Benefit Cost Analysis of Wine Australia R&D Investments 2017-18

Report: 10 May 2019

Prepared by:

AgEconPlus Consulting

Disclaimer

All description, figures, analyses, forecasts and other details have been prepared in good faith from information furnished to Michael Clarke by other parties. These data are believed to be correct at the date of preparation of this report.

However, it should be noted that predictions, forecasts and calculations are subject to assumptions which may or may not turn out to be correct and AgEconPlus expressly disclaim all and any liability to any persons in reliance, in whole or in part, on the report in total or any part of its contents.

AgEconPlus Pty Ltd
ABN 41 107 715 364

Michael Clarke
P: (02) 9817 5888
M: 043 8844024
W: www.AgEconPlus.com.au
E: clarke@AgEconPlus.com.au

Table of Contents

Executive Summary

Economic analyses of six research and development (R&D) projects funded by Wine Australia have been undertaken. The main purpose was to demonstrate the outcomes and benefits that have emerged or are likely to emerge from investment. This forms part of the process for the Council of Rural Research & Development Corporations (CRRDC) that aims to demonstrate the impact, effectiveness and return on investment from the Rural Research and Development Corporations. Wine Australia 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.

Each of the six analyses provides a description of the constituent projects including objectives, outputs, activities, costs, outcomes, and benefits. Benefits are described qualitatively according to their contribution to the triple bottom line of economic, environmental and social benefits. While a range of potential benefits of each project are identified, the analysis focused on the most likely and most significant benefit stream. A number of potential benefits therefore remained unquantified and hence the estimated net benefits of some projects may be considered conservative. The analyses were undertaken for total benefits and Wine Australia benefits, including those expected in the future as a result of the investment.

Investments in all six projects yielded positive results at a 5% discount rate and a 30 year analysis period, with benefit cost ratios ranging from 1.6 to 5.3. When core analysis assumptions were subject to sensitivity testing, three projects (data for MRLs, disease resistant varieties, and elevated temperature/CO_2 effects on Shiraz) produced negative benefit-cost ratios for 'lower end' assumptions – Table ES1.

Table ES1: Benefit Cost Analyses Six Wine Australia R&D Investments 2017-18 (discount rate 5%)

Investment Criteria	Investment Project					
	MRL data (AWRI 2.2.1)	**Brettanomyces (AWR 1304)**	**PGR (CSP 1401)**	**Varieties (CSP 1402)**	**Ion Speciation (NWG 1401)**	**CO_2 Shiraz (DPI 1202)**
Benefit–cost ratio	1.80	2.13	5.07	3.38	5.28	1.57
Benefit-cost ratio range - core assumption sensitivity	0.72 to 3.60	1.07 to 4.48	2.38 to 11.64	0.79 to 13.19	2.64 to 10.57	0.79 to 2.36
Potential unquantified benefits	Grape juice with additional blending.	Avoided remedial processing cost.	Avoided grape loss – overripe fruit	Avoided cost of mildew.	Avoided copper MRL breaches.	Data on future irrigation water needs.
	Minimisation of chemical residues on farm.	Reduced waste and electricity use.	Improved harvesting logistics		Capacity building in researchers and students	More productive regions.

Key: MRL is Maximum Residue Limit, PGR is Plant Growth Regulators

Comparisons between project results should be made with caution due to uncertainties involved with assumptions and differing frameworks for each of the six analyses.

Technical Summary

This report presents the results of economic analyses of investments within the R&D Program of Wine Australia. 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 main purpose of undertaking the analyses was to demonstrate the outcomes and benefits that have emerged or are likely to emerge from investments. This forms part of the process for the Council of Rural Research & Development Corporations (CRRDC) that aims to demonstrate the impact, effectiveness and return on investment of the Rural Research and Development Corporations.

Consistent with Council of Rural Research and Development Corporation Guidelines for random project selection, projects in a list provided by Wine Australia 26 November 2018 were numbered 1 to 37. AgEconPlus then used an online random number generator to select projects. Projects were selected until research investment exceeded $4.7 million i.e. 10% of total Wine Australia investment. The results of random project selection, in the order in which they were selected, is shown in Table 1.

Table 1 Projects Randomly Selected for Benefit Cost Analysis 2017-18

No.	Code	Project Title	Program	Investment ($)
10	AWRI 2.2.1	Collecting and disseminating information regarding agrochemicals registered for use and maximum residue limits in Australian viticulture	Market access	336,076
26	AWR 1304	Ensuring the continued efficacy of Brettanomyces control strategies for avoidance of spoilage	Enhanced yeast and bacterial performance	1,489,492
22	CSP 1401	Understanding and manipulating small signalling molecules to affect the yield/flavour ('quality') nexus	Grape growing for excellence	1,242,271
6	CSP 1402	Evaluating and demonstrating new disease resistant varieties for warm irrigated regions	Enhancing grapevine and rootstock performance	263,468
13	NWG 1401	Metal ion speciation: Understanding its role in wine development and generating a tool to minimise wine spoilage	Wine provenance and measures of quality	753,462
30	DPI 1202	Impact of elevated CO_2 and its interaction with elevated temperature on production and physiology of Shiraz	Climate adaptability	1,650,000
			Investment in projects for analysis	5,734,769
			Total of Wine Australia investment	46,829,387
			Analysis projects share of total investment	12%

Documentation for each of these projects was assembled with assistance from Wine Australia personnel and included project applications, contract schedules and final reports. Each of the six analyses provides a description of the constituent projects including objectives, outputs, activities, costs, outcomes and benefits. Benefits are described qualitatively according to their contribution to the triple bottom line of economic, environmental and social benefits. While a range of potential benefits of each project are identified, the analysis focused on the most likely and most significant benefit stream. A number of potential benefits therefore remained unquantified and hence the estimated net benefit of some projects may be considered conservative.

Benefit cost analysis was conducted on all six projects to generate investment criteria. The Present Value of Benefits (PVB) and Present Value of Costs (PVC) were used to estimate investment criteria of Net Present Value and Benefit-Cost Ratio (BCR) at a discount rate of 5%. The Internal Rate of Return and Modified Internal Rate of Return were also estimated from the annual net cash flows. The PVB and PVC are the sums of the discounted streams of benefits and costs. All dollar costs and benefits were expressed in 2018 dollar terms. Future costs and benefits were discounted to the 2018 year while past costs were inflated to 2018 using the Gross Domestic Product deflator. A 30-year benefit time frame was used in all analyses, with benefits estimated for 30 years from the year of last capital investment in each project. Costs for the R&D projects included cash contributions (includes both Wine Australia and industry investment), as well as any other resources contributed by third parties (e.g. researchers or additional industry funds). Investment criteria were reported for 5 year intervals of benefits from zero to 30 years.

The analyses were undertaken for total benefits, including benefits expected in the future as a result of the investment. A degree of conservatism was used when finalising assumptions.

Sensitivity analysis was undertaken for several assumptions that had the greatest degree of uncertainty or for those that were seen to be key drivers of the investment criteria.

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; and/or
- The magnitude of the value of the benefit was thought to be only minor.

Table 2 presents the investment criteria for each of the six projects analysed at a 5% discount rate and expressed in 2018 dollar terms. Given the assumptions made for each evaluation, all six investments are expected to produce positive net benefits over 30 years from the last year of investment.

Table 2: Benefit Cost Analyses for Six Wine Australia R&D Investments 2017-18 (discount rate 5%)

Investment Criteria	Investment Project					
	MRL data (AWRI 2.2.1)	**Brettanomyces (AWR 1304)**	**PGR (CSP 1401)**	**Varieties (CSP 1402)**	**Ion Speciation (NWG 1401)**	**CO_2 Shiraz (DPI 1202)**
Present value of benefits ($m)	0.87	4.77	13.96	2.66	6.30	6.16
Present value of costs ($m)	0.48	2.24	2.75	0.79	1.19	3.92
Net present value ($m)	0.39	2.52	11.21	1.87	5.10	2.24
Benefit–cost ratio	1.80	2.13	5.07	3.38	5.28	1.57
Benefit-cost ratio range - core assumption sensitivity	0.72 to 3.60	1.07 to 4.48	2.38 to 11.64	0.79 to 13.19	2.64 to 10.57	0.79 to 2.36
Internal rate of return (%)	142.3	10.9	17.0	9.8	41.5	13.2
Modified internal rate of return (%)	10.1	7.5	10.3	8.1	10.7	6.4
Potential unquantified benefits	Grape juice with additional blending.	Avoided remedial processing cost.	Avoided grape loss – overripe fruit	Avoided cost of mildew.	Avoided copper MRL breaches.	Data on future irrigation water needs.
	Minimisation of chemical residues on farm.	Reduced waste and electricity use.	Improved harvesting logistics		Capacity building in researchers and students	More productive regions.

Key: MRL is Maximum Residue Limit, PGR is Plant Growth Regulators

1. Introduction

This report presents the results of economic analyses of investments within the R&D Program of Wine Australia. 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 main purpose of undertaking the analyses was to demonstrate the outcomes and benefits that have emerged or are likely to emerge from investments made in the program. This forms part of the process for the Council of Rural Research & Development Corporations (CRRDC) that aims to demonstrate the impact, effectiveness and return on investment from the Rural Research and Development Corporations.

Six R&D projects were randomly selected by AgEconPlus for evaluation.

Ascertaining the extent of benefits that have accrued as a result of the program investment can demonstrate to stakeholders such as levy payers, the impact of research investment. In addition, it can inform Wine Australia management regarding program performance from past investment decisions as well as for future allocation of program resources.

A summary of methods used in the analysis, is provided in Section 2, including the process of project selection and the steps involved with individual benefit evaluation. Section 3 reports a summary of the benefits and of the investment criteria estimated for the six projects. A brief conclusion is provided in Section 4. Appendices 1 to 6 provide the detailed analyses for each of the projects.

2. Materials and Methods

2.1 Projects for Evaluation

Consistent with Council of Rural Research and Development Corporation Guidelines for random project selection, projects in a list provided by Wine Australia 26 November 2018 were numbered 1 to 37 and an online random number generator was used by AgEconPlus to select projects. Projects were selected until research investment exceeded $4.7 million i.e. 10% of total Wine Australia investment. The results of random project selection, in the order in which they were selected, is shown in Table 2.1.

Table 2.1 Projects Randomly Selected for Benefit Cost Analysis 2017-18

No.	Code	Project Title	Program	Investment ($)
10	AWRI 2.2.1	Collecting and disseminating information regarding agrochemicals registered for use and maximum residue limits in Australian viticulture	Market access	364,686
26	AWR 1304	Ensuring the continued efficacy of *Brettanomyces* control strategies for avoidance of spoilage	Enhanced yeast and bacterial performance	1,489,492
22	CSP 1401	Understanding and manipulating small signalling molecules to affect the yield/flavour ('quality') nexus	Grape growing for excellence	1,242,271
6	CSP 1402	Evaluating and demonstrating new disease resistant varieties for warm irrigated regions	Enhancing grapevine and rootstock performance	263,468
13	NWG 1401	Metal ion speciation: Understanding its role in wine development and generating a tool to minimise wine spoilage	Wine provenance and measures of quality	753,462
30	DPI 1202	Impact of elevated CO_2 and its interaction with elevated temperature on production and physiology of Shiraz	Climate adaptability	1,650,000
			Investment in projects for analysis	5,763,379
			Total of Wine Australia investment	46,829,387
			Analysis projects share of total investment	12%

2.2 Individual Analyses

Each investment was evaluated through the following steps:

1. Information from the original project application, revised schedule and final report or other relevant reports and material was assembled with assistance from Wine Australia.
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 and email discussions were held with relevant Wine Australia personnel and principal investigators.
4. Further information was assembled where appropriate, including from contact with key industry representatives, and the quantitative analysis undertaken.
5. Some analyses proceeded through several drafts, both internally within the project team as well as externally via Wine Australia personnel and others.
6. Final drafts were passed to Wine Australia personnel for comment.

The potential benefits from each investment were identified and described in a triple bottom line context. The value of some of these benefits was then quantified.

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

- The cost of the R&D.
- The magnitude of the net benefit per unit of production affected; this net benefit per unit also takes into account the costs of implementation.
- 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.
- The discount rate.
- The time elapsed between the R&D investment and commencement of the accrual of benefits.
- The time taken from first adoption to maximum adoption.
- An attribution factor can apply when the specific project or investment being considered is only one of several pieces of research or activity that has contributed to the outcome being evaluated.

It is also necessary when quantifying benefits to define a 'without R&D' scenario, referred to as the 'counterfactual'. The 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.

Benefit cost analysis was conducted on all six projects to generate investment criteria. The Present Value of Benefits (PVB) and Present Value of Costs (PVC) were used to estimate investment criteria of Net Present Value and Benefit-Cost Ratio (BCR) at a discount rate of 5%. The Internal Rate of Return and Modified Internal Rate of Return were also estimated from the annual net cash flows. The PVB and PVC are the sums of the discounted streams of benefits and costs. All dollar costs and benefits were expressed in 2018 dollar terms. Future costs and benefits were discounted to the 2018 year while past costs were inflated to 2018 using the Gross Domestic Product deflator. A 30-year benefit time frame was used in all analyses, with benefits estimated for 30 years from the year of last capital investment in each project. Costs for the R&D projects included the cash contributions of the Project (includes both Wine Australia and industry investment), as well as any other resources contributed by third parties (e.g. researchers or additional industry funds). Investment criteria were reported for 5 year intervals of benefits from zero to 30 years.

The analyses were undertaken for total benefits, including benefits expected in the future as a result of the investment. A degree of conservatism was used when finalising assumptions.

Sensitivity analysis was undertaken for several assumptions that had the greatest degree of uncertainty or for those that were seen to be key drivers of the investment criteria.

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; and/or
- The magnitude of the value of the benefit was 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 projects. Each benefit is categorised as economic, environmental or social.

Table 3.1: Summary of Benefits for the Six Projects

Project	Benefits
MRL data	<u>Economic</u> • Avoided cost of market closure due to failure to meet revised agrochemical residue limits. • Grapes and juice with lower agrochemical residues enhancing the flexibility of wine production in terms of increasing blending opportunities. • Maintenance of the status quo with respect to self-regulation and avoidance of high compliance costs associated with legislated regulation. <u>Environmental</u> • Minimisation of chemical residues on-farm with the potential to avoid adverse impacts on biodiversity and water catchments. <u>Social</u> • Regulatory compliance on agrochemicals. • Additional AWRI staff trained in the identification and resolution of agrochemical issues and available for other research projects.
Brettanomyces	<u>Economic</u> • Avoided quality downgrades due to premature failure of the Brett control strategy based on the use of sulfites. • Avoided cost of remedial processing activities (e.g. additional filtration and barrel washing/barrel replacement) due to premature failure of the Brett control strategy. <u>Environmental</u> • Reduced requirements for inputs and wastage including electricity generation (carbon) savings and avoided consequences of unnecessary waste treatment and disposal. <u>Social</u> • Possible negative health impacts from wine consumers adversely impacted by sulfite allergies (e.g. asthma, hay fever and hives). • AWRI staff trained in yeast analysis and available for other research projects.
Plant growth regulators	<u>Economic</u> • Avoided capital costs at wineries processing grapes grown in warm inland areas and requiring fewer tanks and other capital equipment to cope with compressed seasons.

	• Improved grape and wine quality realised as marginally higher prices for Shiraz grapes grown in warm inland areas. • Avoided grape loss associated with having to harvest overripe fruit. • Improved harvesting logistics/reduced costs due to decompression of the harvest window. <u>Environmental</u> • Application of a plant growth regulator (PGR) that is understood to be safe. • Reduced chemical inputs for the treatment of low acid ferments associated with high-sugar grapes. <u>Social</u> • Increased availability and consumption of flavoursome, moderate alcohol wines.
Disease tolerant varieties	<u>Economic</u> • Saved operating costs from a reduction in the use of chemical fungicides for the control of powdery and downy mildew. • Increased saleable production with fewer grapes affected by powdery or downy mildew. <u>Environmental</u> • Reduced use of chemical fungicides in the vineyards to manage mildew. <u>Social</u> • Reduced health risks for vineyard employees working with fungicides.
Ion speciation	<u>Economic</u> • Avoided loss in white wine quality. • Early warning on copper MRL breaches. <u>Environmental</u> • More judicious use of chemicals (copper overdosing) to control sulfidic off-odours and minimisation of the amount of waste produced. <u>Social</u> • Capacity – post-doctorate fellow and CSU research staff with additional skills in the analysis of metals and sulfur in wine. • Capacity – CSU and Adelaide University students trained with up-to-date information on sulfur and copper management in wine.
Elevated CO_2 and Shiraz	<u>Economic</u> • Avoided costs due to earlier development and uptake of adaptive vineyard management strategies (i.e. canopy management). <u>Environmental</u> • Information to help plan trade-offs between production and environmental water in a hotter, dryer Murray-Darling Basin. <u>Social</u> • Reassurance that climate change may not result in an increased demand for water from wine industry with increased optimism for the future. • More productive and profitable regional communities especially in the irrigated inland wine grape production areas of Australia. • Capacity – degree by research completed and additional skill sets developed in DPI and the projects partners (CSIRO, University of Adelaide, University of Melbourne – Primary Industries Climate Change Centre (PICCC) and AWRI). • Capacity – creation of a unique research facility; an open topped chamber for the study of perennial crops with adjustment for both CO_2 and temperature.

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), the Internal Rate of Return (IRR) and the Modified IRR (MIRR). 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. The MIRR is the same as the IRR but assumes that the reinvestment rate is the same as the assumed discount rate i.e. 5%, rather than the level of the estimated IRR.

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

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

Table 3.2: Investment Criteria for Six Wine Australia Investments (discount rate 5%, 30 years from last year of investment)

Investment Criteria	Investment Project					
	MRL data (AWRI 2.2.1)	Brettanomyces (AWR 1304)	PGR (CSP 1401)	Varieties (CSP 1402)	Ion Speciation (NWG 1401)	CO_2 Shiraz (DPI 1202)
Present value of benefits ($m)	0.87	4.77	13.96	2.66	6.30	6.16
Present value of costs ($m)	0.48	2.24	2.75	0.79	1.19	3.92
Net present value ($m)	0.39	2.52	11.21	1.87	5.10	2.24
Benefit–cost ratio	1.80	2.13	5.07	3.38	5.28	1.57
Internal rate of return (%)	142.3	10.9	17.0	9.8	41.5	13.2
Modified internal rate of return (%)	10.1	7.5	10.3	8.1	10.7	6.4

Key: MRL is Maximum Residue Limit, PGR is Plant Growth Regulators

4. Conclusion

The six investment analyses yielded positive results at the 5% discount rate, with B/C Ratios ranging from 1.6 to 5.3. The results show a positive result in terms of those benefits valued and also in terms of the range of benefits identified.

The results from the analyses are dependent on the assumptions made, which in places are uncertain. Assumptions and frameworks could be refined in the future as research outputs are realised, to improve the overall analysis. Comparisons between project results should be made with caution due to uncertainties involved in assumptions and differing frameworks for each of the six analyses.

Appendix 1: Economic Analysis of Wine Australia's Investment in Collecting and Disseminating Information Regarding Agrochemicals Registered for Use and MRLs in Australian Viticulture

1. Background

Since 1993 the Australian Wine Research Institute (AWRI) has provided regulatory and technical advice on agrochemicals and Maximum Residue Limits (MRLs) to grape and wine producers. AWRI has researched, collected and disseminated up-to-date information on agrochemicals, formulate restrictions for grapes destined for export wine and tabulated MRLs set by Australia's major export markets.

This project was to continue to provide information to enable producers to make informed decisions regarding agrochemicals in order to avoid potential barriers to trade and, in the process, maintain Australia's 'clean and green' image.

Agrochemicals are essential for the management of insect pests, fungal disease, weeds and the regulation of plant growth. Countries regulate the use of agrochemicals to maintain the health of consumers and the environment. Information on agrochemicals requires constant updating. New chemicals are placed on the market and new information becomes available about the safety of existing chemicals. Agrochemical residues can also be used as a barrier to international trade in agricultural products including wine.

2. Summary of Projects

A single agrochemical residue project supported by Wine Australia was analysed and Table 2.1 provides a description.

Table 2.1 Project Description

Project No. AWRI 2.2.1 Collecting and disseminating information regarding agrochemicals registered for use and MRLs in Australian viticulture	
Project Details	Research Organisation: AWRI Period: 1 July 2013 to 30 June 2017 Principal Investigator: Marcel Essling
Rationale	Up-to-date information on agrochemicals and market requirements ensures ongoing access to markets for Australian wine, the safety of consumers and the natural environment. Consequently, the aim of this project was to enable grape and wine producers to manage agrochemical residue levels in wine. This aim was to be achieved through the collation and provision of accurate and timely information on regulatory and technical aspects of chemicals registered for use in viticulture and the MRL requirements of those chemicals in domestic and key export markets.
Objectives	1. Research and prepare the annual publication 'Agrochemicals registered for use in Australian viticulture' (the 'Dog book') for distribution to stakeholders. 2. Develop and maintain up-to-date agrochemical information for extension through email bulletins and mobile phone apps. 3. Provide assistance to help industry achieve full compliance with agrochemical MRLs and compositional standards for grapes/wine in major export markets. 4. Assist industry to use agrochemicals in a cost-effective, socially responsible way with minimal impact on the environment. 5. Develop and maintain a skills base that can support the wine industry in the identification and resolution of agrochemical issues.

	6. Develop and maintain a database of information about APVMA registered products (insecticides, fungicides, herbicides and plant growth regulators) for viticulture. 7. Develop and maintain a database of export MRLs for the chemicals registered for use in Australian viticulture. 8. Expand web and mobile extension tools to provide greater detail about active constituents and product information to stakeholders.
Activities and Outputs	• Information on new active constituents assembled early in the APVMA registration process with recommended restrictions on export use. • Review and evaluation of the following active constituents: amisulbrom; boscalid; captan; clothianidin; cyflufenamid; fenamifos; fenpyrazamine; fluazinam; flumioxazin; fluopyram; phosphorous acid; and proquinazid. • A review of the agrochemicals registered with updates for new international MRLs and changes in social and environmental expectations. • Consultation with chemical companies, generation of an updated product list. • Review of APVMA approved label for agrochemicals to confirm registration for viticulture, targets and application timing with update of the relevant database. • Identification of withholding periods by registered active constituent to meet the most stringent requirements of 35 export markets and Codex. • Liaison with the Agrochemicals Reference Group to discuss recommendations and provide updated withholding period data for use in spray diaries. • A new edition of the 'Dog book' published each year of the project with copies posted online, on mobile apps and 3,300 copies distributed to stakeholders. • The new mobile app for the 'Dog book' downloaded more than 5,400 times. • E-bulletins and websites with up-to-date information on agrochemicals. • Integration of data in the 'Dog book' with APVMA label information. Data in the 'Dog book' often differs from label information because of the need to meet export market requirements.
Outcomes	• Up-to-date data on agrochemicals communicated to industry to minimise the risk of loss of domestic and export markets, environmental damage and adverse impacts on human health.
Impacts	• Economic – avoided cost of market closure due to failure to meet revised agrochemical residue limits e.g. European Union (EU) changes to the fungicide Captan MRL in 2015 which prohibited residues and had the potential to close the EU and other markets to Australian wine. Other potential examples include the fungicides Iprodione – potential restrictions in the EU and phosphorous acid – no Codex MRL and potential for difficulty in accessing key markets including China and Canada. • Economic – grapes and juice with lower agrochemical residues enhancing the flexibility of wine production in terms of increasing blending opportunities. • Economic - opportunity to facilitate evidence based public policy using up-to-date science. • Environment – minimisation of chemical residues on-farm with the potential to avoid adverse impacts on biodiversity and water catchments. • Capacity – additional AWRI staff trained in the identification and resolution of agrochemical issues and available for other research projects.

3. Match with Government Priorities

Table 3.1 Strategic Science/Research Priorities and Rural R&D Research Priorities

Australian Government	
Strategic Science/Research Priorities	**Rural R&D Priorities**
1. **Food** – optimising food and fibre production and processing, agricultural productivity and supply chains within Australia and global markets 2. **Soil and water** – improve use of soil and water resources, both terrestrial, marine 3. **Transport** – moving essential commodities, alternative fuels, lowering emissions 4. **Cybersecurity** – for individuals, businesses, government, national infrastructure 5. **Energy** – improve efficiency, reduce emissions and integrate diverse sources into the grid. 6. **Resources** – support exploration traditional resources, rare earths and new technologies. 7. **Advanced manufacturing** – high value and innovative industries in Australia. 8. **Environmental change** – mitigating, managing or adapting to changes. 9. **Health** – improving health outcomes for all Australians.	1. **Advanced technology**: to enhance innovation of products, processes and practices across the food and fibre supply chains through technologies such as robotics, digitalisation, big data, genetics and precision agriculture. 2. **Biosecurity**: to improve understanding and evidence of pest and disease pathways to help direct biosecurity resources to their best uses, minimising biosecurity threats and improving market access for primary producers. 3. **Soil, water and managing natural resources:** to manage soil health, improve water use efficiency and certainty of supply, sustainably develop new production areas and improve resilience to climate events and impacts. 4. **Adoption of R&D:** focussing on flexible delivery of extension services that meet primary producers' needs and recognising the growing role of private service delivery.

The Wine Australia project has addressed Strategic Science/ Research Priorities 1 and 2. The major focus of the project has been on the second, third and fourth of the Rural R&D Priorities.

4. Identification of Potential Costs and Benefits

4.1 Costs

4.1.1 R&D Investment

The R&D investment costs comprised:

- Direct financial outlays by collaborators and participants in the research project, namely Wine Australia.
- In-kind contributions to the research project – non-cash contributions made by research partner AWRI.
- In-kind contributions to the research project – time associated with meetings between the researchers and Wine Australia and a larger group of project collaborators – grape and wine producers serving on the Agrochemical Reference Group, APVMA, State Government Departments of Agriculture, Crop Life Australia and Australian Grape and Wine Inc. (project overhead costs).

4.1.2 Administration

No additional administration costs were identified.

4.1.3 Extension

Extension costs such as communication of project outputs to grape growers and winemakers were included in the project budget.

4.1.4 Adoption

No incremental additional adoption costs have been identified. Grape growers will incur costs making the transition from current practice to accommodate changes in MRLs but this is part of the base case counterfactual and would have occurred regardless of the benefits realised from the project.

4.2 Benefits

4.2.1 Research Output and Impact Pathway

The output of the project is a risk identification process to manage and respond to changed agrochemical residue requirements for Australian wine in domestic and export markets.

The impact pathway is:

1. Up-to-date information on regulatory and technical aspects of chemicals registered for use in Australian viticulture plus MRLs assembled through this project (AWRI 2.2.1).
2. AWRI 2.2.1 communicates up-to-date chemical information to growers through the 'Dog book', website, e-bulletins and mobile phone apps.
3. AWRI 2.2.1 outputs also communicated through AWRI 2.2.4 (Increasing Australia's influence in market access, safety, regulatory and technical trade issues), AWRI 4.1.2 (Specialised technical troubleshooting and responsive helpdesk services for the Australian wine sector) and AWRI (Communication with stakeholders).
4. Growers respond to regulatory, technical and MRL data and produce grapes that are 'fit for purpose' ensuring ongoing market access, health and environmental benefits.

4.2.2 Triple Bottom Line Benefits

A summary of the potential benefits from the project in triple bottom line categories is shown in Table 4.1.

Table 4.1 Triple Bottom Line Categories Benefits from Project Investment

Levy Paying Industry	**Spillovers**		
	Other Industries	**Public**	**Foreign**
Economic Benefits			
Avoided cost of market closure due to failure to meet revised agrochemical residue limits. Grapes and juice with lower agrochemical residues enhancing blending opportunities and winemaker profit.	Nil	Avoided costs associated with any forced change from self-regulation to legislated and compulsory compliance.	Nil
Environmental Benefits			
Minimisation of chemical residues on-farm.	Nil	Minimisation of chemical residues downstream with the potential to adversely impact biodiversity and water catchments.	Nil
Social Benefits			
Additional AWRI staff trained and available for future research projects.	Nil	Nil	Nil

4.2.3 Public versus Private Benefits

The majority of benefits that will arise from project investment will be private in nature. The private benefits will be largely captured by winemakers and exporters. The private benefits will focus on reduced market risk and additional Australian wine sales over and above the 'no project counterfactual'. Public benefits will include minimisation of chemicals in the environment.

4.2.4 Distribution of Benefits along the Supply Chain

The benefits to the wine industry from investment in this project will be shared along the supply chain with exporters, wholesalers, winemakers and grape growers all sharing in some of the benefits.

4.2.5 Benefits to other Primary Industries

No benefits to other primary industries were identified. Market access protocols and regulations are product specific and in this case focus on wine.

4.3 Summary of Costs and Benefits

A summary of principal categories of costs and benefits from the project is shown in Table 4.2.

Table 4.2 Incremental Cost and Benefit Categories

Costs	Benefits
R&D investment costs (cash and in-kind) as well as project administration costs.	Avoided cost of market closure due to failure to meet revised agrochemical residue limits.
Overhead costs including time associated with meetings between the researchers, Wine Australia and collaborating organisations.	Grapes and juice with lower agrochemical residues enhancing blending opportunities and winemaker profit.
	Minimisation of chemical residues on-farm with the potential to avoid adverse impacts on biodiversity and water catchments.
	Additional AWRI staff trained and available for future research projects.

5. Valuation of Costs and Benefits

5.1 Costs

5.1.1 R&D Investment Costs including Administration

The following table shows annual investment in the project by Wine Australia (Table 5.1). There were no other contributions to the project.

Table 5.1 Investment by Wine Australia in the Project for Years Ending June 2014 to June 2017

Project Code	2014	2015	2016	2017	Total
AWRI 2.2.1 – Wine Australia	85,880	89,315	92,888	96,603	**364,686**
Total	**85,880**	**89,315**	**92,888**	**96,603**	**364,686**

Source: Wine Australia Project Application and revised schedule

5.1.2 Overhead Costs including Meetings between the Researchers and Wine Australia

Wine Australia overhead costs are in addition to those shown in the above tables and are estimated at 15% for this project given a substantial requirement for project collaboration.

5.2 Benefits

5.2.1 Avoided Cost of Market Closure

The Counterfactual

If this project had not been funded there is a chance that Australian wine that is not compliant with changed MRLs would get stuck in transit with a subsequent loss of value. AWRI 2.2.1 has provided an early warning system that has prevented this from happening. In the absence of this early warning it is possible that other systems and processes would be in place to prevent non-compliant wine leaving Australia. These might include, for example, advisory notes from the importing country being made available through Wine

Australia on an *ad hoc* basis. For this reason it is not appropriate to 'claim' all of the benefits associated with avoided cost due to early notification of changed market conditions for the project.

Avoided Cost Due to Early Notification of Changed Market Conditions
The main benefit of AWRI 2.2.1 is risk identification and development of a response plan as a result of changed conditions in export markets. For example when the EU introduced a requirement in 2015 that there would be no residue products from the fungicide Captan in wine, early notification provided by a AWRI 2.2.1 e-bulletin complete with recommendations for alternative control options was issued to winemakers, growers and their advisors. Early notification of this change in market conditions ensured that there was no newly non-compliant wine caught in-transit or already in Europe. Australian wine exports to Europe are large in volume (346 million litres) and low in value (FOB $1.63/litre). Wine Australia advice is that Australian wine caught in transit could be disposed of in market, there may not be enough value in the product to recall it, relabel the wine and redirect it to another destination (Steve Guy, Wine Australia, pers. com., January 2019).

Furthermore, because any wine produced in Australia has the potential to end up in the EU, winemakers adopt EU requirements as the *de facto* global standard. Failure to provide an early notification of changed market conditions in the EU of the type provided by AWRI 2.2.1 has the potential to have flow on impacts in all other export wine markets. A summary of key assumptions used to quantify this benefit is shown in Table 5.2.

Table 5.2 Summary of Assumptions

Variable	Assumption	Source
Avoided Cost of Market Closure		
Australian wine exports to the EU.	346,400,000 litres	Wine Australia, export report, various years to give 5 year average.
Share of Australian wine exports to the EU affected by changes in MRL during the project period e.g. Captan and Iprodione.	20%	Consultant assumption after review of project literature. Assumption to tested using sensitivity analysis.
Share of Australian wine exports to secondary export markets affected by changes in MRL during the project period e.g. Captan and Iprodione.	5%	Consultant assumption after review of project literature. Assumption to tested using sensitivity analysis.
Wholesale value of wine affected by changes in MRLs.	$1.63	Wine Australia, average 5 year value FOB (Steve Guy, Wine Australia, pers. com., April 2019).
Period of market closure.	1 week	Consultant estimate assuming short disruption to trade, diversion of wine to other markets and compliance with revised MRLs.
Attribution of benefit to project AWRI 2.2.1.	50%	Consultant estimate based on availability of alternative MRL notification processes.
Probability of output.	90%	Consultant assumption after review of project literature.

Probability of usage.	90%	Consultant assumption after review of project literature.
Probability of impact.	80%	Consultant assumption after review of project literature.

5.2.2 Other Potential Benefits

Other potential benefits identified but not valued include:

- Grapes and juice with lower agrochemical residues enhancing blending opportunities and winemaker profit.
- Minimisation of chemical residues on-farm with the potential to avoid adverse impacts on biodiversity and water catchments.
- Additional AWRI staff trained and available for future research projects.

Other potential benefits were not quantified due to a combination of reasons including time and resources, availability of baseline data, difficulty in quantifying the causal relationships between the research outputs and the specific impact and the difficulty of placing credible monetary values on the environmental and social benefits.

6. Results

All past costs were expressed in 2018 dollar terms using the implicit price deflator for GDP. All costs and benefits from 2018 onwards were discounted to 2018 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for some of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2018).

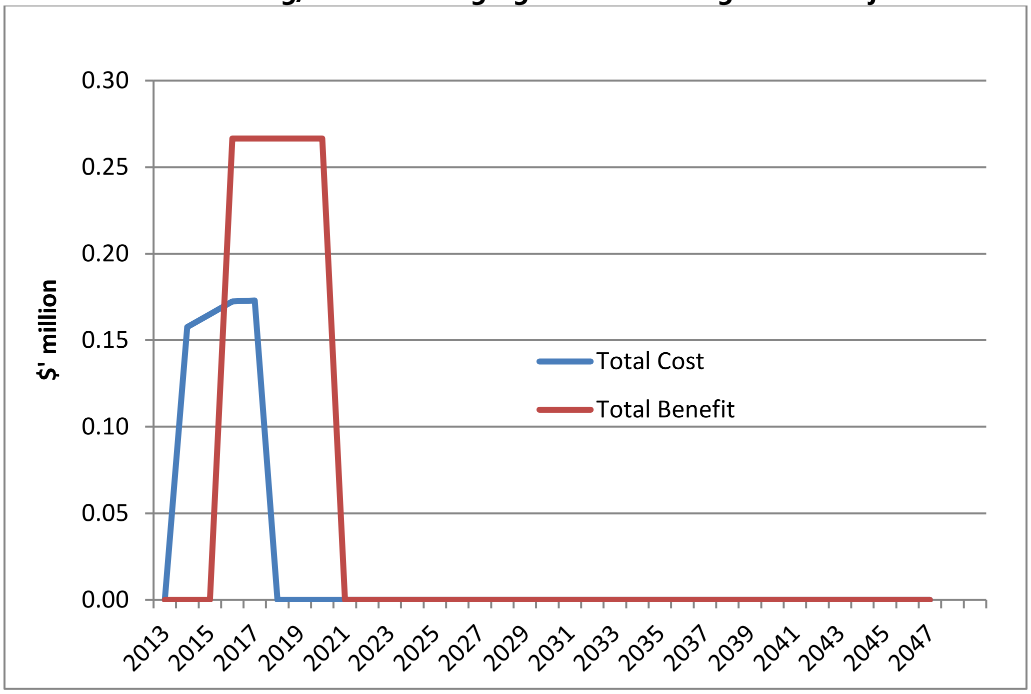
Table 6.1 shows the investment criteria estimated for the different periods of benefits for the total investment. Wine Australia was the only investor in the project so a separate analysis for Wine Australia is not relevant.

Table 6.1 Investment Criteria for Total Investment by Wine Australia and Project Partners (discount rate 5%)

Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.37	0.87	0.87	0.87	0.87	0.87	0.87
Present value of costs ($m)	0.48	0.48	0.48	0.48	0.48	0.48	0.48
Net present value ($m)	-0.11	0.39	0.39	0.39	0.39	0.39	0.39
Benefit–cost ratio	0.77	1.80	1.80	1.80	1.80	1.80	1.80
Internal rate of return (%)	Negative	142.3%	142.3%	142.3%	142.3%	142.3%	142.3%
Modified internal rate of return (%)	Negative	39.7%	21.1%	15.5%	12.8%	11.2%	10.1%

The annual undiscounted benefits and cost cash flows for the total investment for the duration of the investment period plus 30 years from the last year of the initial investment are shown in Figure 6.1.

Figure 6.1 Annual Undiscounted Cash Flows for Estimated Total Benefits and Total RD&E Investment Costs for the Collecting/Disseminating Agrochemicals Registered Project



7. Sensitivity Analysis

A sensitivity analysis was carried out for the central analysis results reported in Section 6 and variations in the discount rate. Table 7.1 presents the results. These indicate that all indicators remain positive for all discount rate assumptions.

Table 7.1 Sensitivity to Discount Rate (Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present value of benefits ($m)	0.87	0.87	0.88
Present value of costs ($m)	0.43	0.48	0.55
Net present value ($m)	0.44	0.39	0.33
Benefit-cost ratio	2.03	1.80	1.61

Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of the investment criteria. The analyses were performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values.

For this project the greatest uncertainty related to the share of Australian wine exports affected by changes in MRL – Table 7.2. Results show if only 10% of Australia's wine exports are affected then project costs exceed project benefits.

Table 7.2 Sensitivity to Share of Wine Exports Affected by Changes to MRL (Total investment, 30 years)

Investment Criteria	Share of Wine Exports (EU plus other markets)		
	10%	25% (base)	50%
Present value of benefits ($m)	0.35	0.87	1.74
Present value of costs ($m)	0.48	0.48	0.48
Net present value ($m)	-0.14	0.39	1.26
Benefit-cost ratio	0.72	1.80	3.60

8. Confidence Ratings

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 8.1). 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 uncertainties in assumptions made

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

Table 8.1 Confidence in Analysis of Program

Coverage of Benefits	Confidence in Assumptions
High	Medium

9. Summary of Results

Funding for the collecting/disseminating agrochemicals registered project was valued at $0.48M (present value terms) and is expected to produce aggregate total benefits of approximately $0.87M (present value terms). This gives an estimated net present value of $0.39M, a benefit-cost ratio of approximately 1.80, an internal rate of return of 142% and a modified internal rate of return of 10%.

Analysis results are dependent on assumptions made and while results are positive for core assumptions, sensitivity testing on share of Australian wine exports affected by changes to MRL at 10% of total, result in investment costs exceeding project benefits.

All investment indicators remain positive for different discount rate assumptions.

Abbreviations

APVMA Australian Pesticides and Veterinary Medicines Authority
AWRI Australian Wine Research Institute
MRL Maximum Residue Limit

Persons Contacted

Marcel Essling, Senior Viticulturist, Australian Wine Research Institute
Steve Guy, General Manager, Market Access, Wine Australia

References

Krstic, M (2017) Final Report for Project Numbers AWRI 2.2.1, AWRI 2.2.4, AWRI 2.2.3, AWRI 3.2.5, AWRI 4.4.1, AWRI 4.4.2, AWRI 4.1.3, AWRI 4.1.4 and AWRI 5.1.3. accessed at https://www.wineaustralia.com/getmedia/3690e9bf-593b-4d60-90ac-6cb5830774ab/AWRI-management-Final-Report

AWRI (2015) Agrochemical update: new captan restrictions in use https://www.awri.com.au/information_services/ebulletin/2015/08/13/agrochemical-update-new-captan-restriction-on-use/

Appendix 2: Economic Analysis of Wine Australia's Investment in Ensuring the Continued Efficacy of *Brettanomyces* Control Strategies for Avoidance of Spoilage

1. Background

Brettanomyces (Brett) is a type of yeast commonly found in wineries, which has the potential to cause significant spoilage in wines, through the production of volatile phenol compounds.

Wine quality downgrades as a consequence of Brett spoilage peaked in the early 2000s and caused economic loss in the Australian wine industry of up to $50 million/year. A strategy developed by AWRI has reduced this cost. However, ongoing costs of Brett management are incurred by producers of premium and ultra-premium red wine, particularly those applying barrel maturation, and in recent years producers of sparkling wine have also been affected.

The strategy for Brett control has significantly decreased levels of Brett spoilage in finished wine. However, the strategy relies on the use of the preservative sulfite to stabilise wine against Brett growth and there is pressure to minimise the quantity of sulfite used in wine. Minimising sulfite potentially creates a situation where Brett yeast develops sulfite resistance and the control strategy fails (AWR 1304 Final Project Application, 2013).

With pressure on the control strategy, timely processing of Brett affected wines to avoid spoilage is key. To facilitate timely processing, access to rapid Brett detection methods is desirable. However, current Brett detection methods are difficult to interpret. Viable but non-culturable (VBNC) *Brettanomyces*, whereby metabolically active cells are undetectable by traditional methods, may explain this phenomenon. Prior to this study, VBNC was well established with bacteria but was only speculated to exist in yeast.

Emergence of sulfite-tolerant strains of Brett and/or VBNC, in the absence of an updated control strategy, has the potential to cause widespread economic loss through wine quality downgrade and/or additional cost incurred in avoidance of spoilage through higher requirements for processing (e.g. additional filtration and barrel washing). Action was required to prevent escalation of costs caused by Brett contamination.

2. Summary of Projects

A single Brett control and avoidance of spoilage project supported by Wine Australia was analysed and Table 2.1 provides a description.

Table 2.1 Project Description

Project No. AWR 1304 Ensuring the continued efficacy of Brettanomyces control strategies for avoidance of spoilage	
Project Details	Research Organisation: AWRI Period: 1 July 2013 to 30 June 2017 Principal Investigators: Dr Chris Curtin, Dr Anthony Borneman
Rationale	To ensure Australian winemakers continue to manage Brett in a cost effective manner, the control strategy must be 'future-proofed' against pressures to minimise levels of sulfite in wine and augmented with rapid detection methods. Consequently, this project was to evaluate the risk of sulfite-tolerant strains of Brett emerging, establish a Brett monitoring strategy, and in parallel, investigate alternatives to sulfite for Brett control. The project was also to deliver knowledge of the VBNC state for *Brettanomyces* and the implications of this for Australian winemakers. An improved test for Brett detection was also required.

Objectives	1. Develop knowledge of mechanisms that enable Brett to adapt to environmental conditions, particularly in response to sulfite stress. 2. Develop molecular diagnostics and apply them to new industry isolates as an early warning system for emergence of sulfite tolerant strains. 3. Determine whether Brett enters a VBNC state, through rigorous experimentation that meets criteria previously described for VBNC bacteria. 4. If VBNC demonstrated, generate knowledge of what wine relevant conditions trigger this state, and under what conditions Brett exits its VBNC state and resumes growth. 5. Develop new or improved rapid tests (qPCR or flow cytometry) that enable accurate assessment of spoilage risk. 6. Investigate alternatives to sulfite for control of Bretts during wine maturation. 7. Provide Australian winemakers with an updated Brett control strategy.
Activities and Outputs	• Brett populations exposed to sub-lethal levels of sulfite and sequenced to detect mutations. Genes implicated in sulfite tolerance cloned and characterised. • Molecular diagnostics designed to markers for sulfite tolerance. Screening program in place and samples from targeted wineries analysed for tolerance. • Sulfite alternatives analysed for efficacy. • Brett strains tested to establish VBNC status. Repeat experiments were completed to induce 'viable' and 'cultured' population divergence. • The study found that Brettanomyces do not enter a VBNC state in response to sulfite. Experiments indicated that resumption of population growth is reliant on low numbers of viable culturable cells that may fall below limits of detection for standard microbiological and rapid tests. • Flow cytometry shown to be an accurate, rapid and cost effective method for the determination of viable Brett populations. • The study also showed that existing Brett strains are evolving tolerance to sulfite and that this will continue to occur in industry. • Attempts to characterise the mechanism by which Brett gains tolerance to sulfite did not reveal a common pattern, although research did show that variations in amino acid sequence of a sulfite efflux pump can partly explain strain variation. • Tools were developed for the genetic transformation of Brett which were used to study the competitiveness of different strains under sulfite stress. • The importance of developing new research tools for Brett was underscored by observed variation in efficacy of the sulfite alternative chitosan.
Outcomes	• At current levels of knowledge, Brett control is dependent on maintaining high dose levels of sulfite and preventing evolved tolerance. • With the development of a rapid test for Brettanomyces that can distinguish strain type, there may be instances where lower doses of sulfite can be used without risking evolved tolerance or sulfite can be substituted for chitosan. • The research has delivered refinements to the current management strategy that will ensure its effectiveness longer than the 'no project' base case.
Impacts	• Economic – avoided quality downgrades due to premature failure of the Brett control strategy based on the use of sulfites. Impacts most relevant to premium, ultra-premium barrel matured red wines (major impact).

	• Economic – avoided cost of remedial processing activities (e.g. additional filtration and barrel washing/barrel replacement) due to premature failure of the Brett control strategy based on sulfites (secondary impact). • Environment – reduced requirements for inputs and wastage including electricity generation (carbon) savings and avoided consequences of unnecessary waste treatment and disposal. • Health – possible negative health impacts from wine consumers adversely impacted by sulfite allergies (e.g. asthma, hayfever and hives). • Capacity – AWRI staff trained in yeast analysis and available for other research projects.

3. Match with Government Priorities

Table 3.1 Strategic Science/Research Priorities and Rural R&D Research Priorities

Australian Government	
Strategic Science/Research Priorities	**Rural R&D Priorities**
1. **Food** – optimising food and fibre production and processing, agricultural productivity and supply chains within Australia and global markets 2. **Soil and water** – improve use of soil and water resources, both terrestrial, marine 3. **Transport** – moving essential commodities, alternative fuels, lowering emissions 4. **Cybersecurity** – for individuals, businesses, government, national infrastructure 5. **Energy** – improve efficiency, reduce emissions and integrate diverse sources into the grid. 6. **Resources** – support exploration traditional resources, rare earths and new technologies. 7. **Advanced manufacturing** – high value and innovative industries in Australia. 8. **Environmental change** – mitigating, managing or adapting to changes. 9. **Health** – improving health outcomes for all Australians.	1. **Advanced technology**: to enhance innovation of products, processes and practices across the food and fibre supply chains through technologies such as robotics, digitalisation, big data, genetics and precision agriculture. 2. **Biosecurity**: to improve understanding and evidence of pest and disease pathways to help direct biosecurity resources to their best uses, minimising biosecurity threats and improving market access for primary producers. 3. **Soil, water and managing natural resources:** to manage soil health, improve water use efficiency and certainty of supply, sustainably develop new production areas and improve resilience to climate events and impacts. 4. **Adoption of R&D:** focussing on flexible delivery of extension services that meet primary producers' needs and recognising the growing role of private service delivery.

The Wine Australia project has addressed Strategic Science/ Research Priorities 1. The project's focus has included the first, second and fourth of the Rural R&D Priorities.

4. Identification of Potential Costs and Benefits

4.1 Costs

4.1.1 R&D Investment

The R&D investment costs comprised:

- Direct financial outlays by collaborators and participants in the research project, namely Wine Australia.
- In-kind contributions to the research project – non-cash contributions made by research partners AWRI and Yalumba Winery.
- In-kind contributions to the research project – time associated with meetings between the researchers and Wine Australia (project overhead costs).

4.1.2 Administration

No additional administration costs were identified.

4.1.3 Extension

Extension costs such as communication of project outputs to winemakers through the AWRI roadshow program were included in the project budget.

4.1.4 Adoption

Marginal additional adoption costs will be incurred by winemakers testing for Brett and implementing the revised Brett control strategy.

4.2 Benefits

4.2.1 Research Output and Impact Pathway

The output of the project is a new test for detecting Brett and a revised Brett control strategy.

The impact pathway is:

1. AWR 1304 completed, results published in a peer reviewed journal and communicated to winemakers through forums such as the AWRI roadshow program.
2. Winemakers adopt Brett testing using flow cytometry and implement revised Brett control strategy.
3. Effective control using testing, chitosan and sulfite keeps the cost of Brett to current low levels.

4.2.2 Triple Bottom Line Benefits

A summary of the potential benefits from the project in triple bottom line categories is shown in Table 4.1.

Table 4.1 Triple Bottom Line Categories Benefits from Project Investment

Levy Paying Industry	**Spillovers**		
	Other Industries	**Public**	**Foreign**
Economic Benefits			
Avoided wine quality downgrades due to premature failure of the Brett control strategy. Avoided cost of remedial wine processing activity (e.g. filtration, barrel washing/replacement) due to premature failure of the Brett control strategy.	New test for detecting Brett may be applicable to other brewing and yeast using industries e.g. beer making.	Nil	New test for detecting Brett will be relevant to winemaking in other countries.
Environmental Benefits			
Reduced requirements for inputs and wastage including electricity generation (carbon) savings and the avoided consequences of unnecessary waste treatment and disposal.	Nil	Nil	Nil
Social Benefits			
Possible negative health impacts from wine consumers adversely impacted by sulfite allergies (e.g. asthma, hayfever and hives). Additional AWRI staff trained and available for future research projects.	Nil	Nil	Possible negative health impacts from wine consumers adversely impacted by sulfite allergies.

4.2.3 Public versus Private Benefits

Benefits arising from project investment will be private in nature and largely captured by winemakers. Private benefits will include avoided wine quality downgrades and avoided costs associated with remedial wine treatment such as additional filtration.

4.2.4 Distribution of Benefits along the Supply Chain

The benefits to the wine industry from investment in this project will be shared along the supply chain with exporters, wholesalers, winemakers and grape growers all sharing in some of the benefits.

4.2.5 Benefits to other Primary Industries

The new test for detecting Brett may be applicable to other Australian brewing and yeast using industries including beer making.

4.2.6 Benefits Overseas

The new test for detecting Brett may be applicable to winemaking in other countries.

4.3 Summary of Costs and Benefits

A summary of principal categories of costs and benefits from the project is shown in Table 4.2.

Table 4.2 Incremental Cost and Benefit Categories

Costs	Benefits
R&D investment costs (cash and in-kind) as well as project administration costs.	Avoided quality downgrades due to premature failure of the Brett control strategy based on the use of sulfites.
Overhead costs including time associated with meetings between the researchers, Wine Australia and collaborating organisations (Yalumba Winery).	Avoided cost of remedial processing activities due to premature failure of the Brett control strategy based on sulfites.
Possible negative health impacts from wine consumers adversely impacted by sulfite allergies.	Reduced wastage including electricity generation (carbon) savings and avoided consequences of unnecessary waste treatment and disposal.
	Additional AWRI staff trained in yeast analysis and available for other research projects.

5. Valuation of Costs and Benefits

5.1 Costs

5.1.1 R&D Investment Costs including Administration

The following tables show annual investment in the project by Wine Australia (Table 5.1) and for researchers and other investors (Table 5.2). Table 5.3 provides the total investment by year for both sources.

Table 5.1 Investment by Wine Australia in the Project for Years Ending June 2015 to June 2017

Project Code	2014	2015	2016	2017	Total
AWR 1304 – Wine Australia	402,232	360,547	402,721	385,789	**1,551,289**
Total	**402,232**	**360,547**	**402,721**	**385,789**	**1,551,289**

Source: Wine Australia Project Application and revised schedule

Table 5.2 Investment by Researchers/Others in the Project for Years Ending June 2015 to June 2017

Project Code	2014	2015	2016	2017	Total
AWR 1304 – AWRI cash	0	0	0	0	**0**
AWR 1304 – AWRI in-kind	34,215	36,934	39,840	41,832	**152,821**
AWR 1304 – Yalumba in-kind	11,050	11,327	11,893	12,190	**46,460**
Total	**45,265**	**48,261**	**51,733**	**54,022**	**199,281**

Source: Wine Australia Project Application and revised schedule

Table 5.3 Annual Investment in the Project (nominal $)

Year Ending 30 June	Wine Australia	Researchers/Others	Total
2014	402,232	45,261	**447,493**
2015	360,547	48,261	**408,808**
2016	402,721	51,733	**454,454**
2017	385,789	54,022	**439,811**
Total	**1,551,289**	**199,277**	**1,750,566**

5.1.2 Overhead Costs including Meetings between the Researchers and Wine Australia

Wine Australia overhead costs are in addition to those shown in the above tables and are estimated at 12% for this project.

5.1.3 Health Costs

A proportion of consumers experience negative health impacts from consumption of wine treated with sulfites. Adverse health impacts may include asthma, hayfever and hives.

5.1.4 Adoption Costs

Adoption costs will be incurred by winemakers using the project developed test for Brett detection and implementing the revised Brett control strategy. Quantification of this cost assumes 290 wineries adopt both test and strategy and these are the premium, ultra-premium producers of red wine.

5.2 Benefits

Counterfactual: if this project had not been funded winemakers may have responded to concerns from some wine consumers about the presence of sulfites in premium and ultra-premium barrel-matured Australian red wine. In response some winemakers may have lowered sulfite levels in these wines. Brett strains exposed to sub-optimal doses of sulfite develop resistance to sulfite. As a consequence, the current Brett control strategy based on the use of sulfites becomes less effective and winemakers incur additional costs associated with wine quality downgrades and remedial processing.

5.2.1 Avoided Cost of Wine Quality Downgrade and Remedial Processing

With AWR 1304 completed and the results communicated to industry additional information is available on Brett. The cost effective test for Brett developed as part of the project is used by winemakers to determine Brett strain. Some Brett strains are treated with chitosan and others with high dose sulfite. Brett resistance to sulfite is delayed due to the correct dosing of wine. Costs associated with wine quality downgrades and remedial processing are avoided.

Quantification of project benefits is consistent with Econsearch (2013) which investigated the cost of Brett to the Australian wine industry and the benefits generated by the Brett control strategy. The two major benefits identified and quantified by Econsearch (2013) were avoided losses from downgraded wine and avoided management costs (remedial processing using filtration and barrel sterilisation/replacement). A summary of key assumptions used to quantify these benefits is shown in Table 5.4.

Table 5.4 Summary of Assumptions

Variable	Assumption	Source
Avoided Cost of Wine Quality Downgrade and Remedial Processing		
Annual wine quality downgrade cost with Brett strategy failure.	$930,000 per year	Econsearch (2013) estimated Brett downgrade cost at NPV$31.9 million between 1998 and 2009.
Annual wine remedial processing cost with Brett strategy failure.	$320,000 per year	Econsearch (2013) estimated Brett remedial processing cost at NPV$11.0 million between 1998 and 2009.
Brett testing by winemakers using the project generated flow cytometry test and implementation of revised Brett control strategy.	$72,500 per year	Estimated assuming 10% of Australia's 2,900 wineries produce premium, ultra-premium red wine and use test at an annual cost of $250/year/winery.
Year in which additional Brett costs begin to occur in the absence of AWR 1304.	2024	Consultant assumption and assumes sulfite resistance begins to occur 5 year into the future in the absence of new research.
Year in which alternate control becomes available for Brett i.e. new science available that allows discontinuation of sulfite.	2034	Consultant assumption based on previous research.
Probability of output	100%	Brettanomyces test developed and revised strategy communicated to winemakers.
Attribution of benefits to this project.	90%	Some additional costs may be incurred communicating project results to winemakers.
Probability of usage.	100%	Positive feedback received by AWRI from winemakers.
Probability of impact.	90%	Some gap may exist between testing and use of correct Brettanomyces management response.

5.2.2 Other Potential Benefits

Other potential benefits identified but not valued include:

- Reduced electricity usage, unnecessary waste treatment and disposal.
- Additional AWRI capacity in yeast analysis, available for other research projects.

Other potential benefits were not quantified due to a combination of reasons including time and resources, availability of baseline data, difficulty in quantifying the causal relationships between the research outputs and the specific impact and the difficulty of placing credible monetary values on environmental and capacity building benefits.

6. Results

All past costs were expressed in 2018 dollar terms using the implicit price deflator for GDP. All costs and benefits from 2018 onwards were discounted to current dollar terms using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for some of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2017).

Table 6.1 and Table 6.2 show the investment criteria estimated for the different periods of benefits for both the total investment and for Wine Australia investment. The present value of benefits (PVB) for the Wine Australia investment, shown in Table 6.2, are estimated by multiplying the total PVB by the Wine Australia proportion of investment.

Table 6.1 Investment Criteria for Total Investment by Wine Australia and Project Partners (discount rate 5%)

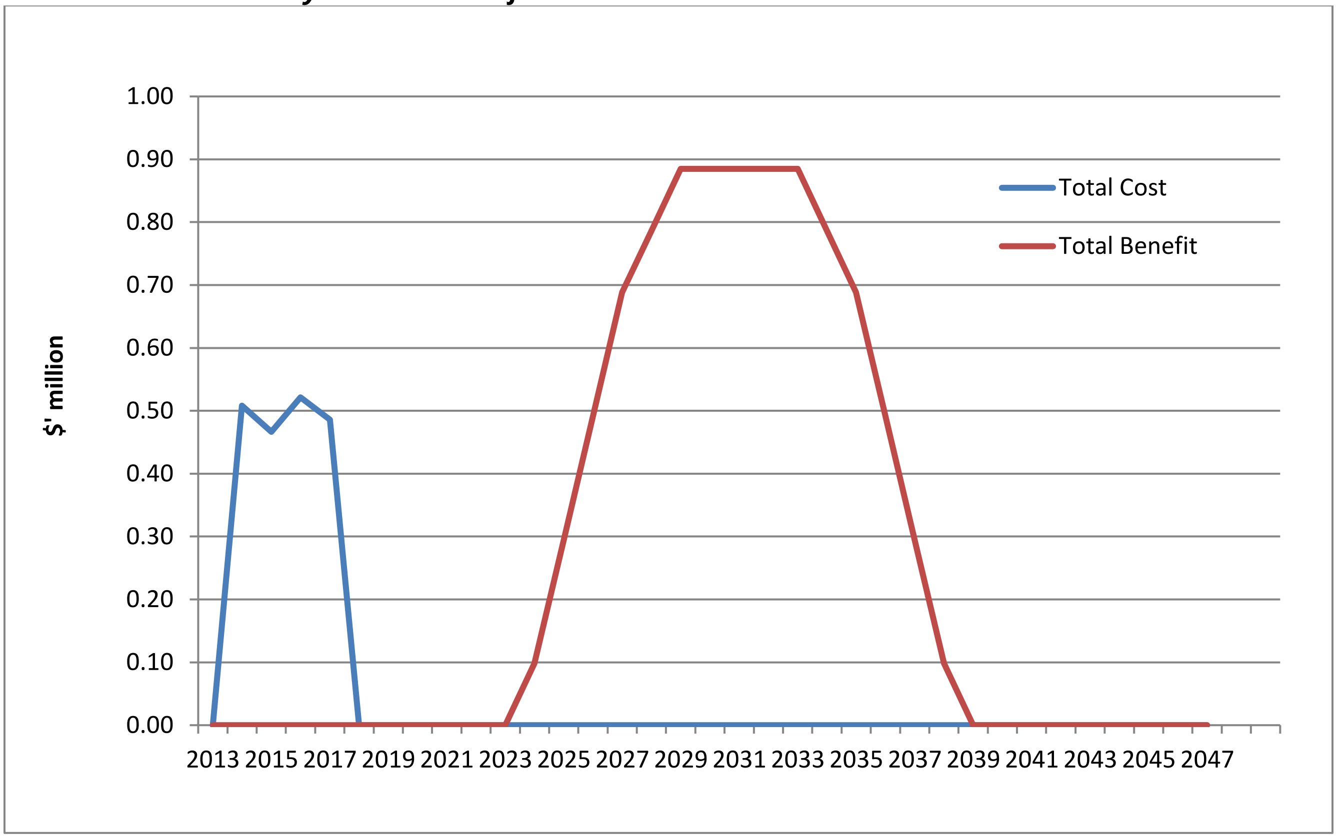
Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.00	0.00	1.03	3.36	4.73	4.77	4.77
Present value of costs ($m)	2.24	2.24	2.24	2.24	2.24	2.24	2.24
Net present value ($m)	-2.24	-2.24	-1.22	1.12	2.49	2.52	2.52
Benefit–cost ratio	0.00	0.00	0.46	1.50	2.11	2.13	2.13
Internal rate of return (%)	Negative	Negative	Negative	8.4%	10.8%	10.9%	10.9%
Modified internal rate of return (%)	Negative	Negative	Negative	7.6%	8.8%	8.1%	7.5%

Table 6.2 Investment Criteria for Wine Australia (discount rate 5%)

Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.00	0.00	0.92	3.02	4.24	4.28	4.28
Present value of costs ($m)	1.85	1.85	1.85	1.85	1.85	1.85	1.85
Net present value ($m)	-1.85	-1.85	-0.93	1.17	2.40	2.43	2.43
Benefit–cost ratio	0.00	0.00	0.50	1.63	2.30	2.31	2.31
Internal rate of return (%)	Negative	Negative	Negative	9.2%	11.6%	11.6%	11.6%
Modified internal rate of return (%)	Negative	Negative	Negative	8.2%	9.3%	8.4%	7.8%

The annual undiscounted benefits and cost cash flows for the total investment for the duration of the investment period plus 30 years from the last year of the initial investment are shown in Figure 6.1.

Figure 6.1 Annual Undiscounted Cash Flows for Estimated Total Benefits and Total RD&E Investment Costs for the *Brettanomyces* Control Project



7. Sensitivity Analysis

A sensitivity analysis was carried out for the central analysis results reported in Section 6 and variations in the discount rate. Table 7.1 presents the results. These indicate that all indicators remain positive for all discount rate assumptions.

Table 7.1 Sensitivity to Discount Rate (Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present value of benefits ($m)	8.87	4.77	2.70
Present value of costs ($m)	1.98	2.24	2.53
Net present value ($m)	6.89	2.52	0.17
Benefit-cost ratio	4.48	2.13	1.07

Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of the investment criteria. The analyses were performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values.

For this project the greatest uncertainty related to the number of wineries undertaking Brett testing – Table 7.2. Results show that at half and double forecast number of wineries, results are largely unaffected.

Table 7.2 Sensitivity to Number of Wineries Undertaking Brett Testing (Total investment, 30 years)

Investment Criteria	Number of Wineries Brett Testing		
	145	290 (base)	580
Present value of benefits ($m)	4.91	4.77	4.44
Present value of costs ($m)	2.24	2.24	2.24
Net present value ($m)	2.67	2.52	2.20
Benefit-cost ratio	2.19	2.13	1.99

8. Confidence Ratings

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 8.1). 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 uncertainties in assumptions made

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

Table 8.1 Confidence in Analysis of Program

Coverage of Benefits	Confidence in Assumptions
High	High

9. Summary of Results

Funding to ensure the continued efficacy of *Brettanomyces* control strategies for avoidance of spoilage project was valued at $2.24 million (present value terms) and is expected to produce aggregate total benefits of approximately $4.77 million (present value terms). This gives an estimated net present value of $2.52 million, a benefit-cost ratio of approximately 2.13, an internal rate of return of 10.9% and a modified internal rate of return of 7.5%.

Analysis results remain positive for both the sensitivity test on discount rate and the number of firms undertaking Brett testing.

Abbreviations

APVMA	Australian Pesticides and Veterinary Medicines Authority
AWRI	Australian Wine Research Institute
NPV	Net Present Value
VBNC	Viable but non-culturable

Persons Contacted

Dr Anthony Borneman, Principal Research Scientist, Molecular Biology, Australian Wine Research Institute
Dr Paul Smith, Senior R&D Program Manager, Wine Australia

References

AWRI (2013) AWR 1304 Final Project Application, Ensuring the Continued Efficacy of *Brettanomyces* Control Strategies for Avoidance of Spoilage

AWRI (2017) AWR 1304 Final Report, Ensuring the Continued Efficacy of *Brettanomyces* Control Strategies for Avoidance of Spoilage

AWRI (undated) *Brettanomyces*, accessed at https://www.awri.com.au/industry_support/winemaking_resources/frequently_asked_questions/brettanomyces-faq/

Econsearch (2013) Economic Analysis of AWRI Projects and Activities: AWRI Problem Solving Capacity

Appendix 3: Economic Analysis of Wine Australia's Investment in Understanding and Manipulating Small Signalling Molecules to Affect the Yield/Flavour (Quality) Nexus

1. Background

Grape berry development is a complex process that is still only partially understood. A number of small signalling molecules including plant growth regulators (PGRs) play pivotal roles in controlling berry development. These molecules coordinate global changes in gene expression and hence berry metabolism, which in turn is responsible for grape composition at harvest. Previously, CSIRO studied the controlling role that some PGRs play in the initiation of ripening e.g. 1-naphthaleneacetic acid (NAA). This work led to the formulation of preliminary strategies to control the timing of ripening and therefore harvest (CSIRO, 2013).

PGRs are organic compounds, either natural or synthetic, that modify or control one or more specific physiological processes within a plant. The plant growth regulator NAA is already registered and used in other horticultural industries as an effective and safe plant growth regulator.

Increases in temperature in Australia due to climate change have caused problems with the quality of grapes and problems with harvesting and processing the fruit into wine. This is particularly the case in the warm inland regions which account for 60% of Australia's total wine production. Warmer seasonal temperatures exacerbate the time lag between sugar ripeness and flavour development. This means that grapes need to hang much longer on the vine for the flavours to 'catch up'. 'Catch up' can potentially lead to a high sugar content and excessive alcohol content following fermentation as well as shrivelling of grapes and grape weight loss. Furthermore, there is an adverse impact from increased temperature on grape colour, as the development of anthocyanin pigments (which give red grapes their colour) becomes uncoupled from normal berry development. Warmer seasons caused by climate change and resultant seasonal compression has also put pressure on the ability (infrastructure capacity) of growers to harvest grapes and wineries to process grapes in a timely manner at the optimal ripening stage (Keith Hayes, Senior R&D Program Manager, Wine Australia, pers. comm., January 2019).

The compression of the harvest season is due to grape cultivars that previously had a wider range of ripening times now ripening over a much shorter period. The practice of spreading the harvest window by harvesting some fruit at the unripe stage and some at the overripe stage can result in reduced wine quality and value (Christopher Davies, Research Scientist, CSIRO, pers. comm., January 2019).

PGRs also have a potential role in fruit quality/flavour. Some fruity esters are increased in concentration with the use of PGRs and more significantly an increase in the compound rotundone that produces desirable 'peppery' aromas in Shiraz has been realised. Theoretically, PGR use could produce wines of greater value and improved returns for winemakers and grape growers (Keith Hayes, Senior R&D Program Manager, Wine Australia, pers. comm., January 2019).

2. Summary of Projects

A single PGR project supported by Wine Australia was analysed and Table 2.1 provides a description.

Table 2.1 Project Description

Project No. CSP 1401 Understanding and manipulating small signalling molecules to affect the yield/flavour (quality) nexus	
Project Details	Research Organisation: CSIRO Period: 1 July 2014 to 31 December 2017 Principal Investigator: Christopher Davies
Rationale	A tool was required by industry to deal with shorter hotter grape growing seasons, compressed harvesting and winemaking seasons, resultant increased capital costs and grape quality loss with the opportunity to improve wine quality.
Objectives	1. Investigate novel PGRs and their role in the control of grape berry ripening. 2. Gain a better understanding of PGRs previously shown to be involved in the timing of berry ripening i.e. mechanisms involved in metabolism and action. 3. Use new knowledge of PGRs to develop improved methods for controlling berry ripening. This will be through manipulating the timing of berry ripening and harvest by optimisation of PGR treatments. 4. Investigate the role of PGRs in sugar and flavour/aroma metabolite accumulation. Determine which PGR treatments can alter flavour/aroma compound production and where possible how they achieve this. 5. Use the above information to develop methods to control flavour metabolite accumulation independently of sugar levels. These methods will be aimed at improving the flavour/aroma potential of grapes without excessive 'hang times' and sugar levels.
Activities and Outputs	• The study focussed on the manipulation of ripening at commercial vineyards using a range of PGRs and included use of bunch girdling as a tool to manipulate sugar accumulation; measurement of berry development (sugar and acid levels, berry size and colour); measurement of key metabolites (substances formed/needed for metabolism); measurement of changes in endogenous PGRs in response to treatments; and measurement of changes in the expression of key genes to give insight into further research priorities. • Winemaking with treated grapes was completed at large and small facilities to test for appropriate flavour metabolites and complete wine sensory analysis. • All experiments were completed using replicated random design to allow for sophisticated statistical analysis and provide confidence in research results. • Experiments generated valuable knowledge about links between PGR action, berry development and vine metabolism. The study generated new information about the role PGRs play in berry development and the effect of PGR treatment on berry development including grape sugar, colour, size, flavour/aroma accumulation and wine sensory properties. • Tools were developed to alter the levels of flavour and aroma compounds in relation to sugar levels, improving berry and wine characteristics. • Recommendations were prepared around the most effective PGR type, treatment regime and treatment timing. The study found that NAA was effective in delaying the onset of ripening and therefore harvest. Use of NAA provided a practical strategy to resolve some climate change-induced grape ripening issues. Where season compression causes problems for harvest and winery intake/processing, part of the vineyard could be ripening-delayed to allow harvesting at the desired stage of ripeness and allow processing and winemaking to be manageable without large increases in winery capacity.

	• Study results were communicated through written publications, oral presentations, to grower/winemaker groups and at relevant conferences.
Potential Outcomes	• Improved grape intake and processing scheduling at wineries, avoided capital costs to process grapes in a shorter window, improved harvesting scheduling, improved grape and wine quality and some avoided grape yield loss.
Potential Impacts	• Economic – avoided capital costs at wineries processing grapes grown in warm inland areas and requiring fewer tanks and other capital equipment to cope with compressed seasons (major). • Economic – improved grape and wine quality realised as marginally higher prices for Shiraz grapes grown in warm inland areas (major). • Economic – avoided grape loss associated with having to harvest overripe fruit (minor). • Economic – improved harvesting logistics/reduced costs due to decompression of the harvest window (minor). • Environment – application of a PGR that is understood to be safe. • Environment – reduced chemical inputs for the treatment of low acid ferments associated with high-sugar grapes. • Health – increased availability and consumption of flavoursome, moderate alcohol wines.

3. Match with Government Priorities

Table 3.1 Strategic Science/Research Priorities and Rural R&D Research Priorities

Australian Government	
Strategic Science/Research Priorities	**Rural R&D Priorities**
1. **Food** – optimising food and fibre production and processing, agricultural productivity and supply chains within Australia and global markets 2. **Soil and water** – improve use of soil and water resources, both terrestrial, marine 3. **Transport** – moving essential commodities, alternative fuels, lowering emissions 4. **Cybersecurity** – for individuals, businesses, government, national infrastructure 5. **Energy** – improve efficiency, reduce emissions and integrate diverse sources into the grid. 6. **Resources** – support exploration traditional resources, rare earths and new technologies. 7. **Advanced manufacturing** – high value and innovative industries in Australia. 8. **Environmental change** – mitigating, managing or adapting to changes. 9. **Health** – improving health outcomes for all Australians.	1. **Advanced technology**: to enhance innovation of products, processes and practices across the food and fibre supply chains through technologies such as robotics, digitalisation, big data, genetics and precision agriculture. 2. **Biosecurity**: to improve understanding and evidence of pest and disease pathways to help direct biosecurity resources to their best uses, minimising biosecurity threats and improving market access for primary producers. 3. **Soil, water and managing natural resources:** to manage soil health, improve water use efficiency and certainty of supply, sustainably develop new production areas and improve resilience to climate events and impacts. 4. **Adoption of R&D:** focussing on flexible delivery of extension services that meet primary producers' needs and recognising the growing role of private service delivery.

The Wine Australia project has addressed Strategic Science/ Research Priorities 1 and 8. The major focus of the project has been on the first and third of the Rural R&D Priorities.

4. Identification of Potential Costs and Benefits

4.1 Costs

4.1.1 R&D Investment

The R&D investment costs comprised:

- Direct financial outlays by collaborators and participants in the research project, namely Wine Australia
- In-kind contributions to the research project – non-cash contributions made by research partner CSIRO
- In-kind contributions to the research project – time associated with meetings between the researchers and Wine Australia (project overhead costs).

4.1.2 Administration

No additional administration costs were identified.

4.1.3 Extension

Extension costs such as communication of project progress to grape growers and winemakers were included in the project budget.

Additional work post CSP 1401 will need to include larger field experiments in a commercial setting and attaining APVMA registration of NAA for use on grapes.

4.1.4 Adoption

Adoption costs will be incurred by grape growers to understand when and how to use NAA (education and training) and in purchasing and applying the PGR.

4.2 Benefits

4.2.1 Research Output and Impact Pathway

The output of the project is confirmation that NAA is a suitable PGR that can be used to delay grape ripening and allow harvest to occur at a desirable stage of ripeness without large increases in winery capacity or the loss of grapes to spoilage.

The impact pathway is:

1. Initial research on NAA completed by CSIRO prior to this project.
2. Confirmation of the usefulness of NAA in both cool and warm climate conditions as part of this project (CSP 1401).
3. Larger field experiments using NAA in a commercial grape growing setting.
4. Securing of interest in NAA for the grape industry with a relevant agrochemical producer.
5. NAA registration for use on grapes and commercial volumes made available.
6. Growers incur costs and realise benefits from NAA use to delay grape harvest.

4.2.2 Triple Bottom Line Benefits

A summary of the potential benefits from the project in triple bottom line categories is shown in Table 4.1.

Table 4.1 Triple Bottom Line Categories Benefits from Project Investment

Levy Paying Industry	**Spillovers**		
	Other Industries	**Public**	**Foreign**
Economic Benefits			
Avoided capital costs at wineries processing grapes grown in warm inland areas and requiring fewer tanks and other capital equipment to cope with compressed seasons. Improved grape and wine quality realised as marginally higher prices for Shiraz grapes grown in 'warm inland' areas. Avoided grape loss associated with having to harvest overripe fruit. Improved harvesting logistics/reduced costs due to decompression of the harvest window.	Technology available for adoption in other grape industries e.g. table and dried grape production.	Nil	Season compression is understood to be an issue in other wine producing countries and it is likely that NAA will be applicable to industries in countries.
Environmental Benefits			
Application of a PGR that is understood to be safe. Reduced chemical inputs for the treatment of low acid ferments associated with high-sugar grapes.	Nil	Nil	Nil
Social Benefits			
Increased availability and consumption of flavoursome, moderate alcohol wines.	Nil	Nil	Nil

4.2.3 Public versus Private Benefits

The majority of benefits that will arise from project investment will be private in nature. The private benefits will be captured largely by wineries and wine grape growers. Private benefits will focus on avoided capital costs for wineries and production of more valuable Shiraz grapes in warm inland areas.

4.2.4 Distribution of Benefits along the Supply Chain

The benefits to the wine industry from investment in this project will be shared along the supply chain with wine grape growers, winemakers, wholesalers and exporters all sharing in some of the benefits.

4.2.5 Benefits to other Primary Industries

Benefits to other primary industries include development of an NAA spray that may be relevant to table grape and dried grape production in the future.

4.2.6 Benefits Overseas

Season compression is understood to be an issue in other wine producing countries and it is likely that NAA will be applicable to industries in countries.

4.3 Summary of Costs and Benefits

A summary of principal categories of costs and benefits from the project is shown in Table 4.2.

Table 4.2 Incremental Cost and Benefit Categories

Costs	Benefits
R&D investment costs (cash and in-kind) as well as project administration costs	Avoided capital costs at wineries.
Overhead costs including time associated with meetings between the researchers and Wine Australia	Improved grape and wine quality realised as marginally higher prices for Shiraz grapes in warm inland areas.
Further development costs including broad-scale trials of NAA and its APVMA registration.	Avoided grape loss associated with having to harvest overripe fruit.
Adoption costs incurred by grape growers – existing spray equipment will be suitable for NAA application but the growth regulator will need to be purchased and costs will be incurred with labour and spray rig operation.	Improved harvesting logistics/reduced costs due to decompression of the harvest window.
Environmental – application of a PGR that is understood to be safe.	Environmental – reduced chemical inputs for the treatment of low acid ferments associated with high-sugar grapes.
	Health – increased availability and consumption of flavoursome, moderate alcohol

5. Valuation of Costs and Benefits

5.1 Costs

5.1.1 R&D Investment Costs including Administration

The following tables show annual investment in the project by Wine Australia (Table 5.1) and for researchers and other investors (Table 5.2). Table 5.3 provides the total investment by year for both sources.

Table 5.1 Investment by Wine Australia in the Project for Years Ending June 2015 to June 2017

Project Code	2015	2016	2017	2018	Total
CSP 1401 – Wine Australia	404,839	415,631	0	421,801	**1,242,271**
Total	**404,839**	**415,631**	**0**	**421,801**	**1,242,271**

Source: Wine Australia Project Application and revised schedule

Table 5.2 Investment by Researchers/Others in the Project for Years Ending June 2015 to June 2017

Project Code	2015	2016	2017	2018	Total
CSP 1401 – CSIRO cash	0	0	0	0	**0**
CSP 1401 – CSIRO in-kind	345,247	356,294	367,696	0	**1,069,237**
Total	**345,247**	**356,294**	**367,696**	**0**	**1,069,237**

Source: Wine Australia Project Application and revised schedule

Table 5.3 Annual Investment in the Project (nominal $)

Year Ending 30 June	Wine Australia	Researchers/Others	Total
2015	404,839	345,247	**750,086**
2016	415,631	356,294	**771,925**
2017	0	367,696	**367,696**
2018	421,801	0	**421,801**
Total	**1,242,271**	**1,069,237**	**2,311,508**

5.1.2 Overhead Costs including Meetings between the Researchers and Wine Australia

Wine Australia overhead costs are in addition to those shown in the above tables and are estimated at 12%.

5.1.3 Further Development Costs

Cost will be incurred completing broad-scale trials of NAA, generating data for NAA registration and the cost of registration. These costs will be incurred by CSIRO and a commercial partner. The cost of broad-scale trials is estimated at $120,000 spread over two years with registration costing $180,000 over a subsequent three year period.

5.1.4 Adoption Costs

Adoption costs will be incurred by grape growers – existing spray equipment will be suitable for NAA application but the growth regulator will need to be purchased and costs will be incurred with labour and spray rig operation. Increased cost to incorporate NAA into the production calendar has been estimated below to derive a net benefit from the production of more valuable Shiraz grapes.

5.2 Benefits

5.2.1 Avoided Capital Costs at Wineries

Counterfactual: if this project had not been funded, winemakers would have adjusted to increases in temperature and a compressed harvest through investment in stainless steel tanks and other processing equipment to manage a shorter wine grape harvest.

Use of NAA will help to decompress the wine grape growing season in warm inland areas saving winery owners investment in capital equipment. A summary of key assumptions used to quantify this benefit is shown in Table 5.4.

5.2.2 Production of More Valuable Shiraz Grapes in Warm Inland Areas

Counterfactual: in the absence of investment in this project Australian Shiraz grapes grown in warm inland areas would have lower levels of the compound rotundone which produces desirable 'peppery' aromas.

Use of NAA to decompress the grape growing season will produce Shiraz grapes of superior quality resulting in a marginally higher price for these grapes. Improved grape price will be net of additional cost incurred spraying wine grapes with NAA. A summary of key assumptions used to quantify this benefit is shown in Table 5.4.

Table 5.4 Summary of Assumptions

Variable	Assumption	Source
Avoided Capital Costs at Wineries		
Quantity of wine produced in wineries in Australia.	1,285,000,000 litres	Wine Australia, Production, Sales and Inventory Report 2017-18.
Quantity of wine produced in wineries using grapes from warm inland areas.	738,600,000 litres	60% of all Australian wine is grown from grapes grown in warm inland areas (Peter Bailey, Wine Australia, pers. comm.).
Cost of winery capital per litre of wine produced.	$0.22/litre	Wine Australia Gross Margin Ready Reckoner.
Increase in capital costs avoided – fewer stainless steel tanks and other processing equipment purchased to cope with compressed seasons.	10%	Consultant assumption following review of winery capital cost profile (Valdez et al., 2015).
Year in which NAA first used by grape growers to delay harvest in warm inland areas.	2024	Consultant assumption and assumes two years of broad-scale trials and three

		years following trials for NAA registration.
Year in which maximum adoption of NAA spray realised.	2029	Consultant assumption after review of project literature.
Year in which NAA spray replaced by alternative technology e.g. new varieties.	2043	Consultant estimate.
Maximum volume of wine produced from grapes grown in warm inland areas that have NAA spray applied.	30%	Consultant assumption after considering that NAA spray only required to stagger grape harvest i.e. not required on all production.
Probability of output.	80%	Consultant assumption recognising that broad-scale trials may not be successful and APVMA may not approve NAA for use on wine grapes.
Attribution of benefits to this project.	50%	Accounts for CSIRO/Wine Australia investment in PGRs prior to CSP 1401 (CSP 0905, CSP 0606, CRV 99/16b and CRCV 03/08) and subsequent trial and registration work required after CSP 1401.
Probability of usage.	90%	NAA appears to be a very important breakthrough but some wineries may choose capital investment rather than use of a spray.
Probability of impact.	90%	Consultant assumption that product will work and be effective after registration.
Production of More Valuable Shiraz Grapes in Warm Inland Areas		
Quantity of wine grapes grown in Australia.	1,794,182 tonnes	Wine Australia, National Vintage Report 2018.
Share of wine grapes that are Shiraz and grown in warm inland areas.	270,859 tonnes	Wine Australia, National Vintage Report 2018.
Average value of Shiraz grapes grown in warm inland areas.	$481/tonne	Wine Australia, National Vintage Report 2018.
Increase in value after spray with NAA.	$529/tonne	10% price improvement assumed.
Cost of production including NAA spray.	$514/tonne	Adapted from AgEconPlus 2016.
Grape grower profit from application of NAA spray and production of higher value Shiraz grapes with additional peppery notes	$15/tonne	$529/tonne less $514/tonne.
Maximum volume of Shiraz grapes grown in warm inland areas that have NAA spray applied.	30%	Consultant assumption after considering that NAA spray only required to stagger grape harvest i.e. not required on all production.

Probability of output.	80%	Consultant assumption recognising that broad-scale trials may not be successful and APVMA may not approve NAA for use on wine grapes.
Attribution of benefits to this project.	50%	Accounts for CSIRO/Wine Australia investment in PGRs prior to CSP 1401 (CSP 0905, CSP 0606, CRV 99/16b and CRCV 03/08) and subsequent trial and registration work required after CSP 1401.
Probability of usage.	90%	NAA appears to be a very important breakthrough but some wineries may choose not to pursue this development.
Probability of impact.	90%	Consultant assumption that product will work and be effective after registration.

5.2.2 Other Potential Benefits

Other potential benefits identified but not valued include:

- Avoided grape loss associated with having to harvest overripe fruit
- Improved harvesting logistics/reduced costs due to decompression of the harvest window
- Application of a PGR that is understood to be safe
- Reduced chemical inputs for the treatment of low acid ferments associated with high-sugar grapes
- Increased availability and consumption of flavoursome, moderate alcohol wines.

Other potential benefits were not quantified due to a combination of reasons including their relatively minor contribution to total impact, time and resources, availability of baseline data, difficulty in quantifying the causal relationships between the research outputs and the specific impact and the difficulty of placing credible monetary values on some of the environmental and social benefits.

6. Results

All past costs were expressed in current dollar terms using the implicit price deflator for GDP. All costs and benefits from 2018 onwards were discounted to current dollar terms using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for some of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2018).

Table 6.1 and Table 6.2 show the investment criteria estimated for the different periods of benefits for both the total investment and for Wine Australia investment. The present value of benefits (PVB) for the Wine Australia investment, shown in Table 6.2, are estimated by multiplying the total PVB by the Wine Australia proportion of investment.

Table 6.1 Investment Criteria for Total Investment by Wine Australia and Project Partners (discount rate 5%)

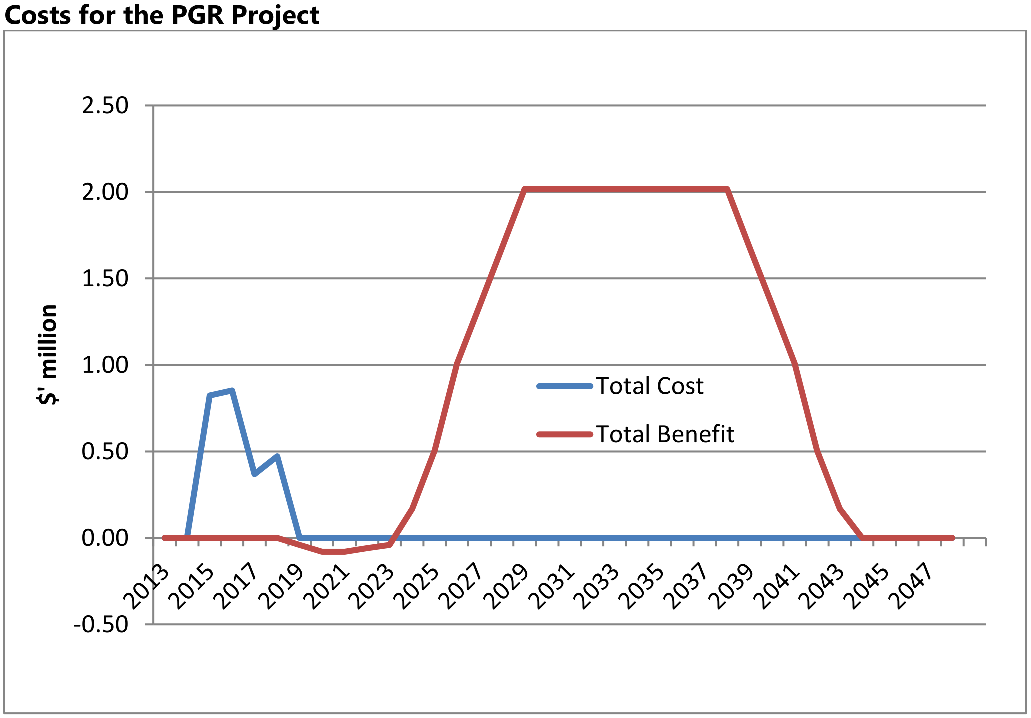
Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.00	-0.26	2.80	8.16	12.37	13.96	13.96
Present value of costs ($m)	2.75	2.75	2.75	2.75	2.75	2.75	2.75
Net present value ($m)	-2.75	-3.01	0.05	5.41	9.61	11.21	11.21
Benefit–cost ratio	0.00	-0.09	1.02	2.97	4.49	5.07	5.07
Internal rate of return (%)	Negative	Negative	4.8%	14.3%	16.6%	17.0%	17.0%
Modified internal rate of return (%)	Negative	Negative	4.9%	11.8%	12.2%	11.3%	10.3%

Table 6.2 Investment Criteria for Wine Australia (discount rate 5%)

Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.00	-0.15	1.59	4.62	6.99	7.90	7.90
Present value of costs ($m)	1.47	1.47	1.47	1.47	1.47	1.47	1.47
Net present value ($m)	-1.47	-1.62	0.11	3.14	5.52	6.42	6.42
Benefit–cost ratio	0.00	-0.10	1.08	3.14	4.75	5.36	5.36
Internal rate of return (%)	Negative	Negative	5.4%	15.0%	17.2%	17.6%	17.6%
Modified internal rate of return (%)	Negative	Negative	5.4%	12.1%	12.5%	11.5%	10.5%

The annual undiscounted benefits and cost cash flows for the total investment for the duration of the investment period plus 30 years from the last year of the initial investment are shown in Figure 6.1.

Figure 6.1 Annual Undiscounted Cash Flows for Estimated Total Benefits and Total RD&E Investment Costs for the PGR Project



7. Sensitivity Analysis

A sensitivity analysis was carried out for the central analysis results reported in Section 6 and variations in the discount rate. Table 7.1 presents the results. These indicate that all indicators remain positive for all discount rate assumptions.

Table 7.1 Sensitivity to Discount Rate (Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present value of benefits ($m)	29.82	13.96	7.16
Present value of costs ($m)	2.52	2.75	3.00
Net present value ($m)	26.76	11.21	4.16
Benefit-cost ratio	11.64	5.07	2.38

Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of the investment criteria. The analyses were performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values.

For this project the greatest uncertainty related to the saving in winery capital with NAA and the increase in net returns for Shiraz grape growers with NAA – Table 7.2 and Table 7.3. Results show that the benefit cost ratio remains above 3:1 even with a halving of these key assumptions.

Table 7.2 Sensitivity to Savings in Winery Capital with NAA (Total investment, 30 years)

Investment Criteria	Saving in Winery Capital (%)		
	5%	10% (base)	15%
Present value of benefits ($m)	8.39	13.96	19.53
Present value of costs ($m)	2.75	2.75	2.75
Net present value ($m)	5.64	11.21	16.78
Benefit-cost ratio	3.05	5.07	7.10

Table 7.3 Sensitivity to Increase in Shiraz Grape Net Returns with NAA (Total investment, 30 years)

Investment Criteria	Increase in Grape Net Returns ($/tonne)		
	$7.50/tonne	$15/tonne (base)	$22.50/tonne
Present value of benefits ($m)	12.42	13.96	15.50
Present value of costs ($m)	2.75	2.75	2.75
Net present value ($m)	9.67	11.21	12.75
Benefit-cost ratio	4.51	5.07	5.63

8. Confidence Ratings

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 8.1). 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 uncertainties in assumptions made

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

Table 8.1 Confidence in Analysis of Program

Coverage of Benefits	Confidence in Assumptions
Medium	Medium

9. Summary of Results

Funding for CSP 1401 'Understanding and manipulating small signalling molecules to affect the yield/flavour (quality) nexus' had a total cost of $2.75 million (present value terms) and is expected to produce aggregate total benefits of approximately $13.96 million (present value terms). This gives an estimated net present value of $11.21 million, a benefit-cost ratio of approximately 5.07, an internal rate of return of 17% and a modified internal rate of return of 10%.

Analysis results are dependent on assumptions made and are positive for core assumptions and remain positive through sensitivity testing.

Completion of broad-scale field trials and APVMA registration of NAA to manage compressed seasons and wine quality would appear to be a priority for the Australian wine industry.

Abbreviations

APVMA Australian Pesticides and Veterinary Medicines Authority
NAA naphthaleneacetic acid
PGRs plant growth regulators

Persons Contacted

Keith Hayes, Senior R&D Program Manager, Wine Australia
Dr Chris Davies, Researcher, CSIRO

References

AgEconPlus (2016) Economic Contribution of the Australian Wine Sector. Report prepared for Wine Australia.

CSIRO (2013) Understanding and Manipulating Small Signalling Molecules to Affect the Yield/Flavour (Quality) Nexus. Final Project Application.

CSIRO (2018) Understanding and Manipulating Small Signalling Molecules to Affect the Yield/Flavour (Quality) Nexus. Final Report Extract.

Valdez, M. Schorr, N. Lothan, A. (2015) Wineries: Equipment, Materials and Corrosion http://www.materialsperformance.com/articles/material-selection-design/2015/09/wineries-equipment-materials-and-corrosion

Appendix 4: Economic Analysis Wine Australia's Investment in Evaluating and Demonstrating New Disease Resistant Varieties for Warm Irrigated Areas

1. Background

This project builds on a previous CSIRO led plant breeding project supported by Wine Australia (CSP 0904), which produced 1,200 new selections from the CSIRO breeding program that showed strong resistance to powdery mildew and reduced susceptibility to downy mildew at a Barossa site. Based on disease resistance and other physiological traits, 20 white selections that demonstrated superior vine performance and a range of potential wine quality attributes were identified. Twenty red selections were also identified but required further evaluation. Powdery and downy mildew are the most economically important diseases in viticulture, causing reduced yield and loss of berry and wine quality, with an estimated cost to the Australian wine industry of approximately $140 million per annum.

2. Summary of Projects

The project established an experimental vineyard for the evaluation of the first generation of Australian mildew resistant vines in a warm irrigated wine region and Table 2.1 provides a description.

Table 2.1 Project Description

Project No. CSP 1402 Evaluating and demonstrating new disease resistant varieties for warm irrigated areas	
Project Details	Research Organisations: CSIRO / National Wine and Grape Industry Centre (NWGIC) Period: 1 November 2013 to 31 October 2017 Principal Investigators: Mark Thomas (CSIRO) and Bruno Holzapfel (NWGIC)
Rationale	The common wine grape cultivars of *Vitis vinifera* have little or no natural genetic resistance to the major fungal (powdery mildew) and oomycete (downy mildew) pathogens. Consequently the industry incurs substantial costs in managing these diseases including the application of chemical fungicides in the vineyard. Breeding of cultivars with high resistance to these pathogens will lower production costs and benefit the environment through the reduced use of chemical fungicides in vineyards. Previous research using 'marker assisted selection' (MAS) techniques, identified grapevine selections with resistance to powdery mildew and reduced susceptibility to downy mildew. The purpose of this project was to establish a trial and demonstration site, undertake field evaluations of new white and red selections including production and vineyard management data, berry parameters as well as testing for suitability for wine production in warm irrigated regions. The site would also be a source block for cuttings to be utilised by industry.
Objectives	The project had the following objectives. 1. Monitor vine establishment performance and compile vineyard management information, inputs and monitor disease levels. 2. Quantify grape yields and parameters and berry composition parameters for comparisons with the Barossa site. 3. Assess the produced experimental wines for their characteristics with the involvement of winemakers from industry, and conduct sensory analysis. 4. Assess the potential of the new selections for warm grape growing regions with respect to yield and irrigation water use efficiency and sensitivity of the vine and berries to heat and sun exposure. 5. Transfer knowledge to the wine industry on the suitability and adaptation of the selections and their wine styles to warm irrigated wine regions.

Activities and Outputs	• Development of project plan and coordinated research activities between CSIRO, NWGIC and McWilliams Wines. • Establishment of an evaluation and demonstration site with replicated trials for white and red varieties of mildew resistant selections in the Riverina. • Site serves as a mother block to provide cuttings for use by industry. • Measurement of vine establishment data, and design and implementation of disease monitoring protocols. • Quantification of vine performance parameters including Water Use Efficiency (WUE) and vine responses to heat. • Assessment of fruit parameters for winemaking in association with industry winemakers. • Increased understanding of management requirements for different varieties in across different climatic regions. • Field day seminars and at least two publications to extend knowledge on suitability of new disease resistance selections for warm region irrigated growers and for winemakers.
Outcomes	• The project established an evaluation and demonstration site with 40 selections (20 white and 20 red) that will provide for ongoing measurement and assessment of selections that are resistant to powdery mildew and downy mildew pathogens. The site is established as a material source block for industry for further development of disease resistant vine selections suitable for warm irrigated regions. • The project generated a number of results increasing understanding of the management requirements for disease resistant selections and their adaptability for warm irrigated regions. The selections demonstrated their disease resistance in a warm irrigated region. Results on establishment phase growth and management practices for all selections, yield/yield components and berry composition for white selections will inform future evaluations. WUE under irrigation was quantified and berry sensitivity to heat events monitored. Yield and pruning weight results for the white selections will inform optimal management strategies for water and nutrient applications. The project found considerable variation in maturation between selections (up to six weeks) with positive implications for industry looking to spread the harvest period. Preliminary assessment of the wines undertaken with industry participants, indicated different styles with considerable differences in aromas. • Results from the project have been communicated through the scientific literature and field days.
Impacts	• The direct economic benefits from this research include cost savings through reduced requirement for chemical fungicide applications in vineyards to manage powdery mildew and downy mildew. In addition, growing pathogen resistant selections will minimise income losses for growers as a consequence of saleable yield loss. As selections are adopted by industry, environmental benefits will be realised through the reduced use of chemical fungicides. • The reduction in chemical use has social impacts contributing to wine consumer and community expectations concerning chemical use in agricultural production systems. The impacts from the technology will positively contribute to industry efforts towards increased environmental sustainability.

3. Match with Government Priorities

Table 3.1 Strategic Science/Research Priorities and Rural R&D Research Priorities

Australian Government	
Strategic Science/Research Priorities	**Rural R&D Priorities**
1. **Food** – optimising food and fibre production and processing, agricultural productivity and supply chains within Australia and global markets 2. **Soil and water** – improve use of soil and water resources, both terrestrial, marine 3. **Transport** – moving essential commodities, alternative fuels, lowering emissions 4. **Cybersecurity** – for individuals, businesses, government, national infrastructure 5. **Energy** – improve efficiency, reduce emissions and integrate diverse sources into the grid. 6. **Resources** – support exploration for traditional resources, rare earths and new technologies. 7. **Advanced manufacturing** – high value and innovative industries in Australia. 8. **Environmental change** – mitigating, managing or adapting to changes. 9. **Health** – improving health outcomes for all Australians.	1. **Advanced technology**: to enhance innovation of products, processes and practices across the food and fibre supply chains through technologies such as robotics, digitalisation, big data, genetics and precision agriculture. 2. **Biosecurity**: to improve understanding and evidence of pest and disease pathways to help direct biosecurity resources to their best uses, minimising biosecurity threats and improving market access for primary producers. 3. **Soil, water and managing natural resources:** to manage soil health, improve water use efficiency and certainty of supply, sustainably develop new production areas and improve resilience to climate events and impacts. 4. **Adoption of R&D:** focussing on flexible delivery of extension services that meet primary producers' needs and recognising the growing role of private service delivery.

The Wine Australia project has addressed Strategic Science/ Research Priority 1 and to a lesser degree Priority 2. The major focus of the project has been on the first, second Rural R&D Priorities, while the project also addresses Priorities three and four.

4. Identification of Potential Costs and Benefits

4.1 Costs

4.1.1 R&D Investment

The R&D investment costs comprised:

- Direct financial outlay by Wine Australia
- In-kind contributions to the research project – non-cash contributions made by research partners CSIRO and NWGIC (NSW DPI and CSU)
- In-kind contributions to the research project – time associated with meetings between the researchers and Wine Australia (project overhead costs).

4.1.2 Administration

No additional administration costs were identified.

4.1.3 Extension

Extension costs such as communication of project outcomes to the industry including regional growers and winemakers via publications and field days, are included in the project budget.

4.1.4 Adoption

Adoption costs will include the additional cost to growers of buying the disease resistant vines above the currently available selections as part of their usual vineyard replanting program. If adoption is greater than this baseline level of adoption then the additional replanting costs and lost production (income foregone) through establishment phase will also be a cost of adoption.

4.2 Benefits

4.2.1 Research Output and Impact Pathway

The output from this project is the Riverina-tested grapevine selections (including white and red varieties) that are resistant to powdery mildew and downy mildew. This regional testing has reduced the risk to growers of adoption of the new selections with increased understanding of establishment phase growth and management practices for selections, and yield/yield components, and berry composition of white varieties.

The impact pathway is:

1. 3½-year research program showing that grapevine selections that are resistant to powdery and downy mildew are adaptable to the Riverina district, which is a warm irrigated region. The selections are productive with known productivity and optimised establishment, and maintenance management including irrigation, nutrition and pruning requirements. Grape characteristics for wine production are also better understood.
2. Communication of research findings through the relevant scientific and industry literature and field days.
3. Grape growers adopt the new selections as plant material becomes available from the source stock established in the project and incorporated into their vineyard replanting programs.

4.2.2 Triple Bottom Line Benefits

A summary of the potential benefits from the project in triple bottom line categories is shown in Table 4.1.

Table 4.1 Triple Bottom Line Categories Benefits from Project Investment

Levy Paying Industry	**Spillovers**		
	Other Industries	**Public**	**Foreign**
Economic Benefits			
Saved operating costs from a reduction in the use of chemical fungicides. Increased saleable production and therefore income since fewer affected grapes from powdery mildew or downy mildew.	Increased viticultural knowledge for the table grape industry	Nil	Project findings may be relevant to wine grape industries in other countries.
Environmental Benefits			
Reduced use of chemical fungicides in the vineyards to manage mildew.	Nil	Reduction in use of chemical fungicide applications in rural region.	Nil
Social Benefits			
Reduced need for vineyard staff to monitor and apply fungicides.	Nil		Nil

4.2.3 Public versus Private Benefits

The majority of benefits that will arise from project investment will be private in nature. The private benefits will be captured largely by the wine grape growing sector. Private benefits will focus on saved operating costs from not having to apply chemical fungicides to control mildews and also improved productivity and income from a reduction in rejected grapes by the winery.

4.2.4 Distribution of Benefits along the Supply Chain

The benefits to the wine industry from investment in this project will be shared along the supply chain with wine grape growers and winemakers sharing the benefits.

4.2.5 Benefits to other Primary Industries

Increased scientific knowledge with possible benefits for the table grape industry.

4.2.6 Benefits Overseas

Project findings may be relevant to wine grape industries in other countries.

4.3 Summary of Costs and Benefits

A summary of principal categories of costs and benefits from the project is shown in Table 4.2.

Table 4.2 Incremental Cost and Benefit Categories

Costs	Benefits
R&D investment costs (cash and in-kind) as well as project administration costs.	Saved operating costs and related capital costs from reduced chemical fungicide applications.
Overhead costs including time associated with meetings between the researchers and Wine Australia.	Income losses avoided from reduced production as a consequence of mildew
Extension costs including contributions specifically addressing industry awareness and technology diffusion made as part of project R&D investment costs.	
Adoption costs – additional cost of purchasing the new resistant varieties.	

5. Valuation of Costs and Benefits

5.1 Costs

5.1.1 R&D Investment Costs including Administration

The following tables show annual investment in the project by Wine Australia (Table 5.1) and for researchers and other investors (Table 5.2). Table 5.3 provides the total investment by year for both sources. The Wine Australia Final Project Application shows that the project commenced 1 July 2014 and was finalised 22 December 2017.

Table 5.1 Investment by Wine Australia in the Project for Years Ending June 2015 to June 2018 (nominal $)

Project Code	2015	2016	2017	2018	Total
CSP 1402 – Wine Australia cash	42,269	20,092	168,140	37,119	**267,620**
Total	**42,269**	**20,092**	**168,140**	**37,119**	**267,620**

Source: Wine Australia End of Project Financial Statement

Table 5.2 Investment by Researchers/Others in the Project for Years Ending June 2015 to June 2018 (nominal $)

Project Code	2015	2016	2017	2018	Total
CSP 1402 – CSIRO in-kind	24,393	25,174	25,979	0	**75,546**
CSP 1402 – NWGIC in-kind	104,963	108,708	112,581	0	**326,252**
Total	**129,356**	**133,882**	**138,560**	**0**	**401,798**

Source: Wine Australia Final Project Application budget

Table 5.3 Annual Investment in the Project (nominal $)

Year Ending 30 June	Wine Australia	Researchers/Others	Total
2015	42,269	129,356	171,625
2016	20,092	133,882	153,974
2017	168,140	138,560	306,700
2018	37,119	0	37,119
Total	**267,620**	**401,798**	**669,418**

5.1.2 Overhead Costs including Meetings between the Researchers and Wine Australia

Wine Australia overhead costs are in addition to those shown in the above tables and are estimated at 12%.

5.1.3 Extension Costs

Extension costs are included in the R&D Investment Cost totals.

5.1.4 Adoption Costs

Adoption costs will be incurred by growers paying a premium for the new resistant grape selections above the cost of currently available vines. If adoption of the resistant selections is at a greater rate than the typical vineyard replanting rate then additional costs and income foregone during the establishment period is also an adoption cost. However, taking a conservative position this later scenario was not considered.

5.2 Benefits

5.2.1 Counterfactual, Operating Cost Savings and Increased Income from the adoption of regionally tested vine selections resistant to powdery and downy mildew

The Counterfactual

If this project had not been funded vineyard operators would have continued to source improved varieties and clones through the regional industry-based vine improvement associations and nursery system. However, selections from the current sources will have lower levels of resistance to powdery and downy mildew at the same point in time as the project's resistant selections. Further the regional evaluation will reduce the production risks faced by producers of adopting the new selections with known adaptability to regional conditions, and increased knowledge about the project's selections establishment and management requirements and grape characteristics for wine production.

Operating Cost Savings and Increased Income

This project is expected to result in saved operating costs for growers through the adoption of vines that are resistant to powdery and downy mildew. This will result directly in a reduction in the amount of chemical fungicide use for the prevention of powdery mildew and eradication and preventions sprays for downy mildew. Growers adopting the mildew-resistant vines will also benefit from increased productivity particularly due to the reduction in diseased grapes that may otherwise be penalised or rejected by buyers, increasing vineyard income.

The benefit is quantified assuming that in the Riverina region growers will adopt the new selections during their vineyard replanting programs, resulting in disease management cost savings and avoidance of income loss when harvests are penalised or rejected by buyers due to powdery or downy mildew infection.

Table 5.4 Summary of Assumptions

Variable	Assumption	Source/explanation
Operating Cost Savings, Increased Income, Adoption of regionally tested powdery and downy mildew resistant selections		
Cost of eradication and preventative treatments for powdery mildew	$310/ha	Derived from Scholefield Robinson Horticultural Services Pty Ltd and EconSearch Pty Ltd (2010).
Cost of eradication and preventative treatments for downy mildew	$245/ha	Derived from Scholefield Robinson Horticultural Services Pty Ltd and EconSearch Pty Ltd (2010).
Increased income (from powdery mildew losses avoided)	$142/ha	Derived from Scholefield Robinson Horticultural Services Pty Ltd and EconSearch Pty Ltd (2010).
Increased income (from downy mildew losses avoided)	$71/ha	Derived from Scholefield Robinson Horticultural Services Pty Ltd and EconSearch Pty Ltd (2010).
Reduction in chemical treatments and income lost from affected grapes	60%	% of cost savings and extra income, based on discussions with researchers.
Area of wine grapes in other applicable regions Murray Darling (NSW) Murray Darling (Vic) Riverland (SA) Swan Hill (Vic +NSW)	6,297 ha 9,319 ha 6,370 ha 9,319 ha 19,041 ha 1,885 ha	ABS (2015) National Vineyard Survey.
Percentage of vineyards replanted each year.	4%	Vineyards have a 25 year life therefore 4% replanted on average (Clarke and Gillespie 2017).
Maximum adoption rate (% of normal vineyard replanting) Riverina Other applicable regions	 20% 10%	Consultant estimate.
No. of vines for replanting	1,786 vines/ha (spacing 2.8m x 2 m)	Consultant estimate of average planting density following ranges provided in Banks et al (1997).
Additional cost of new resistant selections (premium for resistant selection planting materials)	$0.75/ vine	Consultant estimate - based on survey of current royalties and premiums charged by nurseries.
Time for new selections to be commercially available	3 years	Consultant estimate from discussions with researchers.
Commercial harvest achieved after new vine establishment	5 years	Consultant estimate.
Attribution of benefits to project	40%	Consultant estimate.

6. Results

All past costs and benefits were expressed in 2017/18 dollar terms using the GDP deflator. All costs and benefits from 2017/18 onwards were discounted to 2017/18 dollar terms using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for some of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2017/18) to the final year of benefits assumed.

Tables 6.1 and 6.2 show the investment criteria estimated for the different periods of benefits for both the total investment and for Wine Australia/industry investment, respectively. The present value of benefits (PVB) for the Wine Australia investment, shown in Table 6.2, are estimated by multiplying the total PVB by the Wine Australia proportion of investment.

This analysis estimated that the NPV (Net Present Value) of the project is $1.87m with a benefit cost ratio (BCR) of 3.38 to 1 over 30 years. This project has an internal rate of return (IRR) of 9.78% and a modified internal rate of return (MIRR) of 8.10%. Returns to Wine Australia, accounting for its proportion of total investment are a BCR of 3.67, IRR of 10.06% and MIRR of 8.25%.

Figure 6.1 illustrates the undiscounted cashflows of benefits and total research, development and extension costs incurred. The negative of total benefits seen in the early years of the analysis timeframe reflect the adoption cost for vineyards purchasing the new selections and prior to realising cost reductions and increase saleable grapes which occurs from the first commercial harvest.

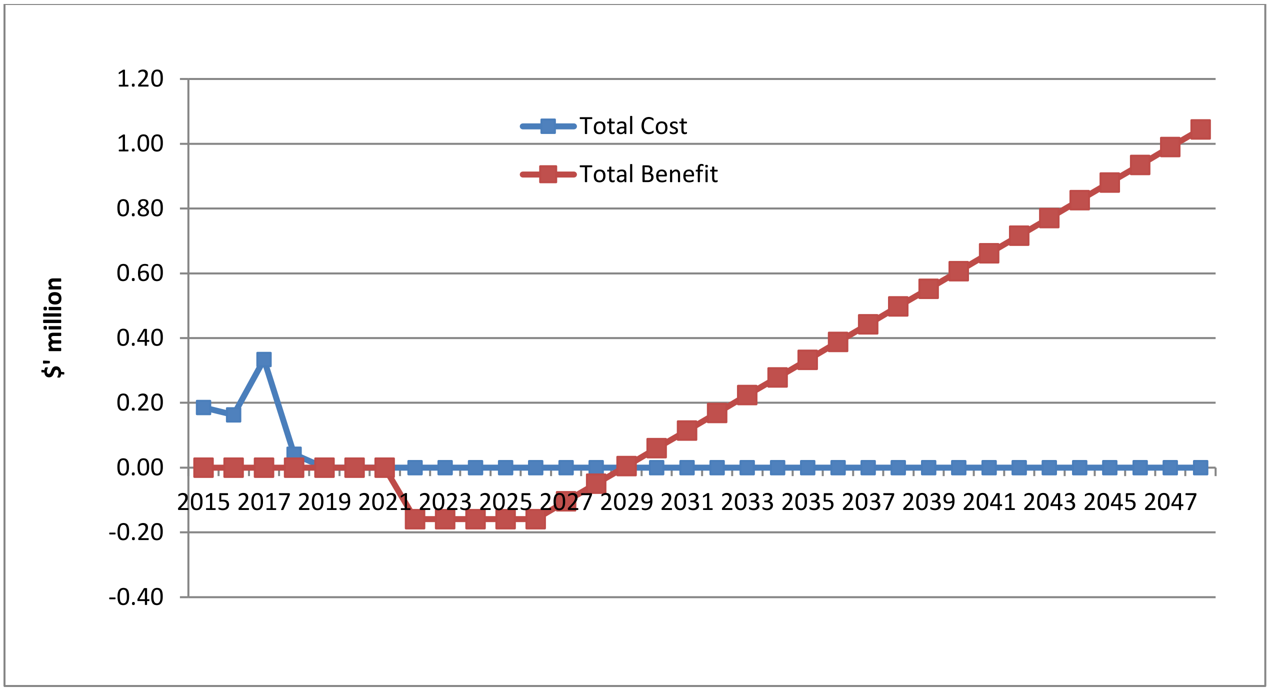
Table 6.1 Investment Criteria for Total Investment by Wine Australia and Project Partners (discount rate 5%)

Years	**0 years**	**5 years**	**10 years**	**15 years**	**20 years**	**25 years**	**30 years**
Present value of benefits ($m)	0	-0.26	-0.69	-0.40	0.40	1.47	2.66
Present value of costs ($m)	0.79	0.79	0.79	0.79	0.79	0.79	0.79
Net present value ($m)	-0.79	-1.04	-1.48	-1.19	-0.39	0.68	1.87
Benefit–cost ratio	0	-0.32	-0.88	-0.51	0.50	1.86	3.38
Internal rate of return (%)	Negative	Negative	Negative	Negative	2.82	7.62	9.78
Modified internal rate of return (%)	Negative	Negative	Negative	Negative	3.46	6.78	8.10

Table 6.2 Investment Criteria for Wine Australia (discount rate 5%)

Years	**0 years**	**5 years**	**10 years**	**15 years**	**20 years**	**25 years**	**30 years**
Present value of benefits ($m)	0	-0.11	-0.29	-0.17	0.17	0.62	1.13
Present value of costs ($m)	0.31	0.31	0.31	0.31	0.31	0.31	0.31
Net present value ($m)	-0.31	-0.42	-0.60	-0.48	-0.14	0.31	0.82
Benefit–cost ratio	0	-0.35	-0.96	-0.55	0.55	2.03	3.67
Internal rate of return (%)	Negative	Negative	Negative	Negative	3.13	7.92	10.06
Modified internal rate of return (%)	Negative	Negative	Negative	Negative	3.69	6.97	8.25

Figure 6.1 Annual Undiscounted Cash Flows for Estimated Total Benefits and Total RD&E Investment Costs for the regional tested disease resistant varieties



7. Sensitivity Analysis

Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of the investment criteria. The analyses were performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values.

For this project, the greatest uncertainty related to:

- the sensitivity of the returns from the project investment to the discount rate. At 10% discount rate the project has a PVB of $0.70 m and a negative NPV of -$0.18m and a benefit cost ratio of 0.79. At a discount rate of 0% the present value of benefits is estimated to be $9.55m with an NPV of $8.82m and a BCR of 13.19.
- the degree of resistance afforded by the genetic traits in the selections over the long term and the extent to which chemical treatment are required is uncertain. A base case of 60% reduction in fungicide treatments and the extent to which income losses from affected grapes in vineyards is used in the analysis. A 33% increase or decrease in the level of effectiveness of the trait (expressed as % change in the amount of spray and loss avoided through changes in vineyard productivity and saleable grapes) from the base assumption results in an NPV of $3.42m and BCR of 5.35 to 1 if the level of effectiveness is 80%, while an NPV of 0.31m and BCR of 1.40 is estimated if effectiveness is only 40%.
- the premium charged for growers to purchase the new resistant selections for planting is also uncertain and has a large influence on the investment returns of the project. This is since the charge is an upfront adoption cost and that benefits do not commence until first commercial harvest of the vines. A 33% increase in the premium charged to growers for the new selection (above the typical cost of vines), that is $1.00/vine, results in an NPV of $1.20m and BCR of 2.52. If the premium

charged is only $0.50/vine (a 33% decrease on the base estimate) then the project NPV is $2.54m with a BCR of 4.23.

Table 7.1 Sensitivity to Discount Rate (Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	**5% (base)**	**10%**
Present value of benefits ($m)	9.55	2.66	0.70
Present value of costs ($m)	0.72	0.79	0.85
Net present value ($m)	8.82	1.87	-0.18
Benefit-cost ratio	13.19	3.38	0.79

Table 7.2 Sensitivity to the level of protection from powdery and downy mildews through reduced chemical applications and income losses avoided (Total investment, 30 years)

Investment Criteria	Reduction in chemical treatments and income loss from affected grapes (%)		
	40%	**60% (base)**	**80%**
Present value of benefits ($m)	1.10	2.66	4.21
Present value of costs ($m)	0.79	0.79	0.79
Net present value ($m)	0.31	1.87	3.42
Benefit-cost ratio	1.40	3.38	5.35

Table 7.3 Sensitivity to price premium for new resistant selection

Investment Criteria	Premium charged /vine		
	$0.50	**$0.75 (base)**	**$1.00**
Present value of benefits ($m)	3.33	2.66	1.99
Present value of costs ($m)	0.79	0.79	0.79
Net present value ($m)	2.54	1.87	1.20
Benefit-cost ratio	4.23	3.38	2.52

8. Confidence Ratings

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 8.1). The rating categories used are High, Medium and Low, where:

- High: denotes good coverage of benefits or reasonable confidence in assumptions made
- Medium: denotes only a reasonable coverage of benefits or some uncertainties in assumptions made
- Low: denotes a poor coverage of benefits or many uncertainties in assumptions made

Table 8.1 Confidence in Analysis of Program

Coverage of Benefits	Confidence in Assumptions
High	Medium/low

9. Summary of Results

Funding for the 'Evaluating and demonstrating new disease resistant varieties for warm irrigated areas' project, was valued at $0.79m (present value terms) and is expected to produce aggregate total present value of benefits of approximately $2.66m. This gives an estimated NPV of $1.87m, a BCR of approximately 3.38, an IRR of 9.78% and an MIRR of 8.10%.

All investment indicators are sensitive to different discount rate assumptions and negative at higher the higher rate tested. Different assumptions around the changes in the level of effectiveness of the resistance traits in terms of chemical treatment costs saved and income and losses avoided, as well as the extra cost of the new selections for growers, influence the investment returns substantially.

In addition to the quantified economic benefits described, there are also important environmental benefits on-farm and to the community from the reduced use of chemical fungicides in the vineyard environment that contribute to improving the sustainability of the wine industry.

Abbreviations

ABS	Australian Bureau of Statistics
BCR	Benefit Cost Ratio
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSU	Charles Sturt University
IRR	Internal Rate of Return
MIRR	Modified Internal Rate of Return
NPV	Net Present Value
NSW DPI	New South Wales Department of Primary Industries
NWGIC	National Wine and Grape Industry Centre
PVB	Present Value of Benefits
WUE	Water Use Efficiency

Persons Contacted

Keith Hayes – Senior R&D Program Manager, Wine Australia
Mark Thomas – Principal Investigator CSIRO

References

ABS 2015. Vineyards, Australia, 2014-15. Cat.no. 1329.0.55.002. Australian Bureau of Statistics, Canberra. http://www.abs.gov.au/ausstats/abs@.nsf/mf/1329.0.55.002

Banks, A, Davidson D, Oag, D, Dullahide S, Dunn T, Puglisi A and James J (1997). Wine Grape Information Kit. Agrilink, your growing guide to better farming guide. Manual. Agrilink Series QAL9706, Queensland Horticulture Institute. Brisbane, Queensland. http://era.daf.qld.gov.au/id/eprint/1690/

Clarke M and Gillespie R (2017) Benefit Cost Analysis of Wine Australia R&D Investments 2015-16. Report to Wine Australia https://www.wineaustralia.com/getmedia/453b9683-ea52-4396-a1e0-70084931fec5/AGWA-Benefit-Cost-Analysis-2015-16

Scholefield Robinson Horticultural Services Pty Ltd and EconSearch Pty Ltd (2010). "Assessment of Economic Cost of Endemic Pests & Diseases on the Australian Grape & Wine Industry; GWRDC PROJECT GWR 08/04. https://www.wineaustralia.com/research/search/completed-projects/gwr-08-04

Appendix 5: Economic Analysis Wine Australia's Investment in Metal Ion Speciation: Understanding its Role in Wine Development and Generating a Tool to Minimise Wine Spoilage

1. Background

Copper and/or iron can influence the rate of oxidation reactions and accumulation of reductive flavour compounds in wine. These can result in colour changes, unpleasant sulfidic aromas loss of varietal aromas and other issues. Reductive winemaking focusses on protecting the original fruit aromas and flavours from grapes. Uncontrolled oxidative, reductive and colloidal (suspended solid) phenomena are recognised as major contributors to wine faults.

Both copper and iron exist in a variety of forms and are bound to wine components at different binding strengths. Differences in a metal's ionic form and binding strength are referred to as its 'speciation'. Effective binding of copper and iron may alter its influence on the development of the wine. Agents responsible for the most efficient binding of copper and iron ions in wine were not known prior to this project, nor were the consequences of such binding.

Wine production is commonly conducted with copper additions to minimise sulfidic-off odours and/or allow further expression of fruit characters. The recommended total concentrations of metals in wine have been given as broad ranges due to difficulty in linking these concentrations to metal induced effects. A number of 'research-oriented' methods for metal speciation measurements in wine had already been developed prior to this project but had not been applied to predict metal-induced processes.

The development of a metal speciation tool would allow winemakers to assess the amount of 'active' copper present in the wine, as well as total copper, thereby giving objective support for decisions related to copper addition. The metal speciation tool may identify wine that is particularly prone to oxygen exposure and/or development of reductive characters.

2. Summary of Projects

A single metal ion speciation project supported by Wine Australia was analysed and Table 2.1 provides a description.

Table 2.1 Project Description

Project No. NWG 1401 Metal ion speciation: Understanding its role in wine development and generating a tool to minimise wine spoilage	
Project Details	Research Organisation: Charles Sturt University (CSU) Period: 1 July 2014 to 28 February 2018 Principal Investigator: Dr Andrew Clark
Rationale	A tool was required to measure iron and copper speciation and control metal induced oxidative and reductive phenomena. The aim of this project was to develop knowledge regarding the 'fine' metal speciation, 'coarse' metal speciation, wine binding agents and also to produce a routine test applicable for winery use that will allow winemakers to assess the impact of residual iron and copper in wine on spoilage and beneficial reactions.
Objectives	1. Survey a range of white wines for copper and iron speciation utilising research orientated techniques. 2. Identify which molecules are the strongest binders of copper and iron in wine, based on studies using model systems.

	3. Relate the metal speciation measures of copper and iron to the rate of wine oxidation and the formation of volatile sulfur compounds in reductive conditions. 4. Relate the copper speciation measures to existing colorimetric assays of copper reactivity and modify the assays as required to reflect the ability of copper to affect spoilage processes. 5. Relate the iron speciation measures to existing colorimetric assays of iron reactivity and modify the assays as required to reflect the ability of iron to affect spoilage processes. 6. Communicate the development of the metal speciation tool to winemakers, including the preparation of a "How to" guide for use of the tool. 7. Prepare teaching notes for use in oenology subjects at CSU and The University of Adelaide.
Activities and Outputs	• A range of white and red wines were surveyed for copper and iron speciation and the results related to general wine composition. • Identification and quantification of binding agents in wine. • Completion of model studies using a variety of potential binding agents (tannins, proteins, polysaccharides, polyphenols) to determine their binding efficiency. Studies repeated over time to assess the change in metal speciation. • Assessment of a range of wines to correlate speciation measures with rates of oxidation, copper sulfide precipitation and low molecular weight sulfur compound formation. • Significant progress made in understanding the different forms of metals in wine and how they can be measured. • Copper mostly exists in wine in a sulfide-bound form. The non-sulfide-bound form is more efficient for mediating oxidation reactions when ascorbic acid was present. The non-sulfide bound form of copper readily sequesters sulfide from precursors during reductive development. • However, over use of copper can have ramification in both the reductive oxidative aging of wine, and the loss of wine quality potentially affecting consumer enjoyment of the wine and exceeding Maximum Residue Limits (MRLs) in some export markets. • Unlike copper, iron binding in wine was not dominated by a single binding agent and had minimal influence on oxidation in the presence of ascorbic acid. • An industry applicable, rapid measure of total copper in white wines was developed based on the colorimetric method. • Further research is required for the development of a measure of total copper in red wines. Further research required for colorimetric determination of a non-sulfide bound copper in white and red wines that could be adoptable by wineries. Further research is required to establish further links between copper speciation and oxidative and reductive aging of wine. • Papers detailing research results and the usefulness of the tool for measuring total copper were produced. A 'How to' guide for use of the tool was prepared and teaching notes developed for oenology students.
Outcomes	• A tool for use by winemakers who have access to an analytical balance and visible spectrophotometer. The tool allows for correct dosing of copper in wines affected by sulfidic off-odours and the prevention of overdosing with

	copper. Overdosing copper results in loss of wine quality and the potential to inadvertently exceed MRLs in export markets.
Impacts	• Economic – avoided loss of white wine quality. • Economic – early warning on copper MRL breaches. • Environmental – more judicious use of chemicals (avoiding copper overdosing) to control sulfidic off-odours and minimisation of the amount of waste produced. • Capacity – post-doctoral fellow and CSU research staff with additional skills in the analysis of metals and sulfur in wine. • Capacity – CSU and Adelaide University students trained with up-to-date information on sulfur and copper management in wine.

3. Match with Government Priorities

Table 3.1 Strategic Science/Research Priorities and Rural R&D Research Priorities

Australian Government	
Strategic Science/Research Priorities	**Rural R&D Priorities**
1. **Food** – optimising food and fibre production and processing, agricultural productivity and supply chains within Australia and global markets 2. **Soil and water** – improve use of soil and water resources, both terrestrial, marine 3. **Transport** – moving essential commodities, alternative fuels, lowering emissions 4. **Cybersecurity** – for individuals, businesses, government, national infrastructure 5. **Energy** – improve efficiency, reduce emissions and integrate diverse sources into the grid. 6. **Resources** – support exploration traditional resources, rare earths and new technologies. 7. **Advanced manufacturing** – high value and innovative industries in Australia. 8. **Environmental change** – mitigating, managing or adapting to changes. 9. **Health** – improving health outcomes for all Australians.	1. **Advanced technology**: to enhance innovation of products, processes and practices across the food and fibre supply chains through technologies such as robotics, digitalisation, big data, genetics and precision agriculture. 2. **Biosecurity**: to improve understanding and evidence of pest and disease pathways to help direct biosecurity resources to their best uses, minimising biosecurity threats and improving market access for primary producers. 3. **Soil, water and managing natural resources:** to manage soil health, improve water use efficiency and certainty of supply, sustainably develop new production areas and improve resilience to climate events and impacts. 4. **Adoption of R&D:** focussing on flexible delivery of extension services that meet primary producers' needs and recognising the growing role of private service delivery.

The Wine Australia project has addressed Strategic Science/ Research Priority 1. The major focus of the project has been on the first of the Rural R&D Priorities.

4. Identification of Potential Costs and Benefits

4.1 Costs

4.1.1 R&D Investment

The R&D investment costs comprised:

- Direct financial outlays by collaborators and participants in the research project, namely Wine Australia.
- In-kind contributions to the research project – non-cash contributions made by research partner CSU.
- In-kind contributions to the research project – time associated with meetings between the researchers and Wine Australia (project overhead costs).

4.1.2 Administration

No additional administration costs were identified.

4.1.3 Extension

Extension costs such as communication of project outputs to winemakers were included in the project budget.

4.1.4 Adoption

No incremental additional adoption costs have been identified. Winemakers with access to an analytical balance and visible spectrophotometer will make use of the new copper testing tool in house. They will test their wine more frequently and incur costs associated with this activity. However, these costs will be offset by expenses previously incurred testing their wine at specialist laboratories.

4.2 Benefits

4.2.1 Research Output and Impact Pathway

The output of the project is a tool to measure total copper in wine and minimise the risk of hydrogen sulfide formation, wine quality loss and the exceeding of certain MRLs in export markets.

The impact pathway is:

1. Tool developed for measuring total copper in wine.
2. Value of the tool and 'How to' communicated to Australian white winemakers.
3. White winemakers with access to an analytical balance and visible spectrophotometer employ tool for measuring total copper reducing the incidence of hydrogen sulfide affected wines.
4. With reduction in hydrogen sulfide affected wines there is an avoided cost to winemakers (reduced sales, reputation damage) and less risk of copper MRLs being exceeded in export markets.

4.2.2 Triple Bottom Line Benefits

A summary of the potential benefits from the project in triple bottom line categories is shown in Table 4.1.

Table 4.1 Triple Bottom Line Categories Benefits from Project Investment

Levy Paying Industry	**Spillovers**		
	Other Industries	**Public**	**Foreign**
Economic Benefits			
Avoided loss of white wine quality. Early warning on copper MRL breaches.	Nil	Nil	Tool for measuring total copper in white wine is relevant to wine industries in other countries.
Environmental Benefits			
More judicious use of chemicals (reduction in copper overdosing) to control sulfidic off-odours and minimisation of the amount of waste produced.	Nil	Minimisation of downstream chemical residues.	Nil
Social Benefits			
Post-doctorate fellow and CSU research staff with additional skills in the analysis of metals and sulfur in wine. CSU and Adelaide University students trained with up-to-date information on sulfur and copper management in wine.	Nil	Nil	Wine consumers in export markets more likely to enjoy Australian white wine.

4.2.3 Public versus Private Benefits

The majority of benefits that will arise from project investment will be private in nature. The private benefits will be largely captured by winemakers and exporters. The private benefits will focus on avoided loss of white wine quality and value as well as additional Australian white wine sales over and above the 'no project counterfactual'. Public benefits will include minimisation of chemicals in the environment.

4.2.4 Distribution of Benefits along the Supply Chain

The benefits to the wine industry from investment in this project will be shared along the supply chain with exporters, wholesalers, winemakers and grape growers all sharing in some of the benefits.

4.2.5 Benefits to other Primary Industries

No benefits to other primary industries were identified. A tool for testing total copper in white wine is specific to that industry.

4.2.6 Benefits Overseas

The copper testing tool is relevant to white wine producers overseas and consumers of Australian white wine stand to gain from a product of even greater consistency.

4.3 Summary of Costs and Benefits

A summary of principal categories of costs and benefits from the project is shown in Table 4.2.

Table 4.2 Incremental Cost and Benefit Categories

Costs	Benefits
R&D investment costs (cash and in-kind) as well as project administration costs.	Avoided loss of white wine quality.
Overhead costs including time associated with meetings between the researchers and Wine Australia.	Early warning on MRL breaches.
	More judicious use of chemicals (copper) to control sulfidic off-odours and minimisation of the amount of waste produced.
	Post-doctoral fellow and CSU research staff with additional skills in the analysis of metals and sulfur in wine.
	CSU and Adelaide University students trained with up-to-date information on sulfur and copper management in wine.

5. Valuation of Costs and Benefits

5.1 Costs

5.1.1 R&D Investment Costs including Administration

The following tables show annual investment in the project by Wine Australia (Table 5.1) and for researchers and other investors (Table 5.2). Table 5.3 provides the total investment by year for both sources.

Table 5.1 Investment by Wine Australia in the Project for Years Ending June 2015 to June 2018

Project Code	2015	2016	2017	2018	Total
NWG 1401 – Wine Australia	229,417	236,247	243,298	44,500	**753,462**
Total	229,417	236,247	243,298	44,500	**753,462**

Source: Wine Australia Project Application and revised schedule

Table 5.2 Investment by Researchers/Others in Project for Years Ending June 2015 to June 2018

Project Code	2015	2016	2017	2018	Total
NWG 1401 – CSU cash	0	0	0	0	**0**
NWG 1401 – CSU in-kind	66,979	68,989	71,058	12,997	**220,023**
Total	66,979	68,989	71,058	12,997	**220,023**

Source: Wine Australia Project Application and revised schedule

Table 5.3 Annual Investment in the Project (nominal $)

Year Ending 30 June	Wine Australia	Researchers/Others	Total
2015	229,417	66,979	**296,396**
2016	236,247	68,989	**305,236**
2017	243,298	71,058	**314,356**
2018	44,500	12,997	**57,497**
Total	**753,462**	**220,023**	**973,485**

5.1.2 Overhead Costs including Meetings between the Researchers and Wine Australia

Wine Australia overhead costs are in addition to those shown in the above tables and are estimated at 12% for this project.

5.2 Benefits

5.2.1 Avoided Cost of Market Closure

The Counterfactual

If this project had not been funded it is likely that winemakers would have continued to add copper to white wine in a less judicious manner, increasing rather than decreasing, the risk of sulfidic-off odours.

Avoided Loss of White Wine Quality

With NWG 1401 completed and the results communicated to winemakers there is opportunity for most white winemakers i.e. those who have or can access an analytical balance and a UV-visible spectrophotometer to more frequently test their wine to ensure just enough copper is added to manage sulfidic-off odours and ensure copper is not over-used with resultant loss of wine quality. Prior to this project winemakers needed to send samples away for testing by external laboratories.

The project has shown that use of copper at low levels can release hydrogen sulfide, which dampens fruit aroma and wine freshness, resulting in a wine that does not spoil but does not reach its full potential. The project has also shown that over-use of copper at higher levels can result in greater release of hydrogen sulfide that reacts with iron in the wine and creates a wine that is yellow-brown in colour. Under these conditions wines taste noticeably 'off' to consumers, flavours are associated with a prematurely aged wine, there may be a haze in the wine, polyphenols (containing antioxidants) are lost and aroma compounds are destroyed. These adverse reactions only become apparent after the wine has been bottled; this diminishes both the reputation of the winemaker and Australian wine. A summary of key assumptions used to quantify avoided loss of white wine quality as a result of being able to access and make use of a tool for testing total copper in white wine is shown in Table 5.4.

Table 5.4 Summary of Assumptions

Variable	Assumption	Source
Avoided Loss of White Wine Quality		
Australian white wine production.	616,000,000 litres	Wine Australia, Production, Sales and Inventory Report 2018-18.
Share of Australian white wine production that is able to readily access an analytical balance and visible spectrophotometer.	60%	Consultant assumption after discussions with Paul Smith, Wine Australia.
Maximum share of those with an analytical balance and visible spectrophotometer using the technology for copper analysis.	50%	Consultant assumption.
Share of Australian white wine production that is affected by sulfidic-off odours perceptible to consumers.	1%	One in ten bottles affected (10%) but only a small percentage of these affected bottles are perceptible to consumers.
Cellar door value of wine affected by sulfidic-off odours that are perceptible to consumers.	$2.63/litre	Prepared with the assistance of Angelica Crabb, Wine Australia and based on commercial Chardonnay with grapes grown in the Riverland South Australia.
Year in which first winery adopts project outputs i.e. winery based tool for measuring total copper in wine.	2019	Two years after research completion.
Year in which a new technology is developed to replace winery based tool for measuring total copper in wine.	2025	New technology currently being investigated that will measure non-sulfide bound copper and establish further links between copper speciation, oxidative and reductive winemaking.
Attribution of benefit to project NWG 1401.	80%	Consultant estimate based on low probability of the research being completed through another channel.
Probability of output.	90%	Consultant assumption after review of project literature.
Probability of usage.	80%	Consultant assumption after review of project literature.
Probability of impact.	80%	Consultant assumption after review of project literature.

5.2.2 Other Potential Benefits

Other potential benefits identified but not valued include:

- Early warning on copper MRL breaches for Australian white wine destined for export markets.
- More judicious use of copper to control sulfidic off-odours and minimisation of the amount of waste produced.

- Post-doctoral fellow and CSU research staff trained with additional skills in the analysis of metals and sulfur in wine.
- CSU and Adelaide University students trained with up-to-date information on sulfur and copper management in wine.

Other potential benefits were not quantified due to a combination of reasons including time and resources, availability of baseline data, difficulty in quantifying the causal relationships between the research outputs and the specific impact and the difficulty of placing credible monetary values on the environmental and capacity building benefits.

6. Results

All past costs were expressed in 2018 dollar terms using the implicit price deflator for GDP. All costs and benefits from 2018 onwards were discounted to 2018 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for some of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2018).

Table 6.1 and Table 6.2 show the investment criteria estimated for the different periods of benefits for both the total investment and for Wine Australia investment. The present value of benefits (PVB) for the Wine Australia investment, shown in Table 6.2, are estimated by multiplying the total PVB by the Wine Australia proportion of investment.

Table 6.1 Investment Criteria for Total Investment by Wine Australia and Project Partners (discount rate 5%)

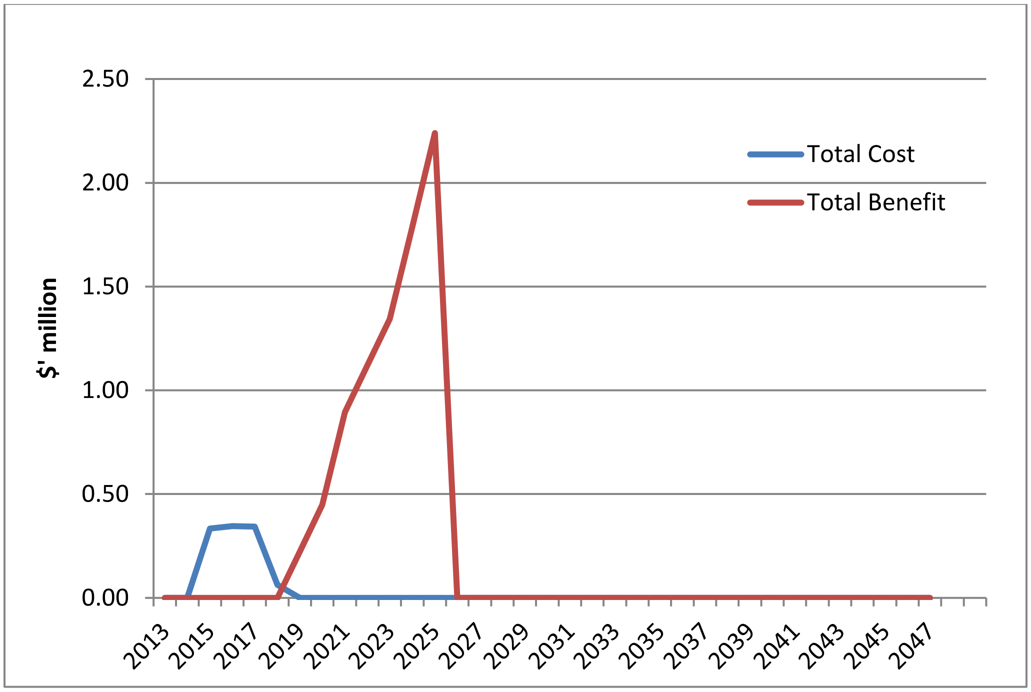
Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.00	3.37	6.30	6.30	6.30	6.30	6.30
Present value of costs ($m)	1.19	1.19	1.19	1.19	1.19	1.19	1.19
Net present value ($m)	-1.19	2.18	5.10	5.10	5.10	5.10	5.10
Benefit–cost ratio	0.00	2.83	5.28	5.28	5.28	5.28	5.28
Internal rate of return (%)	Negative	31.8%	41.5%	41.5%	41.5%	41.5%	41.5%
Modified internal rate of return (%)	Negative	24.2%	21.8%	16.3%	13.5%	11.8%	10.7%

Table 6.2 Investment Criteria for Wine Australia (discount rate 5%)

Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.00	2.67	4.99	4.99	4.99	4.99	4.99
Present value of costs ($m)	0.90	0.90	0.90	0.90	0.90	0.90	0.90
Net present value ($m)	-0.90	1.77	4.09	4.09	4.09	4.09	4.09
Benefit–cost ratio	0.00	2.96	5.53	5.53	5.53	5.53	5.53
Internal rate of return (%)	#NUM!	33.2%	42.8%	42.8%	42.8%	42.8%	42.8%
Modified internal rate of return (%)	-100%	25.1%	22.3%	16.6%	13.7%	12.0%	10.8%

The annual undiscounted benefits and cost cash flows for the total investment for the duration of the investment period plus 30 years from the last year of the initial investment are shown in Figure 6.1.

Figure 6.1 Annual Undiscounted Cash Flows for Estimated Total Benefits and Total RD&E Investment Costs for the Metal Ion Speciation Project



7. Sensitivity Analysis

A sensitivity analysis was carried out for the central analysis results reported in Section 6 and variations in the discount rate. Table 7.1 presents the results. These indicate that all indicators remain positive for all discount rate assumptions.

Table 7.1 Sensitivity to Discount Rate (Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present value of benefits ($m)	8.06	6.30	5.01
Present value of costs ($m)	1.09	1.19	1.30
Net present value ($m)	6.98	5.10	3.70
Benefit-cost ratio	7.42	5.28	3.84

Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of the investment criteria. The analyses were performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values.

For this project the greatest uncertainty related to the share of Australian white wine production that is affected by sulfidic-off odours perceptible to consumers – Table 7.2. Results show if only 0.5% of Australia's white wine is affected then project benefits continue to exceed project costs.

Table 7.2 Sensitivity to Share of Australian White Wine Affected by Sulfidic Off-Odours (Total investment, 30 years)

Investment Criteria	Share of Australian White Wine Production Affected by Sulfidic Off Odours		
	0.5%	**1% (base)**	**2%**
Present value of benefits ($m)	3.15	6.30	12.59
Present value of costs ($m)	1.19	1.19	1.19
Net present value ($m)	1.96	5.10	11.40
Benefit-cost ratio	2.64	5.28	10.57

8. Confidence Ratings

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 8.1). 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 uncertainties in assumptions made

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

Table 8.1 Confidence in Analysis of Program

Coverage of Benefits	Confidence in Assumptions
High	Medium

9. Summary of Results

Funding for the metal ion speciation project was valued at $1.19M (present value terms) and is expected to produce aggregate total benefits of approximately $6.30M (present value terms). This gives an estimated net present value of $5.10M, a benefit-cost ratio of approximately 5.28, an internal rate of return of 42% and a modified internal rate of return of 11%.

The results are not sensitive to changes made in the key assumption – share of Australian white wine affected by sulfidic off odours that are perceptible to consumers. All investment indicators remain positive for different discount rate assumptions.

Abbreviations

AWRI Australian Wine Research Institute
CSU Charles Sturt University

Persons Contacted

Dr Andrew Clark, Senior Lecturer in Wine Chemistry, CSU
Dr Paul Smith, Senior R&D Program Manager, Wine Australia

References

Clark (2018) Metal Ion Speciation: Understanding its Role in Wine Development and Generating a Tool to Minimise Wine Spoilage. Final report accessed at https://www.wineaustralia.com/research/search/completed-projects/nwg-1401

Appendix 6: Economic Analysis Wine Australia's Investment in Understanding the Impact of Elevated CO_2 and its Interaction with Elevated Temperature on Production and Physiology of Shiraz

1. Background

With a variable and changing climate, elevated carbon dioxide (CO_2) and elevated temperatures there is uncertainty in many agricultural industries about the consequences for productivity, profitability and the adaptive strategies required.

In order to allocate resources to areas where adaptation is needed and possible, it is necessary to understand how a changing environment will impact an industry.

For the Australian wine industry the most critical question is whether there is an interaction between temperature and increased CO_2 and whether the interaction will exacerbate the impact of rising temperature on grape and wine production.

2. Summary of Projects

A single climate change project supported by Wine Australia was analysed and Table 2.1 provides a description.

Table 2.1 Project Description

Project No. DPI 1202 Impact of elevated CO_2 and its interaction with elevated temperature on production and physiology of Shiraz	
Project Details	Research Organisation: Department of Primary Industries (DPI), Victoria Period: 1 February 2013 to 31 March 2018 Principal Investigator: Michael Treeby
Rationale	To address the question of what is the combined impact of elevated CO_2 and temperature on wine grape production, an innovative controlled vineyard environment was proposed that incorporated both heating and elevating CO_2 in open-topped chambers (OTC). The primary focus of the project was on examination of the impacts of elevated temperature and CO_2 on grapevine productivity and grape and wine characteristics. Specifically the project was to examine the impact on grapevine development, vegetative growth, fruitfulness, fruit composition and wine quality parameters.
Objectives	1. To further develop and document a field-based system for studying the effect of elevated CO_2 and elevated temperature on grapevines. 2. To develop and document the impact of elevated CO_2 and temperature on growth and biomass production of Shiraz vines in the field. Specifically there was to be a focus on measuring the impact of each factor and their combination on vine phenology and biomass including grape yield. 3. To quantify the impact of elevated temperature and CO_2 on vine physiology and carbohydrate storage. The focus will be on measuring each factor and their combination on leaf gas exchange (net photosynthesis and stomatal conductance) and vine water relations. 4. To employ a simulation model (VineLOGIC) to assess a range of climate (CO_2 and temperature) scenarios.

	5. To use this unique facility as a basis to leverage additional investment from DAWR, national and international collaborators to analyse impacts on grape and wine quality, flavour and aroma, extend results to landscape models; and examine potential adaption strategies (e.g. irrigation, canopy management).
Activities and Outputs	• Develop and test an experimental system for examining elevated temperature, elevated CO_2 and their interaction on grape vines at Mildura. • Establish statistically sound controls, trial design and replications. • Assess phenology, production and growth for a full four years. • Record basic physiological measurements, collect tissue samples and measure carbohydrates to access changes in source-sink relationships. • Analyse fruit at set, veraison (ripening) and harvest. Analyse wines made from project fruit for pH, sugar, flavonols, anthocyanins (antioxidants) and tannins. • Complete flavour and aroma analysis as part of a sister project for DAWR. • Use project data to update the VineLOGIC simulation model. • Seasonal variation is the major driver of vine performance, above and beyond elevated temperature and CO_2. • However, over four seasons the study established that warmer air marginally advanced maturity and resulted in lower quality grapes and wine. • Elevated CO_2 caused a small improvement in yield. • CO_2 alone and in combination with warmer air increased photosynthesis but not water use by vines. • As the climate warms, it is likely that water use in wine grape vineyards will remain static or diminish marginally. • Results were reported through relevant scientific literature and grape/wine industry publications.
Outcomes	• Grape growers aware that climate change will not impact yield or demand for irrigation water in Shiraz. • Grape growers aware that the negative impact from climate change is a marginal loss of grape and wine quality i.e. less tannins, anthocyanins and flavonols. • As a result grape growers are able to make 'wider use of altering the microclimate in the grape vine canopy in order to counter these effects'.
Impacts	• Economic – avoided costs due to earlier development and uptake of adaptive vineyard management strategies (i.e. canopy management). • Environmental – information to help plan trade-offs between production and environmental water in a hotter, dryer Murray-Darling Basin. • Social – reassurance that climate change may not result in an increased demand for water from wine industry or result in a yield penalty, with increased optimism for the future. • Social – more productive and profitable regional communities especially in the irrigated inland wine grape production areas of Australia. • Capacity – degree by research completed and additional skill sets developed in DPI and the projects partners (CSIRO, University of Adelaide, University of Melbourne – Primary Industries Climate Change Centre (PICCC) and AWRI). • Capacity – creation of a unique research facility; an open-topped chamber for the study of perennial crops with adjustment for both CO_2 and temperature.

3. Match with Government Priorities

Table 3.1 Strategic Science/Research Priorities and Rural R&D Research Priorities

Australian Government	
Strategic Science/Research Priorities	**Rural R&D Priorities**
1. **Food** – optimising food and fibre production and processing, agricultural productivity and supply chains within Australia and global markets 2. **Soil and water** – improve use of soil and water resources, both terrestrial, marine 3. **Transport** – moving essential commodities, alternative fuels, lowering emissions 4. **Cybersecurity** – for individuals, businesses, government, national infrastructure 5. **Energy** – improve efficiency, reduce emissions and integrate diverse sources into the grid. 6. **Resources** – support exploration traditional resources, rare earths and new technologies. 7. **Advanced manufacturing** – high value and innovative industries in Australia. 8. **Environmental change** – mitigating, managing or adapting to changes. 9. **Health** – improving health outcomes for all Australians.	1. **Advanced technology**: to enhance innovation of products, processes and practices across the food and fibre supply chains through technologies such as robotics, digitalisation, big data, genetics and precision agriculture. 2. **Biosecurity**: to improve understanding and evidence of pest and disease pathways to help direct biosecurity resources to their best uses, minimising biosecurity threats and improving market access for primary producers. 3. **Soil, water and managing natural resources:** to manage soil health, improve water use efficiency and certainty of supply, sustainably develop new production areas and improve resilience to climate events and impacts. 4. **Adoption of R&D:** focussing on flexible delivery of extension services that meet primary producers' needs and recognising the growing role of private service delivery.

The Wine Australia project has addressed Strategic Science/ Research Priorities 1 and 2. The major focus of the project has been on the first and third of the Rural R&D Priorities.

4. Identification of Potential Costs and Benefits

4.1 Costs

4.1.1 R&D Investment

The R&D investment costs comprised:

- Direct financial outlays by collaborators and participants in the research project, namely Wine Australia.
- In-kind contributions to the research project – non-cash contributions made by research partner CSIRO.
- In-kind contributions to the research project – time associated with meetings between the researchers and Wine Australia (project overhead costs).

4.1.2 Administration

No additional administration costs were identified.

4.1.3 Extension

Extension costs such as communication of project outputs to grape growers were included in the project budget.

4.1.4 Adoption

Additional canopy management costs will be incurred by grape growers in warm inland areas in the medium to longer term to create favourable microenvironments that preserve Shiraz grape qualities (tannins, anthocyanins and flavonols).

4.2 Benefits

4.2.1 Research Output and Impact Pathway

The output of the project is grape grower knowledge on whether elevated CO_2 and temperature will impact Shiraz fruit quality.

The impact pathway is:

1. Knowledge of the impact of elevated CO_2 and elevated temperature on the production and physiology of Shiraz generated by the project.
2. Knowledge communicated to grape growers.
3. Shiraz grape growers in warm inland areas adjust irrigation and production practices (canopy management) to deal with a changing climate.

4.2.2 Triple Bottom Line Benefits

A summary of the potential benefits from the project in triple bottom line categories is shown in Table 4.1.

Table 4.1 Triple Bottom Line Categories Benefits from Project Investment

Levy Paying Industry	Spillovers		
	Other Industries	**Public**	**Foreign**
Economic Benefits			
Avoided cost due to earlier development and uptake of adaptive vineyard management strategies (canopy management).	Canopy management recommendations relevant in other grape industries e.g. table and dried grape production.	Nil	Elevated CO_2 and elevated temperature grape growing seasons will be relevant to other wine producing countries.
Environmental Benefits			
No additional demand for irrigation water.	No additional competition for water licences or drain on the overall catchment.	Information to help plan trade-offs between production and environmental water in a hotter, dryer Murray-Darling Basin.	Nil
Social Benefits			
Reassurance that climate change may not result in any increased demand for water from wine industry with increased optimism for the future. More productive and profitable regional communities especially in the irrigated inland wine grape production areas of Australia. Additional skills developed in DPI and the project partners (CSIRO, University of Adelaide, University of Melbourne and AWRI.	Development and validation of significant in-field infrastructure which can be used to conduct studies on other field crops.	Nil	Nil

4.2.3 Public versus Private Benefits

The majority of benefits that will arise from project investment will be private in nature. The private benefits will be largely captured by wine grape growers and winemakers. The private benefits will focus on altering the microclimate in the grape vine canopy to avoid grape and wine quality loss. Public benefits will include reassurance that elevated CO_2 and elevated temperatures will not increase the industry's demand for irrigation water.

4.2.4 Distribution of Benefits along the Supply Chain

The benefits to the wine industry from investment in this project will be shared along the supply chain with grape growers, winemakers, wholesalers and exporters all sharing in some of the benefits.

4.2.5 Benefits to other Primary Industries

Canopy management options will be relevant to other Australian grape growing industries including table grape and dried grape production. There will be no additional competition for water licences or drain on the overall catchment. In-field infrastructure has been made available which can be used to conduct studies on any field crop.

4.2.6 Benefits Overseas

Project findings in relation to the impact of elevated CO_2 and elevated temperature grape growing seasons will be relevant to other Southern Hemisphere wine producing countries e.g. South Africa, Chile and Argentina.

4.3 Summary of Costs and Benefits

A summary of principal categories of costs and benefits from the project is shown in Table 4.2.

Table 4.2 Incremental Cost and Benefit Categories

Costs	Benefits
R&D investment costs (cash and in-kind) as well as project administration costs.	Avoided costs due to earlier development and uptake of adaptive vineyard management strategies (i.e. canopy management).
Overhead costs including time associated with meetings between the researchers and Wine Australia.	Information to help plan trade-offs between production and environmental water in a hotter, dryer Murray-Darling Basin.
Adoption costs for growers taking up project recommendations in relation to grape vine canopy management.	Reassurance that climate change may not result in any increased demand for water from wine industry with increased optimism for the future.
	More productive and profitable regional communities especially in the irrigated inland wine grape production areas of Australia.
	Degree by research completed and additional skill sets developed in DPI and the projects partners (CSIRO, University of Adelaide, University of Melbourne and AWRI).
	Creation of a unique research facility; an open topped chamber for the study of perennial crops with adjustment for both CO_2 and temperature.

5. Valuation of Costs and Benefits

5.1 Costs

5.1.1 R&D Investment Costs including Administration

The following tables show annual investment in the project by Wine Australia (Table 5.1) and for researchers and other investors (Table 5.2). Table 5.3 provides the total investment by year for both sources.

Table 5.1 Investment by Wine Australia in the Project for Years Ending June 2013 to June 2016

Project Code	2013	2014	2015	2016	2017	2018	Total
Wine Australia	200,000	300,000	320,000	315,000	350,000	165,000	**1,650,000**
Total	**200,000**	**300,000**	**320,000**	**315,000**	**350,000**	**165,000**	**1,650,000**

Source: Wine Australia Project Application and revised schedule

Table 5.2 Investment by Researchers/Others in the Project for Years Ending June 2013 to June 2016

Project Code	2013	2014	2015	2016	2017	2018	Total
DPI cash	180,000	240,000	255,000	120,000	366,4120	165,8840	**1,327,296**
DPI in-kind	0	0	0	0	0	0	**0**
CSIRO in-kind	13,333	40,000	43,333	20,000	68,111	29,889	**214,666**
Total	**193,333**	**280,000**	**298,333**	**140,000**	**434,523**	**195,773**	**1,541,962**

Source: Wine Australia Project Application and revised schedule

Table 5.3 Annual Investment in the Project (nominal $)

Year Ending 30 June	Wine Australia	Researchers/Others	Total
2013	200,000	193,333	**393,333**
2014	300,000	280,000	**580,000**
2015	320,000	298,333	**618,333**
2016	315,000	140,000	**455,000**
2017	350,000	434,523	**784,523**
2018	165,000	195,773	**360,773**
Total	**1,650,000**	**1,541,962**	**3,191,962**

5.1.2 Overhead Costs including Meetings between the Researchers and Wine Australia

Wine Australia overhead costs are in addition to those shown in the above tables and are estimated at 12% for this project.

5.2 Benefits

5.2.1 Avoided Loss in Shiraz Grape Value Warm Inland Areas

The Counterfactual

The issues dealt with in this project are vital to the future of the Australian wine industry – how will grape and wine volume and quality and inputs required be affected by climate change? In the absence of this project it is assumed that another project, either with or without the support of Wine Australia, would have been funded within the next 5 years. The benefits of this project are therefore avoided quality loss for the period 2019 to 2024.

Avoided Loss in Shiraz Grape Value in Warm Inland Areas

The project has provided important information on how Shiraz grapes will perform in warm inland areas in a climate change-affected future. In part the message is good news, Shiraz grapes will not need additional irrigation water and yield may be marginally higher. On the negative side of the equation, the study reported some loss in grape and wine quality – less tannins, anthocyanins and flavonols. The impact is expected to be marginal. "Two thirds of a trained wine tasting panel could not detect any difference between wines made from grapes produced on vines in elevated CO_2/heated chambers and wines made from grapes produced on vines in ambient chambers" (Michael Treeby, Department of Economic Development, Jobs, Transport and Resources, written comm., March 2019). Nevertheless, the study recommends the wider use of altering the microclimate in the grape-vine canopy in order to counter the effects of grape quality loss. A summary of key assumptions used to quantify the benefit of this recommendation is shown in Table 5.4.

Table 5.4 Summary of Assumptions

Avoided loss in Shiraz Grape Value Warm Inland Areas		
Quantity of wine grapes grown in Australia.	1,794,182 tonnes	Wine Australia, National Vintage Report 2018.
Share of wine grapes that are Shiraz and grown in warm inland areas.	270,859 tonnes	Wine Australia, National Vintage Report 2018.
Average value of Shiraz grapes grown in warm inland areas.	$481/tonne	Wine Australia, National Vintage Report 2018.
Increase in value after adoption of microclimate canopy measures recommended as part of this project.	$505/tonne	5% price improvement assumed.
Cost of production including adoption of microclimate canopy measures.	$495/tonne	Adapted from AgEconPlus 2016.
Grape grower profit from adoption of canopy measures recommended as part of this project.	$10/tonne	$505/tonne less $495/tonne.
Maximum volume of Shiraz grapes grown in warm inland areas that adopt microclimate canopy measures as a result of this project.	70%	Consultant assumption.
Attribution of benefits to this project.	100%	Project was a 'world's first' that produced field measures of the impact of both elevated CO_2 and temperature.
Probability of output.	100%	Consultant assumption recognising that the results from the research are well regarded and broadly communicated.
Probability of impact.	90%	Consultant assumption that canopy modification will work and protect tannins, anthocyanins and flavonols in Shiraz.

5.2.2 Other Potential Benefits

Other potential benefits identified but not valued include:

- Environmental – information to help plan trade-offs between production and environmental water in a hotter, dryer Murray-Darling Basin.
- Social – reassurance that climate change may not result in any increased demand for water from wine industry with increased optimism for the future.
- Social – more productive and profitable regional communities especially in the irrigated inland wine grape production areas of Australia.
- Capacity – degree by research completed and additional skill sets developed in DPI and the projects partners (CSIRO, University of Adelaide, University of Melbourne – Primary Industries Climate Change Centre (PICCC) and AWRI).

- Capacity – creation of a unique research facility; an open topped chamber for the study of perennial crops with adjustment for both CO_2 and temperature.

Other potential benefits were not quantified due to a combination of reasons including time and resources, availability of baseline data, difficulty in quantifying the causal relationships between the research outputs and the specific impact and the difficulty of placing credible monetary values on the environmental, social and capacity building benefits.

6. Results

All past costs were expressed in 2018 dollar terms using the implicit price deflator for GDP. All costs and benefits from 2018 onwards were discounted to 2018 using a discount rate of 5%. A reinvestment rate of 5% was used for estimating the Modified Internal Rate of Return (MIRR). The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for some of the estimates. All analyses ran for the length of the investment period plus 30 years from the last year of investment (2018). Table 6.1 and Table 6.2 show the investment criteria estimated for the different periods of benefits for both the total investment and for Wine Australia investment. The present value of benefits (PVB) for the Wine Australia investment, shown in Table 6.2, are estimated by multiplying the total PVB by the Wine Australia proportion of investment.

Table 6.1 Investment Criteria for Total Investment by Wine Australia and Project Partners (discount rate 5%)

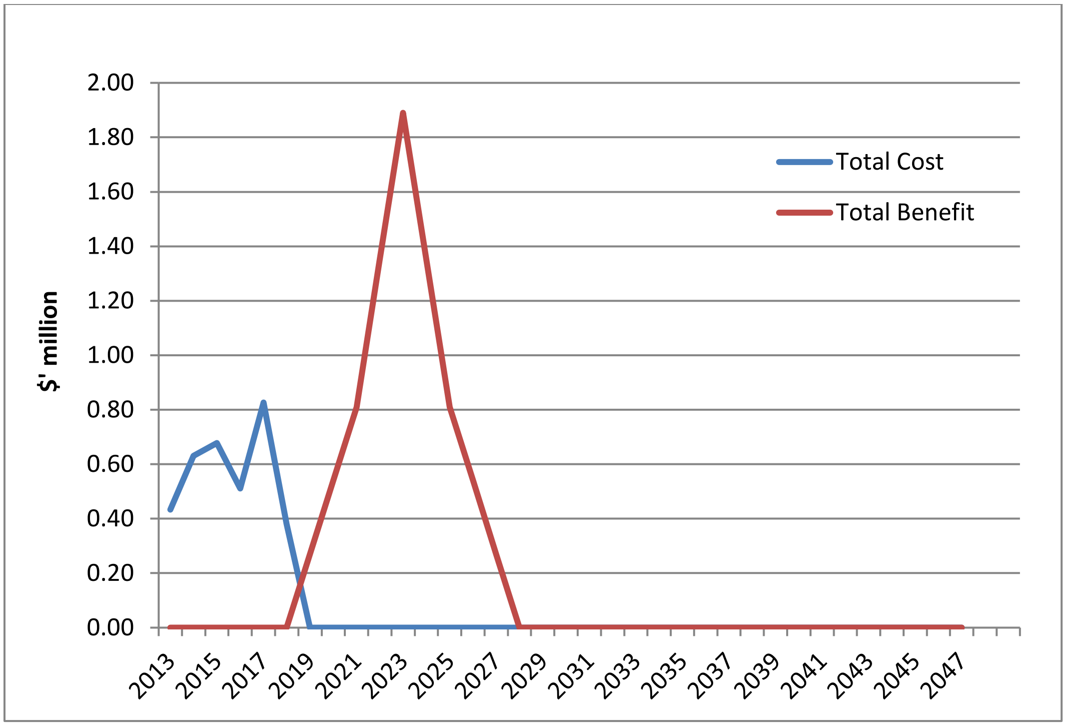
Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.00	4.04	6.16	6.16	6.16	6.16	6.16
Present value of costs ($m)	3.92	3.92	3.92	3.92	3.92	3.92	3.92
Net present value ($m)	-3.92	0.12	2.24	2.24	2.24	2.24	2.24
Benefit–cost ratio	0.00	1.03	1.57	1.57	1.57	1.57	1.57
Internal rate of return (%)	Negative	4.9%	13.2%	13.2%	13.2%	13.2%	13.2%
Modified internal rate of return (%)	Negative	4.9%	9.1%	7.8%	7.1%	6.7%	6.4%

Table 6.2 Investment Criteria for Wine Australia (discount rate 5%)

Years	0 years	5 years	10 years	15 years	20 years	25 years	30 years
Present value of benefits ($m)	0.00	2.20	3.36	3.36	3.36	3.36	3.36
Present value of costs ($m)	1.95	1.95	1.95	1.95	1.95	1.95	1.95
Net present value ($m)	-1.95	0.26	1.42	1.42	1.42	1.42	1.42
Benefit–cost ratio	0.00	1.13	1.73	1.73	1.73	1.73	1.73
Internal rate of return (%)	Negative	7.1%	15.1%	15.1%	15.1%	15.1%	15.1%
Modified internal rate of return (%)	Negative	6.6%	10.0%	8.4%	7.6%	7.1%	6.8%

The annual undiscounted benefits and cost cash flows for the total investment for the duration of the investment period plus 30 years from the last year of the initial investment are shown in Figure 6.1.

Figure 6.1 Annual Undiscounted Cash Flows for Estimated Total Benefits and Total RD&E Investment Costs for the Elevated CO_2/Temperature Shiraz Project



7. Sensitivity Analysis

A sensitivity analysis was carried out for the central analysis results reported in Section 6 and variations in the discount rate. Table 7.1 presents the results. These indicate that all indicators remain positive for all discount rate assumptions.

Table 7.1 Sensitivity to Discount Rate (Total investment, 30 years)

Investment Criteria	Discount rate		
	0%	5% (base)	10%
Present value of benefits ($m)	7.83	6.16	4.94
Present value of costs ($m)	3.46	3.92	4.43
Net present value ($m)	4.37	2.24	0.51
Benefit-cost ratio	2.26	1.57	1.11

Sensitivity analyses were undertaken for those variables where there was greatest uncertainty or for those that were identified as key drivers of the investment criteria. The analyses were performed for the total investment and with benefits taken over the life of the investment plus 30 years from the last year of investment. All other parameters were held at their base values.

For this project the greatest uncertainty related to the increase in profitability that might be attributed to the adoption of canopy management – Table 7.2. Results show that if profit increase is as low as $5/tonne, and other assumptions are held constant, then project costs exceed project benefits.

Table 7.2 Sensitivity to Increase in Grape Grower Profit (Total investment, 30 years)

Investment Criteria	Increase in Profit Attributable to Adoption of Canopy Management		
	$5/tonne	$10/tonne (base)	$15/tonne
Present value of benefits ($m)	3.08	6.16	9.24
Present value of costs ($m)	3.92	3.92	3.92
Net present value ($m)	-0.84	2.24	5.32
Benefit-cost ratio	0.79	1.57	2.36

8. Confidence Ratings

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

Table 8.1 Confidence in Analysis of Program

Coverage of Benefits	Confidence in Assumptions
High	Medium

9. Summary of Results

Funding for the elevated CO_2/temperature Shiraz project was valued at $3.92M (present value terms) and is expected to produce aggregate total benefits of approximately $6.16M (present value terms). This gives an estimated net present value of $2.24M, a benefit-cost ratio of approximately 1.57, an internal rate of return of 13% and a modified internal rate of return of 6%.

Analysis results are dependent on assumptions made and while results are positive for core assumptions, sensitivity testing on increase in profit associated with canopy management at $5/tonne for Shiraz grapes, result in investment costs exceeding project benefits.

All investment indicators remain positive for different discount rate assumptions.

Abbreviations

AWRI Australian Wine Research Institute
DAWR Department of Agriculture and Water Resources (Australian Government)
DPI Department of Primary Industries (Victoria)
PICCC Primary Industries Climate Change Centre (University of Melbourne)

Persons Contacted

Sharon Harvey, R&D Program Manager, Wine Australia
Michael Treeby, Chief Investigator, Department of Economic Development, Jobs, Transport and Resources

References

ABS (2016) Vineyards, Australia 2014-15, Catalogue number 1329.0.55.002 accessed March 2019 http://www.abs.gov.au/ausstats/abs@.nsf/mf/1329.0.55.002

Treeby, M (2019) Impact of elevated CO_2 and its interaction with elevated temperature on production and physiology of Shiraz. Final report accessed at https://www.wineaustralia.com/research/search/completed-projects/dpi-1202