Delivery partner resource

Horticulture Impact Assessment Program

VG16086 – Area Wide Management of Vegetable Diseases: Viruses and Bacteria – Impact Assessment

June 2025

Hort Innovation

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Executive Summary

The Australian vegetable industry plays a vital role in national agricultural production, contributing $5.7 billion in gross value in 2023–24. New South Wales (NSW) is a key production region, valued at over $634 million annually.[1] However, productivity in the sector is significantly impacted by viral and bacterial diseases, particularly in high-value crops such as tomatoes, mushrooms, and cucurbits.

VG16086, *Area Wide Management of Vegetable Diseases: Viruses and Bacteria*, was a collaborative research investment led by the NSW Department of Primary Industries (NSW DPI) and delivered in partnership with the Department of Agriculture and Fisheries Queensland. Running from 2019 to 2023, the project sought to reduce the impact of endemic plant diseases, prevent the introduction of exotic pathogens, and build industry resilience through targeted diagnostics, surveillance, and grower engagement.

The project focused on 4 key objectives:

— surveillance to identify priority viral and bacterial pathogens in NSW

— laboratory research to improve understanding of transmission and management options

— development of diagnostic tools and resources for disease detection

— extension and training to improve grower knowledge and support industry biosecurity capacity.

VG16086 produced a range of significant outputs, including the first detections of key viruses in Australia, new PCR (polymerase chain reaction)-based diagnostics, and the identification of virus reservoirs in common weed species. It also contributed baseline surveillance data to support export market access and informed emergency biosecurity responses to emerging threats such as Cucumber green mottle mosaic virus (CGMMV) and Watermelon crinkle leaf-associated virus-1 (WCLaV-1).

While the outcomes of the project were substantial, the impact assessment was conducted qualitatively due to the lack of available data to conduct a robust quantitative assessment. This limitation stems from the foundational and enabling nature of the research, which focused heavily on knowledge generation, early detection, diagnostic development, and systems strengthening – rather than on immediately measurable yield or financial metrics. Many of the anticipated benefits, such as improved biosecurity response times, reduced reliance on chemical controls, and retention of market access through early surveillance, are inherently long-term, indirect, or dependent on future adoption by industry stakeholders. In particular, impacts such as reduced crop losses or increased economic returns from diagnostics are difficult to isolate or measure without widespread on-farm implementation and follow-up studies. Moreover, the variability in grower practices, regional conditions, and the absence of baseline benchmarking data further constrained the ability to conduct a robust quantitative analysis. In such cases, a structured qualitative framework – focused on logical pathways of change, capacity improvements, and stakeholder feedback – offers a more meaningful and appropriate way to capture the impact of research investments like VG16086.

Overall, VG16086 has strengthened NSW's diagnostic capability, improved disease surveillance and preparedness, and built the foundational knowledge and tools needed for more effective vegetable disease

[1] Hort Innovation 2025, *Horticulture Statistics Handbook 2023-24*

management across Australia.

Context, objective, and details of investment

Australia's national vegetable industry is an important part of agricultural production in Australia. In 2023-24, the vegetable industry produced approximately 3.8 billion tonnes worth $5.7 billion.[2] Australia primarily exports vegetables to Singapore, UAE, Malaysia, Hong Kong and Saudi Arabia.[3] Around 5% of production are exported.[4] Key vegetable commodities such as carrots, broccoli, cauliflower, leafy salad, celery and beans accounted for 80% of the total export value in 2019-20.[5]

New South Wales (NSW) is a key vegetable producing region of Australia.[6] In 2020-21, the total vegetable output value of the state was $634.1 million, with the dominant crop groups identified as brassica, cucurbit, and amaranth.[7] Mushrooms ($97.2 million), tomatoes ($51.9 million) and melons ($48.1 million) were NSW's highest gross value vegetables in 2019-20.[8] In 2020-21, this changed to tomatoes ($103 million), mushrooms ($74.9 million) and cucumbers ($71.4 million).[9] The primary export markets for the state were Singapore, South Korea, Hong Kong, and the United States.[10]

Viruses and bacteria continue to be a major area of concern in production for growers in NSW, hindering productivity. VG16086 was undertaken by the NSW DPI and the Department of Agriculture and Fisheries Queensland. Both departments led separate research studies in their states aimed at developing area wide management (AWM) strategies to address high priority viral and bacterial diseases affecting key vegetable crops. The project studied a diverse range of viral and bacterial pathogens endemic to the NSW region. When undertaking this project, one of the objectives was to minimise the introduction of exotic diseases. Key development goals of the project included an area wide management strategy for bacterial pathogens in brassicas, and viral diseases in cucurbits, and effective diagnostics for Xanthomonas campestris.

VG16086 supported the improvement of capacity and capability in the vegetable industry by focusing on training and developing technical expertise for vegetable pathologists. Additionally, the project intended on investigating the relationships between genetic diversity, pathogenicity, and survivability in pathogens present in plant debris. The research team aimed to comprehensively survey and analyse current bacterial and viral populations to identify and benchmark the dominant pathogen issues for the NSW vegetable industry. VG16086 contributed research discoveries to Project VG22001: Management of foliar bacterial diseases in vegetables. Also, VG14010: Management and detection of bacterial leaf spot in capsicum and chilli crops and

[2] AUSVEG, *Latest official statistics confirm extreme price pressures on vegetable growers*, 2025, https://ausveg.com.au/article/latest-official-statistics-confirm-extreme-price-pressures-on-vegetable-growers/#:~:text=The%20latest%20official%20statics%20reveal%20Australian%20growers%20produced,value%20dropped%20to%20%245.7%20billion%20from%20%245.84%20billion.

[3] AUSVEG, *ASEAN and the Middle East remain primary Australian fresh vegetable export destinations throughout 2021*, 2022, https://ausveg.com.au/knowledge-hub/asean-and-the-middle-east-remain-primary-australian-fresh-vegetable-export-destinations-throughout-2021/.

[4] Ibid.

[5] Hort Innovation, 2021, *Vegetable Strategic Investment Plan*, p.24.

[6] Department of Primary Industries, *Horticulture*, https://www.dpi.nsw.gov.au/about-us/publications/pdi/2022/horticulture.

[7] Ibid.

[8] Ibid.

[9] Ibid.

[10] Ibid.

Project VG15073: Characterisation of a carlavirus of French bean are linked to Project VG16086.

These were the 4 key objectives within Project VG16086:

— Conduct field surveillance to identify key pathogens.

— Carry out experimental assays to understand the pathogens and explore treatment options.

— Implement diagnostic development and industry extension and engagement activities to directly relay key findings to industry.

— Provide an education opportunity to improve knowledge and understanding of important biosecurity principles.

Alignment with Strategic Investment Plan

Project VG16086 supported the Vegetable Strategic Investment Plan (SIP) 2017–2021[11] by contributing to Outcome 3: Improved Farm Productivity, through enhanced early detection, surveillance, and management of bacterial and viral pathogens in key vegetable-growing regions. By promoting integrated pest and disease management (IPDM) practices, improving on-farm diagnostics, and advancing soil health strategies, the project reduced the impact of pests and diseases, supporting more resilient and sustainable production systems. VG16086 also aligned with Outcome 5: Improved Industry Capabilities for Adoption and Innovation by delivering targeted extension activities, building grower and agronomist capacity, and fostering cross-sector collaboration. These efforts strengthened industry biosecurity preparedness, improved on-farm decision-making, and laid the foundation for long-term productivity improvements and innovation across the vegetable sector.

Table 1 Project details of VG16086

Project code	VG16086
Title	Area Wide Management of Vegetable Diseases: Viruses and Bacteria
Research organisation(s)	NSW DPI
Project leader	Toni Chapman
Funding period	2019-20 – 2022-23
Objective	Minimise the effect of high impact endemic viral and bacterial diseases and the introduction and establishment of exotic vegetable diseases.

Source: Hort Innovation

Related investments

The project was linked with the following 2 investments:

— VG15073 Characterisation of a carlavirus of French bean (2016-2019) – The project focused on identifying and managing cowpea mild mottle virus (CPMMV), a new carlavirus affecting Fabaceae crops in Queensland. The research contributed essential knowledge on virus transmission via silverleaf whitefly, outlined critical risk periods for infection, and recommended practical management strategies – such as whitefly monitoring, planting virus-tolerant varieties, and adjusting crop timings – to minimise yield loss and disease spread. These learnings support VG16086's broader aim of

[11] Hort Innovation 2017, Vegetables Strategic Investment Plan 2017-2021

equipping growers with actionable virus management tools across the vegetable production systems.

— VG14010 Management and detection of bacterial leaf spot in capsicum and chilli crops (2015-2018) – The investment redefined the understanding of the pathogens responsible for bacterial leaf spot in capsicum, chilli, and tomato. By identifying multiple Xanthomonas species and their host-specific behaviour, it laid the groundwork for improved diagnostic precision and resistance breeding. Insights into copper resistance, potential essential oil treatments, and the importance of clean seed underline the need for integrated, science-based approaches to disease management – an approach that also underpins VG16086's efforts in improving viral diagnostics, vector management, and crop health outcomes.

Project governance

The *Area Wide Management of Vegetable Diseases: Viruses and Bacteria – NSW* project was delivered under a structured and collaborative governance framework designed to support rigorous scientific delivery, stakeholder engagement, and national alignment on biosecurity priorities. The project was part of a larger Area Wide Management (AWM) initiative, led by Queensland and supported by cross-jurisdictional collaboration, with NSW playing a key role in the surveillance, diagnostics, and extension of findings specific to local production contexts.

Leadership and Oversight
The project was led by NSW DPI, which was responsible for the overall delivery, scientific design, operational coordination, and reporting. Project activities were overseen by a core team of experienced plant pathologists, with Dr Len Tesoriero providing senior technical guidance and mentoring. A designated project leader coordinated day-to-day implementation, supervised technical staff, and represented NSW in national AWM forums.

Collaboration and Integration
Strong alignment was maintained with the national AWM framework through coordinated surveillance activities, regular data sharing, and consistent communication across jurisdictions. Productive partnerships were built with other states – particularly Queensland – to support unified diagnostic methods, exchange isolate collections, and contribute to national contingency planning. Communication was structured and regular, with annual national meetings and Project Reference Group (PRG) sessions, biannual project team catch-ups, and frequent NSW team meetings held every 2 to 4 weeks. This structured engagement ensured that all teams remained well-connected, responsive, and aligned throughout the project's duration.

Stakeholder Engagement
Grower involvement and industry engagement were central to the governance approach. A network of 64 NSW vegetable growers, agronomists, and local industry bodies, including Greater Sydney Local Land Services (GS LLS), Ausveg, and VegNet, were engaged throughout the project lifecycle. Governance mechanisms included regular farm visits, on-site discussions, workshops, webinars, and collaborative field assessments, ensuring that research activities remained closely aligned with grower needs and that project outputs were readily applicable to industry practice.

Researcher Development and Capacity Building
Project governance explicitly incorporated a focus on capacity building, with the mentoring of early-career scientists, a dedicated PhD student contributing to the viral research stream, and participation in formal emergency response training. Diagnostic personnel were upskilled in vegetable field pathology, and several staff gained experience through involvement in state-level emergency responses. This investment in workforce development ensured the project not only met immediate research objectives but also strengthened the long-term diagnostic and biosecurity response capability of the NSW vegetable sector.

Biosecurity and Emergency Preparedness Integration
The NSW AWM team contributed to national preparedness efforts by helping to develop contingency plans for

exotic bacterial and viral threats. Staff also served as Local and Regional Emergency Management Committee representatives, integrating project governance with broader biosecurity response infrastructure and enabling rapid mobilisation in the event of an incursion.

In sum, the project was governed through a multi-tiered model that combined scientific integrity, cross-sectoral collaboration, and grassroots industry engagement. This model ensured that both strategic and operational goals were met, and that the project delivered practical outcomes for NSW vegetable growers while contributing to national plant health priorities.

Impact pathway

A clear pathway from input to impacts can be identified. Overall, the investment produced 5 benefits for both levy payers and the broader communities. Table 2 shows the logical pathway to impact of the investment.

Table 2 Impact pathway of VG16086

Pathway	Description
Inputs and Activities	**Management of the genus Potyvirus** – Investigation into the transmission and management of Potyvirus in cucurbit crop was performed through field observations and virus introduction experiments. **Diagnostics for Xanthomonas campestris** – 200 *X. campestris* isolates dated from 1969 to 2016 underwent genome sequencing to investigate the genetic relatedness of *X. campestris* in Australia. *X. campestris* is a type of seedborne pathogen and lacks a proper treatment solution given the unregulated distribution of brassicas globally. **Vegetable production areas targeted and analysed to build NSW pathogen profile** – Surveillance was conducted across key vegetable production regions in NSW – Sydney Basin, Central Coast, Central Tablelands, Riverina, Central West, North Coast, and Sunraysia – with a focus on identifying and charactering bacterial and viral pathogens affecting brassica and cucurbit crops. Incidence of visible disease symptoms were recorded and the percentage affected was calculated. Both symptomatic and asymptomatic plant and leaf samples were collected for testing. Plant samples then were tested to confirm pathogen identity. **Industry and growers engaged and supported in developing knowledge –** Strong collaboration was fostered throughout the entirety of the project.

Outputs	**Pathogen identification and characterisation**
	Extensive surveillance across NSW was conducted to monitor viral and bacterial pathogens led to:
	• detection and documentation of key reference pathogen isolates banked in NSW DPI Herbarium to support ongoing diagnostic capacity, including:
	  ○ Cucumber green mottle mosaic virus (CGMMV) – first NSW detection, triggering a biosecurity response
	  ○ Watermelon crinkle leaf associated virus-1 (WCLaV-1) – first detection in Australia
	• Comprehensive pathogen lists compiled for viruses and bacteria affecting vegetables in NSW
	• Discovery of new and alternative plant hosts, including weed species acting as virus reservoirs near cropping areas
	• Characterisation of mechanical and environmental transmission pathways for priority pathogens based on field and lab studies
	Diagnostic tools and protocols
	• New PCR based diagnostic assay developed for Xanthomonas campestris

Pathway	Description
	• Validation of existing assays for CGMMV, WCLaV-1, and *Olpidium spp.* under NSW conditions. • Diagnostic reference materials and protocols produced using MALDI-TOF and genome sequencing for bacterial identification. • Development of risk mitigation protocols for bacterial seed disinfestation (to be expanded in future project VG22001) **Management strategies and extension resources** • Data on efficacy of alternative cultural and biological disease control options identified • National bacterial and viral disease management guides co-authored by NSW team • Surveillance informed AWM strategy guide delivered to growers detailing recognition and mitigation strategies for viral and bacterial diseases • Mechanical transmission studies confirmed virus spread through tools and crop handling • Factsheets and news articles developed and distributed **Academic contributions** • 3 scientific manuscripts produced from project research, 2 published, one pending. • PhD thesis on zucchini virus epidemiology in Greater Sydney Basin completed. **Surveillance driven biosecurity and policy outcomes** • Baseline surveillance data contributed to maintaining market access, providing "not detected" evidence in key cucurbit export zones • National collaborations fostered including participation in plant biosecurity reference groups, lead role in Peri-Urban Biosecurity Pilot across NSW, VIC, and SA and contributions to the review of the National CGMMV Management Strategy • Baseline disease distribution maps and host range data shared with stakeholders to guide regional risk management and breeding priorities • NSW Area Wide Management (AWM) team involved in multiple emergency responses informed by field response experience to CGMMV, WCLaV-1, serpentine leafminer, and others **Capacity building and grower engagement** • Surveillance sampling kits and training manual developed for growers to collect and submit samples remotely (especially during COVID-19 lockdowns) • Throughout the project, at least 12 workshops, field days, conferences, engagement activities and on-farm extension activities were delivered or attended by the AWM project team. These events involved direct interaction with vegetable growers, agronomists, and industry stakeholders, across NSW, focusing on building awareness and understanding of key bacterial and viral pathogens, improving the capacity of industry to recognise pathogen symptoms, understand transmission mechanisms, and implement appropriate control and biosecurity measures.
Outcomes	**Faster identification of endemic and suspect bacterial and viral pathogens and development of low-cost specific diagnostic assays** – New diagnostic assays were developed during this project and surveillance has improved understanding of current pathogen populations in NSW. **Reduced impact of bacterial and viral disease with the use of AWM strategies** – Communicating best practice disease management methods to industry. This is a long-term strategy requiring behavioural change from industry and will take time to see results at the farm gate.

Pathway	Description
	Development of low-cost specific diagnostic assays for rapid identification of bacterial and viral presence in horticultural crops, insect pests or seed lots – Development of a Xanthomonas campestris-pv campestris molecular assay. Development of MALDI-TOF analysis of vegetable bacterial pathogens for fast turnaround diagnostics. **Increased speed and capacity of diagnostic capabilities in-field** – Surveillance techniques were practised and provided a new benchmark for NSW production regions. Emergency response procedures in NSW were developed and refined and strongly incorporate new capacity in lab diagnostics. **More effective management decisions** – Producers can make more effective decisions as they have a list of key plant species for targeted removal in close proximity to cucurbit crops to reduce overwintering vector populations on alternative hosts. **Increased grower knowledge capacity** – Producers are better equipped with an understanding of the different types of infections and how they are transmitted. Factsheets and workshops are provided to farmers and producers to better guide their farm management practices. Knowledge on disease transmission mechanisms and management. **Continued capitalisation of NSW research and farming environment to aid in disease threat response capacity** – NSW has a strategic geographical position which supports both temperate and tropical horticulture commodities. This also means there are a diverse variety of pest and disease threats which require specialised management options based on region. **Greater diagnostic capacity and knowledge to assist in future research –** New diagnostic assays have increased the diagnostic capacity and capability for a key national diagnostic laboratory servicing the vegetable industry. Future research is assisted by these developments by determining the most suitable sampling protocol. **Reduced disease pressure –** Selecting breeding lines based upon disease tolerance for each specific region can reduce disease pressure and improve growth and yield. Reducing pathogen populations along with implementing AWM of bacterial and viral diseases will decrease selective pressure on pathogen populations and promote the longevity of resistant genetic breeding lines.
Impacts	**Faster, lower cost diagnostics** The development and ongoing refinement of new diagnostic tools (e.g., PCR, MALDI-TOF) are expected to streamline pathogen identification, enabling faster, more cost-effective disease management decisions for growers. **Reduced crop losses through improved disease identification and management** Adoption of integrated disease management practices – supported by improved diagnostics and grower education – is anticipated to reduce disease prevalence, lower crop losses, and improve decision-making around hygiene, rotations, and vector control. **Market access protection through clean status surveillance** Pathogen “surveyed but not detected” results support the ongoing export viability of NSW produce. **Reduced reliance on chemical controls** Disease management strategies promoted by the project, including cultural and biological controls, have the potential for reduced pesticide use and more sustainable crop protection methods. **Improved waste management** Findings related to pathogen persistence in crop waste and compost have the potential to inform waste management practices, reduce reinfection risk and support environmentally responsible farm operations.

Pathway	Description
	Greater biosecurity resilience Growers have become more engaged in surveillance through better understanding of disease pathways. The project has enhanced NSW's ability to respond to incursions through established diagnostics, trained personnel, and rapid response protocols. **Greater industry government collaboration** Strong collaboration between government, researchers, and growers — through joint surveillance, diagnostics, and training — has improved trust, knowledge exchange, and future readiness for pest and disease management. **Support for breeding and seed health strategies** Pathogen surveillance data is informing the development of disease-resistant crop lines and improved seed disinfestation protocols, supporting long-term disease prevention. **Scientific advancement and ongoing research momentum** Multiple peer-reviewed publications and conference presentations disseminate findings beyond the project. Genome sequencing, assay development, and pathogen discovery continue to inform national diagnostics and research programs.

Source: ACIL Allen

Cost and benefits

Costs

Cost of the investment

The investment was a collaboration between Hort Innovation and NSW Department of Primary Industries (DPI). Hort Innovation contributed about $1.6 million in cash and incurred over $229,000 in overhead costs (ex-GST amounts). NSW DPI contributed about $224,000 through in-kind contributions. Table 3 below shows the total nominal cash and in-kind contributions from each partner across the duration of the investment.

Table 3 Nominal costs of the investment by contributing partners of VG16086

Contribution	2019-20	2020-21	2021-22	2022-23	Total
Hort Innovation – Cash	$1,062,604	$371,778	-	$163,426	**$1,597,808**
Hort Innovation – Overheads	$157,352	$48,413	-	$23,598	**$229,363**
NSW DPI – In kind	$74,519	$74,520	-	$74,520	**$223,559**
Total	**$1,294,76**	**$494,710**	**-**	**$261,544**	**$2,050,730**

Source: Hort Innovation

The total nominal investment of $2.05 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).

Cost of the investment, in nominal terms and real terms, is provided in Table 4 below.

Table 4 Real costs of the investment TG19004

Organisation	Hort Innovation	NSW DPI	Total
Nominal costs	$1,827,171	$223,559	$2,050,730

Real costs ($2025 financial year)	$2,156,587	$253,687	$2,410,273

Source: ACIL Allen, modelled using ABS's implicit GDP deflator

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 VG16086

Type of impact	Assessment	Description
Economic impact	Unquantified	**Faster, lower cost diagnostics** New PCR and MALDI-TOF-based diagnostics potentially reduce the time and cost of identifying priority pathogens like *X. campestris*. However, the diagnostics are still under development, with the endpoint PCR assay yet to complete sensitivity testing and no time or cost benchmarks currently available. The LAMP assay has not entered testing and remains a future objective. Additionally, baseline diagnostic methods are not clearly defined – PCR-based diagnostics for *X. campestris* already exist[12], but their limitations in specificity are not fully quantified, and no standardised information on current turnaround times or costs is available. As a result, there is no empirical basis for assessing how the new endpoint PCR improves upon existing tools or for estimating potential time or cost savings.
	Unquantified	**Reduced crop losses through improved disease identification and management** Earlier detection and better management (e.g. WMV transmission and composting protocols) help growers act before widespread outbreaks. While improved diagnostics for Xanthomonas campestris pv. campestris (black rot) may support earlier intervention, the benefit of reduced crop losses cannot be reasonably quantified because no field data currently demonstrate how these tools have affected actual disease incidence, spread, or yield outcomes. Without this empirical evidence, it is not possible to attribute any reduction in losses directly to the use of diagnostics. While black rot has no effective treatment, the challenge in quantifying the benefit of improved diagnostics alone lies in the variability of how prevention and management strategies are implemented. Measures such as the use of disease-free seedlings, hygiene protocols, and crop isolation are critical but inconsistently applied across different growers and regions. The absence of resistant varieties and the limited, often unreliable, effectiveness of chemical controls like copper further complicate the picture, making it infeasible to reliably estimate the extent of losses avoided through improved diagnostics alone.
	Unquantified	**Market access retention through early disease surveillance**

[12] Berg, T., Tesoriero, L., & Hailstones, D. L. (2005). PCR-based detection of *Xanthomonas campestris* pathovars in *Brassica* seed. *Plant Pathology, 54*(4), 416–427. https://doi.org/10.1111/j.1365-3059.2005.01186.x

Type of impact	Assessment	Description
		Early surveillance through baseline data supports market access retention by demonstrating the absence of disease in surveyed regions. This clean survey data enables timely detection and response to any incursions, helping industry and growers avoid widespread outbreaks and associated economic losses, thereby maintaining continued export opportunities. However, the economic value of retained market access is inherently preventative and highly dependent on hypothetical future scenarios (e.g. a disease incursion that never eventuates). As such, assigning a dollar value would require speculative modelling of avoided losses under uncertain conditions.
Environmental impact	Unquantified	**Reduced reliance on chemical controls** Identification and testing of cultural and biological controls provide viable alternatives to pesticides. However, due to variability in adoption rates, site-specific effectiveness, and the absence of quantified reductions in chemical usage across farms, the scale of benefits could not be reliably estimated.
	Unquantified	**Improved waste management** Evidence showing virus breakdown in compost and pathogen longevity in debris leads to better-informed crop waste handling. While these practices are likely to reduce disease risk and environmental impact, no direct data was available on adoption rates, cost savings, or reductions in reinfection rates, making it inappropriate to quantify their economic value at this stage.
Social impact	Unquantified	**Strengthened biosecurity response capacity** Through participation in surveillance and emergency response training, the DPI team enhanced its capability to respond to real-world pest and disease incursions. While this clearly contributes to institutional resilience and preparedness, the benefit has not been quantified because it is indirect, preventative, and difficult to attribute solely to this project. Any measurable impact would likely be seen only in the event of a future incursion, making it challenging to isolate from broader system-wide improvements. It is therefore excluded from the economic model.
	Unquantified	**Greater industry-government collaboration** The project fostered improved trust and engagement between growers, industry bodies, and government agencies via joint surveillance activities, reference groups, and cross-border initiatives such as the Peri-Urban Pilot. While this collaboration enhances coordination and information sharing, its value lies primarily in enabling future outcomes rather than delivering immediate, attributable economic gains. Quantification would require speculative assumptions about long-term behaviour change and policy influence and is thus not included.

Source: ACIL Allen

Key findings

VG16086 delivered a wide range of outcomes for the Australian vegetable industry, particularly in New South Wales. It focused on understanding and managing endemic viral and bacterial diseases, while strengthening diagnostics, biosecurity preparedness, and industry engagement. The key findings of the project are outlined

below.

- **Improved Understanding of Pathogens**
  - Extensive field surveillance across NSW identified the most impactful viral and bacterial pathogens affecting vegetable crops.
  - The project resulted in the detection and documentation of key pathogen isolates, including:
    - Cucumber green mottle mosaic virus (CGMMV) – first NSW detection.
    - Watermelon crinkle leaf associated virus-1 (WCLaV-1) – first detection in Australia.
  - Several new host plants, including weed species, were identified as virus reservoirs, informing targeted area-wide management (AWM) strategies.

- **Enhanced Diagnostic Capabilities**
  - New PCR-based diagnostic tools were developed for *Xanthomonas campestris*, improving detection accuracy for black rot in brassicas.
  - MALDI-TOF technology was applied for bacterial pathogen identification, increasing speed and reliability of diagnostics.
  - Assays for CGMMV, WCLaV-1, and *Olpidium* spp. were validated under NSW-specific conditions.

- **Area-Wide Management Strategies Delivered**
  - Surveillance-informed AWM guides were developed and distributed to growers, detailing effective recognition and mitigation strategies.
  - Studies confirmed mechanical virus transmission pathways, influencing new hygiene protocols for farm tools and handling practices.
  - Growers were provided with actionable management strategies based on biological and cultural control options, though adoption and impact will require further tracking.

- **Strengthened Industry Capacity and Biosecurity Readiness**
  - Diagnostic and surveillance capacity within NSW DPI was significantly improved.
  - A dedicated PhD program and early-career training supported future research and response capability.
  - Project teams contributed to multiple national emergency responses and helped develop national contingency and biosecurity response strategies.

- **Support for Future Research and Policy**
  - Surveillance data is already being used to inform plant breeding priorities and seed disinfestation protocols.
  - Research outputs, including published papers and a PhD thesis, contribute to a growing knowledge base that supports national plant health initiatives.

While the project delivered important outputs and long-term strategic benefits, its impact assessment has been conducted qualitatively due to the following reasons:

- **Preventative Nature of Impacts**: Many outcomes – such as early detection, improved surveillance, and biosecurity readiness – are inherently preventative. Their value lies in avoided losses or future preparedness, which are difficult to quantify without speculative modelling or counterfactual analysis.
- **Lack of Benchmark Data**: While diagnostic tools and management strategies were developed, there is currently insufficient empirical data (for example, adoption rates, cost savings, yield improvements) to support a robust quantitative assessment. Many tools remain in early stages of implementation or validation.
- **Behavioural and Long-Term Change Required**: Benefits from area-wide management (AWM) strategies and improved diagnostic protocols rely on consistent adoption and long-term changes in grower

behaviour, which take time to demonstrate measurable impact.

— **Attribution Challenges**: The effectiveness of improved disease control is influenced by multiple variables (for example, weather, varietal resistance, hygiene practices). As such, isolating and quantifying the specific contribution of this project is not feasible without controlled trials or comprehensive longitudinal data.

Consultations

The following stakeholders were consulted on this assessment:

— Araz Solomon, R&D manager, Hort Innovation

— Other relevant stakeholders were identified, however, they were unable to be contacted.

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