subsequent strong adoption, there is little difference in the gross value of production between the 'no change' and the 'with R&D' scenarios;
- Over time, as the project benefits start to be eroded, both the 'counterfactual' and 'with R&D' scenarios show an increase in GVP growth rate as crop losses by growers that did not adopt the R&D findings reduce as a result of underlying technological change and growers that switched to growing other crops return to the head lettuce sector; and
- Over the longer term, the 'with R&D' and 'counterfactual' scenarios both trend back to the 'no change' scenario due to assumed underlying technological change as the R&D related benefits are assumed to have been superseded by new technology.

This is a conservative scenario, if it were assumed that technological change was slower to return the counterfactual case to the 'no change scenario' the project benefits would be larger. Another scenario would see any growers that did not adopt the findings forced to leave the sector due to the high crop losses. In this case, the counterfactual GVP would be expected to be zero within a few years, further highlighting the conservative nature of this assessment.

The following table shows the distribution of benefits to growers and to the public over five, ten and twenty years from the start of the project.

Table A.5. NPV of Grower and Public Impacts ($2008 million)

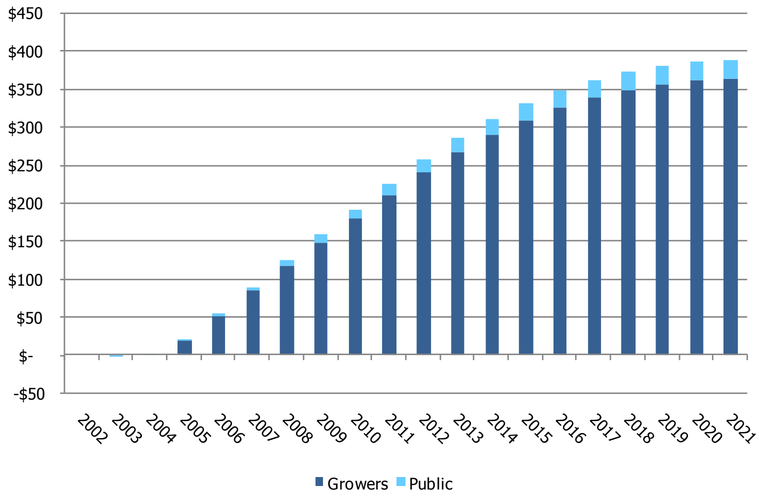
NPV	5 yrs	10 yrs	20 yrs
Grower			
6.00%	$49.5	$209.9	$374.6
7.15%	**$50.7**	**$209.5**	**$362.4**
9.00%	$52.8	$209.0	$345.1
Public			
6.00%	$3.0	$14.6	$26.6
7.15%	**$3.1**	**$14.6**	**$25.7**
9.00%	$3.2	$14.5	$24.5
Total			
6.00%	$52.5	$224.5	$401.2
7.15%	**$53.8**	**$224.1**	**$388.1**
9.00%	$56.1	$223.6	$369.6

Notes: Totals may not sum due to rounding
Source: AEC*group*

These projects have provided a positive outcome to the public and growers across all three time frames and at all three discount rates. The following figure demonstrates that the breakeven point is reached relatively soon after the initial expenditure as unlike other projects this work was initiated before the pest was present in Australia. Most projects are developed in response to an issue which is already impacting on growers and therefore has a longer lag time between initial expenditure and breakeven point as growers are exposed to production losses until an appropriate response solution is developed.

This figure shows the cumulative net present value of this work to growers and the public

Figure A.3. Cumulative NPV to Growers and Public ($2008 million)



Source: AEC*group*

It is estimated that over the twenty year assessment, 93.4 percent (NPV $362.4 million) of the total quantifiable net benefit would accrue directly to growers, with the remaining 6.6 percent (NPV $25.7 million) accruing to the public. The chart also demonstrates the effect of the erosion of the project benefits, which cause the cumulative NPV to tail off. It is assumed that as benefits start to decline, the ongoing maintenance costs would no longer apply.

A.1.7 Sensitivity Analysis

The two major assumptions used in the model relate to the proportion of production grown under the new management approach (90 percent) and the percentage of losses incurred (20 percent) by those growers that do not adopt the project findings. It is considered that the adoption rate is a conservative approach given the scale of losses incurred using broad spectrum chemical controls and the percentage losses where observed in crops and in trials. However, the following table demonstrates the impact on NPV of a range of assumption scenarios.

Table A.6. Sensitivity Analysis of NPV to Adoption and Crop Loss Scenarios, ($ million 2008)

Crop Losses	Adoption Rate			
	70%	80%	90%	100%
5%	$133.1	$113.0	$90.3	$64.8
10%	$186.2	$180.4	$173.9	$166.6
20%	$322.9	$353.7	**$388.5**	$427.4
30%	$474.9	$545.9	$626.4	$716.4

Notes: Totals may not sum due to rounding
Source: AEC*group*

The highlighted cell shows the outcome based on the assumptions used in the model. Using the highest scenario of 100 percent adoption within three years and 30 percent reduction in crop losses, the NPV would be $716.4 million. However, if the lowest scenario were adopted (70 percent adoption rate within three years and 5 percent reduction in losses), the NPV would be $133.1 million. Under the five and ten percent scenarios, the PV decreases as adoption rates increase. This is because the 'benefit' to non-adopters from continuing to grow their crops under the assumed price increase is greater than the value of the potential losses. As the losses increase so does the incentive to adopt the R&D findings. In reality, it would be expected that crop losses of five percent would not result in a five percent price increase as has been assumed in this analysis based on a 20 percent crop loss scenario.

A.1.8 Qualitative Summary

The analysis identified a number of significant impacts that could not be asessed quantitatively and these are highlighted below:

- **Sustainability of the vegetable industry –** as well as considering the short-medium term impacts of these projects, it is important to also recognise the longer term implications. Without control measures for Lettuce Aphid, the future of this whole sector would have been under threat;
- **Strengthening regional communities –** the impacts that growers have on their local communities other than through their direct activities represent a key contribution to the sustainablity of regional communities; and
- **Avoidance of the environmental impacts of transporting and storing imports –** this is particualrly important for lettuce which is highly perishable. It is likely that if imported lettuce were brought to Australia to meet fresh market demand, it would require significant energy inputs with associated environmental impacts.

A.1.9 Confidence Rating

The data used in this CBA is assessed as having a high confidence rating. The rates of crop loss are backed up by experience in both New Zealand and the USA where existing chemical controls were found to be ineffective leaving head lettuce open to significant crop losses. Further, the scale of the threat to the head lettuce sector suggests grower adoption would be high as they sought to avoid these losses. Finally, the assumption that all benefits are eroded within twenty years is conservative, it is likely that the project findings would be leveraged and developed further (and new chemical controls registered) but the management of their application is likely to remain within a similar structure to that developed as part of his project.

A.1.10 Project Summary

- This project is estimated to have produced significant economic, social and environmental benefits to growers and the wider public;
- The division of quantified economic benefits between levy payers and the public is close to equal despite levy payers making a significantly higher total investment (including increased cost of adoption and levy payments), however, there are a number of unquantified beneficial public outcomes delivered by the R&D project;
- As well as the project's immediate impacts on preventing crop losses, it has also contributed to the long-term sustainability and profitability of grower's businesses;
- From the perspective of the public, direct benefits have included the maintenance of consumer choice and avoided costs of more expensive imports as well as allowing growers to continue their social contribution to the areas where they live and work; and
- The project also produced environmental benefits, which are expected to have both short and longer term benefits to both growers and the public.

A.2 Minor Use Registration for Control of Western Flower Thrips

A.2.1 Project Description

Western Flower Thrips (WFT) are one of the world's most economically significant pests, and in 1998 it was estimated that WFT had the potential to cause losses of up to $2 billion in the Australian horticulture sector (pers. comm. P Dal Santo 16th February 2009). WFT is a major pest of multiple horticultural crops, downgrading produce quality and spreading plant viruses including Tomato Spotted Wilt Virus (TSWV). Susceptible crops include:

- Spring onions;
- Silver beet;
- Lettuce;
- Parsley;
- Capsicum;
- Egg plant;
- Tomatoes; and
- Cucumber.

WFT damage crops by both direct feeding on plants and by acting as a vector for diseases (most notably Tomato Spotted Wilt Virus). Without minor use permits, effective control of WFT in Australia horticulture would not be possible (pers. comm. P Dal Santo 11th February 2009).

Since 1998, HAL has supported five completed projects seeking ways to manage WFT:

- VG00065 *(Continued development of management strategies for western flower thrips and tomato spotted wilt virus in vegetables)*;
- VG00078 *(Western flower thrips : industry communication and development of training package)*;
- VG00085 *(Western flower thrips management strategy - Information delivery pilot project)*;
- VG03098 *(Regional extension strategy for managing western flower thrips and tomato spotted wilt virus in the Sydney Region)*; and
- VG03099 *(Provision of western flower thrips technology transfer services in Bundaberg and Bowen)*.

The minor use registration project was a critical element of this work, which helped to develop an integrated management strategy, of which chemical control was one component. Although this assessment focuses on the development of the registration permit, the costs of all five projects are included below as it is considered to be the combined project outcomes which have delivered the benefits.

A.2.2 Project Deliverables

Prior to 2004, there was no effective insecticide registered for the control of WFT, nor was there an alternative control mechanism. Several products were registered for control of other thrips species, but as in the case of Lettuce Aphid, these controls had quickly become ineffective due to the WFT's ability to rapidly develop insecticide resistance and in some cases over use of the available controls.

The pesticide strategy for WFT was based on the generation of the necessary data to support the registration of minor use chemicals. The supporting projects undertook significant research into the WFT and TSWV as a means of further understanding the disease and its vector. It is recognised that managing WFT provides a means of control for TSWV but only a more detailed understanding of the disease itself is likely to lead to its eradication.

A.2.3 Project Adoption

WFT are found throughout Australia (with the exception of the Northern Territory) and cause most damage in the spring and autumn growing periods. To reflect the reduction in damage in the summer production period, the CBA assumes that only 50 percent of the total annual production of the affected crops is susceptible to WFT damage. The severity of the crop losses and the rapid spread of the pest are expected to have provided a significant incentive to growers to adopt these findings.

In the following CBA it is assumed:

- Although WFT affects multiple commodities, for the purposes of this CBA only lettuce, capsicum and onions have been included in the analysis;
- 90 percent of the growing area of affected crops was managed using the outputs of the project outputs within three years;
- Of the remaining growing area (10 percent):
    - 50 percent was used to grow the same crops, sustaining enduring 30 percent losses; and
    - 50 percent was switched to alternative (less profitable) crops.

A.2.4 Impact Identification

The following table introduces the identified project impacts and introduces the basis of the calculations used in the CBA. Where it has not been possible to assign a dollar value to an impact, a qualitative assessment has been used, the details of which are included in the table.

Table A.7. Impact Identification Table

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
	Economic Cost		
Project and Related Expenditure	**Project costs:** • The four projects associated with WFT had combined costs of $2.3 million, equivalent to $2.6 million ($2008).	Quantitative	Both
	Ongoing maintenance costs: • Annual ongoing costs are estimated to be $200,000 per annum ($2008) reflecting the large number of commodities that this projects benefits, the need to maintain the currency of the benefits and the need for continuing education and extension.	Quantitative	Both
	Increased chemical costs: • Chemical costs are based on nine applications per crop with average costs of $250 per hectare for broad spectrum insecticides and $907 per hectare for the newly registered chemical control measures. • The older chemicals are less expensive as in many cases the patent protection has expired. • It could be argued that these additional costs should not be included as the high levels of resistance in WFT mean they would be much less effective than the newer chemical controls. However, a conservative approach has been adopted, recognising the additional costs of the new chemistry and assuming the same number of applications per crop. • To reflect the declining efficacy of older chemicals, their costs are assumed to reduce by ten percent per annum after the initial extension activities begin. The scale of benefits received (in the form of reduced externalities) is reduced by the same factor.	Quantitative	Private
	Economic Benefits		
Reduced Operating Costs	**Avoided crop losses:** • It is assumed crop losses of 30 percent per annum are experienced on properties that continue to operate without adopting the project findings. • Ten years after the findings are released, the average loss experienced by non-adopters is assumed to reduce by two percent per annum (reaching zero after a further 15 years), reflecting the adoption of other chemical control measures and alternative technologies in the future. • The value of avoided crop losses has been calculated as the annual loss rate multiplied by the total output of growers that have adopted the project findings.	Quantitative	Both
	Avoided lost revenues: • For non- adopters (following crop losses of 30 percent) it is assumed that within five years of the project extension activities 50 percent of growers would switch production to the next most profitable crops. • Alternative crops are assumed to be ten percent less profitable than growing current crops. • As the benefits of the R&D diminish over time, growers would be expected to return to current crops.	Quantitative	Grower

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
Market Development	**Avoided higher priced imports:** • Although the project is not considered to have developed any new markets, it is likely to have protected the domestic market from overseas competition. It is anticipated that if growers sustained repeated heavy crop losses, with no effective means of controlling the pest and there had been repeated incidents of consumers purchasing a diseased product, domestic market share would have eroded by overseas production and that: ○ Prices of affected commodities would be five percent higher than under the 'no change scenario' due to scarcity of supply ○ Higher prices would encourage consumers to purchase substitute goods ○ Domestic demand would be lower with 10 percent of production losses replaced by imports • This avoided additional cost (under the R&D adoption scenario) is included as a benefit to the consumer and is calculated as the cost of substituting 10 percent of the reduction in output with imported products which are 5 percent more expensive.	Quantitative	Public
	Contribution to regional and national economies: • By maintaining the viability of the vegetable sector, the project is expected to have to have reduced the risks of losing the contribution vegetable growers make to regional economies through both their direct expenditure and the associated flow on effects as that expenditure passes through regional economies. It is therefore **likely** (will probably occur in most circumstances) that this project has produced a **negligible** (unlikely to be measurable against benchmarks) benefit to regional economies. Resulting in a **low** impact score.	Qualitative	Both
Social Benefits			
Reduced Social Impact	**Reduced risks to physical and mental health:** • Growers and their families affected by WFT would be likely to experience considerable stress relating to the short-term viability of their business as well as the long-term future of the business. The projects undertaken to control WFT provide growers with control mechanisms which whilst not infallible do give growers far better control over the action of this pest. It is thought **almost certain** (expected to occur in most circumstances) that this provides a **negligible** (unlikely to be measurable against benchmarks) social benefit to growers. Resulting in a **low** impact score.	Qualitative	Private
	Strengthening regional communities: • Growers contribute to their local communities in a wide range of ways including their participation in community activities as well as the contribution they make towards retaining the critical population mass needed to sustain other rural sector businesses and community services including schools and health care facilities. It is **almost certain** (expected to occur in most circumstances) that growers of crops affected by WFT provide a **negligible** (unlikely to be measurable against benchmarks) social benefit to regional communities. Resulting in a **low** impact score.	Qualitative	Public
	Increasing the sustainability of the Australian vegetable sector: • This project has provided growers with a series of tools to manage DBM and has therefore also contributed to the continuation of a viable brassica sector in Australia. In doing so the project has helped to maintain the future of the industry, which encourages growers to make investments in equipment and other technology as well as giving them re-assurance about their own positions and the likelihood of being able to pass on a viable operation to the next generation of their family. This is **likely** (will probably occur in most circumstances) to have a **negligible** (unlikely to be measurable against benchmarks) impact on growers. Resulting in a **low** impact score.	Qualitative	Grower
	Skill and knowledge development: • Research into WFT and TSWV contributes to increased knowledge of that pest and will inform future work in this area, it also assists in the development of IPM strategies developed for other pests. These projects have also contributed to the development and retention of R&D posts in Australia as well as developing researchers' knowledge and skills. This helps to retain researcher skills within Australia and has the potential to lead to benefits in other related fields. • This is considered **almost certain** (expected to occur in most circumstances) to provide a **negligible** (unlikely to be measurable against benchmarks) economic grower benefit through the development of greater understanding of WFT. Resulting in a **low** impact score.	Qualitative	Both

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
Environmental Benefits			
Reduced Environmental Impacts	**Reduced environmental impacts of grower activity:** • The externalities of the chemicals registered through the minor use schemes are estimated to be approximately $1.39 per application per hectare (Leach and Mumford 2008), significantly lower than for the older chemicals (approximately $22.09 per application per hectare) (Leach and Mumford 2008). • In the analysis it is assumed there are nine chemical applications per crop using the old and new chemicals. This is a conservative assumption as during periods of intense pest activity growers using 'older style' insecticides may be forced to spray on a more frequent basis, especially where resistance levels are significant.	Quantitative	Both

Source: AEC*group*

A.2.5 Counterfactual Case

A.2.5.1 What are the main benefits that would have eluded growers without this project?

When WFT was first detected in Australia in 1993 (Broughton, Jones and Coutts 2004), it had already developed some degree of insecticide resistance due to the incoming population being exposed to the available insecticides in the source country. Unlike plague thrips, which are relatively easily controlled by insecticides, WFT proved to be exceptionally difficult to control with the available chemical controls, quickly developing resistance and proving highly destructive.

Without access to effective control and management options, growers would be faced with significant losses across a wide range of crops. It is unlikely that there would be a viable market for these crops as the cost of physical control (for example erecting fine mesh netting) is likely to exceed market price in all but the very highest value commodities. Without an effective control mechanism, it is likely that none of the crops affected by WFT could be grown in Australia outside of the summer months. As well as the impacts on growers' livelihoods, the costs of imported vegetables to the consumer would be anticipated to be higher than for domestic production and the consumer's range of choice would be reduced.

A.2.5.2 Has the project brought forward any benefits that may not otherwise have emerged?

The wide range of crops that are affected by WFT and TSWV mean these projects outcomes, in particular the registration of the chemical controls, produce a significant benefit to non-vegetable commodities including stone fruit and ornamentals.

In addition to the potential crop losses, outcomes of not funding the minor-use program could include:

- If a grower's crops were threatened by pest insects, growers may take the risk of using product off-label. This could lead to rejection of the produce if discovered;
- The variety of crops produced would decline as growers were forced to focus on crops and cropping systems with lesser plant pest issues, thereby reducing availability and increasing prices;
- Growers would be forced to only use the available registered pesticides, which would likely result in their overuse and the rapid and/or increased development of resistance; and
- Growers would be forced to rely on biological control systems, which are not currently adequate as a sole management method.

A.2.5.3 Would the same outcomes have emerged from overseas research and how long would the lag-time have been?

The chemicals which are supported through the minor use chemical scheme are developed overseas, usually for use in larger agricultural sectors. However, it is very unlikely that these would ever be registered for legal use in Australia without the support of HAL. This support is not only financial, through completing multiple applications over the last fifteen years a series of networks have been established between researchers, chemical companies and equivalent bodies overseas. These relationships promote significant information exchange, reducing costs per permit application and allowing Australian growers to more readily gain access to a wider range of chemicals than would otherwise be the case.

A.2.5.4 Are other groups working on substitute technologies which might make the project findings obsolete?

It is very unlikely that another group would be working on registering alternative chemical controls and if additional chemicals were to be registered this would produce a benefit by reducing reliance on the available chemistry. Whilst in the long term (more than twenty years) there might be a chance that chemical controls would no longer be necessary due to genetically modified disease resistant strains being developed, this is outside the term of this assessment and subject to significant unknowns. Within the period of this assessment, while new chemical control measures will be developed as required, it is likely that chemical control measures will remain a central component of all IPM approaches.

A.2.5.5 Without the input of HAL, would other groups have supported the project?

As discussed above, the chemical control measures are usually developed overseas for use in major commodities. Without the HAL funding, it is unlikely that these chemicals would be registered for use in Australian horticulture.

A.2.5.6 Has the involvement of HAL increased adoption rates?

HAL's involvement is likely to have increased adoption rates through its communication, education and extension activities. Even where growers do not find out about the project findings directly from HAL, it is likely that the informal networks that growers suggest are so important in disseminating project findings are initially informed through HAL.

A.2.6 Cost Benefit Analysis Results

The following table summarises the economic cost impacts used in the CBA (no social or environmental costs have been identified).

Table A.8. Present Value of Project Costs

Costs	Cost ($2008)	PV ($M)		
		6.00%	7.15%	9.00%
Project cost	$2.6 million	$3.3	**$3.5**	$3.8
Ongoing costs (per annum)	$200,000	$1.8	**$1.8**	$1.8
Increased chemical cost	$657 [(a)]	$15.7	**$15.8**	$16.0
Total		**$20.9**	**$21.2**	**$21.7**

Notes: Totals may not sum due to rounding (a) per hectare per crop
Source: AEC*group*

The present value of the economic costs of the project is estimated to be $21.2 million. Total project costs and ongoing costs would be split equally between levy payers and the public, however, growers alone would be faced with the higher chemical costs.

The following table summarises the economic benefit impacts used in the CBA.

Table A.9. Present Value of Project Benefits

Benefits	Benefits ($2008)	PV ($M)		
		6.00%	7.15%	9.00%
Avoided crop losses	$348/tonne[(a)]	$643.2	**$620.1**	$587.6
Avoided lost revenues due to switching crops	$116/tonne[(a)]	$15.7	**$15.1**	$14.4
Import savings	$122/tonne[(a)]	$32.9	**$31.8**	$30.2
Reduced risks to physical and mental health	$2.79[(b)]	$0.1	**$0.1**	$0.1
Reduced environmental impact of grower activities	$17.92[(b)]	$0.5	**$0.5**	$0.5
Total		**$643.2**	**$620.1**	**$587.6**

Notes: Totals may not sum due to rounding (a) average across the three crops in the assessment, CBA uses actual cost for each crop, (b) per hectare, per application
Source: AEC*group*

The total present value of the stream of benefits from the projects is estimated to be $620.1 million. The table below outlines the distribution of costs, benefits and net present value between levy payers and the public.

Table A.10. CBA Outcomes ($2008 million)

Discount Rate	PV Costs		PV Benefits		NPV		BCR	
	Private	Public	Private	Public	Private	Public	Private	Public
6.00%	$18.3	$2.6	$659.0	$33.4	$640.7	$30.8	36.1	13.0
7.15%	**$18.5**	**$2.7**	**$635.4**	**$32.3**	**$616.9**	**$29.6**	**34.4**	**12.1**
9.00%	$18.9	$2.8	$602.1	$30.7	$583.2	$27.9	31.9	10.9

Notes: Totals may not sum due to rounding
Source: AEC*group*

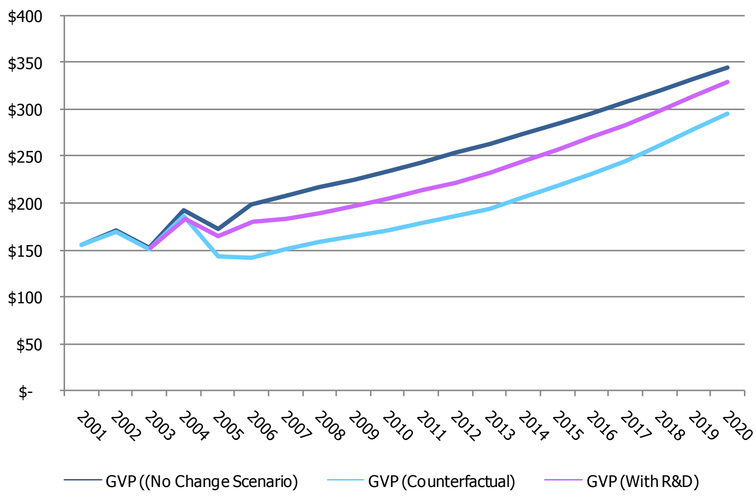
The table demonstrates that this research produce a positive return on investment to both growers ($616.9 million) and the public ($29.6 million). Costs to growers are higher than those to the public due to the additional costs of switching production to the new chemistry. This assessment is based on the assumption that the older (and much lower cost) chemistry would still work in the counterfactual case, which is a conservative assumption given the losses experienced elsewhere when using these products.

Benefits to growers are mainly related to avoided crop losses, on farm environmental benefits from adopting the new chemical control measures and avoided reductions in profitability which they would have incurred in the counterfactual case as they were forced to move into other crops due to high losses. This project is anticipated to deliver significantly more benefits than presented in this analysis due to the number of crops that are potentially affected by WFT and the extent of the damage WFT can inflict if not adequately controlled.

Benefits to the public are principally related to the significantly lower environmental impacts associated with the newer chemical controls and avoiding price increases above the rate of inflation a result of reduced domestic supply. As with the private benefits, the scale over which these findings can be applied, imply the benefits resulting from the research are significantly larger than the assessment considering just three crops examined in this assessment.

The following figure compares the gross value of production between the no change, counter factual and with R&D adoption cases. It should be noted that the 'with R&D' case includes output from both growers adopting the project findings and those that continue to grow affected crops despite incurring significant losses.

Figure A.4. Gross Value of Production Comparison ($2008 million)



Source: AEC*group*

It can be seen from the chart that:

- WFT has caused significant damage since the late 1990's;
- As the R&D benefits are eroded over time, the scenarios converge as:
  - Growers that continue to grow affected crops without adopting the R&D findings are able to access alternative control methods;
  - Growers that switched to alternative crops due to high losses return to the sector; and
  - The benefits to growers that adopted the R&D findings relative to non-adopters reduce as a result of underlying technological change.

This is a conservative scenario, if it were assumed that technological change was slower to return the counterfactual case to the 'no change scenario' the project benefits would be larger. Another scenario would see any growers that did not adopt the findings being forced to leave the sector due to the high crop losses. In this case, the counterfactual GVP would be expected to approach zero within a few years.

The following table shows the distribution of benefits to growers and to the public over five, ten and twenty years from the start of the project.

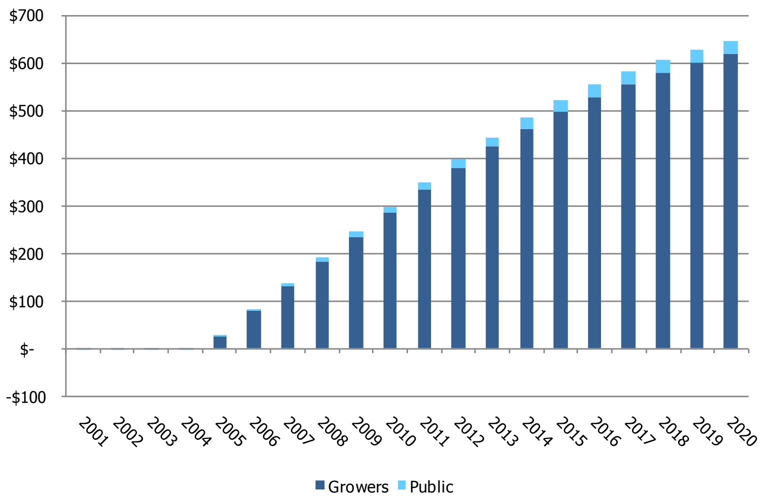
Table A.11. NPV of Grower and Public Impacts ($2008 million)

NPV	5 yrs	10 yrs	20 yrs
Grower			
6.00%	$25.7	$282.9	$640.7
7.15%	**$26.5**	**$283.8**	**$616.9**
9.00%	$27.9	$285.3	$583.2
Public			
6.00%	$0.8	$13.2	$30.8
7.15%	**$0.8**	**$13.1**	**$29.6**
9.00%	$0.8	$13.1	$27.9
Total			
6.00%	$26.5	$296.1	$671.5
7.15%	**$27.3**	**$296.9**	**$646.5**
9.00%	$28.7	$298.5	$611.1

Notes: Totals may not sum due to rounding
Source: AEC*group*

The project returns a positive benefit to both growers and the public after five, ten and twenty years across all three discount rates. The following figure shows the cumulative net present value of this work to growers and the public.

Figure A.5. Cumulative NPV to Growers and Public ($2008 million)



Source: AEC*group*

It is estimated that over the twenty years following the start of the project 95.4 percent ($616.9 million) of the total quantifiable net benefit would accrue directly to growers, with the remaining 4.6 percent ($29.6 million) accruing to the public.

A.2.7 Sensitivity Analysis

The two major assumptions used in the model relate to the proportion of production grown under the new management approach (90 percent) and the percentage of losses incurred (30 percent). It is considered that the adoption rate is a conservative approach given the scale of losses incurred using broad spectrum chemical controls and the percentage losses where observed in crops and in trials. However, the following table demonstrates the impact on NPV of a range of assumption scenarios.

Table A.12. Sensitivity Analysis of NPV to Adoption and Crop Loss Scenarios, (2008)

Crop Losses	Adoption Scenario			
	70%	80%	90%	100%
10%	$185.1	$181.5	$177.4	$172.8
20%	$329.6	$364.7	$404.3	$448.7
30%	$484.1	$560.2	**$646.5**	$742.9
40%	$638.5	$755.8	$888.7	$1,037.2

Notes: Totals may not sum due to rounding
Source: AEC*group*

The highlighted cell shows the outcome based on the assumptions used in the model. Using the highest scenario of 100 percent adoption and 40 percent reduction in crop losses, the NPV would be $1,037.2 million. However, if the lowest scenario were adopted (70 percent adoption rate within ten years and 10 percent reduction in losses), the NPV would be $185.19.3 million. As in the previous case study, at the lowest crop loss scenario, it appears that the NPV achieved is lower as more growers adopt the findings, this is due to the assumed price increase as a result of crop losses. If crop losses were as low as ten percent it is unlikely prices would increase by as much as if losses were 30 percent.

A.2.8 Qualitative Summary

This group of projects has again produced a series of important qualitative benefits. Many of which are likely to be contribute to longer term strategic objectives including:

- **Increasing the sustainability of Australian vegetable sector** – ensuring the long term future of the vegetable growing industry by maintaining the competitiveness and variety of domestic production; and
- **Skill and knowledge development –** ensuring researchers have sufficient skills and understanding to continue their role in maintaining a competitive vegetable sector.

A.2.9 Confidence Rating

The outcomes of the CBA are thought to have high confidence rating. As with Lettuce Aphid, the extent of losses caused by WFT is well known and the scale of the losses is sufficiently large to promote high rates of grower adoption. Given that the project has only assessed three of the multiple commodities the project could potentially benefit (i.e. commodities affected by WFT) it is likely that this result represents a low scenario for the benefits from this project.

A.2.10 Project Summary

- The wide range of commodities which are susceptible to damage from direct WFT action as well as from the disease which it spreads means that any project which can reduce production losses and is likely to provide significant benefits to growers and the public;
- The outcomes of this work have assisted growers by giving them an effective means of pest control, which has reduced losses and helped to safeguard the viability of the sector;
- The public has also benefited through greater choice, lower prices and the indirect benefits of grower activity including their economic and social contributions to regional communities and the sustainability of the broader vegetable and horticulture sectors; and
- Both growers and the public have benefited from the registration of chemicals with fewer impacts on human health and the wider environment.

B. Productivity Increases

B.1 Agronomic Packages for Reduced Pass Harvesting of Export Cauliflower

B.1.1 Project Description

In Australia, the majority of brassica crops (including broccoli, cabbage and cauliflower) are harvested by hand and require several passes over a period of up to several days primarily due to their uneven rate of maturity, making mechanical harvesting impractical. Labour requirements at harvest time account for approximately 40 percent of variable costs of cauliflower and broccoli production (approximately $12,000 per hectare) and some growers have found it difficult to find skilled staff to carry out this work.

In 2002/2003, the Australian export cauliflower industry was valued at $23.4 million (AusVeg, 2009). Since then, the export cauliflower industry has been subjected to extensive competition in the traditional markets of Singapore and Malaysia, which has saw the value of the industry fall to $1.5 million in 2006/2007 (AusVeg, 2009).

Project VG02051 (*Agronomic packages for reduced pass harvesting of export cauliflower)* studied a range of agronomic techniques, which were identified as having the potential to reduce the number of passes required to harvest a cauliflower or broccoli crop. Greater uniformity of maturity means that a grower might only need to conduct one manual harvest before harvesting the remaining crop mechanically.

Work conducted overseas on reducing the number of harvests in vegetable brassica crops (in particular in cauliflower crops) has focused on identification of the crop stages when vegetable brassicas move from juvenile, to adult and reproductive vegetative stages. However, there have been relatively few reports of making changes to existing management practices to increase the uniformity of crop maturity in the vegetable brassicas.

The aims of the project were to;

- Investigate crop agronomy techniques which might reduce the number of harvests required to remove a cauliflower or broccoli crop;
- Undertake an economic assessment of the impact of agronomic management changes in cauliflower and broccoli, when grown using a reduced pass harvest system; and
- Demonstrate a reduced pass harvesting agronomic technique to cauliflower and broccoli producers.

B.1.2 Project Deliverables

The project outputs demonstrated that by careful management of the agronomic inputs into the crops (primarily water and fertiliser), it was possible to harvest both cauliflower and broccoli in one pass particularly during the summer months. Most of the agronomic techniques developed are useful for soils that contain some clay and have an adequate water holding capacity. The agronomic techniques developed did not achieve total uniformity of cauliflower or broccoli crops, although a single pass harvest was still possible due to approximately 80 percent of the crop being uniform when it was harvested.

The most important factors in achieving increased crop uniformity involved ensuring the accurate and timely application of fertiliser and water. By controlling these inputs, it was possible to control the timing of crop maturity. Previous studies had indicated that the application of the basal fertiliser on loam soils in a strip was beneficial for reducing the number of harvests (Lancaster *et al*, 2003) as the plants are surrounded by fertiliser from the time of transplanting. This study was the first to make the connection between those studies, and the use of a fertiliser incorporator at the time of transplanting and the careful control of water inputs.

Other benefits gained from the new agronomic program include a reduction in water use. For cauliflowers this resulted in a 30 percent increase in water use efficiency and for broccoli a 17 percent increase.

Genetic factors also influence the spread of crop uniformity making the achievement of 100 percent crop uniformity unlikely. However, by using the agronomic techniques identified in the R&D project, producers can reduce the variability of crop maturity timing, so it becomes economically feasible to remove the crop in one harvest. The removal of the crop in one harvest provides labour cost savings for producers. The reduction in number of harvests also makes mechanical harvesting on large scale crops feasible, particularly if the product is destined for the processing sector.

Economic analysis of the yield from the cauliflower and broccoli demonstration crops was conducted to determine if changing the method of harvesting and the irrigation regime would be cost effective for producers. The economic analysis was conducted so that variable and some fixed costs were taken into account, providing an enterprise margin for each treatment.

B.1.3 Project Adoption

Broccoli and cauliflowers were grown over approximately 9,871 hectares in 2006 (ABS 2007). It is assumed that the findings are applicable over approximately 60 percent of the growing area as it is most effective in loam soils. Although there are some benefits in non-prime conditions, these are likely to be less significant.

Project adoption rates were not monitored. Given the substantial savings on offer it is likely that those growers that are in a position to adopt the findings (i.e. are not on sandy soils) would adopt at least some of the findings with larger growers purchasing (or adapting existing equipment) to develop the fertiliser incorporating machinery and harvesting equipment. Therefore, it has been assumed:

- 60 percent of cauliflower and broccoli output is grown using the new management techniques within five years of the project conclusion; and
- 20 percent of production under the new techniques utilises the incorporator within five years, with the remaining 80 percent of growers adopting the findings but continuing to harvest by hand but over a reduced number of passes.

Applying the fertiliser at the transplanting stage around the root ball rather than in bands several centimetres to either side was also identified to increase yields by up to 12 percent. This technique gives the plant an initial boost, which is particularly useful in winter when soils are cooler. However, this benefit is recognised in the analysis of VG00044 *(Total crop management of Clubroot in brassica vegetable)* and is not included in this project to avoid double counting. There have been some claims that the incorporator helps to reduce crop losses due to pest action as the plant is better able to absorb some damage once established. No decrease in losses have been included in the CBA, as there was insufficient data available to quantify these benefits.

B.1.4 Project Impact Identification

The following table introduces the identified project impacts and introduces the basis of the calculations used in the CBA. Where it has not been possible to assign a dollar value to an impact, a qualitative assessment has been used, the details of which are included in the table.

Table B.1. Impact Identification Table

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
Economic Costs			
Project and Related Expenditure	**Project costs:** • This project is currently a one-off although additional funding may become available in the future for further developments. Total project costs were $526,364 equivalent to $550,729 ($2008).	Quantitative	Both
	Ongoing maintenance costs: • It is estimated that annual ongoing costs are estimated to be $50,000 per annum ($2008) largely associated with additional education and extension work required to increase awareness and grower adoption.	Quantitative	Both
	One-off implementation costs: • As well as the changes to crop management (notably irrigation timing and quantity) growers also have the option of implementing a precision incorporator. It should be noted that the project benefits are not contingent on this aspect of the project findings. It is considered that most growers would adapt existing equipment and that his could be done at an average cost of $25,000.	Quantitative	Grower
Economic Benefits			
Reduced Operating Costs	**Reduction in labour cost:** • Labour costs for brassica crops are approximately $11,239 ($2008) (NSW Agriculture, 2001). It is estimated that these costs can be reduced by up to 40 percent by increasing the uniformity of maturity of brassica crops, reducing the need for multiple harvest and developing the potential to harvest brassica crop using machinery reducing labour costs associated with manual and multiple pass harvesting. • Growers save on direct labour inputs as well as indirect labour costs including recruiting, training and managing additional staff. • In the CBA, it has been assumed that total variable costs are 30 percent lower than the pre-project costs.	Quantitative	Grower
	Reduced water consumption: • One of the key project findings was the role of irrigation quantity and timing in controlling the crop's passage between growth stages. This has resulted in a reduction in total water consumption of approximately15 percent of the average irrigation costs identified to be approximately $100 per hectare per crop ($2008) (NSW Agriculture 2001).	Quantitative	Grower
	Contribution to regional and national economies: • This group of projects has significantly improved the viability of the brassica sector and in doing so has reduced the risks of losing the contribution that brassica growers make to regional economies (and the national economy) through both their direct expenditure and the flow on effects. It is **likely** (will probably occur in most circumstances) that this project has produced a **negligible** (unlikely to be measurable against benchmarks) economic public benefit. Resulting in **low** impact score.	Qualitative	Public

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
Social Benefits			
Reduced Social Impact	**Strengthening regional communities:** • In addition to economic contribution of growers, their activities also help to strengthen communities providing employment opportunities, maintaining viable population sizes and patronising local businesses. It is thought **almost certain** (expected to occur in most circumstances) that the project has made a **negligible** (unlikely to be measurable against benchmarks) economic benefit to the effected communities. Resulting in a **low** impact score. • The wider community also **likely** (will probably occur in most circumstances) to receive a **negligible** (unlikely to be measurable against benchmarks) economic social benefit through the contribution brassica growers to make to communities and the employment opportunities which they support. Resulting in a **low** impact score.	Qualitative	Both
	Increasing the sustainability of the Australian vegetable sector: • Providing the tools to increase productivity is likely to contribute to the continuation of a viable brassica sector in Australia. In doing so the project helps to develop a sustainable future for the industry which encourages growers to make investments in equipment and other technology. It also gives growers re-assurance about their positions and the likelihood of being able to pass on a viable operation to the next generation of their family. This is **likely** (will probably occur in most circumstances) to have a **negligible** (unlikely to be measurable against benchmarks) beneficial impact on growers. Resulting in a **low** impact score.	Qualitative	Grower
	Skill and knowledge development: • In undertaking this project, researchers have continued to develop their skills including the study of the life cycle triggers of brassica crops and the utilisation of the incorporator. This knowledge can be used to inform further work in the brassica sector. This project has also contributed to the development and retention of R&D posts in Australia as well as developing researchers' knowledge and skills. This helps to retain researcher skills within Australia and has the potential to lead to benefits in other related fields. • This is considered **almost certain** (expected to occur in most circumstances) to provide a **negligible** (unlikely to be measurable against benchmarks) public benefit and a **negligible** (unlikely to be measurable against benchmarks) grower benefit through the development of greater understanding of the transition between brassica crop growing stages. Resulting in **low** impact scores.	Qualitative	Both
Environmental Benefits			
Reduced Environmental Impact	**Reduced indirect environmental impacts:** • By increasing grower understanding of the effects of water and fertiliser on crop uniformity the project has led to a positive environmental outcome by using these resources more efficiently. This would be expected to reduce run-off into water courses and the overall water take of each property. This is **almost certain** (expected to occur in most circumstances) to produce a **negligible** (unlikely to be measurable against benchmarks) economic environmental benefit to growers. Resulting in a **low** impact score.	Qualitative	Growers

Source: AEC*group*

B.1.5 Counterfactual Case

B.1.5.1 What are the main benefits that would have eluded growers without this project?

Without this project growers would still have to make several passes of each crop in order to harvest their crops. This not only incurs additional direct labour costs but where growers require additional labour this has costs associated with finding and managing this additional labour.

Growers would also be likely to continue to apply fertiliser and irrigation inputs at the same rates as they did prior to the study as this had proven to be effective in the past. By reducing water consumption growers are likely to reduce the amount they pay for irrigation but also reduce the pressure on their available supply. Similarly, the incorporator increases production yields, increases production efficiency by reducing the amount of fertiliser and other inputs required per plant

B.1.5.2 Would the project have happened without the funding provided by HAL?

It is unlikely the project would have been funded from alternative sources. The benefits are principally achieved by managing the use of inputs in such a way that a more uniform rate of growth is achieved throughout the crop. It is unlikely that an organisation could fund this type of research and have any hope of recovering the project costs. There is no way for such an organisation to control the flow of information or to make any charge for it.

Although the incorporator may have been developed it is considered unlikely significant adoption would have been achieved, as the critical break through has been in the use of the tool rather than in the tool itself. Therefore, a company that paid for the project would not be able to recover their costs through equipment sales as existing equipment can be adapted at a lower cost.

B.1.5.3 Has the project brought forward any benefits that may not otherwise have emerged?

The project has reduced water demand amongst growers that can apply the project findings and identified that by using the incorporator to surround seedling root balls with fertiliser helps establish each seedling more quickly following transplantation. There is anecdotal evidence which suggests seedlings which become established more quickly are less susceptible to pest damage although these claims require further investigation.

B.1.5.4 Would the same outcomes have emerged from overseas research and how long would the lag-time have been?

The project findings are highly specific to the growing conditions and it is unlikely that they would have been produced from overseas research. Without this project, it is likely that cauliflower and broccoli growers would still be harvesting their crops manually with additional passes and incurring the additional direct and indirect costs associated with the additional labour. Growers would also be unaware of the potential to reduce the volume of water used in irrigation.

Although overseas research had identified the crop growing stages as a key determinant of crop maturity timing, it was this work that recognised the role of irrigation supply in triggering the movement from one stage to the next and then harnessed this information to increase crop maturity.

Given the need to reduce costs wherever possible and difficulties in finding sufficient appropriately skilled labour, without this project, it is likely that Australian brassica growers would be faced with significantly higher input costs making it more susceptible to competition from overseas producers.

B.1.5.5 Are other groups working on substitute technologies which might make the project findings obsolete?

It is considered unlikely that new findings will make this work obsolete. Additional work may seek to build on the understanding that has been developed about the growth cycles of brassica crops to increase further the degree of uniformity in the crop but, this is likely to be based on the extension of these findings rather developing a new approach. While there is a chance that the technology could become obsolete if a variety was developed which had been selected for its uniform maturity and which could also produce sufficient quality and quantity, this is unlikely in the short to medium term, and in any case the research to develop and test those varieties would likely build on the findings of this report and include aspects such as careful control of water and fertiliser inputs rather than replace them with entirely new technology.

B.1.5.6 Has the involvement of HAL increased adoption rates?

HAL's communications network and their knowledge of the growers that could adopt these findings are likely to have significantly increased the extent of adoption. Unlike previous examples where vegetable sectors were at risk of becoming unviable, this project has been a proactive attempt to improve the productivity of vegetables growers and therefore is more reliant on grower education and awareness networks to increase adoption rates.

B.1.6 Cost Benefit Analysis Results

The following table summarises the economic cost impacts used in the CBA (no social or environmental costs have been identified).

Table B.2. Present Value of Project Costs

Impact	Cost ($2008)	PV ($M) – Discount Rate		
		6.00%	7.15%	9.00%
Project cost	$550,729	$0.5	**$0.5**	$0.5
Ongoing costs	$50,000	$0.3	**$0.3**	$0.3
Implementation costs	$25,000	$2.8	**$2.8**	$2.8
Total		**$3.7**	**$3.7**	**$3.7**

Notes: Totals may not sum due to rounding (a) per hectare per crop
Source: AEC*group*

The present value of the economic costs of the project are estimated to be $3.7 million (using a 7.15 percent discount rate).Total project costs and ongoing costs would be split equally between levy payers and the public, however, growers alone would be faced with the higher chemical costs and the implementation cost of the incorporator.

The following table summarises the economic benefit impacts used in the CBA.

Table B.3. Present Value of Project Benefits

Impact	Benefit ($2008)	PV ($M) – Discount Rate		
		6.00%	7.15%	9.00%
Water savings	$100/hectare	$0.6	**$0.5**	$0.5
Variable costs	$2,697/hectare	$114.3	**$108.0**	$98.9
Avoided price increases	$22/hectare(a)	$8.2	**$7.8**	$7.2
Total		**$123.1**	**$116.3**	**$106.6**

Notes: Totals may not sum due to rounding (a) average
Source: AEC*group*

The total present value of the stream of benefits from the projects is estimated to be $116.3 million.

The table below outlines the net present value of the impacts of these projects.

Table B.4. CBA Outcomes ($2008 million)

Discount Rate	PV Costs		PV Benefits		NPV		BCR	
	Grower	Public	Grower	Public	Grower	Public	Grower	Public
6.00%	$3.2	$0.4	$114.9	$8.2	$111.7	$7.7	35.6	18.8
7.15%	**$3.2**	**$0.4**	**$108.5**	**$7.8**	**$105.3**	**$7.4**	**33.4**	**18.1**
9.00%	$3.3	$0.4	$99.4	$7.2	$96.1	$6.8	30.4	17.1

Notes: Totals may not sum due to rounding
Source: AEC*group*

The table demonstrates that this work produces a positive return on investment to both growers ($105.3 million) and the public ($7.4 million). Costs to growers are higher than those to the public due to the implementation costs to growers in developing the incorporator and harvester.

The main benefits to growers are in reduced variable costs associated with the labour costs of harvesting as well as a smaller reduction in water costs. The following table shows the distribution of benefits to growers and to the public over five, ten and twenty years from the start of the project.

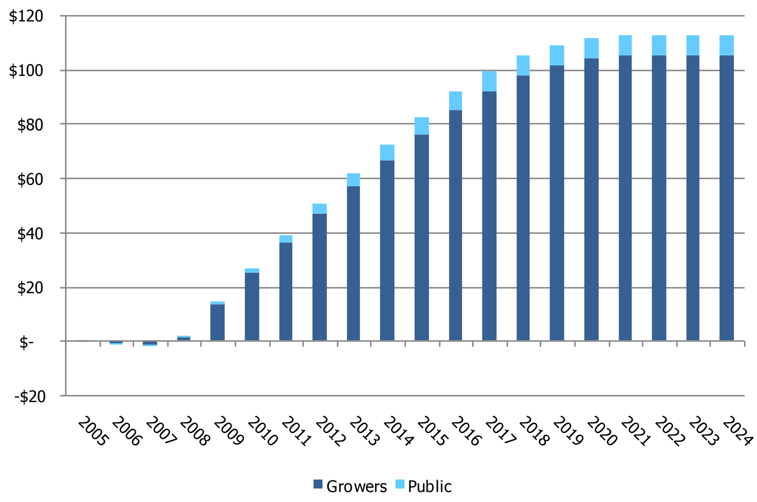
Table B.5. NPV of Grower and Public Impacts ($2008 million)

	5 yrs	10 yrs	20 yrs
Grower			
6.00%	$13.4	$69.2	$111.7
7.15%	**$13.3**	**$66.7**	**$105.3**
9.00%	$13.0	$63.0	$96.1
Public			
6.00%	$1.0	$5.6	$7.7
7.15%	**$1.0**	**$5.4**	**$7.4**
9.00%	$1.0	$5.1	$6.8
Total			
6.00%	$14.5	$74.8	$119.4
7.15%	**$14.3**	**$72.1**	**$112.6**
9.00%	$14.0	$68.1	$102.9

Notes: Totals may not sum due to rounding
Source: AEC*group*

The project breaks even within the first five years after the project inception for the public and growers. This is expected to be due to the significant benefits that accrue to growers who are able to reduce their variable costs and therefore recover the required one-off expenditure. The benefits to the public are smaller and increase gradually as more and more growers adopt the project findings and price reductions come into greater effect. Public benefits would have accrued much faster where less conservative assumptions had been used regarding the speed at which growers adopt these findings and the downward impact on prices.

Figure B.1. Cumulative NPV to Growers and Public ($2008 million)



Source: AEC*group*

The grower expenditure in 2007 is the result of the implementation of costs of purchasing (or adapting existing equipment) an incorporator. Over the twenty years from the start of the project, it is anticipated that 93.5 percent of benefits will accrue to growers ($105.3 million) and that the remaining 6.5 percent ($7.4 million) will accrue to the public.

B.1.7 Sensitivity Analysis

The two major assumptions used in the model relate to the proportion of productive area which are suitable for the project findings and the percentage of the suitable land that adopts the findings. The assumptions used in the model are considered to be conservative however, the following table demonstrates the impact on NPV of a range of assumption scenarios.

Table B.5. Sensitivity Analysis of NPV to Applicable Area and Adoption Rate Scenarios, ($2008 million)

Potential Applicable Area	Adoption of Findings			
	60%	70%	80%	90%
40%	$39.9	$55.7	$73.9	$94.5
50%	$50.8	$70.5	$93.2	$119.0
60%	$61.7	$85.4	**$112.6**	$143.5
70%	$72.6	$100.2	$132.0	$168.0

Notes: Totals may not sum due to rounding
Source: AEC*group*

The highlighted cell shows the outcome based on the assumptions used in the model. Using the highest scenario of the findings being applicable to 70 percent of the productive area and being adopted on 90 percent of the potential area, the NPV would be $168.0 million. However, if the lowest scenario were adopted (applicable to 60 percent of the area and adopted over 60 percent of the potential area), the NPV would be $39.9 million. In this case study, there is an incremental benefit for each additional adopter under all scenarios.

B.1.8 Qualitative Summary

The qualitative assessment has highlighted a series of important beneficial impacts which could not be assessed on a quantitative basis including:

- **Increasing the sustainability of the Australian vegetable sector –** in order for the Australian vegetable sector to remain competitive in both domestic and international markets, it must continue to identify production efficiencies such as those identified in this project; and

- **Skills and knowledge development –** in addition to the immediate project findings; this project has also increased knowledge and understanding of brassica crops which may be used to inform further research in the future.

B.1.9 Confidence Rating

The project is assessed as having a medium confidence rating. The benefits of this technique have been demonstrated in trials, and this is supported by growers that have adopted the techniques. However, little is known about the extent to which the incorporator has been adopted in other areas and therefore the extent of the benefits. Given the extent of the available benefits, it is likely that this assessment is a minimum likely return from the project however, at this stage further detail on the rate and geographic extent of adoption is required.

C. Integrated Pest Management

C.1 Implementing Pest Management of Diamond Back Moth

C.1.1 Project Description

Work on this collection of projects began in 1998, the completed projects are:

- VG97014 *(Advancing the integrated management of diamondback moth in Brassica vegetables)*;
- VG00055 *(Implementing pest management of diamondback moth)*; and
- VG03034 *(Control of diamondback moth in brassica vegetables with fungi)*.

In 2006-07, the principle brassica crops (broccoli, cabbage and cauliflower had a combined gross value of production of $159 million (ABS 2008). The diamond backed moth (DBM) *Plutella xylostella* (L.), is the most destructive pest to brassica vegetables in Australia (VG97014). A combination of characteristics make DBM difficult to control with traditional broad spectrum insecticides and even where these were successful, DBM rapidly developed resistant populations. By the mid to late 1990's, repeated applications of traditional organo-phosphate and synthetic pyrethroid based insecticides had not only led to increased resistance amongst DBM populations, it had also killed ,many non-target species including DBM's natural enemies. This left growers without an effective means of controlling the pest.

DBM work was initiated in response to significant crop losses experienced by growers as a result of declining efficacy of the available broad spectrum insecticides. As resistance increased, growers were forced to apply more insecticide at higher frequencies with limited effect other than to increase resistance levels still further.

VG97014 developed the AVCARE Insecticide Resistance Action Committee (AIRAC) "two-window" spraying strategy in an attempt to limit the development of resistance by controlling each population's exposure to the available insecticides. VG00055 and VG03034 attempted to build on the initial work of VG97014 to further develop Integrated Pest Management (IPM) and Insecticide Resistance Management (IRM) strategies to control DBM.

The extent of damage caused by DBM varies from cosmetic leaf damage, which has very little impact on yield and market value, to the destruction of crops to the point where the crop is ploughed back into the soil as the damage is so extensive it is no longer viable to the harvest the remaining crop.

The principle aim of VG00055 was to develop IPM and IRM tools for growers that would allow them to better control DBM in a cost-effective way while limiting insecticide resistance, promoting the action of natural enemies and addressing wider community concerns about the impacts of the widespread use of insecticides. The project also recognised the need to develop a new management approach in order to safeguard the long-term sustainability of the brassica production sector.

C.1.2 Project Deliverables

Key project deliverables and outcomes included:

- Growers were encouraged to make spray decisions based on the newly developed crop-monitoring guide and the AIRAC two-window IRM strategy (this was reinforced by reminders to growers and other industry stakeholders issued when the new window came into effect);
- An insecticide toxicity chart, which allowed growers to understand the likely effect of using different sprays on beneficial populations. This information was used to identify the insecticide which best meets the specific pest and beneficial population mix at any particular stage in the growing cycle and to schedule insecticide application to target DBM during its more susceptible stages;
- Insecticide resistance tests, which found that continued spraying for DBM actually increased resistance by selecting for insecticide resistance in the pest population;

- By adopting the project findings, growers were able to make savings by reducing operating costs and crop losses without compromising output quality;
- Grower surveys showed increasing adoption of the two-window resistance management strategy, allowing more effective pest control and reducing the selection pressure for resistance amongst DBM, which was supported by:
  - The review of insecticide effectiveness showing high levels of resistance to synthetic pyrethroids (broad spectrum insecticides) throughout all brassica growing regions;
  - Testing resistance levels to the new DBM insecticides and *Bacillus thuringenesis* (narrow spectrum) showed little resistance other than in one Queensland population;
- Movement studies showed that while DBM tended to remain within several tens of metres of the point at which they emerged, parisitoids tended to be more active. There was little evidence of DBM or parisitoids moving between adjacent properties. These findings were used to inform future insecticide resistance management projects including the provision of nectar rich plants as a food source for parisitoids.

C.1.3 Project Adoption

DBM has been identified as the most significant pest problem for brassica producers in all growing areas in Australia. It has been assumed that 100 percent of the growing area had the potential to suffer losses as a result of DBM and that project outcomes would be relevant to all brassica growers.

As DBM resistance to broad spectrum synthetic insecticides increased, so too did the level of losses sustained by growers. As the DBM population is also affected by external factors such as climatic patterns, there were variations in the extent of losses, however, it is estimated that in a bad year (one in every three) additional losses of between 30-40 percent were recorded by many growers with some examples of still higher losses (*pers. comm.* Greg Baker State Entomologist SARDI 18th November 2008).

Losses of this magnitude were approaching a point where harvesting the crop was becoming uneconomical because of the high level of wastage. In some cases, the amount of processing required to identify the saleable product was so great, growers were faced with having to plough crops back into the ground.

The serious threat posed to the viability of brassica growers by DBM and the ineffectiveness of the available alternative control measures were likely to have significantly increased interest in the outcomes of this collection of projects. In the following CBA it is assumed:

- Although DBM affects all brassica crops, this assessment has only included broccoli, cabbage and cauliflower crops, and should be considered a minimum assessment of the returns provided by the research;
- Of the productive area which could adopt the R&D findings, 80 percent had adopted the R&D outputs within three years of the initial extension activities;
- Of the remaining growing area (20 percent):
  - 50 percent was used to continue growing brassica crops, enduring 15 percent losses; and
  - 50 percent was switched to alternative (less profitable) crops.

C.1.4 Project Impacts

The following table introduces the identified project impacts and introduces the basis of the calculations used in the CBA. Where it has not been possible to assign a dollar value to an impact, a qualitative assessment has been used, the details of which are included in the table.

Table C.1. Impact Identification Table

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
Economic Costs			
Project and Related Expenditure	**Project costs:** • The three projects associated with this group of projects had combined costs of $4.0 million, equivalent to $4.7 million ($2008).	Quantitative	Both
	Ongoing maintenance costs: • It is estimated that annual ongoing costs of $100,000 per annum ($2008) would be required to maintain the currency of the project findings. These costs end at the same time as the project benefits.	Quantitative	Both
	Increased chemical costs: • Chemical costs are based on nine applications per crop with average costs of $250 per hectare for broad spectrum insecticides and $907 per hectare for the newly registered chemical control measures. • The older chemicals are less expensive as in many cases the patent protection has expired. • It could be argued that these additional costs should not be included in the CBA as the high levels of resistance in DBM mean they would be much less effective than the newer chemical controls. However, a conservative approach has been adopted, recognising the additional costs of the new chemistry and assuming the same number of applications per crop. • To reflect the declining efficacy of older chemicals, their costs are assumed to reduce by ten percent per annum after the initial extension activities begin. The scale of benefits received (in the form of reduced externalities) is reduced by the same factor.	Quantitative	Growers
Economic Benefits			
Reduced Operating Costs	**Labour and equipment saving:** • Labour and equipment costs of brassica production are estimated to be $728 per hectare ($2008) (NSW Department of Agriculture 2001). • Growers are able to labour and equipment costs as a result of fewer spray applications (from up to 60 times per crop during periods of high pest activity in mid 1990's to less than ten per crop). • It is assumed that the reduction in labour and equipment inputs equates to a five percent reduction in labour and equipment costs. • This saving reduces by 1 percent per annum (reaching zero after five years) as technological advances increase operating efficiency in the no change and counterfactual scenarios.	Quantitative	Growers

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
	Avoided crop losses: • It is assumed crop losses of 15 percent per annum are experienced on properties that continue to operate without adopting the project findings. • Ten years after the initial extension activities, the average loss experienced by non-adopters is assumed to reduce by two percent per annum (reaching zero after a further 7.5 years), reflecting the adoption of other chemical control measures and alternative technologies in the future (likely to be further development of this work rather than an entirely new management approach). • The value of avoided crop losses has been calculated as the annual loss rate multiplied by the total output from growers that have adopted the project findings.	Quantitative	Growers
	Avoided lost revenues: • For non- adopters (following crop losses of 15 percent) it is assumed that within five years of the project extension activities 50 percent of growers would switch production to the next most profitable crops. • Alternative crops are assumed to be ten percent less profitable than current crops. • As the benefits of the R&D diminish over time, growers would be expected to return to growing brassica crops.	Quantitative	Growers

	Avoided higher priced imports:
	• Although the project is not considered to have developed any new markets, it is likely to have protected the domestic market from overseas competition. It is anticipated that without the R&D findings domestic market share would have eroded by overseas production and that:
	  ○ Prices would be five percent higher than under the 'no change scenario' due to scarcity of supply;
	  ○ Higher prices would encourage consumers to purchase substitute goods; and
	  ○ Domestic demand would be lower with 10 percent of production losses replaced by imports.
	• This avoided additional cost (under the R&D adoption scenario) is included as a benefit to the consumer and is calculated as the cost of substituting 10 percent of affected crops grown under R&D conditions with imported products which are 5 percent more expensive.
	• As the R&D benefits diminish, this price premium reduces by 1 percent per annum (reaching zero after five years).
		Quantitative	Public

	Contribution to regional and national economies: • In 2006-07, the brassica sector (cabbage, cauliflower and broccoli) had an estimated gross value of production of $144.5 million and was grown on more than 200 properties. This group of projects has significantly improved the viability of the brassica sector and in doing so has reduced the risks of losing the contribution that brassica growers make to regional economies (and the national economy) through both their direct expenditure and the flow on effects. It is **likely** (will probably occur in most circumstances) that this project has produced a **negligible** (unlikely to be measurable against benchmarks) economic public benefit. Resulting in a **low** impact score.	Qualitative	Public
Social Benefits			
Reduced Social Impact	**Reduced risks to physical and mental health:** • Growers and their families affected by DBM would be likely to experience considerable stress relating to the short-term viability of their business as well as the long-term future of the business. The projects undertaken to control the impacts of DBM provide growers with control mechanisms which whilst not infallible do give growers far better control over the action of this pest. It is thought **almost certain** (expected to occur in most circumstances) that this provides a **negligible** (unlikely to be measurable against benchmarks) social benefit to growers. Resulting in a **low** impact score.	Qualitative	Grower

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
	Strengthening regional communities: • Growers contribute to their local communities in a wide range of ways including their participation in community activities as well as the contribution they make to retain the critical population mass needed to sustain other rural sector businesses and community services including schools and health care facilities. It is thought **almost certain** (expected to occur in most circumstances) that the project has made a **negligible** (unlikely to be measurable against benchmarks) social benefit to the effected communities. Resulting in a **low** impact score.	Qualitative	Public
	Increasing the sustainability of the Australian vegetable sector: • This project has provided growers with a series of tools to manage DBM and has therefore also contributed to the continuation of a viable brassica sector in Australia. In doing so the project has helped to maintain the future of the industry, which encourages growers to make investments in equipment and other technology as well as giving them re-assurance about their own positions and the likelihood of being able to pass on a viable operation to the next generation of their family. This is **likely** (will probably occur in most circumstances) to have a **negligible** (unlikely to be measurable against benchmarks) social impact on growers. Resulting in a **low** impact score.	Qualitative	Both
	Skill and knowledge development: • Research into DBM contributes to increased knowledge of that pest and will inform future work in this area, it also assists in the development of IPM strategies developed for other pests. It is **likely** (will probably occur in most circumstances) that this group of projects has provided a **negligible** (unlikely to be measurable against benchmarks) social benefit by informing future studies both of DBM and IPM strategies in general. Resulting in a **low** impact score. • These projects have contributed to the development and retention of R&D posts in Australia as well as developing researchers' knowledge and skills. This helps to retain researcher skills within Australia and has the potential to lead to benefits in other related fields. This is considered **almost certain** (expected to occur in most circumstances) to provide a **minor** (small relative to the wider context of the population/area being affected) public benefit through the applicability of research findings to other crops, thereby also contributing economic outcomes to other crops. Resulting in a **medium** impact score.	Qualitative	Both
Environmental Benefits			
	Reduced environmental impacts of grower activity: • The externalities of the chemicals registered through the minor use schemes are estimated to be approximately $1.39 per application per hectare (Leach and Mumford 2008), significantly lower than for the older chemicals (approximately $22.09 per application per hectare) (Leach and Mumford 2008). • It is assumed that there are nine applications per crop. This is a conservative assumption as during periods of intense pest activity growers using 'older style' insecticides may be forced to spray on a more frequent basis, especially where resistance levels are significant.	Quantitative	Grower
	Reduced indirect environmental impacts: • A fall in domestic production would be expected to trigger higher prices, leading to decline in demand as the higher prices encouraged consumers to switch to lower cost alternative products. Remaining demand would be met from overseas production with associated environmental impacts as a result of the additional transportation and storage. It is **almost certain** (expected to occur in most circumstances) that avoiding these additional transport requirements has produced a **negligible** (unlikely to be measurable against benchmarks) environmental and likely economic public benefit. Resulting in a **low** impact score.	Qualitative	Both

Source: AEC*group*

C.1.5 Counterfactual Case

C.1.5.1 What are the main benefits that would have eluded growers without this project?

In the short-term brassica growers have benefitted from having a means of controlling DBM losses and increasing their production efficiency by limiting wastage. In the longer term, growers have also benefited from the development of a sustainable management model for the sector which is not solely reliant on chemical control mechanisms.

C.1.5.2 Would the project have happened without the funding provided by HAL?

It is unlikely that the project would have been funded by any other agency. The principle benefits have accrued to growers and the general public but there is considered to be insufficient scope for a private sector organisation to consider undertaking this funding. Even if they were willing to fund this work, it would be very difficult for them to recover their costs from growers.

C.1.5.3 Has the project brought forward any benefits that may not otherwise have emerged?

The project's development of a two-window approach to the application of chemical controls has been adapted for use in other commodities. By managing the rate at which insecticide resistance develops, the two-window strategy reduces the extent of crop losses to resistant populations, saves growers from applying ineffective chemicals, reduces environmental impacts and reduces the costs of applying for additional minor use chemical registration permits.

In addition to the short-term losses of crops, the medium-long term sustainability of the sector was under threat. Not only was the activity of the DBM resulting in significant crop losses, the high level of insecticide use and associated environmental consequences were not management options that could be maintained in the longer term. Without this project it is likely that growers would have ended brassica production. Although growers had the option of switching to other commodities, this decision would have been influenced by the suitability of their property and the ability of the market to absorb additional production of that commodity without resulting in lower prices.

Some growers in Western Australia reported that prior to adopting IPM, they were spraying crops up to ten times per week during periods of intense DBM activity. This not only has implications in terms of the costs of the chemicals, the grower's time and equipment costs, there are also significant environmental costs. Further, in many cases this was not an effective strategy but growers were left with little alternative given the high degree of insecticide resistance that had built up, the absence of beneficial species and the potential crop losses they might suffer.

C.1.5.4 Would the same outcomes have emerged from overseas research and how long would the lag-time have been?

Whilst research into diamond backed moth has been under taken overseas, it is unlikely that the findings would be applicable in Australia. The specific characteristics of the growing regions as well as the DBM population mean that whilst some overseas findings and techniques are applicable the majority of findings cannot simply be applied in Australia.

C.1.5.5 Are other groups working on substitute technologies which might make the project findings obsolete?

IPM approaches are widely recognised as offering growers the most effective and sustainable control options. While the project findings are subject to continual improvement the fundamental principles are unlikely to change. It is much more likely that new developments will build on the work undertaken as part of these projects to further refine techniques and adapt to changes in the pest population rather than to develop an entirely new approach.

C.1.5.6 Has the involvement of HAL increased adoption rates?

Communication of the project findings through HAL's media and grower connections is likely to have increased adoption rates. Many of the project findings require changes to grower behaviours rather than the purchase of new equipment and in some cases may result in reduced input costs. It is therefore unlikely that a private sector organisation would be willing to promote the wider adoption of a technique which might reduce their revenues.

C.1.5.7 Cost Benefit Analysis Results

The following table summarises the economic cost impacts used in the CBA (no social or environmental costs have been identified).

Table C.2. Present Value of Project Costs

Impact	Cost ($2008)	PV ($M) – Discount Rate		
		6.00%	7.15%	9.00%
Project cost	$4.7 million	$5.1	**$5.4**	$6.0
Ongoing costs	$100,000	$0.8	**$0.8**	$0.8
Increased chemical cost	$657 [(a)]	$14.3	**$14.6**	$15.1
Total		**$20.2**	**$20.8**	**$21.9**

Notes: Totals may not sum due to rounding (a) per hectare per crop
Source: AEC*group*

The present value of the economic costs of the project is estimated to be $20.8 million. Total project costs and ongoing costs would be split equally between levy payers and the public, however, growers alone would be faced with the higher chemical costs. The following table summarises the economic benefit impacts used in the CBA.

Table C.3. Present Value of Project Benefits

Impact	Benefit ($2008)	PV ($M) – Discount Rate		
		6.00%	7.15%	9.00%
Labour and equipment saving	$36.40/hectare	$1.6	**$1.6**	$1.7
Avoided crop losses[(a)]	$919.00/tonne	$143.4	**$142.4**	$141.1
Avoided lost revenues due to switching crops[(a)]	10% ($91.90/tonne)	$13.0	**$12.8**	$12.5
Import saving[(a)]	5% ($45.95/tonne)	$42.1	**$41.3**	$40.2
Reduced risks to health	$2.79[(b)]	$0.1	**$0.1**	$0.1
Reduced environmental impacts	$20.70[(b)]	$0.5	**$0.5**	$0.5
Total		**$200.8**	**$198.7**	**$196.1**

Notes: Totals may not sum due to rounding (a) average across the three crops in the assessment, CBA uses actual cost for each crop, (b) per hectare per application
Source: AEC*group*

The total present value of the stream of benefits from the projects is estimated to be $198.7 million.The table below outlines the net present value of the impacts of these projects.

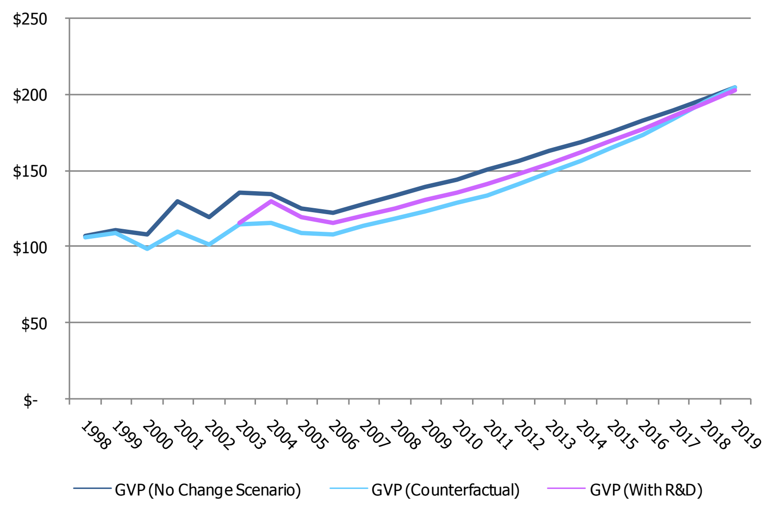
Table C.4. CBA Outcomes ($2008 million)

Discount Rate	PV Costs		PV Benefits		NPV		BCR	
	Private	Public	Private	Public	Private	Public	Private	Public
6.00%	$17.3	$2.9	$158.2	$42.6	$140.9	$39.7	9.2	14.5
7.15%	**$17.7**	**$3.1**	**$156.9**	**$41.8**	**$139.2**	**$38.7**	**8.8**	**13.4**
9.00%	$18.5	$3.4	$155.4	$40.7	$136.9	$37.3	8.4	11.9

Notes: Totals may not sum due to rounding
Source: AEC*group*

The table demonstrates that this work produces a positive return on investment to both growers $139.2 and the public $38.7 million. The following figure compares the gross value of production between the no change, counter factual and with R&D adoption cases, it should be noted that the 'with R&D' case includes output from both growers adopting the project findings and those that continue to grow brassica crops despite incurring significant losses as a result of DBM activity.

Figure C.1. Gross Value of Production Comparison ($2008 million)



Source: AEC*group*

It is clear the project delivers a significantly higher GVP than would be anticipated under the counterfactual scenario. As the R&D benefits are eroded, all three scenarios come back together. It is also anticipated that the project has produced several benefits which do not flow through to the GVP. These benefits include, reduced variable costs, avoided higher import costs to consumers and environmental benefits from use of chemical controls with lower impacts.

The following table shows the distribution of benefits between growers and the public over five, ten and twenty years from the start of the project and the following figure shows the cumulative net present value of this work to growers and the public.

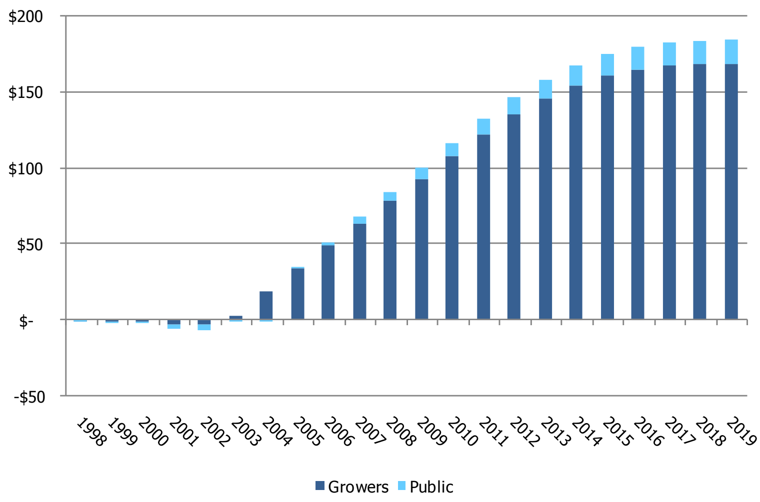
Table C.5. NPV of Grower and Public Impacts ($2008 million)

	5 yrs	10 yrs	20 yrs
Grower			
6.00%	$34.3	$107.8	$171.7
7.15%	**$35.6**	**$109.1**	**$169.6**
9.00%	$37.9	$111.4	$166.9
Public			
6.00%	$1.9	$9.8	$17.5
7.15%	**$2.0**	**$9.9**	**$17.1**
9.00%	$2.0	$9.9	$16.5
Total			
6.00%	$36.2	$117.6	$189.2
7.15%	**$37.6**	**$119.0**	**$186.7**
9.00%	$39.9	$121.3	$183.3

Notes: Totals may not sum due to rounding
Source: AEC*group*

Within five years of the project starting, it is estimated to have produced a positive return on investment for growers ($169.6 million) and the public ($17.1 million). The flow of net benefits from the project over time is shown in the following figure.

Figure C.2. Cumulative NPV to Growers and Public ($2008 million)



Source: AEC*group*

It is estimated that over the twenty years following the start of the project, 90.8 percent ($169.6 million) of the total quantifiable net benefit would accrue directly to growers, with the remaining 9.2 percent ($17.1 million) accruing to the general public.

C.1.6 Sensitivity Analysis

The two major assumptions used in the model relate to the proportion of production grown under the new management approach (15 percent) and the percentage of losses incurred (80 percent). It is considered that the adoption rate is a conservative approach given the scale of losses incurred using broad spectrum chemical controls and the percentage losses where observed in crops and in trials. However, the following table demonstrates the impact on NPV of a range of assumption scenarios.

Table C.6. Sensitivity Analysis of NPV to Adoption and Crop Loss Scenarios, ($2008 million)

Crop Losses	% Adoption			
	70%	80%	90%	100%
5%	$47.7	$48.7	$48.0	$45.6
10%	$96.9	$112.1	$127.5	$143.1
15%	$154.7	$186.7	$221.0	$257.5
20%	$219.9	$270.8	$326.4	$386.6

Notes: Totals may not sum due to rounding
Source: AEC*group*

The highlighted cell shows the outcome based on the assumptions used in the model. Using the highest adoption scenario of 100 percent adoption and 20 percent crop losses, the NPV would be $386.6 million. However, if the lowest scenario were adopted (70 percent adoption and 5 percent crop losses), the NPV would be $47.7 million. Therefore, even at the lowest scenario, the project is seen to record a positive NPV.

C.1.7 Qualitative Summary

There are a series of benefits to growers and the public from this work that cannot be assessed quantitatively but which are expected to provide significant benefits to growers and the public, including:

- **Contribution to regional economies:** given the significance of the brassica sector to the vegetable growing industry, it would be anticipated that brassica growers make a significant contribution to their local economies through their expenditure and the flow-on affects as that the expenditure pass through the local economies.

- **Reduced environmental impacts:** in 2006-07, more than 210,000 tonnes of broccoli, cabbage and cauliflower was grown in Australia (ABS 2008). It is likely that importing even a small proportion of these goods if growers could not manage losses due to DBM would be likely to have significant environmental impacts.

C.1.8 Confidence Rating

The confidence rating for this project assessment is considered to be high. Researchers have worked on this project over almost ten years and have a detailed understanding of the issues facing growers in terms of the potential losses they face and the extent of adoption. Although growers in different regions operate different management systems in terms of their precise inputs, the figures used are based on industry benchmarks and conservative assumptions have been used throughout to ensure that project benefits are not overstated.

Assumptions regarding the impact of reducing domestic supply on prices and demand are the most difficult to make as it could be argued that lower overseas production costs would result in price decreases if overseas growers could access Australian markets as a result of reduced Australian competition. However, when anticipated transport and storage costs are considered, it is reasonable to assume costs would increase.

C.1.9 Summary

In Australia, brassica crops are one of the most significant groupings of vegetable crops in terms of the number of growers, the value of the crops and the area under production. As a result, the cumulative impact of cost and benefits is likely to be significant. Even though the scale of crop losses facing brassica growers is lower than in other projects, the risks the industry faced were significant. As well as allowing growers to control losses to DBM, the projects have also established a management framework (including the two-window spraying strategy), which has the potential to guide pest management over the medium to long-term.

C.2 Insect Pest Management in Sweet Corn

C.2.1 Project Description

In 2006-07, sweet corn had a gross value of production of more than $48 million (ABS 2008). In the mid to late 1990s, sweet corn growers in Queensland, NSW and Victoria experienced increasing difficulties producing cobs free from damage caused by *Helicoverpa armigera* (Heliothis). Heliothis had developed high levels of insecticide resistance resulting in significant crop losses and increasing chemical input costs as growers unsuccessfully attempted to combat resistance by increasing spray frequency.

The damage caused by Heliothis is difficult to detect in the field, which means infected cobs made their way onto the market (in several cases, the damage was not recognised until the product was about to be consumed), with negative effects on demand and price. This meant a grower might have already incurred the full preparation, planting, management, harvesting and processing costs before realising their crop could not be sold.

As a first step, VG97036 *(Insect pest management in sweet corn)* assessed the extent of insecticide resistance among Heliothis populations and found it had reached critical levels throughout the growing areas including:

- In the Lockyer Valley (Queensland) in Dec/Jan 1995-96, synthetic pyrethroid insecticide resistance was 57 percent and 41 percent respectively in two samples and Carbamate resistance was 15 percent;
- In North Queensland levels of resistance (up to 100 percent) were recorded in the winter of 1996;
- In East Gippsland (Victoria) in 1996-97, Heliothis had developed 96 percent and 50 percent resistance levels against synthetic pyrethroids (fenvalerate) and carbamate (methomyl) as well as 35 percent resistance against organochlorines and 6 percent resistance against profenofos. By 2000, resistance had doubled for synthetic pyrethroids; and
- In Dalmore and Lindenow (Victoria), resistance increased by between 10 and 39 times between 1997 and 2000.

Although damage caused by Heliothis activity does not impair the flavour of the remaining cob, sweet corn which has any sign of pest presence on the cob or which has been damaged will be rejected by the fresh market. The increase in pre-packaged fresh sweet corn and processed sweet corn in NSW means that some affected cobs can be cut to remove damaged areas but this considerably increases wastage, packaging time, production costs and the overall profitability of the crop.

C.2.2 Project Deliverables

The project developed a series of best management options (BMOs) for growers based around an IPM approach. This involved a fundamental shift from the traditional method of insect control through calendar based spraying of relatively inexpensive broad spectrum insecticides (usually synthetic pyrethroids and organo-phosphates) to a more holistic system which utilised a variety of management options (including some targeted chemical usage) to manage insect damage in the crop. The BMOs included:

Crop Scouting

A crop scouting protocol was developed allowing growers to determine when and where Heliothis infestations (and other pests and beneficial species) were likely to occur, and where necessary, the best time to make spray treatments.

By the end of the project, all states reported the use of monitoring protocols and increased grower understanding of monitoring procedures and results. All sweet corn grown in the Dry Tropics in Queensland is now monitored professionally, and the area monitored in South Queensland had doubled by the time the project was completed. In NSW, there has been a 20 percent increase in the area of sweet corn regularly monitored and in Victoria, 85 percent of the industry now check crops for large and small larvae and eggs.

Beneficial Species

Several naturally occurring beneficial species were identified as having the potential to contribute to the management of Heliothis. Their effectiveness has now increased considerably because of the reduced use of broad spectrum insecticides, which had previously resulted in almost entirely sterile growing areas.

Targeted Pesticide Application

Insecticide application remained an integral part of the sweet corn IPM approach, however, the chemicals used and their application was amended. Targeting synthetic and biological insecticides to the cob and silk area and focussing the timing of spraying to the period when the pest is most susceptible to insecticide significantly reduced pest damage. The study found a 400 percent increase in the average deposit on silks when using a boom spray modified with droppers compared to a traditional boom spray without droppers.

Use of 'Softer Chemicals'

The project also identified alternative chemical management options. These included narrow spectrum insecticides (which have less off target impacts) as well as biologically based products such as Bacillus thuringiensis (Bt). These had proven to be effective at controlling Heliothis and the results from this project were used to support the successful application for the registration of Success® and Gemstar® (narrow spectrum insecticides) for use in sweet corn in Australia.

Some of the softer insecticides were already registered for use in cotton crops, were highly effective and profitable to chemical manufacturers. The chemical companies had to be convinced that growers would use the new chemicals responsibly as part of a wider management approach and not over use them leading to resistance.

C.2.3 Project Adoption

Sweet corn is grown through Australia, with the exception of the Northern Territory and is available all year round from domestic production. It has been assumed that:

- The project findings are potentially applicable to 100 percent of Australian sweet corn production;
- High levels of crop loss and a lack of an effective means of controlling Heliothis damage meant that this project is considered to have been widely adopted, especially amongst growers that supply the fresh market;
- The less rigorous cosmetic standards required by the processed sweet corn sector (largely NSW production) mean in these areas adoption and implementation of the entire suite of IPM measures has been less widespread. It has been assumed that 75 percent of total Australian production was grown under management regimes which have adopted the critical aspects of the BMO within the three years of the extension elements of the project;
- Of the remaining growing area (25 percent):
    - 50 percent was used to continue growing brassica crops, enduring 30 percent losses; and
    - 50 percent was switched to alternative (less profitable) crops.

C.2.4 Project Impact Identification

Table C.7. Impact Identification Table

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
	Economic Costs		
Project and Related Expenditure	**Project costs:** The three projects associated with this project had combined costs of $3.4 million, equivalent to $4.1 million ($2008)	Quantitative	Both
	Ongoing maintenance costs: It is estimated that annual ongoing costs of $100,000 per annum ($2008) would be required to maintain the currency of the project findings. These costs end at the same time as the project benefits.	Quantitative	Both
	Increased chemical costs: • Chemical costs are based on nine applications per crop with average costs of $250 per hectare for broad spectrum insecticides and $907 per hectare for the newly registered chemical control measures. • The older chemicals are less expensive as in many cases the patent protection has expired. • It could be argued that these additional costs should not be included in the CBA as the high levels of resistance in Heliothis mean they would be much less effective than the newer chemical controls. However, a conservative approach has been adopted, recognising the additional costs of the new chemistry and assuming the same number of applications per crop. • To reflect the declining efficacy of older chemicals, their costs are assumed to reduce by ten percent per annum after the initial extension activities begin. The scale of benefits received (in the form of reduced externalities) is reduced by the same factor.	Quantitative	Grower
	One-off implementation costs: • The project found that in order to target insecticides to the appropriate area of the cob, boom sprayers should be fitted with droppers. Most existing sprayers can be adjusted (at an estimated cost of approximately $10,000) without the need to replace existing equipment. • It is estimated that all R&D adopters adapt their spraying equipment as they adopt the project findings.	Quantitative	Grower
	Economic Benefits		
Reduced Operating Costs	**Reduce crop losses:** • Between 1996 and 2000 (as levels of broad spectrum insecticide resistance increased), Australian domestic sweet corn production fell by 44.8 percent (36,686 tonnes) from 81,901 tonnes in 1996 to 45,215 tonnes in 2000 (ABS 2007). • Prior to the study, losses in some growing regions were as high as 100% with most growers reporting losses of between 30 to 40 percent per annum. • In the CBA, an average loss figure of 20 percent per annum has been assumed for the first ten years before reducing at a rate of two percent per annum (reaching zero after a further 10 years) as alternative control methods become available (these are likely to be extensions of this work rather than a change of management approach).	Quantitative	Grower

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
	Avoided lost revenues: • For non- adopters (following crop losses of 20 percent) it is assumed that within five years of the project extension activities 50 percent of growers would switch production to the next most profitable crops • Ten years after the initial extension activities, the average loss experienced by non-adopters is assumed to reduce by two percent per annum (reaching zero after a further 10 years), reflecting the adoption of other chemical control measures and alternative technologies in the future (likely to be further development of this work rather than an entirely new management approach). • The value of avoided crop losses has been calculated as the annual loss rate multiplied by the total output from growers that have adopted the project findings.	Quantitative	Grower

Market Development	**Avoided higher priced imports:**
	• Although the project is not considered to have developed any new markets, it is likely to have protected the domestic market from overseas competition. It is anticipated that if growers sustained repeated heavy crop losses, with no effective means of controlling the pest and there had been repeated incidents of consumers purchasing a diseased product, domestic market share would have eroded by overseas production and that:
	  ○ Prices would be five percent higher than under the 'no change scenario' due to scarcity of supply;
	  ○ Higher prices would encourage consumers to purchase substitute goods; and
	  ○ Domestic demand would be lower with 10 percent of production losses replaced by imports.
	• This avoided additional cost (under the R&D adoption scenario) is included as a benefit to the consumer and is calculated as the cost of substituting 10 percent of affected crops grown under R&D conditions with imported products which are 5 percent more expensive.
		Quantitative	Public

	International market expansion: • In the mid 1990's Australia exported sweet corn to several markets. Since then, the emergence of China as a significant vegetable exporter has significantly reduced demand for Australian grown vegetables, in particular where price is the primary differentiating factor. However, the adoption of the BMOs has made it possible for growers to produce sweet corn which is of sufficient quality (i.e. blemish free) to supply high value demand in Singapore and Malaysia. Although lucrative for the growers that supply these markets, from the perspective of total supply the impact of this trade is **likely** (will probably occur in most circumstances) to be **minor** (small relative to the wider context of the population/area being affected) economic due to the low volumes involved. Resulting in a **medium** impact score.	Qualitative	Grower
	Contribution to regional and national economies: • This project has significantly improved the viability of the sweet corn sector and in doing so has reduced the risks of losing the contribution that sweet corn growers make to regional economies (and the national economy) through both their direct expenditure and the flow on effects. It is **likely** (will probably occur in most circumstances) that this project has produced a **negligible** (unlikely to be measurable against benchmarks) economic public benefit. Resulting in a **low** impact score.	Qualitative	Public
Social Impacts			
Reduced Social Impact	**Reduced risks to physical and mental health:** • Growers (and their families) affected by Heliothis would be expected to experience considerable stress relating to the short-term viability of their business and its long-term prospects. The projects undertaken to control Heliothis provide growers with control mechanisms, which whilst not infallible do give growers far greater control. It is thought **almost certain** (expected to occur in most circumstances) that this provides a **negligible** (unlikely to be measurable against benchmarks) social benefit to growers. Resulting in a **low** impact score.	Qualitative	Grower

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
	Strengthening regional communities: • Growers contribute to their local communities in a wide range of ways including their participation in community activities as well as the contribution they make to retain the critical population mass needed to sustain other rural sector businesses and community services including schools and health care facilities. It is thought **almost certain** (expected to occur in most circumstances) that the project has made a **negligible** (unlikely to be measurable against benchmarks) to the effected communities. Resulting in a **medium** impact score.	Qualitative	Public
	Increasing the sustainability of the Australian vegetable sector: • Providing the tools to effectively manage Heliothis damage in particular and pests in general is likely to contribute to the continuation of a viable sweet corn sector in Australia. In doing so, the project helps to develop a sustainable future for the industry, which encourages growers to make investments in equipment and other technology. It also gives growers re-assurance about the security of their positions and the likelihood of being able to pass on a viable operation to the next generation of their family if they wish to do so. This is **likely** (will probably occur in most circumstances) thought to have a **negligible** (unlikely to be measurable against benchmarks) beneficial impact on growers. Resulting in a **low** impact score.	Qualitative	Grower
	Skill and knowledge development: • Research into Heliothis contributes to increased knowledge of that pest and will inform future work in this area, it also assists in the development of IPM strategies developed for other pests. It is **likely** (will probably occur in most circumstances) that this group of projects has provided a **negligible** (unlikely to be measurable against benchmarks) social benefit by informing future studies both of DBM and IPM strategies in general. Resulting in a **low** impact score. • These projects have contributed to the development and retention of R&D posts in Australia as well as developing researchers' knowledge and skills. This helps to retain researcher skills within Australia and has the potential to lead to benefits in other related fields. This is considered **almost certain** (expected to occur in most circumstances) to provide a **negligible** (unlikely to be measurable against benchmarks) public benefit through the applicability of research findings to other crops, thereby also contributing economic outcomes to other crops. Resulting in a **low** impact score.	Qualitative	Both
Environmental Impacts			
Reduced Environmental Impact	**Reduced environmental impacts of grower activity:** • The externalities of the chemicals registered through the minor use schemes are estimated to be approximately $1.39 per application per hectare (Leach and Mumford 2008), significantly lower than for the older chemicals (approximately $22.09 per application per hectare) (Leach and Mumford 2008). • It is assumed that there are nine applications per crop. This is a conservative assumption as during periods of intense pest activity growers using 'older style' insecticides may be forced to spray on a more frequent basis, especially where resistance levels are significant.	Quantitative	Both

Source: AEC*group*

C.2.5 Counterfactual Case

C.2.5.1 What are the main benefits that would have eluded growers without this project?

A 2007-08 season trial of new narrow spectrum insecticides carried out by the NSW Department of Primary Industries found that while narrow spectrum controls resulted in over 80 per cent of cobs being suitable for the processing market, broad spectrum insecticides could only achieve between 50 and 60 percent and the control 30 percent (Napier and McDougall 2008). It is likely that losses of at least 40 to 50 percent would be common throughout the growing area without this project making the industry unviable in regions of high pest activity.

Stakeholder consultations suggest that without this IPM strategy development, the sweet corn industry would have suffered such significant losses many growers would have been forced to switch production to alternative crops. Even if a new broad spectrum chemical could have been adopted this would only have provided short-term relief as it would be expected resistance would have quickly developed if it were used as a sole response. The chemical companies were also reluctant to support the registration of their chemicals, which were effective in controlling Heliothis in cotton (estimated export value $823 million 2006-07, ABARE 2009) for use in sweet corn (estimated value 2006-07 $53.8 million, ABS 2007) in case overuse led to resistance and ended the revenue stream from cotton growers.

C.2.5.2 Would the project have happened without the funding provided by HAL?

It is unlikely that any other organisation would have been willing to support this project. Although a significant horticultural crop in Australia, in a wider context the Australian sweet corn industry is not large enough to attract the interest of major chemical or equipment manufacturers.

Despite the significant threat to the industry from Heliothis damage, it would be difficult for any private sector investor to find a way of recovering the project costs from growers. For example, one recommendation of the project was that growers adapt their machinery to better target the application of insecticides. It is considered unlikely that a chemical company would have sponsored work that reduces the volume of their product they can sell and the work would be equally unlikely to be sponsored by equipment manufacturers as existing equipment can easily be adapted.

C.2.5.3 Has the project brought forward any benefits that may not otherwise have emerged?

In common with many other commodities, the export market for sweet corn has been affected by increased Chinese based production (USA is also an important competitor). This problem was been exacerbated by the relative strength of the Australian dollar over the same period, effectively increasing the cost of all Australian exports. Australian products are often required to compete at the premium end of the market rather than as a low cost supplier. This means it is difficult to determine the relative impacts of Heliothis against increased overseas competition. In recent years decreasing exports have been more than offset by increased domestic demand (*pers. comm.* Peter Deuter 21st November 2008). It is unlikely this would have been possible without the outputs from this project.

C.2.5.4 Would the same outcomes have emerged from overseas research and how long would the lag-time have been?

Chemical controls were available overseas but these had not been registered for use on sweet corn in Australia. Minor use permits were approved and have been adopted as one component of the IPM strategy. However, although this technology existed overseas, it would not have been approved for use in Australia without this project work. Further, this project's findings were specifically adapted to Australian growing conditions. Whilst it might have been apparent that an integrated approach was needed as insecticide resistance increased, local research and extension was required to determine the appropriate components of the strategy and how these should be applied in Australia.

C.2.5.5 Are other groups working on substitute technologies which might make the project findings obsolete?

It is widely acknowledged by growers and other stakeholders that IPM strategies are vital to the future of a sustainable and viable horticulture sector. It is therefore unlikely that new technology will emerge that makes these findings obsolete. Over time, some resistance may develop requiring the introduction of new chemicals and as understanding of pest and beneficial species and pests other controls may emerge but these are likely to build upon these findings rather than replace them.

C.2.5.6 Has the involvement of HAL increased adoption rates?

Assessment of the extent of grower adoption was not part of the project scope of the research project, however, a number of factors suggest the adoption rate is likely to have been high:

- Relative to other major Australian vegetable crops, sweet corn growers are fewer in number with production concentrated between a few large producers. As a result, it is relatively easier to achieve a higher rate of adoption than would have been the case with some other commodities where production is more fragmented;
- The project team invested considerable time and energies in the extension aspects of the project, producing a CD-ROM and undertaking many field workshops and grower meetings to disseminate the project findings; and
- Prior to this project, sweet corn growers faced a serious threat to the future of the sector, which highlighted the need to adopt a new management approach.

The severity of the losses facing sweet corn growers mean, at least initially, every grower would have been aware of the problems facing the sector and so HAL's involvement is likely to have been limited. However, in communicating the project findings and in follow up work through VegeNotes and other publications it is likely that HAL has played a role in increasing adoption rates.

C.2.6 Cost Benefit Analysis Results

The following table summarises the economic cost impacts used in the CBA (no social or environmental costs have been identified).

Table C.8.Present Value of Project Costs

Impact	Cost ($2008)	PV ($M) – Discount Rate		
		6.00%	7.15%	9.00%
Project cost	$4.1 million	$6.2	**$6.6**	$7.5
Ongoing costs	$100,000	$0.8	**$0.8**	$0.8
One-off implementation costs	$10,000[(a)]	$2.8	**$2.8**	$3.0
Increased chemical cost	$657 [(b)]	$10.9	**$11.1**	$11.5
Total		**$20.7**	**$21.4**	**$22.7**

Notes: Totals may not sum due to rounding (a) per grower (b) per hectare per crop
Source: AEC*group*

The present value of the economic costs of the project is estimated to be $21.4 million. Total project costs and ongoing costs would be split equally between levy payers and the public, however, growers alone would be faced with the implementation cost and ongoing higher chemical costs. The following table summarises the economic benefit impacts used in the CBA.

Table C.9. Present Value of Project Benefits

Impact	Benefit ($2008)	PV $M) – Discount Rate		
		6.00%	7.15%	9.00%
Avoided crop losses	$819/tonne	$110.0	**$108.6**	$106.9
Avoided lost revenues due to switching crops	$81.90/tonne	$14.7	**$14.5**	$14.2
Import saving	$40.97/tonne	$25.4	**$25.0**	$24.5
Reduced risks to health	$2.79[a]	$0.1	**$0.1**	$0.1
Reduced environmental impact	$17.92[a]	$0.4	**$0.4**	$0.4
Total		**$150.5**	**$148.6**	**$146.0**

Notes: Totals may not sum due to rounding (a) per hectare per application
Source: AEC*group*

The total present value of the stream of benefits from the projects is estimated to be $148.6 million. The majority of these benefits are associated with avoided crop losses and the avoided costs of importing alternative supplies. The table below outlines the net present value of the impacts of these projects.

Table C.10. CBA Outcomes ($2008 million)

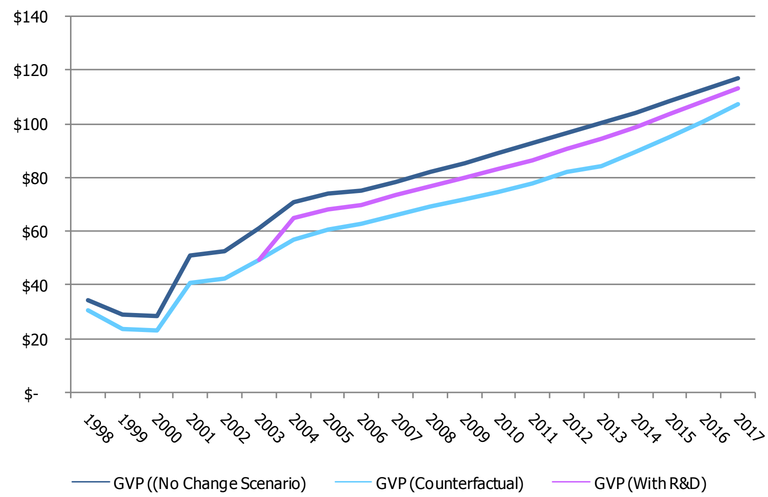
Discount Rate	PV Costs		PV Benefits		NPV		BCR	
	Private	Public	Private	Public	Private	Public	Private	Public
6.00%	$17.2	$3.5	$124.8	$25.7	$107.6	$22.2	7.3	7.4
7.15%	**$17.7**	**$3.7**	**$123.2**	**$25.4**	**$105.5**	**$21.6**	**7.0**	**6.8**
9.00%	$18.6	$4.2	$121.1	$24.8	$102.6	$20.7	6.5	6.0

Notes: Totals may not sum due to rounding
Source: AEC*group*

The table demonstrates that this work produces a positive NPV to both growers ($105.5 million) and the public ($21.6 million). Costs to growers are higher than those to the public due to the additional costs of switching production to the new chemistry and the one off implementation costs associated with adapting boom sprayers.

The following figure compares the gross value of production between the no change, counter factual and with R&D adoption scenarios.

Figure C.3. Gross Value of Production Comparison ($2008 million)



Source: AEC*group*

Levels of insecticide resistance (and therefore crop losses) had been significant since the mid 1990s. As a result, the GVP in the 'counterfactual' case is below the 'no change' scenario when the initial project expenditure is undertaken. The chart shows the decline in the value of production in the counterfactual case despite the increase in price. The GVP under the 'with R&D' scenario remains beneath the 'no change' value due to the losses incurred by those growers that have not adopted the project findings and the reduction in the GVP experienced by growers that switch to alternative crops.

Ten years after the project findings are first made available to growers, the project benefits begin to diminish and eventually the R&D and counterfactual scenarios approach the GVP of the no change scenario as alternative technologies supersede the project findings. Another scenario would see any growers that did not adopt the findings forced to leave the sector due to the high crop losses. In this case, the counterfactual GVP would be expected to be zero within a few years.

The following table shows the distribution of benefits to growers and to the public over five, ten and twenty years from the start of the project and the following figure shows the cumulative net present value of this work to growers and the public.

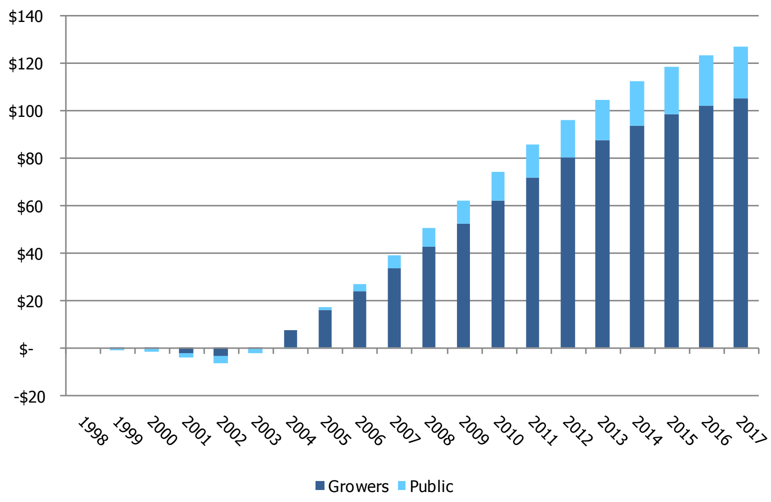
Table C.11. Project NPV of Grower and Public Impacts ($2008 million)

	5 yrs	10 yrs	20 yrs
Grower			
6.00%	-$3.1	$32.5	$107.6
7.15%	**-$3.3**	**$33.3**	**$105.5**
9.00%	-$3.7	$34.5	$102.6
Public			
6.00%	-$3.1	$5.5	$22.2
7.15%	**-$3.3**	**$5.5**	**$21.6**
9.00%	-$3.7	$5.5	$20.7
Total			
6.00%	-$6.1	$38.0	$129.9
7.15%	**-$6.6**	**$38.8**	**$127.1**
9.00%	-$7.5	$40.0	$123.2

Notes: Totals may not sum due to rounding
Source: AEC*group*

For growers and the public, the project breaks even between five and ten years after the first expenditure is incurred. This is as due to the length of time between the first project expenditure and the initial extension activities. The scale of the problem facing researchers was such that before control measures could be developed, it was first necessary to study the extent of resistance, the characteristics of the pest and then consider what management approaches could be implemented to give growers some control. After ten years both growers and the public are estimated to have received a positive return on their investment in the project and this is anticipated to increase over the useful life of the project findings. The following figure illustrates the cumulative distribution of benefits to growers and the public over time.

Figure C.4. Cumulative NPV to Growers and Public ($2008 million)



Source: AEC*group*

It is estimated that over the twenty years following the start of the project 83.0 percent ($105.5 million) of the total quantifiable net benefit would accrue directly to growers, with the remaining 17.0 percent ($21.6 million) accruing to the public. The relatively slow start to the flow of benefits means the figure shows benefits increasing steadily to both growers and the public. If the time frame covered by the chart were extended by a five more years, the increase in cumulative benefits would tail off as the R&D benefits diminished.

C.2.7 Sensitivity Analysis

The two major assumptions used in the model relate to the proportion of production grown under the new management approach (75 percent) and the percentage of losses incurred (20 percent). It is considered that the adoption rate is a conservative approach given the scale of losses incurred using broad spectrum chemical controls and the percentage losses where observed in crops and in trials. However, the following table demonstrates the impact on NPV of a range of assumption scenarios.

Table C.12. Sensitivity Analysis of NPV to Adoption and Crop Loss Scenarios, ($2008 million)

	65%	75%	85%	95%
10%	$64.1	$62.0	$59.7	$57.0
20%	$114.9	**$127.1**	$141.1	$156.8
30%	$166.3	$193.0	$223.5	$257.8
40%	$217.8	$258.9	$305.9	$358.8

Notes: Totals may not sum due to rounding
Source: AEC*group*

The highlighted cell shows the outcome based on the assumptions used in the model. Using the highest scenario of 95 percent adoption and 40 percent crop losses, the NPV would be $358.8 million. However, if the lowest scenario were adopted (65 percent adoption and 10 percent crop losses), the NPV would be $64.1 million. Therefore, even at the lowest scenario, the project is seen to record a positive NPV.

C.2.8 Qualitative Summary

The project has provided several benefits that cold not be quantified and which have been assessed using a qualitative framework, the most significant of these include:

- **Contribution to a sustainable Australian vegetable industry –** sweet corn growers were faced with a serious threat to the long-term survival of their industry. This project has developed a longer term management approach which will guide growers through the adoption of a sustainable management approach which will make a significant contribution to the long-term survival of the sector; and
- **Reduced environmental impacts –** demand for sweet corn has increased significantly over the last ten years and through this project the vast majority of demand is met by domestic production. Recognising that not all domestic demand would be met by imports it is likely that this project has avoided significant environmental impacts associated with the additional storage and transportation of imported sweet corn.

C.2.9 Confidence Rating

The outcomes of the project assessment are considered to have a high confidence rating. Sweet corn is generally produced on larger properties (compared to other vegetable commodities) with fewer growers making it is easier to develop an understanding of what is occurring in the sector and therefore to assess adoption rates and the impact on outputs. The very serious threat to the industry as broad spectrum insecticides lost their effectiveness is also likely to have increased the rate and scope of adoption of the R&D findings, supporting the assumption that at least 75 percent of production is grown using these techniques.

C.2.10 Summary

Prior to this project, sweet corn growers were faced with serious crop losses and no means of controlling them. The effectiveness of traditional calendar based spraying was decreasing, driving further increases in spray frequency as growers had no other viable means of controlling Heliothis. Conditions in some regions were so bad growers were being forced to leave the sector despite strong domestic and export demand.

This project allowed growers to remain the industry and although the export market had been eroded by Chinese based production, there has been a significant increase in domestic demand, which the sector could not have met without the outcomes from this project.

As a result, growers have been able to increase yields, avoid wasting crop inputs and have reduced the quantity of pesticides applied to the crop.

Public benefits have included lower market prices than would be the case if sweet corn demand was met by overseas production and there has been a significant reduction in the environmental impacts associated with pesticide application and increased goods transport with the avoidance of overseas imports.

D. Environmental Management

D.1 Developing the EnviroVeg Program as a National Environmental Program in the Vegetable Industry

D.1.1 Project Description

This project was initiated to allow growers to make an objective assessment of their efforts to limit the detrimental environmental impacts of the operations, to provide advice and support to reduce those impacts and eventually to develop a recognised third party accreditation for growers to display when the required standard of environmental management is achieved. The project is free to all National Vegetable Levy payers and was initially developed in Victoria VG00016 *(How to demonstrate good environmental performance: a practical mechanism for vegetable growers)* before being developed further by VG03088 in an attempt to roll the scheme out at a national level and subsequently updated by VG06003 *(EnviroVeg manual new sections - hydroponic, greenhouse and organic production).*

EnviroVeg is a straightforward off the shelf environmental self-assessment kit, which provides growers a systematic approach to assessing their environmental management practices. Through this assessment, growers are able to demonstrate the steps they have already taken to ensure responsible environmental management. The program also provides the building blocks for growers to establish environmental management operating plans.

The scheme attempts to reward growers for steps that they have taken to reduce the impact of their activities and to demonstrate to the wider community that vegetable growers take their environmental responsibilities seriously and are taking appropriate steps towards operating in a sustainable manner. The longer term intention for the scheme is to align it with auditable national standards, which would allow growers to achieve nationally recognised environmental management accreditation.

D.1.2 Project Deliverables

The project modules have been updated to maintain currency and reflect new developments in environmental best practice. The latest versions include greater complexity, reflecting increased environmental management requirements and the development of grower understanding and awareness of the importance of environmental management. New modules were added including one on whole of farm planning and biosecurity.

As well as engaging growers, the project team also sought to involve other stakeholder bodies. Recognising the program does not exist in isolation, the project team has engaged with catchment management authorities to establish how growers' efforts can tie-in with wider natural resource management plan targets. The project team held six workshops leading to greater integration between grower environmental management and Natural Resource Management targets.

The overall program aim is to develop an environmental management strategy for every vegetable grower. VG00016 *(How to demonstrate good environmental performance: a practical mechanism for vegetable growers)* began with 50-60 members in Victoria but many of the original participants thought that EnviroVeg was a one-off project and these growers proved difficult to re-engage in subsequent years. Under VG03088 *(Developing the EnviroVeg program as a national environmental program in the vegetable industry)* the program has gained an additional 120 members and this number is thought likely to increase as more growers recognise the benefits of establishing an environmental management regime.

It is expected that over time the program will move away from self-certification towards an auditable third party assessment against external standards. In doing so, this will allow growers to display the relevant logo on all of their produce.

D.1.3 Project Adoption

To date, approximately 150 farms have signed up to the EnviroVeg program, this is out of an estimated 2,822 commercial vegetable enterprises with agricultural operations greater than $40,000 in 2005-06 (ABARE 2007).

The latest focus of the program is on the redevelopment of the assessment towards a more rigorous process which meets the requirements of external accreditation bodies. Once this is in place, a sustained recruitment drive is planned, which is expected to greatly increase the number of growers joining the program. As the program is rolled out and promoted more widely it would be expected that greater number of growers will join the scheme, increasing the benefits from the program to both growers and the wider community. For the purposes of this assessment it is assumed that 50 percent of growers will be in the EnviroVeg scheme within the next ten years.

D.1.4 Impact Identification

Table D.1. Impact Identification Table

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
Economic Costs			
Project and Related Expenditure	**Project costs:** • Total project costs of VG00016 and VG03088 were $675,700 ($832,540 $2008).	Quantitative	Both
	Ongoing maintenance costs: • It is estimated that this project would require ongoing annual expenditure of approximately $200,000 per annum to fund ongoing extension activity as well as ensuring the program remains up to date with best practice developments.	Quantitative	Both
Economic Benefits			
Reduced Operating Costs	**Saving on costs of environmental audit:** • The estimated average cost of an on farm environmental audit to ISO 14000 standards is between $10,000-$20,000 depending on the size of the property and the extent of current environmental management in place Helena Whitam pers. comm. 13th Nov 2008). • Growers would also be required to pay additional annual re-inspection fees to maintain accreditation. For the purposes of the CBA, it is assumed that each grower would need to pay $15,000 in the first year and a further $5,000 per annum in subsequent years. • Although the project is unlikely to cover the full costs of undertaking these audits, it would be expected that they could negotiate a reduced price with a service provider. It has been assumed that growers can access saving of ten percent per assessment and follow up appraisal.	Quantitative	Grower
	Reduced chemical usage: • It is difficult to assess the impact of the scheme because each grower that signs up has a different operation and therefore different potential to make savings. It is thought that for the majority of growers, implementing any changes involves practice change rather than any significant investment above the level of normal operating costs and whilst no assessment has been made of the impacts of adopting the scheme it is possible to assess the impact of the program using a scenario approach. • This assessment assumes each grower that joins the scheme reduces chemical applications by one percent hectare per annum (assumed chemical costs per ha per annum are $500 (based on applying broad spectrum products to two crops per year). This is likely to be as a result of improved on farm storage and handling. It is likely that there would also be a range of other similar direct benefits to growers from the appropriate handling, storage and application of other inputs.	Quantitative	Both
	Reduced/avoided habitat rehabilitation costs: • It is **possible** that improved environmental management on properties is **likely** (will probably occur in most circumstances) to result in a **minor** (small relative to the wider context of the population/area being affected) economic benefit to the wider community as the value of public investment required in rehabilitating damaged ecosystems reduces. This includes work to cope with emergency situations (such as chemical spills) as well as longer-term rehabilitation work. Resulting in a **medium** impact score.	Qualitative	Public
Increased Production Efficiency	**Increased production efficiency:** • By avoiding activities which might cause environmental degradation of their properties and surrounding areas, growers can benefit from increased yields and use fewer inputs. The scheme also encourages growers to follow best practice in the appropriate usage and storage of materials and this is **almost certain** (expected to occur in most circumstances) to have produced a **negligible** (unlikely to be measurable against benchmarks) economic benefit for growers. Resulting in a **low** impact score.	Qualitative	Grower

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
	Domestic market expansion: • Consumers are increasingly aware of the environmental impacts of food production. In 2007, free-range eggs accounted for 20 percent of eggs sold and 30 percent of the value of eggs sold (Australian Egg Corporation Limited), in the same way that sales of free range eggs and similar products have increased in the last ten years there may be some scope for growers that are part of an externally accredited scheme to extract some premium for their product or avoid a loss if they are not accredited. It is **possible** (might occur at some time) this may result in a **negligible** (unlikely to be measurable against benchmarks) economic benefit to growers. Resulting in a **low** impact score.	Qualitative	Grower
	Export market expansion: • Raising consumer awareness of an accreditation scheme may help to differentiate Australian produced vegetables from potentially cheaper imported alternatives. Increasing consumer awareness of the environmental impacts of food production (and transportation) could provide growers with a valuable point of difference. It is **possible** (might occur at some time) that growers would derive a **negligible** (unlikely to be measurable against benchmarks) economic benefit from increased competitiveness in export markets. Resulting in a **very low** impact score.	Qualitative	Growers
	Social Benefits		
Reduced Social Impact	**Reduced risks to physical and mental health** • By adopting appropriate environmental best practices growers can reduce the risk of harm to themselves, their workers and other farm inhabitants, for example, through the inappropriate storage of insecticides and other toxic chemicals. This is likely to produce a moderate benefit to growers as they are likely to have adopted many of these kinds of changes already as they are covered under other guidelines and in some cases legislation. It is thought **almost certain** (expected to occur in most circumstances) that this provides a **negligible** (unlikely to be measurable against benchmarks) social benefit to growers. Resulting in a **low** impact score.	Qualitative	Growers
	Strengthening regional communities: • Some members of the public have developed the perception that agriculture is environmentally damaging to both the immediate and wider environment. EnviroVeg is an opportunity for growers to communicate to the public that they take their environmental responsibilities seriously and are engaged in developing and applying management techniques that limit the environmental impacts of their activities. It is considered that this is **almost certain** (expected to occur in most circumstances) to have a **negligible** (unlikely to be measurable against benchmarks) social benefit to growers. Resulting in a **low** impact score.	Qualitative	Growers
	Increasing the sustainability of the Australian vegetable sector: • The program recognises good practice where it is already in place and provides support for the adoption of additional measures. By recognising previous grower efforts the program is **almost certain** (expected to occur in most circumstances) to provide a **negligible** (unlikely to be measurable against benchmarks) social benefit to growers, as they can show that they have made some steps to managing their environmental impacts and that they recognise their duty of care. Resulting in a **low** impact score. • Being able to display the EnviroVeg logo (and/or equivalent external accreditation) on their property and produce provides a signal to the community that the grower operates in an environmentally responsible way. This is **likely** (will probably occur in most circumstances) to provide a **negligible** (unlikely to be measurable against benchmarks) social benefit to growers. Resulting in a **low** impact score.	Qualitative	Both
	Skill and knowledge development: • It is **likely** (will probably occur in most circumstances) growers will receive a **minor** (small relative to the wider context of the population/area being affected) benefit from the program as it will allow them to overcome concerns that environmental management will be expensive, complex and time consuming. In many cases growers outside of the program are likely to be doing many of the actions already. The EnviroVeg program allows growers access to specialist knowledge but without incurring costs and presents the information in a user friendly way. Resulting in a **medium** impact score.	Qualitative	Growers

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
Environmental Benefits			
Reduced Environmental Impact	**Reduced environmental impacts of grower activity:** • The externalities of the chemicals registered through the minor use schemes are estimated to be approximately $1.39 per application per hectare (Leach and Mumford 2008), significantly lower than for the older chemicals (approximately $22.09 per application per hectare) (Leach and Mumford 2008). • In the analysis it is assumed there are fifteen chemical applications per crop using the old chemicals and nine using the new. This is a conservative assumption as during periods of intense pest activity growers using 'older style' insecticides may be forced to spray on a more frequent basis, especially where resistance levels are significant.	Quantitative	Both

Source: AEC*group*

D.1.5 Counterfactual Case

D.1.5.1 What are the main benefits that would have eluded growers without this project?

Fewer growers having environmental management plans in place is likely to increase environmental impacts potentially resulting in industry sustainability issues in the longer term. Given increased consumer awareness (domestically and overseas) regarding environmental impacts of food production, high levels of environmental damage may reduce potential markets (and price) for food grown without a recognised environmental accreditation.

The increase in sales of organically produced foods and eggs from free range sources are examples of the potential development opportunities for vegetables grown using environmentally responsible practices. However, it is recognised that at this time there are limited price premiums available to vegetables grown in this way.

Growers are also part of their local communities and it is important that their efforts to manage their business in an environmentally responsible way are also recognised. This would not be the case without the EnviroVeg project. In the medium to long-term it is likely the level of environmental control growers face will continue to increase through consumer demands, retailer demands and further legislation. Additional controls are likely to build upon the initial gains and awareness of the issue generated as a result of this project and so the benefits of this project are considered to continue into the future.

D.1.5.2 Would the project have happened without the funding provided by HAL?

It is unlikely that this project would have happened without HAL funding. Although there are many accredited environmental auditors in operation, these all operate on a commercial basis. Whilst the largest growers may have considered it worthwhile taking a provocative approach to their environmental management plans, for the majority of smaller growers the perceived costs and complexity of this service might dissuade them from investigating the potential savings.

D.1.5.3 Has the project brought forward any benefits that may not otherwise have emerged?

The project is likely to have established environmental management plans on properties which would not otherwise have made any formal assessment of the environmental impact of their properties or developed strategies to reduce their environmental impacts.

D.1.5.4 Would the same outcomes have emerged from overseas research and how long would the lag-time have been?

The basic building blocks of this work may have emerged overseas but their practical application to the Australian vegetable sector require an on the ground presence to be able to understand the specific environmental problems facing growers and to be able to offer practical solutions which can be applied on their properties.

D.1.5.5 Are other groups working on substitute technologies which might make the project findings obsolete?

No other technology is likely to develop that would make the findings from this project obsolete. It is anticipated that the scheme will continue to develop adding complexity as grower understanding (and potentially legislative requirements) increase. However, that work is likely to build upon this initial phase rather than replace it.

D.1.5.6 Has the involvement of HAL increased adoption rates?

HAL's communication network is likely to have increased grower awareness of the project outcomes. Like the reduced pass harvesting project, this is a proactive attempt to develop industry capability rather than an attempt to control a threat to the survival of a vegetable crop. As a result, adoption is likely to be slower than for other project findings. Further, for many growers misconceptions about the likely requirements of environmental management protocols may put off some growers and the HAL communication network are likely to play a key role in breaking down those barriers to further adoption.

D.1.6 Cost Benefit Analysis Results

The following table summarises the economic cost impacts used in the CBA (no social or environmental costs have been identified).

Table D.2. Present Value of Project Costs

Impact	Cost ($2008)	PV ($M) – Discount Rate		
		6.00%	7.15%	9.00%
Project cost	$484,968	$0.5	**$0.6**	$0.6
Ongoing costs	$200,000	$2.6	**$2.4**	$2.2
Total		**$3.1**	**$3.0**	**$2.8**

Notes: Totals may not sum due to rounding (a) per grower (b) per hectare per crop
Source: AEC*group*

The present value of the economic costs of the project is estimated to be $3.0 million. Total project costs and ongoing costs would be split equally between levy payers. The following table summarises the benefits used in the CBA.

Table D.3. Present Value of Project Benefits

Impact	Benefit ($2008)	PV $M) – Discount Rate		
		6.00%	7.15%	9.00%
Management plan in place	$1,500/grower	$2.2	**$2.2**	$2.2
Management plan update	$500/grower	$8.3	**$7.8**	$7.0
Chemical cost saving	$10/hectare[(a)]	$3.4	**$3.1**	$2.8
Reduced risks to health	$0.06/hectare[(b)]	$0.8	**$0.7**	$0.6
Reduced environmental impacts	$0.36/hectare[(b]	$5.0	**$4.6**	$4.2
Total		**$19.6**	**$18.5**	**$16.9**

Notes: Totals may not sum due to rounding (a) per crop, (b) per application
Source: AEC*group*

The total present value of the stream of benefits from the projects is estimated to be $18.5 million. The major benefits come from the saving on annual updates to environmental management plans and reduced externalities associated with the over use of chemical controls. The table below outlines the net present value of the impacts of these projects.

Table D.4.CBA Outcomes ($2008 million)

Discount Rate	PV Costs		PV Benefits		NPV		BCR	
	Public	Private	Public	Private	Public	Private	Public	Private
6.00%	$1.6	$1.6	$14.6	$5.0	$13.0	$3.4	9.1	3.1
7.15%	**$1.5**	**$1.5**	**$13.8**	**$4.6**	**$12.3**	**$3.1**	**9.2**	**3.1**
9.00%	$1.4	$1.4	$12.7	$4.2	$11.3	$2.8	9.2	3.0

Notes: Totals may not sum due to rounding
Source: AEC*group*

The table demonstrates that this work produces a positive return on investment to both growers ($12.3 million) and the public ($3.1 million). This benefit is based on the likely impacts of the current scheme, it is anticipated that this will continue to develop and that additional benefits will emerge for growers and the public.

The following table shows the distribution of benefits to growers and to the public over five, ten and twenty years from the start of the project and the following figure shows the cumulative net present value of this work to growers and the public.

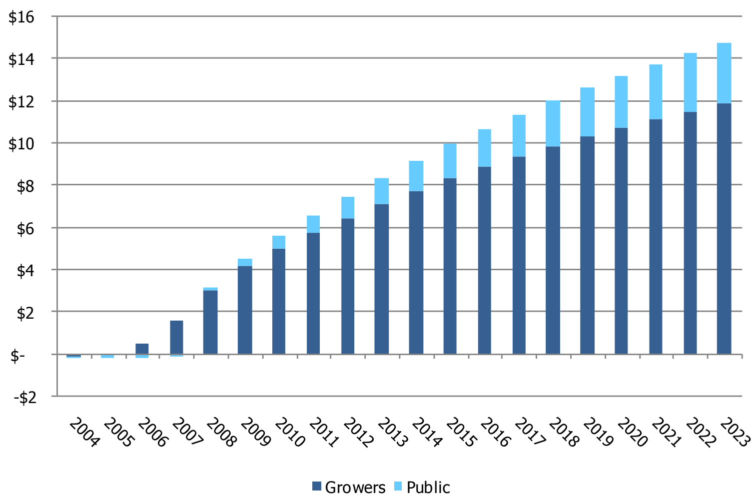
Table D.5. Project NPV of Grower and Public Impacts ($2008 million)

	5 yrs	10 yrs	20 yrs
Grower			
6.00%	$4.3	$8.0	$13.0
7.15%	**$4.3**	**$7.8**	**$12.3**
9.00%	$4.3	$7.6	$11.3
Public			
6.00%	$0.5	$1.6	3.4
7.15%	**$0.4**	**$1.5**	**3.1**
9.00%	$0.4	$1.5	2.8
Total			
6.00%	$4.7	$9.6	$16.4
7.15%	**$4.8**	**$9.4**	**$15.4**
9.00%	$4.8	$9.1	$14.1

Notes: Totals may not sum due to rounding
Source: AEC*group*

From the public and grower perspective, the project breaks even within the first five years. Although the project appears to offer a smaller absolute return on investment than some of the preceding studies, it should be recognised that the project has much smaller inputs costs and returns to growers and the public. It is also important to recognise the potential strategic importance of this project if agriculture were to be included in any future carbon pollution reduction scheme.

Figure D.1. Cumulative NPV to Growers and Public ($2008 million)



Source: AEC*group*

Over the twenty years from the start of the project, it is anticipated that 79.7 percent of benefits will accrue to growers ($12.3 million) and that the remaining 20.3 percent ($3.1 million) will accrue to the public. The benefits to growers tail off as the project reaches its maximum adoption under the assessment assumptions. It is likely that as the project is continually developed and extension and education activities increase so benefits would be given an additional stimulus.

D.1.7 Sensitivity Analysis

The two major assumptions used in the model relate to the percentage of growers (and area) that is within the EnviroVeg scheme and the scale of any savings. It is considered that the adoption rate is a conservative approach given the likely pressures to growers to adopt more environmentally friendly management techniques and to demonstrate that these changes have been implemented. The scale of the savings are unknown, however the scenarios are considered conservative and demonstrate the aggregate effective of multiple minor savings by each grower.

Table D.6. Sensitivity Analysis of NPV to Adoption and Adoption Timing (years), ($2008 million)

Time to Adoption	Adoption Rates			
	30%	40%	50%	60%
2	$11.9	$15.1	$18.3	$21.5
5	$10.2	$12.8	$15.4	$18.0
7	$9.0	$11.2	$13.4	$15.6
10	$7.7	$9.4	$11.2	$13.0

Notes: Totals may not sum due to rounding
Source: AEC*group*

The highlighted cell shows the outcome based on the assumptions used in the model. Using the highest adoption scenario of 60 percent within the shortest period of time (two years), the NPV would be $21.5 million. However, if the lowest adoption scenario were used (30 percent) in the longest period of time (ten years), the NPV would be $7.7 million. Therefore, even at the lowest scenario, the project is seen to record a positive NPV.

D.1.8 Qualitative Summary

Many of the benefits of this project are difficult to value, especially as the project is in its infancy. However, several benefits have been identified, which have been assessed using a qualitative approach including:

- **Reduced/avoided habitat rehabilitation costs –** by controlling their environmental impacts, the public is able to avoid significant costs associated with rehabilitating land and habitats damaged as a result of either long-term practices or one off events such as accidental spills;
- **Increased production efficiency –** although on a grower by grower basis, the savings that can be made might seem small, taken in aggregate savings of a few percent of chemical use in vegetable production in Australia equate to significant aggregate savings; and
- **Knowledge and skills development –** the project has the potential to remove some significant barriers to greater adoption of environmental management, in particular a fear of the unknown amongst some growers who are concerned about the cost and time implications of implementing environmental management controls.

D.1.9 Confidence Rating

This project is assessed as having a medium confidence rating. Although the assumptions used are considered to be conservative, there is very little evidence of the actual impacts of adoption other than the anecdotal. It is considered likely the project findings represent a lower threshold of potential benefits however, additional survey would be required to support this.

D.1.10 Summary

Increasing scrutiny from multiple stakeholders of the environmental impacts of all forms of agricultural production has increased the need for improved environmental management. However, for many growers (especially those on smaller properties) the thought of having to establish an environmental plan can be daunting. The EnviroVeg projects have sought to overcome some of these perceptions and to help growers to initially review their practices and then establish increasingly sophisticated environmental management plans. The project is in its infancy and has the potential ti continue to develop and possibly establish an independently audited environmental management standard.

E. Soil Borne Diseases

E.1 Total Crop Management of Clubroot in Brassica Vegetables

E.1.1 Project Description

Clubroot (*Plasmodiophora brassicae)* is a soil borne disease, which is estimated to account for crop losses of between five and ten percent of total Australian brassica production. The disease is found throughout the brassica growing regions of Australia and overseas and is one of the most significant diseases affecting brassica crops. The main brassica crops are cauliflower, cabbage and broccoli. It is estimated that in 2006 the total value of the cauliflower, cabbage and broccoli crops was approximately $150.0 million up from $133.6 million in 1998 (ABS 2007). Other smaller brassica crops included Brussel sprouts, chinese cabbage and other Asian vegetable brassicas (not included in the CBA).

Project VG00044 *(Total crop management of Clubroot in brassica vegetable)* was developed in response to grower concerns about the extent of losses to Clubroot and attempted to develop a holistic approach covering the entire production system from seedling establishment and transfer to final harvest.

The project outputs included advice to growers and other industry stakeholders on the most appropriate control mechanisms rather than targeting one aspect of the production system in isolation. The project produced recommendations for all stakeholders involved in the production process to develop an integrated management approach.

E.1.2 Project Deliverables

The project produced a series of best practice protocols for each stage of the growing process, which sought to provide short, medium and long-term approaches to controlling the disease. The key project outputs were:

- Best practice protocols for nurseries to limit the likelihood of seedlings being infected with Clubroot, measures included:
  - Identification of potential sources of Clubroot:
  - Designing nurseries to limit Clubroot risks;
  - Restricting and monitoring access to the nursery;
  - Establishment of a rigorous hygiene regime;
  - Ensuring soil, water and seeds are all free of Clubroot;
  - Ongoing monitoring for Clubroot infestations; and
  - Ensuring staff know the appropriate response if Clubroot is detected.
- Demonstration of integrated management strategies including the appropriate use of limes, fertilisers and fungicides, which were tailored to each state;
- Development of a new piece of a machinery (incorporator) to incorporate Clubroot treatment alongside the seedling and fertilisers in one pass, saving labour and operating costs and ensuring consistent treatment throughout the crop; and
- A molecular diagnostic protocol to quantify the extent of Clubroot disease in the soil and testing of its predictive ability at 54 sites.

E.1.3 Project Adoption

Clubroot is endemic in most of the major production regions in Australia, and is considered to be a significant problem in every state. Anecdotally, the project has been widely adopted amongst brassica growers with significant savings in terms of avoided losses are sufficient to generate grower interest with some growers also choosing to invest in the incorporator in order to access the additional productivity gains. However, adoption of the incorporator is thought to have been slower than some for the other project findings which have lower initial costs.

In the following analysis, it has been assumed that:

- Within two years of the project completion 80 percent of growers have adopted the project findings (except the incorporator);
- Within five years 25 percent of growers have adopted all project findings including the incorporator;
- Within five years of the initial losses 50 percent of growers that do not adopt the R&D findings are still growing brassica crops and sustaining losses of up to five percent; and
- Within five years of the initial losses 50 percent of growers that do not adopt the R&D findings have switched to alternative crops.

E.1.4 Benefit Identification

Table E.1. Impact Identification Table

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
Economic Costs			
Project and Related Expenditure	**Project costs:** • This project is currently a one-off although additional funding may become available in the future for further developments. Total project costs were $1.2 million equivalent to $1.4 million ($2008).	Quantitative	Both
	Ongoing maintenance costs: • It is estimated that annual ongoing expenditure of $100,000 per annum ($2008) would be required to maintain the currency of the project findings. These costs end at the same time as the project benefits.	Quantitative	Both
	Implementation costs: • The primary project implementation costs relate to the incorporator. These are difficult to establish as most growers would be expected to choose to modify existing equipment rather than investing in an entirely new piece of equipment. It has been estimated that the average cost of these modifications is approximately $25,000 per grower.	Quantitative	Grower
	Additional variable inputs: • One of the project recommendations was that burnt lime is applied to alter soil pH to a level which Clubroot cannot tolerate (but which does not affect the brassica crop). It is estimated the annual costs of the lime and its application are $250 per hectare per annum.	Quantitative	Grower
Economic Benefits			
Increased production	**Increased profitability:** • The use of the incorporator has been shown to increase per hectare profits by up to $4,000 per hectare ($2003) in winter grown cauliflower. Although it is likely that there will be similar benefits to other brassica crops (especially when grown during colder months) however, no increase has been included for crops grown at other times of the year, as there is no available data regarding this.	Quantitative	Grower
Reduced Operating Costs	**Avoided crop losses:** • The first significant crop losses as a result of Clubroot occurred in the late 1990's and it has been assumed losses of up to 10 percent would have been experienced by growers that did not adopt the R&D findings for ten years following the completion of the project extension activities. • After ten years, the average loss experienced by non-adopters is assumed to reduce by two percent per annum (reaching zero after a further five years), reflecting the adoption of other chemical control measures and alternative technologies in the future (likely to be further development of this work rather than a totally new management approach). • The value of avoided crop losses has been calculated as the annual loss rate multiplied by the total output of growers that have adopted the project findings.	Quantitative	Grower

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted

	Avoided higher priced imports:
	• Although the project is not considered to have developed any new markets, it is likely to have protected the domestic market from overseas competition. It is anticipated that if growers sustained repeated heavy crop losses, with no effective means of controlling the pest and there had been repeated incidents of consumers purchasing a diseased product, domestic market share would have eroded by overseas production and that:
	  ○ Prices would be five percent higher than under the 'no change scenario' due to scarcity of supply
	  ○ Higher prices would encourage consumers to purchase substitute goods
	  ○ Domestic demand would be lower with 10 percent of production losses replaced by imports
	• This avoided additional cost (under the R&D adoption scenario) is included as a benefit to the consumer and is calculated as the cost of substituting 10 percent of output that would be lost if growers did not adopt the project findings, including a 5 percent price premium.
		Quantitative	Public

	Avoided lost revenues: • For non- adopters (following crop losses of 10 percent) it is assumed that within five years of the project extension activities 50 percent of growers would switch production to the next most profitable crops. • Alternative crops are assumed to be ten percent less profitable than growing brassica crops. • As the benefits of the R&D diminish over time, growers would be expected to return to brassica crops.	Quantitative	Grower
	Contribution to regional and national economies: • Direct grower expenditure and its flow on impacts both contribute to regional economies in the brassica growing regions and to the national economy. This project has significantly improved the viability of the brassica sector and in doing so has reduced the risks of losing the contribution these growers make to regional economies (and the national economy) through both their direct expenditure and the flow on effects. It is **likely** (will probably occur in most circumstances) that this project has produced a **negligible** (unlikely to be measurable against benchmarks) public benefit. Resulting in a **low** impact score.	Qualitative	Public
Social Benefits			
Reduced Social Impact	**Reduced risks to physical and mental health:** • Growers (and their families) affected by Clubroot would be expected to experience considerable stress relating to the short-term viability of their business and its long-term prospects. The projects undertaken to control Clubroot provide growers with control mechanisms, which whilst not infallible do give growers far greater control. It is thought **almost certain** (expected to occur in most circumstances) that this provides a **negligible** social benefit to growers. Resulting in a **medium** impact score.	Qualitative	Grower
	Strengthening regional communities: • Growers contribute to their local communities in a wide range of ways including their participation in community activities as well as the contribution they make to retain the critical population mass needed to sustain other rural sector businesses and community services including schools and health care facilities. This is thought **likely** (will probably occur in most circumstances) to result in a **negligible** (unlikely to be measurable against benchmarks) benefit to growers. Resulting in a **low** impact score.	Qualitative	Public

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
	Increasing the sustainability of the Australian vegetable sector: • Clubroot losses can have significant impacts on the viability of brassica growers. As noted above, growers may incur all of the costs of ground preparation, seed buying, planting and crop management only to find that the crop must be discarded. By developing these best practice protocols for the whole growing cycle, the project has made a significant contribution to the viability of growers and is **likely** (will probably occur in most circumstances) to have resulted in a **negligible** (unlikely to be measurable against benchmarks)benefit to growers. Resulting in a **medium** impact score.	Qualitative	Growers
	Skill and knowledge development: • The development of additional understanding of Clubroot is likely to be used to inform future research on fungicide treatments and disease resistant varieties. The incorporator has several potential applications with other commodities especially given the increase in productivity which has been observed in winter cauliflowers. It has also been adapted for other uses by other projects (see VG02051) with significant additional benefits. This is **likely** (will probably occur in most circumstances) to result in a **negligible** (unlikely to be measurable against benchmarks) social benefit to growers. Resulting in a **low** impact score. • This project has also contributed to the development and retention of R&D posts in Australia as well as developing researchers' knowledge and skills. This helps to retain researcher skills within Australia and has the potential to lead to benefits in other related fields. This is considered **likely** (will probably occur in most circumstances) to provide a **negligible** (unlikely to be measurable against benchmarks) public benefit. Resulting in a **low** impact score.	Qualitative	Both
Environmental Benefits			
Reduced Environmental Impact	**Reduced indirect environmental impacts:** • Increased understanding of the disease, its causes, an effective test and appropriate management techniques means growers are no longer applying chemical treatments which have shown to be ineffective in controlling the disease. This not only reduces the impacts of the chemicals themselves, it also reduces greenhouse gas emissions associated with applying the chemicals. This is **likely** (will probably occur in most circumstances) to produce a **minor** (small relative to the wider context of the population/area being affected) public and private benefit. Resulting in a **medium** impact score.	Qualitative	Both

Source: AEC*group*

E.1.5 Counterfactual Case

E.1.5.1 What are the main benefits that would have eluded growers without this project?

It is estimated that Clubroot is responsible for losses of between 5 and 10 percent of Australian brassica output, and it is likely that without the work of this project losses of at least this magnitude would have continued. Previous studies have found that 70 percent of growers in Victoria were affected in 1994 (Donald 2003) with losses of approximately 25 hectares per property. Increased production rotations of up to four crops per annum and poor inter farm contamination control were increasing the risk of greater contamination and losses.

In the absence of a detailed understanding of the disease characteristics, it would not be possible to establish the operating protocols, which have been successful in managing the disease. For example, the research identified that nurseries are a high risk area for the spread of infections, especially through returned seed trays which may be contaminated and need to be thoroughly cleaned and sterilised prior to re-use.

As well as reducing the risk of losses to Clubroot from nurseries, the project has also increased grower awareness of preventative measures they can take to limit the extent of Clubroot. These include farm hygiene measures, techniques to spot Clubroot outbreaks, appropriate treatments once an outbreak has been detected and techniques and management practices to reduce the risk of repeat infections.

Without this project, it is unlikely that growers would have the understanding of Clubroot to enable them to manage the disease as effectively or to prevent its return once infestation has occurred. It could be argued that without the project findings club root losses would be significantly higher and the range of management options greatly reduced resulting in significantly fewer growers producing brassicas.

E.1.5.2 Would the project have happened without the funding provided by HAL?

It is unlikely that the project would have been funded without HAL. Although the brassica sector is a significant part of the horticulture industry and the threat posed by Clubroot significant, it is unlikely that any other body would have made this investment. In common with other projects, it is difficult to see how any other body could recover their costs from growers on completion of the project. The outcomes of this particular piece of work are focused on practice changes rather than the adoption of expensive new equipment or chemical controls. The fragmentation of the industry means that a collaborative approach between growers would be a significant administrative task with the risk of large numbers of growers benefitting without making any financial contribution.

E.1.5.3 Has the project brought forward any benefits that may not otherwise have emerged?

The development of the incorporator has been shown to increase profits by $4,000 per hectare in winter cauliflower plantings, this is due to the precise incorporation of hot lime, fungicides and nutrients surrounding the root ball rather than a small distance to either side of the root ball. This means that the plant is immediately able to access the nutrients and is protected by the fungicide rather than having to grow unsupported before being able to reach the band of fertiliser.

E.1.5.4 Would the same outcomes have emerged from overseas research and how long would the lag-time have been?

Brassica crops are grown in many regions throughout the world, with an associated high amount of R&D activity. While research into Clubroot undertaken elsewhere may have been of use to Australian growers, it is likely that without a local perspective on the appropriate techniques to manage the disease in an Australia context the overall benefit would have been considerably less. It is also likely that local strategies such as the application of hot limes and the development of the incorporator might not have emerged, considerably diminishing the total benefits from the project.

E.1.5.5 Are other groups working on substitute technologies which might make the project findings obsolete?

It is unlikely that any other R&D will supersede these findings. Work on the identification of Clubroot in the soil and suggested management practices to limit infestation are much more likely to be incorporated into further research than become obsolete.

E.1.5.6 Has the involvement of HAL increased adoption rates?

HAL's communication network is likely to have increased grower awareness of the project outcomes in conjunction with the extension activities undertaken by the project team.

E.1.6 Cost Benefit Analysis Results

The following table summarises the economic cost impacts used in the CBA (no social or environmental costs have been identified).

Table E.2. Present Value of Project Costs

Impact	Cost ($2008)	PV ($M) – Discount Rate		
		6.00%	7.15%	9.00%
Project cost	$550,729	$2.1	$2.2	$2.5
Ongoing costs	$50,000	$0.8	$0.8	$0.8
Implementation costs	$25,000	$2.8	$2.8	$2.8
Additional inputs (lime)	$250[(a)]	$25.5	$24.7	$23.6
Total		**$31.2**	**$30.6**	**$29.8**

Notes: Totals may not sum due to rounding (a) per hectare per crop
Source: AEC*group*

The present value of the economic costs of the project is estimated to be $30.6 million. The majority of the costs relate to the cost of applying lime. Total project costs and ongoing costs would be split equally between levy payers and the public, however, growers would need to fund all other costs.

The following table summarises the benefits used in the CBA.

Table E.3. Present Value of Project Benefits

Impact	Benefit ($2008)	PV ($M) – Discount Rate		
		6.00%	7.15%	9.00%
Avoided crop losses [(a)]	$48.40/tonne	$121.9	**$119.3**	$115.7
Avoided lost revenues due to switching crops[(b)]	$48.40/tonne	$13.2	**$12.9**	$12.5
Import saving	$24.20/tonne	$35.8	**$34.8**	$33.5
Incorporator benefits	$4,000/hectare[(b)]	$42.5	**$40.7**	$38.2
Total		**$213.4**	**$207.7**	**$199.8**

Notes: Totals may not sum due to rounding (a) average across the three crops in the assessment, CBA uses actual cost for each crop (b) winter crop only
Source: AEC*group*

The total present value of the stream of benefits from the projects is estimated to be $207.7 million. Avoided crop losses account for the largest benefit however, although the incorporator has only been assumed to increase production in winter crops it has still produced a significant benefit. The claims made in the report about these benefits are supported by grower interviews where it has been claimed that growers are able to recoup the costs of the incorporator within one season.

The following figure compares the gross value of production between the no change, counter factual and with R&D adoption cases, it should be noted that the 'with R&D' case includes output from both growers adopting the project findings and those that continue to grow affected crops despite incurring significant losses. The table below outlines the net present value of the impacts of these projects.

Table E.4. CBA Outcomes ($2008 million)

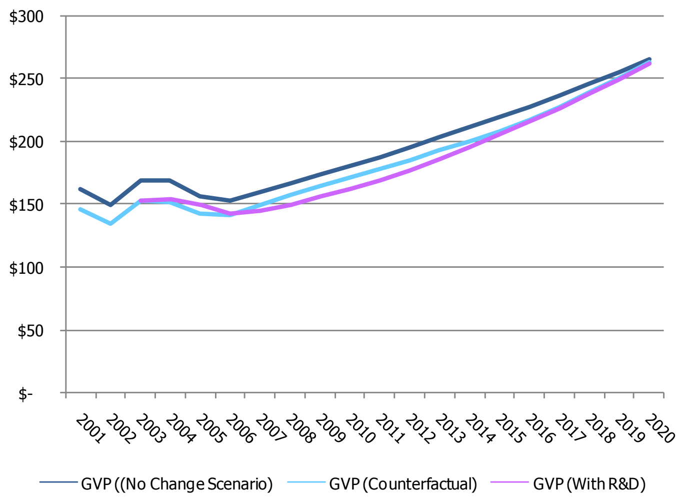
Discount Rate	PV Costs		PV Benefits		NPV		BCR	
	Grower	Public	Grower	Public	Grower	Public	Grower	Public
6.00%	$29.7	$1.4	$177.6	$35.8	$147.9	$34.3	6.0	24.8
7.15%	**$29.0**	**$1.5**	**$172.9**	**$34.8**	**$143.9**	**$33.3**	**6.0**	**22.9**
9.00%	$28.1	$1.7	$166.3	$33.5	$138.2	$31.8	5.9	20.3

Notes: Totals may not sum due to rounding
Source: AEC*group*

The table demonstrates that this work produces a positive return on investment to both growers ($143.9 million) and the public ($33.3 million). Costs to growers are higher than those to the public due to the implementation costs to growers in developing the incorporator.

The following figure shows the impact of the project on the gross value of production.

Figure E.1. Gross Value of Production Comparison ($2008 million)



Source: AEC*group*

The relatively small crop losses (compared to loss scenarios associated with other pests and diseases) that are avoided under the R&D scenario are not sufficient to offset the 'benefit' under the counterfactual scheme of increased prices due to product scarcity, which results in the counterfactual case having a higher GVP than the with R&D scenario. As the price premium on the counterfactual case and the R&D benefits erode over time the counterfactual and with R&D cases merge before rejoining the no change case as all benefits from R&D are eroded. The figure demonstrates that although the overall benefits from the project are significant for growers and the public, their impact on GVP is relatively small.

The following table shows the distribution of benefits to growers and to the public over five, ten and twenty years from the start of the project and the following figure shows the cumulative net present value of this work to growers and the public.

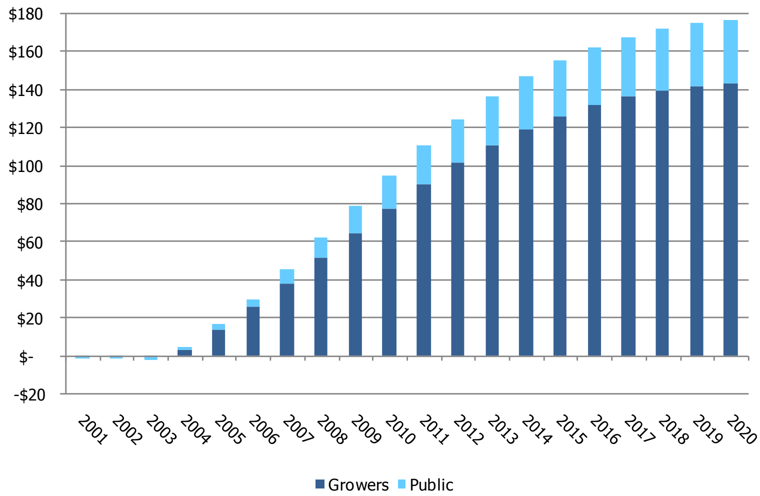
Table E.5. Project NPV of Grower and Public Impacts ($2008 million)

	5 yrs	10 yrs	20 yrs
Grower			
6.00%	$13.4	$77.3	$147.9
7.15%	**$13.8**	**$77.7**	**$143.9**
9.00%	$14.5	$78.3	$138.2
Public			
6.00%	$2.3	$17.3	$34.3
7.15%	**$2.4**	**$17.3**	**$33.3**
9.00%	$2.4	$17.4	$31.8
Total			
6.00%	$15.7	$94.6	$182.2
7.15%	**$16.2**	**$95.0**	**$177.2**
9.00%	$17.0	$95.7	$170.0

Notes: Totals may not sum due to rounding
Source: AEC*group*

The project provides a positive return to the public and growers within five years as the avoided crop losses, avoided imports and benefits from using the incorporator all contribute to grower and public benefits.

Figure E.2. Cumulative NPV to Growers and Public ($2008 million)



Source: AEC*group*

It is estimated that over the twenty years following the start of the project 81.2 percent ($143.9 million) of the total quantifiable net benefit would accrue directly to growers, with the remaining 18.8 percent ($33.3 million) accruing to the general public. Although this might appear to offer growers a far greater return, the BCR data shows the return relative to the value of each party's investment. The BCR for growers is 6.0, indicating that growers receive $5.95 for each dollar they invest. The BCR for the public is 22.9, indicating that they receive $22.93 for every dollar they invest, a proportionately greater return on investment.

The relatively low crop loss scenario (which is quickly eroded) and the limited maximum adoption scenario used for the incorporator means that grower benefits quickly tail off. It would be anticipated that given the scale of the potential benefits from the adoption of the incorporator further benefits may be forthcoming.

E.1.7 Sensitivity Analysis

The two major assumptions used in the model relate to the proportion of production grown under the new management approach and the percentage of losses incurred. It is considered that the adoption rate is a conservative approach given the scale of losses incurred using broad spectrum chemical controls and the percentage losses where observed in crops and in trials. However, the following table demonstrates the impact on NPV of a range of assumption scenarios.

Table E.6. Sensitivity Analysis of NPV to Adoption and Crop Loss Scenarios, ($2008 million)

Crop Losses	Adoption Rates			
	60%	70%	80%	90%
5%	$108.4	$106.2	$103.6	$100.6
10%	$153.4	$164.4	**$177.2**	$191.6
15%	$203.4	$229.1	$258.8	$292.4
20%	$253.3	$293.8	$340.4	$393.3

Notes: Totals may not sum due to rounding
Source: AEC*group*

The highlighted cell shows the outcome based on the assumptions used in the model. Using the highest scenario of 90 percent adoption and 20 percent crop losses, the NPV would be $393.3 million. However, if the lowest scenario were adopted (60 percent adoption and a five percent reduction in losses), the NPV would be $108.4 million. Therefore, even at the lowest scenario, the project is seen to record a positive NPV, which would have an estimated BCR of.

E.1.8 Qualitative Summary

This project has produced several benefits that could not be quantified and which have been assessed using a qualitative approach, including:

- **Increasing the sustainability of the Australian vegetable sector –** brassica crops are a significant component of the total Australian vegetable sector and by providing growers with management techniques to control losses as a result of Clubroot, identifying the productivity benefits from the application of hot limes and the use of the incorporator the project has made a significant contribution to the sustainability of the sector; and
- **Reduced risks to mental and physical health –** by providing these tools, the project has also contributed to the mental and physical well being of growers and their families by providing a means of controlling losses on their properties and increasing the economic viability of the businesses.

E.1.9 Confidence Rating

The outcomes of the CBA are assessed as being high/medium. The benefits of using the incorporator are reportedly so large that additional research is required to verify the increase in outputs. All other outcomes are considered to have a high degree of confidence given the extent of research that has been carried out and the significant extension activities.

E.1.10 Project Summary

Unlike pests, soil borne diseases cannot be spotted using the naked eye, which means a grower might incur all of the soil preparation, planting, crop management and harvesting costs only to find that their crop has been affected by Clubroot and cannot be sold. This problem is exacerbated because prior to this project little was known about the spread of the disease or how long it could lie dormant. The outcomes of the project mean that stakeholders throughout the growing process (including nurseries) are aware of how their actions can reduce the spread of the disease and what actions to take if the disease is found.

Further, in undertaking this work, the impact of using an incorporator to establish seedlings was discovered, which appears to offer growers significant productivity improvement.

E.2 Managing Bean Root and Stem Diseases

E.2.1 Project Description

Project VG03002 *(Managing bean root and stem disease)* sought to update knowledge and understanding of diseases affecting green beans (*Phaseolus vulgaris L*. – French or dwarf beans, runner or climbing beans). In 2005, the sector produced 34,000 tonnes valued at $63 million (ABS 2005) to meet demand from both the fresh and processing sector. The study focused on diseases of the stem and root, which had been causing significant losses across all production areas since the principle fungicide, which controlled the disease, was removed from sale in Australia.

E.2.2 Project Deliverables

Grower surveys in Tasmania, Queensland and NSW were used to identify the spread of known diseases to new areas and identified *Aphanomyces euteiches* (ARR) and Black Root Rot in Tasmania and Black Root Rot in Queensland for the first time in beans. The surveys also confirmed ARR as the main disease of beans on the north coast of NSW.

The project went on to consider a series of potential disease control methods, the principle findings included:

- Non-chemical management of ARR appears to be difficult due to the characteristics of the fungus. Avoiding land that has grown beans for up to ten years is the only identified cultural control option;
- An antagonistic bacterium was identified during the project, which might offer a potential control mechanism for the disease. This area was identified as a priority for future research subject to available funding;
- Some fungicides controlled ARR when used as either seed dressings or soil drenches but the products tested were either not available or registered for use in Australia. Fumigation is an option to control these diseases but may not be economical and bio-fumigation had no success at reducing disease levels;
- A pre-plant soil test was established so that growers could have some knowledge of ARR disease levels before planting;
- All bean varieties tested were found to be susceptible;
- Work investigating fungicide control of white mould (*Sclerotinia sclerotiorum*) on beans in Tasmania and Queensland was undertaken due to the withdrawal of a commonly used fungicide; and
- Seed dressings were examined and found to be capable of controlling damping off of beans and other seedling diseases.

The principle project outcomes were to increase researcher knowledge of the disease and to develop grower understanding of the impacts on their crops and soils and the available management options to control its spread.

Planting is usually in staggered blocks, now with the soil test. If the grower knows a block is contaminated they can avoid that block or plant with a non-host crop until the level of disease has reduced to a manageable level.

The project recommended changes in grower behaviour. It is now known that the disease is very resistant to available fungicides so growers have been advised to stop spraying as this costs them money and has no effect. Growers are now much more aware of the characteristics of the disease (in particular the ten-year lifecycle in soil to achieve a very low risk of repeat infection) although it is considered that after five years beans could be replanted in conjunction with other controls. It is proposed that subsequent work should focus on the development of supporting chemical control techniques.

This project only considered bean growers in NSW, Tasmania and Queensland. Although no formal assessment of grower adoption has been undertaken, the project included significant extension activities including:

- Grower meetings in trial areas;

- Information sheets were distributed amongst growers;
- A NSW Primefacts information worksheet was produced; and
- The study is mentioned in a Department of Primary Industry (Queensland) disease management booklet.

E.2.3 Project Adoption

The study considered NSW, Tasmania and Queensland. In 2006-07, total production of french and runner beans in these States totalled 26,796 tonnes grown over 4,203 hectares, equivalent to 84.4 percent of the national growing area and 93.0 percent of production (ABS 2008). In the CBA, it has been assumed that:

- Project findings are applicable to 80 percent of the total Australian growing area;
- Within two years of the initial extension activities, 75 percent of applicable output was grown using the findings of this project;
- Within five years of the initial extension activities, 50 percent of applicable land which is not cultivated using the R&D findings continues to grow brassica crops and sustain losses of 10%; and
- Within five years of the initial extension activities, 50 percent of applicable land has been switched to the production of alternative crops.

E.2.4 Benefit Identification

Table E.7. Impact Identification Table

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
	Economic Costs		
Project and Related Expenditure	**Project costs:** • This project is currently a one-off although additional funding may become available in the future for further developments. Total project costs were $274,836 equivalent to $305,605 ($2008).	Quantitative	Both
	Ongoing maintenance costs: • It is estimated that annual ongoing costs are $50,000 per annum ($2008).	Quantitative	Both
	Economic Benefits		
Reduced Operating Costs	**Avoided crop losses:** • It has been assumed losses of up to 10 percent would have been experienced by growers that did not adopt the R&D findings for ten years following the project extension activities. • After ten years, the average loss experienced by non-adopters is assumed to reduce by two percent per annum, (reaching zero after a further five years) reflecting the adoption of other disease management measures and alternative technologies in the future (likely to be further development of this work rather than a totally new management approach). • The value of avoided crop losses has been calculated as the annual loss rate multiplied by the total output of growers that have adopted the project findings.	Quantitative	Grower
Market Development	**Avoided higher priced imports:** • Although the project is not considered to have developed any new markets, it is likely to have protected the domestic market from overseas competition. It is anticipated that if growers sustained repeated heavy crop losses, with no effective means of controlling the pest and there had been repeated incidents of consumers purchasing a diseased product, domestic market share would have eroded by overseas production and that: ○ Prices would be five percent higher than under the 'no change scenario' due to scarcity of supply ○ Higher prices would encourage consumers to purchase substitute goods ○ Domestic demand would be lower with 10 percent of production losses replaced by imports • This avoided additional cost (under the R&D adoption scenario) is included as a benefit to the consumer and is calculated as the cost of substituting 10 percent of output that would be lost if growers did not adopt the project findings, including a 5 percent price premium.	Quantitative	Public
	Avoided lost revenues: • For non- adopters (following crop losses of 10 percent) it is assumed that within five years of the project extension activities 50 percent of growers would switch production to the next most profitable crops. • Alternative crops are assumed to be ten percent less profitable than growing current crops. • As the benefits of the R&D diminish over time, growers would be expected to return to current crops.	Quantitative	Grower

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
	Contribution to regional and national economies: • In 2006-07, the estimated gross value of production of French and runner beans was $11.44 million in the study area (Tasmania, NSW, and Queensland). This project has significantly improved the viability of the beans sector and in doing so has reduced the risks of losing the contribution the growers of beans make to regional economies (and the national economy) through both their direct expenditure and the flow on effects. It is **likely** (will probably occur in most circumstances) that this project has produced a **negligible** (unlikely to be measurable against benchmarks) public benefit. Resulting in a **low** impact score.	Qualitative	Public
Social Benefits			
Reduced Social Impact	**Reduced risks to physical and mental health** • Growers (and their families) affected by root and stem diseases would be expected to experience considerable stress relating to the short-term viability of their business and its long-term prospects. The projects undertaken to control the identified soil borne diseases in peas provide growers with control mechanisms, which whilst not infallible do give growers far greater control. It is thought **almost certain** (expected to occur in most circumstances) that this provides a **negligible** social benefit to growers. Resulting in a **low** impact score.	Qualitative	Grower
	Strengthening regional communities: • Growers contribute to their local communities in a wide range of ways including their participation in community activities as well as the contribution they make to retain the critical population mass needed to sustain other rural sector businesses and community services including schools and health care facilities. It is thought **almost certain** (expected to occur in most circumstances) that the project has made a **negligible** (unlikely to be measurable against benchmarks) benefit to the effected communities. Resulting in a **low** impact score.	Qualitative	Grower
	Increasing the sustainability of the Australian vegetable sector: • Providing the tools to manage root and stem diseases is likely to contribute to the continuation of a viable beans sector in Australia. In doing so the project helps to maintain the future of the industry which encourages growers to make investments in equipment and other technology as well as giving them re-assurance about their own positions and the likelihood of being able to pass on a viable operation to the next generation of their family. This is thought **likely** (will probably occur in most circumstances) to result in a **negligible** (unlikely to be measurable against benchmarks) benefit to growers. Resulting in a **low** impact score.	Qualitative	Grower
	Skill and knowledge development: • Growers would be expected to benefit from greater control over their operations rather than the application of the broad spectrum insecticides based on a stated rate of application. These more complex management practices are more challenging and give greater control of farming operations back to the grower. This project is also likely to be important in further work on root and stem diseases in beans as well as other related crops. It is **likely** (will probably occur in most circumstances) growers will receive a **negligible** (unlikely to be measurable against benchmarks) social benefit from this project. Resulting in a **low** impact score. • These projects have contributed to the development and retention of R&D posts in Australia as well as developing researchers' knowledge and skills. This helps to retain researcher skills within Australia and has the potential to lead to benefits in other related fields. This is considered **almost certain** (expected to occur in most circumstances) to provide a **negligible** (unlikely to be measurable against benchmarks) public benefit. Resulting in a **low** impact score.	Qualitative	Both

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
Environmental Benefits			
Reduced Environmental Impact	**Reduction in ineffective fungicide applications:** • Growers are now aware of the ineffectiveness of registered fungicides reducing the incidence of wasted applications. By making more efficient use of their inputs, growers are almost certain to reduce the impact of their direct activities. The reduction in fertilizer application and fungicide are **almost certain** (expected to occur in most circumstances) to result in a **negligible** (unlikely to be measurable against benchmarks) environmental benefit to growers and are **likely** (will probably occur in most circumstances) to produce a **negligible** (unlikely to be measurable against benchmarks) environmental benefit to the wider community. Resulting in **low and medium** impact scores.	Qualitative	Both
	Reduced indirect environmental impacts: • If domestic production had collapsed, it would be expected that demand would fall as higher prices encouraged consumers to switch to lower cost alternative products. Remaining demand would be met from overseas production with associated environmental impacts as a result of the additional transportation and storage. It is **almost certain** (expected to occur in most circumstances) that avoiding these additional transport costs has produced a **negligible** (unlikely to be measurable against benchmarks) public benefit. Resulting in a **medium** impact score.	Qualitative	Public

Source: AEC*group*

E.2.5 Counterfactual Case

E.2.5.1 What are the main benefits that would have eluded growers without this project?

Without this project growers had a very limited understanding of these diseases and were suffering significant losses. Having suffered these losses, in some instances of up to 100 percent of a crop but typically 25-50 percent, growers were in many cases spraying the area with a broad spectrum fungicide then replanting. However, as this project demonstrated, this had very little impact on the disease and a grower was likely to lose their crop again.

The lack of effective identification tools or management options to control the diseases means that it was likely that growers would have started to exit the sector. This would be likely to trigger price increases forcing some consumers to choose other food products with any remaining demand being met by overseas production, which is likely to be more expensive due to the additional transportation costs.

E.2.5.2 Would the project have happened without the funding provided by HAL?

It is unlikely that bean growers or any other group would have funded this project. Although significant in terms of Australian Horticulture the Australian bean sector is not large enough to attract a major chemical company to fund research work into in this sector as there are limited opportunities for them to recover their costs through additional sales.

E.2.5.3 Are other groups working on substitute technologies which might make the project findings obsolete?

Other groups are not thought to be working on alternative technologies. This project had contributed to greater understanding of soil borne diseases in beans and it is likely that these findings along with those of other similar studies will be used to develop better controls for growers. However, it is unlikely that the findings of this work will be superseded by alternative findings.

E.2.5.4 Has the involvement of HAL increased adoption rates?

HAL's communication network means that the adoption of the findings is greater than would otherwise have been the case.

E.2.6 Cost Benefit Analysis Results

The following table summarises the economic cost impacts used in the CBA (no social or environmental costs have been identified).

Table E.8. Present Value of Project Costs

Impact	Cost ($2008)	PV ($M) – Discount Rate		
		6.00%	7.15%	9.00%
Project cost	$305,605	$0.3	**$0.3**	$0.3
Ongoing costs	$50,000	$0.3	**$0.4**	$0.4
Total		**$0.6**	**$0.7**	**$0.7**

Notes: Totals may not sum due to rounding
Source: AEC*group*

The present value of the economic costs of the project is estimated to be $0.7 million. Total project costs and ongoing costs would be split equally between levy payers and the public. The following table summarises the benefits used in the CBA.

Table E.9. Present Value of Project Benefits

Impact	Benefit ($2008)	PV ($M) – Discount Rate		
		6.00%	7.15%	9.00%
Avoided crop losses	$92.00/tonne	$11.5	**$10.7**	$9.6
Avoided lost revenues due to switching crops	$46.00/tone	$1.3	**$1.2**	$1.1
Import saving	$46.00/tonne	$2.1	**$1.9**	$1.7
Total		**$14.8**	**$13.9**	**$12.5**

Notes: Totals may not sum due to rounding
Source: AEC*group*

The total present value of the stream of benefits from the projects is estimated to be $13.9 million. The majority of the benefits relate to avoided crop losses and avoided imports. The table below outlines the net present value of the impacts of the project.

Table E.10. CBA Outcomes ($2008 million)

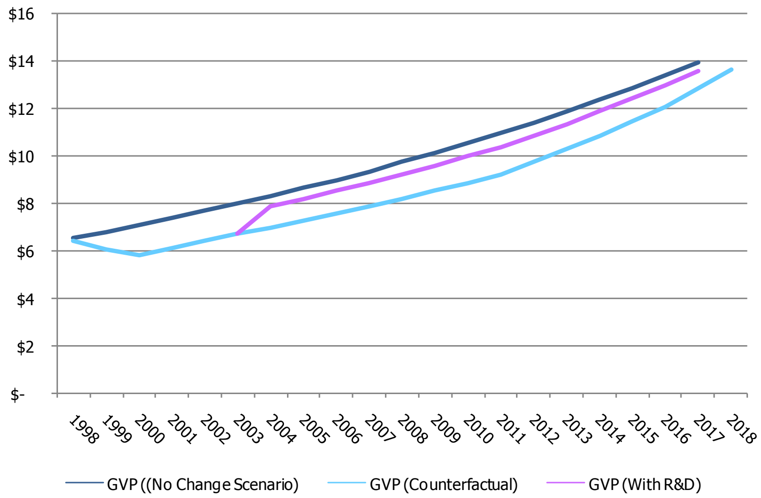
Discount Rate	PV Costs		PV Benefits		NPV		BCR	
	Private	Public	Private	Public	Private	Public	Private	Public
6.00%	$0.3	$0.3	$12.8	$2.1	$12.4	$1.7	38.0	6.1
7.15%	**$0.3**	**$0.3**	**$11.9**	**$1.9**	**$11.6**	**$1.6**	**35.9**	**5.8**
9.00%	$0.3	$0.3	$10.7	$1.7	$10.4	$1.4	32.9	5.3

Notes: Totals may not sum due to rounding
Source: AEC*group*

The table demonstrates that this work produces a positive return on investment to both growers ($11.6 million) and the public ($1.6 million).

The following figure compares the gross value of production between the no change, counter factual and with R&D adoption cases, it should be noted that the 'with R&D' case includes output from both growers adopting the project findings and those that continue to grow affected crops despite incurring significant losses.

Figure E.3. Gross Value of Production Comparison ($2008 million)



Source: AEC*group*

It can be seen from the chart that:

- The sector was already sustaining significant losses when the project findings are released;
- By implementing the project findings growers are able to reduce the loss relative to the no change scenario;

- The no change scenario has a higher GVP due to the losses sustained by growers that continue to grow beans and sustain losses and the reduced revenues bean growers that are forced to switch to alternative crops due to the high losses; and
- Over time the benefits will reduce as other technological changes area adopted. It is likely that as growers return to bean production and losses suffered by those growers that continue production with adopting the findings reduce, all three scenarios will meet.

The following table shows the distribution of benefits to growers and to the public over five, ten and twenty years from the start of the project and the following figure shows the cumulative net present value of this work to growers and the public.

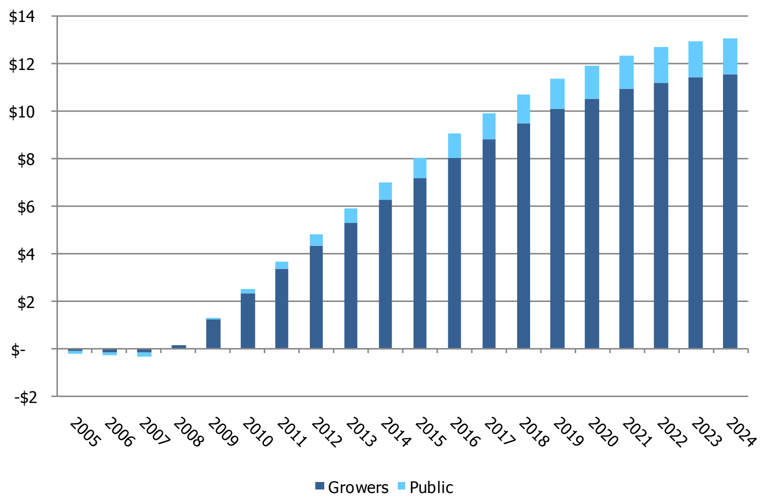
Table E.11. Project NPV of Grower and Public Impacts ($2008 million)

	5 yrs	10 yrs	20 yrs
Grower			
6.00%	$1.3	$6.5	$12.4
7.15%	**$1.3**	**$6.3**	**$11.6**
9.00%	$1.3	$5.9	$10.4
Public			
6.00%	$0.1	$0.8	$1.7
7.15%	**$0.1**	**$0.8**	**$1.6**
9.00%	$0.1	$0.7	$1.4
Total			
6.00%	$1.4	$7.3	$14.2
7.15%	**$1.4**	**$7.1**	**$13.2**
9.00%	$1.4	$6.7	$11.8

Notes: Totals may not sum due to rounding
Source: AEC*group*

The project is anticipated to provide a positive return on investment to both growers and the public within five years.

Figure E.4. Cumulative NPV to Growers and Public ($2008 million)



Source: AEC*group*

It is estimated that over the twenty years following the start of the project 87.9 percent ($11.6 million) of the total quantifiable net benefit would accrue directly to growers, with the remaining 12.1 percent ($1.6 million) accruing to the general public.

E.2.7 Sensitivity Analysis

The two major assumptions used in the model relate to the proportion of production grown under the new management approach (80 percent) and the percentage of losses incurred (20 percent). It is considered that the adoption rate is a conservative approach given the scale of losses incurred using broad spectrum chemical controls and the percentage losses where observed in crops and in trials. However, the following table demonstrates the impact on NPV of a range of assumption scenarios.

Table E.12. Sensitivity Analysis of NPV to Adoption and Crop Loss Scenarios, ($2008 million)

Crop Losses	Rate of Adoption			
	60%	70%	80%	90%
5%	$5.4	$4.8	$4.1	$3.4
10%	$6.9	$6.8	$6.7	$6.6
20%	$10.8	$11.9	**$13.2**	$14.6
30%	$15.0	$17.3	$20.1	$23.2

Notes: Totals may not sum due to rounding
Source: AEC*group*

The highlighted cell shows the outcome based on the assumptions used in the model. Using the highest scenario of 90 percent adoption and 30 percent crop losses, the NPV would be $23.2 million. However, if the lowest scenario were adopted (60 percent adoption rate and five percent crop losses), the NPV would be $3.4 million. Therefore, even at the lowest scenario, the project still records a positive NPV.

E.2.8 Confidence Rating

The confidence rating for the outcomes of the CBA of this project is high. The project included a grower survey and in involved in the study of a relatively small commodity group allowing greater confidence in growing losses and adoption scenarios. The high level of losses experienced and lack of an effective control is also likely to have increased awareness of the issues facing growers and increased adoption of the project findings.

E.2.9 Project Summary

Growers of beans have been faced with the spread of soil borne diseases which pose a significant threat to their industry. Without a registered soil fumigant they were faced with a highly uncertain future, exacerbated by the absence of any effective means of testing for the presence of the disease. In some cases growers suffered repeat crop losses as they replanted areas where the disease was present. By adopting the project findings, they have been able to reduce losses and to develop a foundation for further research into the diseases.

It is likely that the findings of this project will be used to develop additional controls (for example new fungicides) which will also provide additional benefits within the lifetime of the benefits from this project.

E.3 Integrated Management of Pythium Diseases of Carrots

E.3.1 Project Description

Carrot growers in Western Australia enjoyed considerable success exporting to markets in South-East Asia during the late 1990's and early part of the 2000's. Since then, increased production in China has all but wiped out export to bulk markets however, where quality remains a central differentiating factor Australian grown carrots still compete effectively especially in high value markets in Malaysia and Singapore.

These export markets demand very high quality and reject consignments for minor cosmetic imperfections. Increasingly, this quality standard is also being adopted by large retailers in Australian domestic markets.

Pythiums are soil borne fungi, which cause a range of diseases in carrots throughout the world, the fungi tend to be most prevalent in sites where carrots are repeatedly cropped. A previous report VG95010 found the one strain *P. sulactum* was the cause of cavity spot in Western Australia. Cavity Spot is a significant disease in carrots, which causes small spots that may lead to rejection at market severely impacting on marketable yields.

The success of growers in the late 1990's in supplying export markets meant that there was an incentive to grow the crop almost continuously rather than introduce less profitable break crops. At the time, there was no diagnostic test for the disease, so growers only knew there was a problem at harvest once the majority of their input costs had been incurred.

The problem was exacerbated by a lack of understanding of the disease characteristics. If a grower checked a crop and found cavity spot, they might plough the crop back in rather than incur harvesting costs. However, in doing so they increased the concentration of pathogens. VG98011 *(Integrated management of Pythium diseases of carrots)* studied the host range of the fungus. This was an important aspect as it identified other potential host crops, which allowed the identification of break crops that would not provide a host for the pathogens.

A much earlier study VG036, found that almost half of the crops surveyed had cavity spot present and that this resulted in a 10 percent or greater loss of yield in 16 percent of these crops. Pythiums have also been found to be responsible for causing damping off, which results in low root numbers at harvest and root die back. At harvest, affected carrots are usually forked and misshapen and achieve much lower market prices.

VG95010 investigated means of controlling Pythium diseases in order to develop an integrated disease management approach for local growers in Western Australia. This project (VG98011) attempted to build on those findings by assessing the extent to which they were applicable in carrot growing regions in other states and to extend the findings to the industry.

Initially, a survey of the incidence and origins of Pythiums associated with cavity spot and associated diseases was undertaken. The project then went on to review the effectiveness of cultural, chemical and biological methods of Pythium control including:

- A rotation trial on a severely infested site using a non-host species (broccoli);
- Assessment of the effects of solarisation on a range of Pythiums;
- Assessment of the rate of breakdown (and effectiveness) of metalyxl (a phenylamide fungicide) used to control Pythium;
- Assessment of other chemical control measures; and
- Assessment of three resistant cultivars.

E.3.2 Project Deliverables

Key findings from the study included:

- Grasses and unrelated vegetables are unaffected by *Pythium sulcatum*;

- When carrots followed a non-host crop (broccoli) the harvested crop exhibited decreased forking and increased root length, resulting in an increased yield (it was also suggested that this approach resulted in reduced incidence of cavity spot although the results were inconclusive);
- Oospores of *P. sulcatum* were able to survive up to 21 months in the absence of a host;
- The temperatures that can be realistically achieved through solarisation are only effective against some Pythium strains with *P. sulcatum* able to survive for 2 hours at 45C;
- Chemical control tests found that Pythium infection was only effectively controlled by metalaxyl;
- Where metalaxyl had been applied previously however, the half life varied from between 1 day to 43 days (published half life is 70 days). This suggested a serious problem associated with enhanced breakdown of metalaxyl where it has been used previously;
- Many of the cultivars which proved resistant to cavity spot did not produce export quality carrots; and
- The "Stefano" variety combined resistance and moderate yield, and is now adopted at the industry standard variety throughout Australia.

E.3.3 Project Adoption

Carrots are grown throughout Australia (except NT and ACT), and are available all year round. For the purposes of this assessment it has been assumed that:

- The project findings are applicable to 80 percent of carrot producing land;
- Within two years of the initial extension activities, 75 percent of applicable output was grown using the findings of this project;
- Within five years of the initial extension activities, 50 percent of applicable land which is not cultivated using the R&D findings continues to grow carrot crops and sustain losses of 10%; and
- Within five years of the initial extension activities, 50 percent of applicable land has been switched to the production of alternative crops.

E.3.4 Benefit Identification

Table E.13. Impact Identification Table

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
	Economic Costs		
Project and Related Expenditure	**Project costs:** Total project costs were $274,836 equivalent to $305,605 ($2008).	Quantitative	Both
	Ongoing maintenance costs: It is estimated that approximately $50,000 per annum would be required to maintain the benefits from the project by conducting additional research into the disease, alternative management controls and ongoing grower awareness and education.	Quantitative	Both
	Economic Benefits		
	Avoided crop losses: • It has been assumed losses of up to 10 percent would have been experienced by growers that did not adopt the R&D findings for ten years following the project extension activities. • After ten years, the average loss experienced by non-adopters is assumed to reduce by two percent per annum (reaching zero after a further five years), reflecting the adoption of other disease management measures and alternative technologies in the future (likely to be further development of this work rather than a totally new management approach). • The value of avoided crop losses has been calculated as the annual loss rate multiplied by the total output of growers that have adopted the project findings.	Quantitative	Grower
	Avoided higher priced imports: • Although the project is not considered to have developed any new markets, it is likely to have protected the domestic market from overseas competition. It is anticipated that if growers sustained repeated heavy crop losses, with no effective means of controlling the pest and there had been repeated incidents of consumers purchasing a diseased product, domestic market share would have eroded by overseas production and that: ○ Prices would be five percent higher than under the 'no change scenario' due to scarcity of supply ○ Higher prices would encourage consumers to purchase substitute goods ○ Domestic demand would be lower with 10 percent of production losses replaced by imports • This avoided additional cost (under the R&D adoption scenario) is included as a benefit to the consumer and is calculated as the cost of substituting 10 percent of output that would be lost if growers did not adopt the project findings, including a 5 percent price premium.	Quantitative	Public
	Avoided lost revenues: • For non- adopters (following crop losses of 10 percent) it is assumed that within five years of the project extension activities 50 percent of growers would switch production to the next most profitable crops. • Alternative crops are assumed to be ten percent less profitable than growing carrots. • As the benefits of the R&D diminish over time, growers would be expected to return to carrots.	Quantitative	Grower

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
	Export market expansion: • Carrot production has been a lucrative business for growers compared to other vegetable products (as evidenced by the absence of a viable break crop). Much of that production had been to service export markets but the combination of increased overseas competition and the incidence of Pythium diseases greatly reduced this trade. Although the production which had previously been exported has largely been absorbed buy the domestic market (this is thought to have occurred due to the drought in other states) the ability to control Pythium diseases is central to the maintenance and possible expansion of the carrot export market. This project is **likely** (will probably occur in most circumstances) to have produced a **negligible** (unlikely to be measurable against benchmarks) economic benefit to growers. Resulting in a **low** impact score.	Qualitative	Growers
	Contribution to regional and national economies: • In 2006-07, the estimated gross value of Australian carrot production $151.1 million. This project has contributed to the viability of the carrot sector and in doing so has reduced the risks of losing the contribution affected growers make to regional economies (and the national economy) through both their direct expenditure and the associated flow on effects of that expenditure. It is **likely** (will probably occur in most circumstances) that this project has produced a **negligible** (unlikely to be measurable against benchmarks) public benefit. Resulting in a **low** impact score.	Qualitative	Public
	Social Benefits		
Reduced Social Impact	**Reduced risks to physical and mental health:** • By developing improved techniques to manage the impact of Pythium diseases the project outcomes are likely to have reduced stress amongst growers by increasing their ability to control the disease in the short term and increasing the longer term viability of the sector. This is **likely** (will probably occur in most circumstances) to have resulted in a **negligible** (unlikely to be measurable against benchmarks) social benefit to growers. Resulting in a **low** impact score.	Qualitative	Grower
	Strengthening regional communities: • Growers contribute to their local communities in a wide range of ways including their participation in community activities as well as the contribution they make to retain the critical population mass needed to sustain other rural sector businesses and community services including schools and health care facilities. It is thought **likely** (will probably occur in most circumstances) that the project has made a **negligible** (unlikely to be measurable against benchmarks) benefit to the effected communities. Resulting in a **low** impact score.	Qualitative	Public
	Increasing the sustainability of the Australian vegetable sector: • This project has contributed to the overall sustainability of the vegetable sector as a whole, which encourages growers to make investments in equipment and other technology as well as giving them re-assurance about their own positions and the likelihood of being able to pass on a viable operation to the next generation of their family. Losses due to Pythium diseases can have significant impacts on the viability of carrot growers. It is **likely** (will probably occur in most circumstances) this project has provided a **negligible** (unlikely to be measurable against benchmarks) benefit to growers. Resulting in a **low** impact score.	Qualitative	Grower
	Skill and knowledge development: • The development of additional understanding of Pythium diseases is likely to be used to inform future research on fungicide treatments and disease resistant varieties. This will be available to other researchers who might develop this work further for example in testing disease resistant varieties. This is **likely** (will probably occur in most circumstances) to resulting **negligible** (unlikely to be measurable against benchmarks) benefit to growers. Resulting in a **low** impact score. • These projects have contributed to the development and retention of R&D posts in Australia as well as developing researchers' knowledge and skills. This helps to retain researcher skills within Australia and has the potential to lead to benefits in other related fields. This is considered **almost certain** (expected to occur in most circumstances) to provide a **negligible** (unlikely to be measurable against benchmarks) public benefit. Resulting in a **low** impact score.	Qualitative	Both

Impact Category	Impact Description	Assessment Type	Stakeholder Impacted
	Environmental Benefits		
Reduced Environmental Impact	**Reduced environmental footprint of direct grower activities:** • Increasing understanding of a range of control measures also reduces the incidence of growers being tempted to apply ever increasing volumes of metalaxyl. The greater understanding as a result of this project means that growers now understand that this is unlikely to produce positive benefits and that other control measures are more effective. By making more efficient use of their inputs, growers are able to reduce the impact of their direct activities. The reduction in fertilizer application and fungicide are **almost certain** (expected to occur in most circumstances) to result in a **negligible** (unlikely to be measurable against benchmarks) environmental benefit to growers and the public. Resulting in **low** impact scores.	Qualitative	Both

Source: AEC*group*

E.3.5 Counterfactual Case

E.3.5.1 What are the main benefits that would have eluded growers without this project?

Pythiums are found throughout Australia and so quarantine controls are not an effective tool to control their incidence, it also means that even when clearing new land there is a chance that Pythiums will be present. Prior to this project there was no diagnostic test for the presence of Pythium. This meant that a grower could easily incur all of the production costs of growing a crop to maturity only to find that the crop was worthless. To compound this issue the lack of understanding about the causes of the diseases meant that some growers chose to plough in diseased crops, which avoided harvesting costs but returned all of the pathogens to the soil.

Without this work, it is likely that some growers would have switched to other less profitable crops which are not affected by the disease while others might still be experiencing significant losses. Although a chemical control measure may have been developed, without this work to gain an understanding of the disease this would be expected to be a stop gap measure as it would not have been possible to develop an integrated approach without the underlying understanding.

E.3.5.2 Would the project have happened without the funding provided by HAL?

It is unlikely that this project would have happened without HAL funding. It would be difficult for any other organisation to recover the project costs from growers. Although carrots are one of the most economically significant vegetable commodities in Australia, it is unlikely that the market is sufficiently large to attract private sector funding for this type of work.

E.3.5.3 Would the same outcomes have emerged from overseas research and how long would the lag-time have been?

Pythium diseases are found throughout carrot growing areas of the world and much work has been done overseas. However, this work was focussed on the particular needs of Australian growers and ensured a much more rapid response to the issue than would have been the case if waiting for the trickle down from overseas research.

E.3.5.4 Are other groups working on substitute technologies which might make the project findings obsolete?

It is not thought likely that other groups are working on projects that would make these findings obsolete. Ongoing work is likely to be focused on further development of the principles adopted in this work through additional chemical, biological and physical control mechanisms but the overarching management structure is unlikely to be superseded in the short-medium term.

E.3.5.5 Has the involvement of HAL increased adoption rates?

The potential crop losses, as well as the lack of an effective soil test for Pythium gave growers a strong incentive to follow the progress of this work and to adopt the project findings however, HAL's communication network means that the adoption of the findings is greater than would otherwise have been the case.

E.3.6 Cost Benefit Analysis Results

The following table summarises the economic cost impacts used in the CBA (no social or environmental costs have been identified).

Table E.14. Present Value of Project Costs

Impact	Cost ($2008)	PV ($M) – Discount Rate		
		6.00%	7.15%	9.00%
Project cost	$1.1 million	$1.7	**$1.8**	$2.0
Ongoing costs	$50,000	$0.7	**$0.7**	$0.6
Total		**$2.4**	**$2.5**	**$2.7**

Notes: Totals may not sum due to rounding (a) per hectare per crop
Source: AEC*group*

The present value of the economic costs of the project is estimated to be $2.5 million. Total project costs and ongoing costs would be split equally between levy payers and the public. The following table summarises the economic benefit impacts used in the CBA.

Table E.15. Present Value of Project Benefits

Impact	Benefit ($2008)	PV $M) – Discount Rate		
		6.00%	7.15%	9.00%
Avoided crop losses	$61.80/tonne	$70.4	$70.1	$69.8
Avoided lost revenues due to switching crops	$61.80/tonne	$18.9	$18.8	$18.7
Import saving	$30.90/tonne	$33.0	$33.0	$33.1
Total		**$122.3**	**$121.8**	**$121.6**

Notes: Totals may not sum due to rounding (a) per hectare per crop, (b) per hectare per application
Source: AEC*group*

The total present value of the stream of benefits from the projects is estimated to be $121.8 million. The table below outlines the net present value of the impacts of these projects over a 20 year period from inception.

Table E.16. CBA Outcomes ($2008 million)

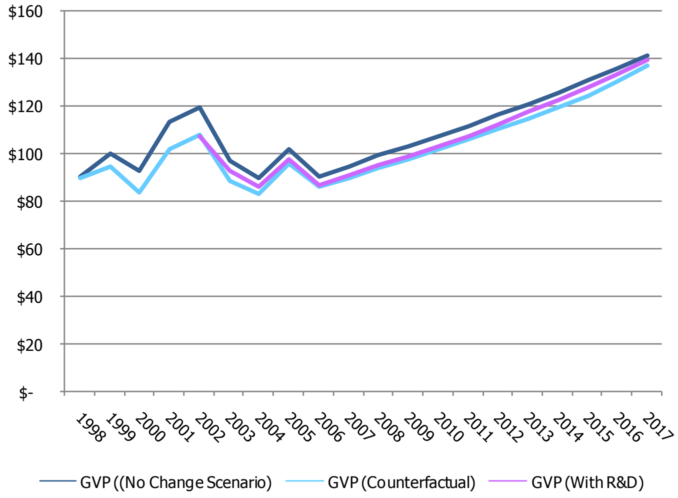
Discount Rate	PV Costs		PV Benefits		NPV		BCR	
	Grower	Public	Grower	Public	Grower	Public	Grower	Public
6.00%	$1.2	$1.2	$89.3	$33.0	$88.1	$31.8	75.3	27.8
7.15%	**$1.2**	**$1.2**	**$88.9**	**$33.0**	**$87.6**	**$31.7**	**71.6**	**26.6**
9.00%	$1.3	$1.3	$88.5	$33.1	$87.2	$31.8	66.0	24.7

Notes: Totals may not sum due to rounding
Source: AEC*group*

The table demonstrates this work produces a positive return on investment to both growers ($87.6 million) and the public ($31.7 million). The principle benefits to growers are avoided crop losses and reduced revenues from having to grow alternative crops, while for the public the principle benefit is the avoidance of having to pay higher costs for carrots due to falling domestic production.

The following figure compares the gross value of production between the no change, counter factual and with R&D adoption cases, it should be noted that the 'with R&D' case includes output from both growers adopting the project findings and those that continue to grow affected crops despite incurring significant losses.

Figure E.5. Gross Value of Production Comparison ($2008 million)



Source: AEC*group*

It can be seen from the chart that:

- The large total GVP of the carrot sector, relative to the potential losses avoided by adopting this project means that its influence on GVP is limited; and
- As in previous assessments, the R&D outcomes mean that growers are able to increase GVP above that which would have been achieved under the counterfactual scenario and that as benefits diminish over time, all three scenarios return to the same level.

The following table shows the distribution of benefits to growers and to the public over five, ten and twenty years from the start of the project.

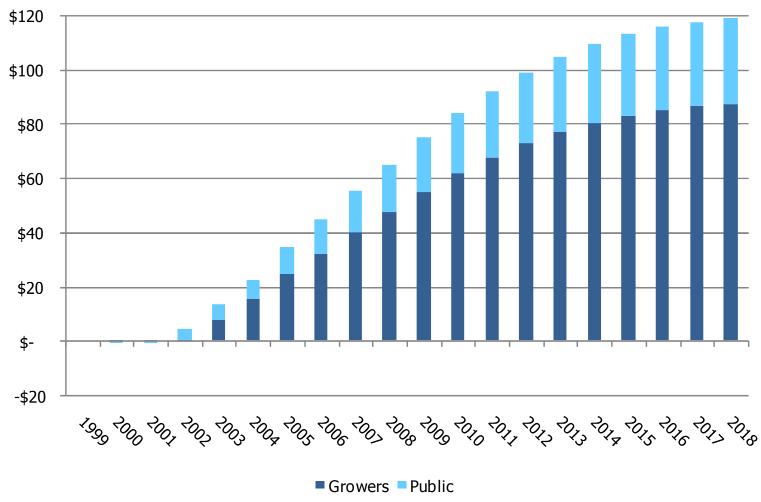
Table E.17. NPV of Grower and Public Impacts ($2008 million)

	5 yrs	10 yrs	20 yrs
Grower			
6.00%	$7.3	$46.3	$88.1
7.15%	**$7.7**	**$47.6**	**$87.6**
9.00%	$8.3	$49.7	$87.2
Public			
6.00%	$5.4	$17.2	$31.8
7.15%	**$5.7**	**$17.7**	**$31.7**
9.00%	$6.3	$18.7	$31.8
Total			
6.00%	$12.6	$63.5	$119.9
7.15%	**$13.4**	**$65.3**	**$119.3**
9.00%	$14.6	$68.4	$118.9

Notes: Totals may not sum due to rounding
Source: AEC*group*

Growers and the public both receive a positive return on investment from the project within five years of the initial investment and the total return continues to increase over the ten and twenty year time horizons.

Figure E.6. Cumulative NPV to Growers and Public ($2008 million)



Source: AEC*group*

It is estimated that over the twenty years following the start of the project 73.4 percent ($87.6 million) of the total quantifiable net benefit would accrue directly to growers, with the remaining 26.6 percent ($31.7 million) accruing to the public. The annual benefits to growers begin to tail off as the R&D benefits diminish over time.

E.3.7 Sensitivity Analysis

The two major assumptions used in the model relate to the proportion of production grown under the new management approach and the percentage of losses incurred. It is considered that the adoption rate is a conservative approach given the scale of losses incurred using broad spectrum chemical controls and the percentage losses where observed in crops and in trials. However, the following table demonstrates the impact on NPV of a range of assumption scenarios.

Table E.18. Sensitivity Analysis of NPV to Total Potential Adoption Area and Crop Loss Scenarios, ($2008 million)

Crop Losses	Total Potential Adoption Area			
	50%	60%	70%	80%
5%	$62.9	$76.0	$89.1	$102.1
10%	$99.0	**$119.3**	$139.7	$160.0
15%	$137.4	$165.4	$193.4	$221.4
20%	$175.8	$211.5	$247.1	$282.8

Notes: Totals may not sum due to rounding
Source: AEC*group*

The highlighted cell shows the outcome based on the assumptions used in the model. Using the highest scenario of 80 percent adoption and 20 percent crop losses, the NPV would be $282.8 million. However, if the lowest scenario were adopted (50 percent adoption and five percent crop losses), the NPV would be $62.9 million. Therefore, even at the lowest scenario, the project is seen to record a positive NPV.

E.3.8 Qualitative Summary

As well as the quantifiable benefits discussed above, this project is considered to have provided a range of additional non-quantifiable benefits including:

- **Reduced indirect environmental impacts –** by avoiding imports of carrots, the project has avoided the environmental impacts that would be associated with the additional transportation and storage of these crops; and
- **Export market expansion –** the ability to reliably produce blemish free carrots has allowed Australian producers to maintain their position in existing export markets as

well as seeking additional opportunities in developing markets. It is unlikely that this would have been possible without the ability to control damage as a result of Pythiums.

E.3.9 Summary

Although no adoption survey has been carried out, it is thought that the findings have been widely implemented. The potential losses after incurring significant input costs have provided growers with a large incentive to adopt the findings of the project. The problem for growers in adopting the findings has been in identifying a profitable break crop. Compared to carrot production there are few alternatives that can offer similar levels of return.

The principle economic benefits to growers are in the avoidance of losses associated with Pythium diseases. This has been achieved through the development of a diagnostic test for the diseases, as well as through increased understanding of cultural, chemical and varietal control methodologies. Although growers have been forced to reduce the frequency of their production in order to establish non-host break crops with lower returns, this approach does mean that their is still a viable carrot industry. Without this additional understanding it is likely that the incidence of the disease would increase through repeated back to back cropping and other previous practices such as ploughing in diseased crops. Combined with the lowered impact of metalaxyl when applied repeatedly to the same area the carrot industry may have been in far more serious trouble.

F. Grower Education, Development and Collaboration

F.1 Integrated Pest Management - Research to Practice for Brassicas

F.1.1 Project Description

Over the last ten to fifteen years there has been a significant shift in the paradigm of pest management from a calendar based spraying regime which relied almost entirely on the application of broad spectrum chemicals as a means of controlling pest populations to the current use of integrated pest management (IPM) systems. In order to achieve this shift, and realise the benefits to the grower and public, it is essential the requirements, benefits and costs of adopting the change are communicated to growers so they may make an informed choice regarding the adoption of the findings.

As noted in the IPM sub-program, for some growers the shift to an IPM strategy from 'traditional approaches' can sometimes appear daunting. This issue can be exacerbated where growers have a limited understanding of their direct and indirect operating costs, which makes it difficult to assess the potential economic impact of adopting an IPM based approach. Further, compared to calendar spraying regimes, IPM requires a greater understanding of a series of variables (including, pest and beneficial populations and the stages in the pest and crop lifecycles) and can be off putting to some growers if they are unsure about exactly what is involved.

To overcome some of these hurdles, VG99006 *(Integrated pest management 'Research to Practice' for brassicas)* was initiated to communicate the findings of a series of IPM projects in a readily accessible format. The project was initially based on the 'Research and Practice' model which had been developed with viticulturalists in Victoria. However, this had involved a workshop approach run over several days. It was recognised that growers would find it difficult to commit that length of time to an extension activity and that growers were likely to respond best to hearing about the experiences of other growers. To address this, a DVD was developed featuring several vegetable growers on their farms talking about the requirements, costs and benefits of adopting an IPM based management approach.

F.1.2 Project Deliverables

The key deliverable from the project was a DVD, which included interviews with a series of growers who had already adopted IPM on their properties and are seen discussing the advantages and disadvantages of the new systems, what it actually meant for them on a day-to-day basis and their experience of the final outcomes. The DVD also features a number of research scientists in the field giving practical demonstrations of pest and beneficial species counting techniques, checking for Clubroot infestation and discussing the two-window DBM spraying technique as a way of limiting the development of insecticide resistance.

F.1.3 Project Adoption

No records are available of the number of copies of the DVD that were distributed although it estimated that more than a thousand were provided direct to growers as well as other distribution channels such as industry development officers and local agricultural agents.

F.1.4 Impact Identification

The benefits from the project are likely to have been included in the quantification of benefits from other projects and so to avoid double counting are not included here.

F.1.5 Counterfactual Case

F.1.5.1 What are the main benefits that would have eluded growers without this project?

Adopting IPM strategies has the potential to offer growers and the public significant benefits. These include economic benefits from reduced crop losses and more efficient use of inputs and social and environmental benefits from the implementation of practices which reduce environmental impacts. Without this project it is likely that some growers would not have adopted IPM strategies and therefore would not have been able to access these benefits.

F.1.5.2 Would the project have happened without the funding provided by HAL?

It is unlikely this project would have been funded by any other organisation. Although suppliers of agricultural inputs invest in marketing and promotional materials this is done in an attempt to generate additional business and is often limited in its scope and detail to reduce costs. The topics covered in the DVD are unlikely to generate additional revenues which a supplier could use as a means of recovering their costs.

The central theme of IPM strategies is that they draw on several management techniques to control pests. Where one unique strategy is applied for example controlling pests through chemical control or soil borne diseases through resistant varieties alone then the companies that manufacture the critical element of the process have an obvious incentive to promote its use. In an integrated system, especially one that relies on cultural practice changes as part of its approach, the incentive for the private sector to promote the adoption of these strategies is much smaller.

F.1.5.3 Has the project brought forward any benefits that may not otherwise have emerged?

It is likely that the project has increased the rate of adoption of IPM management techniques. By breaking down some of the perceived barriers to adoption, and providing growers with the reassurance that the same techniques had worked well in practice on similar properties, many more growers are expected to have adopted the project findings than may otherwise have been the case.

F.1.5.4 Would the same outcomes have emerged from overseas research and how long would the lag-time have been?

Although it would be anticipated that research bodies in other countries also engage in marketing activity to their members, it is unlikely that growers would have been as convinced by examples from overseas growers as they were by Australian based examples. As noted earlier, one of the key factors contributing to the success of this project was the fact that growers could learn from other growers they could strongly relate to, this would be difficult to replicate with growers from overseas and in any case their experiences would almost certainly have been different.

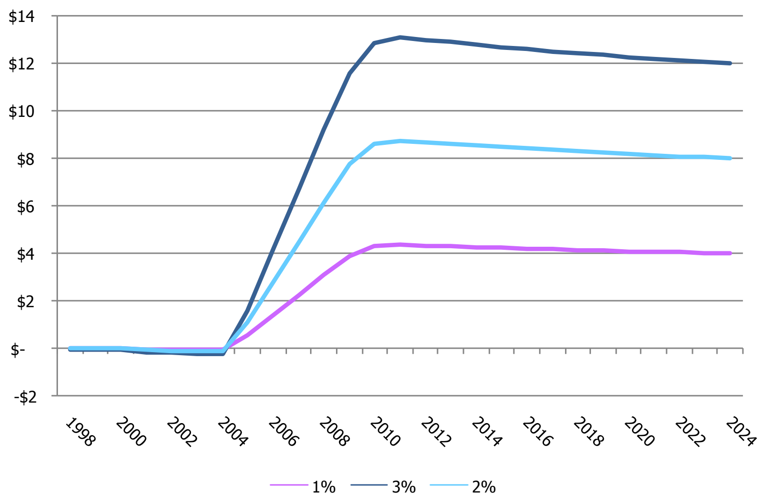
F.1.5.5 Are other groups working on substitute technologies which might make the project findings obsolete?

The physical components of IPM (for example specific chemicals) and the management framework on which IPM is based (including crop scouting, spraying to preserve beneficial populations and the use of bacterial agents) is unlikely to change in the short to medium term. Further, the DVD introduces the concept of IPM and what it means in a practical sense is unlikely to become obsolete.

F.1.6 Cost Benefit Analysis

The quantitative benefits of the project are likely to have been included in the IPM projects assessed in a preceding chapter. However, without this extension project it is expected the rates of adoption and the speed of adoption would have been lower. In order to avoid double counting these benefits a quantitative analysis has not been undertaken for this project. However, by way of illustration, the following figure shows the impact that the project would have had if it were responsible for increasing adoption of the DBM project by even only a small amount.

Figure F.1. Additional Benefit Scenarios ($2008 million)



Source: AEC*group*

The three scenarios show the additional benefit that would accrue to growers and the public if the extension DVD had led to an additional one, two or three percent adoption of the outcomes of the DBM project.

F.1.7 Qualitative Assessment

As with the quantitative assessment, it is likely that the project would contribute to all measurable outcomes by increasing the rate of adoption of other project findings but to avoid double counting these are not included.

F.1.8 Project Summary

The project played a key role in the communication of ideas, key issues and learning to brassica growers. By using growers that had already adopted IPM in the film, as well as research staff, growers were able to see the process of IPM in operation greatly increasing their buy in to the key messages. It is almost certain that this project has produced a benefit across each of the qualitative categories.

Although the benefits from discrete extension projects like this one are difficult to quantify and should ultimately be attached and considered in conjunction with the underlying R&D program, growers repeatedly highlighted the need for this type of work to link the outcomes of R&D projects to observed and practical solutions that growers can then have confidence putting into practice.

The most important contribution of this project was most likely in breaking down grower concerns about the costs and complexity involved in adopting IPM strategies. Given the overall shift towards IPM based approaches, the increasing scrutiny of the impacts of broad spectrum insecticides as well as the potential economic benefits it is important that as many growers as possible are given the opportunity to implement these types of approaches.

F.2 Developing Strategic Alliances with New Zealand Vegetable Industry: Study Tour for Young Growers 2005

Although nominally competing with one another, growers are also faced with the need to compete with alternative food groups and vegetable growers overseas. The need for continuous inputs and crop management and the distances between properties can work to limit opportunities for grower interaction and to establish both formal and informal groups.

The establishment of both formal and informal groups is important because where such groups exists they can provide a powerful tool in the communication of examples of best practice as well as a discussion forums for new technologies and other industry developments. This is particularly so for younger growers who represent the future for the industry and who must embrace new technologies and techniques in order to remain competitive. Without access to new ideas and processes, including both on and off farm topics, it will be difficult for growers to remain viable using out dated practices.

In such a competitive operating environment it is vital that growers are given opportunities to learn from other growers in Australian and overseas to help ensure the long term future of the sector.

F.2.1 Project Description

This project, its predecessors and successors (the trip has been run in each year since 2001) attempt to provide opportunities for young Australian vegetable growers to experience the vegetable industry in New Zealand first hand, to attend the New Zealand vegetable industry annual conference and to build up networking contacts with other growers. Growers that want to be considered for the trip must complete an application form explaining how they think the experience would benefit their growing activities and how they would hope to apply the learning on their return to Australia. Usually, between six and twelve participants are selected to make the trip each year.

F.2.2 Project Deliverables

Once in New Zealand the growers undertake a range of farm visits, which usually cover a variety of stages in the value chain including growing, packing and marketing. In 2005, the attendees also took the opportunity to assess the way in which the New Zealand growers had established individual brands for some of their premium products and how this branding was highlighted to consumers in local supermarkets. Following a series of farm visits, the participants then attended the New Zealand Vegetable Grower's Annual Conference, providing an opportunity to learn more about developments in the industry in New Zealand and to establish new contacts.

New Zealand is considered a beneficial location for information exchange and learning, given that vegetable growers in New Zealand have to address many of the same pest and disease issues as are present in Australia and because New Zealand has a relatively limited domestic market, it must continue to innovate throughout the value chain to maintain its competitiveness against other overseas suppliers, including Australia, for export market share.

F.2.3 Project Adoption

Although the attendees represent a small proportion of vegetable growers in Australia, the trip findings are disseminated through a project report and articles in industry publications. Further, the outcomes of the project and lessons learned are also distributed through word of mouth once the participant returns. This can lead to the adoption of new technologies both on their own properties but also in surrounding areas. In this way the project reaches far wider than the number of attendees may suggest. As noted in the IPM DVD project, many growers seem more confident of findings they have seen or another grower has seen in practical application than those they have only read about in a project report.

F.2.4 Impact Identification

The benefits from the project are likely to have been included in the quantification of benefits from other projects and so to avoid double counting are not included here.

F.2.5 Counterfactual Case

F.2.5.1 What are the main benefits that would have eluded growers without this project?

The principle project benefits that would have eluded growers include the opportunity to observe and learn from alternative practices throughout the value chain, to interact with fellow attendees and to meet growers in New Zealand. These experiences are considered a significant learning opportunity, which not only benefits the growers themselves but also other growers in Australia who hear about the attendees experiences and the industry which benefits from the development of potential future industry leaders and figureheads.

F.2.5.2 Would the project have happened without the funding provided by HAL?

Without these projects is very unlikely that any of the young growers that have attended the courses would have made this trip. Without these trips the growers themselves and the network of growers they subsequently come into contact within Australia would not have access to the developments the Australian delegates observed on the trip. Delegates would also miss out on the opportunity to extend their Australian based contacts. For many growers, opportunities to meet and exchange ideas with other growers outside of their immediate locality are limited, however, anecdotal feedback identifies strong benefits from such interaction. Rates of adoption and change throughout the industry are likely to be much slower because of this characteristic.

F.2.5.3 Has the project brought forward any benefits that may not otherwise have emerged?

Development opportunities like this also help to identify industry leaders that can become more heavily involved in the strategic leadership of the industry. Some younger growers have expressed the view that there are limited opportunities for them to make their voices heard on industry committees. Equally some older growers have expressed reticence about joining committees because so few people are willing to give their time that it can be difficult to get off committees again once you are on them.

This trip is one opportunity to identify potential industry leaders and to develop the necessary skills for such a role, particularly surrounding the experience of understanding, evaluating and extending the relevance of alternative approaches.

F.2.6 Project Summary

This trip is an opportunity for young growers to benefit from experiencing the vegetable industry (at all levels of the supply chain) in a different environment as well as building contacts amongst other growers and vegetable industry stakeholders in Australia and New Zealand. These types of networks are essential to the development of individual growers and the industry as a whole helping to spread the adoption of new technologies and techniques as well as providing development opportunities for the attendees. In assessing these projects it is vital to recognise the trickle down effects on growers who do not attend but who benefit when those growers that do attend return to Australia and pass on what they have learned.

F.3 Industry Development Officers

F.3.1 Project Description

During extensive consultations with growers, the network of Industry Development Officers (IDOs) was one of the most frequently cited examples of a successful National Vegetable Levy funded project. In the opinion of the majority of the growers consulted, these positions played a vital role in making R&D project findings and recommendations accessible to growers.

Although these posts are not directly related to an R&D project, it does appear that they are an important catalyst in increasing the extent of adoption of project findings. For example, many growers identified they were unaware of some of the projects that had been funded through the levy or that they found some final project reports hard to interpret and implement. In their opinion, rates of project adoption would be considerably lower without the support of the IDOs.

F.3.2 Project Deliverables

IDOs provide a range of services to growers determined by factors including the geographic area they have to cover, the range of commodities grown and the particular issues facing growers. In general terms, their principle roles are in communicating project outcomes through one to one meetings, organising field demonstrations and providing a feedback mechanism for growers. At a more strategic level, some IDOs have invested time and effort in developing databases of growers, their crops and characteristics of their properties. This information is then used to provide regular updates to growers on project findings and other information relevant to their operation.

F.3.3 Project Adoption

It has not been possible to determine the rate of adoption (i.e. how many growers come into contact with an IDO) as at present each IDO provides a different service and this information is not counted. It is understood the terms of reference for these roles is under review and a more uniform approach across these positions may emerge.

F.3.4 Impact Identification

The benefits from the project are likely to have been included in the quantification of benefits from other projects and so to avoid double counting are not included here.

F.3.5 Counterfactual Case

F.3.5.1 Would the project have happened without the funding provided by HAL?

Grower consultation suggests that without the IDO positions many of the beneficial R&D outcomes would not be realised due to a lack of communication to growers in a suitable format. Whilst the IDOs are not responsible for the project findings, it appears that without their involvement adoption rates would be significantly lower. It was also suggested during the consultation stages that IDOs play an important role in ensuring that growers are aware that a particular project finding has been developed from a National Vegetable Levy funded project. It was suggested that without the IDO role growers might be made aware of project outcomes through alternative sources (agronomists, seed and chemical companies) without any mention of the levy having funded the work. This is important to ensure growers understand the benefits they receive and the validity of the levy.

F.3.5.2 Has the project brought forward any benefits that may not otherwise have emerged?

It is likely that the IDO network has increased the sharing of information and best practice between growers. This has been achieved by facilitating events including grower field days and by acting as a conduit between growers. As noted in the review of the visits to New Zealand, it can be difficult for growers to find the time to meet other growers and discuss industry developments. However, because the IDO spends a considerable amount of their time with a range of growers, it is much easier for them to provide growers with information about the latest development in the sector.

F.3.5.3 Are other groups working on substitute technologies which might make the project findings obsolete?

HAL has a wide range of grower publications and several other industry bodies and government departments also produce publications for the extension and dissemination of research findings. It is undoubtedly true that these publications either in hard copy or electronic format are able to reach far more growers than an IDO may be able to. However, growers consistently remarked on the high value they received from an IDO visit where as some felt snowed under by the weight of literature they received from other sources.

F.3.5.4 Has the involvement of HAL increased adoption rates?

Without the work of the IDO network, it is almost certain that the rate and extent of adoption of many of the project findings would be considerably lower. In many cases stakeholders suggested that if it were not for their IDO they would know very little about project outcomes other than those which took place either on their property or the property of a neighbour. Given the often significant extension activities undertaken on completion of the project and the level of grower communication outside of the IDO network (for example through magazines and websites), grower impressions may be a slight over simplification, however, it is quite clear that growers value the IDO network very highly.

F.3.6 Cost Benefit Analysis

It has not been possible to conduct a cost benefit analysis of the IDO network. It is almost certain that the network plays a crucial part in communicating with growers preferring one to one communication over other media. Whilst one to one communication can be more expensive compared to dissemination of research material through other means. The key benefits if the IDO appear to be in the genuine understanding of the application of research findings on 'each growers' property following interaction with the IDO. The benefits of the expenditure are likely to be included in the analysis of the preceding projects, where the rate of adoption, ease and the appropriateness of application are higher as a result of the work of the IDO network.

F.3.7 Qualitative Assessment

As with the quantitative assessment, it is likely that the project would contribute to all measurable outcomes by increasing the rate of adoption of other project findings but to avoid double counting these are not included.

F.3.8 Project Summary

According to grower consultation, the IDO network was one of the most popular and useful pieces of work funded by HAL. Growers in general, strongly prefer a one to one conversational style to being provided with electronic and hard copy reports and articles. However, there were significant variations in what each IDO actually did, with some spending significant amounts of time with growers while others concentrated their efforts on making information available to growers rather than actually explaining what it all meant in terms of each property.

Whilst the vast majority of growers that came into contact with their IDO were very supportive of the role, some growers reported unhappiness that they saw very little if anything of the IDO. Queensland does not currently have a vegetable IDO in place. It appears the IDOs do play a key role in encouraging the greater adoption of project findings by communicating project outcomes to growers through a variety of media. However, HAL need to consider the effectiveness of this approach against the costs for each R&D project outcome and the stage and level of adoption to ensure IDOs are able to prioritise and maximise the benefit from their extension activities.

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Appendix A: National Vegetable Levy Roles and Responsibilities

Australian Government and Department for Agriculture, Fisheries and Forestry

The Australian Government sets a series of national priorities for R&D expenditure, which seek to identify topics of national importance and to focus efforts in these areas. The priorities are necessarily broad with the application of funds to programme areas and the setting of more detailed R&D objectives left to individual Government Departments. The Department for Agriculture, Fisheries and Forestry (DAFF) collect a series of industry specific levies through the Levies Revenues Service. These funds are administered by sixteen Rural Regional Development Corporations (RDCs).

Horticulture Australia Limited

HAL is the RDC responsible for coordinating, investing and managing R&D in the horticulture sector, including work that is funded through the National Vegetable Levy. HAL is responsible for all decisions relating to the expenditure of levy funds and is ultimately answerable to Government, DAFF and levy partners.

HAL looks after the interests of thirty-seven member bodies, each of which is the Peak Industry Body (PIB) for a specific commodity or group of commodities within the horticultural industry. Every statutory horticulture levy that collects more than $150,000 per annum (including the National Vegetable Levy) must also have an Industry Advisory Committee (IAC). Each IAC is a sub-group of the HAL board and has four principle objectives:

- To understand the needs of the relevant industry sector;
- To develop a 3-5 year strategic plan for investment (R&D and marketing expenditure) in the industry;
- To prepare an annual investment plan for submission to HAL, establishing the IAC's recommendations for project expenditure designed to achieve the outcomes of the strategic plan; and
- To prepare an annual report to HAL detailing the outcomes achieved by the Annual Investment Plan.

AusVeg - Peak Industry Body

The final decision on which R&D projects are approved for funding rests with the HAL Program Manager, however, industry bodies like AusVeg play a key role in communicating grower priorities for the R&D program and ensuring that member's interests are represented in setting the priorities for the expenditure of levy finds. AusVeg's strategic objectives include:

- Agripolitical advocacy and representation on behalf of vegetable and potato growers;
- Delivery of national projects in the areas of communication and the environment on behalf of industry, funded from a wide variety of sources including Government grants, sponsorship and levies; and
- The third of these roles relates specifically to R&D and includes:
    - Establishing the case for a levy by seeking a mandate from growers and making submissions to the Australian Government;
    - Making recommendations to HAL about membership of the IAC for the purpose of making decisions on annual investment in the National Vegetable and Potato Levies;
    - Managing the levy investment consultation process and providing recommendations from industry to HAL on where the National Vegetable and Potato Levies should be invested; and
    - Undertaking general consultation on behalf of the vegetable industry.

DAFF and Australian Vegetable Industry Research and Development Priorities

The following tables track the changes in DAFF and the vegetable industry's priorities over the last ten years and the measurable outcomes that are associated with each. Priorities usually have multiple outputs that can affect several outcomes and so in most cases each priority has more than one measurable outcome. It is important to recognise that these priorities guide the IAC in making decisions about which projects to approve but the ultimate decision is made by HAL.

DAFF Research and Development Priorities

DAFF updated its R&D priorities in 2006 and the number of priorities reduced from nine to seven. These priorities apply to all Commonwealth Government sponsored R&D expenditure that is administered by the Department across the whole agriculture, forestry and fisheries sector. Each priority is explicitly aligned to the overarching national R&D priorities. There are two main groups of priorities, one dealing with operational issues both on and off farm, the other with indirect activities including management and technology. Although DAFF have simplified their priorities, the topics covered are similar. Water, soil erosion and pest management have been brought together into the environment category under natural resource management. Expenditure on farm management and the supply chain has been split between on farm processes and the supply chain between the farm gate and point of sale.

Table AP.A.1. DAFF Research and Development Priorities 1998-2008

DAFF Priorities	Measurable Outcomes
1998-2006	
Transforming Industries	• All outcomes
Sustainable use of Biodiversity	• All outcomes
Protection from Pests and Weeds	• New markets • Quality differential • Environmental and/or social impact
Water – A Critical Issue	• Production efficiency • Reduced costs • Quality differential • Environmental and/or social impact
Responding to Climate Change	• Increased production • Reduced costs • Environmental and/or social impact
Frontier Technologies	• Environmental and/or social impact
Overcoming Soil Loss	• All outcomes
Reducing Emissions	• Reduced costs • Environmental and/or social impact
Innovative Culture and Economy	• Environmental and/or social impact
2007-2008	
Productivity and Adding Value	• Production efficiency • New markets • Quality differential • Management/ administration
Supply Chain and Markets	• All outcomes
Natural Resource Management	• All outcomes
Climate Variability and Climate Change	• Reduced costs • Quality differential • Environmental and/or social impact • Management/ administration
Biosecurity	• Environmental and/or social impact • Management/ administration
Innovation Skills	• All outcomes
Technology	• All outcomes

Source: DAFF

In revising the priorities, 'Innovative Culture and Economy' has been removed, although it may be considered that this is a part of all R&D projects and does not need to be identified as a separate priority. Overall, it appears that whilst the wording and structure of the priorities may have changed, the overarching themes that underlie the priorities remain the same.

Australian Vegetable Industry Priorities Since 1998

Although the vegetable industry priorities have been updated twice since 1998, first in 2003 and again in 2006 (when the VegVision 2020 Strategy was launched) the core themes of the programme have remained the same. For example, the 1998 R&D priorities included:

- Increase domestic consumption of vegetables; and
- Increase exports sales of vegetable in selected markets.

In 2003 this became:

- Domestic market development; and
- Export market development.

And in 2006 these priorities were combined into:

- Market recognition for Australian quality, safety, reliable supply (markets).

Although the wording of the priorities has been revised, it is clear that the underlying priorities remain the same; the development of the domestic and export markets for Australian vegetables.

A similar relationship is also evident for other priorities. For example, under each version of the priorities there has been a specific priority regarding the need to increase efficiency in the supply chain:

- Manage the value chain to increase competitiveness (1998);
- Supply chain competitiveness (2003); and
- Internationally competitive Australian vegetable supply chains (competitiveness) (2006).

The 2006 revision also added two new priorities relating to management information and leadership in the sector. This reflects a need that had been identified for more data to analyse the existing position of the industry and the direction that it is moving in as well as the importance of industry leadership in order to remain competitive and implement new practices (VegVision 2020) (2006).

Table AP. A.26.1. Australian Vegetable Industry Research and Development Priorities 1998-2008

Australian Vegetable Industry Priorities	Outcome Descriptors
1998-2002	
Provide support for regional-specific industry issues.	• All outcomes
Improve communication and collaboration within the industry	• All outcomes
Increase domestic consumption of vegetables	• Production efficiency • Reduced costs • New Markets • Quality differential
Increase export sales of vegetable in selected markets	• Production efficiency • Reduced costs • New Markets • Quality differential
Manage the value chain to increase competitiveness	• All outcomes
Enhance the capability of all participants in the value chain.	• Production efficiency • Reduced costs • Quality differential

Australian Vegetable Industry Priorities	Outcome Descriptors
2003-2005	
Product development	• Quality differential
Domestic market development	• Production efficiency • Reduced costs • New markets
Export market development	• Production efficiency • Reduced costs • New markets
Sustainability	• Reduced environmental and/or social impact
Supply chain competitiveness	• Production efficiency • Reduced costs • Quality differential
Industry communication and collaboration	• All groups
2006-2008	
Delivering to changing consumer preferences and increasing demand for vegetables (consumers)	• New markets • Production efficiency • Quality differential • Management/ administration
Market recognition for Australian quality, safety, reliable supply (markets)	• All outcomes
Internationally competitive Australian vegetable supply chains (competitiveness)	• All outcomes
Advanced industry data and information systems (information)	• All outcomes
Visionary leadership and change management (leadership)	• All outcomes
Australian Vegetable Industry Priorities	• Outcome Descriptors
1998-2002	
Provide support for regional-specific industry issues.	• All outcomes

Source: AEC*group*

The different versions of the vegetable industry priorities vary their emphasis rather than the underlying themes. For example, the latest priorities introduce the need to ensure the supply chain in competitive in international terms, this is not a significant shift in direction but a realisation of the need to view productivity relative to that achieved by competing nations rather than having a target to improve competitiveness in domestic terms.

Alignment of DAFF and Australian Vegetable Industry Research and Development Priorities

Although the scope of work is different for each organisation, the priorities should be clearly linked to ensure an integrated approach between the National R&D Priorities (Commonwealth Government), the agricultural sector (DAFF), the horticulture industry (HAL) and each levy within that industry (National Vegetable Levy). The following table shows the direct linkages between the DAFF and vegetable industry priorities, however, it should be recognised that some strategic priorities may overlap.

The vegetable industry has a greater focus on improvements to production, marketing and the supply chain and less on wider environmental issues. This may be due to the significant R&D expenditure already taking place at the national and DAFF scale considering the impact of agriculture as a whole on natural resources and climate change.

It may also be that there are natural resource management, climate change and biosecurity projects within broad priorities such as ‘Market recognition for Australian quality, safety, reliable supply’. Management and support type priorities can be aligned to all measurable outcomes given that it is likely that aspects of expenditure on marketing, and improvements to the value chain will include management, leadership and support elements.

Table AP. A.3. Linkages Between DAFF and Australian Vegetable Industry Research and Development Priorities and Measurable Outcomes

Rural R&D Priorities	Australian Vegetable Industry Priorities	Measurable Outcomes
• Productivity and Adding Value	• Delivering to changing consumer preferences and increasing demand for vegetables (consumers)	• Production efficiency • New markets • Quality differential • Management/ administration
• Supply Chain and Markets	• Market recognition for Australian quality, safety, reliable supply (markets)	• All outcomes
	• Internationally competitive Australian vegetable supply chains (competitiveness)	
• Natural Resource Management		• All outcomes
• Climate Variability and Climate Change		• Reduced costs • Quality differential • Environmental and/or social impact • Management/ administration
• Biosecurity		• Environmental and/or social impact • Management/ administration
• Innovation Skills		• All outcomes
• Technology		• All outcomes
	• Advanced industry data and information systems (information)	• All outcomes

Source: AEC*group*

Appendix B: CRRDCC Guidelines

In May 2007, the Council of Chairs of Rural Research and Development Corporations (CRRDCC) produced a set of guidelines for evaluation of R&D activities funded by Rural Development Corporations (RDCs). This set out a review framework which it was felt should lead the review of RDC R&D expenditure allowing the establishment of a rolling process which would provide evidence of the return on investment from expenditure already undertaken and guide the allocation of future funding.

The preceding analysis is based on the principles developed in the guidelines. However, as this project undertook a ten-year assessment and seeks to establish a process for a three-year review cycle the following sampling approach was used. Any variance from the CRRDCC Guidelines and the reasoning behind them are outlined in the following table.

Table AP. B.1. Comparison of CRRDCC Guidelines and AEC*group* Response

CRRDCC Guideline	AEC Response
Selection of Projects for Review: The CRRDCC guidelines establish selection criteria for projects to be reviewed: • Clusters of projects that contribute to a defined area of investigation • Random sample • Must have reached a milestone • Data available to test outcomes • CBA should be based on a three year cycle	**Selection of Projects for Review:** • The projects selected for analysis have met all of the CRRDCC criteria, however as it took a 10-year horizon a targeted sample selection process was used rather than a random sampling process that would be used in subsequent three-year rolling reviews.. • In both cases, because this is the first overall review of HAL R&D expenditure the review could not comply without incurring significant additional costs and ignoring seven years of R&D support (undertaken prior to the latest 'three year cycle'). • Having completed this initial review of the last ten years, it is considered that subsequent analyses will meet all CRRDCC guidelines, including a full random sample of completed projects.
Sampling Technique: • The reviews should build a pool of consistent CBAs using a random sampling technique that can be used to provide an indication of the range and trends in returns from the total RDCs investments over a three year period.	**Sampling Technique:** • All projects funded between 1998 and 2008 were considered for review. This was a necessary first step to establish an indication of the scale of returns that have been achieved during this period. • Now that this project has been completed, it will be possible to develop a 3-year review cycle utilising random sampling. • Had this project had only considered projects within the last three years it would have omitted R&D expenditure of approximately $97 million ($2008).
Analysing Sufficient Numbers of Projects to Demonstrate a Positive Return on Investment: Analysis of a sufficient number of significant successful large scale projects or programs to demonstrate that the entire RDC portfolio is producing positive private and public benefits	**Analysing Sufficient Numbers of Projects to Demonstrate a Positive Return on Investment:** • The quantifiable return on investment from the assessed projects clearly demonstrates a positive return to growers and the public from R&D expenditure over the last ten years.
Early Stage Projects: An analysis of two early stage collaborative R&D projects each year which are expected to have major public interest in order to measure the value of work in progress and the private and public opportunities early stage research creates	**Early Stage Projects:** Two early stage projects have been assessed: • EnviroVeg • Beans These projects are expected to produce a positive return on investment given the current assumptions and outcomes but are also expected to develop significantly over the coming years. It is recommended that both be included in subsequent reviews as a means of assessing their future progress

Source: AEC*group*

Appendix C: Consultation Outcomes

Responses ranged according to the background of the stakeholder, however, common responses emerged for the three principle stakeholder groups and these are summarised below:

Growers

- The industry development officer (IDO) network was essential to the extension of R&D findings;
- Without the minor use chemical registration scheme several commodities would no longer be in commercial production in Australia;
- Integrated pest management work is already providing benefits to growers (reduced losses and greater reduced insecticide resistance) and to the public (reduced applications of broad spectrum insecticides) and is essential to the long-term sustainability (economic and environmental) of the vegetable industry;
- In some cases, relatively small amounts of HAL funding have had a significant impact on individual growers for example, one grower had introduced a new product line following a HAL funded grower trip to Holland, the new line was now one of their most successful products;
- Some growers felt there was a disconnect between grower needs and the projects that were approved by the Industry Advisory Committee;
- Some research findings failed to reach growers and in some instances when findings did reach growers they were difficult to understand especially in terms of practical application, which highlights the need for clear and effective extension of research findings to ensure their "potential" benefits are adopted and "realised"; and
- Growers felt the most successful projects were clustered around a relatively small number of key topics. Most growers were able to provide details of groups of projects they felt had produced particularly good outcomes but few were able to nominate specific projects or to quantify the benefits they had received from adopting R&D findings.

Researchers

- R&D in general, and in the vegetable sector in particular can take a long-time to produce a quantifiable benefit and when a benefit becomes apparent it may be the cumulative result of several years of previous studies. There is a lack of understanding surrounding the R&D process and why in some instances it takes significant time and investment to attain results;
- There can be difficulties in gaining funding for ongoing or follow up work (especially ensuring continuity of funding for projects running over a significant period of time); and
- In some instances, there can be difficulties in gaining funding for the education and extension aspects of some projects.

Other Stakeholders

- Anecdotally there is a good story to be told about the positive impacts of R&D expenditure;
- Growers often incorrectly apportion the benefits from HAL funded R&D to other groups (including agricultural consultants and seed/fertilizer companies). There may be an issue about the promotion and branding of HAL work; and
- Some work does not lend itself to assessment and/or might only become evident over the medium-long term for example the benefits of the Industry Development Officer network.

Appendix D: CBA and Qualitative Assessment Methodologies

Because costs and benefits are specified over time it is necessary to reduce the stream of benefits and costs to present values. The present value concept is based on the time value of money – the idea that a dollar received today is worth more than a dollar to be received in the future. The present value of a cash flow is the value today that is equivalent to a cash flow in the future. The time value of money is determined by the given discount rate to enable the comparison of options by a common measure.

The selection of appropriate discount rates is of particular importance because they apply to much of the decision criteria and consequently the interpretation of results. In this case, the appropriate discount rate is set by the CRRDC as the long term bond rate plus three percent. The higher the discount rate, the less weight or importance is placed on future cash flows.

The formula for determining the present value is:

$$PV = \frac{FV_n}{(1+r)^n}$$

Where:

PV = present value today, FV = future value n periods from now, r = discount rate per period, n = number of periods.

Extending this to a series of cash flows the present value is calculated as:

$$PV = \frac{FV_1}{(1+r)^1} + \frac{FV_2}{(1+r)^2} + \cdots + \frac{FV_n}{(1+r)^n}$$

Once the stream of costs and benefits have been reduced to their present values the Net Present Value (NPV) can be calculated as the difference between the present value of benefits and present value of costs. If the present value of benefits is greater than the present value of costs then the option or project would have a net economic benefit.

Because the NPV can result from the combination of any magnitude of benefits and costs it is not all that useful when comparing projects. A useful measure to use to compare between two different projects is the benefit cost ratio (BCR). The BCR is calculated by dividing the present value of benefits by the present value of costs. If the resulting BCR is greater than one (1) then the project has a net economic benefit. The higher the BCR the greater the quantified economic benefits compared to the quantified economic losses.

The first step in applying a qualitative risk assessment framework is identifying the possible impacts (cost or benefit), followed by an assessment of the likelihood of the impact occurring and the anticipated consequences of the impact should it occur (Table AP. D. and Table AP. D.). Once complete, the combination of the likelihood and consequence of each impact identifies the associated risk and impact level (Table AP. D.). Descriptions of each of the assigned risk levels are discussed following the risk assessment table.

Table AP. D.1.Qualitative Measure of Likelihood

Level	Descriptor	Description
1	Almost certain	It is expected to occur in most circumstances
2	Likely	It will probably occur in most circumstances
3	Possible	Might occur at some time
4	Unlikely	Could occur but not expected
5	Rare	May only occur in very exceptional circumstances
6	Remote	Never heard of, but not impossible

Source: Modified from Crawford (2003) and Fletcher et al. (2004)

Table AP. D.2. Qualitative Measure of Consequence

Level	Descriptor	Description: Benefits	Description: Costs
1	Negligible	Very insignificant impacts. Unlikely to be measurable against benchmarks.	Very insignificant impacts. Unlikely to be measurable against benchmarks.
2	Minor	Possibly detectable impacts but minimal changes to the established structure and function. The impact and its magnitude are small relative to the wider context of the population/area being impacted. Benefits maintained over the short term without extended management and/ or works	Possibly detectable impacts but minimal changes to the established structure and function. The impact and its magnitude are small relative to the wider context of the population/area being impacted. Return to pre impact levels achievable and expected to occur over the short term once management initiatives are implemented.
3	Moderate	Detectable impacts, characterised by significant changes in structure, composition and function. The benefit is maintained over the medium term with minimal management and/or works.	Detectable impacts, characterised by significant changes in structure, composition and function. Recovery from impacts is achievable over the medium term once management initiatives are implemented.
4	Major/ Severe	Wider and longer term impacts occurring and likely to result in a highly changed structure, composition and function. The benefit is maintained over the longer term with minimal management and/or works.	Wider and longer term impacts occurring and likely to result in a highly changed structure, composition and function. Recovery from impacts possible with sustained effort over the long term.
5	Outstanding/ Catastrophic	Wider and longer term impacts occurring and likely to result in a highly changed structure, composition and function. The benefit is maintained over the longer term without management and/or works.	Wider and longer term impacts occurring and likely to result in a highly changed structure, composition and function. Return to pre impact levels unlikely to occur even with mitigation and intervention.

Source: Modified from Crawford (2003) and Fletcher et al. (2004)

Table AP. D.3. Qualitative Impact Assessment Matrix

Likelihood	Consequence				
	Negligible	Minor	Moderate	Major/Severe	Outstanding/ Catastrophic
Remote	Very Low	Very Low	Very Low	Low	Medium
Rare	Very Low	Very Low	Low	Medium	Medium
Unlikely	Very Low	Low	Low	Medium	High
Possible	Very Low	Low	Medium	High	High
Likely	Low	Medium	Medium	High	Very High
Almost certain	Low	Medium	High	Very High	Very High

Source: Modified from Crawford (2003) and Fletcher et al. (2004)

Appendix E: Environmental Impact Quotient

While a great deal of research has been undertaken to assess the impact of chemical application at an industry wide scale (for example the impact of chemical use in the entire agriculture sector) or in a specific crops (for example the impact of chemicals in grain production) however, research failed to identify a relevant study which had been produced for chemicals applied to vegetables (or other similar commodities) in Australia.

However, a recent study has undertaken a review of the external costs of individual pesticide applications. Leach and Mumford (2008) have developed an accounting method which places an economic value across a range of effects of different pesticide applications on a per hectare per application basis. The costs are broken down across eight categories. The original values were produced in 2006 in Euro currency and compared the externalities across UK, USA and Germany as well as Spain Israel and Turkey. These figures have been inflated to Australian $2008 terms using the 2006 exchange rate of AUD 0.61/ Euro, and an inflation multiplier for 2006 to 2008 of 0.11 (Reserve Bank of Australia, 2008a and 2008b).

The data produced average external costs for 14 commonly used pesticides in the UK, USA and Germany as well as adjusted figures for Spain, Israel and Turkey which were adjusted to reflect the lower impact costs in those countries and a higher proportion of agricultural employment relative to the base case. A similar technique is used to rate the toxicity of insecticides in the preparation of minor use chemical application submissions for the Australian Pesticide and Veterinary Medicine Association.

Table AP.E.1 shows the 2006 data in AUD $2008 terms using the average inflation and exchange rate over the same period.

Table AP. E.1. Comparison of External Costs of Pesticide Application (AUD$2008)

Chemical Name	Application	UK, USA & Germany	Spain	Israel	Turkey
Spinosad	Bait	$0.00	$0.00	$0.00	$0.00
Malthion	Bait	$0.05	$0.05	$0.04	$0.02
Deltamethrin	Cover	$0.15	$0.15	$0.09	$0.04
Fluvalinate	Cover	$0.33	$0.29	$0.20	$0.11
Spinosad	Cover	$1.39	$1.28	$0.84	$0.42
Trichlorfon	Bait	$2.77	$2.43	$1.61	$0.77
Fenthion	Cover	$11.36	$12.26	$7.79	$5.05
Malathion	Cover	$12.13	$11.22	$7.35	$3.85
Dimethoate	Cover	$22.09	$23.31	$14.87	$9.39
Chloropyriphos	Cover	$22.53	$19.59	$12.99	$6.09
Trichlorfon	Cover	$23.60	$20.61	$13.64	$6.48
Fenitrothion	Cover	$25.61	$25.74	$16.56	$9.81
Mthidathion	Cover	$25.94	$27.91	$17.75	$11.47
Phosmet	Cover	$26.83	$24.61	$16.13	$8.32

Source: Leach & Mumford (2008)

The authors drew upon previous work including that of Pretty *et al*. to develop a means of applying the costs to different parties. The distribution for the highest (Phosmet - a broad spectrum organophosphate) and lowest external cost (Spinosad – one of the newer ‘narrow spectrum’ insecticides which cause fewer ‘off-target’ impacts) is shown in the following table. The average distribution has been used throughout the project to allocate benefits associated with reduced insecticide usage between growers and the public.

Table AP. E.2. Distribution of External Costs Spinosad and Phosmet

Distribution of Costs	Phosmet	%	Spinosad	%	Average	
Applicator effects	$2.12	7.9%	$0.11	7.9%	$1.11	7.9%
Picker effects	$1.50	5.6%	$0.07	5.3%	$0.78	5.6%
Consumer effects	$9.81	36.6%	$0.51	36.8%	$5.16	36.6%
Ground water effects	$2.35	8.8%	$0.24	17.1%	$1.30	9.2%
Aquatic effects	$5.44	20.3%	$0.27	19.7%	$2.85	20.2%
Bird effects	$2.04	7.6%	$0.05	3.9%	$1.05	7.4%
Bee effects	$1.51	5.6%	$0.07	5.3%	$0.79	5.6%
Beneficial insect effects	$2.04	7.6%	$0.05	3.9%	$1.05	7.4%
Total	$26.83	100.0%	$1.39	100.0%	$14.10	100.0%

Notes: Totals may not sum due to rounding
Source: Leach & Mumford (2008)

In the following cost benefit analyses, the average external cost of using Spinosad (cover application) in the UK, USA and Germany has been used a as proxy for the externalities associated with newer chemistry, while Dimethoate has been used as a proxy for older broad spectrum insecticides. Although there are potential differences in externalities between countries it is likely that the developed nations like Australia, the UK, USA and Germany have similar cost factors. The choice of Dimethoate is considered conservative as it has the lowest externalities of the older style chemicals, many chemicals with higher externalities are still widely in use in the vegetable growing sector.

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