Final report

Project title:

Protecting Australia's citrus genetic material

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Auscitrus

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Public summary

Citrus is one of Australia's most important horticultural export crops. In FY25, the industry produced 909,674 tonnes of citrus fruit worth $1,234.8 million (Horticulture Innovation 2026). Diseases can destroy an industry therefore it is vital that we protect the health status of the national citrus industry by ensuring that disease-free, true-to-type propagation material is available to prevent incurable diseases from entering citrus nurseries and orchards. Use of healthy planting material will avoid potential yield loss and the costly exercise of replanting infected blocks.

Graft-transmissible diseases, spread by infected plant material, are of most concern because they can kill trees and there is no cure. Major graft-transmissible citrus diseases, such as huanglongbing (HLB) and citrus variegated chlorosis (CVC), are not known to occur in Australia. However, within our country, there are several graft-transmissible viruses and viroids that can cause stunting, yield loss and even death in some scion and rootstock combinations. The disease-causing agents may also be present in plants without symptoms, but these plants are a source of future infections. Examples of endemic graft-transmissibles include citrus exocortis viroid (CEVd), cachexia (citrus viroid IIb - CVd-IIb) and citrus psorosis virus (CPsV). Transmission of these diseases must be prevented by using uninfected budwood and rootstock seed to propagate new plants. Some diseases, such as citrus tristeza virus (CTV), HLB and CVC can also be transmitted via insect vectors. It is vital that industry protects the high health status of Australian citrus through the National Citrus Repository Program.

The National Citrus Repository Program maintains high health status foundation trees as a source of budwood for industry. Trees may be disease-free or inoculated with a mild isolate of CTV to protect against severe isolates of CTV. Budwood from the foundation trees is used by Auscitrus to create daughter trees and multiply large numbers of buds for industry, available for purchase from www.auscitrus.com.au. New varieties can enter the program if no known diseases are detected after pathogen testing and elimination.

This project continues the work of previous projects funding the long-term repository program. The project supports the maintenance and testing of the foundation trees of publicly owned varieties in the National Citrus Repository and the testing and removal of pathogens from new Australian citrus selections. Repository houses are located on the Auscitrus property at Dareton and at the NSW Department of Primary Industries' Elizabeth Macarthur Agricultural Institute (NSW DPI EMAI) at Menangle. Pathogen testing and elimination is undertaken by NSW DPI. Currently, 114 publicly owned citrus clones are housed in the repository, from Australian and overseas sources. Twenty-two of these were new introductions to the repository over the course of the project from July 2021 to July 2026; three imported and nineteen from local sources including fifteen rootstock varieties.

The National Citrus Repository is an industry asset that serves as an insurance policy for the future health and economic viability of the Australian citrus industry.

Keywords

Citrus; biosecurity; germplasm; repository; budwood; true-to-type; graft-transmissible disease; prevention

List of acronyms

ASGV	apple stem grooving virus
CBCVd	citrus bark cracking viroid or CVd-IV
CBLVd	citrus bent leaf viroid or citrus viroid I
CCGaV	citrus concave gum associated virus
CDVd	citrus dwarfing viroid or citrus viroid III
CEVd	citrus exocortis viroid
CLBV	citrus leaf blotch virus
CPsV	citrus psorosis virus
CTV	citrus tristeza virus
CVC	citrus variegated chlorosis
CVd-IIb	citrus viroid IIb or cachexia
CVd-V	citrus viroid V
CVd-VI	citrus viroid VI
CVd-VII	citrus viroid VII
CiVA	citrus virus A
DAFF	Department of Agriculture, Fisheries and Forestry
DNA	deoxyribonucleic acid
DTBIA	direct tissue blot immunoassay
EMAI	Elizabeth Macarthur Agricultural Institute
HLB	huanglongbing
HSVd	hop stunt viroid or citrus viroid II
NSW DPIRD	New South Wales Department of Primary Industries and Regional Development
NZ MPI	New Zealand Ministry for Primary Industries
PCR	polymerase chain reaction
RNA	ribonucleic acid
RT-PCR	reverse transcription polymerase chain reaction
RT-qPCR	reverse transcription quantitative polymerase chain reaction
qPCR	quantitative polymerase chain reaction

Introduction

Biosecurity is a priority for the Australian citrus industry as outlined in the Australian Citrus Strategic Investment Plan 2022-26 under 'Outcome 1: Protect the Production Base' through 'robust biosecurity systems' and 'ensuring access to superior scion and rootstock varieties'. It is important to maintain the high health status of Australian citrus to maximize orchard productivity and maintain market access. Graft-transmissible diseases are spread by propagating infected plant material, mechanically on infected cutting tools during grafting, pruning and hedging, and in some cases by aphids or other insect vectors. There is no cure for these diseases hence they must be prevented by using uninfected propagation material.

Major graft-transmissible citrus diseases, such as huanglongbing (HLB) and citrus variegated chlorosis (CVC), are not known to occur in Australia. However, within our country, there are several graft-transmissible viruses and viroids that can cause stunting, yield loss and even death in some scion and rootstock combinations. The disease-causing agents may also be present in plants without symptoms, but these plants are a source of future infections. Examples of endemic graft-transmissible diseases include citrus exocortis viroid (CEVd), cachexia (CVd-IIb strain of hop stunt viroid; HSVd) and citrus tristeza virus (CTV). Studies recorded yield loss in an orchard infected by CEVd was nearly 50% on citrange and 69% on trifoliata rootstock during the first 9 years of production (Bevington and Bacon 1977). For most graft-transmissible diseases, symptoms will not be seen in nursery trees, the signs will appear a few years later in the orchard. By that time, the disease is likely to have spread to surrounding trees. Nothing can be done to save infected trees.

Viroids and viruses are not all pathogenic, some can be beneficial. 'Mild strain cross protection' is used successfully in Australia to protect white grapefruit trees against severe stem pitting isolates of CTV by inoculation with a mild CTV isolate. Inoculating trees with a viroid that induces mild dwarfing can be useful for high density plantings and ease of orchard management. Whilst some viroids and viruses can be non-pathogenic on their own, in combination their effects can be detrimental to the tree. Studies have shown that citrus viroid V (CVd-V) has little impact on trees but co-infection with citrus bent leaf viroid (CBLVd or CVd-I) or citrus dwarfing viroid (CDVd or CVd-III) results in severe dwarfing (Serra et al. 2008). This highlights the importance of knowing what organisms are present in propagation material before its use.

Australian quarantine managed by the federal Department of Agriculture, Fisheries and Forestry (DAFF) significantly reduces the risk of entry of graft-transmissible diseases into Australia. Graft-transmissible citrus diseases are managed within Australia by:

- Government and industry driven surveillance programs for early detection to increase the chance of eradication,
- the post-entry quarantine system managed by DAFF where newly imported citrus varieties undergo pathogen elimination and testing for quarantine plant pathogens before release,
- the National Citrus Repository Program where foundation trees of commercial citrus varieties are maintained in biosecure repositories and tested for citrus pathogens,
- and the Auscitrus propagation scheme, a non-profit industry organisation that supplies high health status, true-to-type budwood and rootstock seed to nurseries for tree production.

The current project continues the work of previous levy-funded projects to support the long-term National Citrus Repository Program. The current project supports the pathogen testing of new Australian citrus selections and the maintenance and pathogen testing of the foundation trees of publicly owned varieties in the National Citrus Repository. Trees may be pathogen-free or inoculated with a mild protective isolate of CTV. Small quantities of budwood from the foundation trees are used by Auscitrus to create daughter trees and multiply large numbers of buds for industry. New Australian varieties are tested for graft-transmissible pathogens and pathogens are removed by shoot-tip grafting. These varieties can enter the program if no known diseases are detected in a tree; this becomes the foundation tree for that variety.

Independent testing of the repository trees is provided by the NSW Department of Primary Industries and Regional Development (NSW DPIRD) citrus pathology team based at Elizabeth Macarthur Agricultural Institute (EMAI). This work is part of the NSW DPIRD Citrus Pathology Program which aims to protect the health status of the Australian citrus industry by expanding our knowledge and capability on disease threats, including preparing to respond to new threats.

Detecting graft-transmissible pathogens can be difficult because the pathogen particles may be present below detectable levels or unevenly distributed within the tree. It is important that diagnostic tests are specific to the target organism, sensitive (i.e. will detect even at low levels), and efficient (time and cost). Current and new diagnostic tests for graft-transmissible citrus pathogens are evaluated through levy-funded Hort Innovation projects (CT14009, CT17007 and CT21005) to ensure we are using the most reliable, sensitive and efficient methods available. Improved diagnostic tools developed and validated through the projects have been adopted by the National Citrus Repository program and the

Auscitrus propagation scheme to test plant material prior to supply to industry. Testing of nucleic acid extracts from repository trees, or local varieties submitted for pathogen testing and elimination, provides further validation of the diagnostic assays.

The work undertaken in this project enhanced the ability of Auscitrus and the NSW DPIRD team to deliver for industry and government by:

- ensuring the availability of healthy planting material to industry of existing and new citrus varieties; and
- helping to prepare for an incursion of exotic graft-transmissible disease threats like HLB, the worst disease reported to affect citrus globally.

Methodology

The current phase of 'Protecting Australia's citrus genetic material', active from July 2021 to 2026, supported the maintenance and testing of public varieties held in the National Citrus Repositories and pathogen elimination of locally selected public varieties.

The maintenance and testing of private varieties in the repository system are covered by a contract agreement between the private variety owner and Auscitrus and is paid for by the variety owner as fee for service.

National Citrus Repositories

The 'National Citrus Repository for High Health Status Clones' contains foundation trees of 114 public citrus clones (Appendix 1). A minimum of 1 tree of each variety is held in screen houses in two secure locations at Dareton and Menangle, NSW. The Dareton repository is situated on the Auscitrus property in the Sunraysia citrus growing region. A second repository is housed at NSW DPIRD EMAI, on the outskirts of southwestern Sydney, and is not in a citrus producing area. Repository houses are in two different regions to provide a level of redundancy should a catastrophic event such as fire, storm, vandalism, or disease incursion occur at one of the sites.

The 'National Repository for Inoculated Citrus Clones' contains high health status mother trees that have been graft-inoculated with a mild isolate of CTV. This mild isolate serves to protect against more severe isolates of the virus that may be introduced to trees in the field by aphid vectors. This management tool is called mild strain cross protection. The inoculated trees are housed in a controlled environment greenhouse at EMAI.

Plant maintenance

The foundation trees are maintained using industry best practice. Quarantine mesh is used on the repository screen houses at EMAI and Dareton to exclude insects, most recently repaired/replaced at Dareton in 2020 and replaced at EMAI in June/July 2021. The inoculated clones are maintained in a controlled environment greenhouse. All houses have double entry doorways. The trees are regularly inspected for pest infestation, disease symptoms and off-type shoots. Fruit on foundation trees are observed and photographed and the images are maintained in a database. Strict nursery hygiene is observed during all management activities. Trees are drip irrigated and fertigated. Organic fertiliser is also used at EMAI. The repository houses are secure facilities with access only given to essential staff or external auditors, with approval from Auscitrus.

A tree replacement program is ongoing to create new daughter trees from older foundation trees (more than 20 years of age).

Health status

Before a new variety enters the repository system, a foundation tree is propagated and rigorously tested for graft-transmissible citrus pathogens. A range of biological, serological and molecular methods are used to check the health status of the tree. If a pathogen is detected it must be eliminated by shoot tip grafting before the variety can enter the repository system. This ensures the high health status of trees held in the National Citrus Repositories.

Auscitrus provides the service of pathogen testing and elimination by shoot tip grafting for new varieties selected in Australia, outsourced to the independent EMAI Citrus Pathology team. Imported varieties are tested and undergo pathogen elimination in post-entry quarantine run by DAFF. However, during this project a pilot program involved pathogen elimination of two public varieties at EMAI prior to their release.

After entering the repository system, foundation trees are re-tested for graft-transmissible pathogens by the EMAI citrus pathology team according to a designated schedule. Trees are tested annually for CTV but are scheduled for testing every 5 years for those pathogens not transmitted by insect vectors. This is because the risk of infection with non-vectored pathogens is low for trees managed under strict biosecurity protocols in the repository.

It is important to note that the high health status of repository trees means that no graft-transmissible pathogens have been detected in the trees. These trees have a high health status, but pathogens may be detected in these trees through improved test methods or the discovery of new pathogens.

During the current project, samples were collected from repository trees representing all publicly owned clones. One budstick, with leaves attached, was collected from each quadrant of each tree and grouped to create a sample. Leaf petioles were blotted on nitrocellulose membranes to test for CTV and nucleic acids were extracted from green bark for testing for several endemic and exotic graft-transmissible citrus pathogens.

Table 1 outlines the detection methods used for graft-transmissible citrus pathogens. As new pathogen threats are discovered, diagnostic tools are validated or adopted through project CT21005 prior to adoption by the National Citrus Repository Program, although testing of repository trees serves as part of the validation process.

Table 1: Detection assays used to test trees in the National Citrus Repository

Pathogen	Assay type	Reference
citrus exocortis viroid (CEVd) hop stunt viroid (HSVd or CVd-II) citrus bark cracking viroid (CBCVd or CVd-IV)	multiplex probe-based RT-qPCR	Osman et al. 2017
citrus bent leaf viroid (CBLVd or CVd-I) citrus dwarfing viroid (CDVd or CVd-III) citrus viroid V (CVd-V) citrus viroid VI (CVd-VI) citrus viroid VII (CVd-VII)	multiplex probe-based RT-qPCR	Chambers et al. 2025
citrus tristeza virus (CTV)	direct tissue blot immunoassay	Garnsey et al. 1993
citrus leaf blotch virus (CLBV) citrus psorosis virus (CPsV) apple stem grooving virus (ASGV; citrus tatterleaf)	multiplex probe-based RT-qPCR	Osman et al. 2015 (CLBV) Donovan et al. 2025 adapted from Osman et al. 2015 (CPsV) Donovan et al. 2023 (ASGV)
citrus virus A (CiVA)	RT-PCR	Diaz-Lara et al. 2021
citrus concave gum associated virus (CCGaV)	RT-PCR	
'*Candidatus* Liberibacter asiaticus' (CLas)	qPCR	Li et al. 2006 / Coy et al. 2014 or Qunitana Gonzalez-Chavez et al. 2023
'*Candidatus* Liberibacter africanus' (CLaf)	qPCR	
'*Candidatus* Liberibacter americanus' (CLam)	qPCR	
Xylella fastidiosa subsp. *pauca*	qPCR	Dupas et al. 2019

Citrus tristeza virus (CTV)

CTV is the most devastating viral disease affecting citrus globally and is endemic throughout Australia. There are many isolates of the virus, from mild to severe, causing a range of disease symptoms. The most economically significant symptoms include tree decline and stem pitting.

Every tree in both citrus repositories is tested annually for the presence of CTV using a serological test called direct tissue blot immunoassay (DTBIA) (Garnsey et al. 1993). This test is used to confirm that the virus is not present in the high health status clones and to confirm that the virus is present in every inoculated tree.

Trees are tested for CTV in either autumn or spring. Trees are not tested in winter or summer because viral titre (i.e. the levels of viral particles present in the plant) are affected by temperature and therefore fluctuate across the seasons.

If CTV is not detected in trees in the repository for inoculated clones, they are tagged and re-tested. It is likely that the virus is still present in these plants but at such a low level that it escaped detection. If the tree is still found to be negative upon re-testing the tree is either re-inoculated or discarded. Budwood is only sourced from inoculated trees that have tested positive for CTV during the past year (their most recent test). Each bud stick is blotted before dispatch and tested to confirm the presence of CTV.

Citrus viroids

Eight viroids are known to infect citrus around the world and there are different viroid strains within each of those viroid species; CEVd, citrus bent leaf viroid (CBLVd or CVd-I), HSVd, citrus dwarfing viroid (CDVd or CVd-III), citrus bark cracking viroid (CBCVd), citrus viroid V (CVd-V), citrus viroid VI (CVd-VI) and citrus viroid VII (CVd-VII). Viroids that are known to be most devastating to citrus production are CEVd and a strain of HSVd that causes cachexia (CVd-IIb). CBCVd is a minor pathogen of citrus. All repository trees are scheduled for testing for citrus viroid infection every 5 years (Table 1).

Apple stem grooving virus (ASGV)

ASGV, associated with citrus tatterleaf disease, is known to occur in Australia and causes stunting and chlorosis in infected scions when grafted onto susceptible rootstocks such as *Citrus* (syn. *Poncirus*) *trifoliata*, citrange or Swingle citrumelo. A yellow ring is seen at the bud union of symptomatic trees and may be mistaken for horticultural incompatibility. Repository trees on susceptible rootstocks would show symptoms of stunting, chlorosis and a yellow ring if infected with ASGV and therefore are self-indexing. Repository trees on tolerant (symptomless) rootstocks are scheduled for testing for ASGV every 5 years but in 2025/26 all repository trees were tested (Table 1).

Citrus leaf blotch virus (CLBV)

CLBV, known to occur in Australia, causes a bud union disorder of susceptible scions (such as Nagami kumquat and calamondin) on trifoliate type rootstocks and is known to occur in Australia. Trees are scheduled for testing for CLBV every 5 years (Table 1).

Citrus psorosis virus (CPsV)

CPsV is known to occur in Australia, and infection leads to tree decline and reduced production in susceptible scions. All repository trees are scheduled for testing for CPsV every 5 years (Table 1).

Citrus virus A (CiVA)

CiVA was first reported in Australia in 2022 (Donovan et al. 2022a). Leaf flecking and oak leaf symptoms were observed in a Symons sweet orange plant in the living pathogen collection at EMAI previously identified as CPsV. Gum in the fruit albedo has been reported in association with CiVA infection (Beris et al. 2021), but more work is needed to determine the symptoms associated with CiVA infection in different varieties. Trees are scheduled for testing for CiVA every 5 years (Table 1).

Citrus concave gum associated virus (CCGaV)

CCGaV, first described in citrus in association with symptoms of concave gum-blind pocket (Navarro et al. 2018), is known to occur in citrus in Australia (Donovan et al. 2022b). Trees are scheduled for testing for CCGaV every 5 years (Table 1).

Huanglongbing (HLB)

HLB is one of the most destructive diseases of citrus in the world and one of the major factors limiting citrus production in Southeast Asia, Florida and Brazil. Three forms of HLB have been described in association with phloem-limited bacteria '*Candidatus* Liberibacter asiaticus' (CLas), '*Ca*. L. americanus' (CLam) and '*Ca*. L. africanus' (CLaf); none of which have been recorded in Australia. The pathogen of most concern to Australia, and the one reported to be closest to our shores is the Asiatic strain (CLas). All repository trees are scheduled for testing for the causal agents of HLB prior to entry to the repository (Table 1).

Citrus variegated chlorosis (CVC)

CVC is a serious disease caused by *Xylella fastidiosa* subsp. *pauca*. Symptoms include reduced tree growth and vigour, leaf lesions and defoliation and small, hard fruit. A selection of repository trees were tested for *X. fastidiosa* subsp. *pauca* when validating test molecular methods for Hort Innovation project CT21005 (Table 1).

High-throughput sequencing

High throughput sequencing was used to test five foundation trees (Etrog, Prior Lisbon lemon, Pera Limeira orange, Pera Olympia orange, Salustiana orange) in the EMAI repository.

New introductions to the repository

Graft-transmissible pathogens can be removed from infected mother trees by heat treatment and shoot tip grafting. Successful shoot tip grafted plants then require testing to determine if all known pathogens have been eliminated. Imported varieties are tested and undergo pathogen elimination in post-entry quarantine run by DAFF. Auscitrus provides the service of pathogen testing and elimination by shoot tip grafting for Australian selections using the methods outlined in Table 1, with testing undertaken by NSW DPIRD at EMAI.

When an Australian or imported variety is 'released', the high health status mother tree is placed in one of the repository houses at Menangle or Dareton and a daughter tree is propagated for placement in the other repository house.

Quality assurance

The Auscitrus Board meets annually at EMAI to tour the facilities to ensure industry standards are maintained.

The EMAI repository for high health status citrus clones is accredited as a New Zealand Ministry of Primary Industries (NZ MPI) offshore quarantine facility for the introduction of new citrus varieties to NZ. A re-accreditation audit was undertaken by NZ MPI in October 2023 and is scheduled for November 2026.

Results and discussion

National Citrus Repositories

Table 2 details the number of publicly owned clones of each citrus type currently housed in the 'National Citrus Repository for High Health Status Clones' that were supported by the current project.

Appendix 1 provides a full list of public varieties, also published each year in the Auscitrus Annual Report (https://auscitrus.com.au/services/). The annual report will also list the total distribution of budwood from the daughter trees grown from repository material, indicating the widespread benefit of this project.

Table 2: The number of publicly owned clones of each citrus type housed in the National Citrus Repository for High Health Status Clones (as of July 2026)

Citrus type	No. publicly owned clones
orange	41
mandarin and hybrids	25
grapefruit	7
pomelo	2
lime	2
lemon	8
citron	2
papeda	5
kumquat	5
sour orange and hybrids	1
rootstocks	16
TOTAL	114

Trueness to type testing

The foliage and fruit of new varieties are checked for trueness to type. Images are taken of fruit produced on repository trees of new varieties.

Health status testing

No CTV was detected in foundation trees in the 'National Citrus Repository for High Health Status Citrus Clones' using DTBIA.

All trees in the 'National Repository for Inoculated Citrus Clones' tested positive for CTV each year from 2021 to 2026 using DTBIA, except for those outlined in Table 3. Some trees were weakly positive but viral particles were still detected. Backup trees have been propagated and budwood is only sourced from inoculated trees that test positive for CTV during their last test.

Table 3: Publicly owned citrus clones where citrus tristeza virus (CTV) has been difficult to detect in inoculated repository trees using direct tissue blot immunoassay

Testing year	Public citrus clones inoculated with a mild strain of CTV where CTV was not detected in at least one inoculated tree
2022	-
2023	Delta seedless
2024	-
2025	K15 pomelo Avana Apireno*, Pera Limeira*, Pera Olympia*
2026	Bintangcheng Renbin #5, Ray Ruby Avana Apireno*, Clementine (Fina)*, CSIRO 5*, Newhall (Spain)*, Sisi Aissa*

* Clones no longer in the repository program as of July 2026

No citrus viroids (CEVd, CBLVd, HSVd, CDVd, CBCVd, CVd-V, CVd-VI, CVd-VII) were detected using molecular methods in samples collected from the repository trees of public varieties.

No symptoms consistent with citrus tatterleaf disease were observed in repository trees of public varieties on susceptible rootstocks. ASGV, CLBV, CPsV, CCGaV and CiVA were not detected in repository trees of public varieties using molecular test methods, except in one variety which has been removed from the program. Pera Limeira tested positive for CiVA using an improved detection method (Diaz-Lara et al. 2021) and the detection was confirmed using high-throughput sequencing.

Exotic pathogens '*Ca*. Liberibacter asiaticus', '*Ca*. L. africanus' and '*Ca*. L. americanus' and *X. fastidiosa* subsp. *pauca* were not detected in repository trees of public varieties using molecular test methods.

No pathogens were detected in Etrog, Prior Lisbon lemon, Pera Olympia orange, and Salustiana orange trees using high-throughput sequencing.

New introductions to the repository

Table 4 outlines the new introductions to the 'National Citrus Repository for High Health Status Clones' from July 2021 to June 2026.

Table 4: Publicly owned citrus clones introduced to the repository system from July 2021 to June 2026

Accession number	Clone	Year entered repository	Source
Scion varieties			
I.N.23.1113	Yura satsuma mandarin	2023	South Korea
I.N.23.1114	Hiroshima 7 satsuma mandarin	2023	South Korea
A.N.23.1115	Maltese blood orange	2023	NSW
A.N.23.1116	Australian sweet lime	2023	NSW
A.N.26.1150	Variegated calamondin	2026	NSW
A.Q.26.1153	Calamansi	2026	NSW
A.N.26.1154	Musk lime	2026	NSW
Rootstock varieties			
A.N.23.1109	West Indian lime	2023	NSW
A.N.23.1110	*Citrus macrophylla*	2023	NSW
A.N.23.1122	Troyer citrange	2023	NSW
A.N.23.1123	Trifoliata	2023	NSW
A.N.23.1124	C35 citrange	2023	NSW
A.N.23.1125	Carrizo citrange	2023	NSW
A.N.23.1126	Cox citrange	2023	NSW
A.N.23.1127	Cleopatra mandarin	2023	NSW
I.N.24.1134	C22 citrange	2024	United States
A.N.24.1136	Rough lemon	2024	NSW
A.N.24.1137	Volkameriana	2024	NSW
A.N.24.1138	Rangpur lime	2024	NSW
A.N.24.1139	Barkley	2024	NSW
A.N.24.1140	Swingle citrumelo	2024	NSW
A.N.26.1152	Flying dragon	2026	NSW

Budwood exports

Budwood was sourced from both EMAI and Dareton repository trees over the course of the project, to establish new budwood or seed multiplication trees for subsequent distribution of propagation material to the wider citrus and nursery industries.

Budwood of Tarocco Ippolito was sent to Chile in 2023 from the Dareton repository screen house for high health status clones.

Communication

Communication activities were delivered by project team members to disseminate the message about the importance of citrus biosecurity, graft-transmissible diseases and the health status of Australian citrus germplasm (Appendix 3). Multiple groups have also visited the Auscitrus facility and EMAI and, whilst they are not allowed to enter the repository houses, they are given an overview of the program.

Outputs

Table 5. Output summary

Output	Description	Detail
Propagation material	High health status, true-to-type budwood of publicly owned citrus scion and rootstock varieties (114)	Table 4 outlines the new varietal introductions during the project term. Appendix 1 outlines the current varieties in the National Citrus Repository and the date of their most recent pathogen tests. Appendix 2 outlines the varieties removed from the National Citrus Repository during the project term and the date of their most recent pathogen tests. Buds are collected from repository trees for propagation of source trees for supply of budwood and rootstock seed to industry – available for purchase from Auscitrus (www.auscitrus.com.au). Over the past 5 years, 3.9 million buds of public varieties have been distributed by Auscitrus, predominantly from daughter trees established from foundation tree budwood sourced from the repository.
Publications and presentations	Publications and presentations to scientific and industry audiences	The National Citrus Repository Program was communicated at scientific and industry forums and through written communications to raise awareness of the importance of citrus biosecurity, prevention and management of graft-transmissible diseases and the health status of Australian citrus germplasm. Communication outputs are listed in Appendix 3.

Outcomes

Table 6. Outcome summary

Outcome	Alignment to fund outcome, strategy and KPI	Description	Evidence
Intermediate outcomes			
Trees tested routinely for viruses, viroids, trueness to type	**O1S1K5** Outcome 1: Protect the production base Strategy 1: Improve industry preparedness, responsiveness and resilience to biosecurity threats including plant material, including contingency plans against exotic threats, diagnostic capacity, strong post-entry quarantine capacity, a register of nurseries, and budwood traceability systems. KPI: Improved industry responsiveness to biosecurity incursions through better traceability systems (e.g., budwood, nursery stock).	High health status and inoculated repository trees tested for trueness to type and graft-transmissible pathogens (8 viroids, 6 viruses and 4 exotic bacteria).	Most recent pathogen test date for each variety in Appendices 1 and 2
Trees maintained with adequate high health budwood to support the citrus budwood scheme		Trees maintained in biosecure screenhouses at Dareton and EMAI under best practice management for nutrition and irrigation.	114 varieties maintained at 2 sites, including 22 new varieties over the project term.
Citrus budwood scheme multiplication trees established from high health true to type foundation budwood		High health and true to type budwood used to propagate budwood multiplication trees for supply to industry. Budwood multiplication trees either planted in the field or kept in biosecure houses.	Bud sales of public varieties reported in Auscitrus Annual Reports. [Annual Reports - Auscitrus]
Not in M&E plan Capability for managing citrus biosecurity threats		The foundation trees will serve as a readily available source of health-tested, true-to-type propagation material to rebuild the industry in the event of an incursion of an emergency plant pest.	114 varieties covering all citrus types
Not in M&E plan General awareness activities include the importance of high health planting material	**O3S1** Outcome 3: Communication, extension and capability Strategy 1: Deliver communication and extension programs to create positive change in the areas of biosecurity preparedness, varieties that meet consumer demand, sustainable production, pest and disease management, and export protocols and markets	Extension activities undertaken throughout the project (in conjunction with project CT21005) have increased biosecurity awareness of the importance of using health-tested and true-to-type budwood due to exotic and established disease threats.	Presentations, reports and publications outlined in Appendix 3

End of project outcomes			
Provide a disease-free source of genetic material protected from insects associated with disease transmission.	**O1S1K5**	A high health status source of genetic material maintained and protected from insects associated with disease transmission.	High health status and inoculated trees of 114 varieties maintained in biosecure houses under best practice management at 2 sites and used to propagate budwood multiplication trees for industry supply.

Monitoring and evaluation

Table 7. Key Evaluation Questions

Key Evaluation Question		Project performance	Continuous improvement opportunities
Effectiveness			
1. To what extent has the project achieved its expected outcomes?	Has routine testing been carried out?	Foundation trees were tested for endemic graft-transmissible pathogens (14) and for exotic pathogens prior to entry to the repository (4)	Improved detection methods identified in Hort Innovation project CT21005
	Have the trees and insect-screened structures been maintained?	Foundation trees were maintained in biosecure structures using best practice management. Quarantine mesh was replaced at Dareton in 2020 and EMAI in 2021.	Continual inspection of infrastructure identifies when repairs are needed. Auscitrus Board members include practicing nursery operators who inspect both sites at least annually and make recommendations for improvement. The cooling system at Dareton was renovated/partially replaced in 2021. Maintenance will continue subject to available funding.
	Have extension activities been carried out	Extension activities were undertaken in conjunction with project CT21005 to increase awareness of the importance of using health-tested and true-to-type budwood due to exotic and established disease threats.	Communication and engagement will continue.

Relevance			
2. How relevant was the project to the needs of intended beneficiaries?	Does the foundation repository provide a suitable source of clean material for the budwood schemes purposes?	Auscitrus was able to access healthy material for propagation of daughter trees to be used as a healthy budwood source for nurseries and growers around Australia.	The repository is the only form of graft-transmissible disease prevention and management and is an insurance policy in the event of an incursion of a new disease.
Process appropriateness			
3. How well have intended beneficiaries been engaged in the project?	Is the management committee of the budwood scheme satisfied with the resource provided by it?	The Auscitrus Board, comprised of citrus nurserymen and growers, are provided with updates at each quarterly meeting, as well as via the Auscitrus annual report, and inspect the repository facility at both sites at least annually. No concerns have been raised.	Sectors of the industry have been closely engaged with the project, but this could be strengthened by continued engagement activities.
	Is the industry aware of the need to use high health planting material?	Extension activities undertaken throughout the project (in conjunction with project CT21005) have increased awareness of the importance of using health-tested and true-to-type budwood due to exotic and established disease threats.	It is important to continue to raise awareness of citrus biosecurity threats.
4. To what extent were engagement processes appropriate to the target audience/s of the project?		Outputs are communicated to Auscitrus quarterly, and to the larger industry via the Auscitrus annual report and articles in industry publications. Outputs are also highlighted during presentations at industry forums such as the Citrus Australia Australian Citrus Congresses.	Industry engagement occurs across platforms and will continue.
Efficiency			
5. What efforts did the project make to improve efficiency?		Hort Innovation funded projects CT17007 and CT21005, led by the NSW DPIRD Citrus Pathology Program, provided the opportunity to assess current and new procedures for detection of graft-transmissible citrus pathogens to ensure we are using the most reliable, sensitive and efficient	Diagnostic procedures will continue to be reviewed through project CT21005 until May 2027. The varieties included in the repository will undergo regular review with consideration of past and current budwood demand by industry and the community, if there are

		methods available. Testing of nucleic acid extracts from repository trees, or local varieties submitted for pathogen testing and elimination, provided further validation of the diagnostic assays. The varieties included in the repository were reviewed and 40 varieties were removed, reducing the cost of maintenance and testing.	other varieties that could serve as a substitute, and new pathogen detections in a variety. However, it is not possible to accurately predict potential demand and the commercial relevance, as measured by bud sales, does not fully recognize the biosecurity benefit.

Recommendations

The National Citrus Repository Program should be considered an ongoing commitment, with a long-term view to the maintenance of this industry resource.

- The value of the citrus repositories should continue to be recognized in industry biosecurity plans as a resource of high health status material available in the event of an incursion of an exotic graft-transmissible disease.
- To maximise the return on this investment, the use of high health status propagation material supplied from daughter trees of this repository via the Auscitrus budwood scheme should be supported by the citrus industry and actively promoted to growers.
- All varieties included in the repository program should be tested for newly discovered pathogens as they are reported, even if discovered outside of Australia, to track whether the new pathogen has been distributed nationally in Auscitrus budwood.

The National Citrus Repository Program is one component of an integrated biosecurity program. The biosecurity risk to the Australian industry from graft-transmissible citrus diseases would be further reduced by:

- the introduction of a mandatory certification scheme across all states and territories governing the use of health tested propagation material, supported by the newly developed Citrus Nursery Stock Specification for nurseries who use Auscitrus material.
- a nursery registration system to allow the tracking of 'at risk' commodities like citrus and orange jasmine; given orange jasmine is the preferred host of the Asiatic citrus psyllid associated with transmission of HLB.

These initiatives will only be successful if supported by industry and, in conjunction with existing biosecurity strategies, will help to maintain the high health status of Australian citrus germplasm and allow industry and government to respond efficiently to disease threats.

Refereed scientific publications

The following publications were not direct outputs from this project but were delivered by project team members to disseminate the message about the importance of citrus biosecurity, management of graft-transmissible diseases and the health status of Australian citrus germplasm.

Journal article

Donovan NJ, Herrmann T, ADW Geering. 2026. History and evolution of the Auscitrus budwood scheme. Journal of Citrus Pathology 13(1) DOI: 10.5070/C4.61329

Chambers GA, Geering ADW, Holford P, Vidalakis G, Donovan NJ. 2025. Development and application of a multiplex RT-qPCR assay detecting citrus apscaviroids in viroid surveys of Australian citrus. Australasian Plant Pathology 54: 559-568 DOI: 10.1007/s13313-025-01072-z

Chambers GA, Englezou A, Donovan N. 2025. First report of citrus-associated rhabdovirus in Australia in citrus. Plant Disease 109(1) DOI: 10.1094/PDIS-09-24-1969-PDN

Donovan NJ, Chambers GA, Englezou A, Forbes W, Dando A, Holford P. 2022. First report of citrus virus A in Australia. Journal of Citrus Pathology 9 DOI: 10.5070/C49157292

Paper in conference proceedings

Donovan NJ, Herrmann T. 2025. History and evolution of the Auscitrus budwood scheme. Abstracts XXIII Conference of the International Organization of Citrus Virologists, Mildura Australia. 16-20 March 2025. Journal of Citrus Pathology 12(2):43. DOI: 10.5070/C4.61717

Chambers GA, Englezou A, Vidalakis G, Holford P, Geering A, Donovan NJ. 2025. Determining citrus viroid prevalence in Australia with multiplex RT-qPCR assays. Abstracts XXIII Conference of the International Organization of Citrus Virologists, Mildura Australia. 16-20 March 2025. Journal of Citrus Pathology 12(2):46. DOI:10.5070/C4.61717

Donovan N, Lye J, Herrmann T. 2024. Best foot forward: Australian efforts to stay in front of HLB. Abstracts 2024 International Research Conference on Huanglongbing VII. Journal of Citrus Pathology 11(1):57. DOI: 10.5070/C411163652

Donovan NJ, Chambers GA. 2022. Viroids in Australasia. Abstracts of the XXII International Organization of Citrus Virologists Conference, online 7, 14, 21 and 28 September 2022. Journal of Citrus Pathology 9(2):8. DOI: 10.5070/C4.46540

Intellectual property

There is shared IP with Hort Innovation associated with project reports, extension articles and other publications.

There are no project IP, project outputs, commercialisation or confidentiality issues to report.

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Thank you to citrus growers, nurserymen and representatives of the Australian citrus industry for their valuable feedback and guidance after discussing the project at industry forums.

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Diaz-Lara A, Wunderlich L, Nouri M, Golino D, Rwahnih M. 2021. Incidence and detection of negative-stranded RNA viruses infecting apple and pear trees in California. Journal of Phytopathology 170:15-20 DOI: 10.1111/jph.13051

Donovan, N., Chambers, G., Englezou, A., Forbes, W., Dando, A., Holford, P. 2022a. First report of citrus virus A in Australia. Journal of Citrus Pathology 9. DOI: 10.5070/C49157292

Donovan N, Chambers G, Englezou A, Holford P. 2022b. Improving diagnostics and biosecurity for graft-transmissible diseases in citrus. Horticulture Innovation Australia ISBN 978-0-7341-4833-9

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Appendices

Appendix 1: Public varieties in the 'National Citrus Repository for High Health Status Clones' as of June 2026 and date of most recent pathogen testing for citrus viroids (citrus exocortis viroid, citrus bent leaf viroid, hop stunt viroid, citrus dwarfing viroid, citrus bark cracking viroid, citrus viroid V, citrus viroid VI, citrus viroid VII), citrus viruses (citrus tristeza virus, apple stem grooving virus, citrus leaf blotch virus, citrus psorosis virus, citrus virus A, citrus concave gum associated virus) and the causal agents of huanglongbing (HLB) ('*Candidatus* Liberibacter asiaticus', '*Ca*. L. africanus' and '*Ca*. L. americanus') and citrus variegated chlorosis (CVC; *Xylella fastidiosa* subsp. *pauca*).

Appendix 2: Public varieties in the 'National Citrus Repository for High Health Status Clones' removed from the repository during the project term to reduce costs. These varieties were reviewed and determined not to have future relevance for industry. Date of most recent pathogen testing for citrus viroids (citrus exocortis viroid, citrus bent leaf viroid, hop stunt viroid, citrus dwarfing viroid, citrus bark cracking viroid, citrus viroid V, citrus viroid VI, citrus viroid VII), citrus viruses (citrus tristeza virus, apple stem grooving virus, citrus leaf blotch virus, citrus psorosis virus, citrus virus A, citrus concave gum associated virus) and the causal agents of huanglongbing (HLB) ('*Candidatus* Liberibacter asiaticus', '*Ca*. L. africanus' and '*Ca*. L. americanus').

Appendix 3: Publications, reports and presentations that are not all direct outputs from this project but were delivered by project team members to disseminate the message about the importance of citrus biosecurity, management of graft-transmissible diseases and the health status of Australian citrus germplasm.

Appendix 1: Public varieties in the 'National Citrus Repository for High Health Status Clones' as of June 2026 and date of most recent pathogen testing *

Accession No.	Variety	Date of most recent test*		
		Viroids / viruses	HLB	CVC
Grapefruit				
I.N.91.0736	Flame	05/05/2026	02/06/2021	
A.N.73.0068	Marsh (3970 Druitt)	20/04/2026	18/02/2015	
A.N.91.0632	Marsh (3962 Druitt)	20/04/2026	18/02/2015	
I.N.89.0619	Ray Ruby	20/04/2026	18/02/2015	
I.N.89.0708	Rio Red	20/04/2026	11/03/2015	
I.N.89.0709	Star Ruby	20/04/2026	18/02/2015	
A.N.04.0950	Star Ruby (Cant)	20/04/2026	11/03/2015	
Pomelo				
A.Q.19.1061	K15	05/05/2026	24/06/2019	
I.N.01.0925	Namroi	21/04/2026	02/06/2021	
Citron				
I.N.94.0904	Buddha's Hand	21/04/2026	11/03/2015	
I.N.09.0979	Etrog	21/04/2026	11/03/2015	
Lemon				
I.N.01.0927	Eureka (Allen)	21/04/2026	29/10/2014	
A.N.75.0035	Eureka (Taylor)	20/04/2026	29/10/2014	
I.N.89.0703	Fino	20/04/2026	29/10/2014	
A.Q.93.0785	Lemonade	21/04/2026	29/10/2014	
I.N.00.0918	Lisbon (Limoneira 8A)	20/04/2026	29/10/2014	
I.N.75.0036	Lisbon (Prior)	20/04/2026	29/10/2014	
A.NT.15.1032	Tropical Meyer	05/05/2026	29/10/2014	
I.N.89.0705	Verna	20/04/2026	29/10/2014	
Lime				
A.N.23.1116	Australian Sweet Lime	14/05/2026	24/05/2023	24/05/2023
A.N.08.0969	Tahiti lime	21/04/2026	18/02/2015	
Orange				
A.S.10.0985	Arnold blood	21/04/2026	08/12/2014	
I.N.86.0600	Atwood	20/04/2026	11/02/2015	
A.N.94.0783	Barnfield	20/04/2026		
A.Q.75.4022	Benyenda (Valencia)	21/04/2026	08/12/2014	
A.Q.78.4021	Benyenda – thorny (navel)	21/04/2026	12/11/2014	
A.S.94.0782	Berri 3501	20/04/2026	08/12/2014	
I.N.06.0960	Bintangcheng # 2	21/04/2026	12/11/2014	
I.N.08.0973	Bintangcheng Renbin # 5	21/04/2026	12/11/2014	
I.N.97.0924	Cara Cara	21/04/2026	18/02/2015	
A.N.14.0993	Cara Cara new	21/04/2026	01/05/2015	
I.N.94.0902	Delta seedless	20/04/2026	08/12/2014	
I.N.86.0597	Fisher	20/04/2026	11/02/2015	
I.N.86.0548	Hamlin	20/04/2026	29/10/2014	
A.S.75.5077	Hockney	21/04/2026	12/11/2014	
A.N.73.0073	Houghton	20/04/2026	11/02/2015	
I.N.02.0930	Jaffa	05/05/2026	27/03/2018	
A.N.75.0032	Lanes Late 3976	21/04/2026	12/11/2014	
A.N.73.0072	Leng	21/04/2026	11/02/2015	
I.N.92.0901	Lima 156 (acidless orange)	21/04/2026	29/10/2014	
A.N.23.1115	Maltese Blood	14/05/2026	21/06/2023	21/06/2023
I.N.94.0903	Midknight	20/04/2026	08/12/2014	
I.N.92.0900	Natal	20/04/2026	12/11/2014	
I.N.87.0546	Navelina Spain 7.5	20/04/2026	12/11/2014	
I.N.93.0899	Navelina 315 ex Italy	20/04/2026	12/11/2014	

Accession No.	Variety	Date of most recent test*		
		Viroids / viruses	HLB	CVC
Orange cont.				
A.S.92.0773	Neilson	20/04/2026	12/11/2014	
I.N.86.0598	Newhall California	20/04/2026	29/10/2014	
A.N.75.0029	Newton – Keenan 3125	20/04/2026	03/06/2019	
A.N.75.0030	Newton – Keenan 3247	21/04/2026	02/06/2021	
A.N.94.0844	Nugan	21/04/2026		
I.N.10.0984	Palmer 1051	21/04/2026	11/02/2015	
I.N.86.0549	Parson Brown	20/04/2026	18/02/2015	
A.N.94.0784	Pasin	21/04/2026	21/04/2026	21/04/2026
I.N.90.0739	Pera Bianchi	21/04/2026	21/04/2015	
I.N.87.0547	Pineapple	20/04/2026	11/02/2015	
A.S.17.1043	Poorman's orange	05/05/2026	30/04/2018	
I.N.93.0860	Salustiana	21/04/2026	18/02/2015	
I.N.98.0921	Sanguine	20/04/2026	29/10/2014	
I.N.08.0968	Tarocco Ippolito	21/04/2026	11/02/2015	
I.N.07.0965	Tarocco Meli C8158	21/04/2026	08/12/2014	
I.N.07.0966	Tarocco Rosso C4977	21/04/2026	12/11/2014	
A.S.75.5074	Thomson	21/04/2026	11/02/2015	
Mandarins and hybrids				
I.N.99.0909	Afourer	21/04/2026	20/01/2015	
I.N.99.0913	Avana Tardivo	20/04/2026	20/01/2015	
I.N.91.0770	Clementine (Arrufatina)	20/04/2026	20/04/2026	20/04/2026
I.N.98.0920	Clementine (Caffin)	21/04/2026	20/01/2015	
I.N.91.0740	Clementine (Hernandina)	20/04/2026	20/04/2026	20/04/2026
I.N.87.0543	Clementine (Nules)	20/04/2026	20/01/2015	
I.N.91.0733	Daisy	20/04/2026	03/02/2015	
A.N.75.0090	Ellendale (Herps)	20/04/2026	11/02/2015	
A.Q.94.0777	Eloise	20/04/2026	20/04/2026	20/04/2026
A.Q.94.0787	Fremont	20/04/2026	03/02/2015	
A.N.75.0041	Hickson	20/04/2026	03/02/2015	
A.N.75.0043	Imperial 0043/2	20/04/2026	03/02/2019	
A.Q.90.4149	Murcott tangor (Turner)	20/04/2026	29/03/2018	
I.N.91.0734	Nova (Spain)	21/04/2026	08/12/2014	
I.N.86.0599	Pixie	20/04/2026	08/12/2014	
I.N.23.1114	Satsuma (Hiroshima 7)	12/01/2023	12/01/2023	12/01/2023
I.N.91.0853	Satsuma (Miho Wase)	20/04/2026	11/02/2015	
I.N.91.0852	Satsuma (Okitsu Wase)	20/04/2026	03/02/2015	
A.N.75.0065	Satsuma (Silverhill)	20/04/2026	30/06/2019	
I.N.23.1113	Satsuma (Yura)	14/05/2026	23/02/2024	23/02/2024
I.N.20.1068	Shiranui	05/05/2026	02/06/2021	23/02/2024
A.Q.04.0949	Success	20/04/2026	20/04/2026	20/04/2026
I.N.90.0818	Topaz tangor	20/04/2026	11/02/2015	
A.NT.15.1034	Tropical Emperor	05/05/2026	27/03/2018	
I.N.98.0919	Tsunokaori	20/04/2026	20/04/2026	20/04/2026
Kumquat				
A.Q.26.1152	Calamansi	08/07/2026	08/07/2026	08/07/2026
A.N.15.1033	Calamondin	05/05/2026	27/03/2018	
A.N.26.1153	Musk lime	08/07/2026	08/07/2026	08/07/2026
I.N.04.0956	Nagami	21/04/2026	29/10/2014	
A.N.26.1150	Variegated calamondin	07/11/2025	07/11/2025	07/11/2025
Papeda				
I.N.00.0916	Eyles Thai lime (syn. kaffir)	20/04/2026	18/02/2015	
I.N.94.0776	Malaysia 4669 Thai lime (syn. kaffir)	20/04/2026	18/02/2015	
A.D.97.0907	Nathanael Thai lime (syn. kaffir)	20/04/2026	18/02/2015	
I.N.15.1020	Sudachi	05/05/2026	27/03/2018	
A.N.13.0991	Yuzu	21/04/2026	01/05/2015	
Sour orange and hybrids				
I.N.01.0926	Bergamia Bergamot Castagnaro	21/04/2026	18/02/2015	

Accession No.	Variety	Date of most recent test*		
		Viroids / viruses	HLB	CVC
Rootstock				
A.N.24.1139	Barkley	14/05/2026	30/10/2024	
A.N.18.1054	Benton citrange	05/05/2026	29/05/2018	
I.N.24.1134	C22	14/05/2026	14/05/2026	14/05/2026
A.N.23.1124	C35 citrange	14/05/2026	03/11/2023	03/11/2023
A.N.23.1125	Carrizo citrange	14/05/2026	06/12/2023	06/12/2023
A.N.23.1110	*Citrus macrophylla*	14/05/2026	12/01/2023	12/01/2023
A.N.23.1127	Cleopatra mandarin	14/05/2026	06/12/2023	06/12/2023
A.N.23.1126	Cox citrange	14/05/2026	03/11/2023	03/11/2023
A.N.26.1151	Flying Dragon	08/07/2026	08/07/2026	08/07/2026
A.N.24.1138	Rangpur lime	14/05/2026	05/07/2024	05/07/2024
A.N.24.1136	Rough lemon	14/05/2026	20/05/2024	20/05/2024
A.N.24.1140	Swingle citrumelo	14/05/2026	14/05/2026	14/05/2026
A.N.23.1122	Troyer citrange	14/05/2026	18/10/2023	18/10/2023
A.N.23.1123	*Citrus (Poncitrus) trifoliata*	14/05/2026	03/11/2023	03/11/2023
A.N.24.1137	Volkameriana	14/05/2026	20/05/2024	20/05/2024
A.N.23.1109	West Indian lime	14/05/2026	06/12/2022	06/12/2022

* Date of nucleic acid extraction, not the date of individual pathogen assays, for citrus viroids (citrus exocortis viroid, citrus bent leaf viroid, hop stunt viroid, citrus dwarfing viroid, citrus bark cracking viroid, citrus viroid V, citrus viroid VI, citrus viroid VII), citrus viruses (citrus tristeza virus, apple stem grooving virus, citrus leaf blotch virus, citrus psorosis virus, citrus virus A, citrus concave gum associated virus) and the causal agents of huanglongbing (HLB; '*Candidatus* Liberibacter asiaticus', '*Ca*. L. africanus' and '*Ca*. L. americanus') and citrus variegated chlorosis (CVC; *Xylella fastidiosa* subsp. *pauca*).

Appendix 2: Public varieties in the 'National Citrus Repository for High Health Status Clones' removed from the repository during the project term to reduce costs. These varieties were reviewed and determined not to have future relevance for industry.

Accession No.	**Variety**	**Date of most recent test***	
		Viroids / viruses	**HLB**
Grapefruit			
I.N.89.0620	Henderson	20/04/2026	30/06/2019
A.N.91.0633	Thompson (Eagle)	20/04/2026	18/02/2015
Pomelo			
I.N.94.0786	Tambun (4670)	20/04/2026	29/10/2014
Lemon			
A.N.75.0034	Eureka (Lambert)	20/04/2026	29/10/2014
A.Q.91.0631	Lisbon (Queensland)	20/04/2026	29/10/2014
Lime			
A.N.90.0771	Schweppes	20/04/2026	18/02/2015
Orange			
A.S.75.5095	B/3010	20/04/2026	08/02/2014
A.V.94.0780	CSIRO 5	20/04/2026	03/02/2015
I.N.99.0912	Fukumoto	21/04/2026	29/10/2014
A.S.92.0772	Hutton	21/04/2026	11/02/2015
A.V.93.0774	Jenner 4439	20/04/2026	03/02/2015
I.N.06.0959	Jincheng	21/04/2026	29/10/2014
A.V.94.0781	Leng (Lloyd 3)	21/04/2026	12/11/2014
I.N.86.0550	Navelate	20/04/2026	12/11/2014
I.N.87.0551	Newhall (55-1 Spanish)	20/04/2026	12/11/2014
I.N.90.0742	Pera Limeira	21/04/2026	18/02/2015
I.N.90.0741	Pera Olympia	20/04/2026	11/02/2015
A.Q.78.4020	Smith (Joppa)	21/04/2026	12/11/2014
Mandarin and hybrids			
I.N.99.0914	Avano apireno	20/04/2026	20/01/2015
I.N.89.0704	Clementine (Clementard)	20/04/2026	20/01/2015
I.N.99.0910	Clementine (Corsica 1)	20/04/2026	03/02/2015
I.N.99.0911	Clementine (Corsica 2)	20/04/2026	20/01/2015
I.N.87.0544	Clementine (Fina)	20/04/2026	03/02/2015
I.N.87.0552	Clementine (Marisol)	20/04/2026	20/01/2015
I.N.05.0957	Clementine (Nour)	21/04/2026	08/12/2014
I.N.04.0955	Clementine (Orogrande)	21/04/2026	03/02/2015
I.N.87.0545	Clementine (Oroval)	20/04/2026	08/12/2014
I.N.04.0953	Clementine (Sidi Aissa)	21/04/2026	20/01/2015
	Ellendale / EM3	21/04/2026	11/02/2015
I.N.90.0736	Encore	20/04/2026	20/01/2015
I.N.90.0695	Fallglo (S-837-4-2)	21/04/2026	20/01/2015
I.N.89.0707	Fallglo (VI 484)	20/04/2026	20/01/2015
I.N.93.0859	Fortune	20/04/2026	09/07/2019
A.Q.04.0952	Murcott tangor (Benham)	20/04/2026	02/06/2021
A.Q.94.0778	Nova (Trott)	21/04/2026	08/12/2014
I.N.04.0951	Parsons Special	21/04/2026	20/01/2015
I.N.04.0954	Primosole	21/04/2026	03/02/2015
I.N.89.0706	Satsuma (Clausellina)	20/04/2026	03/02/2015
I.N.08.0974	Satsuma (Etna)	21/04/2026	20/01/2015
A.Q.94.0886	Sunburst	20/04/2026	08/12/2014

*Date of nucleic acid extraction, not the date of individual pathogen assays, for citrus viroids (citrus exocortis viroid, citrus bent leaf viroid, hop stunt viroid, citrus dwarfing viroid, citrus bark cracking viroid, citrus viroid V, citrus viroid VI, citrus viroid VII), citrus viruses (citrus tristeza virus, apple stem grooving virus, citrus leaf blotch virus, citrus psorosis virus, citrus virus A, citrus concave gum associated virus) and the causal agents of huanglongbing (HLB) ('*Candidatus* Liberibacter asiaticus', '*Ca*. L. africanus' and '*Ca*. L. americanus').

Appendix 3: Publications, reports and presentations that are not all direct outputs from this project but were delivered by project team members to disseminate the message about the importance of citrus biosecurity, management of graft-transmissible diseases and the health status of Australian citrus germplasm.

Industry publications

Donovan N, Herrmann T. 2026. Risky business: the cost of not using healthy citrus budwood and seed. Submitted for publishing in citrus industry media.

Creek A, Donovan N, Falivene S, Golding J, Mahmud K, Khurshid T, Thakur M and Monks D. 2025. Citrus plant protection guide, NSW Primary Industries and Regional Development, Orange.

Fattore A, Creek A, Donovan N, Thakur M, Weppler R, Pattison E, Falivene S and Johnstone R. 2025. Pests, beneficials, diseases and disorders in citrus: a field identification guide. NSW Department of Primary Industries and Regional Development, Orange.

Creek A, Donovan N, Falivene S, Golding J, Mahmud K, Khurshid T, Mo J and Monks D. 2024. Citrus plant protection guide, NSW Department of Primary Industries and Regional Development, Orange. Citrus plant protection guide 2024

Thakur M, Donovan N, Lye J, Mo J. 2024. Citrus Huanglongbing. Primefact PUB24/1029, first edition. New South Wales Department of Primary Industries and Regional Development and Citrus Australia Limited. https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/1594768/Citrus-Huanglongbing.pdf

Fattore A, Donovan N. 2024. Citrus Diseases. Poster. Hort Innovation. https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0008/1580723/Citrus-diseases-poster.pdf

Fattore, A, Donovan N. 2024. Huanglongbing. Fact sheet. Hort Innovation. https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/1564179/Huanglongbing.pdf

How high-health citrus nursery material reduces your risk. Jessica Lye. Australian Citrus News, Issue 3 2024 p 26-28. Article prepared in consultation with Tim Herrmann and Nerida Donovan.

Creek A, Donovan N, Falivene S, Golding J, Mahmud K, Khurshid T, Mo J and Monks D. 2023. 'Citrus plant protection guide', NSW Department of Primary Industries, Orange

Johnstone R, Donovan N. 2023. Skill up on how to best protect your trees from diseases with tips from citrus pathologist Dr Nerida Donovan. WA Grower Winter 2023 p 76-77 https://wagrower.vegetableswa.com.au/collections/wa-grower-winter2023/disease-management

Reducing risks posed by imported budwood. Jessica Lye, Australian Citrus News, Issue 3 2023 p 31-33. ACN-2023-3-FINAL-web.pdf (citrusaustralia.com.au). Article prepared in consultation with Tim Herrmann and Nerida Donovan.

Donovan N, Creek A. 2021. Diseases and disorders. In: Citrus Plant Protection and Management Guide 2021-22 pp 51-62. Eds: Falivene S, Creek A. State of New South Wales through NSW Department of Industry. ISSN – 2208-5963 (print) ISSN – 2208-5971 (online).

Donovan N, Sanderson G, Falivene S (2021) Budwood and graft-transmissible disease. In: Citrus Plant Protection and Management Guide 2021-22 pp 69. Eds: Falivene S, Creek A. State of New South Wales through NSW Department of Industry. ISSN – 2208-5963 (print) ISSN – 2208-5971 (online).

Industry reports

Donovan N, Forbes W. 2026. Auscitrus operations at EMAI. Australian Citrus Propagation Association Inc Annual Report 2026. In press

Donovan N, Forbes W. 2025. Auscitrus operations at EMAI. Australian Citrus Propagation Association Inc Annual Report 2025. pp 11-15

Donovan N, Dando A, Forbes W. 2024. Auscitrus operations at EMAI. Australian Citrus Propagation Association Inc Annual Report 2024. pp 7-9, 11-12

Donovan N, Dando A, Forbes W. 2023. Auscitrus operations at EMAI. Australian Citrus Propagation Association Inc Annual Report 2023. pp 9-14

Donovan N, Dando A, Forbes W. 2022. Auscitrus operations at EMAI. Australian Citrus Propagation Association Inc Annual Report 2022. pp 8-11

Donovan N, Dando A, Forbes W. 2021. Auscitrus operations at EMAI. Australian Citrus Propagation Association Inc Annual Report 2021. pp 8-10

Industry forums

Donovan N. Global snapshot of citrus diseases. Australian Citrus Congress. Adelaide, Australia 2-4 March 2026

Chambers G, Geering ADW, Englezou A, Holford P, Vidalakis G, Donovan N. Viroids in Australian citriculture – where are they? Australian Citrus Congress. Adelaide, Australia 2-4 March 2026

Herrmann T, Donovan N. Auscitrus' role in our biosecurity. Australian Citrus Congress. Adelaide, Australia 2-4 March 2026

Donovan N. Managing citrus disease threats to Australian citrus. Grower workshop: International perspectives on disease threats to your citrus: guest presenters from Brazil, South Africa and the United States. Griffith, New South Wales, Australia, 12th March 2025. Loxton, South Australia and Mildura, Victoria, Australia, 14th March 2025.

Donovan N. Healthy nursery stock and graft-transmissible diseases. Citrus Australia Riverina Forum. Griffith, New South Wales Australia, 22nd October 2024

Donovan N. Healthy nursery stock and graft-transmissible diseases. Citrus Australia Southern Queensland Forum. Mundubberra, Queensland Australia, 10th October 2024

Donovan N. Healthy nursery stock and graft-transmissible diseases. Citrus Australia Far North Queensland Forum. Mareeba, Queensland Australia, 2nd October 2024

Donovan N. Healthy nursery stock and graft-transmissible diseases. Citrus Australia Murray Valley Forum. Nangiloc, Victoria Australia, 17th September 2024

Donovan N. Managing graft transmissible citrus diseases in Australia and the importance of high health budwood. Australian Citrus Biosecurity Symposium. Sunshine Coast, Australia 5 March 2024

Donovan N. Protecting Australia from exotic diseases. Dareton Citrus Field Day, Dareton NSW, Australia, 13th September 2023

Donovan N. Citrus diseases. Farm walks as part of the Citrus industry IPDM extension program, Burekup and Gin Gin, Western Australia, Australia, 28th and 29th March 2023

Donovan N, Herrmann T, Chambers G, Englezou A, Forbes W, Dando A. Protecting our industry from incurable diseases. Citrus Technical Forum, Sunshine Coast, Australia 8-9 March 2022

Scientific papers

Donovan NJ, Herrmann T, ADW Geering. 2026. History and evolution of the Auscitrus budwood scheme. Journal of Citrus Pathology 13(1) DOI: 10.5070/C4.61329

Chambers GA, Geering ADW, Holford P, Vidalakis G, Donovan NJ. 2025. Development and application of a multiplex RT-qPCR assay detecting citrus apscaviroids in viroid surveys of Australian citrus. Australasian Plant Pathology 54: 559-568 DOI: 10.1007/s13313-025-01072-z

Chambers GA, Englezou A, Donovan N. 2025. First report of citrus-associated rhabdovirus in Australia in citrus. Plant Disease 109(1) DOI: 10.1094/PDIS-09-24-1969-PDN

Donovan NJ, Chambers GA, Englezou A, Forbes W, Dando A, Holford P. 2022. First report of citrus virus A in Australia. Journal of Citrus Pathology 9 DOI: 10.5070/C49157292

Scientific forums

Donovan NJ. 2025. Citrus pathology in Australia – past, present and future. Daniel McAlpine lecture. 25th Australasian Plant Pathology Society Conference, Sydney Australia. 26-28 May 2025. Oral Presentation — ASN Events

Donovan NJ, Herrmann T. 2025. History and evolution of the Auscitrus budwood scheme. Abstracts XXIII Conference of the International Organization of Citrus Virologists, Mildura Australia. 16-20 March 2025. Journal of Citrus Pathology 12(2):43. DOI: 10.5070/C4.61717

Chambers GA, Englezou A, Vidalakis G, Holford P, Geering A, Donovan NJ. 2025. Determining citrus viroid prevalence in Australia with multiplex RT-qPCR assays. Abstracts XXIII Conference of the International Organization of Citrus Virologists, Mildura Australia. 16-20 March 2025. Journal of Citrus Pathology 12(2):46. DOI:10.5070/C4.61717

Donovan N. Plant Health and Biosecurity. Guest lecture presented to 3rd year students in the Hawkesbury Institute for the Environment, Western Sydney University, NSW Australia. Annually from 2017-2024

Donovan N, Lye J, Herrmann T.2024. Best foot forward: Australian efforts to stay in front of HLB. Abstracts 2024 International Research Conference on Huanglongbing VII. Journal of Citrus Pathology 11(1): 57 DOI: 10.5070/C411163652

Donovan N. Facing the yellow dragon: managing biosecurity threats to citrus. Sydney Institute of Agriculture's Annual RD Watt lecture, University of Sydney, Sydney Australia. 8th March 2024

Donovan N. Facing Plant Biosecurity Challenges. New South Wales: Doing Well by Doing Good. The Crawford Fund New South Wales Forum 2023. Sofitel Sydney Wentworth Hotel, Sydney, Australia 22nd November 2023.

Donovan NJ, Chambers GA. 2022. Viroids in Australasia. Abstracts of the XXII International Organization of Citrus Virologists Conference, online 7, 14, 21 and 28 September 2022. Journal of Citrus Pathology 9(2):8 DOI: 10.5070/C4.46540

Donovan N. Citrus biosecurity R&D. Invited presentation to the Horticulture COVID Working Group attended by industry leads. Online. 1st September 2022.

Donovan N. Viroid research in citrus – from discovery to dwarfing trials. Webinar. 21st July 2021