Delivery partner resource

# Horticulture Impact Assessment Program

## CT19003 Impact Assessment

June 2026



Hort Innovation

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# CT19003 Citrus Postharvest Program

## Executive Summary

The Australian citrus industry has been experiencing large and continuous growth in recent years, on the back of strong demand from international markets. Australian citrus receives a premium in international markets due to its excellent quality and high eating quality attributes. This premium ensures the profitability and viability of Australian citrus exporters, with input costs higher for Australian citrus than other competitor markets. To maintain Australian Citrus' competitive advantage in export markets, it's vital that fruit quality is maintained and built upon.

An integral component of the supply chain is postharvest, with packhouses linking growers to consumers. Postharvest practice enables the maintenance of fruit quality from farm to table, mitigating the impacts of elongated transport times, mould, and chilling injury. As packhouses are, in most cases, not vertically integrated into the citrus supply chain there is a need to inform and upskill packhouses on postharvest best practice for citrus. The work of postharvest projects such as the Citrus Postharvest Program (CT19003), ensures the quality of Australian citrus is maintained, supports adherence to the phytosanitary requirements of export markets, and aids adoption of best practice sanitation in packhouses and reducing the risk of pathogenic resistance and postharvest disease incidence.

Continuing on from the work of the Citrus Postharvest Science Program (CT15010), CT19003 worked to inform the Australian citrus industry on postharvest best practice and to support widespread adoption of best practice. This work ensures the continual improvement of fruit quality through the provision of new information and technologies to industry. Beyond improvements to fruit quality the investment also sought to reduce postharvest fruit losses and improve market access.

This investment has a total nominal cost of $1,280,923, of this $664,977 was funded by Hort Innovation. This impact assessment identified a clear pathway to impact for the research undertaken. Three of the benefits identified were quantified to demonstrate the impacts of Hort Innovation's investment, these included:

— Supported the growth and maintenance of citrus export markets – the project has supported the growth and maintenance of Australia's citrus export markets through improved market access, strengthening compliance with international phytosanitary requirements and enhancing industry capability to sustain rising international demand.

— Maintenance of the price premium – the project has directly supported the continuation of the price premium received by Australian citrus in export markets by improving fruit quality, ensuring compliance with phytosanitary requirements, and maintaining strong consumer preference for Australian produce.

— Reduced susceptibility of citrus to postharvest pests and diseases – the project has aided increased adoption of postharvest treatments which have reduced the susceptibility of fruit to pests and diseases after harvest, reducing financial losses incurred through importer claims on damaged fruit.

There were additional benefits identified through the research that were not quantified due to data limitations and high rates of uncertainty around attributable impact. These benefits include:

— Increased consumer confidence and preference for Australian citrus – the project supported increased consumer confidence in Australian citrus by improving fruit quality, reducing residues, and strengthening its reputation as a safe, high-quality product in local and export markets.

— Reduced run-off from packhouses – the research supports more sustainable postharvest treatments by reducing reliance on harsher pesticides and fungicides. This may also benefit the environment by lowering run-off and contamination risks to waterways and ecosystems.

— Enhanced health outcomes – shifting away from pesticides and adopting best-practice postharvest treatments can further reduce chemical residues and lower exposure for consumers and producers. While current practices already control most of the risk, packhouse workers may still see small long-term health and wellbeing benefits.

— New researchers – the project also helped train future researchers by giving PhD students practical, hands-on experience in the field. This built research capability and supported the long-term growth of agricultural science, especially in citrus and postharvest work.

The results show that, taking all quantified costs and benefits into account, the investment produced a positive net result. The investment has a net present value (NPV) of $7.69 million and a benefit-cost ratio (BCR) of 6.21 at 5 years after investment completion using a 5% discount rate. This shows that the investment delivers a net positive return to levy payers and the broader community, returning $6.21 for every $1 in investment. This project has been attributed with 13.4% of the impacts, as the projects investment accounts for 48% of the total investment to date and the research to date accounting for 100% of the research required to realise the benefits identified.

## Context, objective, and details of investment

The Australian citrus industry is a valuable contributor to regional Australia. In 2022-23, 815,750 tonnes, valued at $977.1 million, were produced.[1] Most (72%) was sold as fresh produce.[2] The Australian citrus industry is growing, but to remain profitable, it needs to not only expand existing markets but also develop new ones.

Australia receives a premium for its fruit due to its high quality. Maintaining that premium requires ongoing improvements in how fruit is handled after harvest, which involves using technologies that improve and maintain fruit quality. However, maintaining fruit quality is challenging due to long storage times and phytosanitary (quarantine) end-point treatments required for many export markets. At the same time there is also rising pressure from consumers and markets to lower chemical residues in fruit.

The continued success of the Australia citrus industry hinges on the delivery and adoption of relevant and timely information that is under-pinned by science-based research results. The program delivered up to date postharvest resources and program updates at grower forums and workshops. These are essential to ensure the industry is receiving the latest information, is using best practices and meeting retailers' and consumers' expectations. The overall objectives of this project were to:

— keep the Australian citrus industry informed on postharvest best practices with clear pathways for adoption identified

— ensure that the Australian citrus industry has access to new technologies to maintain postharvest quality

— develop resources to enable growers to meet export maximum residue levels (MRLs) while ensuring postharvest quality.

Underpinning these key program objectives were a series of research trials conducted to:

— assess the efficacy and practicalities of alternative postharvest decay control

— improve market access outcomes

— reduce chilling injury

[1] Hort Innovation (2024) Final Report Citrus Postharvest Program

[2] Ibid.

— improve fruit quality outcomes.

The key research provider was the NSW Department of Primary Industries (DPI). The funding came from the Hort Innovation Citrus Fund and contributions from the Australian Government.

## Alignment with Strategic Investment Plan

The project (CT19003) was developed to align closely with, and contribute to, the Citrus Strategic Investment Plan (SIP) 2017-2021. During the project a new 5-year SIP was released (Citrus SIP 2022-26). The 4 key outcomes specified by the 2022-26 SIP were:

- Outcome 1: Protect the production base to maintain local and international competitiveness and viability of supply
- Outcome 2: Contribute to demand generation and market optimisation, driving growth across domestic and international markets
- Outcome 3: Enhance adoption of R&D outcomes through effective communication, extension and capability initiatives
- Outcome 4: Business insights. Measure industry supply (production) and demand (consumer behaviour) data and insights to inform decision making.

Despite changes to the framing of the outcomes underpinning citrus R&D investment, the project's design remained aligned with the outcomes specified in the Citrus SIP 2022-26, with Outcomes 1, 2 and 3 each met by the project:

— improved fruit quality by identifying and implementing best-practice postharvest treatments aligns with Outcome 1

— enhanced postharvest quality and adoption of best practices aligns with Outcome 2, supporting existing markets and export demand

— grower engagement, outreach, and regular dissemination of findings (online and in-person) aligns with Outcome 3.

**Table 1 Project details of CT19003**

| | |
|---|---|
| **Project code** | CT19003 |
| **Title** | Citrus Postharvest Program |
| **Research organisation(s)** | NSW Department of Primary Industries |
| **Project leader** | John Golding |
| **Funding period** | 2020-2023 |
| **Objective** | To improve postharvest quality and storability of Australian citrus through research on decay control, chilling injury, alternative treatments and orchard-to-storage practices to support market access and industry sustainability. |

*Source: Hort Innovation*

### Related investments

The project was linked with 2 other investments, these are:

— CT15010 – Australian Citrus Postharvest Science Program: focuses on understanding and maintaining

postharvest decay using fungicides, sanitisers and physical treatments. A key aim was to reduce chemical residues. The project also investigated fruit quality issues over the supply chain.

— CT23009 – Citrus Postharvest Program Phase 2: this project builds on previous work to continue to understand, extend and develop best practice postharvest management strategies.

## Governance

The governance structure of CT19003 was designed to ensure strategic alignment, scientific integrity, and effective industry engagement.

Hort Innovation provided strategic oversight for the project, ensuring the research objectives were met and that the research aligned with industry priorities. The project was funded by Citrus producers through Hort Innovation's Citrus Fund, with matched funding from the Australian Government and significant in-kind contributions from the delivery partner – NSW Department of Primary Industries (NSW DPI). Within NSW DPI, the research team was led by John Golding.

A Project Reference Group (PRG) was established to guide project priorities and ensure the research aligned with the needs of the industry and that it conformed with the Citrus SIP. Additionally, the project held regional forums and growers' workshops, as well as presentations at major events like the Citrus Congress to share research findings and engage with growers. These engagement activities addressed industry needs and facilitated the adoption of best practices by growers and packers.

The governance structure enabled the ongoing alignment of research activities with the needs of industry. Further, it facilitated comprehensive stakeholder engagement, ensuring the collation of diverse perspectives and dissemination of information to growers across Australia. The governance structure also ensured that research findings were practical and applicable, in order to support citrus growers to adopt best practice crop management and postharvest treatments.

The governance structure and the inclusion of growers within the project reference group (PRG) helped to ensure the research aligned with the current needs of growers and reflected the current market. This inclusion enabled the project to adapt to the unforeseen and significant disruptions to supply chains resulting from COVID-19. The supply chains disruptions had adverse impacts on transport and storage times, significantly increasing them. This placed a premium on knowledge relating to the maintenance of citrus quality during transport and storage, including research on chill injuries, anthracnose and decay. With the inclusion of industry representatives and growers, the PRG was able to advise and work with the research team to re-orient some project resources to explore these issues. This demonstrates the clear benefits of inclusion of growers in PRGs and governance structures moving forward.

## Impact pathway

A clear pathway from input to impacts can be identified for the investment.

**Table 2 Impact pathway of CT19003**

| Pathway | Description |
|---|---|
| **Inputs and activities** | **Project inputs**<br>• **Citrus producers/growers** – the research was made possible through the ongoing collection of the Citrus Levy for R&D, collected from citrus producers across Australia.<br>• **The Australian Government** – the Australian Department of Agriculture, Fisheries and Forestry collects the levies paid by producers. Further, the Australian Government matches funds collected through R&D levies, effectively doubling the quantum of funds available for research and development activities. |

| Pathway | Description |
|---|---|
| | • **Hort Innovation Australia** – Hort Innovation is responsible for managing and investing the levies collected from citrus growers/producers into strategic R&D initiatives.<br>• **Citrus Advisory Panel** – The Citrus advisory panel provides strategic oversight and guidance for investment R&D investment decisions, having final say over Hort Innovation's investment recommendations.<br>• **NSW Department of Primary Industry** – NSW DPI were contracted to deliver the research by Hort Innovation, with the lead researcher and core research team coming from NSW DPI. NSW DPI made significant in-kind contributions to deliver the research including staffing, travel expenses, and property plant and equipment.<br>• **Sub-Contractors** – to support delivery of the research, NSW DPI collaborated with various domestic and international researchers.<br>• **Existing products** – the project utilised many commercially (or semi-commercially) available chemistries and other products during its various trials.<br>• **Existing research** – the use of some products was informed by existing international literature on their effectiveness (i.e. Natamycin inhibiting the growth of blue-and green mould). Additionally, the project leveraged information from the previous Hort Innovation funded iteration of the project Australian Citrus Postharvest Science Program (CT15010).<br>**Governance and reporting activities**<br>• **Formation of a Project Reference Group (PRG)** – the PRG included growers, technical advisors, and Hort Innovation. The PRG provided project advice and guidance to the project and facilitated industry engagement in the project.<br>• **Reporting activities** – throughout the research team undertook milestone-based reporting activities, in-line with contract requirements.<br>• **Extension activities** – including the presentation of results and findings, conducting post-harvest workshops to disseminate guidance on best practice to growers, and the provision of articles and research papers for publication in peer reviewed journals.<br>**Research activities**<br>• **Examination of alternative controls for postharvest decay** – trials were conducted to assess the efficacy and practicalities of alternative controls for postharvest decay beyond the current fungicides. This included trialling: 4 alternative commercial treatments, 2 essential oils, photo-oxidation, 3 organic salts, elevated treatment temperatures, non-chemical (physical) and low-pressure treatments.<br>• **Trials for postharvest management of anthracnose in Imperial Mandarins** – three trials were conducted over 3 years, exploring the use of pre-registered postharvest fungicides to reduce expression of anthracnose.<br>• **Trials were conducted to reduce the chemical residues in packing lines** – a pilot project was conducted to assess various postharvest cleaning products, to potentially remove/decontaminate packing lines.<br>• **Evaluation of postharvest Wetcit® application**– trials were conducted to assess the effects of postharvest applications of WetCit® on in vivo survival of Fuller's rose weevill eggs in Navel oranges (6 treatments were trialled during 4 replicated trials), Wetcit® concentration effects on red scale removal when dipping and high-pressure washing (7 treatments were trialled on 3 different infestation levels), and the effect of WetCit® on postharvest decay (7 treatments were trialled).<br>• **Trials for maintaining calyx condition** – four trials were conducted to examine alternative postharvest treatments to 2,4-Dichlorophenoxyacetic acid (2,4-D) in order to maintain calyx condition. These included: an evaluation of 3,5,6-trichloro-2-pyridiloxyacetic acid dipping; an evaluation of hydrogen sulphide fumigation; a comparison of 2,4-D, fluroxypyr, dicamba, MCPA |

| Pathway | Description |
|---|---|
| | and hydrogen sulphide treatments; and, the effect of 'low' dicamba levels on the shelf life of Navel oranges.<br>• **Survey of navel chilling injury** – a survey of fruit from the same fruit trees, rootstock and orchard management system was conducted annually between 2019 and 2023 to investigate the seasonal and varietal differences in the development of chilling industry. Six replicates of early, mid and late season fruit was harvested each year during the survey period.<br>• **Chilling injury susceptibility of new mandarin cultivars** – storage trials were undertaken to assess the effects of long-term storage on Satsuma mandarins and Clementine mandarins. Trials were conducted at 2 different harvest dates for both mandarin cultivars.<br>• **Trials on various production effects on fruit quality and shelf life** – long-term storage trials of citrus were conducted to quantify the preharvest growing treatments on postharvest fruit quality and storage life. The treatments trialled included: the effects 3 different irrigation frequencies; the effects of plant growth regulator applications; the effects of lower rates of gibberellic acid application during postharvest (3 rates were tested); and 2 postharvest techniques for managing ethylene in storage.<br>• **Evaluation of methods that improve fruit quality** – the research team evaluated alternative waxes to improve fruit quality and appearance, in addition a preliminary evaluation was conducted to assess cheap and practical methods of assessing Navel fruit firmness.<br>• **Literature review** – following an albedo breakdown in citrus produced in eastern Australia during 2022, the research team reviewed and updated literature on the disorder. |
| **Outputs** | **Project planning, governance and reporting**<br>• **Monitoring and evaluation plan** – a monitoring and evaluation plan was developed with the PRG to guide the project.<br>• **Milestone reports** – an annual work plan was developed with the PRG and delivered to Hort Innovation, in addition to the delivery of 6 monthly milestone reports.<br>• **Best Practice Postharvest Manual** – the project delivered a *Best Practice Postharvest Manual*, centralising resources into a single document for ease of access and use.<br>• **Final report** – a finalised project report was delivered at the end of the project, including the method, findings and results of the research, and recommendations.<br>**Extension, communication, and industry engagement**<br>• **Regional postharvest workshops** – the project delivered 6 regional postharvest workshops/presentations covering all growing regions.<br>• **Presentations at national Citrus Australia forums** – the project team presented at 9 Citrus Australia Regional Forums, with 3 general postharvest presentations. Additionally, 8 presentations were delivered at the 2022 Citrus Technical Forum, 2 presentations at the Citrus Australia Market Outlook Forum, and 7 presentations at the 2024 Citrus Technical Forum.<br>• **Article contributions** – the project delivered 22 articles to industry communications platforms, such as Australian Citrus News and the Citrus Australia Podcast, The Full Bottle. Additionally, an article was published in Australian Citrus News on the findings from the albedo breakdown literature review.<br>• **NSW DPI extension activities** – regular contributions to NSW DPI extension activities were made during the Program.<br>• **Research papers** – ten international peer-reviewed scientific papers were produced with assistance from the program. One book chapter on the use of 'green' technology for reducing postharvest losses in fresh horticultural produce was published.<br>**Data and knowledge products** |

| Pathway | Description |
|---|---|
| | • **Literature review** – the project delivered a literature review on albedo breakdown, this was presented to the industry and is now a funded Hort Innovation R&D project. |
| **Outcomes** | **Increased quality of Australian citrus**<br>• The research has provided growers and packhouses with the information and tools necessary to improve the quality of Australian citrus and ensure its ongoing compliance with international trade standards and regulations.<br>**Improved knowledge of postharvest best practice**<br>• The research has supported improved knowledge and awareness among growers and packhouses of best practice for post-harvest treatment of citrus. The project has also developed a centralised resource called the best practice guide for post-harvest treatment ensuring materials are easily accessible for any new market entrants. This was a particularly important outcome due to the large growth in citrus exports preceding and during the project.<br>**Rapid and widespread adoption of postharvest best practice**<br>• The research team ensured best practice was adopted rapidly by packhouses across Australia through the project's extension work. The research team were consistently out in the field engaging with growers and packhouses throughout the growing regions in addition to providing methods of online engagement. This supported the timely adoption of new practices and processes across the industry.<br>**Increased availability of alternative postharvest treatment options**<br>• The research identified a variety of alternative treatment methods, providing growers with various options and choices for adoption depending on their circumstances.<br>**Aided the registration of Ortocil®**<br>• Research and data collected through the project were utilised by Collin Campbell to aid the registration of Ortocil® with AVPMA for use in Australian. This is an important outcome as it provides a new mode of action for the prevention of post-harvest rot.<br>**Reduced reliance on pesticides**<br>• Research findings have supported growers to access alternative, natural, treatments to maintain and improve fruit quality. Reducing their reliance on existing fungicides which hampered export market access and damaged consumer confidence.<br>**Demonstrated the effectiveness of current commercial postharvest cleaning products**<br>• The research project demonstrated that current commercial postharvest cleaning products were effective at removing specific chemical residues from packing line equipment, reducing the risk of MRL breaches and subsequent loss of market access.<br>**Improved decay control and citrus longevity**<br>• The research aided improvements to the control of fruit decay and its longevity through the provision of guidance on pre- and post-harvest practices.<br>**Provided exporters with confidence in the maintenance of fruit quality despite transport disruptions**<br>• The research was able to demonstrate that Australian citrus could endure supply chain disruptions and associated increases in transit duration with minimal impact on fruit quality. This provided exporters with renewed confidence to continue trade during pro-longed periods of disruption resulting from the COVID-19 pandemic.<br>**Ensured the ongoing flexibility and responsiveness of industry to changing market/supply shocks** |

| Pathway | Description |
|---|---|
| | • The research was flexible to the changing needs of industry, supporting the rapid adaptation of producers and exporters to changing export market requirements and flow-on impacts from the COVID-19 pandemic.<br>**New researchers**<br>• The project supported the training of 3 PhD students for the industry. Aiding the development of new agricultural researchers and the development of new information and knowledge for citrus growers and packhouses in the medium to long term future.<br>**Provision of new information**<br>• The research produced significant new technical information through the development of 12 peer reviewed scientific papers. |
| **Impacts** | **Sustained growth in demand for Australian citrus**<br>• The research has supported the expansion of Australian citrus within existing markets, supported access to new markets, and aided exporters and packhouses' ongoing compliance with the market access requirements of countries importing Australian citrus.<br>**Maintained the price premium received by Australian citrus in international markets**<br>• The project has ensured Australian citrus continues to receive a price premium in international markets through the maintenance of fruit quality and compliance with export market access requirements.<br>**Maintained market access**<br>• A key impact resulting from the project was the maintenance of market access to protocol markets. The project supported packhouses to rapidly adapt to changing export requirements in certain markets, ensuring continued access for Australian citrus. Were access to have been revoked through non-compliance, exports in affected countries would likely have been significantly reduced and would have damaged the price premium received by Australian citrus in other markets.<br>**Avoided issues of oversupply during a period of rapid industry growth**<br>• The Australian citrus industry has been moving through a period of large growth, with new orchards appearing across the growing regions. The project has aided growth in international demand for Australian citrus providing a release for what would likely have resulted in a domestic oversupply.<br>**Embedded knowledge, skills and trust within the workforce**<br>• The dissemination and adoption of best practice postharvest treatment, embed practice within the workforce, supporting process efficiency and increasing the readiness of industry to implement future postharvest practice recommendations.<br>**Reduced susceptibility of citrus to postharvest pests and diseases**<br>• Greater adoption of best practice postharvest treatments has reduced the susceptibility of citrus to pests and disease postharvest. This has aided a reduction in produce lost in packhouses and during transit through the reduction in adverse diseases such as postharvest rot and blue/green mould. This reduces claims on fruit by importers and aids increased international demand for Australian citrus through reputation enhancement.<br>**Lower concentrations of chemical residues in fruit**<br>• By switching to effective, natural alternatives Australian citrus will have lower concentrations of chemical residues, ensuring ongoing compliance with Maximum Residue Limits (MRL) in regulated markets and supporting consumer confidence in the quality of Australian citrus.<br>**Increased consumer confidence** |

| Pathway | Description |
|---|---|
| | • Improved fruit quality and lower chemical residues in citrus will grow consumer confidence, supporting future demand growth for Australian citrus.<br>**Improved environmental outcomes**<br>• By switching from harsher pesticides and fungicides to natural and sustainable treatments, the environmental impacts of crop and packhouse run-off will be reduced. This will support the maintenance of cleaner waterways and support the natural ecosystems they sustain.<br>**Enhanced health outcomes for consumers and packhouse workers**<br>• By further reducing the concentration of chemical residues below the MRL, the research will support reduced exposure to potentially toxic chemicals both through consumption and for packing line workers who are exposed to these chemicals through their work. |

*Source: ACIL Allen*

# Cost and benefits

## Costs

### *Cost of the investment*

The investment was a collaboration between Hort Innovation and the New South Wales Department of Primary Industry (NSW DPI). Hort Innovation contributed $567,010 in cash and $97,967 in overheads, while the NSW DPI contributed $615,946 in kind (ex. GST amounts). Table 3 below shows the total nominal cash and in-kind contributions from each research partner.

**Table 3 Nominal costs of the investment by contributing partners of CT19003**

| Organisation | 2019-20 | 2020-21 | 2021-22 | 2022-23 | 2023-24 | Total |
|---|---|---|---|---|---|---|
| Hort Innovation – Cash | $82,273 | $205,031 | $66,521 | $66,522 | $146,663 | **$567,010** |
| Hort Innovation – Overheads | $14,765 | $33,556 | $11,007 | $11,627 | $27,012 | **$97,967** |
| NSW DPI – In kind | $123,189 | $123,189 | $123,189 | $123,189 | $123,189 | **$615,946** |
| **Total** | **$220,227** | **$361,776** | **$200,717** | **$201,339** | **$296,864** | **$1,280,923** |

*Source: Hort Innovation*

The total nominal investment of $1.28 million is adjusted for inflation to represent the real value of investment. Adjustment for inflation is meant to present historical costs in today's dollars, by making periods comparable by converting nominal values to real values (adjusted for changes in purchasing power due to inflation).

Costs of the investment, in nominal terms and real terms, are provided in Table 4 below.

**Table 4 Real costs of the investment CT19003**

| Organisation | Hort Innovation | Partners | Total |
|---|---|---|---|
| Nominal costs | $664,977 | $615,946 | **$1,280,923** |
| Real costs ($2025 financial year) | $768,284 | $707,730 | **$1,476,014** |

*Source: ACIL Allen, modelled using ABS inflation data*

After converting to real terms, the cost of the investment is around $1.48 million, and Hort Innovation's

portion of all investments is $768,284.

## Benefits

Table 5 below summarises the potential benefits of the investment and categorised them into 3 categories: economic, environmental and social impact. It provides a description of the benefits and how the investment could achieve them. The table also shows the assessment method that was used for each benefit.

**Table 5 Summary of potential impacts of CT19003**

| Type of impact | Assessment | Description |
|---|---|---|
| **Economic impact** | Quantified | **Supported the growth and maintenance of citrus export markets** – the project has supported the growth and maintenance of Australia's citrus export markets through improved market access, strengthening compliance with international phytosanitary requirements and enhancing industry capability to sustain rising international demand. Through targeted research on pest management, post-harvest treatments, and export protocols, the project has helped reduce trade barriers, maintain existing markets, and support expansion into new ones. The project enabled rapid adaptation to changing protocols for international markets and was in one instance directly responsible for continued market access to an export market. To quantify the benefits of sustained market access, the avoided losses through continued access to this export market have been estimated. |
| | Quantified | **Maintenance of the price premium** – Australian citrus remains commercially viable largely due to the sustained price premium it commands in export markets. This project has directly supported the continuation of that premium by improving fruit quality, ensuring compliance with phytosanitary requirements, and maintaining strong consumer preference for Australian produce. Failure to meet export standards or a decline in quality would likely reduce demand not only in individual markets but across all export destinations due to reputational impacts, ultimately eroding the premium position of Australian citrus globally. This impact is quantified through the avoided loss of this price premium associated with an increased probability of reputational damage were this program to have not existed. |
| | Quantified | **Reduced susceptibility of citrus to postharvest pests and diseases** – Greater adoption of best-practice postharvest treatments has reduced citrus susceptibility to pests and diseases after harvest. This has lowered losses in packhouses and during transit by minimising issues such as postharvest rot and blue and green mould. As a result, importer claims have declined, supporting stronger demand for Australian citrus through enhanced reputation. This benefit has been quantified through the faster reduction in claims associated with the adoption of best practice. |
| | Unquantified | **Increased consumer confidence and preference for Australian citrus** – the project increased consumer preference and confidence in Australian citrus by improving fruit quality and reducing chemical residues. Better postharvest treatments and decay control help fruit look and taste better at purchase, reinforcing a reputation for reliable, high-quality citrus. Reducing reliance on older pesticides and lowering residues also supports |

| Type of impact | Assessment | Description |
|---|---|---|
| | | the perception that Australian citrus is safer and cleaner, which strengthens consumer trust in both domestic and export markets. Consumer confidence and preference are intangible benefits that are challenging to quantify given the available data. |
| **Environmental impact** | Unquantified | **Reduced run-off from packhouses** – by switching from harsher pesticides and fungicides to the natural and sustainable treatments identified in the research there are potential environmental benefits, due to reduced run-off and contamination of local waterways and the ecosystems they sustain. This benefit has not been quantified due to a lack of data to support the estimated impact of the research on environmental run-off. |
| **Social impact** | Unquantified | **Enhanced health outcomes** – by shifting processes and treatments away from pesticides and further reducing chemical residues through the adoption of best-practice postharvest treatments, both consumers and producers are likely to experience lower exposure to potentially toxic chemicals. Although current practices already address most of these risks, there may be modest long-term health and wellbeing improvements for packhouse workers. Given data limitations and the likely small scale of any benefits, the improvement of health outcomes have not been quantified. |
| | Unquantified | **New researchers** – the project embedded PhD students into the research program, giving them practical, in-the-field exposure and hands-on experience that builds the next generation of researchers. The knowledge and skills gained through the project support the long-term development of new research capabilities and help strengthen the future of agricultural sciences, particularly in citrus and postharvest research. This benefit has not been quantified due to the high degree of uncertainty of future impacts and the difficulty of isolating attributable impact from other factors. |

Source: ACIL Allen

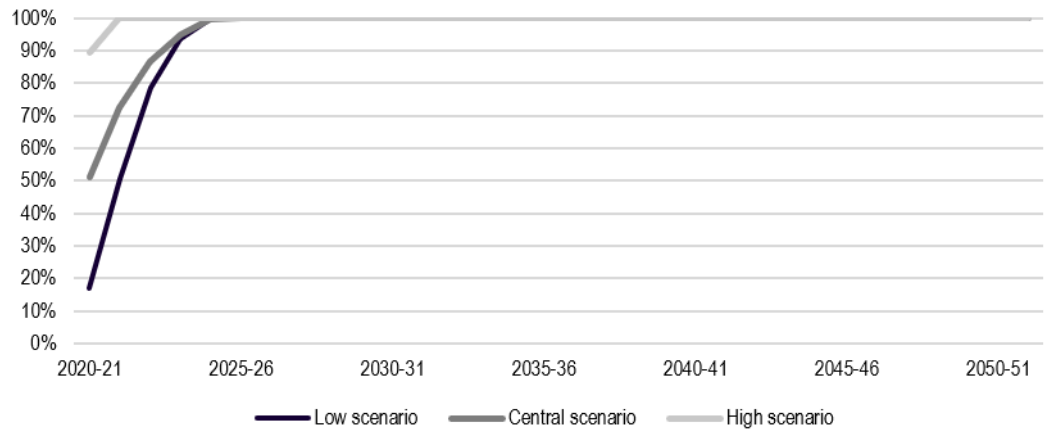
## Data and assumptions

The required data, assumptions and calculations used to estimate the impacts of the investment are presented in Table 6 below. The data were sourced from project data, external sources through literature review, industry data provided by Hort Innovation and other publicly available databases.

**Table 6 Data and assumptions used for CT19003**

| Data/Assumption | Source and rationale |
|---|---|
| Data | |
| Annual claims as a percentage of export value | 0.33%<br>This percentage is sourced through consultation with the lead researcher. The percentage is derived from observed claims by importers against growers prior to best practice adoption. Given the small sample of observations and claims being largely negated by best practice adoption, this value is a conservative estimate of claims across industry before the project. With a lower bound of 0.16% and upper bound of 0.66%. |

| Data/Assumption | Source and rationale |
|---|---|
| Reduction in claims per annum with the project | Linear reduction of 0.0825 percentage points (25% of original percentage). This percentage is informed by analyst's assessment and discussions with researchers. |
| Reduction in claims per annum with the project | Linear reduction of 0.04125 percentage points (12.5% of original percentage). This percentage is informed by analyst's assessment and discussions with researchers. |
| Average value of citrus trade with Thailand | $34,000,000<br>Hort Innovation Statistics Handbook 2024-25 – Trade. This value is the average of citrus exports (mainly mandarins) to Thailand between the 2021 and 2025 financial years. Thailand has been used as an indicative market to measure the impact of revoked export access due to changes in phytosanitary requirements during the research project, that significantly increased the likelihood of non-compliance for Australian citrus. The project was able to support industry to quickly adapt to changing requirements, sustaining market access in an instance where it may otherwise have been revoked. |
| Likelihood of Thai market closure without the project | Linear reduction from 75% to 0% over 5 years<br>This percentage is derived from discussions with researchers and an analyst assumption around the reduced likelihood of closure without the project over time. |
| Extend of closure | 90% closure in the first years, before partial closure (75%) in remaining years.<br>This percentage is derived from discussions with researchers and an analyst assumption around the reduced likelihood of total market closure over time. The extent of closure is considered to be 90% in the first year due to prior instances of non-compliance creating an environment where a further breach of the new phytosanitary requirements would result in revoked access for most Australian citrus exporters. This tapers off over the life of the project, as continued compliance over time reduces the likelihood of major changes to market access. |
| Average value of exports | $490,860,000<br>This value is the average of citrus exports between the 2021 and 2025 financial years. |
| Export price premium | 10%<br>This figure is derived from the comparative per kilogram price of Australian citrus in export markets compared to large comparator export nations, coupled with advice from the researcher.<br>The average range of observed price premiums was between 5% and 14% between 2021 and 2025, thus a mid-point was taken of 10% to evaluate this benefit. |
| Likelihood of price premium degradation without the project | 25%<br>Analyst assumption based on stakeholder interviews. |
| Extent of premium lost without the project | 10%<br>Analyst assumption based on stakeholder interviews. |
| Assumption | |

| Data/Assumption | Source and rationale |
|---|---|
| Attribution | Attribution for the project was 48%, this is based on the nominal costs of the investment as a proportion of the total nominal costs of related investments. These investments include projects such as:<br>CT15010 – Australian Citrus postharvest science program<br>CT23009 – Citrus postharvest program phase 2 |
| Counterfactual | Given the size and scale of the project, it is unlikely that the project would otherwise have been funded through the private market. Further, reliance on international knowledge transfer may have resulted in some benefits for select members of industry, however it would not have occurred anywhere near to the same extent as with this project. This is due to the key roles played by the research team to support adoption. The research team aggregated and freely publicised information and resources on postharvest best practice, they also sustained long term engagement with growers and packhouses through localised workshops and site visits. These would not have occurred without the project.<br>Finally, the reputation of the lead researcher within industry further aided adoption in a way that private R&D would not be able to replicate. The lead researcher has strong relationships across industry and are a trusted voice for growers, this and their neutral position in the private market ensured the practices advised through the project were quickly and widely adopted. These benefits are unlikely to have been accessible were the project to have occurred through a private channel. |
| Adoption | Adoption of the findings, recommendations, and best practice post-harvest treatment provided through this research were rapidly adopted by industry, leveraging the significant extension activities undertaken by researchers. Adoption commenced shortly after the project, with information consistently disseminated to industry by researchers. Adoption is assumed to have risen from 26% in the first year of the project to 95% by the project's conclusion in the base case, reflecting information provided by researchers and Hort Innovation Australia.<br>**Figure 1 Adoption curve**<br><br><br>*Source: ACIL Allen* |
| Confidence level | Given the uncertainty of predicting what-if scenarios for avoided losses, the impact assessment uses to confidence levels to impact, diluting the impact to reflect this uncertainty. The dilution ensures that applied assumptions are at the lower bound of benefit realisation to avoid overstating benefits.<br>The confidence level for this impact assessment is 50%. |
| Calculation | |

| Data/Assumption | Source and rationale |
|---|---|
| Reduction in claims by importers | *Adoption of best practice by industry x Savings from accelerated reduction in claims x Proportion of Impacts Delivered by the Investment x Confidence* |
| Avoided degradation of price premium induced by quality | *Adoption of best practice by industry x Proportion of Impacts Delivered by the Investment x Value assigned to price premium x Likelihood of quality degradation without the project x Extent of degradation x Confidence* |
| *Avoided loss of Thai market closure* | *Value of Thai exports x Proportion of Impacts Delivered by the Investment x Likelihood of closure without the project x Extent of market closure x Confidence* |

*Source: ACIL Allen*

## Net impact

A summary of the net impact of the investment is presented in Table 7. The results show that, taking all quantified costs and benefits into account, the investment produced a positive net result. The investment has an NPV of $7,691,370 and a BCR of 6.21 from 5 years after investment completion. All benefits are realised within the first 5 years following on from the investment, with future benefits attributed to the citrus postharvest program phase 2.

When taking only costs and benefits attributable to Hort Innovation into account, the investment generated an NPV of $4,003,455 and a BCR of 6.21. The benefits attributed to Hort Innovation were in proportion to the nominal cost contribution.

**Table 7 Net impact results of CT19003**

| | Years after investment completion | |
|---|---|---|
| | 0 | 5 |
| Whole investment | | |
| PV of Costs ($m) | $1.48 | $1.48 |
| Benefits ($m) | $7.25 | $8.08 |
| PV of Benefits ($m) | $8.35 | $9.17 |
| NPV ($m) | $6.87 | $7.69 |
| BCR | 5.66 | 6.21 |
| IRR | Negative | Negative |
| MIRR | Negative | Negative |
| Attributable to Hort Innovation | | |
| PV of Costs ($m) | $0.77 | $0.77 |
| Benefits ($m) | $3.77 | $4.20 |
| PV of Benefits ($m) | $4.35 | $4.77 |

| | | |
|---|---|---|
| NPV ($m) | $3.58 | $4.00 |
| BCR | 5.66 | 6.21 |
| IRR | Negative | Negative |
| MIRR | Negative | Negative |

*Note: IRR and MIRR are negative because the majority of the benefits occur before the model's base year (2025-2026). As IRR and MIRR are measures of rate of return, it also takes into account future benefits (positive cashflows) and not past benefits, resulting in negative figures.*

*Source: ACIL Allen*

### *Sensitivity analysis*

Sensitivity analysis was conducted to test the robustness of susceptibility of the analysis to key assumptions and parameters. Given the uncertainty of a number of assumptions used in this CBA, sensitivity testing is important to determine the appropriateness of underlying assumptions.

The results of the sensitivity analysis are presented in Table 8 below.

**Table 8 Sensitivity analysis results of CT19003**

| | NPV | BCR | IRR | MIRR |
|---|---|---|---|---|
| Under standard assumptions (Central case scenario and 5% discount rate) | $7.69 | 6.21 | Negative | Negative |
| 3% Discount rate | $7.24 | 5.91 | Negative | Negative |
| 7% Discount rate | $8.16 | 6.53 | Negative | Negative |
| Low adoption | $7.57 | 6.13 | Negative | Negative |
| High adoption | $7.85 | 6.32 | Negative | Negative |
| Low impact attribution | $3.68 | 3.49 | Negative | Negative |
| High impact attribution | $12.85 | 9.70 | Negative | 2.8% |
| Low reduction in claims | $7.51 | 6.09 | Negative | Negative |
| High reduction in claims | $7.87 | 6.33 | Negative | 0.6% |
| Low price premium | $7.38 | 6.00 | Negative | Negative |
| High price premium | $8.00 | 6.42 | Negative | Negative |
| Low probability of price degradation | $7.38 | 6.00 | Negative | Negative |
| High probability of price degradation | $8.00 | 6.42 | Negative | Negative |
| Low extent of price degradation | $7.38 | 6.00 | Negative | Negative |
| High extent of price degradation | $8.00 | 6.42 | Negative | Negative |
| Low avoided loss | $3.60 | 3.44 | Negative | Negative |
| High avoided loss | $11.79 | 8.98 | Negative | 0.2% |
| Low likelihood of closure without project | $3.60 | 3.44 | Negative | Negative |

| | NPV | BCR | IRR | MIRR |
|---|---|---|---|---|
| High likelihood of closure without project | $11.24 | 8.62 | Negative | 0.2% |
| Low extent of market closure | $3.60 | 3.44 | Negative | Negative |
| High extent of market closure | $9.70 | 7.57 | Negative | Negative |
| Low confidence – avoided loss | $3.60 | 3.44 | Negative | Negative |
| High confidence – avoided loss | $11.79 | 8.98 | Negative | 0.2% |
| Low confidence – maintained premium | $7.20 | 5.88 | Negative | Negative |
| High confidence – maintained premium | $8.18 | 6.54 | Negative | 1.0% |

*Source: ACIL Allen*

## Key findings

The following key findings have been identified for this assessment:

The project closely aligned with 3 of the 4 outcomes listed in the 2022-26 SIP. The project supported improved fruit quality, increased demand for Australian citrus, adoption of best practice post-harvest treatments by growers, ongoing and new access to export markets, and embedded outreach and extension activities in delivery of the project. Specifically, the project has supported the citrus industry to:

— grow and maintain export markets through research on pest management, postharvest treatments, and export protocols by reducing trade barriers, enabling rapid adaptation to changing international requirements, and in one case directly securing continued access to a key export market.

— maintain the price premium of Australian citrus in export markets by improving fruit quality, ensuring compliance with phytosanitary requirements, and maintaining strong consumer preference for Australian produce.

— reduce the susceptibility of citrus to postharvest pests and diseases, leading to lower spoilage and rejection rates, reduced losses across the supply chain, and improved pack-out efficiency

There are additional benefits associated with this research that have not been quantified due to data and methodology limitations. Were these benefits quantified they may enhance the research's BCR. This further highlights the significant positive returns to industry resulting from the investment. The unquantified benefits associated with this research include:

— increased consumer confidence and preference for Australian citrus

— improved environmental outcomes through reduced run-off from packhouses

— enhanced health outcomes by supporting post-harvest practice change to reduce chemical residues

— supported the development of new researchers by embedding PhD students in the research program.

Moving forward, there are opportunities to build upon and adopt observed enablers for this research. These enablers include:

— continued integration of industry within the PRG. For this project, industry's involvement in the PRG enabled the project to quickly respond to the emerging needs of industry and aligned the project's outcomes with these needs.

— flexibility in regard to project deliverables and activities. The project was established with a defined

number of research activities to be undertaken per annum, rather than set research objectives. This enabled resources to be redistributed across the project to quickly respond to emerging issues, such as transport delays caused by COVID-19 and changing phytosanitary requirements.

— consistent outreach through extension activities and stakeholder engagement. This ensured widespread adoption of best practice across industry, and site visits conducted by the research team could identify issues and respond to them while in the field – ensuring compliance across the supply chain.

## Consultations

The following stakeholders were consulted on this assessment:

— John Holding, NSW DPI

— Kevin Quinlan, NSW DPI

— Andrea Magiafoglou, Hort Innovation Australia

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