Program evaluation for Processed Potatoes

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HAL

Know-how for Horticulture™

ECONOMIC ASSESSMENT OF
HAL INVESTMENT IN SIX PROJECT CLUSTERS
FOR THE PROCESSED AND FRESH POTATO INDUSTRIES
(PT08045 & PT08050)

Final Report

To
Horticulture Australia

29 October 2009

by

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HAL Project No. PT08045 & PT08050

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Purpose of report: To undertake benefit-cost analyses of randomly selected clusters of investment funded by the Potato Industry Research and Development Program. The analyses follow the guidelines provided by the Council of the Rural Research and Development Corporations Chairs (CRRDCC) so that they are able to report on a whole of Corporations basis to the Australian Government.

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Media Summary

Economic analyses of six clusters of randomly selected research and development investments funded by the Processing and Fresh Potato R&D Program of Horticulture Australia have been undertaken. The Program is funded by statutory levies and voluntary contribution paid by industry participants, with matching funding provided by the Australian Government up to 0.5 per cent of the industry's gross value of production.

The principal purpose of the economic analyses was to contribute to a process being undertaken for the Council of Rural Research & Development Corporation Chairs (CRRDCC) that aims to demonstrate through examples the outcomes and benefits that have emerged or are likely to emerge from the 15 Rural Research and Development Corporations (RDCs). Valuation of these benefits, along with identification of investment expenditure, is required in order to demonstrate their contribution to Australian rural industry as well as environmental and social benefits to Australia.

Each of the analyses provides a description of the constituent project backgrounds, objectives, activities, costs, outputs, outcomes, and benefits. The benefits were described in a triple bottom line context. Some of the potential benefits were then valued in monetary terms. Analyses were undertaken for total benefits that included future expected benefits. A degree of conservatism was used when finalising assumptions.

The six investment analyses all yielded positive results at the 5% discount rate, with B/C Ratios ranging from 3.5:1 to 10.0:1. Care should be taken in any comparisons of the results between clusters due to the different frameworks used for each analysis and the uncertainties involved in each set of assumptions.

Technical Summary

This report presents the results of economic analyses of investments within the Processing and Fresh Potato R&D Program of Horticulture Australia. The Program is funded by statutory levies and voluntary contribution paid by industry participants, with matching funding provided by the Australian Government up to 0.5 per cent of the industry's gross value of production.

The principal purpose of the economic analyses was to contribute to a process being undertaken for the Council of Rural Research & Development Corporation Chairs (CRRDCC) that aims to demonstrate through examples the outcomes and benefits that have emerged or are likely to emerge from the 15 Rural Research and Development Corporations (RDCs). Valuation of these benefits, along with identification of investment expenditure, is required in order to demonstrate their contribution to Australian rural industry as well as environmental and social benefits to Australia.

Cluster selection satisfied the random selection process of the CRRDCC. This entailed the definition of the population of projects in the program, clustering projects into groups, and a process of random sampling of the clusters so defined.

Information from the original project proposals in each cluster, milestone reports, and other relevant reports were assembled with assistance from Horticulture Australia. Discussions were held with Program Managers or Principal Investigators for each research area as well as horticulture industry personnel as appropriate.

Each of the analyses provides a description of the constituent project backgrounds, objectives, activities, costs, outputs, outcomes, and benefits. The benefits were described in a triple bottom line context. Some of the potential benefits were then valued in monetary terms.

The Present Value of Benefits (PVB) and Present Value of Costs (PVC) were used to estimate investment criteria of Net Present Value (NPV), Benefit-Cost Ratio (B/C Ratio) and Internal Rate of Return (IRR) at a discount rate of 5%. The PVB and PVC are the sums of the discounted streams of benefits and costs. The discounting is used to allow for the time value of money.

Analyses were undertaken for total benefits that included future expected benefits. A degree of conservatism was used when finalising assumptions.

Sensitivity analyses were undertaken in most cases for those variables where there was greatest uncertainty or for those that were thought to be key drivers of the investment criteria. The sensitivity analyses were conducted for the 5% discount rate.

Some identified benefits were not quantified mainly due to:

- A suspected, weak or uncertain scientific or causal relationship between the research investment and the actual R&D outcomes and associated benefits
- The magnitude of the value of the benefit was thought to be only minor

Table 1 presents the investment criteria for each of the six clusters analysed at a 5% discount rate and expressed in 2008/09 dollar terms.

Given the assumptions made for each evaluation, all cluster investments appear to have produced positive net benefits.

Table 1: Investment Criteria for Six Potato Industry Investments
(discount rate = 5%)

Investment Cluster	**PVB ($m)**	**PVC ($m)**	**NPV ($m)**	**B/C Ratio**	**IRR (%)**
Seed Production and Seed Quality (13 projects)	10.1	2.0	8.1	5.1	16
Processor – disease – soil amendments (1 subprogram)	16.0	3.2	12.8	5.0	16
Processor – DNA monitoring tools (1 subprogram)	10.1	1.6	8.5	6.5	17
Agronomy and Production Management (16 projects)	16.6	2.3	14.3	7.2	12
Environment and Health (4 projects)	3.0	0.8	2.2	3.5	7
Extension (8 projects)	15.4	1.5	13.9	10.0	18

1. Introduction

Horticulture Australia Limited (HAL) required cost-benefit analyses to be undertaken on a number of their past research investments in the processed and fresh potato industries. The Program is funded by statutory levies paid by industry participants, with matching funding provided by the Australian Government up to 0.5 per cent of the industry's gross value of production.

The principal purpose of the economic analyses was to contribute to a process being undertaken for the Council of Rural Research & Development Corporation Chairs (CRRDCC) that aims to demonstrate through examples the outcomes and benefits that have emerged or are likely to emerge from the 15 Rural Research and Development Corporations (RDCs). Valuation of these benefits, along with identification of investment expenditure, is required in order to demonstrate their contribution to Australian rural industry as well as environmental and social benefits to Australia.

Cluster selection satisfied the random selection process of the CRRDCC. This entailed the definition of the population of projects in the program, clustering projects into groups, and a process of random sampling of the clusters so defined.

This analysis evaluates the benefits to be delivered from six clusters of project investments drawn at random across the total HAL potato industry R&D investment.

Assessing the impact of investment in research is important as it can demonstrate to stakeholders that the research is making or is likely to make a difference and is providing benefits to industry, commerce and Australia's economic growth.

One method identified for improving the ability to report on the effectiveness of the research investment is to undertake some formalised investment analyses (cost-benefit analyses) in order to estimate the returns to investment. Such analyses take into account the time differences between when the investment occurs and when benefits accrue.

Section 2 of the report provides a brief summary of the methods used in the analyses. Section 3 reports a summary of the benefits and of the investment criteria estimated for the six clusters. A brief conclusion is provided in Section 4. Appendices 1 to 6 provide the detailed analyses for each of the six clusters.

2. Materials & Methods

2.1 Project Selection

The population of projects was defined as those with a completion date in the period from July 2004 to June 2009. Very small projects (in value terms) were excluded from the population in order to ensure that the random selection did not result in only a small proportion of the portfolio (in value terms) being analysed, if only clusters containing low value projects were selected. The population of projects was listed by descending value, the total value of the population determined, and then the 'bottom 5%' of the projects by value was excluded. This resulted in a total population of 151 projects, which were grouped into 14 clusters. The total value of the projects (HAL and industry funds only) was more than $15 million.

It was determined that six clusters could be analysed given the time and resources available. The six clusters drawn for analysis were:

- Seed Production and Seed Quality (includes 13 projects)
- Processor – Disease – Soil Amendments (includes 1 subprogram)
- Processor – DNA Monitoring Tools (includes 1 subprogram)
- Agronomy and Production Management (includes 16 projects)
- Environment and Health (including 4 projects)
- Extension (including 8 projects)

Together, the investment in these six clusters represented approximately 42% of the total investment in the potato industry R&D over the period.

2.2 Individual Analyses

Each investment was evaluated through the following steps:

1. Information from the original project schedules, and any progress reports or other relevant reports and material was assembled with assistance from Principal Investigators and others.
2. An initial description of the project background, objectives, activities, costs, outputs, and expected outcomes and benefits was drafted. Additional information needs were identified.
3. Telephone contact was made with Program Managers and/or Principal Investigators and the draft sent to that person for perusal and comment, together with specific information requests.
4. Further information was assembled where appropriate from industry and others associated with the industry, and the quantitative analysis undertaken.
5. Some analyses proceeded through several drafts, both internally within the project team as well as externally via Program Managers and others.
6. Final drafts were passed by Program Managers for comment.

The potential benefits from each investment were identified and described in a triple bottom line context. Some of these benefits were then valued.

The factors that drive the investment criteria for R&D include:

C The cost of the R&D.

K The magnitude of the net benefit per unit of production affected; this net benefit per unit also takes into account the costs of implementation.

Q The quantity of production affected by the R&D, in turn a function of the size of the target audience or area, and the level of initial and maximum adoption ultimately expected, and level of adoption in the intervening years.

D The discount rate.

T_1 The time elapsed between the R&D investment and commencement of the accrual of benefits.

T_2 The time taken from first adoption to maximum adoption.

A An attribution factor can apply when the specific project or investment being considered is only one of several pieces of research or activity that have contributed to the outcome being valued.

P Probability of an R&D output, commercialisation etc. occurring. Can be applied when the research is not complete or when some further investment is required before the outputs of the research are translated into adoptable outcomes and extended to the industry.

Defining the 'without R&D' scenario to assist with defining and quantifying benefits is often one of the more difficult assumptions to make in investment analyses. The 'without' scenario (referred to here as counterfactual) usually lies somewhere between the status quo or business as usual case and the more extreme positions that the research would have happened anyway but at a later time; or the benefit would have been delivered anyway through another mechanism. The important issue is that the definition of the counterfactual scenario is made as consistently as possible between analyses.

The Present Value of Benefits (PVB) and Present Value of Costs (PVC) were used to estimate investment criteria of Net Present Value (NPV), Benefit-Cost Ratio (B/C Ratio) and Internal Rate of Return (IRR) at a discount rate of 5%. The PVB and PVC are the sums of the discounted streams of benefits and costs. The discounting is used to allow for the time value of money. All dollar costs and benefits were expressed in 2008/09 dollar terms and discounted to the year 2008/09. All analyses ran for the length of the investment period plus 30 years from the last year of investment to the final year of benefits assumed. Costs for the R&D project included the cash and in-kind contributions, as well as any other resources contributed by third parties (e.g. researchers or industry).

Analyses were undertaken for total benefits that included future expected benefits. A degree of conservatism was used when finalising assumptions.

Sensitivity analyses were undertaken in most cases for those variables where there was greatest uncertainty or for those that were thought to be key drivers of the investment criteria.

Some identified benefits were not quantified mainly due to:

- A suspected, weak or uncertain scientific relationship between the research investment and the actual R&D outcomes and associated benefits.
- The magnitude of the value of the benefit is thought to be only minor.

3. Summary of Results

3.1 Qualitative Results

Table 3.1 identifies the benefits from investment in each of the six clusters. Each benefit is categorised as economic, environmental or social. Not all of the clusters demonstrated benefits from each category.

Table 3.1: Summary of Benefits for Four Clusters

Cluster	Benefits
Seed Production and Seed Quality	Economic • Increased yields of seed potatoes. • Increased quality of seed potatoes, resulting in fewer rejections. • Increased yields and quality of commercial potato crops. • Potential exports of seed potatoes to Sri Lanka. Environmental • Nil. Social • Nil.
Processor – Disease – Soil Amendments	Economic • Reduced rejection of processed potatoes due to quality concerns. • Reduced processing costs and improved product recovery. • Reduced rejection of seed and fresh potatoes due to quality concerns. • Reduced rejection of potatoes due to quality concerns for foreign potato industries who also use the research outputs Environmental • Potentially reduced chemical use and therefore reduced risk to the environment. Social • Improved cooperation in industry, resulting in capacity building of researchers and industry. • Reduced chemical use and therefore reduced risk to human health.
Processor – DNA Monitoring Tools	Economic • Reduced rejection of processed potatoes due to quality concerns. • Reduced rejection of fresh potatoes due to quality concerns. • Reduced rejection of potatoes due to quality concerns for foreign potato industries that also use the research outputs. Environmental • Reduced chemical use and therefore reduced risk to the

	environment. Social • Improved cooperation in industry, resulting in capacity building of researchers and industry. • Reduced chemical use and therefore reduced risk to human health.
Agronomy and Production Management	Economic • Yield improvements seed, fresh and processing sectors. • Export sales. • Possible opportunities for young NZ growers resulting from the strategic alliance project. Environmental • Accelerated phase out of formaldehyde, methyl bromide and more effective biological pesticides. • Less use of 'hard' chemicals with benefits for neighbours, waterways and the broader environment. Social • Social networks and opportunities for young Aust and NZ growers facilitated by the strategic alliances project.
Environmental Management and Health	Economic • Increased potato demand from a Biodegradable Plastics Industry. • Increased Potato Yield and Quality. • Avoided Loss of export sales. Environmental • Nil Social • Control of cadmium in potato tubers inside MPC limits. • Control of cadmium project also included research addressing other Aust root and leaf vegetables. • Risk of cadmium residues in Australian potatoes
Extension	Economic • Increased potato yield, Tasmanian processing potato industry. • Production cost savings. Environmental • Less use of irrigation water, chemical insecticides and chemical fertilisers in the Tasmanian processing potato industry. • Less use of irrigation water and chemicals in the Tasmanian processing potato industry resulting in better environmental outcomes for regional communities. Social • Ongoing viability of the Tasmanian processing potato industry with linked regional employment opportunities. • Ongoing regional employment.

3.2 Quantitative Results

The investment criteria calculated for each research area were the Net Present Value (NPV), the Benefit Cost Ratio (B/C Ratio) and the Internal Rate of Return (IRR). The NPV is the difference between the Present Value of Benefits (PVB) and the Present Value of Costs (PVC). Present values are the sum of discounted streams of benefits and/or costs. The B/C Ratio is the ratio of the PVB to the PVC. The IRR is the discount rate that would equate the PVB and the PVC, thus making the NPV zero and the B/C Ratio 1:1.

Table 3.2 presents the investment criteria for each of the six cluster investments analysed at a 5% discount rate.

Further details on each of these investments and the associated results are provided in the individual cluster reports (Appendices 1 to 6).

Table 3.2: Investment Criteria for Six Potato Industry Cluster Investments
(discount rate = 5%, 30 years)

Investment Cluster	**PVB ($m)**	**PVC ($m)**	**NPV ($m)**	**B/C Ratio**	**IRR (%)**
Seed Production and Seed Quality (13 projects)	10.1	2.0	8.1	5.1	16
Processor – disease – soil amendments (1 subprogram)	16.0	3.2	12.8	5.0	16
Processor – DNA monitoring tools (1 subprogram)	10.1	1.6	8.5	6.5	17
Agronomy and Production Management (16 projects)	16.6	2.3	14.3	7.2	12
Environment and Health (4 projects)	3.0	0.8	2.2	3.5	7
Extension (8 projects)	15.4	1.5	13.9	10.0	18

4. Conclusions

The six investment analyses all yielded positive results at the 5% discount rate, with B/C Ratios ranging from 3.5 to 10.0. Care should be taken in any comparisons of the results between clusters due to the different frameworks used for each analysis and the uncertainties involved in each set of assumptions.

The results produced are only as credible as the assumptions made, so that refinement of assumptions and frameworks is where any future focus would be most valuable.

APPENDIX 1: An Economic Analysis of HAL Investment in Projects in the Seed Production and Seed Quality Cluster (Potato Program)

1. Background

In 2006 Australian potato production totalled 1,255,463 tonnes and the area planted was 35,485 hectares, with the average yield per hectare of 35.4 tonnes. The gross value of potatoes grown in Australia in 2006 was $465.1 million. Potato production area in Australia has declined over time, but yields have been rising for the past decade. The national potato crop is mostly grown in Victoria (22%), South Australia (31%) and Tasmania (23%).

Fifty-six percent of Australian potato production is sold for processing (42% frozen, 14% crisping). Processed frozen potatoes are sold primarily as frozen chips, and other varieties such as potato gems. Processed crops are sold as potato chips. The remainder of potato production is for the fresh market.

The seed potatoes segment of the industry supports the other three segments (fresh, processed frozen, processed crisps) and makes up approximately 10% of total production. Commercial potato growers require vigorous high yielding tubers that are true to type and are disease free (or meet minimum disease presence requirements). An example of how the seed potato industry operates is provided by the Victorian Certified Seed Potato Authority (ViCSPA). Laboratories accredited by ViCSPA produce plantlets, microtubers, or mini tubers for all Australian Certified seed schemes. These are known as G0 stock. The G0 stock is then planted out by ViCSPA member growers in the field. This then becomes the G1 crop. The tubers harvested from the G1 crop are then planted into a larger field the following year, and become the G2 crop. This process can be repeated up until the G5 crop (fifth year). Produce from generations G1 to G5 may all be sold as Certified seed (once graded, inspected and labelled). Generally, seed growers produce more than one generation (up to 5) in order to provide greater returns from the high value G0 tubers.

The quality of the seed potatoes sold to commercial potato growers (both fresh and processed potatoes) also has an impact on the subsequent yield and quality of the commercial crops. Factors affecting the quality of the seed potatoes sold include the age of the seed potato tuber, the levels of disease present on the seed potatoes, the conditions in which they are kept during packing and storage, and correct labelling to ensure seeds are ‘true to type’.

2. The Cluster

Projects

Table 1 presents the details for each of the 13 projects included in the seed production and seed quality cluster.

Table 1: Summary of Project Details

Project Number	Project Title	Other Details
PT99052	Potato tuber quality management in relation to environmental and nutritional stress	Organisation: Department of Employment, Economic Development & Innovation (QPI&F) Period: January 2000 to April 2004 Principal Investigator: Stephen Harper
PT01030	Seed potato handling and storage – implementing best practice	Organisation: Serve-Ag Pty Ltd Period: March 2002 to July 2004 Principal Investigator: Doris Blaesing
PT01032	Breeding Australia's potato germplasm: the resource for varietal development	Organisation: Vic DPI Period: July 2001 to January 2004 Principal Investigator: Roger Kirkham
PT02017	Effects of potato seed characteristics on seed-piece breakdown and poor emergence	Organisation: Serve-Ag Pty Ltd Period: July 2002 to September 2004 Principal Investigator: Hoong Pung
PT02022	Crop management service development for seed potato production in Tasmania	Organisation: Simplot Australia Pty Ltd – Tasmania Period: October 2002 to July 2005 Principal Investigator: Mark Heap
PT02035	Maintenance and refreshment of the certified seed public variety potato	Organisation: Victorian Certified Seed Authority Inc Period: August 2002 to June 2005 Principal Investigator: Keith Blackmore
PT02046	Identifying seed potato production variability using precision farming techniques	Organisation: Gunning Rural Supplies Period: July 2002 to February 2004 Principal Investigator: Peter Baines
PT03064	Support for seed potatoes sales to Sri Lanka: determining constraints to production	Organisation: Department of Agriculture Western Australia Period: July 2004 to August 2005 Principal Investigator: Peter Dawson
PT03069	Management strategy for elimination of viruses from certified seed potatoes	Organisation: University of Tasmania Period: February 2004 to March 2005 Principal Investigator: Frank Hay
PT04013	Seed Potato Certification Workshop 2004	Organisation: Victorian Certified Seed Potato Authority Inc Period: July 2004 to January 2005 Principal Investigator: Keith Blackmore

PT06011	Increasing G1 potato seed yields	Organisation: University of Tasmania Period: November 2006 to May 2009 Principal Investigator: Philip Brown
PT06030	Certified Seed Potatoes – Certification Officers Training Workshop	Organisation: Victorian Certified Seed Potato Authority Inc (ViCSPA) Period: August 2006 to March 2007 Principal Investigator: Keith Blackmore
PT06041	Virus monitoring of ViCSPA Seed Plots 2	Organisation: Victorian Certified Seed Potato Authority Inc (ViCSPA) Period: April 2007 to September 2007 Principal Investigator: Keith Blackmore

Project Objectives

Table 2 presents the objectives for each of the projects included in the cluster.

Table 2: Description of Project Objectives

Project Number	Objectives
PT99052: Tuber quality (brown fleck)	• Development and publishing of criteria for conditions favourable for internal tuber disorders. • Presentation to industry of management strategies aimed at eliminating or minimising internal tuber disorders. • Evaluate the effects of nutrition, irrigation and other management strategies (e.g. in crop mulching and green top removal) on incidence of internal disorders. • Allow growers to reliably increase yield of consistent quality potatoes free of major defects. • Educational workshops on management of internal tuber defects. • Conduct technology transfer trials to extend new management practices for internal tuber defects. • Screen new potato cultivars for resistance to internal disorders.
PT01030: Handling and storage	• Collate national and international information on desirable seed potato handling and storage conditions and 'deviation risks'. • Develop and launch a Seed Potato Storage and Handling Manual and a Technical Information Guide, which document handling, storage, monitoring and recording procedures and describe the impact of particular conditions on seed health and quality. • Develop and implement a training program that facilitates the adoption of best practice seed potato handling and storage.
PT01032: Germplasm development	• Develop potato germplasm adapted to Australian conditions and markets which will underpin the long term competitiveness of the industry. • Maximise adoption of the cultivars and technology developed throughout the program and encourage investment by other sectors.

PT02017: Seed-piece breakdown and poor emergence	• Investigate the potentials of specific gravity, nutrient analysis and rate of wound healing as indicators of seed quality and performance.
PT02022: Crop management service	• Provide a crop management service to seed potato growers in Tasmania that is modelled on a successful service provided to French fry potato growers in South Eastern Australia.
PT02035: Maintenance of certified seed public varieties	• Maintenance of the certified seed public variety in-vitro collection. • Refreshment of the certified seed public variety in-vitro collection. • Increased capacity building through overseas travel by the principal investigator to Centres of Excellence in the diagnosis of potato diseases.
PT02046: Precision farming	• Identify soil variation on seed potato production properties to focus on micro-nutrient deficiencies leading to variability of plant performance. • Identify soil variability using precision farming technology. • Confirm soil and plant growth variability with on ground crop monitoring.
PT03064: Exports to Sri Lanka	• Identify agronomic practices that will maximise yield and quality of Australian seed potatoes in Sri Lanka.
PT03069: Elimination of viruses	• Develop a management strategy to eliminate Potato Virus S (PVS) and Potato Virus X (PVX) in seed potato in Tasmania. • Define the extent of the virus problem (already completed as part of PT02037). • Determine the rate of virus spread, the means by which viruses are spread and identify the sources of inoculums. • Use this information to design and implement a cost-effective management strategy. • Monitor the effectiveness of the management strategy with limited surveys.
PT04013: Certification workshop	• Provide courses that update the existing skills of current staff and provide less experienced staff with the knowledge and skills needed for the duties. • Topics to be covered include: National Standards for Certified Seed Potatoes; tuber inspection methods; field inspection methods, production of G0 produce; specialist lectures from scientists on targeted diseases; practical field inspection methods; practical tuber inspection methods; identification of potato varieties.
PT06011: Increasing G1 potato seed yields	• Identify key agronomic practices that can be used by seed potato producers to increase seed tuber number and uniformity produced from minitubers.
PT06030: Certification workshop	• To deliver workshops that assist in the uniform implementation of the National Standards for Certified seed potatoes as well as focusing on variety identification skills and disease identification skills. • To bring together people involved in field inspection of certified seed crops

	from all Australian certified seed schemes and/or seed potato growers or industry professionals. • To improve knowledge of and ability to identify potato varieties in the field. • To review best practice methodology for inspection of certified seed crops. • To improve knowledge of the identification of plant diseases. • To further the implementation of the national standards. • To improve knowledge of and methodology of conducting tuber quality assessments.
PT06041: Virus monitoring	• To identify seed lots with virus problems and prevent them being submitted for certification. • To further improve the consistency of quality of ViCSPA certified seed for Australian potato growers. • To monitor the levels of all viruses in the seed plots. If problems are identified then ViCSPA will need to put into place appropriate strategies to minimise those problems. • To improve the seed growers' hygiene practices by highlighting how easily virus can spread. • Reduce virus levels in all potato crops.

Project Investment

Table 3 shows the annual investment by project for HAL; this funding includes any voluntary contributions made by industry. As most projects in this cluster were managed by industry groups or consultants, there were no outside resource contributions.

Table 3: Investment by Project by HAL Including Both Levy and Voluntary Contributions

Project Number	**Year ending June**									
	2000	2001	2002	2003	2004	2005	2006	2007	2008	Total
PT99052	27,590	43,494	47,910	43,734	26,222	0	0	0	0	188,950
PT01030	0	0	30,000	24,500	4,500	3,000	0	0	0	62,000
PT01032	0	0	202,671	210,711	19,507	0	0	0	0	432,889
PT02017	0	0	0	70,000	0	15,000	0	0	0	85,000
PT02022	0	0	0	66,450	83,350	93,650	0	0	0	243,450
PT02035	0	0	0	35,670	18,592	19,150	0	0	0	73,412
PT02046	0	0	0	15,719	0	0	0	0	0	15,719
PT03064	0	0	0	0	18,182	15,000	0	0	0	33,182
PT03069	0	0	0	0	10,455	10,455	0	0	0	20,910
PT04013	0	0	0	0	0	12,825	0	0	0	12,825
PT06011	0	0	0	0	0	0	0	29574	29575	59,149
PT06030	0	0	0	0	0	0	0	17835	0	17,835
PT06041	0	0	0	0	0	0	0	38500	10000	48,500
Total	27,590	43,494	280,581	466,784	180,808	169,080	0	85,909	39,575	1,293,821

3. Activities and Outputs

Summary of Outputs

Table 4 provides a brief summary of the activities and outputs for each of the projects.

Table 4: Summary of Cluster Activities and Outputs

Project	Activities and Outputs
PT99052: Tuber quality (brown fleck)	• Incidence and development of Brown Fleck (BF) symptoms appear to be two separate processes. • Initiation of BF relates to the death of specific sugar conducting cells in the tuber and as a consequence further severe cellular disruption occurs. • There is a strong relationship between crops having high yield potential and high BF incidence, hence factors that favour rapid tuber growth also favour high BF incidence. • BF incidence was increased specifically by elevated night temperature and vigorous crop foliage growth. High soil temperature enhanced symptom development. • To minimise incidence of BF growers should prevent prolific canopy development through avoiding excessive nutrient application and irrigation. • Early monitoring of tubers for BF incidence can form the basis for determining whether preventative measures are required. • Short-term weather outlooks can be used as a tool to determine whether imminent weather conditions are favourable for rapid tuber growth. • Management of crop foliage can be achieved through spraying defoliants or agents that might harden the crop up including copper or calcium. • The maintenance of weed or vegetative cover at crop senescence should be encouraged to provide shade to soil and prevent excessive soil temperatures. • The application of calcium or boron did not significantly or reliably reduce incidence of BF. • The cause of the initial cell death requires further research, as does the potential of different defoliants or retardants and their rates and timing of application. • Technology transfer presentations were made to grower groups in Gatton, Atherton, Bundaberg and to Qld and NSW crisping growers. • Articles on the research findings were published in Potato Australia in 2001, 2002 and 2003.

	• A poster presentation of results was made at the UQ Gatton Horticulture Expo field day in 2002. • A Queensland Government DPI&F Farmnote was prepared and made available on the website.
PT01030: Handling and storage	• A survey of current Australian practices with respect to potato seed handling and storage management was undertaken. Seed potato storage operations and persons associated with the seed potato industry (processing and ware potato growers, consultants, IDO's, processors) in Victoria, Tasmania, NSW, SA and WA were surveyed. • An understanding was provided of the variability of seed potato handling chains from seed potato paddock, through handling, transport and storage steps to the next seed or commercial paddock. • International information was also reviewed with regards to storage and handling practices. • A manual for potato seed handling and storage management was prepared, including handling, hygiene and disease prevention information. • The guidelines and references in the manual cover the following operational steps: harvest, holding in the paddock, transport and intake, curing, storage, grading, cutting and seed transport from store to commercial or seed grower. • The manual uses brief checklists to highlight the most important considerations for each step and operator, as well as self-assessment tables to allow operators to prioritise areas of improvement in their part of the chain. • Further references, diagrams, photos, assessment sheets, a glossary, a troubleshooting guide and a list of reading material are also included in the manual.
PT01032: Germplasm development	• Screening trials were carried out on new potato lines produced by the National Potato Improvement program from crosses made in 2000. • No new French Fry lines were identified that could significantly outperform the existing Russet Burbank variety for processing yield grade. However one variety showed considerable potential and three lines were considered worthy of further evaluation by industry. • For the fresh market five new white skin lines and one new red skin line were identified with considerable potential for the washed market sector. These will be considered by industry for further evaluation in production districts across Australia. • For the crisping sector nine lines were identified with considerable potential. • Further evaluation on the identified lines will be carried out to

	determine their suitability for the three main market segments and a diverse range of regional production environments throughout the year. • One of the aims of the screening was to identify varieties suited to the different diverse production regions, in order to achieve a national year round supply which satisfies market specifications.
PT02017: Seed-piece breakdown and poor emergence	• A feasibility study was conducted to investigate the potential of a range of seed values that may be useful indicators of potato seed quality and performance. • The values examined were specific gravity, seed and tissue firmness, wound-healing, nutrient elements in sap and dry tissue from tuber seeds, susceptibility to dry rot, sprouting capacity, and field performance in a replicated field trial. • Several novel methods for determining seed values that have potential as seed quality indicators were identified. The methods are wound healing, seed-piece breakdown, assessing cut seed susceptibility to dry rot, seed and tissue firmness, the nutrient elements in sap and dry tissue of tuber seeds. The methods developed are readily available and relatively cheap, rapid and simple to carry out. • The seed values that showed the greatest potential as quality indicators are susceptibility to dry rot, seed firmness, manganese, nitrate, phosphorous and magnesium in sap of tuber seeds, and manganese and nitrogen in dry tissue of tuber seeds. • It was recommended that further investigations be carried out over several years to determine the potential of the seed quality indicators identified with respect to their consistency and reliability.
PT02022: Crop management service	• A crop management program called SMS was developed aimed at assisting Tasmanian seed growers adopt new technologies. The program is based on a model that had been successfully delivered to French fry potato growers in southeastern Australia. • The program has four core modules including Plant Nutrition Strategy; Pest and Disease Management; Irrigation Scheduling; and Pre-Plant Planning. • A steering committee was established to oversee the general direction of the service development and setting priorities for the future. • The program provides a complete crop management service that is tailored to the specific needs of seed potato production for each individual grower. • The service has an ongoing process of identification, development and adoption of new technology. • The program includes regular and constant contact with growers, as well as several workshops throughout the year to discuss SMS

	technology and data. All growers also receive detailed reports for each crop, in each year and one-on-one meetings were held annually with an agronomist to discuss the implications of the crop report.
	• A database of grower data was maintained and has provided several significant technical insights including:
	  o A large influence of seed crop planting date on the rejection rate for certification
	  o Rates of applied fertiliser were not well correlated with nutrient levels in tissue analysis and poorly correlated with yield
	  o Heavy rates of fertiliser were more likely to result in tuber defects, such as increased hollow heart
	  o Soil trace element status was related to disease incidence in vines and tubers

PT02035: Maintenance of certified seed public varieties	• All Australian potato businesses will have access to the collection of cultures that the 9 ViCSPA accredited laboratories use to produce G0 (minitubers, plantlets or microtubers) for Certified seed schemes in WA, SA, Tas, NSW and Vic. They will have access to this even if they don't purchase certified seed directly. • Previously the cost of maintaining this collection was on ViCSPA members, and it will now be supported by growers Australia wide. • All batches will be checked for trueness to type to provide additional assurance to growers that stocks have been correctly labelled and not mixed, as well as minimise the risk of off types and mutations. • The in-vitro collection will be regularly refreshed to ensure confidence that it contains vigorous true to type culture of each variety. • Up to date information on the diagnosis and control of potato viruses will be gained from the overseas trip of the researcher.
PT02046: Precision farming	• No evidence was found of micro nutrient deficiencies from the targeted tissue and soil testing results. • It was concluded that precision farming in the potato industry will require several years of investigation to fully evaluate its potential, however initial results were positive. • An agronomy package was developed based on results from the 2003 season and was made available to all growers. • It was found that there was an opportunity to increase irrigation efficiency on different soil types to produce uniform whole round potatoes, through targeted soil moisture monitoring.
PT03064: Exports to Sri Lanka	• Agronomic conditions and practices in a number of crops were surveyed to identify which factors could be used to maximise yield and quality of Sri Lankan potatoes. Key factors found that might improve yield included:

	◦ Management of micronutrients (such as copper, zinc and possibly iron and manganese) to avoid excess application. ◦ Farmers capacity to identify pest and diseases. ◦ Time of planting. ◦ Improved management of disease such as late blight. • The survey showed that yield could be increased to at least twice the national average by improved agronomic practices in each growing region (26 t/ha up from 13 t/ha). A longer term goal is to improve yields to 40 t/ha. • Recommendations were made for future R&D in Sri Lanka including: ◦ Investigate methods to reduce excess use of trace elements such as copper and zinc. ◦ Investigate the cost benefit of improved irrigation systems. ◦ Develop training courses to enable farmers to improve their pest and disease identification skills. ◦ Further investigate time of planting. ◦ Introduce IPM systems to potato production to delay the onset of strains of late blight resistant to currently used fungicides.
PT03069: Elimination of viruses	• Monitoring of the success of interim management strategies to control Potato viruses S (PVS) and X (PVX) in the Tasmanian seed potato scheme. This was undertaken through testing second field generation (G2) crops. • An audit of seed handling practices was also undertaken to determine how management could be improved. • Research was conducted to identify how the viruses were being transmitted in Tasmania. • The prevalence of PVX was found to be quite low, and it was determined that the virus could be eliminated from the seed scheme in the short term. • PVS was more prevalent and it was thought elimination of this virus would be more difficult to achieve. • Monitoring indicated that only limited spread of PVS and PVX occurred in the field over the season, which suggested that modern agronomic practices that minimise movement of machinery through the crop have been effective at reducing virus spread in the field. • Spatial analysis detected a random pattern of PVS and PVX infection, which was suggestive of planting of infected seed species. Some aggregation of PVS along (but not across rows) was detected suggesting some mechanical spread along rows during the season. • Weed species had previously been implicated as reservoirs of PVS and PVX overseas, however none was detected in weed species

	collected from trial fields in Tasmania. • Aphids were trapped and tested as they can be vectors of PVS, but none were found to be transmitting the virus. • A trial suggested that PVS was spread by seed-cutting, but the extent to which seed cutting contributes to virus incidence in Tasmania was unable to be quantified. • A significant negative correlation was detected between the incidence of PVS in plots of Russet Burbank potatoes and processing yield. On average, plots completely infected with PVS yielded 5.4 t/ha lower than those with no virus.

PT04013: Certification workshop	• This project provided the funding for the fourth annual workshop for Seed Potato Certification officers from around Australia and was carried out by ViCSPA.
	• The workshop was held over five days in December 2004 and 18 officers from five states attended the workshop.
	• The workshop included:
	    o Shared experience from the existing knowledge of those in the group.
	    o Specialist lectures from ViCSPA and DPI.
	    o Variety training plots at Toolangi for use in training for variety identification and to assess skill levels on test plots.
	    o Field visits to look at commercial crops and seed crops.
	    o Competency based assessments of the class-room subjects.

PT06011: Increasing G1 potato seed yields	• Field and glasshouse studies are being carried out to investigate the effects of soil type, irrigation regimes and strategic nutrient application on potato development and tuber formation. • The project is not yet complete, however expected outputs include agronomic information regarding timing of nutrient applications and irrigation regimes to increase uniformity of tubers and final tuber numbers in early generation seed potato crops. • The project will also result in the training of a PhD candidate.

PT06030: Certification workshop	• This project provided the funding for the fifth (now bi-annual) workshop for Seed Potato Certification officers from around Australia and was carried out by ViCSPA.
	• The workshop was held over five days in December 2006 and 12 people from four states attended the workshop.
	• The workshop included:
	    o Shared experience from the existing knowledge of those in the group.
	    o Specialist lectures from ViCSPA and DPI.
	    o Variety training plots at Toolangi for use in training for variety identification and to assess skill levels on test plots.
	    o Field visits to look at commercial crops and seed crops.
	    o Competency based assessments of the class-room subjects.

PT06041:	• An extensive survey was carried out that benchmarked the virus

Virus monitoring	levels of potato seed plots from which Certified generation seed potatoes are grown. The survey was carried out for ViCSPA. Similar surveys have previously been carried out in Tasmania and Western Australia. • ELISA testing of potato tissue was used to identify plants that are virus infected. The survey collected 500 leaves from each seed grower's property from plots used to grow the following year's certified seed potatoes. The samples were tested for the presence of Potato Leaf Roll Virus (PLRV), Tomato Spotted Wilt Virus (TSWV), Potato Virus Y (PVY), Potato Virus S (PVS) and Potato Virus X (PVX). A total of 1,743 samples were tested from more than 34,000 leaves. • No PVX was detected in any sample, PVY was found in 10 samples, PLRV was found in 16 samples, TSWV was found in 103 samples and PVS was found in 273 samples.

4. Outcomes

A brief summary of outcomes by project is provided in Table 5.

Table 5: Summary of Cluster Outcomes

Project	Outcomes
PT99052: Tuber quality (brown fleck)	• The project has resulted in the development of knowledge regarding best practices, which can be converted into guidelines and extended to growers in order to minimise the incidence of brown fleck in potatoes.
PT01030: Handling and storage	• The manual extended to those responsible for transport, handling and storage of seed potatoes and will contribute to improved quality of potatoes through adoption of improved practices
PT01032: Germplasm development	• A final report was produced and it was recommended that the full and summary results of the screening be made available to the industry sectors for consideration of which lines should be taken forward for further field evaluations in various production environments.
PT02017: Seed-piece breakdown and poor emergence	• It was recommended that after further investigations, standard protocols for the test methodology should be established, and tests for seed quality and performance can then be conducted in a consistent manner in different facilities.
PT02022: Crop management service	• For those growers that have participated in the program, mean tuber yield for seed potato did not significantly increase over the three seasons of the project. However, there was also a sharp reduction in the number of growing days for seed crops throughout

	the project driven by the need to improve seed quality and lower rejection rates. Yield could have been expected to be reduced by 15%, however it has been maintained. • The percentage of seed tubers rejected (3 year rolling mean) has reduced from 52% pre-SMS to 27% in the third year of SMS. • The average processing yield (t/ha) using a three year rolling mean has increased from 46.1 in the first year to 48.3 in the third year. • The project has impacted on the attitudes of seed potato growers in Tasmania, with the growers now more active than in the past at pursuing new technology. • Several growers now own and operate electronic soil moisture monitoring equipment and the routine use of soil tests and plant tissue analysis is now widespread.
PT02035: Maintenance of certified seed public varieties	• VicSPA continues to maintain and refresh the certified seed public variety in-vitro collection.
PT02046: Precision farming	• The knowledge developed in the program can be further developed into an agronomy package and delivered to growers for use on farms.
PT03064: Exports to Sri Lanka	• Statistics indicate that there is still limited export of seed potatoes to Sri Lanka.
PT03069: Elimination of viruses	• The Tasmanian industry has put in place management strategies to eliminate PVX and PVS from the seed scheme. • Virus incidence is continuing to be monitored to ensure the success of these strategies. • Tasmanian seed potatoes sent interstate are now laboratory tested for PVS and PVX to ensure crops meet the requirements of the National Standard for Certification of Seed Potato and therefore undergo a higher level of scrutiny than seed in most other states.
PT04013: Certification workshop	• The workshop has assisted in the uniform implementation of the National Standards for Certified seed potatoes, and also built variety identification and disease identification skills. • The aim is to produce uniform quality certified seed for domestic and export markets.
PT06011: Increasing G1 potato seed yields	• Agronico Technology is a partner in the project and will immediately adopt the findings of the project. • It is anticipated that the findings may lead to a 20% increase in the number of seed potatoes per plant in G1 seed crops grown from mini tubers. • New minituber production technologies allow production of higher numbers of clean (G0) tubers for planting out in the first field multiplication (G1 tubers) and has lead to a reduction in the

	number of field generations required for production of seed tubers for sale. However, when minitubers are planted in the field, tuber numbers per plant are typically very low resulting in low yields or the need to use multiple cuts of large tubers for the next field generation – it is this issue that the manipulations researched through this project (irrigation, nutrients) etc is trying to address. • A PhD scientist has been trained, which is a significant outcome due to the low number of skilled young scientists that have been available to support industry development.
PT06030: Certification workshop	• The workshop has assisted in the uniform implementation of the National Standards for Certified seed potatoes, and also has built variety identification and disease identification skills. • The aim is to produce uniform quality certified seed for domestic and export markets. • An evaluation of the workshop was carried out and attendees gave very positive feedback, with no suggestions for changes to the program.
PT06041: Virus monitoring	• Growers with infected seed plots were able to replace the infected seed to ensure healthy certified seed potatoes next season. • The survey aided the development of future industry funded sampling protocols. • The survey assisted with the education of growers in management methods to minimise re-infection of their plots with virus through personal visits, newsletters and district meetings. • ViCSPA will use the survey results to develop future policies for virus monitoring of growers stock. • PVS does not show visual symptoms and is not included in the Certification standard. Growers with PVS infected plots will be advised on methods to minimise future re-infection of their seed stocks.

5. Benefits

The aggregate outcomes of this cluster of projects will contribute to increasing the yield and quality of seed potatoes, as well as the yield and quality of subsequent potato crops (for both fresh and processed markets). Some of the improvements in yield and quality will be as a result of disease prevention, while others will be as a result of improved skill in certification and improved agronomic practices. The potential benefits, including examples, from each of the individual projects, are described below.

PT99052: Tuber quality (brown fleck)

Internal tuber disorder brown fleck (BF) reduces potato growing profitability in problem regions and is a major cause of potato consumer dissatisfaction. The presence of BF and Hollow Heart can prevent growers achieving a retail market specification of a maximum of 2% major defects. A survey of growers affected by these disorders suggests that the price on severely affected commercial crops is downgraded by a minimum of 50%. In a particularly bad year it is estimated that BF and Hollow Heart cost the Qld and NSW potato industry more than $20 million. No disease is involved in the conditions, and since the disorders produce no external symptoms, affected tubers cannot be graded out using conventional grading technology.

This research project has increased knowledge regarding how agronomic practices (including irrigation and nutrient applications) can be manipulated in order to reduce the likelihood and severity of such disorders in crops of seed potatoes. Therefore, it is likely that incidence of brown fleck, and therefore downgrading of crops, has been reduced to some degree.

PT01030: Handling and storage
Seed potato handling and storage practices impact on seed quality, and therefore the performance and yield of commercial potato crops. By improving such practices, it is likely that the yield of commercial potato crops will be increased to some degree.

PT01032: Germplasm development
This project comprises the screening process for the breeding program, but not the breeding program itself. Therefore the major benefit of this investment is ensuring that the varieties meet grower and market demand for seed, fresh and processed potatoes. The ultimate benefits of the project are therefore likely to be increased demand for certified seed potatoes, and fresh and processed potatoes, through the varieties selected for further development better matching market (both consumers and growers of commercial potatoes) demands.

PT02017: Seed-piece breakdown and poor emergence
Seed-piece breakdown and poor and uneven emergence have been issues to some growers. Other characteristics of seed indicate susceptibility to disease etc. Current certification was focusing on visual assessment, and this project has provided skills to allow seed analysis to be based on more detailed analysis. This has the potential to result in improved quality of certified seed supplied to commercial growers, resulting in improved yields of subsequent commercial crops grown using that seed.

PT02022: Crop management service
The Australian French fry potato industry supplies about 600,000 tonnes of tubers worth about $140m to four factories. Two thirds of that volume is produced in Tasmania, and the dominant species used is Russet Burbank. Studies in the USA have demonstrated yield increases of 25 tonnes/ha of USA #1 processing tubers for Russet Burbank crops using physiologically young seed compared with crops grown with old seed. Recent work had indicated that much of the Russet Burbank seed supplied in Tasmania was too old. Also, improved technology for seed potato production could also boost production efficiency and quality of processing potatoes, reducing the chance of crop defects or rejection.

It was also increasingly being recognised that crop management decisions were becoming increasingly complex at the same time as extension services had moved towards mass and group methods, rather than 1:1 consultation with growers. In the years leading up the project around 50% of the planted seed potato crop had been rejected for certification. Growers had also expressed dissatisfaction with the apparent vigour and physiological age of the seed tubers. It was thought that improved crop management decisions would reduce the chances of crop rejection and improve the productivity of processing crops grown from better seed. Table 6 summaries the estimated benefits of participation in the SMS program, as reported in the final report for the project. The table shows that the potential for increased values and yields of processing tubers is significant.

Table 6: Estimate of the Financial Impact of SMS

Item	Beneficiary	Source of benefit	Annual value
Reduced rejection for certification	Seed grower	Rejection reduced from 52% to 27%. Seed value $330/T vs $220/T processing tubers	$495k
Increased yield of processing tubers	Processing growers	Yield increase 2.2T/ha X 6,000 ha at nett value (after harvest and freight) $160/T	$2.1 m
More efficient use of pesticides, fertilisers and water to produce seed crops	Seed grower, environment	Reduced incidence of unnecessary insurance applications	Not quantified
Annual total			$2.6 m

Source: final report for project PT02022

Other benefits from this project not included in the estimates above include R&D advances from systematic collection of crop data, environmental benefits, reliability of supply and improved relationships between processors, growers and researchers.

PT02035: Maintenance of certified seed public varieties

The major benefit of this project is the maintenance of a quality collection of certified minitubers, plantlets and microtubers to be used as the G0 generation of certified seed grown. This in turn has the potential to result in maintained quality and therefore yield of subsequent seed crop generations.

PT02046: Precision farming

Precision farming uses tools such as electro magnetic surveying (EM) and multi-spectral imagery (MSI) to map the variability of soil and potato growth across a plot. The maps produced provide quantifiable information on variability across a plot and identify factors leading to good and poor potato growth. This information can be used to identify different management zones in order to target inputs or selective harvesting. Such management has the potential to provide benefits by ensuring uniform whole round potatoes to meet market specifications. Table 7 shows the findings of the project in terms of how targeting planting on the most appropriate soil types, can increase yields for seed potato crops significantly.

Table 7: Yields for Differing Soil Types

Soil types (EM zones)	**Potato yield (T/ha)**	**Net return (per ha)**	**Increase on low EM**
Basalt (high EM)	34.6	$10,040	1.6 fold increase
Red loam (Medium EM)	44.3	$14,385	2.3 fold increase
Grey clay (low EM	26.2	$6,320	

Source: Final report for Project PT02046

PT03064: Exports to Sri Lanka
Western Australian seed potato exports grew from 600 tonnes in 1999/2000 to 1,421 tonnes in 2003/04, and they were continuing to increase. Sri Lanka was identified as a potentially new market which had produced over 89,000 tonnes of potatoes in 2001/02. The average yield for potatoes in Sri Lanka was 12 t/ha (compared with 40 t/ha average for Australia).

Poor seed quality had been identified as a limiting factor with regard to low yields, however a yield response to improved seed will only occur if there are no other major constraints. Assisting the Sri Lankan industry to overcome these other constraints will eventually allow Australian seed imports to perform to their true potential, and therefore increase exports of Australian seed to Sri Lanka. There will also be benefits to the Sri Lankan growers themselves, in terms of increased yields.

PT03069: Elimination of viruses
The potential benefits from this project will be a reduction in the likelihood of crops from Tasmanian seed potatoes having widespread infestations of PVS and PVX, resulting in improved yields for commercial crops.

PT04013 and PT06030: Certification workshops
The potential benefits of this project include improved quality and consistency of seed potatoes in Australia, resulting in improved yields of subsequent (commercial) crops (through better quality seed, reduced disease, variety guarantee etc).

PT06011: Increasing G1 potato seed yields
It is anticipated that the findings of this research may contribute to a 20% increase in the number of seed potatoes per plant in G1 seed crops grown from mini tubers. Increasing the yield of the G1 crop can either increase the yield of seed producers overall, or allow

fewer generations of seed crops to be required to be grown before sale to commercial growers.

PT06041: Virus monitoring
As a result of this research, there is the potential for crop rejections due to virus diseases carried over in seed plots to be minimised. With a reduced volume of virus present, the overall health of certified seed has improved and will continue to do so. As a result of this, seed growers will benefit from reduced crop rejections and a more reliable income. Also, commercial growers buying seed will financially benefit from a more consistent supply of quality seed.

Summary of Benefits
A summary of the principal types of benefits and related costs associated with the outcomes of the project is shown in Table 8.

Table 8: Categories of Benefits from the Investment

Levy Paying Industry	**Spillovers**		
	Other Industries	**Public**	**Foreign**
Economic Benefits			
Increased yields of seed potatoes Increased quality of seed potatoes, resulting in fewer rejections Increased yields and quality of commercial potato crops Potential exports of seed potatoes to Sri Lanka			Increased yields for Sri Lankan potato growers
Environmental Benefits			
Nil			
Social Benefits			
Nil			

Public versus Private Benefits
All of the benefits that will arise from the investment in the projects within this cluster will be private in nature. The private benefits will be captured by both the seed growing and commercial growing (for fresh and processed markets) sectors of the potato industry in Australia. These private benefits will be in the form of increased yields of both commercial and seed crops and increased quality of seed crops, resulting in less rejection of seed potatoes for certification with associated increases in prices received.

Distribution of Benefits along the Potato Supply Chain
Some benefits will be captured by the seed potato sector of the industry in the form of lower costs assuming the same sales, with other benefits captured by the commercial potato sector through increased yields.

Benefits to other Primary Industries
There are likely to be limited benefits to other primary industries, however there is the possibility that some scientific findings may be relevant to other vegetable crops.

Benefits Overseas
There will be some benefits to overseas countries to which Australian potato seed is exported. There will be potential benefits to Sri Lanka in particular, in terms of improved yields due to agronomic changes if exports of Australian seed potatoes occur.

Additionality and Marginality
Supporting these studies was a relatively high priority for the potato R&D Program as improvements in the yield and quality of seed potatoes are significant factors in maintaining and growing the industry. Further detail is provided in Table 9.

Table 9: Potential Response to Reduced Public Funding to HAL

1. What priority were the projects in this cluster when funded?	High
2. Would HAL and state agencies have funded this cluster if only half of public funding of HAL had been available?	Yes, but with a lesser total investment (50% -100%)
3. Would the cluster have been funded if no public funding for HAL had been available?	Yes, 50% of that actually funded

Match with National Priorities
The Australian Government's national and rural R&D priorities are reproduced in Table 10.

Table 10: National and Rural R&D Research Priorities 2007-08

Australian Government	
National Research Priorities	**Rural Research Priorities**
1. An environmentally sustainable Australia 2. Promoting and maintaining good health 3. Frontier technologies for building and transforming Australian industries 4. Safeguarding Australia	1. Productivity and adding value 2. Supply chain and markets 3. Natural resource management 4. Climate variability and climate change 5. Biosecurity *Supporting the priorities:* 1. Innovation skills 2. Technology

The major focus of the projects in this cluster has been on the first Rural Research Priority, and to some degree the second Rural Research Priority. The third National research priority has also been addressed.

6. Measurement of Benefits

The projects in this cluster have all contributed in some degree to improvements in the yield and quality of seed potatoes in Australia. The level of detail available on the likely contribution of each individual project to such benefits is highly variable. For this reason, it is assumed that together, the projects have contributed to an increase in the yield of seed potatoes and this is the benefit that is valued in the following analysis.

Increased yield
The average reported area of seed potatoes grown in Australia in 2005/07 and 2006/7 was 5,095 hectares, with an average production of 120,070 tonnes and an average yield of 23.6 tonnes per hectare. It is assumed that this average yield applies to the certified seed industry only, and that non-certified seed would be additional to this volume.

It is assumed that due to the projects in this cluster, a combined increase in the average yield of 5% can be assumed. This yield increase is assumed to commence in the year ending June 2008, and that it takes a period of 10 years for the full increase to be realised. However, as the demand for seed potatoes is not expected to increase significantly, this benefit is measured through a cost reduction, rather than valuing the increased yield. For the purposes of the analysis, it is assumed that the cost of production for certified seed potatoes is equal to the average price for certified seed potatoes ($541/t). At the base yield of 23.6 t/ha, this equates to a production cost of $12,767/ha. When the yield is increased by 5% to 24.8 t/ha, the cost of production per tonne is reduced to $514.80/t if it is assumed the costs of production per hectare do not change. Therefore, a cost saving of $26.20 per tonne is realised for certified seed potatoes.

It is assumed that the cost reduction only applies to the part of the industry that is certified and therefore potentially to the 120,070 tonnes of original production. To be conservative it is assumed that 25% of the certified seed potato production achieves the cost reduction. As the yield increase is assumed to be an average gain due to a number of technology and production changes, it is assumed that the increase is net of any additional adoption and production costs required to achieve this gain.

Summary of Assumptions
A summary of the key assumptions made is shown in Table 11.

Table 11: Summary of Assumptions

Variable	Assumption	Source
Yield improvement		
Hectares of certified seed potatoes	5,095 hectares	Ausveg
Total production of certified seed potatoes	120,070 tonnes	Ausveg
Average yield of certified seed potatoes	23.6 t/ha	Ausveg
Proportion of certified seed that experiences yield increase	25%	Agtrans Research
Assumed yield increase due to research	5%	Agtrans Research
Cost of production of certified seed without research	$541/t	Ausveg
Cost of production of certified seed after yield increase due to research	$515/t	Derived
Cost reduction due to research	$26/t	Derived
First year of benefit	2007/08	Agtrans Research
Time from first year of benefit to maximum benefit realised	10 years	Agtrans Research

Benefits not valued

Some potential benefits have not been valued, including the potential increase in exports to Sri Lanka, and potential yield and quality improvements for subsequent fresh and processed potato crops, due to the improved quality of the seed potatoes. Some of the potential benefit to commercial potato growers would be reduced through the additional price paid for seed (that is already valued in the seed producers benefit). There is also the potential for some growers to reduce the proportion of their crop that is rejected for certification, and therefore achieve a higher price for that seed. It is noted that it is possible that producers of non-certified seed will also benefit from the outputs of some of the projects, but this benefit is also not valued in the analysis.

7. Results

All past costs and benefits were expressed in 2008/09 dollar terms using the CPI. All benefits after 2008/09 were expressed in 2008/09 dollar terms. All costs and benefits were discounted to 2008/09 using a discount rate of 5%. The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for many of the estimates. Investment criteria were estimated for both total investment and for the HAL investment alone. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2007/08) to the final year of benefits assumed (2037/38).

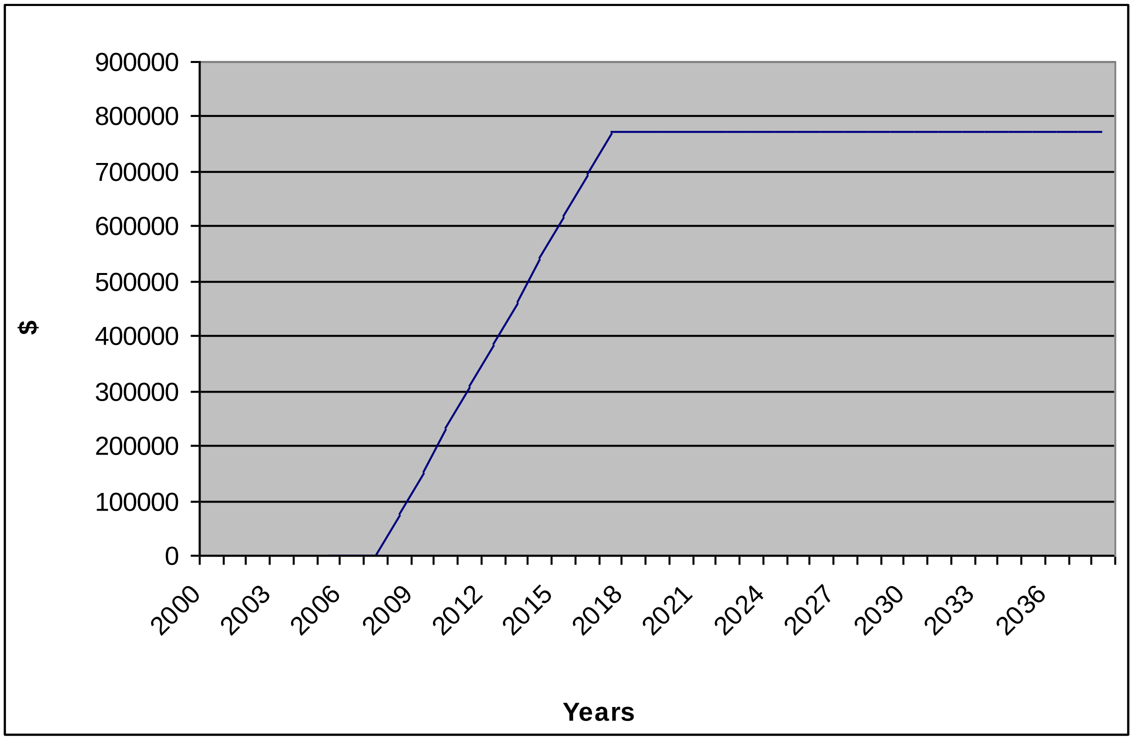
Table 12 shows the investment criteria for the different periods of benefits.

Table 12: Investment Criteria for Total Investment
(discount rate 5%)

Years	0	5	10	20	30
Present value of benefits ($m)	0.08	1.45	3.86	7.70	10.07
Present value of costs ($m)	1.99	1.99	1.99	1.99	1.99
Net present value ($m)	-1.91	-0.54	1.87	5.72	8.08
Benefit–cost ratio	0.04 to 1	0.73 to 1	1.94 to 1	3.88 to 1	5.06 to 1
Internal rate of return (%)	neg	0.01	11.6	15.5	16.0

The cash flow of benefits is shown in Figure 1 for the total investment.

Figure 1: Annual Cash Flow of Benefits



Sensitivity Analyses

Sensitivity analyses were carried out on a range of variables and results for the total investment are reported in Table 13 and 14. All sensitivity analyses were performed using a 5% discount rate with benefits taken over the life of the investment plus 30 years from the year of last investment. All other parameters were held at their base values.

Table 13: Sensitivity to Discount Rate
(Total investment, 5% discount rate, 30 years)

	Discount rate		
Criterion	0%	5%	10%
Present value of benefits (m$)	20.49	10.07	5.84
Present value of costs (m$)	1.51	1.99	2.60
Net present value (m$)	18.98	8.08	3.23
Benefit cost ratio	13.6 to 1	5.1 to 1	2.2 to 1

Table 14: Sensitivity to assumed cost reduction
(Total investment, 5% discount rate, 30 years)

	Cost Reduction		
Criterion	2%	5%	10%
Present value of benefits (m$)	4.15	10.07	19.22
Present value of costs (m$)	1.99	1.99	1.99
Net present value (m$)	2.16	8.08	17.23
Benefit cost ratio	2.1 to 1	5.1 to 1	9.7 to 1
Internal rate of return (%)	9.5	16.0	21.9

8. Confidence Rating

The results produced are highly dependent on the assumptions made, many of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 15). The rating categories used are High, Medium and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some significant uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 15: Confidence in Analysis of Seed Production and Quality Cluster

Coverage of Benefits	Confidence in Assumptions
Medium	Medium

Lessons Learnt for Future Investment

The current evaluation was not intended to assess reporting performance or to develop a framework for a future monitoring evaluation strategy. However, it was noted that sufficient information was not always available on outcomes and impacts for a confident economic evaluation. Follow-up to initiatives to assess impact are not only important to facilitate improved evaluations but also to guide future investment.

9. Conclusions and Lessons Learned

The projects included in this cluster are focused on the improvement of the yield and quality of seed potatoes in Australia. The analysis has shown that the majority of these projects have been successful in developing knowledge and transferring knowledge and skills that will help in achieving these aims at grower level. The potential benefits from a reduction in production costs for the seed potato crop has been quantified, and it was found that it is likely the research has resulted in significant benefits, with a Net Present Value of $8m and a Benefit to Cost Ratio of 5 to 1 (over 30 years, at a discount rate of 5%).

Acknowledgments

Iain Kirkwood, Tasmanian Institute of Agricultural Research

APPENDIX 2: An Economic Analysis of HAL Investment in Projects in the Processor – Disease – Soil Amendments Cluster (Potato Program)

Background

In 2006 total Australian potato production totalled 1,255,463 tonnes and the area planted was 35, 485 hectares, with the average yield per hectare of 35.4 tonnes. The gross value of potatoes grown in Australia in 2006 was $465.1 million. Potato production area has declined over time, but yields have been rising for the past decade. The national potato crop is mostly grown in Victoria (22%), South Australia (31%) and Tasmania (23%) with most of the Tasmanian crop going to processing. There are three markets for potatoes in Australia, fresh potatoes (44%), processed frozen potatoes (42%) and processed crisping potatoes (14%). Processed frozen potatoes are sold primarily as frozen chips, and other varieties such as potato gems. Processed crisps are sold as potato chips.

Frozen processing in Australia is dominated by two large companies: McCain Foods from Canada and Simplot from the USA. Processing plants are located in Tasmania, South Australia and Victoria. Most potatoes for the frozen market are grown under contract. For crisping, the two major processing companies are Arnott's and Smiths (Frito-Lay). Most potatoes are grown under contract and processing plants are located nation wide.

Separate R&D programs have been established for the fresh potato and processed potato industries. As part of the processed potato program, Horticulture Australia Ltd (HAL) and the University of Tasmania (UTAS) have a Research Development and Commercialisation Agreement (RD&CA) under which HAL provides funding to UTAS in relation to the Processing Potato Research and Development (R&D) Plan (HAL Project No. PT04016). PT04016 runs from July 2004 to June 2009.

UTAS acts as the coordinator of the projects and subcontracts certain subprograms to subcontractors. There are six subprograms:

1. DNA monitoring tools for soil-borne diseases of potato (Dr Kathy Ophel-Keller, SARDI)
2. Disease resistance – screening and mechanisms (Mr Tony Slater, DPI Vic)
3. Soil amendments for the control of potato diseases (Dr Nigel Crump, DPI Vic)
4. Optimal crop rotations for the control of soil-borne disease (Dr Leigh Sparrow, Tasmanian Institute of Agricultural Research)
5. Enhancing resistance to common scab by somaclonal selection and tomato spotted wilt virus through marker development (Associate Professor Calum Wilson, UTAS/TIAR)
6. Investigation of the factors affecting disease expression and the effects of crop rotations (Richard Falloon, New Zealand CFR)

As well as the six subprograms, there is a coordination project. Dr Iain Kirkwood is the coordinator and his role is to:

- Ensure program delivery against milestones.
- Encourage coordination and collaboration between participants.
- Resolve disputes, facilitate meetings, liaise with the communications program, manage program reviews, investigate further funding opportunities and additional collaborative work nationally and internationally.

The research program as a whole was funded to address a number of disease issues, which are one of the industry's most pressing problems and cost the industry collectively around $50 million per year. The program seeks to provide a balance of basic, strategic and applied research. The program also seeks to provide short and medium term outcomes, and also increase industry support and involvement. The intent is to have a large integrated program that provides for the structured acquisition of information and also delivers decision support systems.

The work also involves collaboration with New Zealand and Canada, as the diseases being studied are present in other countries.

The focus of this analysis is Subprogram 3, the Soil Amendments (or Soil Health) subprogram which was managed by Dr Nigel Crump from DPI Victoria and ran from July 2004 to September 2009.

The focus of Subprogram 3 was major soilborne potato diseases including common scab, powdery scab and Rhizoctonia. The major economic impacts of these diseases are through the rejection of tubers for processing and seed. The diseases also result in increased costs and lower product recovery to processors.

The Cluster

Project Objectives

The objectives of Subprogram 3 are:

- Develop new, commercially acceptable techniques to reduce the impact of soil-borne disease on potato crops by manipulating soil conditions.
- Develop practical organic soil ameliorant recommendations, which encourage natural disease suppression in potato soils.
- Help calibrate and validate DNA soil assays.
- Develop integrated disease control strategies.

Project Investment

Table 1 shows the annual investment in Subprogram 3 for HAL; this funding includes any voluntary contributions made by industry.

Table 1: Investment by Project by HAL Including Both Levy and Voluntary Contributions (nominal $)

Year ending June	HAL (includes government, compulsory and voluntary levies)	Research partners (including New Zealand) (cash and in-kind)	Total
2005	81,000	409,000	490,000
2006	84,000	421,000	505,000
2007	86,000	434,000	520,000
2008	168,000	447,000	615,000
2009	177,000	461,000	638,000
Total	596,000	2,172,000	2,768,000

Outputs

The activities and outputs to date in terms of scientific findings from the Australian component of the collaborative the subprogram are:

- A survey of growers was completed to determine the impact of management practices on disease. A total of 108 surveys were completed and were used to compare management practices with disease incidence and the severity of impact on the tubers.
- Numerous organic, nutrient and fungicide amendments and their strategic application to the potato root zone were investigated for powdery scab control in eight field trials over five seasons in Victoria.
- The most effective treatment of those tested for reducing powdery scab on tubers at harvest was Shirlan, where three applications strategically applied into the rootzone using trickle tape reduced disease incidence by 90%.
- Five field trials were conducted in Victoria over four seasons with respect to the effectiveness of two fungicides and six high nitrogen amendments for reducing common scab on tubers at harvest. All were found to be effective and in susceptible cultivars disease incidence was reduced by up to 65%.
- Results suggested that pH alone may not be a driver for common scab symptom development, and that further study is required on the influence on pH for common scab development.
- The use of nutrient (e.g. calcium, magnesium, potassium) manipulation for common scab control was found to show promise, but further study is required to understand the complex interactions between nutrients, pH, soil microflora and disease suppression.
- The potato variety was found to have a large effect on both common scab and powdery scab disease at harvest, with treatments more effective on resistant varieties than susceptible varieties.
- Several fungicide treatments applied at recommended rates to seed tubers before planting as dusts, dips or sprays, or sprayed onto the seed and into the furrow at planting were evaluated for the control of Rhizoctonia stem canker (*R. solani*) and

black scurf on tubers in three field trials in Victoria. None of the treatments improved total or marketable yields.

- Organic amendments and novel compounds were tested for activity against *R. solani*. In glasshouse trials, fish emulsion, formic acid, willow twig & leaf concoctions, salicyclic acid and liquid chitin all showed activity against *R. solani*.
- A preliminary plant trial found pre plant fumigation with metham sodium did not reduce the incidence of black scurf, powdery or common scab or improve the yield or quality of potatoes.
- Two field trials were conducted to evaluate the effect of green manure incorporation on soilborne disease and soil microbiology. Results were mixed, however disease incidence overall was low. The incorporation of these plant residues did however increase soil active carbon and biological activity.
- Soil samples were collected and analysed over two seasons, from a total of 219 commercial field sites in three states (South Australia, Tasmania and Victoria). Disease levels at harvest were also assessed and correlation analyses carried out. Key findings included:
    - Iron was consistently identified at increased levels in soils with low powdery scab disease.
    - In the first year of the survey, powdery scab severity was positively correlated with high soil potassium and phosphorus content, but negatively correlated with high soil sodium and iron content. Common scab severity was positively correlated with pH, calcium, magnesium and molybdenum content. High severity was also associated with high cation exchange capacity, high organic matter, and high levels of boron, copper, hydrogen, iron and manganese. Low common scab severity was associated with increased levels of potassium and sodium.
    - In the second year of the survey, disease levels were much lower and relationships were less apparent. This was a reflection of the overriding influence of environment on disease expression.
    - The influence of pH was the most consistent factor associated with common scab, with low pH reducing disease.

Communication outputs include presentations, publications and field days including:

- Eleven international conference papers
- Four papers in preparation at the time of the final report
- One published refereed publication
- Nine national conference papers
- Eleven articles in industry magazines
- Nine field days over six years, at Ballarat, Cora Lynn and Gembrook in Victoria
- A Rhizoctonia workshop was organised by the Victorian DPI team and held in Melbourne in October 2007.
- A seed growers discussion group in Ballarat was formed as a result of this project. A number of meetings have been held and member feedback has been positive.
- The project co-hosted the 3rd biennial potato conference in Marysville Victoria that was attended by 180 delegates.

Outcomes

The expected outcomes of the project were:

- affordable, safe disease reduction strategies
- natural disease suppression strategies
- integrated management strategies to reduce disease risk
- decision support systems to support the above

At this stage, these outcomes have been partially achieved. The research has successfully identified soil chemical properties associated with common and powdery scab disease regulation in collaboration with AAFC Canada. Significant scientific progress has been made in terms of the trials and analysis of how soil amendments influence disease, however further work needs to be carried out before any specific recommendations for practice changes by potato growers can be developed, recommended and adopted. A project to continue the work and achieve these outcomes has been approved for funding and will commence in 2009/10. This project will have two components. The first component relates to further developing recommendations associated with the role of soil amendments for controlling disease and is a closely linked extension to the project being analysed here. The second component relates to endophyte and hormone studies and will investigate novel strategies for disease management. It is less directly related to the project being analysed, however is still linked as one mechanism of amendment activity may be through soil microbes.

A significant outcome of Subprogram 3 is due to data generated during the trials being used to assist CropCare Australia to obtain registration for fluazinam (Shirlan) to control powdery scab in Australia. If this registration is achieved, it will allow this product to be available for potato growers to use for controlling powdery scab.

The project involved significant collaboration with researchers in Canada. This collaboration allowed the project to gain access to a new DNA soil fingerprinting technique using cpn60 (chaperone gene) sequence-based methods for the analysis of complex microbial communities. The use of this technology is continuing to be used to understand the mechanisms of disease suppressive soil amendments.

An indirect outcome was the raising of the profile of potato research amongst growers, through the publishing of regular articles in the Potatoes Australia industry magazine, and through the regular field days held in Victoria.

Benefits

Potential benefits to the processed potato industry will be from the development of disease reduction, suppression and management strategies based on soil additives and nutrient management. Such outcomes will have the potential to benefit the industry through reducing the impact of a number of diseases (powdery scab, common scab and Rhizoctonia) in terms of reducing the rejection of tubers for processing and seed, and decreasing processing costs associated with lower product recovery. There may also be benefits in reduced control and treatment costs. Examples of the impact of the use of potential strategies and technologies developed include:

- Reduced probability of disease outbreaks for processed potatoes, through improved decision making by growers with respect to disease management options when planting a crop.
- The reduced probability of disease outbreak will potentially result in reduced production losses to disease.
- The eventual recommended practices associated with soil amendments for disease control will also have the potential to be used by potato growers overseas, with the Canadian researchers being involved in the project.
- The improved understanding of the complexities of soil/disease interaction may potentially lead to reduced use of chemicals to treat and prevent disease through changes in recommended application levels of soil amendments and chemicals compared to what is applied currently. There is the potential for decreased risks for environmental and human health associated with using such chemicals. However, it should be noted that there is also the potential for increased use of chemicals in some circumstances depending on the recommendations made.
- Due to the structure of the program and its communication efforts there were a number of benefits from this subprogram, and the program as a whole with respect to building research/industry relationships.

As noted above, the majority of these benefits will not be realised until recommendations for application rates and other practices are developed further in a Phase 2 project.

Summary of Benefits

A summary of the principal types of benefits associated with the outcomes of the project is shown in Table 2.

Table 2: Categories of Benefits from the Investment

Levy Paying Industry (processed potatoes)	**Spillovers**		
	Other Industries	**Public**	**Foreign**
Economic Benefits			
Reduced rejection of processed potatoes due to quality concerns. Reduced processing costs and improved product recovery.	Reduced rejection of seed and fresh potatoes due to quality concerns.		Reduced rejection of potatoes due to quality concerns.
Environmental Benefits			

		Potentially reduced chemical use and therefore reduced risk to the environment.	
<u>Social Benefits</u>			
Improved cooperation in industry, resulting in capacity building of researchers and industry. Reduced chemical use and therefore reduced risk to human health.		Potentially reduced chemical use and therefore reduced risk to human health.	

Public versus Private Benefits
The majority of the benefits that will arise from the investment in the project will be private in nature. The private benefits will be captured largely by the processed potato sector. These private benefits will be in the form of reduced damage due to disease, and therefore reduced rejection of potatoes by processors and improved product recovery. There will also be some private benefits to the industry through improved relationships and capacity building in the research sector. The public benefits are in the form of potentially reduced use of chemicals and fungicides, if strategies and technologies developed result in the reduced need for their use.

Distribution of Benefits Along the Potato Supply Chain
Benefits will be captured by both processed potato growers, and the processing companies themselves, through the availability of greater quantities of quality potatoes for processing.

Benefits to other Primary Industries
There will be benefits to the fresh potato industry, and also potentially the fresh seed potato industry. There are likely to be limited benefits to other primary industries, however there is the possibility that some scientific findings may be relevant to other vegetable crops.

Benefits Overseas
There will be some benefits to overseas countries whose fresh and processed potato industries may also make use of the scientific knowledge and disease prevention and management strategies developed, including Canada, New Zealand, and the United Kingdom.

Additionality and Marginality
Supporting these studies was a high priority for the processed potato R&D Program as disease is one of the significant factors limiting the quality of potatoes. Further detail is provided in Table 3.

Table 3: Potential Response to Reduced Public Funding to HAL

4. What priority were the projects in this cluster when funded?	High
5. Would HAL and industry have funded this cluster if only half of public funding of HAL had been available?	Yes, but with a lesser total investment (perhaps 75%)
6. Would the cluster have been funded if no public funding for HAL had been available?	Yes, 50% of that actually funded

Match with National Priorities
The Australian Government's national and rural R&D priorities are reproduced in Table 4.

Table 4: National and Rural R&D Research Priorities 2007-08

Australian Government	
National Research Priorities	**Rural Research Priorities**
5. An environmentally sustainable Australia 6. Promoting and maintaining good health 7. Frontier technologies for building and transforming Australian industries 8. Safeguarding Australia	6. Productivity and adding value 7. Supply chain and markets 8. Natural resource management 9. Climate variability and climate change 10. Biosecurity *Supporting the priorities:* 3. Innovation skills 4. Technology

The major focus of the projects in this cluster has been on the first Rural Research Priority, and to some degree the second Rural Research Priority. The third National research priority has also been addressed.

Quantification of Benefits

As part of the development of a Phase 2 project that builds on the research of Subprogram 3, an ex-ante benefit-cost analysis was conducted by the proponents. The ex-ante analysis quantifies the benefits from Subprogram 3, as well as the Phase 2 project. That analysis quantifies several benefits, including declines in losses to the processing crop industry, and the processing seed industry caused by common scab, powdery scab, Rhizoctonia and bacterial wilt; and reductions in losses to potato processors, and costs associated with storage and seed preparation.

For the purposes of the current analysis, the benefits attributable to Subprogram 3 are assumed to be quite limited compared to the Phase 2 project, as the second phase considers a wider range of diseases (e.g. bacterial wilt) and involves the development of novel treatments not considered in Subprogram 3.

The benefit valued in the current analysis is the reduction in the proportion of processed potatoes rejected due to common scab, powdery scab and Rhizoctonia. A separate analysis undertaken on the investment in Subprogram 1 of PT04016 (DNA monitoring tools) assumed that currently, the rejection rate for processed potatoes due to these diseases is 20%. This same assumption (20%) is used in this analysis, and it is assumed that through implementing soil amendments developed based on science in Subprogram 3, that a grower can reduce this rejection rate by 5 percentage points, to 15%.

The average area of processed potatoes grown in Australia in 2005/06 and 2006/7 was 19,047 hectares, with an average production of 770,641 tonnes and an average yield of 40 tonnes per hectare. It is assumed that the reduction in the rejection rate of 5% is equivalent to obtaining an additional 5% saleable yield per hectare. However, as the demand for potatoes is not expected to increase significantly, this benefit is measured through a cost reduction, rather than valuing the increased yield or sales. For the purposes of the analysis, it is assumed that the cost of production is equal to the average price for processed potatoes ($280/t). At the base yield of 40 t/ha, this equates to a production cost of $11,200/ha. When the yield is increased by 5% to 42 t/ha, the cost of production per tonne is reduced to $267/t if it is assumed the costs of production per hectare do not change. Therefore, a cost saving of $13 per tonne is realised. This cost reduction is assumed to be an average benefit across all growers who adopt the amendments.

It is assumed that a maximum of 50% of the processed potato industry will adopt potential recommended management practices such as soil amendments. Adoption is assumed to commence in 2012/13, which is the fourth year of the second phase of investment. It is assumed that adoption will be linear, and take place over seven years (with maximum adoption occurring in 2018/19).

For the purposes of this analysis, it is assumed that the benefit estimated is net of any additional costs to growers associated with the adoption of different nutrient and soil amendment regimes.

In order to achieve these assumed benefits, an additional research program is required (Phase 2 about to commence). The benefits to the PT04016 Subprogram 3 investment are therefore taken as a proportion of the total benefits, and it is assumed that this proportion is 50%. This proportion is quite high, as it is assumed that the bulk of the investment in the Phase 2 project, will not be related to this assumed benefit, and that other benefits will flow from that research that are not considered in this analysis. Therefore the benefits quantified in this analysis, are significantly attributable to Subprogram 3.

Due to Phase 2 not having yet commenced, a probability of success of the Phase 2 research of 60% is assumed.

Summary of Assumptions
A summary of the key assumptions made is shown in Table 5.

Table 5: Summary of Assumptions

Variable	Assumption	Source
Hectares of processed potatoes	19,047 hectares	Ausveg
Total production of processed potatoes	770,641 tonnes	Ausveg
Average yield of processed potatoes	40 t/ha	Ausveg
Proportion of industry adopting recommended practices at maximum adoption	50%	Agtrans Research
Assumed yield increase due to research	5%	Ian Black, SARDI
Cost of production of processed potatoes without research	$280/t	Derived from Ausveg
Cost of production of processed potatoes after yield increase due to research	$267/t	Derived
Cost reduction due to research	$13/t	Derived
First year of benefit	2012/13	Agtrans Research
Time from fist year of benefit to maximum benefit realised	7 years	Agtrans Research
Attribution of total benefits to PT04016 Subprogram 3 (versus Phase 2 research in PT09026)	50%	Agtrans Research
Probability of success of Phase 2 research	60%	Agtrans Research

Benefits not valued
Some potential benefits have not been valued, including the potential benefit to the fresh and seed potato industries, and potential benefits to processors themselves.

Results
All past costs and benefits were expressed in 2008/09 dollar terms using the CPI. All benefits after 2008/09 were expressed in 2008/09 dollar terms. All costs and benefits were discounted to 2008/09 using a discount rate of 5%. The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for many of the estimates. Investment criteria were estimated for both total investment and for the HAL investment alone. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2008/09) to the final year of benefits assumed (2038/39).

Table 6 shows the investment criteria for the different periods of benefits for the total investment. Table 7 shows the investment criteria for the different periods of benefits for the HAL investment only.

Table 6: Investment Criteria for Total Investment
(discount rate 5%)

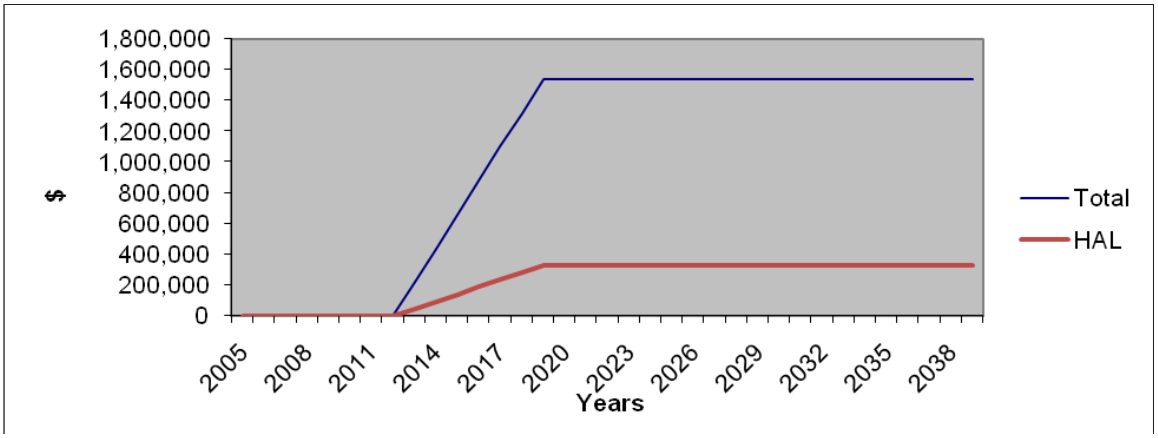
Years	0	5	10	20	30
Present value of benefits ($m)	0	0	4.19	11.493	15.98
Present value of costs ($m)	3.19	3.19	3.19	3.19	3.19
Net present value ($m)	-3.19	-2.67	0.99	8.30	12.79
Benefit–cost ratio	0	0.2 to 1	1.3 to 1	3.6 to 1	5.0 to 1
Internal rate of return (%)	neg	neg	7.9	15.3	16.2

Table 7: Investment Criteria for HAL Investment
(discount rate 5%)

Years	0	5	10	20	30
Present value of benefits ($m)	0	0	0.89	2.45	3.41
Present value of costs ($m)	0.67	0.67	0.67	0.67	0.67
Net present value ($m)	-0.67	-0.56	0.22	1.78	2.74
Benefit–cost ratio	0	0.2 to 1	1.3 to 1	3.7 to 1	5.1 to 1
Internal rate of return (%)	neg	neg	8.2	15.7	16.6

The undiscounted cash flow of benefits is shown in Figure 1 for the total and HAL investment.

Figure 1: Annual Cash Flow of Benefits



Sensitivity Analyses

Sensitivity analyses were carried out on a range of variables and results for the total investment are reported in Tables 8 to 10. All sensitivity analyses were performed using a 5% discount rate with benefits taken over the life of the investment plus 30 years from the year of last investment. All other parameters were held at their base values.

Table 8: Sensitivity to Discount Rate
(Total investment, 5% discount rate, 30 years)

	Discount rate		
Criterion	0%	5% (base)	10%
Present value of benefits (m$)	36.99	15.98	7.98
Present value of costs (m$)	2.90	3.19	3.52
Net present value (m$)	34.09	12.79	4.46
Benefit cost ratio	12.7 to 1	5.0 to 1	2.3 to 1

Table 9: Sensitivity to Assumed Cost Reduction
(Total investment, 5% discount rate, 30 years)

	Cost reduction (saleable yield increase)		
Criterion	2%	5%	10%
Present value of benefits (m$)	6.58	15.98	30.51
Present value of costs (m$)	3.19	3.19	3.19
Net present value (m$)	3.39	12.79	27.31
Benefit cost ratio	2.1 to 1	5.0 to 1	9.5 to 1
Internal rate of return (%)	9.5	16.2	21.8

Table 10: Sensitivity to Assumed Increase in Maximum Proportion of Industry Adopting Use of the Recommended Practices
(Total investment, 5% discount rate, 30 years)

	Maximum Adoption		
Criterion	25%	50%	75%
Present value of benefits (m$)	7.99	15.98	23.97
Present value of costs (m$)	3.19	3.19	3.19
Net present value (m$)	4.80	12.79	20.78
Benefit cost ratio	2.5 to 1	5.0 to 1	7.5 to 1
Internal rate of return (%)	10.9	16.2	19.6

The sensitivity analyses demonstrate that the investment criteria are highly sensitive to the discount rate, largely due to the long period between the research being completed and the benefits commencing. The investment criteria are relatively robust to movements in some of the other key assumptions.

Confidence Rating

The results produced are highly dependent on the assumptions made, many of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 11). The rating categories used are High, Medium and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some significant uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 11: Confidence in Analysis of PT04016 Subprogram 1

Coverage of Benefits	**Confidence in Assumptions**
Medium	Low

Conclusions

This project is focused on the improvement of the quality of processed potatoes in Australia, through providing scientific knowledge that will be used to develop recommended practices surrounding the use of soil amendments and soil management to minimise disease impacts. The analysis has shown that the research to date has been successful but that further research is required to further develop recommended practices and make them suitable for widespread adoption by processed potato growers. This is being undertaken in a Phase 2 project. The potential benefits from an increase in the quality of processed potatoes has been quantified, and it was found that it is likely the research has resulted in significant benefits, with a Net Present Value of $12.8 m and a Benefit to Cost Ratio of 5 to 1 (over 30 years, at a discount rate of 5%).

Acknowledgments

Iain Kirkwood, Tasmanian Institute of Agricultural Research
Jacqueline Edwards, Department of Primary Industries, Victoria

APPENDIX 3: An Economic Analysis of HAL Investment in Projects in the Processor – DNA Monitoring Tools

1. Background

In 2006 total Australian potato production totalled 1,255,463 tonnes and the area planted was 35, 485 hectares, with the average yield per hectare of 35.4 tonnes. The gross value of potatoes grown in Australia in 2006 was $465.1 million. Potato production area has declined over time, but yields have been rising for the past decade. The national potato crop is mostly grown in Victoria (22%), South Australia (31%) and Tasmania (23%) with most of the Tasmanian crop going to processing. There are three markets for potatoes in Australia, fresh potatoes (44%), processed frozen potatoes (42%) and processed crisping potatoes (14%). Processed frozen potatoes are sold primarily as frozen chips, and other varieties such as potato gems. Processed crisping potatoes are sold as potato chips.

Frozen processing in Australia is dominated by two large companies: McCain Foods from Canada and Simplot from the USA. Processing plants are located in Tasmania, South Australia and Victoria. Most potatoes for the frozen market are grown under contract. For crisping, the two major processing companies are Arnott's and Smiths (Frito-Lay). Most potatoes are grown under contract and processing plants are located nation wide.

Separate R&D programs have been established for the fresh potato and processed potato industries. As part of the processed potato program, Horticulture Australia Ltd (HAL) and the University of Tasmania (UTAS) have a Research Development and Commercialisation Agreement (RD&CA) under which HAL provides funding to UTAS in relation to the Processing Potato Research and Development (R&D) Plan (HAL Project No. PT04016). PT04016 runs from July 2004 to June 2009.

UTAS acts as the coordinator of the projects and subcontracts certain subprograms to subcontractors. There are six subprograms:

7. DNA monitoring tools for soil-borne diseases of potato (Dr Kathy Ophel-Keller, SARDI)
8. Disease resistance – screening and mechanisms (Mr Tony Slater, DPI Vic)
9. Soil amendments for the control of potato diseases (Dr Nigel Crump, DPI Vic)
10. Optimal crop rotations for the control of soil-borne disease (Dr Leigh Sparrow, Tasmanian Institute of Agricultural Research)
11. Enhancing resistance to common scab by somaclonal selection and tomato spotted wilt virus through marker development (Associate Professor Calum Wilson, UTAS/TIAR)
12. Investigation of the factors affecting disease expression and the effects of crop rotations (Richard Falloon, New Zealand CFR)

As well as the six subprograms, there is a coordination project. Dr Iain Kirkwood is the coordinator and his role is to:

- Ensure program delivery against milestones.
- Encourage coordination and collaboration between participants.
- Resolve disputes, facilitate meetings, liaise with the communications program, manage program reviews, investigate further funding opportunities and additional collaborative work nationally and internationally.

The research program as a whole was funded to address a number of disease issues, which are one of the industry's most pressing problems and cost the processed potato industry collectively around $50 million per year. The program seeks to provide a balance of basic, strategic and applied research. The program also seeks to provide short and medium term outcomes, and also increase industry support and involvement. The intent is to have a large integrated program that provides for the structured acquisition of information and also delivers decision support systems.

The work also involves collaboration with New Zealand and Canada, as the diseases being studied are present in other countries.

The focus of this analysis is Subprogram 1, the DNA monitoring tools subprogram which is managed by Dr Kathy Ophel-Keller from SARDI and runs from July 2004 to June 2009.

2. The Cluster

Project Objectives

The objectives of Subprogram 1 are:

- Develop validated quantitative soil assays for common scab, powdery scab and *Rhizoctonia*
- Determine critical soil pathogen thresholds for potato disease
- Provide an assay service to the research program for the target potato pathogens

Project Investment

Table 1 shows the annual investment by project for HAL; this funding includes any voluntary contributions made by industry.

Table 1: Investment by Project by HAL Including Both Levy and Voluntary Contributions (nominal $)

Year ending June	HAL (includes government, compulsory and voluntary levies)	Research partners (cash and in-kind)	Total
2005	252,911	393,918	646,830
2006	301,492	397,715	699,207
2007	298,971	396,309	695,280
2008	234,218	397,322	631,540
2009	243,360	392,000	635,360
Total	1,330,952	1,977,264	3,308,217

3. Activities and Outputs

The outputs to date from the subprogram are scientific findings that are split into those relating to bioassays, and those relating to soil analysis.

Bioassays

- There is an excellent correlation between the DNA test for powdery scab and bioassays. The bioassay data and field data combined give a putative damage threshold for powdery scab at about 800-1000 pg/g soil.
- The DNA assays can be used effectively to quantify pathogens on peel. Results to July 2007 indicated that pathogen levels as measured by DNA are higher than those observed by visual assessment, and that even visually clean seed carried pathogen DNA. It was also found that visual assessment can confuse symptoms of powdery scab, common scab and *Meloidogyne fallax* damage on field-grown tubers.
- A specific quantitative real-time PCR test was developed for *Meloidogyne fallax*. The *M. fallax* test can quantify 2 eggs/g of soil.
- The sensitivity of the common scab and powdery scab tests was improved. The powdery scab test was available prior to commencement of the project and was not modified, but the sensitivity was increased through combining it with a more robust soil DNA extraction system. The common scab test was modified in order to increase sensitivity. In trials with artificial inoculums the DNA test appears to detect the economic damage threshold.
- Thaxtomin A gene assay (txtA) is the most robust primer for detecting Streptomyces scabies capable of causing common scab.
- In glasshouse experiments the txtA assay results showed a strong relationship between seed-borne *Streptomyce*s DNA levels on peel and incidence and severity of common scab on tubers.
- In summary, new tests were developed for Rhizoctonia and *Meloidogyne fallax,* while the sensitivity of existing tests for common scab and powdery scab were improved.

All tests were developed in the same assay platform so that they can be delivered together.

Soil Analysis

- Information on pathogen distribution from intensive field sampling shows that pathogen distribution in soil is highly variable.
- A survey of soils from South Australia, Victoria and Tasmania revealed that *M. fallax* was present in 59% of SA soils with levels ranging from 0 to 20 eggs/g soil. The nematodes were less frequent and at lower levels in Tasmania (23% of samples with *M. fallax* levels up to 1 egg/g soil) and Victoria (19% of samples with *M. fallax* levels up to 1 egg/g soil).
- In Victorian field tests it was found that the level of common scab DNA in soil at planting had a greater effect on disease symptoms than the level of common scab DNA on the seed piece skin. This was also true for powdery scab. However the level of AG3 DNA in the soil at planting was the best indicator of black scurf at harvest, and the severity of black scurf on seed at planting was the best indicator of stem canker at 11 weeks followed by the level of AG3 DNA in the soil at planting.
- There was found to be a correlation between common scab incidence and the amount of pathogenic Streptomyces DNA/gram of soil prior to planting. A preliminary inoculum threshold of soil prior to planting would be greater than 200 pg pathogenic Streptomyces DNA/gram soil to cause significant disease at harvest.
- Field results indicate that there is a significant disease risk when pathogen soil DNA levels are greater than:
    - 1000 pg DNA/ g soil for *Spongospora subterranea*
    - 200 pg DNA/g soil for *Streptomyces scabies*
    - 25 pg DNA/g soil for *Rhizoctonia solani* AG-3
    - 1000 g DNA / g soil for *Rhizoctonia solani* AG-2.1
- Results also indicate other factors are critical for disease development, particularly seed inoculum level, as well as environmental conditions during the growing season.

Communication outputs

Other outputs include presentations, publications and field days including:

- An oral presentation was given to the 16th Australasian Plant Pathology Conference in September 2007.
- Findings of the research were presented to the biannual meeting of the PPIAC in March 2008.
- A field day was held in Ballarat in June 2008, which was attended by 50 growers and industry representatives.
- A Cora Lynn Field day was held in July 2008.
- Papers were presented at the 2nd European Powdery Scab Workshop in Switzerland in September 2007, at the International Congress of Plant Pathology in Italy in August 2008, and the 4th International Symposium on Rhizoctonia in Germany.
- Findings of the research were presented at the ARPRP Technical Symposium in October 2008.

4. Outcomes

The DNA tests developed to quantify pathogens in soil and on potato peel are useful for quantifying pathogen loads on seed at planting. They are also a useful research tool for accurately measuring pathogen levels on daughter tubers.

The DNA tests developed in the program were run to assist with research in Subprograms 3 and 4 to monitor rotations and amendment trials.

In relation to commercialisation of the tests, outcomes to date include:

- Material Transfer Agreements have been completed with the New Zealand Institute for Crop and Food Research and Scottish Crops Research Institute for transfer of specific *Rhizoctonia* anastomosis group primers and probes.
- Discussions regarding commercialisation were held between Greg Skinner, Bayer Crop Science and Iain Kirkwood, PPRD Coordinator.
- A methodology for transferring the DNA probes within the PPRD program was agreed where SARDI will administer Material Transfer Agreements on behalf of PPRD, recognising the equity arrangements agreed in the PPRD Program.
- The July 2007 to Dec 2007 milestone report notes that commercialisation plans for the DNA probes were disrupted by Bayer withdrawing from the probe development/commercialisation process.

The tests have been run on grower paddocks as part of this project, and tests have been provided to industry groups such as Agronico to test on seed potato paddocks on a fee for service basis with a proviso that the tests are still under evaluation. Robust thresholds, validated in a range of environments, are required as well as a clearer understanding of the role of seed inoculum.

The tests will be used to assess risk of disease from both soil and seed. The tests are not a management practice in themselves, but rather are a key step in delivery of management options to control risk. They are used as the initial decision point indicating whether control treatments are required. The tests developed and improved have significant benefits compared to previous technologies including speed, accuracy, sensitivity, specificity, and being better targeted with improved understandings of thresholds and sampling strategies.

A second phase of research has been funded and is about to commence, that will further improve the interpretation of the tests for use in quantifying soil-borne inoculums, so that the tests can then be used by growers to assess disease risk prior to planting a crop. The second phase of the project will also have input from the fresh potato industry, as well as from the United Kingdom, New Zealand and Canada.

5. Benefits

Potential benefits to the processed potato industry are from the use of the tests developed to quantify pathogens and include:

- Reduced probability of disease outbreaks for processed potatoes, due to improved identification and quantification of disease potential from seed and soil. This will allow improved decision making by growers with respect to disease management options when planting a crop.
- The test may also be of value in accurately determining disease levels when certifying seed potatoes, and in determining appropriate maximum acceptable levels of disease on seed potatoes.
- The reduced probability of disease outbreak will potentially result in reduced production losses to disease.
- There were some benefits to other parts of the research program (Subprograms 3 and 4), through having access to technology to rapidly measure inoculums of multiple pathogens in soil and on seed. This has been of particular use in SP4 to monitor inoculums changes with rotation.
- The ability to assess disease risk prior to planting a crop may lead to decreased use of chemicals if the soil/seed test showed that inoculums levels were low risk.
- Due to the structure of the program there were a number of benefits from this subprogram, and the program as a whole with respect to building research/industry relationships. For example, a close relationship was developed between the researchers and McCains in this subprogram when evaluating the DNA tests in SA and Victoria.
- The tests will also have the potential to be used by potato growers overseas, with the United Kingdom, New Zealand and Canada all being involved in the second phase of the project.
- The use of the tests may lead to reduced use of chemicals and more reliance on chemicals, and therefore there will be decreased risks for environmental and human health associated with using such chemicals.

Summary of Benefits

A summary of the principal types of benefits associated with the outcomes of the project is shown in Table 2.

Table 2: Categories of Benefits from the Investment

Levy Paying Industry (processed potatoes)	**Spillovers**		
	Other Industries	**Public**	**Foreign**
Economic Benefits			
Reduced rejection of processed potatoes due to quality concerns.	Reduced rejection of fresh potatoes due to quality concerns.		Reduced rejection of potatoes due to quality concerns for foreign potato industries who also use the research outputs.
Environmental Benefits			
		Reduced chemical use and therefore reduced risk to the environment.	
Social Benefits			
Improved cooperation in industry, resulting in capacity building of researchers and industry. Reduced chemical use and therefore reduced risk to human health.		Reduced chemical use and therefore reduced risk to human health.	

Public versus Private Benefits
The majority of the benefits that will arise from the investment in the project will be private in nature. The private benefits will be captured largely by the processed potato sector. These private benefits will be in the form of reduced damage due to disease, and therefore reduced rejection of potatoes by processors. There will also be some private benefits to the industry through improved relationships and capacity building in the research sector. The public benefits are in the form of potentially reduced use of chemicals and fungicides, when the tests determine that such treatment is not required or appropriate.

Distribution of Benefits Along the Potato Supply Chain
Benefits will be captured by both processed potato growers, and the processing companies themselves, through the availability of greater quantities of quality potatoes for processing.

Benefits to other Primary Industries
There will be benefits to the fresh potato industry, and also potentially the seed potato industry. There are likely to be limited benefits to other primary industries, however there is the possibility that some scientific findings may be relevant to other vegetable crops.

Benefits Overseas
There will be some benefits to overseas countries whose fresh and processed potato industries may also make use of the diagnostic tests, including Canada, New Zealand, and the United Kingdom.

Additionality and Marginality
Supporting these studies was a high priority for the processed potato R&D Program as disease is one of the significant factors limiting the quality of potatoes. Further detail is provided in Table 3.

Table 3: Potential Response to Reduced Public Funding to HAL

1. What priority were the projects in this cluster when funded?	High
2. Would HAL and industry have funded this cluster if only half of public funding of HAL had been available?	Yes, but with a lesser total investment (perhaps 75%)
3. Would the cluster have been funded if no public funding for HAL had been available?	Yes, 50% of that actually funded

Match with National Priorities
The Australian Government's national and rural R&D priorities are reproduced in Table 4.

Table 4: National and Rural R&D Research Priorities 2007-08

Australian Government	
National Research Priorities	**Rural Research Priorities**
1. An environmentally sustainable Australia 2. Promoting and maintaining good health 3. Frontier technologies for building and transforming Australian industries 4. Safeguarding Australia	11. Productivity and adding value 12. Supply chain and markets 13. Natural resource management 14. Climate variability and climate change 15. Biosecurity *Supporting the priorities:* 1. Innovation skills 2. Technology

The major focus of the projects in this cluster has been on the first Rural Research Priority, and to some degree the second Rural Research Priority. The third National research priority has also been addressed.

6. Measurement of Benefits

As part of the development of a Phase 2 project that builds on the research of this subprogram, an ex-ante benefit-cost analysis was conducted by Ian Black of SARDI. The ex-ante analysis quantifies the benefits from Subprogram 1, as well as Phase 2. That analysis forms the basis of the framework and many of the assumptions used here to analyse the impacts from Subprogram 1.

The analysis assumes that the processed potato industry will benefit from the research through a decrease in the proportion of diseased potatoes that are rejected. It is assumed that currently, the rejection rate is 20%, and that through using the tests a grower can reduce this rejection rate to 10%.

The average area of processed potatoes grown in Australia in 2005/06 and 2006/7 was 19,047 hectares, with an average production of 770,641 tonnes and an average yield of 40 tonnes per hectare. It is assumed that the reduced rejection rate of 10% is equivalent to obtaining an additional 10% saleable yield per hectare. However, as the demand for potatoes is not expected to increase significantly, this benefit is measured through a cost reduction, rather than valuing the increased yield. For the purposes of the analysis, it is assumed that the cost of production is equal to the average price for processed potatoes ($280/t). At the base yield of 40 t/ha, this equates to a production cost of $11,200/ha. When the yield is increased by 10% to 44 t/ha, the cost of production per tonne is reduced to $254/t if it is assumed the costs of production per hectare do not change. Therefore, a cost saving of $25.50 per tonne is realised. This cost reduction is assumed to be an average benefit across all growers who “use the tests”.

It is assumed that a maximum of 70% of the processed potato industry will adopt the tests, and that adoption will commence in 2014/15, after the completion of the second phase of investment. It is assumed that adoption will be linear, and take place over seven years (with maximum adoption occurring in 2020/21).

The total cost of the test is $350 per test, with one test required for every 10 ha of planted potatoes. Therefore the cost is equivalent to $35/ha.

It is assumed that for those who use the test, 60% of tests will show that some action is required on the part of the grower in order to minimise disease impact. For the 60% where action is required, it is assumed that 80% take an action that results in a 3% yield decrease for the potatoes that are not thrown out in order to improve the quality. This means that most actions result in a higher sale of potatoes due to less being rejected but yield of the accepted potatoes is actually lower.

These actions will include either moving to another area to grow potatoes, or using a disease resistant but lower yielding cultivar. The remaining 20% are assumed to use a fungicide treatment with a cost of $180/ha and do not have a yield decrease.

In order to achieve these assumed benefits, an additional research program is required (Phase 2 about to commence) together with an investment in extension of the tests to the industry. The benefits to the PT04016 Subprogram 1 investment are therefore taken as a proportion of the total benefits, using the proportion of Subprogram 1 costs of the total investment as a dilution factor. The assumed costs for Phase 2 and the extension investment are as presented in Table 5.

Table 5: Additional Research and Extension Costs Required to Achieve Assumed Benefits

Year ending June	Costs ($)
2010	823,999
2011	852,838
2012	804,761
2013	752,493
2014	869,655
2015	100,000
2016	100,000
2017	100,000
Total	4,403,746

It is also assumed that some of the other subprograms within the overall project (PT04016) may have made some contributions to the ultimate benefits assumed, and therefore only 75% of the total benefits estimated are attributed to Subprogram 1. Also, due to Phase 2 not having yet commenced, a probability of success of the Phase 2 research of 75% is assumed.

Summary of Assumptions

A summary of the key assumptions made is shown in Table 6.

Table 6: Summary of Assumptions

Variable	Assumption	Source
Hectares of processed potatoes	19,047 hectares	Ausveg
Total production of processed potatoes	770,641 tonnes	Ausveg
Average yield of processed potatoes	40 t/ha	Ausveg
Proportion of industry	70%	Ian Black, SARDI

adopting tests at maximum adoption		
Proportion of those adopting who are required to take action	60%	Ian Black, SARDI
Assumed yield increase due to research	10%	Ian Black, SARDI
Cost of production of processed potatoes without research	$280/t	Derived from Ausveg
Cost of production of processed potatoes after yield increase due to research	$254/t	Derived
Cost reduction due to research	$25.50/t	Derived
Proportion of those making changes and have less potatoes rejected who experience a yield decrease to achieve quality increase	80%	Ian Black, SARDI
Assumed yield decrease for those achieving a quality increase	3%	Ian Black, SARDI
Proportion of those making changes who use fungicide	20%	Ian Black, SARDI
Cost of fungicide	$180/ha	Ian Black, SARDI
First year of benefit	2014/15	Ian Black, SARDI
Time from fist year of benefit to maximum benefit realised	7 years	Ian Black, SARDI
Attribution of total benefits to PT04016 Subprogram 1 (versus other subprograms in PT04016)	75%	Agtrans Research
Probability of success of Phase 2 research	75%	Agtrans Research

Benefits not valued

Some potential benefits have not been valued, including the potential benefit to the fresh potato industry, any potential international benefits through use of the tests overseas, and any cost reduction to those who use the test to avoid taking unnecessary disease control measures.

7. Results

All past costs and benefits were expressed in 2008/09 dollar terms using the CPI. All benefits after 2008/09 were expressed in 2008/09 dollar terms. All costs and benefits were discounted to 2008/09 using a discount rate of 5%. The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for many of the estimates. Investment criteria were estimated for both total investment and for the HAL investment alone. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2008/09) to the final year of benefits assumed (2038/39).

Table 7 shows the investment criteria for the different periods of benefits for the total investment. Table 8 shows the investment criteria for the different periods of benefits for the HAL investment only.

Table 7: Investment Criteria for Total Investment
(discount rate 5%)

Years	0	5	10	20	30
Present value of benefits ($m)	0	0	3.93	16.95	25.08
Present value of costs ($m)	3.87	3.87	3.87	3.87	3.87
Net present value ($m)	-3.87	-3.87	0.06	13.08	21.21
Benefit–cost ratio	0	0	1.0 to 1	4.4 to 1	6.5 to 1
Internal rate of return (%)	neg	neg	5.2	15.7	16.7

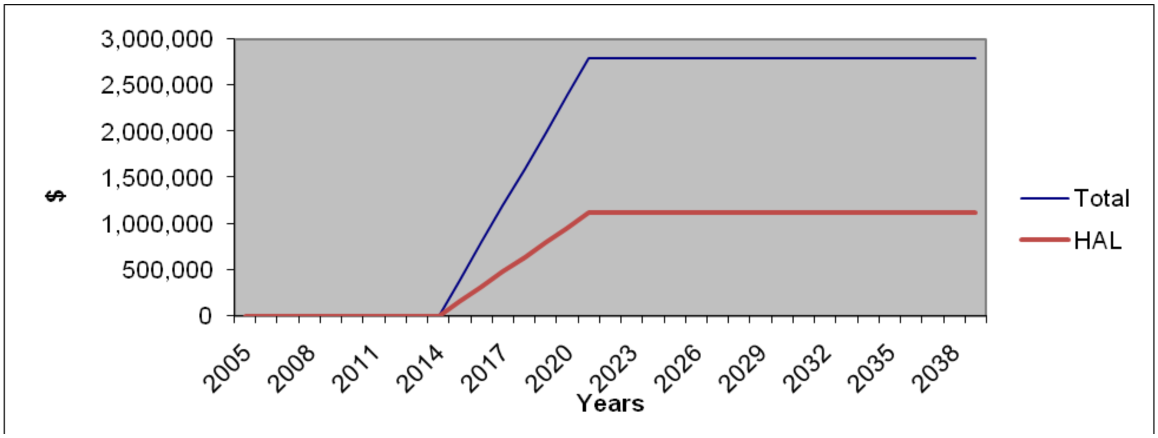
Table 8: Investment Criteria for HAL Investment
(discount rate 5%)

Years	0	5	10	20	30
Present value of benefits ($m)	0	0	1.58	6.83	10.10
Present value of costs ($m)	1.56	1.56	1.56	1.56	1.56
Net present value ($m)	-1.56	-1.56	0.02	5.27	8.54
Benefit–cost ratio	0	0	1.0 to 1	4.4 to 1	6.5 to 1
Internal rate of return (%)	neg	neg	5.1	15.7	16.7

These results are lower than those reported in the ex-ante analysis carried out for Phase 2 of the program, which is largely due to the current analysis quantifying the return to the initial research project only. In addition, some additional conservative assumptions have been made through the exclusion of potential benefits to the fresh industry, and the inclusion of a probability of success of the Phase 2 research project.

The cash flow of benefits is shown in Figure 1 for the total and HAL investment.

Figure 1: Annual Cash Flow of Benefits



Sensitivity Analyses

Sensitivity analyses were carried out on a range of variables and results for the total investment are reported in Tables 9 to 11. All sensitivity analyses were performed using a 5% discount rate with benefits taken over the life of the investment plus 30 years from the year of last investment. All other parameters were held at their base values.

Table 9: Sensitivity to Discount Rate
(Total investment, 5% discount rate, 30 years)

	Discount rate		
Criterion	0%	5% (base)	10%
Present value of benefits (m$)	61.50	25.08	11.68
Present value of costs (m$)	3.49	3.87	4.29
Net present value (m$)	58.01	21.21	7.38
Benefit cost ratio	17.6 to 1	6.5 to 1	2.7 to 1

Table 10: Sensitivity to Assumed Cost Reduction
(Total investment, 5% discount rate, 30 years)

	Cost reduction (yield increase)		
Criterion	5%	10%	15%
Present value of benefits (m$)	9.90	25.08	38.94
Present value of costs (m$)	3.87	3.87	3.87
Net present value (m$)	6.03	21.21	35.07
Benefit cost ratio	2.6 to 1	6.5 to 1	10.1 to 1
Internal rate of return (%)	10.4	16.7	20.0

Table 11: Sensitivity to Assumed Increase in Proportion of Industry Adopting

Use of the Test
(Total investment, 5% discount rate, 30 years)

	Adoption		
Criterion	20%	70%	90%
Present value of benefits (m$)	7.17	25.08	32.25
Present value of costs (m$)	3.87	3.87	3.87
Net present value (m$)	3.30	21.21	28.38
Benefit cost ratio	1.9 to 1	6.5 to 1	8.3 to 1
Internal rate of return (%)	8.5	16.7	18.6

The sensitivity analyses demonstrate that the investment criteria are highly sensitive to the discount rate, largely due to the long period between the research being completed and the benefits commencing. The investment criteria are relatively robust to movements in some of the other key assumptions.

8. Confidence Rating

The results produced are highly dependent on the assumptions made, many of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 12). The rating categories used are High, Medium and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some significant uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 12: Confidence in Analysis of PT04016 Subprogram 1

Coverage of Benefits	**Confidence in Assumptions**
High	High

9. Conclusions

This project is focused on the improvement of the quality of processed potatoes in Australia, through providing tools to assist with identifying disease risk, and selecting appropriate treatment options. The analysis has shown that the research to date has been successful but that further research is required to further develop tests and make them suitable for widespread adoption by processed potato growers. This is being undertaken in a Phase 2 project. The potential benefits from an increase in the quality of processed potatoes has been quantified, and it was found that it is likely the research has resulted in significant benefits, with a Net Present Value of $21.2m and a Benefit to Cost Ratio of 6.5 to 1 (over 30 years, at a discount rate of 5%).

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APPENDIX 4: An Economic Analysis of HAL Investment in the Potato Agronomy and Production Management Cluster

1. Background

The Australian potato crop averaged 1.29 million tonnes and was valued at $556 million over the three years to 30 June 2008 (AUSVEG analysis of ABS data). Victoria, South Australia and Tasmania produce almost 80% of production. Production fell 1995 to 2007 before rebounding in 2008. Production costs are rising, consumption is declining and low cost imports threaten the domestic potato industry.

Approximately 44% of Australian production is marketed in a fresh form (36% sold as fresh potatoes for consumption, 8% sold as seed potatoes). Some 56% of production is sold for processing (42% frozen, 14% crisping).

Fresh potatoes are marketed through wholesalers, independent retailers and supermarkets. Only a small proportion of the fresh potato crop is exported (7% by value) and exports are mainly directed to South East Asia and South Korea. There is little growth in exports and the search for export markets is underway although hindered by trade barriers. At the current time the volume of low cost fresh imports is small.

Total per capita potato consumption is currently around 63 kg. The proportion of fresh potato consumption has declining as processed potato consumption has increased.

The frozen processing potato industry is dominated by McCain Foods (Canada) and Simplot (US). Processing plants are located in Tasmania, South Australia and Victoria. The two major large crisping companies are Arnott's (Campbell's) and Smiths (Frito-Lay). Most crisping potatoes are grown under contract and crisping plants are located nationally.

Research and development (R&D) levies are in place for both the fresh and processing potato industries. Grower levies collected from the processing industry are matched by processors through the Potato Processing Association of Australia (PPAA). R&D levies collected from both industries are matched by the Australian Government.

AUSVEG is the peak industry body for both the Australian fresh and processing potato industries. The vision for the fresh potato industry is to enhance the profitability and sustainability of the industry by increasing the value of the fresh potato category. The vision for the Australian processing potato industry is that it will be sustainable and globally competitive and driven by consumer needs.

These visions will be achieved by industry who will deliver four strategic imperatives:

1. Improve consumer demand for Australian potatoes;
2. Increase industry competitiveness;

3. Improve industry communication and information systems; and
4. Improve leadership and management capability.

Strategic imperative two is relevant to the agronomy and production management cluster of R&D investments.

The agronomy and production cluster analysed in this economic evaluation addressed:

- Agronomy and crop management – for the french fry industry, for export potatoes, for seed potato quality, production of small round seed (SRS) for processing potatoes and development of a young professionals network.
- Pests and diseases – viruses (control in certified seed), funguses, disease research priorities, disease status and management on Kangaroo Island, soil insects, monitoring district wide insect movements, monitoring pests and diseases, crop rotations to manage soil borne pests/disease and improved biological pesticides.

Investments focus on the creation of technologies to improve potato yield, lower production costs and secure new markets.

2. The Cluster

Projects

Table 1 presents the details for each of the sixteen projects included in the potato agronomy and production management cluster.

Table 1: Summary of Potato Agronomy and Production Management Projects

Project Number	Project Title	Other Details
PT01008	Monitoring and developing management strategies for soil insect pests of potatoes	Organisation: Department of Agriculture & Food, Western Australia Period: July 2001 to January 2004 Principal Investigator: Stewart Learmonth
PT01041	Crop management tools for the French fry industry in the south east of South Australia	Organisation: South Australia Research & Development Institute (SARDI) Period: December 2001 to March 2006 Principal Investigator: Robert Peake
PT02012	Optimising production and storage conditions for seed potato physiological quality	Organisation: University of Tasmania Period: July 2002 to July 2005 Principal Investigator: Philip Brown
PT02014	Sustainable agronomy packages for export potatoes	Organisation: Department of Agriculture & Food, Western Australia Period: July 2002 to January 2006 Principal Investigator: Ian McPharlin

PT02036	Disease management of potatoes on Kangaroo Island	Organisation: South Australia Research & Development Institute (SARDI) Period: August 2002 to May 2004 Principal Investigator: Trevor Wicks
PT02037	Strategy for management of viruses from certified seed potato stocks	Organisation: University of Tasmania Period: October 2002 to March 2004 Principal Investigator: Frank Hay
PT02045	The monitoring of potato crops for insect movement on a district scale	Organisation: Ag-Challenge Pty Ltd Period: February 2003 to August 2005 Principal Investigator: Tony Pitt
PT02047	Minimising virus infection in early generation seed potato crops in Western Australia *(Final Report: "Virus testing of early generation seed potato crops in WA")*	Organisation: Department of Agriculture & Food, Western Australia Period: February 2003 to December 2003 Principal Investigator: Mark Holland
PT02048	Developing a pests and disease crop monitoring program for Western Australian seed potato crops	Organisation: Department of Agriculture & Food, Western Australia Period: February 2003 to December 2003 Principal Investigator: Mark Holland
PT03041	Potato disease control research priorities	Organisation: Horticulture Australia Ltd Period: July 2003 to May 2004 Principal Investigator: John Oakeshott
PT06044	Improving management of Potato Virus S through a better understanding of mechanisms of virus transmission.	Organisation: University of Tasmania Period: May 2007 to July 2009 Principal Investigator: Susan Lambert
PT97015	New chemical treatments for fungal diseases of seed potatoes	Organisation: Agriculture Victoria Period: 2001 to 2004 Principal Investigator: Rudolf de Boer
PT99022	An agronomic and economic blueprint for using whole, round seed for processing potatoes	Organisation: Davey & Maynard Period: July 1999 to May 2004 Principal Investigator: John Maynard
VX00013	Biofumigation - optimising biotoxic Brassica rotations for soil-borne pest and disease management	Organisation: CSIRO Entomology Period: July 2000 to October 2003 Principal Investigator: John Matthiessen
VX01006	Developing cost effective UV protection of biological pesticides	Organisation: The University of Sydney Period: December 2001 to March 2005 Principal Investigator: Brian Hawkett
VX01026	Building strategic alliances with young Australian and New Zealand vegetable and potato industry representatives	Organisation: AUSVEG Ltd Period: April 2002 to September 2002 Principal Investigator: Brian Newman

Project Objectives

Table 2 presents the objectives for each of the projects included in the cluster.

Table 2: Description of Project Objectives

Project Number	Objectives
PT01008	• To improve the ability of growers to determine whether potato crops face risk of damage from the better known soil insect pests by providing tools to define pest populations and the risk of damage prior to applying a pre-plant soil pesticide. • To implement appropriate management strategies for the use of soil pesticides to minimise or eliminate the risk from soil insect pests. • To confirm the distribution and occurrence of the main soil insect pests of potatoes Australia wide and clarify the situation regarding reports of damage by other less well-known soil insects. • To clarify the identity and pest status of the less well understood soil insect pests such as cockchafers and rice root aphid and investigate management options.
PT01041	• To collect and adapt crop management technologies and tools to improve the quality, yields and production efficiencies of French fry potatoes produced in the South East region of South Australia.
PT02012	• To understand the factors that influence seed physiological age (which refers to the tubers internal processes rather than its chronology) in order to produce seed of desired quality. Seed physiological age is thought to have a direct bearing on product quality and yield. Different physiological age profiles are required for the fresh and processed potato industries.
PT02014	• To gather and create agronomic information packages for Australian growers regarding export potato crisp and potato seed production. • To maximise Small Round Seed (SRS) yield by examining factors other than plant spacing density and harvest timing, such as use of growth regulators and manipulation of seed age using varieties important in the export seed market.
PT02036	• To provide a base level of information to allow the fledgling Kangaroo Island seed potato industry to make informed decisions on how best to develop disease and risk management plans to continue producing high health status and quality seed potatoes.
PT02037	• To gather data on virus incidence in Tasmanian potato seed crops and to prepare a comprehensive review of literature on the topic. • To develop management strategies to reduce infection levels / eliminate targeted viruses from certified seed stocks in Tasmania and other States. • To obtain information on the economic penalty resulting from abundant viruses found under local conditions in Australian grown varieties, the mode and rate of reinfection of healthy crops, sources of inoculum and means of transmission.

PT02045	• To determine how a district based crop monitoring program in Gippsland would operate, what sort of information and benefits it would generate for improved potato crop management and to implement such a service in Gippsland for the 2002/2003 season, making use of existing information and observations that were available from a multiple of sources.
PT02047	• To establish the virus status of WA certified and registered seed potatoes by testing Generation 2 sown crops during the 2002/03 season so as to assist and demonstrate the advantages to seed growers of identifying Generation 3 seed lots infected by WA's four most serious seed-borne virus diseases: Potato Leaf Roll Virus (PLRV), Tomato Spotted Wilt Virus (TSWV), Potato Virus S (PVS), Potato Virus X (PVX). In addition, samples were tested for the presence of Potato Virus Y (PVY), a serious virus disease of potatoes never previously found in WA by serological methods. • To assist the seed certification authority to evaluate the effectiveness of the two schemes to control viruses.
PT02048	• To develop a pests and disease crop monitoring program for WA seed potato crops. • Crop monitoring has the potential to lower insecticide use, result in production cost savings and decrease the risk of insect virus vectors developing insecticide resistance.
PT03041	• To prepare a business plan that sets priorities and 'kick starts' an R&D program for potato processors.
PT06044	• To provide further information to seed growers to enhance the effectiveness of management strategies put in place to eliminate PVS and PVX in Tasmanian seed potatoes. • PVS, for example, can reduce the yield in Russet Burbank crops by up to 10%.
PT97015	• To evaluate chemical treatments (fungicides) used on seed potatoes for the control of diseases passed from mother tuber to daughter tuber. • The project would provide potato growers with more options for the control of seed-borne diseases and information on the most appropriate and effective use of chemical treatments for disease management.
PT99022	• To prepare an agronomic and economic blueprint for using whole round Russet Burbank seed for processing potatoes and to estimate the potential benefits of processing growers using round seed. • Round seed offers elimination of the seed cutting process, reduced levels of disease, more uniform crops and improved yields. It also offers benefits for the processing industry – more uniform raw material with higher recovery rates. However, current weight based payment methods for seed growers inhibit the switch to whole round seed.
VX00013	• To optimise biotoxic Brassica rotations for soil-borne pest and disease management. • To further the systematic development of biofumigation using brassicas as an option giving a broad range of horticultural producers wider choice in

	methods to combat soil pests and diseases, and promote soil health and production systems and pest management practices that are sustainable in the long term. • Biofumigation is needed as Methyl bromide is faced out under the Montreal Protocol and questions are raised about the economics and sustainability of its replacement, metham sodium.
VX01006	• To develop a cost effective tank mix additive based on titanium dioxide (or a similar screening agent) that is compatible with a wide range of formulation types so that it may be used as a UV screen to protect both biological and hard chemical actives from UV degradation. • If a cost-effective generic UV protection technology could be developed, many presently non-viable biological pesticides would become available for incorporation into IPM programs. Moreover, many of those currently in use could be made much more efficacious, require less frequent application and more effectively displace chemical alternatives.
VX01026	• To build strategic alliances with young Australian and New Zealand vegetable and potato industry representatives. • Twelve young potato growers visited NZ in 2002 to attend the NZ Horticultural Industries Conference and visit production areas and companies involved in packing and marketing vegetables.

Project Investment

Table 3 shows the annual investment by project for HAL and Industry. Contributions from other sources, including the research provider are shown in Table 4.

Table 3: Investment per Project by HAL Including Both Levy, Government Matching and Voluntary Contributions (Potato Agronomy and Production Management Cluster)

Project Number	HAL and Industry Year ending 30 June ($)										
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
PT01008	-	88,000	92,500	88,000	10,000	-	-	-	-	-	278,500
PT01041	-	-	-	11,818	10,000	-	10,000	-	-	-	31,818
PT02012	-	-	60,000	60,000	50,000	10,000	-	-	-	-	180,000
PT02014	-	-	90,000	100,500	42,500	5,000	5,000	-	-	-	243,000
PT02036	-	-	-	-	10,000	-	-	-	-	-	10,000
PT02037	-	-	104,935	5,000	-	-	-	-	-	-	109,935
PT02045	-	-	2745	-	-	720	-	-	-	-	3,465
PT02047	-	-	-	4,000	-	-	-	-	-	-	4,000
PT02048	-	-	-	38,182	-	-	-	-	-	-	38,182
PT03041	-	-	-	6,560	-	-	-	-	-	-	6,560
PT06044	-	-	-	-	-	-	6,900	-	-	1,725	6,900
PT97015	184,598	69,607	5,000	5,000	-	-	-	-	-	-	264,205
PT99022	65,660	55,490	-	-	25,500	-	-	-	-	-	146,650
VX00013	-	23,749	25,612	22,873	-	-	-	-	-	-	72,234
VX01006	-	11,250	8,250	-	2,648	-	-	-	-	-	22,148
VX01026	-	25,000	-	5,000	-	-	-	-	-	-	30,000
Total	250,258	273,096	389,042	346,933	150,648	15,720	21,900	-	-	1,725	1,449,322

Source: HAL Project Database

Table 4: Investment by Project by Other Sources Including Research Provider Contributions (Potato Agronomy and Production Management Cluster)

Project Number	Other Sources Year ending 30 June ($)										
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Total**
PT01008	-	62,058	65,232	62,058	7,052	-	-	-	-	-	196,400
PT01041	-	-	-	8,357	7,071	-	7,071	-	-	-	22,500
PT02012	-	-	22,667	22,667	18,889	3,778	-	-	-	-	68,000
PT02014											
PT02036					29,580			-	-	-	29,580
PT02037	-	-	64,996	3,097	-		-	-	-	-	68,093
PT02045			3,355								3,355
PT02047				7,000					-	-	7,000
PT02048	-			7,000				-	-	-	7,000
PT03041											
PT06044	-	-	-	-	-	-	64,413	-	-	16,103	80,516
PT97015											
PT99022											
VX00013	-	43,951	47,399	42,330	-	-	-	-	-	-	133,680
VX01006	-	66,121	48,489	-	15,560	-	-	-	-	-	130,170
VX01026											
Total	**-**	**172,130**	**252,137**	**152,509**	**78,153**	**3,778**	**71,484**	**-**	**-**	**16,103**	**746,294**

Source: HAL Research Agreement Schedule Reports

An annual summary of investment in the Potato Agronomy and Production Management cluster is provided in Table 5.

Table 5: Investment in Potato Agronomy and Production Management Cluster

Year ending 30 June	**HAL and Industry** (nominal $)	**Other Sources** (nominal $)	**Total** (nominal $)
2001	250,258	-	252,259
2002	273,096	172,130	447,228
2003	389,042	252,137	643,182
2004	346,933	152,509	501,446
2005	150,648	78,153	230,806
2006	15,720	3,778	21,504
2007	21,900	87,587	111,494
2008	-	-	-
2009	-	-	-
2010	1725	-	-
Total	**1,449,322**	**746,294**	**2,207,919**

3. Activities and Outputs

Table 6 provides a brief summary of outputs for each of the projects.

Table 6: Summary of Potato Agronomy and Production Management Cluster Activities and Outputs

Project	Activities and Outputs
PT01008	• The soil insect pest monitoring and management project studied insect populations prior to planting potatoes and the efficiency of current and new insecticides post planting. • The study identified the main soil insect pests of potatoes and made recommendations in relation to their monitoring and control.
PT01041	• The crop management tools for the SA french fry industry project reviewed existing tools with growers and delivered a folder that consisted of checklists, measurement-recording pages, texts of information on potential pests and diseases for growers. • The study concluded that SA crop management by growers was sound and that only incremental improvements associated with nitrogen application rate determination, budgeting and general management were possible. Nevertheless these changes would result in substantial yield improvements.
PT02012	• The optimising seed potato physiological quality project revealed that factors other than the inherent physiological quality of the tuber at the point of planting have a significant impact on stem number and subsequent growth and performance of the crop. Therefore specific recommendations for seed crop management and storage could not be made. • Trials demonstrated that crop management practices and growing climate of the previous generation(s) of seed potatoes can have a significant effect on physiological ageing. Soil type and temperature, particularly seasonal variations in night/day temperature, may have contributed to this result.
PT02014	• The agronomy for export potatoes project revealed that locally developed varieties outperformed those currently used by SE Asian export customers. Improved performance indicators included increased yield (20% to 27%) and lower nitrogen use. Applying gibberellic acid (GA) was an effective way of creating more SRS yield. Removal or pruning shoots from germinated seed prior to planting increased the number of stems and resultant yield. The use of paclobutrazol (PBZ) and carvone to increase SRS yield doesn’t appear to be commercially viable.
PT02036	• Sampling of all potato fields to determine what potato diseases occur on Kangaroo Island, visit growers and educate them on the importance of producing healthy crops and help growers recognise and control potential diseases. • Recommendations included retention of quarantine restrictions on the importation of potatoes to Kangaroo Island, the encouragement of growers to continue testing planting material for the presence of disease before planting and further investigations to develop management practices for the control of black scurf.

PT02037	• Delivery of the strategy for management of viruses in seed potato stocks included literature review and a field survey. • Outputs included recommendations for management strategies to control common latent viruses. Information generated included the economic penalty for abundant viruses found under local conditions in Australian grown potato varieties, the mode and rate of reinfection of healthy crops, sources of inoculum and the means of transmission.
PT02045	• The Gippsland district wide crop monitoring for insects project included scoping the crop monitoring service with growers, project implementation and review. • Project outputs included weekly reports for growers throughout the 2002/03 season. Reports included aphid trap results, entomologist reports and interpretation. A review of the project concluded that its operation increased grower awareness of the viral threat posed by winged aphids and the importance of informal information sharing. The review also found that while district wide data provided useful crop management information, to be really effective growers need to take the extra step and observe each individual crop to see whether aphids are present and if so, whether they are the winged or wingless forms. Winged forms spread potato viruses.
PT02047	• Activities included sampling, testing and reporting Generation 2 seed potato crop and leaf sample results from all 21 WA grower properties. • Results of the survey show 139 positive results for virus infection from 10,450 plants tested equalling an infection rate of 1.3%. No virus was detected in seven growers' crops. • The results were used by seed growers to identify any emerging viral problems and the lots most at risk so as to determine the appropriate remedial action. • The testing program was reviewed at grower meetings at the end of the season and by the Western Australian Seed Advisory Committee. Both groups endorsed the value, focus and continuation of the program.
PT02048	• The seed potato industry in WA will be monitored across five growing regions by Dept Ag WA (DAWA) trained staff. Monitoring for both insects and diseases will take place on a weekly basis and recommendations will be made for grower responses. An annual review of the program will determine whether the service will continue. • Weekly reports to seed growers to show the levels of pests, beneficial insects and diseased plants along with control recommendations. Analysis of costs of a commercial crop monitoring service for WA. Cost benefit analysis of a commercial monitoring program presented to growers at the annual WA seed growers' workshop.
PT03041	• Potato processor R&D plan preparation included 'face to face' meetings with key researchers and the IAC to establish priorities and documentation of R&D needs in a business plan format.

PT06044	• Activities associated with the project to determine PVS transmission in Tas seed potatoes included survey of G1 crops, determining if strains are transmitted by Green Peach Aphid and determining if treating seed with antiviral agents can reduce virus transmission without phyto toxicity. • Outputs included a report and presentation to seed growers and affiliated parties including Simplot Australia, McCain Foods Australia, Forth Farm Produce and fresh and processing growers. Study outputs will improve current management strategies aimed at reducing virus incidence by identifying those practices which are beneficial / not beneficial for management of viruses and provide methods of reducing virus spread during seed cutting.
PT97015	• The new chemical treatments for fungal diseases of seed potatoes project involved field trials over four seasons and found use of fungicides on 'new' ground to be very effective in the control of black scurf, silver scurf and Rhizoctonia. On old ground results were less predictable give n background levels of pathogens in soils. Growers are advised to complete their own trials. The project identified a useful replacement for formaldehyde, a harmful chemical used by seed growers as a post harvest treatment.
PT99022	• The whole round seed potato agronomic and economic blueprint project for processing potatoes included field trials in Tasmania and development of gross margin models for each of whole round seed potatoes and cut seed tuber setts. • The study found that for seed producers both seed types produced similar yields and as a result the cheaper method of using cut seed should be applied. Increasing density from 1.5 to 20 sets per square metre did not affect yield but did increase round seed yield. If seed growers are to maximise round seed production a premium of $500/ha will be required to offset cost additions. Russet whole round seed is best produced on the Ferrosol soils of the North-West Coast of Tasmania.
VX00013	• Activities associated with the biofumigation project using brassicas to control soil borne pests and diseases included measuring the control chemicals released when various brassicas breakdown and assessing impact on different soil characteristics. • Outputs included knowledge on the biofumigant effects from brassicas, communication of outputs and opportunities for plant breeder collaborators to develop more appropriate brassicas varieties based on sound information of how effects occur.
VX01006	• The development of UV protection for biological pesticides project included both laboratory and field testing stages. • The project produced an effective UV protection agent to improve the effectiveness of *Bacillus thuringiensis* (Bt) insecticides in situations where the active is under UV pressure. The UV protectant formulation is prepared by dispersing a commercial grade of titanium dioxide in water using an optimised blend of biocompatible surfactants. The product tank mixes well

	over a pH range from 4 to 10, thus covering most conditions likely to be encountered in Australia. Feeding tests involving measurement of leaf areas consumed on both treated and untreated cabbage leave discs showed that the UV protectant did not deter the feeding of targeted larvae. Experiments conducted on the Eureka AgResearch rainfall simulator showed that the product was also very effective as a sticker to enhance rainfastness.
VX01026	• The strategic alliances for young Australian and NZ vegetable and potato growers' project required each participant to prepare a brief report on the visit detailing information gained, contacts made, opportunities discussed and potential for follow-up actions. These individual reports were combined to provide an overview report of the project. Participants were also required to make presentations to potato growers' organisations. Presentations were designed to provide the project participant with an opportunity to raise issues and discuss opportunities for strategic partnerships as a method of improving potato industry competitiveness.

4. Outcomes

Table 7 provides a brief summary of outcomes for each of the projects.

Table 7: Summary of Potato Agronomy and Production Management Cluster Outcomes

Project	Outcomes
PT01008	Soil insect pest monitoring and management • More consistent use of monitoring to assess the level of risk of damage from soil insects prior to planting potatoes. • Growers better able to decide on the need for and select appropriate soil pest control options including the new chemical insecticides tested. • Improved reliability of strategic soil insect pest control leading to improved crop production efficiency with a higher proportion of potato crop yield meeting consumer quality specification with respect to soil insect pest damage and a reduction in the risk of transferring soil pests. • Better definition of risk of crop damage by some of the lesser understood soil insect pests.
PT01041	Crop management tools South Aust french fry industry • Crop planning tools that will assist growers and industry to manage their potato crops more efficiently in the future. This will, with time and experience, improve the average yield over a large area of potatoes by reducing the numbers of *large* tubers and reducing the number of *smalls (< 100 grams)* to offset ever-increasing costs of production. • The industry has developed targets for production and quality: YEAR (t/ha) 2001-02: 55; 2002-03: 58; 2003-04: 62; 2004-05: 65.
PT02012	Optimising production and storage conditions for seed potato quality. • Prediction of stem number per plant is not possible at present using analytical tests. Therefore, prediction based on previous experience (growers using seed from a single supplier over a number of seasons and planting in similar conditions each year) remains the most accurate method of physiological age assessment.
PT02014	Production and storage conditions to optimise seed potato quality • Increased international competitiveness of the Australian potato industry. • Improved consistency of performance for new export varieties. • Increased opportunity for commercial uptake of new export varieties. • Increased impact of the National Potato Improvement and Evaluation Scheme (NAPIES)
PT02036	Disease management Kangaroo Island seed potatoes • Ongoing growth and viability of the high quality and high health status seed potato industry on Kangaroo Island. • This niche industry supplies seed to the WARE (fresh table sales), french fry and other processing industries and therefore supports the greater seed potato industry.

PT02037	Strategies for virus management in seed stocks • Improved understanding of latent viruses within seed stocks, communicated through the National Standard for Certification of Seed Potatoes with resultant potential for improved returns to growers and additional exports of quality seed potatoes.
PT02045	Crop monitoring on a district scale • The district crop monitoring and reporting service, pioneered in Gippsland in the 2002/2003 season through this project, has continued in 2003/2004 and 2004/2005 and is now in the commercial arena operating as a state-wide scheme under the guidance of and fully funded by Seed Potatoes Victoria. • Outcomes include better seed potato crop management (better yield, higher revenue), lower incidence of potato leaf roll virus and other pests (better yield, higher revenue) and reduced use of and reliance on unnecessary insecticide or fungicide sprays (less cost and higher returns) all leading to improved quality, sustainability and industry returns.
PT02047	Virus infections in WA seed potato crops • Better quality seed potatoes. • Improved abilities for inspectors to recognise viruses. • Reduced risk of serious virus outbreaks in WA seed potato domestic and export markets. • Increased yield / production in WA commercial crops by identifying crops with viral problems and removing seriously infected seed lots. • Expanded export opportunities (eg outcomes critical to maintaining the Sri Lankan potato seed market) • New export opportunities – potentially the ability to demonstrate to WTO that Australia has area freedom from PVY and PVY^{NTN} (necrotic strain)
PT02048	Crop monitoring program for WA seed potatoes • Improved WA potato seed health. • Introduction of IPM principles to growers. • Improved virus vector monitoring and virus control in seed crops. • More efficient use of pesticides. • Costs of monitoring service itemised.
PT03041	• A plan that sets R&D priorities for processing potato disease control.
PT06044	Improved management of potato Virus S • This study delivered an effective virus management strategy for the Tas seed potato industry. • An effective virus management strategy will allow the growing of new varieties which may be particularly susceptible to latent viruses. • An effective virus management strategy will maintain or increase yields by up to 10%, as it will reduce the incidence of latent viruses such as PVS that may be reducing yield when they occur at high incidence or in mixed infections within seed stocks. • Freeing seed potato lines of PVS will allow the movement of seed potato between States within Australia and would preserve current exports of

	quality seed potatoes to other countries and potentially open up new export markets.
PT97015	New chemical treatments for fungal diseases of seed potatoes • Better fungus control knowledge for potato growers (more cost effective treatments and higher yields). • A replacement for formaldehyde, a harmful chemical used by seed growers as a post harvest treatment.
PT99022	Use of whole round seed potatoes • Russet Burbank potatoes growing under good conditions produced similar yields irrespective of whether they were established with cut or round setts. • Increasing density up to 20 setts per m^2 exerted a major influence over round seed yield and round tuber number but not necessarily total yield and total tuber number. • The highest yield of round seed was produced at the highest density trialled. • Despite this however, the density resulting in the highest gross margin for seed crops (based on the current payment structure for seed growers) was determined to be around 6.5 setts per m^2 • To encourage profitable round seed production, a price premium is required, this being calculated to be 45% or $490 per tonne (ferrosol soils on the North-West) • A transportable economic methodology that can be adapted to other situations in potato crops throughout Australia. • More work is required to complete the blueprint that would effectively allow the processing industry to move from cut seed tuber setts to whole round seed and realise the benefits of seed cutting cost savings, reduced levels of disease, more uniform crops and potentially improved yields.
VX00013	Use of brassicas to kill soil pests and diseases • Outputs associated with the biofumigation project using brassicas to control soil borne pests and diseases potentially include a wider choice of biological controls to avoid total reliance on expensive and potentially unsustainable chemical pesticides, notably metham sodium. • Offering soil borne pest and disease suppression options where the use of chemical fumigants is uneconomic or not desired on health, safety or environmental grounds. Avoidance of over-use and enhanced biodegradation of soil-applied pesticides. • Adjunct green manuring soil carbon supplementation for improved soil structure and health. • Opportunity for industries to better capture 'clean & green' marketing advantages associated with Australia's 'clean-green' production image. • Better focussing and coordination of researchers, and achievement of economies of scale in R&D. • Improved soil pest and disease suppression in organically-certified production systems.

VX01006	UV protection for biological pesticides • The development of UV protection for biological pesticides project delivers a definite agronomic benefit by providing significant protection for Bt against UV degradation and can be used with both biological and hard chemical pesticides. Thus, it has the potential to render biological actives more effective as well as reduce the amount of any UV susceptible hard chemical pesticide required to achieve a given result. • An added, unplanned, advantage of the protectant formulation is that it is also effective as a sticker, enhancing the rainfastness of the Bt formulation. • The University of Sydney and HAL are now seeking an industry partner who is interested in taking this product to the market. • Successful commercialisation of this product will allow growers to expect improved performance from soft pesticide options and reductions in the application rates for UV susceptible hard chemical pesticides.
VX01026	Strategic alliances for young Australian and NZ vegetable and potato growers • The strategic alliances for young Australian and NZ vegetable and potato growers' project will potentially create a group of better informed (younger) growers who will appreciate the similarities between their own objectives and those of vegetable and potato growers in NZ. The group will deliver a better level of appreciation of possibilities presented by globalisation and individuals will become key people who will influence the attitude of their peer group. A changed mindset will encourage an outward looking and thinking group of growers who will be potentially willing to pursue export market opportunity through strategic partnerships and alliances.

A summary of the principal outcomes in each of the activity areas is as follows:

Soil Insect Pest Monitoring and Management

- Improved monitoring resulting in lower insect control costs (eg less chemical) and increased saleable yield due to reduced insect damage.

Crop Management Tools South Australian French Fry Industry

- Forecast additional saleable yield of 'right sized' tubers, increasing from 55t/ha in 2002 to 65t/ha in 2005.

Production and Storage Conditions to Optimise Seed Potato Physiological Quality

- The project failed to deliver new ways of predicting seed performance measured by the number of stems per resultant plant.

Agronomy Packages for Export Potatoes

- Additional exports of Australian developed varieties of seed potatoes to SE Asian markets.

Disease Management Kangaroo Island Seed Potatoes

- Ongoing growth and viability of the Kangaroo Island potato seed production industry.

Strategies for Virus Management in Seed Stocks

- Additional grower production and improved export seed sales.

Crop Monitoring on a District Scale

- Improved crop management with yield benefits and spray cost savings across Victoria.

Virus infections in WA seed potato crops

- Improved WA seed crops with yield benefits for commercial crops and improved export sales.

Crop monitoring program for WA seed potatoes

- Yield and production cost savings.

Processed potato disease control plan

- Long term potential for increased processing potato yields.

Improved management of potato Virus S

- Improved seed potato yields of up to 10% with improved export sales.

New chemical treatments for fungal diseases of seed potatoes

- Improved yields for commercial growers due to better fungus treatment.

Use of whole round seed potatoes

- More work required to deliver promised yield improvements.

Use of brassicas to kill soil pests and diseases

- Sustainable, lower cost and less environmentally damaging soil pest control alternatives

UV protection for biological pesticides

- Less environmentally damaging pesticides one the product has been commercialised

Strategic alliances for young Australian and NZ vegetable and potato growers

- Social benefits – networks interactions and problem sharing
- Export opportunities from a more outwardly looking Australian industry.

Actual and expected outcomes are allocated across potato industry sectors and regions in Table 8.

Table 8: Allocation of Cluster Outcomes to Potato Industry Subsectors and Regions

Project	Industry	Region	Benefit (principal)
Soil insect management and monitoring	Fresh and Processing	Nationally relevant	Yield improvements
Crop management tools South Aust french fry industry	Processing	South Australia only	Yield improvements
Production and storage conditions to optimise seed potato physiological quality	Seed	Nil	Nil
Agronomy packages for export potatoes	Seed	SE Asian exports	Additional export sales
Disease management Kangaroo Island seed potatoes	Seed	Kangaroo Island	Additional production and sales
Strategies for virus management in seed stocks	Seed	Nationally relevant	Additional export sales
Crop monitoring on a district scale	Fresh and Processing	Victoria	Yield improvements
Virus infections in WA seed potato crops	Seed, Fresh and Processed	Western Australia	Yield improvements
Crop monitoring program for WA seed potatoes	Seed	Western Australia	Yield improvements
Processed potato disease control plan	Processed	Nationally relevant	Yield improvements
Improved management of potato Virus S	Seed	Nationally relevant	Yield improvements and additional export sales
New chemical treatments for fungal diseases of seed potatoes	Fresh and Processing	Nationally relevant	Yield improvements, improved environmental outcomes
Use of whole round seed potatoes	Seed	Nil	Nil
Use of brassicas to kill soil pests and diseases	Seed, Fresh and Processed	Nationally relevant	Cost saving, improved environmental outcomes
UV protection for biological pesticides	Seed, Fresh and Processed	Nationally relevant	Cost saving, improved environmental outcomes
Strategic alliances for young Aust and NZ potato growers	Seed, Fresh and Processed	Nationally relevant	Social benefits and additional export sales

Cluster investments and benefits are strongly focussed on yield improvements, export sales and environmental outcomes across the seed, fresh and processing sectors of the industry.

5. Benefits

Yield Improvements Seed, Fresh and Processing Sectors

- Additional yield associated with soil insect management and monitoring, crop management, virus, fungus and other disease control.
- At cluster commencement in 2001 average industry yield across the seed, fresh and processing sectors of the Australian industry was 32.9t/ha. By 2008 average industry yield reached 36.7t/ha (See Table 9 below). Part of this growth and future yield improvement is attributable to investments made as part of the agronomy and production management cluster.

Table 9: Potato Yield by State

	2005/06	**2006/07**	**2007/08**	**Average**
NSW	25.4	26.9	25.7	
Victoria	33.9	31.7	30.1	
Queensland	25.7	25.2	29.6	
SA	37.7	38.7	39.3	
WA	41.6	41.2	44.0	
Tasmania	45.7	45.6	52.1	
NT			7.5	
Average	35.4	35.5	36.7	35.9

Source: AUSVEG analysis of ABS data

Export Sales

- Cluster investments associated with the development of agronomy packages for export potatoes to South East Asia, strategies for virus management in seed stocks targeting additional export sales, improved management of potato Virus S and strategic alliances for young Australian and NZ potato growers will all help to grow Australian potato exports.
- Exports of fresh Australian potatoes are currently valued at approximately $12.6 million pa and have been stagnant for some time (AUSVEG analysis of ABS data).

Environmental Outcomes

- Improved environmental outcomes associated with accelerated phase out of formaldehyde use as a post harvest fungus control, methyl bromide as a soil fumigant and availability of more effective biological pesticides.

Social

- Social networks and opportunities associated with the development of strategic alliances between young Australian and NZ vegetable and potato growers.

Overview of Benefits

An overview of benefits in a triple bottom line categorisation is shown in Table 10.

Table 10: Categories of Benefits from the Cluster Investment

	Levy paying industry and its supply chain	**Spillovers**		
		Other industries	**Public**	**Foreign**
Economic	1. Yield improvements seed, fresh and processing sectors. 2. Export sales.	Nil	Nil	6. Possible opportunities for young NZ growers resulting from the strategic alliance project.
Environmental	3. Accelerated phase out of formaldehyde, methyl bromide and more effective biological pesticides.	Nil	5. Less use of 'hard' chemicals with benefits for neighbours, waterways and the broader environment.	Nil
Social	4. Social networks and opportunities for young Aust and NZ growers facilitated by the strategic alliances project.	Nil	Nil	Nil

Public versus Private Benefits

The benefits identified from the investment are predominantly private benefits, namely benefits to potato growers and their supply chains. There also will have been some public benefits produced, mainly environmental in nature, from reduced use of hard chemicals (formaldehyde and methyl bromide).

Benefits to Other Primary Industries

It is likely that industry benefits will be confined to the potato industry.

Distribution of Benefits along the Potato Supply Chain

In so far as some segments of the industry supply inputs to other segments (e.g. seed potatoes are supplied to commercial growers and commercial processing potato growers supply crisping companies), benefits from the initial impacts are shard both forwards and backwards along the supply chain, as well as with consumers.

Benefits Overseas

It is unlikely that knowledge produced by this investment will directly benefit overseas potato industries to any great extent. Some spin off benefits might be realised by young NZ growers participating in the strategic alliance between Australia and NZ but given that the NZ industry is generally regarded as further advanced than its Australian cousin, benefits are most likely to be realised by NZ from joint opportunities with third country exports.

Match with National Priorities

The Australian Government's national and rural R&D priorities updated in May 2007 and current July 2009 (http://www.daff.gov.au/agriculture-food/innovation/priorities) are reproduced in Table 11.

Table 11: National and Rural R&D Research Priorities

Australian Government	
National Research Priorities	**Rural Research Priorities**
1. An environmentally sustainable Australia 2. Promoting and maintaining good health 3. Frontier technologies for building and transforming Australian industries 4. Safeguarding Australia	5. Productivity and adding value 6. Supply chain and markets 7. Natural resource management 8. Climate variability and climate change 9. Biosecurity *Supporting the priorities:* 1. Innovation skills 2. Technology

Table 12 identifies the relative importance of the rural research priorities addressed by the plant improvement cluster as a whole.

Table 12: Categorisation of Benefits by Priorities

Benefit	National Research Priority Addressed	Rural Research Priorities Addressed
1. Yield improvements seed, fresh and processing sectors.		Priority 1 *** Priority 2 **
2. Export sales		Priority 2 **
3. Less 'hard' chemical use on potato farms	Priority 1 *	Priority 3 ***
4. Social networks and opportunities for young Australian and NZ growers	Priority 2 *	Priority 1 * Priority 2 *

*** Strong contribution **Some contribution * Marginal contribution

Additionality and Marginality

The investment in this cluster was targeted principally towards benefits to potato growers and others in the potato supply chain involved with marketing. As agronomy, crop management, pests and diseases are a key industry priority aimed at lowering production costs and increasing industry competitiveness, these projects would have been regarded as a high priority by levy payers. In the event that public funding to HAL was restricted, it is likely that most of the projects in the cluster would have still been funded by industry, assuming a levy system was still in place.

The limited public spillovers that have been identified (less ‘hard’ chemical usage) would therefore still have been delivered. If no public funding at all had been available for HAL, it is likely that the investment would have been 50% of the investment actually recorded. Resources simply would not have been available to tackle the full complement of investments. This could have resulted in a less effective investment. A summary is provided in Table 13.

Table 13: Potential Response to Reduced Public Funding to HAL

7. What priority were the projects in this cluster when funded?	Most were high priority for HAL and industry.
8. Would the investments still have been made in this cluster if 50% less public funds were available to HAL?	Yes, but with less total funding.
9. Would industry and others have funded this cluster if no public funds were available to HAL?	Yes, to the extent of about 50% of that actually funded.

Pathway to Adoption

The potato agronomy and production management cluster is reasonably diverse and appropriate targeted adoption pathways have been and are being employed. A summary of the different adoption pathways by project are presented in Table 14.

Table 14: Adoption Pathways

Project Number	Adoption Pathway
PT01008	• Soil insect management and monitoring findings were communicated via grower groups, crop scouts, consultants, insecticide companies and on-farm demonstrations.
PT01041	• Crop management tools for the South Australian french fry industry were developed jointly by growers and industry crop agronomists. Ongoing feedback received by the researchers indicates successful uptake of project results.
PT02012	• Findings from the production and storage conditions to optimise seed potato project were communicated and adopted via processing company research managers, presentation of findings at industry field days and workshops. Annual updates were provided in ‘Potatoes Australia’ magazine.
PT02014	• The target audience for the agronomy packages for export potatoes project are existing and potential crisp and seed growers, exporters, packers and

	consultants. These groups were targeted via field trials and supporting field days, production and dissemination of written extension material and close liaison with the Potato Growers Association of WA which incorporates a group of leading WA seed growers.
PT02036	• The target audience for the disease management Kangaroo Island seed potatoes project were growers, industry agronomists, potential industry investors and seed purchasers. The results of this project have been conveyed to growers by direct contact during the frequent property visits. In addition, a formal presentation (seminar) was given at the start of the project when the main soil borne diseases and their management was discussed with growers. On other occasions, the authors held several informal discussion groups with key growers on the property of Mr. P. MacGill.
PT02037	• The main audience for the strategies for virus management in seed stocks project are Tasmanian seed growers. Project outcomes were communicated through the Tasmanian potato industry "Virus Strategy Group" (including Simplot, McCains, Forth Farm, grower representatives from both processing and fresh market sectors, DPIWE, TIAR and the TFGA). Recommendations were further extended by DPIWE and reported in 'Potatoes Australia'.
PT02045	• The monitoring potato crops for insect movement on a district scale project was requested by the Gippsland Seed Potato Growers Association and supported by Gippsland growers throughout its duration. Ongoing insect monitoring on this basis is less certain.
PT02047	• Findings from the minimising virus infection in early generation seed potato crops in WA project were communicated to the Seed Potato Advisory Committee of WA and to all WA seed growers via the 'Potato Grower' magazine.
PT02048	• Findings from the crop monitoring program for WA seed growers were communicated to both growers and commercial crop scouts using publications and personal communications that demonstrated that the benefits of monitoring outweighed the costs and that the system was superior to routine spraying alternatives.
PT03041	• The potato processor R&D plan informed levy investments.
PT06044	• Results from the improved management of potato Virus S project were communicated to the industry via the Tasmanian based 'Virus Strategy Group' consisting of representatives from Simplot, McCains, Forth Farm (a fresh market potato company), grower representatives from both processing and fresh market sectors, DPIWE, TIAR and TFGA). Nationally results were communicated through groups such as the Seed Potato Advisory Group.
PT97015	• Findings from the new chemical treatments for fungal diseases of seed potatoes project were communicated to growers, industry and the scientific community through twenty six seminars and workshops and the publication

	of twenty two conference papers, abstracts and journal articles.
PT99022	• Results from the 'blueprint' project for use of whole round seed potatoes was communicated to via field days, grower meetings and targeted publications in 'Potato Australia', 'Eyes on Potatoes' and 'Good Fruit & Vegetables'. Key stakeholders with which meetings were held included: Potato Growers of Australia, APIC, Simplot & McCain Foods, the Potato Improvement Group, Tasmania Seed and commercial potato grower organisations.
VX00013	• Results from the use of brassicas to kill soil pests and diseases project were communicated to growers, consultants, advisers and merchants via field days and articles in the 'potato press'.
VX01006	• Results from the UV protection for biological pesticides were communicated to commercial pesticide manufacturers.
VX01026	• Key messages from the strategic alliances for young Aust and NZ potato growers project were conveyed by participating growers to their peer group though meetings, newsletter articles and the project report.

The pathways include effective and proven grower extension options and direct placement of results with appropriate industry bodies (eg DPIs, consultants, processing companies, exporters). The adoption pathways described provide convincing reasons why uptake of research results associated with this cluster will be high.

6. Measurement of Benefits

The benefits of the investment that are valued in this analysis are:

- Yield improvements seed, fresh and processing sectors
- Export sales

Yield Improvements Seed, Fresh and Processing Sectors

- The Australian potato industry averages production of 1.1 million tonnes per annum on 32,000 ha after excluding the Tasmanian processing potato sector (data derived from AUSVEG/ABS information for the three years to 30 June 2008. Yield improvement in the Tasmanian processing sector is accounted for in a separate cluster analysis).
- It is assumed that due to the projects in the cluster, a combined increase in the average yield of 5% can be assumed. This yield increase commences in the year ending June 2008, and it takes a period of ten years for the full increase to be realised. However, as the demand for potatoes is not expected to increase significantly during this time, the benefit is measured through a cost reduction, rather than valuing the increased yield. For the purposes of the analysis, it is assumed that the cost of production is equal to the average farm gate price of potatoes of $382/tonne (derived from AUSVEG/ABS data for the three years to 30 June 2008 as an average of fresh and processing potato farm gate prices). At a base yield of 35.9t/ha (three year industry average derived from data provided in

Table 9 above), this equates to a production cost of $13,714/ha. When the yield is increased by 5% to 37.7t/ha, the cost of production per tonne is reduced to $363.8/t if it is assumed the costs of production per hectare do not change. Therefore, a cost saving of $18.20/t is realised.

- A maximum of 20% of the Australian industry is assumed to adopt cluster results and this is phased in over ten years (2008 to 2018).
- As the yield increase is assumed to be an average gain due to a number of technology and production changes, it is assumed that the increase is net of any additional adoption and production costs required to achieve this gain.

Export Sales

- Investment in the agronomy and production management cluster will result in additional seed and fresh potato exports.
- Effective cluster investments associated with improving Australian potato exports include agronomy packages, virus management and building strategic alliances.
- Australian fresh potato exports, including exports of seed potatoes have averaged $12.6 million pa over the five years to 30 June 2008 (Table 15).
- For analysis purposes investment in the cluster generates a 1% lift in Australian potato exports five years after 2009, the last export focused cluster investment.

Table 15: Major Export Markets ($'million)

	2003/04	2004/05	2005/06	2006/07	2007/08	Average
Singapore	1.416	1.884	2.323	1.576	1.553	1.750
Korea, South	5.005	3.730	4.582	2.989	1.161	3.493
Malaysia	2.507	2.969	1.772	2.062	0.749	2.012
Indonesia	0.149	1.956	1.247	0.485	0.342	0.836
UAE	0.551	0.557	0.463	0.623	0.815	0.602
Hong Kong	0.661	0.542	0.633	0.740	0.763	0.668
Other	4.186	4.528	3.566	2.329	1.525	3.227
Total	14.473	16.166	14.586	10.803	6.908	12.587

Source AUSVEG using ABS data
Includes seed potatoes

Benefits not Valued

The principal benefits identified but not valued in the analysis include:

- Environmental outcomes – associated with accelerated phase out of 'hard' agricultural chemicals.

- Social benefits – social networks and opportunities associated with the development of strategic alliances between young Australian and NZ potato growers.

Attribution

Projects other than the sixteen described here also contributed to the benefits valued. A total of 50% of the benefits estimated above have been assigned to the sixteen projects. For example, yield improvements will be attributable to new variety breeding which is not accounted for in this analysis. Yield benefits attributable to the processing sector will also need to be accounted for in the following clusters:

- Potato processor – disease – soil amendments
- Potato processor – disease – DNA monitoring tools
- Extension

Summary of Assumptions

A summary of the key assumptions made is shown in Table 16.

Table 16: Summary of Assumptions

Variable	Assumption	Source
Potato production in Australia.	Three year average to 30 June 2008 of approximately 38,800 ha of production, averaging 1.29 million tonnes per annum worth around $556 million.	AUSVEG analysis of ABS data (Ian James pers comm. Sept 2009)
Yield Improvements Seed, Fresh and Processing Sectors		
Average yield for Australian potato industry without investment at beginning of the analysis period.	35.9t/ha.	AUSVEG analysis of ABS data (Ian James pers comm. Sept 2009)
Yield increase as a result of agronomy and production management investments.	5%	Consultant estimate after review of relevant research reports and checked against AUSVEG date for 2007/08.
Share of the Australian potato industry Area experiencing yield increase.	20% phased in over ten years.	Consultant estimate after review of relevant research reports.
Cost of production saving as a result of yield increase.	Estimate of $382/t	Derived from AUSVEG/ ABS data for the three years to 30 June 2008).
Export Sales		
Additional export sales resulting from export targeted agronomy, virus control and strategic alliances	1% improvement in the value of fresh and seed potato export sales. Value of sales shown in Table 15.	Consultant estimate after reviewing relevant export data.
Attribution		
Attribution	50% for both Yield Improvements and Increase in Export Sales.	Consultant's estimate based on knowledge of previous R&D investments funded by HAL and analysis of other relevant potato investment clusters.

7. Results

All past costs and benefits were expressed in 2008/09 dollar terms using the Consumer Price Index (CPI). All benefits after 2008/09 were expressed in 2008/09 dollar terms. All costs and benefits were discounted to 2008/09 using a discount rate of 5%. The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2009/10) to the final year of benefits assumed.

Investment criteria were estimated for both total investment and for the HAL investment alone. Each set of investment criteria were estimated for different periods of benefits. The investment criteria were all positive after year ten as reported in Tables 17 and 18.

Table 17: Investment Criteria for Total Investment and Total Benefits for Each Benefit Period
(discount rate 5%)

Criterion	0 years	5 years	10 years	20 years	30 years
Present value of benefits (m$)	0	2.6	8.4	18.7	25.0
Present value of costs (m$)	2.6	2.6	2.6	2.6	2.6
Net present value (m$)	(2.6)	0	5.8	16.1	22.4
Benefit cost ratio	0	1	3.3	7.2	9.7
Internal rate of return (%)	negative	0	11	14	15

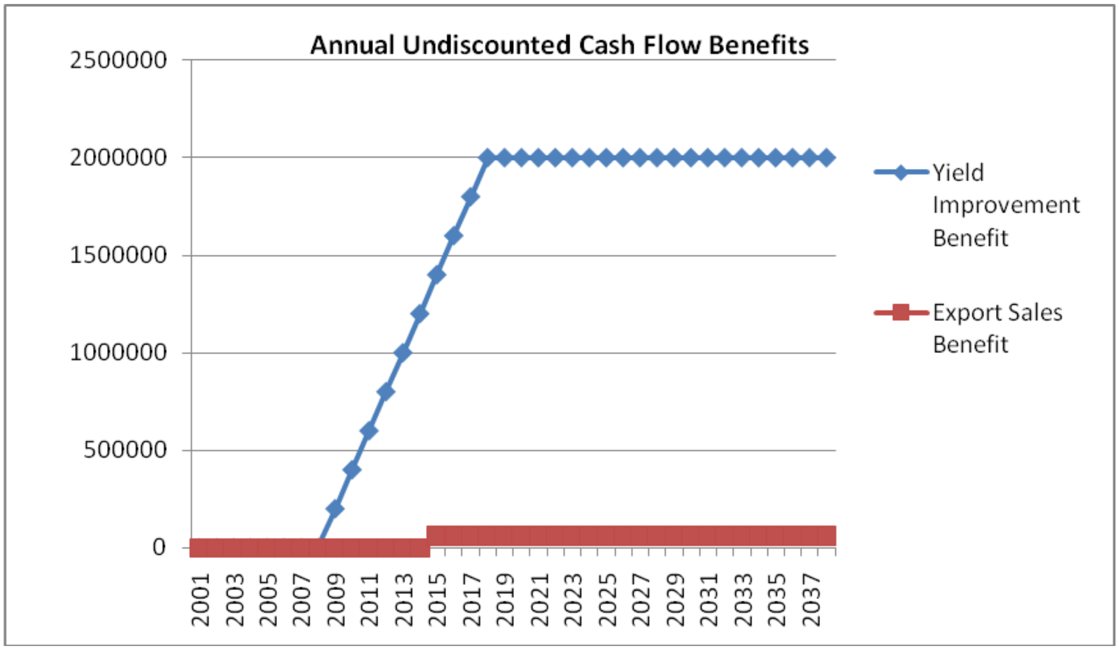
Table 18: Investment Criteria for HAL Investment and Benefits to HAL for Each Benefit Period
(discount rate 5%)

Criterion	0 years	5 years	10 years	20 years	30 years
Present value of benefits (m$)	0	1.8	5.6	12.4	16.6
Present value of costs (m$)	2.3	2.3	2.3	2.3	2.3
Net present value (m$)	(2.3)	(0.5)	3.3	10.1	14.3
Benefit cost ratio	0	0.8	2.4	5.4	7.2
Internal rate of return (%)	negative	negative	8	12	12

The proportion of total benefits from the increased potato yield was 97% while the value of export sales contributed 3%.

The annual cash flows of undiscounted benefits are shown in Figure 1.

Figure 1: Annual Benefit Cash Flow



Sensitivity Analyses

Sensitivity analyses were carried out on several variables and results are reported in Tables 19 to 20. All sensitivity analyses were performed using a 5% discount rate with benefits taken over the life of the investment plus 30 years from the year of last investment. All other parameters were held at their base values.

Table 18 shows the relatively low impact of the discount rate on the investment criteria.

Table 19: Sensitivity to Discount Rate
(HAL investment, 5% discount rate, 30 years)

	Discount rate		
Criterion	0%	5%	10%
Present value of benefits (m$)	34.9	16.6	9.3
Present value of costs (m$)	1.7	2.3	3.1
Net present value (m$)	33.2	14.3	6.2
Benefit cost ratio	20.3	7.2	3.0

Table 20 shows the sensitivity of the investment criteria to changed assumptions regarding increased potato yield and quality.

Table 20: Sensitivity to Increased Potato Yield
(HAL investment, 5% discount rate, 30 years)

	Increase in potato yield		
Criterion	Half Increment	Increment as per Table 16	Double Increment
Present value of benefits (m$)	11.6	16.6	43.8
Present value of costs (m$)	2.3	2.3	2.3
Net present value (m$)	9.3	14.3	41.5
Benefit cost ratio	5.0	7.2	18.9
Internal rate of return	10	12	20

Table 21 shows the sensitivity of the investment criteria to changed assumptions regarding production cost savings.

Table 21: Sensitivity to Rate of Adoption of Yield Increasing Recommendations
(HAL investment, 5% discount rate, 30 years)

	Rate of Adoption		
Criterion	Half Increment	Increment as per Table 16	Double Increment
Present value of benefits (m$)	18.5	16.6	32.8
Present value of costs (m$)	2.3	2.3	2.3
Net present value (m$)	6.2	14.3	30.5
Benefit cost ratio	3.7	7.2	14.2
Internal rate of return	7	12	18

8. Confidence Rating

The results produced are highly dependent on the assumptions made, many of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes.

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 22). The rating categories used are High, Medium and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some significant uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 22: Confidence in Analysis of Grain Storage Investment

Coverage of Benefits	**Confidence in Assumptions**
High	Medium

9. Conclusions and Lessons Learned

The major focus of the sixteen projects evaluated in this HAL potato agronomy and production management cluster has been on crop management and the control of pests and diseases. Key outputs target agronomy and crop management for the processing sector, seed potatoes and the development of a young professionals' network. Pests and diseases targeted included viruses, funguses and soil insects.

The investment in agronomy and production management described in this evaluation has been assumed to produce a number of benefits, two of which were valued (yield improvement and export sales). The total HAL investment of $2.3 million (present value terms) has been estimated to produce gross benefits of $16.6 million (present value terms) providing a net present value of $14.3 million and a benefit cost ratio of 7 to 1 (over 30 years, using a 5% discount rate).

Acknowledgments

Lucy Keatinge	Industry Services Manager HAL
Stuart Burgess	Industry Services Manager HAL
Ian James	Economist AUSVEG

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Strategic Business Development (2006) Australian Processing Potato Industry Strategic Plan 2006-2011. Prepared for HAL and the Australian Fresh Potato Industry.

Abbreviations

DAWA	Department of Agriculture, WA
ELISA	Enzyme-linked Iimmunosorbent Assay
GA	gibberellic acid
GM	Genetically Modified
IPM	Integrated Pest Management
QDPI&F	Queensland Department of Primary Industries and Fisheries
MRL	Maximum Residue Levels
NAPIES	National Australian Potato Improvement Evaluation Scheme
PBZ	Paclobutrazol
PLRV	Potato Leaf Roll Virus
PPAA	Potato Processing Association of Australia
PVS	Potato Virus S
PVX	Potato Virus X
PVY	Potato Virus Y
SRS	Small Round (potato) Seed
TSWV	Tomato Spotted Wilt Virus
UV	ultra violet light
WARE	potato produced for fresh sale

APPENDIX 5: An Economic Analysis of HAL Investment in the Potato Environment and Health Cluster

1. Background

The Australian potato crop averaged 1.29 million tonnes and was valued at $556 million over the three years to 30 June 2008 (AUSVEG analysis of ABS data). Victoria, South Australia and Tasmania produce almost 80% of production. Production fell 1995 to 2007 before rebounding in 2008. Production costs are rising, consumption is declining and low cost imports threaten the domestic potato industry.

Approximately 44% of Australian production is marketed in a fresh form (36% sold as fresh potatoes for consumption, 8% sold as seed potatoes). Some 56% of production is sold for processing (42% frozen, 14% crisping).

Fresh potatoes are marketed through wholesalers, independent retailers and supermarkets. Only a small proportion of the fresh potato crop is exported (7% by value) and exports are mainly directed to South East Asia and South Korea. There is little growth in exports and the search for export markets is underway although hindered by trade barriers. At the current time the volume of low cost fresh imports is small.

Total per capita potato consumption is currently around 63 kg. The proportion of fresh potato consumption has declining as processed potato consumption has increased.

The frozen processing potato industry is dominated by McCain Foods (Canada) and Simplot (US). Processing plants are located in Tasmania, South Australia and Victoria. The two major large crisping companies are Arnott's (Campbell's) and Smiths (Frito-Lay). Most crisping potatoes are grown under contract and crisping plants are located nationally.

Research and development (R&D) levies are in place for both the fresh and processing potato industries. Grower levies collected from the processing industry are matched by processors through the Potato Processing Association of Australia (PPAA). R&D levies collected from both industries are matched by the Australian Government.

AUSVEG is the peak industry body for both the Australian fresh and processing potato industries. The vision for the fresh potato industry is to enhance the profitability and sustainability of the industry by increasing the value of the fresh potato category. The vision for the Australia processing potato industry is that it will be sustainable and globally competitive and driven by consumer needs.

These visions will be achieved by industry who will deliver four strategic imperatives:

1. Improve consumer demand for Australian fresh potatoes;
2. Increase industry competitiveness;
3. Improve industry communication and information systems; and

4. Improve leadership and management capability.

Strategic imperatives one and two are relevant to environment and health R&D investments.

The environment and health cluster analysed in this economic evaluation addressed:

- Potential use of potato waste products in the manufacture of biodegradable plastics.
- Black dot disease management options and techniques for potato growers.
- Minimisation and management of the accumulation of the heavy metal cadmium in Australian potatoes.

2. The Cluster

Projects

Table 1 presents the details for each of the projects included in the environment and health cluster.

Table 1: Summary of Plant Protection Projects

Project Number	Project Title	Other Details
PT02001	Biodegradable plastics: The potential for Australian potato as an input for biodegradable polymers	Organisation: Wondu Business and Technology Services Period: July 2002 to August 2004 Principal Investigator: David Michael
PT01001	Control of black dot disease in potatoes	Organisation: South Australian Research and Development Institute (SARDI) Period: July 2001 to January 2005 Principal Investigator: Trevor Wicks
PT96020	Mechanisms of cadmium accumulation by potato tubers (continued PT620)	Organisation: CSIRO Land and Water Period: Sept 1997 to April 2003 Principal Investigator: Mike McLaughlin
VX03013	Coordination of the National Cadmium Minimisation strategy	Organisation: CSIRO Land and Water Period: July 2003 to December 2006 Principal Investigator: Michael Warne

Project Objectives

Table 2 presents the objectives for each of the projects included in the cluster.

Table 2: Description of Project Objectives

Project Number	Objectives
PT02001	To examine opportunities, benefits, costs, risks and constraints for Australian potatoes being used as an industrial feedstock material for the production of polymers and plastic products.
PT01001	This project builds on other studies and aims to develop management strategies to control black dot disease. Black dot is caused by the fungus *Colletotrichum coccodes* and is a widespread disease of potatoes in Australia, common in both soils of potato growing areas and on seed tubers.
PT96020	This project aims to determine the mechanisms of cadmium uptake by potatoes in order to allow selection in breeding programs of physiological traits which minimise cadmium accumulation in tubers and to allow the identification of management techniques to minimise cadmium uptake by tubers
VX03013	To have all sectors of root and leafy vegetable industry collaborating to manage the cadmium level in soils, fertilisers and produce. To ensure the cadmium content of root and leafy vegetables does not exceed the Maximum Prescribed Concentration (MPC) in Australia and New Zealand, and does not present any opportunity for other countries to use cadmium content as a non-tariff trade barrier.

Project Investment - Environment and Health Cluster

Table 3 shows the annual investment by project for HAL and Industry. Contributions from other sources, including the research provider are shown in Table 4.

Table 3: Investment by Project by HAL Including Both Levy and Voluntary Contributions (nominal $)

Project Number	**HAL and Industry Year ending June**										
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Total**
PT01001		94,802	86,255	80,661	10,000						271,718
PT02001			53,400	35,000	10,000						98,400
PT96020	57,900						9,860	-			67,760
VX03013					38,942	6,250	-	1,250			46,442
Total	**57,900**	**94,802**	**139,655**	**115,661**	**58,942**	**6,250**	**9,860**	**1,250**			**484,320**

Source: HAL Project Database

Table 4: Investment by Project by Other Sources Including Research Provider Contributions (nominal $)

Project Number	**Other Sources Year ending June**										
	2001	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**Total**
PT01001	-	87,242	79,377	74,229	9,203	-	-	-	-	-	250,050
PT02001	-	-	5,932	3,888	1,111						10,930
PT96020											
VX03013											
Total	**-**	**87,242**	**85,308**	**78,116**	**10,313**						**260,980**

Source: HAL Project Database

An summary of annual total investment in the Environment and Health cluster is provided in Table 5.

Table 5: Investment in Environment and Health Cluster (nominal $)

Year ending June	**HAL and Industry**	**Other Sources**	**Total**
2001	57,900	-	57,900
2002	94,802	87,242	182,044
2003	139,655	85,308	224,963
2004	115,661	78,116	193,777
2005	58,942	10,313	69,256
2006	6,250	-	6,250
2007	9,860	-	9,860
2008	1,250	-	1,250
Total	**484,320**	**260,980**	**745,300**

3. Activities and Outputs

Table 6 provides a brief summary of outputs for each of the projects.

Table 6: Summary of Cluster Activities and Outputs

Project	Activities and Outputs
PT02001	• Outputs from the potato as an input in biodegradable plastics project included progress reports in 'Eyes on Potatoes' and 'Potato Australia', a draft final report for stakeholder comment, a final report on polymer from potato potential and indirectly and in time new products or new markets for waste potato products.
PT01001	• Outputs from the control of black dot disease in potatoes project included articles in 'Potato Australia', 'The Grower' and 'Eyes on Potatoes'. Newsletters were also prepared and distributed to growers and a series of field days were held to demonstrate black dot control options. Data was also produced suitable for registration of new black dot control products.
PT96020	• Outputs from the mechanisms of cadmium accumulation by potato tubers project produced scientific papers that detail methods by which cadmium uptake occurs, cultivars which are most susceptible to cadmium accumulation and breeding strategies and cultural practices to minimise cadmium risk.
VX03013	• Outputs from the coordination of the national cadmium minimisation strategy include research findings to manage cadmium in soils, fertilisers and produce.

The principal outputs from the plant protection cluster were knowledge on the potential of biodegradable potato plastics, improved black dot disease management techniques and cadmium minimisation strategies for the potato industry.

4. Outcomes

Table 7 provides a brief summary of outcomes for each of the projects.

Table 7: Summary of Cluster Outcomes

Project	Outcomes
PT02001	Biodegradable potato plastics • Improved understanding of the potential for potatoes to be used in the industrial polymer market. • Improved understanding of potato plant properties required for polymer production. • Prefeasibility of establishing a potato based biopolymer supply chain. • Possibility of a new industrial market for Australian potatoes, subject to feasibility and resource availability. • Possibility, subject to feasibility, of increased farm-gate demand for potato through decreased processing costs and/or increased value added from waste products.
PT01001	Black dot disease control • Improved productivity from reduced levels of black dot in washed and seed potatoes • An understanding of levels of soil populations of *Colletotrichum* and other factors that give rise to disease. • The levels of disease in certified seed producing areas determined. • New chemicals registered for the control of black dot.
PT96020	Mechanisms of cadmium accumulation • An understanding of the mechanisms by which potatoes accumulate cadmium in their issues, particularly tubers. • Knowledge of the physiological basis for cultivar differences in cadmium uptake. • Directions for breeding strategies to produce potatoes with low cadmium accumulating characteristics. • Improved cultural practices to minimise cadmium accumulation in tubers.
VX03013	National cadmium minimisation strategy • All sectors of root and leafy vegetable industry collaborating to manage the cadmium level in soils, in fertilisers and produce. • The cadmium content of root and leafy vegetables does not exceed the Maximum Prescribed Concentration in Australia and New Zealand, and does not present any opportunity for other countries to use cadmium content as a non-tariff trade barrier.

A summary of the principal outcomes are the basis for a potato based biodegradable plastics industry, better black dot control (additional potato yield) and cadmium management so that this heavy metal does not become a domestic food safety issue or a non-tariff trade barrier.

5. Benefits

Increased Potato Demand from a Biodegradable Plastics Industry

- A biodegradable plastics industry might use Australian grown potatoes as well as waste resources from existing potato processors.
- To realise this opportunity a 'high tech' starch-processing facility would need to be built in Australia, possibly in southern NSW. The facility would require approximately 2,400t of potatoes per day or around 480,000t per annum (operating at 65-70% efficiency).
- Capital ($150 million plus) and an assured large volume water supply for starch processing together with currently cheaper sources of synthetic polymers (eg polyethylene) are likely to constrain opportunity realisation in the short to medium term.

Increased Potato Yield and Quality

- Black dot disease control options and strategies arising from this research will enhance potato yield and quality across the seed, fresh and processing sectors of the Australian industry.
- Benefits arising from fungal disease control of the type associated with black dot disease have been scoped and quantified in a separate potato industry economic evaluation – Agronomy and Production Management.

Social Benefits

- Control of cadmium in potato tubers inside Maximum Prescribed Concentration (MPC) limits will ensure domestic food quality, safety, nutrition and human health are maintained for potato consumers.
- Longer term, potato consumers in Australia and overseas export markets will benefit from cadmium control within MPC limits.

Avoided Loss of Export Sales

- Control of cadmium in potato tubers inside MPC limits will also ensure Australian potatoes do not present any opportunity for other countries to use cadmium content as a non-tariff barrier.
- Avoided loss of existing export markets is a further benefit of research completed within the environment and health cluster.

Overview of Benefits

An overview of benefits in a triple bottom line categorisation is shown in Table 8.

Table 8: Categories of Benefits from the Cluster Investment

	Levy paying industry and its supply chain	Spillovers		
		Other industries	**Public**	**Foreign**
Economic	1. Increased potato demand from a Biodegradable Plastics Industry 2. Increased Potato Yield and Quality 3. Avoided Loss of export sales	Nil	Nil	Nil
Environmental	Nil	Nil	Nil	Nil
Social	4. Control of cadmium in potato tubers inside MPC limits	5. Control of cadmium project also included research addressing other Aust root and leaf vegetables.	6. Risk of cadmium residues in Australian potatoes	Nil

Public versus Private Benefits

The benefits identified from the investment are predominantly private benefits, namely benefits to potato growers and their supply chains. It can be argued that ensuring cadmium levels remain inside MPC limits is a public benefit given the large proportion of Australian consumers who are potato consumers (eg hot chips, crisps and home consumption of fresh and processed products).

Benefits to Other Primary Industries

It is likely that most industry benefits will be largely confined to the potato industry. The control of cadmium project also included research addressing other Australian root and leaf vegetables.

Distribution of Benefits along the Potato Supply Chain

In so far as some segments of the industry supply inputs to other segments (e.g. seed potatoes are supplied to commercial growers and commercial processing potato growers supply crisping companies), benefits from the initial impacts are shared both forwards and backwards along the supply chain, as well as with consumers.

Benefits Overseas

It is unlikely that there will be significant spillover benefits to overseas interests. It is noted that the national cadmium minimisation strategy includes NZ root and leafy vegetables.

Match with National Priorities

The Australian Government's national and rural R&D priorities updated in May 2007 and current July 2009 (http://www.daff.gov.au/agriculture-food/innovation/priorities) are reproduced in Table 9.

Table 9: National and Rural R&D Research Priorities

Australian Government	
National Research Priorities	**Rural Research Priorities**
1. An environmentally sustainable Australia 2. Promoting and maintaining good health 3. Frontier technologies for building and transforming Australian industries 4. Safeguarding Australia	5. Productivity and adding value 6. Supply chain and markets 7. Natural resource management 8. Climate variability and climate change 9. Biosecurity *Supporting the priorities:* 1. Innovation skills 2. Technology

Table 10 identifies the relative importance of the rural research priorities addressed by the environment and health cluster as a whole.

Table 10: Categorisation of Benefits by Priorities

Benefit	National Research Priority Addressed	Rural Research Priorities Addressed
1. Increased potato demand from a biodegradable plastics industry	Priority 1 ** Priority 3 **	Priority 1 *** Priority 2 ***
2. Increased potato yield and quality		Priority 1 ***
3. Social benefits – cadmium MPC	Priority 2 **	Priority 3 *
4. Avoided loss of export sales – cadmium MPC		Priority 1 ** Priority 2 **

*** Strong contribution **Some contribution * Marginal contribution

Additionality and Marginality

The investment in this cluster was targeted principally towards benefits to potato growers and others in the potato supply chain including consumers of potato products. As enhancing the profitability, sustainability and global competitiveness of the industry is part of the vision for both the fresh and processed potato industries it is likely that these projects would have been regarded as a high priority by levy payers and industry leaders. In the event that public funding to HAL was restricted, it is likely that most of the projects in the cluster would have still been funded by industry, assuming a levy system was still in place.

The limited public spillovers that have been identified (i.e. less risk of cadmium contamination in potatoes) would therefore still have been delivered. If no public funding at all had been available for HAL, it is likely that the investment would have been 50% of the investment actually recorded. Projects such as the 'blue sky' style examination of biodegradable potato based plastics would not have been funded and other projects would have been funded at a marginally lower level. This could have resulted in a less effective investment. A summary is provided in Table 11.

Table 11: Potential Response to Reduced Public Funding to HAL

1. What priority were the projects in this cluster when funded?	Most were high priority for HAL and industry.
2. Would the investments still have been made in this cluster if 50% less public funds were available to HAL?	Yes, but with less total funding.
3. Would industry and others have funded this cluster if no public funds were available to HAL?	Yes, to the extent of about 50% of that actually funded.

Pathway to Adoption

A summary of the different adoption pathways used for projects within the environment and health cluster are presented in Table 12.

Table 12: Adoption Pathways

Project Number	**Adoption Pathway**
PT02001	○ Outputs from the potato as an input in biodegradable plastics research were made available to the industry throughput the life of the project and a final report is available in the form of a prefeasibility assessment for a would be investor.
PT01001	○ Outputs from the control of black dot disease in potatoes project were made available through grower magazines and field days.
PT96020	○ Outputs from the mechanisms of cadmium accumulation by potato tubers project have been published in relevant scientific journals.
VX03013	○ Outputs from the national cadmium minimisation strategy are available as Best Management Practices (BMPs). The strategy coordinator has brought all sections of the industry together with the fertiliser industry and the state DPIs to ensure BMP uptake.

The pathways employed are effective and proven for the principle project outcomes and benefits. The adoption pathways described provide convincing reasons why uptake of research results associated with this cluster will be high.

6. Measurement of Benefits

The benefit of the investment that is valued in this analysis is:

- Avoided loss of export sales

Avoided Loss of Export Sales

- Investment in the environment and health cluster will protect export markets that might be at risk under the ‘no investment’ situation.
- Control of cadmium in potato tubers inside Maximum Prescribed Concentration limits will ensure Australian potatoes do not present any opportunity for other countries to use cadmium content as a non-tariff barrier.
- Table 13 provides a summary of the value of fresh Australian potato exports by market over the five years to 30 June 2008.

Table 13: Major Export Markets ($’million)

	2003/04	**2004/05**	**2005/06**	**2006/07**	**2007/08**	**Average**
Singapore	1.416	1.884	2.323	1.576	1.553	1.750
Korea, South	5.005	3.730	4.582	2.989	1.161	3.493
Malaysia	2.507	2.969	1.772	2.062	0.749	2.012
Indonesia	0.149	1.956	1.247	0.485	0.342	0.836
UAE	0.551	0.557	0.463	0.623	0.815	0.602
Hong Kong	0.661	0.542	0.633	0.740	0.763	0.668
Taiwan	0.202	0.496	0.180	0.368	0.279	0.305
Other	3.984	4.032	3.386	1.961	1.246	2.922
Total	14.473	16.166	14.586	10.803	6.908	12.587

Source AUSVEG using ABS data
Includes seed potatoes

- In the absence of cadmium control there is a risk that, over time, cadmium levels in Australian export potato tubers will breach international Maximum Prescribed Concentrations limits and be banned from certain high value markets. This situation recently arose with export sales of wild catch Australian prawns to Spain.
- It is assumed that in the absence of cadmium control investments, Australia might lose access to one of its more valuable export markets – such as the United Arab Emirates (UAE). The loss of the UAE market is assumed to occur five years from now as the concentration of cadmium in Australian soils from fertiliser application and other sources continues to climb i.e. in 2014. The loss of this market is not offset by equivalent export sales and the product is unsaleable on the Australian domestic market.
- In the absence of cluster investment a deadweight loss is incurred by the Australian potato industry.

Benefits not Valued

The principal benefits identified but not valued in the analysis include:

- Increased potato demand from a biodegradable plastics industry – high capital and water demands along with the low cost of synthetics will 'see off' this opportunity for the foreseeable future.
- Increased potato yield and quality associated with improved black dot control – yield and quality improvements associated with fungus control (of which black dot is a type) are quantified in other evaluation clusters.
- Social benefits – potato products whose cadmium content falls within MPC limits will ensure domestic food quality, safety, nutrition and human health.

Attribution

Projects other than the four described here also contributed to the benefits valued. A total of 50% of the benefits estimated above have been assigned to the four projects. For example, 'mechanisms of cadmium accumulation by potato tubers' project PT96020 is a continuation of PT620.

Summary of Assumptions

A summary of the key assumptions made is shown in Table 14.

Table 14: Summary of Assumptions

Variable	Assumption	Source
Avoided Loss of Export Sales		
Loss of single export market, say UAE.	$602,000 pa as per Table 13. Benefit (avoided loss) is realised in 2014.	Consultant estimate after review of relevant research reports.
Attribution		
Attribution	50% for Avoided Loss of Export Sales.	Consultant's estimate based on knowledge of previous potato research and extension work funded by HAL.

7. Results

All past costs and benefits were expressed in 2008/09 dollar terms using the Consumer Price Index (CPI). All benefits after 2008/09 were expressed in 2008/09 dollar terms. All costs and benefits were discounted to 2008/09 using a discount rate of 5%. The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2007/08) to the final year of benefits assumed.

Investment criteria were estimated for both total investment and for the HAL investment alone. Each set of investment criteria were estimated for different periods of benefits. The investment criteria were all positive after year five as reported in Tables 15 and 16.

Table 15: Investment Criteria for Total Investment and Total Benefits for Each Benefit Period
(discount rate 5%)

Criterion	0 years	5 years	10 years	20 years	30 years
Present value of benefits (m$)	0	0	1.1	2.6	3.5
Present value of costs (m$)	1.0	1.0	1.0	1.0	1.0
Net present value (m$)	(1.0)	(1.0)	0.1	1.6	2.5
Benefit cost ratio	0	0	1.1	2.6	3.5
Internal rate of return (%)	Negative	Negative	1	6	7

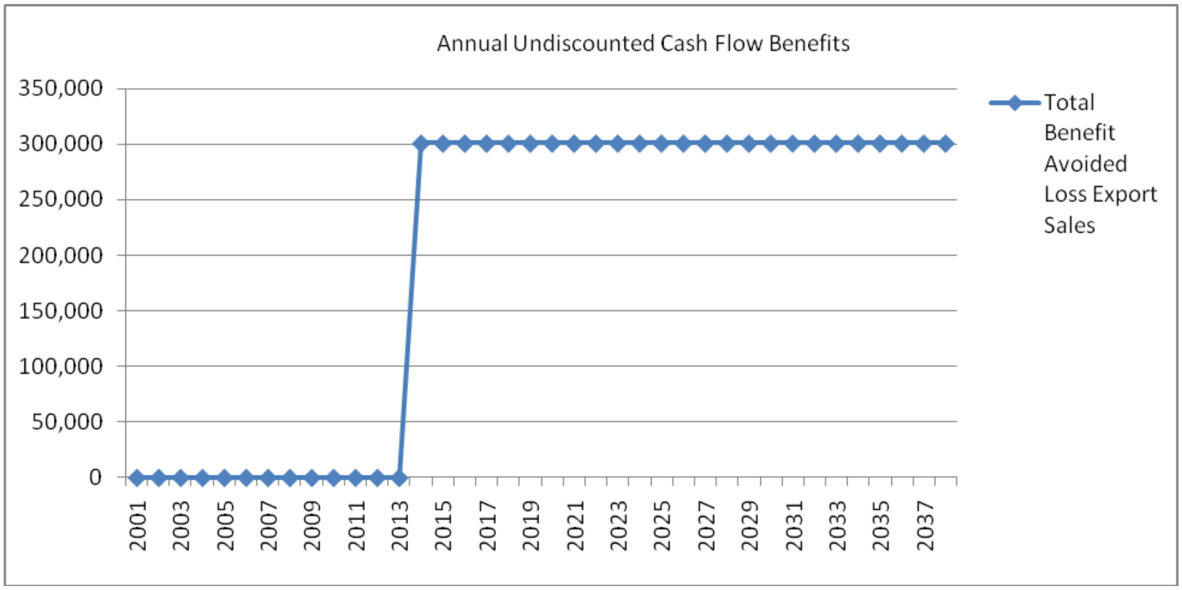
Table 16: Investment Criteria for HAL Investment and Benefits to HAL for Each Benefit Period
(discount rate 5%)

Criterion	0 years	5 years	10 years	20 years	30 years
Present value of benefits (m$)	0	0	0.9	2.2	3.0
Present value of costs (m$)	0.8	0.8	0.8	0.8	0.8
Net present value (m$)	(0.8)	(0.8)	0.1	1.4	2.2
Benefit cost ratio	0	0	1.1	2.6	3.5
Internal rate of return (%)	Negative	Negative	1	6	7

The proportion of total benefits from avoided loss of export markets was 100%.

The annual cash flows of undiscounted benefits are shown in Figure 1.

Figure 1: Annual Benefit Cash Flow



Sensitivity Analyses

Sensitivity analyses were carried out on several variables and results are reported in Tables 17 to 18. All sensitivity analyses were performed using a 5% discount rate with benefits taken over the life of the investment plus 30 years from the year of last investment. All other parameters were held at their base values.

Table 17 shows the relatively low impact of the discount rate on the investment criteria.

Table 17: Sensitivity to Discount Rate
(HAL investment, 5% discount rate, 30 years)

	Discount rate		
Criterion	0%	5%	10%
Present value of benefits (m$)	6.4	3.0	1.6
Present value of costs (m$)	0.6	0.8	1.0
Net present value (m$)	5.8	2.2	0.6
Benefit cost ratio	11.2	3.5	1.6

Table 18 shows the sensitivity of the investment criteria to changed assumptions regarding loss of a potato export market.

Table 18: Sensitivity to Loss of Export Market
(HAL investment, 5% discount rate, 30 years)

	Loss in Export Market		
Criterion	Half Market Value	Export Market Value as per Table 14	Double market Value
Present value of benefits (m$)	1.5	3.0	5.9
Present value of costs (m$)	0.8	0.8	0.8
Net present value (m$)	0.7	2.2	5.1
Benefit cost ratio	1.8	3.5	7
Internal rate of return	3	3.0	11

8. Confidence Rating

The results produced are highly dependent on the assumptions made, many of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 19). The rating categories used are High, Medium and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some significant uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 19: Confidence in Analysis of Grain Storage Investment

Coverage of Benefits	**Confidence in Assumptions**
High	Medium

9. Conclusions and Lessons Learned

The focus of the four projects included in the environment and health cluster was reasonably diverse – potato plastics, black dot disease and soil cadmium management. The major benefit quantified results from soil cadmium management.

The investment in this cluster has been assumed to produce a number of benefits, one of which was valued (avoided loss of export markets). The total investment of $0.8 million (present value terms) has been estimated to produce gross benefits of $3 million (present value terms) providing a net present value of $2.2 million and a benefit cost ratio of 3.5 to 1 (over 30 years, using a 5% discount rate).

Acknowledgments

Lucy Keatinge	Industry Services Manager HAL
Stuart Burgess	Industry Services Manager HAL
Ian James	Economist AUSVEG

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Strategic Business Development (2006) Australian Processing Potato Industry Strategic Plan 2006-2011. Prepared for HAL and the Australian Fresh Potato Industry.

Abbreviations

BMPs	Best Management Practices
DAWA	Department of Agriculture, WA
ELISA	Enzyme-linked Iimmunosorbent Assay
GA	gibberellic acid
GM	Genetically Modified
IPM	Integrated Pest Management
QDPI&F	Queensland Department of Primary Industries and Fisheries
MPC	Maximum Prescribed Concentration
MRL	Maximum Residue Levels
NAPIES	National Australian Potato Improvement Evaluation Scheme
PBZ	Paclobutrazol
PLRV	Potato Leaf Roll Virus
PVS	Potato Virus S
PVX	Potato Virus X
PVY	Potato Virus Y
SRS	Small Round (potato) Seed
TSWV	Tomato Spotted Wilt Virus
UV	ultra violet light
WARE	potato produced for fresh sale

Appendix 6: An Economic Analysis of HAL Investment in the Potato Extension Cluster

1. Background

The Australian potato crop averaged 1.29 million tonnes and was valued at $556 million over the three years to 30 June 2008 (AUSVEG analysis of ABS data). Victoria, South Australia and Tasmania produce almost 80% of production. Production fell 1995 to 2007 before rebounding in 2008. Production costs are rising, consumption is declining and low cost imports threaten the domestic potato industry.

Approximately 44% of Australian production is marketed in a fresh form (36% sold as fresh potatoes for consumption, 8% sold as seed potatoes). Some 56% of production is sold for processing (42% frozen, 14% crisping).

Fresh potatoes are marketed through wholesalers, independent retailers and supermarkets. Only a small proportion of the fresh potato crop is exported (7% by value) and exports are mainly directed to South East Asia and South Korea. There is little growth in exports and the search for export markets is underway although hindered by trade barriers. At the current time the volume of low cost fresh imports is small.

Total per capita potato consumption is currently around 63 kg. The proportion of fresh potato consumption has declining as processed potato consumption has increased.

The frozen processing potato industry is dominated by McCain Foods (Canada) and Simplot (US). Processing plants are located in Tasmania, South Australia and Victoria. The two major large crisping companies are Arnott's (Campbell's) and Smiths (Frito-Lay). Most crisping potatoes are grown under contract and crisping plants are located nationally.

Research and development (R&D) levies are in place for both the fresh and processing potato industries. Grower levies collected from the processing industry are matched by processors through the Potato Processing Association of Australia (PPAA). R&D levies collected from both industries are matched by the Australian Government.

AUSVEG is the peak industry body for both the Australian fresh and processing potato industries. The vision for the fresh potato industry is to enhance the profitability and sustainability of the industry by increasing the value of the fresh potato category. The vision for the Australia processing potato industry is that it will be sustainable and globally competitive and driven by consumer needs.

These visions will be achieved by industry who will deliver four strategic imperatives:

1. Improve consumer demand for Australian fresh potatoes;
2. Increase industry competitiveness;
3. Improve industry communication and information systems; and

4. Improve leadership and management capability.

Strategic imperative three is relevant to extension investments.

The extension cluster analysed in this economic evaluation addressed:

- National coordination of the transfer of technology to potato growers – a major investment in communication tools and people.
- Marketing of the potato industry to school children - the next generation of consumers and policy makers.
- Improvements in the management of Tasmanian processing potato crops through establishment of both a crop management service and support for grower business groups.
- Extension workshops and grower meetings targeting particular aspects of the potato industry including common scab control, best practice seed potato production and ensuring breeding programs for new potato varieties are efficient.

Investments focus on the take up of technology by growers with the eventual aim of improving industry profitability. Spin off benefits are created for potato growing regions (improved social outcomes) and the environment (less demand for irrigation water, chemical insecticides and chemical fertiliser).

2. The Cluster

Projects

Table 1 presents the details for each of the eight projects included in the potato extension cluster.

Table 1: Summary of Extension Projects

Project Number	Project Title	Other Details
PT96009	Coordinating technology transfer in the Australian potato industry	Organisation: SA Farmers Federation Period: October 1997 to August 2005 Principal Investigator: Leigh Walters
PT02007	The Workboot Series - The story of potatoes in Australia	Organisation: Kondinin Group Inc Period: November 2002 to February 2004 Principal Investigator: Catriona Nicholls
PT02013	International R&D workshop and industry extension meetings on common scab disease	Organisation: University of Tasmania Period: July 2002 to July 2004. Principal Investigator: Calum Wilson
PT03058	Seed potato workshop, Portland,	Organisation: Ag-Challenge Pty Ltd

	Victoria, August 18 & 19, 2003	Period: July 2003 to October 2003 Principal Investigator: Tony Pitt
PT04002	Supplying information on demand via the Potato Internet Service (NB: Project terminated Feb 2006, outputs incorporated into the AUSVEG internet site.)	Organisation: SA Farmers Federation Period: October 2004 to May 2007 Principal Investigator: Leigh Walters
PT05027	A potato crop management service to promote new technology in Tasmania	Organisation: Simplot Australia Pty Ltd - Tasmania Period: September 2005 to September 2008 Principal Investigator: Chris Russell
PT05030	Workshops for evaluation of horticultural annual crops	Organisation: Agricultural Supply Chain Services Pty Ltd Period: January 2006 to March 2006 Principal Investigator: Jeff Peterson
PT07016	Potato Grower Business Groups	Organisation: RDS Partners Pty Ltd - Tasmania Period: August 2007 to July 2010 Principal Investigator: Annabel Fulton

Project Objectives

Table 2 presents the objectives for each of the projects included in the cluster.

Table 2: Description of Project Objectives

Project Number	**Objectives**
PT96009	• To improve adoption of outcomes from the potato R&D program by facilitating improved technology transfer. • To undertake a specific project to evaluate the effectiveness of a national technology coordinator position by developing information on management of soil borne diseases and introduction of a national "code of practice" for minimising spread of Potato Cyst Nematode (PCN) and other soil borne diseases.
PT02007	• The project developed a 68 page hardcover, high quality educational WORKBOOT SERIES book on the story of potatoes in Australia. This book aimed to address the lack of well developed and presented educational materials for children of primary and secondary school age and their teachers and families.
PT02013	• This project looked to take advantage of a major international meeting in Australia of actinomycete specialists (the 13th International Conference on

	the Biology of Actinomycetes to be held in Melbourne in November 2003) to create a forum where the world's best researchers can meet, share current knowledge and formulate R&D strategies. • Effectively tackling actinomycete has the potential to reduce losses from common scab disease which conservatively costs the Tasmanian potato industry $3.5 million per annum in rejected crops and processing costs.
PT03058	• To hold a 'Best Practice' Seed Potato Workshop in Portland, Victoria to provide a technical update to seed potato growers and the wider industry in order to improve potato crop management (quality and returns) and for participants to develop industry links.
PT04002	• To establish a new password protected Internet service for the Australian potato industry so as to provide users with rapid access to research information and the ability for information of choice to be forwarded directly to the user by email when it becomes available. The service was to be designed to provide access to past information quickly through Potato Archives and to keep growers and others in the industry up to date with new information and developments. • The project commenced in November 2004 and was terminated in Feb 2006 when the industry's Communication Program was transferred to AUSVEG. AUSVEG already had an internet service in place and to impose another system onto the AUSVEG server would have caused considerable problems.
PT05027	• To boost the international competitiveness of the Tasmanian processing potato industry by the rapid adoption of new crop management technology, the widespread use of agronomists and the use of pooled industry agronomy data to advance industry yield, productivity and reduce costs to achieve more profitable farming enterprises. • To achieve a favourable environmental outcome through the rational use of irrigation water, chemicals and fertilisers. • The Tasmanian french fry industry valued at $85 million pa risks closure through failure to adopt new technology. In 2004 yields were stagnant at 48t/ha. The equivalent NZ yield is 65t/ha.
PT05030	• To increase the awareness and skills of Australian horticulturists and to explore opportunities for further cooperation with Dr Eric Allen from Cambridge University. • In the longer term, to ensure best practice science and optimal efficiency and accuracy in varietal evaluation and therefore better outcomes from genetic improvement investments.
PT07016	• To build on existing Tasmanian Potato Grower Business Groups established by Simplot Australia and deliver an increase in crop profitability, productivity and overall business performance of group members. • To have all Tasmanian potato growers participate at some level in the Potato Grower Business Groups project. • To develop a shared five-year strategic plan for the future of the Tasmanian potato industry by March 2009.

Project Investment - Potato Extension Cluster

Table 3 shows the annual investment by project for HAL and Industry. Contributions from other sources, including the research provider, are shown in Table 4.

Table 3: Investment by Project by HAL Including Both Levy and Voluntary Contributions

Project Number	**HAL and Industry Year ending June ($)**										
	2001	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**Total**
PT96009	391,894	-	-	-	-	10,000					401,894
PT02007		-	94,000	11,700	-	-					105,700
PT02013		10,000	8,000	2,000							20,000
PT03058			37,333								37,333
PT04002				138,410	-90,909	-30,177					17,323
PT05027*						95,000	75,000	60,000			230,000
PT05030					28,577	6,284					34,861
PT07016							56,000	75,000	75,000	19,000	225,000
Total	**391,894**	**10,000**	**139,333**	**152,110**	**-62,332**	**81,107**	**131,000**	**135,000**	**75,000**	**19,000**	**1,072,111**

Source: HAL Project Database.
* Actual figure less than budget due to impact of drought on reducing participating growers.
NB: Negative figures arise after PT04002 was terminated and part of the project budget was repaid.

Table 4: Investment by Project by Other Sources Including Research Provider Contributions

Project Number	**Other Sources Year ending June ($)**										
	2001	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**Total**
PT96009											
PT02007			59,050	7,350							66,400
PT02013		25,878	20,702	5,176							51,755
PT03058											
PT04002				179,769	118,074	39,195					22,500
PT05027						242,374	191,348	153,078			586,800
PT05030											
PT07016											
Total		**25,878**	**9,752**	**192,295**	**118,074**	**203,179**	**191,348**	**153,078**	**-**		**727,455**

Source: HAL Project Database

An annual summary of investment in the Potato Extension cluster is provided in Table 5.

Table 5: Investment in Potato Extension Cluster
(nominal $)

Year ending June	HAL and Industry	Other Sources	Total
2001	391,894	-	391,894
2002	-	-	-
2003	10,000	25,878	35,878
2004	139,333	79,752	219,085
2005	152,110	192,295	344,405
2006	- 62,332	-118,074	- 180,407
2007	81,107	203,179	284,286
2008	131,000	191,348	322,348
2009	135,000	153,078	288,078
2010	75,000	-	75,000
2011	19,000	-	19,000
Total	**1,072,111**	**727,455**	**1,799,566**

3. Activities and Outputs

Table 6 provides a brief summary of outputs for each of the projects within the Potato Extension cluster.

Table 6: Summary of Cluster Activities and Outputs

Project	Activities and Outputs
PT96009	• The national pilot project to coordinate potato industry technology transfer to the Australian potato industry with a view to appointing longer term a Potato Industry Technology Coordinator (PITC) included: establishing a technology transfer network, introducing the code of practice for soil borne disease management and developing a long term technology transfer strategy. • A pilot national project managed by Potato Growers SA was established, a PITC was appointed, databases were developed and on-ground networks were established along with a national distribution system with state groups. A new quarterly industry newsletter 'Eyes on Potatoes' was developed, a Potato Internet Starter Pak and Potato Archives were also established.
PT02007	• The educational WORKBOOT SERIES book on the story of potatoes in Australia was researched and published by the Kondinin Group. The book was designed to educate children about the Australian potato industry and research was completed with industry technology transfer officers. • Initially 5000 copies of a 68 page hardcover book titled THE WORKBOOT SERIES THE STORY OF POTATOES IN AUSTRALIA were published but it is anticipated additional print runs will be required at a later date to supply on-going demand.
PT02013	• The international R&D workshop on common scab gathered together world experts to formulate disease future research priorities, initiate and strengthen strategic alliances between research groups to create a common research focus, avoid duplication of effort and re-invention of data, and to discuss issues of specific Australian importance within such a peer group. • Two industry-focussed extension days followed the workshop, one in Victoria and one in Tasmania. At these meetings keynote speakers (and local researchers in the field) from the workshop transferred the best extension knowledge available from their collective experiences of these world experts to local industry. • A monograph was produced from the workshop meeting (with invited authors contributing chapters on the current state of knowledge of these economically important pathosystems.

PT03058	• The 'Best Practice' Seed Potato Workshop in Portland, Victoria was held over two days in August 2003 and attended by 140 participants, including both growers and industry personnel. Speakers at the conference were local and international. Speaker notes were prepared and distributed to participants of each session along with a loose leaf binder to ensure retention of BMP information.
PT04002	• Project terminated
PT05027	• The project provided an agronomist and data analysis service in Partnership with Simplot Australia to 300 Tas processing potato crops over four seasons to collect and collate data and reveal which factors drive yield and quality in the local setting and prepare a plan to increase yield from its current 5 year average of 48t/ha to the 65t/ha achieved in NZ. • Data collected included: soil tests; fertiliser application; plant nutrient analysis; irrigation/rain data; soil moisture; soil and air temperature; insect and disease data; yield and quality data. • Outputs included individual crop management and data reports, an annual R&D technical report from crop data analysis published and made available to whole of industry, formation of grower agronomy groups, a database to record and analyse pooled crop management and agronomy data, rapid and widespread adoption of technology to measure soil moisture, plant nutrition and pest and disease management and a widespread use of formal crop management planning and the use of agronomists.
PT05030	• The workshop with Dr Allen to learn better horticultural annual crop varietal evaluation techniques included researchers and agronomists working in potatoes, vegetables, strawberries, etc. Workshops were held in Southern Qld, NSW, Southern Vic, Tas and SA. Each was attended by between 6 and 8 people drawn from DPI's, universities and private companies. • Outputs included increased knowledge and skills in varietal evaluation procedures amongst Australian horticulturists, routine use of best practice methodologies in future evaluation projects, ongoing cooperation between Australian and international researchers to maintain and develop best practice in evaluation methodologies and outcomes and identification of breeding objectives for productivity.
PT07016	• Activities and outputs associated with delivery of the Tas Potato Grower Business Groups project included independent facilitation of the eight groups, creation of development activities and tools, evaluation protocols to determine group contribution to farm profit and communication of learning and changes taking place as a result of the project to internal and external stakeholders.

4. Outcomes

Table 7 provides a brief summary of outcomes for each of the projects within the Potato Extension cluster.

Table 7: Summary of Cluster Outcomes

Project	Outcomes
PT96009	• The coordination of technology transfer project has delivered a national tech transfer distribution system, a new quarterly newsletter ('Eyes on Potatoes'), a PITC (that has contributed to the development and delivery of at least six major projects), the Potato Internet Starter Pak (helps people find information on the internet), Potato Archives (information on R&D program outcomes), support to industry technical service providers (eg rural merchants), refined the code of practice for soil borne diseases and provided effective liaison with other industries through the PITC.
PT02007	• The WORKBOOT SERIES Potato book will meet the educational standards and requirements of children in the 10-14 year old age group. It was aimed at broadening / changing children's perceptions about the importance of potatoes in their diet, how they are produced and the variety of ways in which they can be eaten. It was made accessible to over 9,000 schools throughout Australia, as well as the general public. • The publication will provide tomorrow's consumers with balanced, accurate information about Australia's modern potato industry.
PT02013	• The international R&D workshop and industry extension meetings on common scab resulted in research cost efficiencies and savings and more rapid and the potential for more significant breakthroughs in common scab disease control – an economic problem that costs the Tasmanian industry alone in excess of $3.5 million pa.
PT03058	• The 'Best Practice' Seed Potato Workshop in Portland, Victoria delivered advice in relation to better seed potato crop management, improved hygiene practices and thus less transfer of disease and increased knowledge of disease management (eg Potato leaf roll, Tomato Spotted Wilt Virus, Rhizoctonia, Powdery scab).
PT04002	• Project terminated.
PT05027	• The potato crop management service to promote new technology in Tasmania has delivered higher potato productivity and quality; more reliable production, with less crop failures; more efficient use of water, fertiliser and agricultural chemicals; reduced environmental impact (irrigation water use and fertiliser use savings); improved knowledge of agricultural system in Tasmania and a competitive potato processing

	industry in Tasmania. Data shows an improvement in average yields.
PT05030	• The workshops to evaluate horticultural annual crops have the potential to deliver quicker and more efficient outcomes from breeding and importation programs for all annual crops including potato crops.
PT07016	• The project was designed to achieve on-ground change to increase the crop profitability, productivity and the overall business performance of Tas Potato Grower Business Group members.

The principal outcomes from each of the extension projects in this cluster were:

- Coordination of technology transfer – more effective uptake of research results across all levy funded potato industry R&D projects.
- The workboot story of potatoes – provides a better understanding of the potato industry by the next generation of consumers (with knock on effects for both consumption and public policy).
- Common scab workshop and extension meetings – more rapid reduction in the economic cost of this disease (eg cost to the Tasmanian potato industry conservatively estimated at $3.5 million pa in rejected crops and processing costs).
- The 'Best Practice' Seed Potato Workshop in Portland, Victoria – produced better seed potato crop management outcomes including hygiene practices and disease control (additional grower yield).
- Information on demand internet service – project terminated.
- Potato crop management service to promote new technology in Tasmania - understanding and technology that will close the gap between current Tasmanian french fry processing potato yields of 48t/ha to best practice NZ yields of 65t/ha by 2013/14 (with an interim target of 56t/ha by 2007/08. AUSVEG data reveals actual outcome was 52.1t/ha in 2007/08 across the whole Tasmanian industry).
- Workshops to evaluate horticultural annual crops - quicker and more efficient outcomes from breeding programs.
- Tasmanian Potato Grower Business Group members – potentially achieved on ground change to increase profitability, productivity and the overall business performance. Potentially project outcomes add to results being delivered by the Tasmanian crop management service – PT05027.

5. Benefits

Increased Potato Yield, Tasmanian Processing Potato Industry

- Additional potato yield across the Tasmanian processing industry, valued at $85 million pa, was achieved through establishment of a crop management service in 2005 (PT05027) and the supporting of grower business groups from 2007 (PT07016).
- Additional yield in this industry will also be facilitated by national coordination of technology transfer (PT96009), workshops dealing with common scab disease (PT02013) and seed potato improvements (PT02013).
- At initial project commencement, five year average Tasmanian processing potato industry yield was 48t/ha while the NZ industry which competes with Tasmanian production was able to achieve an industry average of 65t/ha. The difference in yield translates into both grower profitability and the ongoing viability of a local Tasmanian processing sector.
- The crop management service set itself a target of lifting average yields to 65t/ha by 2013/14 with an interim target of 56t/ha by 2007/08 with an adoption rate of 40% of the total Tasmanian industry. Actual yield across the whole Tasmanian industry, which includes lower yielding seed and fresh potato crops, was 52.1t/ha in 2007/08.

Production Cost Savings

- The workshops dealing with potato common scab disease also have the potential to generate a cost saving for potato producers. Successful outcomes from the workshop are able to lower the cost of rejected crops and processing costs in Tasmania where common scab disease currently costs the industry a minimum of $3.5 million per annum.

Environmental Benefits

- The Tasmanian crop management service, through the greater use of agronomists and a NZ developed ‘Potato Calculator’ computer model have potentially been able to increase average processed potato grower yields and lower the use of irrigation water, chemical sprays and fertilisers with benefits for stream flows (lower extraction levels) and, potentially the quality of water in the natural system (less runoff of chemical insecticides and fertilisers).

Social Benefits

- A higher yielding and more competitive Tasmanian processing potato growing sector is able to ensure the ongoing viability of the industry in the island state and maintain what is an important regional economic activity with flow on implications for regional employment.

Overview of Benefits

An overview of benefits in a triple bottom line categorisation is shown in Table 8.

Table 8: Categories of Benefits from the Cluster Investment

	Levy paying industry and its supply chain	**Spillovers**		
		Other industries	**Public**	**Foreign**
Economic	1. Increased potato yield, Tasmanian processing potato industry. 2. Production cost savings.	Nil	Nil	Nil
Environmental	3. Less use of irrigation water, chemical insecticides and chemical fertilisers in the Tasmanian processing potato industry.	Nil	5. Less use of irrigation water and chemicals in the Tasmanian processing potato industry resulting in better environmental outcomes for regional communities.	Nil
Social	4. Ongoing viability of the Tasmanian processing potato industry with linked regional employment opportunities.	Nil	6. Ongoing regional employment.	Nil

Public versus Private Benefits

The benefits identified from the investment are predominantly private benefits, namely benefits to processing potato growers and their supply chains. There also will have been some public benefits produced, mainly environmental and social in nature, from reduced use of irrigation water and chemicals and ongoing regional employment.

Benefits to Other Primary Industries

It is likely that industry benefits will be confined to the potato industry.

Distribution of Benefits along the Potato Supply Chain

In so far as some segments of the industry supply inputs to other segments (eg processing potatoes are supplied to processing companies such as Simplot Australia and processing potato growers purchase seed from specialist growers), benefits from the initial impacts are shared both forwards and backwards along the supply chain, as well as with consumers.

Benefits Overseas

It is unlikely that any of the knowledge produced by this investment will directly benefit overseas potato industries. The NZ developed Potato Calculator computer model will have achieved additional sales in Australia as a result of investment in this cluster but this is not a benefit to a competing potato industry. Adoption of cluster outcomes, and the closing of the yield gap, may in fact result in a dis-benefit (an economic loss) for the NZ potato industry.

Match with National Priorities

The Australian Government's national and rural R&D priorities updated in May 2007 and current July 2009 (http://www.daff.gov.au/agriculture-food/innovation/priorities) are reproduced in Table 9.

Table 9: National and Rural R&D Research Priorities

Australian Government	
National Research Priorities	**Rural Research Priorities**
1. An environmentally sustainable Australia 2. Promoting and maintaining good health 3. Frontier technologies for building and transforming Australian industries 4. Safeguarding Australia	5. Productivity and adding value 6. Supply chain and markets 7. Natural resource management 8. Climate variability and climate change 9. Biosecurity *Supporting the priorities:* 1. Innovation skills 2. Technology

Table 10 identifies the relative importance of the rural research priorities addressed by the plant improvement cluster as a whole.

Table 10: Categorisation of Benefits by Priorities

Benefit	**National Research Priority Addressed**	**Rural Research Priorities Addressed**
1. Increased potato yield, Tas processing potato industry		Priority 1 ***
2. Production cost savings		Priority 1 ***
3. Less use of irrigation water and chemicals in the Tas processing potato industry	Priority 1 *	Priority 3 ***
4. Ongoing viability and employment in the Tas processing potato industry		Priority 1 *

*** Strong contribution **Some contribution * Marginal contribution

Additionality and Marginality

The investment in this cluster was targeted principally towards benefits to potato growers and others in the potato supply chain involved with processing. As improved industry communication, information systems, leadership and management capability were all strategic imperatives for the processed potato industry it is likely that these projects would have been regarded as a high priority by levy payers. Furthermore, technology transfer and extension is a high priority for HAL. In the event that public funding to HAL was restricted, it is likely that most of the projects in the cluster would have still been funded by industry, assuming a levy system was still in place.

The limited public spillovers that have been identified (less irrigation water and chemical usage) would therefore still have been delivered. If no public funding at all had been available for HAL, it is likely that the investment would have been 90% of the investment actually recorded. Levy payers would probably have sacrificed other projects to advance extension outcomes. This could have resulted in a marginally less effective investment. A summary is provided in Table 11.

Table 11: Potential Response to Reduced Public Funding to HAL

1. What priority were the projects in this cluster when funded?	Most were high priority for HAL and industry.
2. Would the investments still have been made in this cluster if 50% less public funds were available to HAL?	Yes, but with very slightly less total funding.
3. Would industry and others have funded this cluster if no public funds were available to HAL?	Yes, to the extent of about 90% of that actually funded.

Pathway to Adoption

A summary of the different communication tools used in the extension cluster is presented in Table 12.

Table 12: Adoption Pathways

Project Number	Adoption Pathway
PT96009	• Communication tools used in the coordinating technology transfer in the Australian potato industry project included employment of a Potato Industry Technology Coordinator, establishing a national technology transfer network, developing a long term technology transfer strategy, database development, publishing a new quarterly newsletter ('Eyes on Potatoes'), preparation and release of an Internet Starter Pak and Potato Archives on line.
PT02007	• The Potato Workboot Series, the STORY OF POTATOES IN AUSTRALIA was marketed to schools nationally with expectations for sales of 9,000 copies. The publication is hard cover and high quality and based on Kondinin's experience with similar publications should have a long shelf life in school and other libraries servicing children in the 10-14 year age group. Kondinin will also market the book through its own web site.
PT02013	• The international common scab workshop and industry extension meetings attracted the enthusiastic participation of key common scab researchers including Prof Rosemary Loria and the extension meetings were well attended by potato growers and the industry support sector (eg private agronomists and relevant DPIs).
PT03058	• The seed potato workshop Portland Victoria was a technology transfer project where the request for information came from the growers – adoption was therefore relatively certain. Exit surveys from the workshop indicated that growers perceived the meeting to be good value and relevant to their businesses.
PT04002	• Project terminated.
PT05027	• The crop management service to promote new technology amongst Tas processing potato growers provided financial assistance to adopt technology and employ professional agronomists (starting Sept 04), formed and conducted grower agronomy groups (several groups of 6-10 growers, starting Sept 04), produced technical reports annually for all participating

	growers and the broader industry (starting in June 05). In 2009 the project is on track to deliver forecast yield improvements.
PT05030	• The workshop for evaluation of horticultural annual crops resulted in more effective and efficient approaches to variety evaluation for use by both researchers and agronomists. Consequently HAL is demanding and expecting higher methodological standards in future plant breeding proposals. Institutionalisation of the results will be achieved by developing a relationship between Dr Allen's university (Cambridge) and an Australian university via a PhD studentship.
PT07016	• Ten existing Tasmanian potato grower business groups were supported by this project, meetings were, and continue to be, held on a regular basis and formal feedback from members indicates success in improving business outcomes.

The communication tools and pathways described provide confidence that investment in this cluster resulted in an improved uptake of R&D outcomes.

6. Measurement of Benefits

The benefit of the investment that is valued in this analysis is:

- Increased potato yield, Tasmanian processed potato industry

Increased Potato Yield, Tasmanian Processed Potato Industry

- The Tasmanian processing potato industry produces, on average, a total of 200,000 tonnes on 4,000 ha with an average yield of 50t/ha (derived from AUSVEG/ABS data for the three years to 30 June 2008).
- It is assumed that due to the projects in the cluster, a combined increase in the average yield of 20% can be assumed. This yield increase commences in the year ending June 2009, and it takes a good ten years for the full increase to be realised. However, as the demand for processing potatoes is not expected to increase by a large amount during this time, the benefit is measured through a cost reduction, rather than valuing the increased yield. For the purposes of the analysis, it is assumed that the cost of production is equal to the average farm gate price for processing potatoes of $280/t (derived from AUSVEG/ABS data for the three years to 30 June 2008). At a base yield of 50t/ha, this equates to a cost of production of $14,000/ha. When the yield is increased by 20% to 60t/ha, the cost of production per tonne is reduced to $233.3/t if it is assumed that the costs of production per hectare do not change. Therefore, a cost saving of $46.70/t is realised.
- A maximum of 40% of the Australian industry is assumed to adopt cluster results and this is phased in over ten years (2008 to 2018).
- As the yield increase is assumed to be an average gain due to a number of technology and production changes, it is assumed that the increase is net of any additional adoption and production costs required to achieve this gain.

Benefits not Valued

The principal benefits identified but not valued in the analysis include:

- Production cost savings – potential benefits associated with extension outcomes dealing with potato common scab disease.
- Environmental benefits - any environmental costs avoided due to lower levels of irrigation water and chemical usage in the Tasmanian potato industry.
- Social benefits – associated with the ongoing viability of the Tasmanian potato processing industry.

Attribution

Projects other than the eight described here also contributed to the benefits valued. A total of 50% of the benefits estimated above have been assigned to the eight projects. For example, yield benefits attributable to this cluster may also have been realised through both the *potato processor – disease – soil amendments* and the *potato processor – disease – DNA monitoring tools* clusters as well as the growers own initiatives and successes outside the R&D program.

Summary of Assumptions

A summary of the key assumptions made is shown in Table 13.

Table 13: Summary of Assumptions

Variable	Assumption	Source
Processing potato production in Tasmania.	Average of 200,000 tonnes.	Consultant extrapolation of AUSVEG data
Increased Potato Yield, Tasmanian Processing Potato Industry		
Average yield for Tasmanian potato processing industry without investment at beginning of the analysis period.	50t/ha	PT05027 project application and final report checked against AUSVEG data
Yield increase as a result of extension investments.	20%	Consultant estimate after review of relevant research reports and checked against the AUSVEG estimate for 2007/08.
Share of Tasmanian potato processing industry experiencing yield increase.	40% phased in over ten years.	Consultant estimate after review of relevant research reports.
Cost of production savings as a result of yield increase.	Estimate of $46.70/t.	Derived from AUSVEG/ABS data for the three years to 30 June 2008
Attribution		
Attribution	50% for Increased Potato Yield, Tasmanian Processing Potato Industry.	Consultant's estimate based on knowledge of alternative adoption pathways (eg over the fence learning).

7. Results

All past costs and benefits were expressed in 2008/09 dollar terms using the Consumer Price Index (CPI). All benefits after 2008/09 were expressed in 2008/09 dollar terms. All costs and benefits were discounted to 2008/09 using a discount rate of 5%. The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for many of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2010/11) to the final year of benefits assumed.

Investment criteria were estimated for both total investment and for the HAL investment alone. Each set of investment criteria were estimated for different periods of benefits. The investment criteria were all positive after year zero as reported in Tables 14 and 15.

Table 14: Investment Criteria for Total Investment and Total Benefits for Each Benefit Period
(discount rate 5%)

Criterion	0 years	5 years	10 years	20 years	30 years
Present value of benefits (m$)	0	4.6	10.2	19.5	25.2
Present value of costs (m$)	1.6	2.0	2.0	2.0	2.0
Net present value (m$)	(1.6)	2.6	8.2	17.5	23.2
Benefit cost ratio	0	2.3	5.1	9.8	12.7
Internal rate of return (%)	negative	15	21	23	23

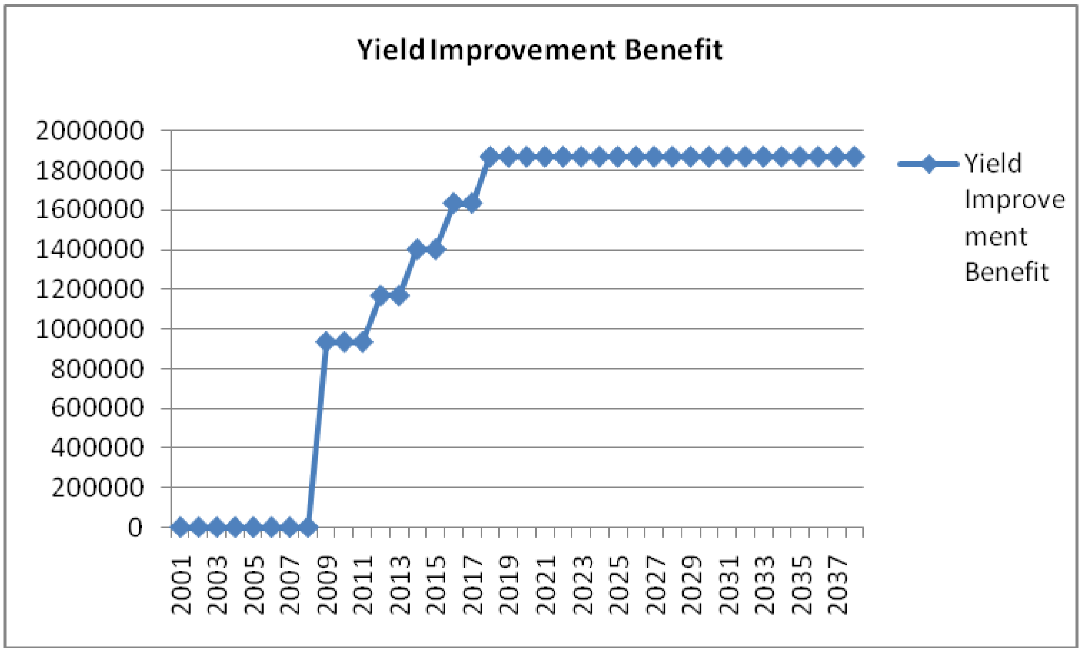
Table 15: Investment Criteria for HAL Investment and Benefits to HAL for Each Benefit Period
(discount rate 5%)

Criterion	0 years	5 years	10 years	20 years	30 years
Present value of benefits (m$)	0	2.8	6.3	11.9	15.4
Present value of costs (m$)	1.3	1.5	1.5	1.5	1.5
Net present value (m$)	(1.3)	1.3	4.7	10.4	13.9
Benefit cost ratio	0	1.8	4.1	7.8	10.0
Internal rate of return (%)	negative	9	15	17	18

One hundred percent of benefits are attributable to increased potato yield in the Tasmanian processing potato industry.

The annual cash flows of undiscounted benefits are shown in Figure 1.

Figure 1: Annual Benefit Cash Flow



Sensitivity Analyses

Sensitivity analyses were carried out on several variables and results are reported in Tables 16 to 18. All sensitivity analyses were performed using a 5% discount rate with benefits taken over the life of the investment plus 30 years from the year of last investment. All other parameters were held at their base values.

Table 16 shows the relatively low impact of the discount rate on the investment criteria.

Table 16: Sensitivity to Discount Rate
(HAL investment, 5% discount rate, 30 years)

	Discount rate		
Criterion	0%	5%	10%
Present value of benefits (m$)	30.8	15.4	9.2
Present value of costs (m$)	1.2	1.5	2.0
Net present value (m$)	29.6	13.9	7.2
Benefit cost ratio	25.3	10.0	4.7

Table 17 shows the sensitivity of the investment criteria to changed assumptions regarding increased potato yield and adoption rate.

Table 17: Sensitivity to Increased Potato Yield
(HAL investment, 5% discount rate, 30 years)

	Increase in Potato Yield		
Criterion	Half Increment	Increment as per Table 13	Double Increment
Present value of benefits (m$)	7.7	15.4	30.8
Present value of costs (m$)	1.5	1.5	1.5
Net present value (m$)	6.2	13.9	29.3
Benefit cost ratio	5.0	10.0	20.1
Internal rate of return	11	18	25

Table 18 shows the sensitivity of the investment criteria to changed assumptions regarding adoption rate.

Table 18: Sensitivity to Rate of Adoption of Yield Increasing Recommendations
(HAL investment, 5% discount rate, 30 years)

	Rate of Adoption		
Criterion	Half Increment	Increment as per Table 13	Double Increment
Present value of benefits (m$)	12.6	15.4	50.5
Present value of costs (m$)	1.5	1.5	1.5
Net present value (m$)	11.1	13.9	49.0
Benefit cost ratio	8.2	10.0	32.9
Internal rate of return	16	18	31

8. Confidence Rating

The results produced are highly dependent on the assumptions made, many of which are uncertain. There are two factors that warrant recognition. The first factor is the coverage of benefits. Where there are multiple types of benefits it is often not possible to quantify all the benefits that may be linked to the investment. The second factor involves uncertainty regarding the assumptions made, including the linkage between the research and the assumed outcomes

A confidence rating based on these two factors has been given to the results of the investment analysis (Table 19). The rating categories used are High, Medium and Low, where:

High: denotes a good coverage of benefits or reasonable confidence in the assumptions made

Medium: denotes only a reasonable coverage of benefits or some significant uncertainties in assumptions made

Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 19: Confidence in Analysis of Grain Storage Investment

Coverage of Benefits	**Confidence in Assumptions**
Medium	High

9. Conclusions and Lessons Learned

The major focus of the eight projects evaluated in the HAL extension cluster has been on national coordination of technology transfer, extension workshops and improvements in the management of Tasmanian processing potato crops.

The investment in extension has been assumed to produce a number of benefits, one of which was valued (an increase in Tasmanian processing potato grower yield). The total HAL investment of $1.5 million (present value terms) has been estimated to produce gross benefits of $15.5 million (present value terms) providing a net present value of $13.9 million and a benefit cost ratio of 10 to 1 (over 30 years, using a 5% discount rate).

Acknowledgments

Lucy Keatinge	Industry Services Manager HAL
Stuart Burgess	Industry Services Manager HAL
Ian James	Economist AUSVEG

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Strategic Business Development (2006) Australian Processing Potato Industry Strategic Plan 2006-2011. Prepared for HAL and the Australian Fresh Potato Industry.

Abbreviations

BMPs	Best Management Practices
DAWA	Department of Agriculture, WA
ELISA	Enzyme-linked Iimmunosorbent Assay
GA	gibberellic acid
GM	Genetically Modified
IPM	Integrated Pest Management
QDPI&F	Queensland Department of Primary Industries and Fisheries
MPC	Maximum Prescribed Concentration
MRL	Maximum Residue Levels
NAPIES	National Australian Potato Improvement Evaluation Scheme
PBZ	Paclobutrazol
PITC	Potato Industry Technology Coordinator
PLRV	Potato Leaf Roll Virus
PVS	Potato Virus S
PVX	Potato Virus X
PVY	Potato Virus Y
SRS	Small Round (potato) Seed
TSWV	Tomato Spotted Wilt Virus
UV	ultra violet light
WARE	potato produced for fresh sale