Australian Government

Department of Agriculture, Fisheries and Forestry

Biosecurity

Provisional final import risk analysis report for the importation of fresh decrowned pineapple (*Ananas comosus* (L.) Merr.) fruit from Malaysia

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Cover image: Fresh pineapple fruit (DoA 2009)

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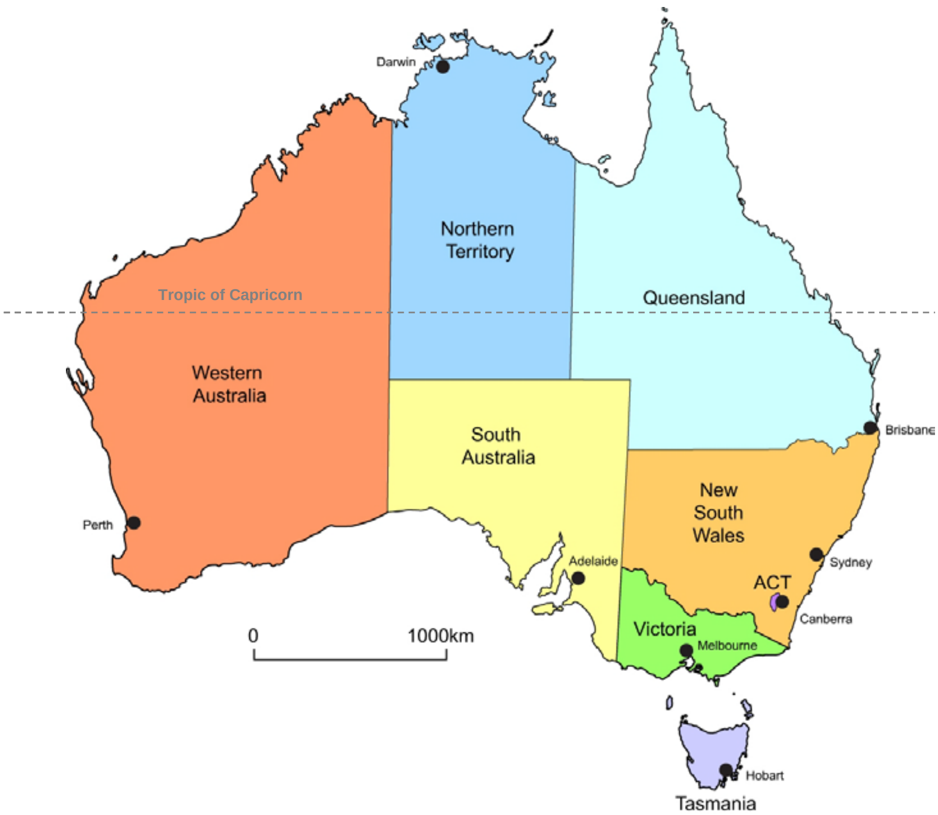


Figure 1 **Map of Australia**

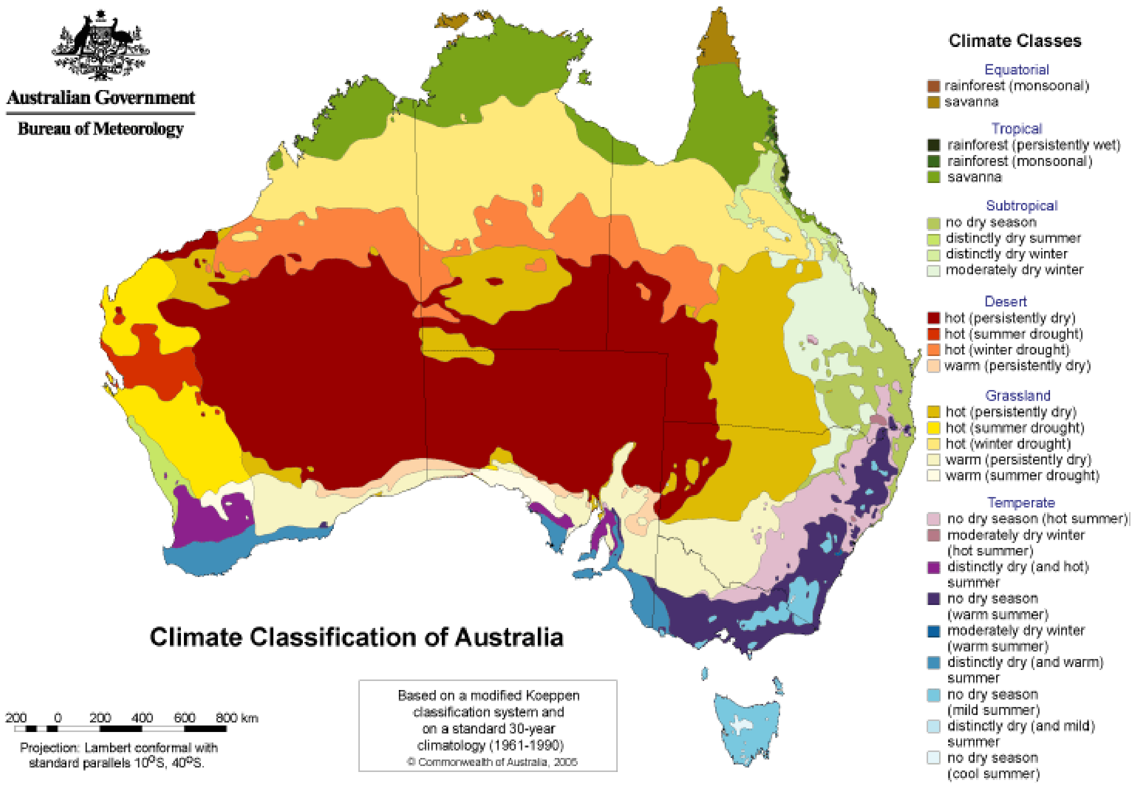


Figure 2 **A guide to Australia's bio-climate zones**

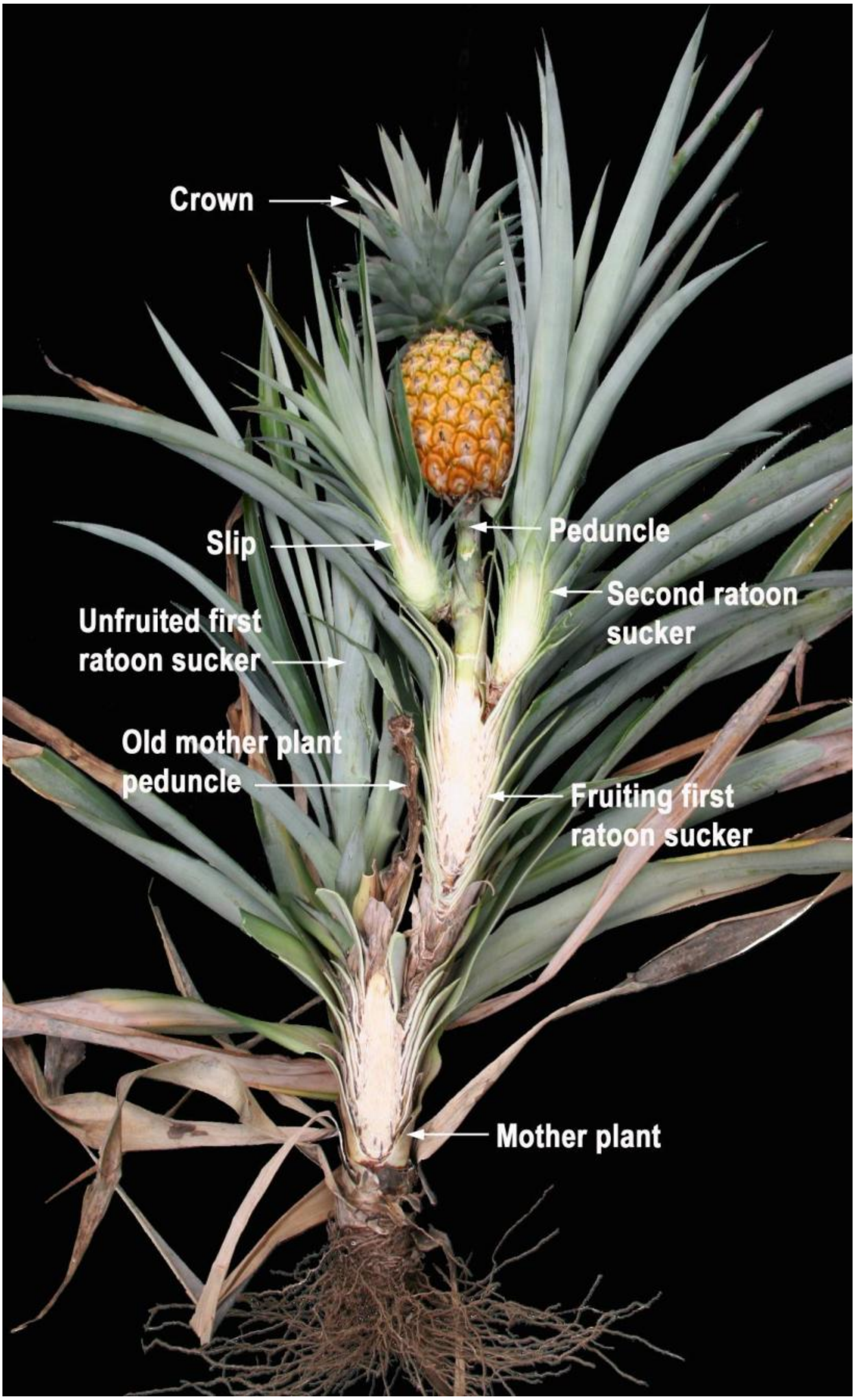


Figure 3 **Image showing the major parts of a pineapple plant**
(Reproduced with permission from Dr Garth M. Sanewski)

Figure 4 Decrowned pineapples

Acronyms and abbreviations

Term or abbreviation	Definition
ACT	Australian Capital Territory
AFAS	Australian Fumigation Accreditation Scheme
ALOP	Appropriate level of protection
DAFF	Australian Government Department of Agriculture, Fisheries and Forestry
DoA	Department of Agriculture, Malaysia
EP	Existing policy
FAO	Food and Agriculture Organization of the United Nations
GAP	Good agriculture practice
ICON	DAFF Import Conditions Database
IPC	International Phytosanitary Certificate
IPM	Integrated pest management
IPPC	International Plant Protection Convention
IRA	Import Risk Analysis
IRAAP	Import Risk Analysis Appeals Panel
ISPM	International Standard for Phytosanitary Measures
NPPO	National Plant Protection Organization
NSW	New South Wales
NT	Northern Territory
PRA	Pest risk analysis
Qld	Queensland
SA	South Australia
Tas.	Tasmania
Vic.	Victoria
WA	Western Australia
WTO	World Trade Organization

Abbreviation of units

Term or abbreviation	Definition
ºC	degree Celsius
ºB	degree Brix
cm	centimetre
g	gram
kg	kilogram
m	metre
ml	millilitre
mm	millimetre

Summary

This import risk analysis (IRA) report assesses a proposal from Malaysia for market access to Australia for fresh decrowned pineapple fruit.

Australia permits the importation of fresh pineapple fruit from the Philippines, Thailand, Sri Lanka and Solomon Islands, subject to a range of phytosanitary measures.

The report recommends that the importation of fresh decrowned pineapple fruit from all commercial production areas of Malaysia be permitted, subject to a range of quarantine conditions.

This report identifies pests that require quarantine measures to manage risks to a very low level in order to achieve Australia's appropriate level of protection (ALOP). The pests requiring measures are four species of mealybugs: *Dysmicoccus grassii*, *Dysmicoccus neobrevipes*, *Planococcus minor* and *Pseudococcus jackbeardsleyi*.

Only one pest has been identified as regional quarantine pest: *Planococcus minor* for Western Australia. The recommended quarantine measures take into account regional differences.

This report recommends a combination of risk management measures and operational systems that will reduce the risk associated with the importation of decrowned fresh pineapple fruit from Malaysia into Australia to achieve Australia's ALOP, specifically:

- pre-shipment or on-arrival methyl bromide fumigation or alternative post harvest treatment as approved by DAFF for mealybugs
- an operational system for the maintenance and verification of the phytosanitary status of pineapple fruit, including:
  - registration of export plantations
  - registration of packing houses and auditing of procedures
  - registration of fumigators/treatment facilities and auditing of procedures
  - packaging and labelling requirements
  - specific conditions for storage and transport
  - pre-export phytosanitary inspection and certification by the Department of Agriculture, Malaysia
  - on-arrival phytosanitary inspection, remedial action when required, and clearance by the Department of Agriculture, Fisheries and Forestry (DAFF) Biosecurity.

DAFF Biosecurity has made a number of changes to the risk analysis following consideration of stakeholder comments on the draft IRA report and subsequent review of the literature. These changes include:

- additional points under probability of importation and distribution in the risk assessment of bacterial fruit collapse and heart rot disease caused by *Erwinia chrysanthemi* (pineapple strain, *Dickeya* sp.), and minor changes to the rating for consequences but not resulting in any change to the unrestricted risk estimate
- identifying the armoured scale, *Unapsis citri*, as a pest of regional concern to South Australia
- addition of photos of a labelled pineapple plant and decrowned pineapple
- a summary of major stakeholder issues and how they were considered
- minor corrections and rewording for consistency and clarity.

The provisional final import risk analysis report is open to appeal. Stakeholders who believe there was a significant deviation from the import risk analysis process set out in the *Import Risk Analysis Handbook 2011* that adversely affected their interests must lodge their appeals with the Import Risk Analysis Appeals Panel (IRAAP) within 30 days of this provisional final IRA report being issued.

The appeals process is independent of DAFF Biosecurity. The IRAAP will consider any appeal and report its findings to the appellant(s) and Australia's Director of Animal and Plant Quarantine within 45 days of the closing date for appeals. At the conclusion of the appeals process, and after any issues arising from the appeals process have been addressed, DAFF Biosecurity will provide a final report recommending a quarantine policy to the Director of Animal and Plant Quarantine for determination.

1 Introduction

1.1. Australia’s biosecurity policy framework

Australia's biosecurity policies aim to protect Australia against the risks that may arise from exotic pests[1] entering, establishing and spreading in Australia, thereby threatening Australia's unique flora and fauna, as well as those agricultural industries that are relatively free from serious pests.

The import risk analysis (IRA) process is an important part of Australia's biosecurity policies. It enables the Australian Government to formally consider the risks that could be associated with proposals to import new products into Australia. If the risks are found to exceed Australia’s appropriate level of protection (ALOP), risk management measures are proposed to reduce the risks to an acceptable level. But, if it is not possible to reduce the risks to an acceptable level, then no trade will be allowed.

Successive Australian Governments have maintained a conservative, but not a zero-risk, approach to the management of biosecurity risks. This approach is expressed in terms of Australia's ALOP, which reflects community expectations through government policy and is currently described as providing a high level of protection aimed at reducing risk to a very low level, but not to zero.

Australia’s IRAs are undertaken by DAFF Biosecurity using teams of technical and scientific experts in relevant fields, and involves consultation with stakeholders at various stages during the process. DAFF Biosecurity provides recommendations for animal and plant quarantine policy to Australia’s Director of Animal and Plant Quarantine (the Secretary of the Australian Department of Agriculture, Fisheries and Forestry, DAFF). The Director or delegate is responsible for determining whether or not an importation can be permitted under the Quarantine Act 1908, and if so, under what conditions. DAFF Biosecurity is responsible for implementing appropriate risk management measures.

More information about Australia’s biosecurity framework is provided in Appendix C of this report and in the *Import Risk Analysis Handbook 2011* (IRA Handbook) located on the DAFF website www.daff.gov.au.

1.2. This import risk analysis

1.2.1 Background

The Department of Agriculture Malaysia (DoA) formally requested market access for fresh pineapple fruit to Australia in a submission received in May 2004 (DoA 2004). This submission included information on the pests associated with pineapple crops in Malaysia, including the plant part affected, and the standard commercial production practices for fresh pineapple fruit in Malaysia (DoA 2004). A supplementary submission was provided in 2009 (DoA 2009). In January 2010, the scope of the request was changed to consider fresh decrowned pineapple fruit.

[1] A pest is any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2009).

On 9 June 2010, Biosecurity Australia (now DAFF Biosecurity) formally announced commencement of this import risk analysis advising stakeholders that it would be progressed as a standard IRA, using the process described in the IRA Handbook.

1.2.2 Scope

The scope of this IRA is to consider the quarantine risk that may be associated with the importation of commercially-produced fresh decrowned pineapple fruit *Ananas comosus* (L.) Merr. (hereafter they will be referred to as decrowned pineapple fruit) free from trash from Malaysia, for human consumption in Australia.

In this IRA decrowned pineapple fruit are defined as fruit with crown and basal leaves removed (Figure 4). This IRA assesses all commercially-produced pineapple fruit *Ananas comosus* (L.) Merr. varieties of Malaysia and the regions in which they are grown.

1.2.3 Existing policy

Australia currently permits the importation of fresh pineapple fruit from the Philippines, Thailand, Sri Lanka, and Solomon Islands, subject to a range of phytosanitary measures, including decrowning.

DAFF Biosecurity has considered all pests previously identified in the *Import risk analysis (IRA) for the importation of fresh pineapple fruit: final IRA report* (Philippines, Thailand, Sri Lanka and the Solomon Islands) (Biosecurity Australia 2002) and taken them into account in this current policy where relevant.

The conditions under which fresh pineapple fruit are permitted entry into Australia from these countries can be viewed on the DAFF import conditions (ICON) database at www.aqis.gov.au/icon32/asp/homecontent.asp.

Domestic Arrangements

The Australian Government is responsible for regulating the movement of plants and plant products into and out of Australia. However, the state and territory governments are responsible for plant health controls within their individual jurisdiction. Legislation relating to resource management or plant health may be used by state or territory government agencies to control interstate movement of plants or their products. It is the importer’s responsibility to identify, and to ensure it has complied with all requirements.

1.2.4 Contaminating pests

In addition to the pests of decrowned pineapple fruit from Malaysia that are identified in this IRA, there are other organisms that may arrive with decrowned pineapple fruit. These organisms could include pests that have no specific relation to the commodity or the export pathway. DAFF Biosecurity considers these organisms to be contaminating pests that could pose sanitary and phytosanitary risks. These risks are addressed by the procedures indicated in section 5.4.

The *Import risk analysis (IRA) for the importation of fresh pineapple fruit: final IRA report* (Philippines, Thailand, Sri Lanka and the Solomon Islands) (Biosecurity Australia 2002) recommended decrowning (i.e. fruit with crown and basal leaves removed) for weed pest species as a risk management measure that reduced the risk associated with weed pest species to a very low level to meet Australia's ALOP. The scope of the IRA for Malaysia is for fresh decrowned pineapple fruit and decrowning is considered part of the standard production procedures. Standard hygiene and cleaning practices, the registration of export grade fresh pineapple fruit plantations and phytosanitary inspections further reduce the risk of weed species entering Australia on decrowned fresh pineapple fruit. These procedures are outlined in further detail in Section 5.

1.2.5 Consultation

DAFF Biosecurity advised stakeholders in September 2007 that changes to the import risk analysis (IRA) process had been implemented when regulations made under the *Quarantine Act 1908* formally took effect. That advice also notified the transitional arrangements for Biosecurity's import work program, including pineapples from Malaysia that would be conducted under the new regulated IRA process.

On 9 June 2010, DAFF Biosecurity notified stakeholders in a Biosecurity Australia Advice 2010/18 of the formal commencement of this IRA as a standard IRA under the regulated process to consider a proposal to import fresh decrowned pineapple from Malaysia.

DAFF Biosecurity provided a draft pest categorisation table for decrowned pineapple from Malaysia to state and territory departments of primary industry/agriculture on 11 April 2011 for their informal consideration of regional pests.

Additional informal consultation including a face to face meeting with industry representatives in July 2010 occurred in the development of the draft IRA report.

DAFF Biosecurity released the draft IRA report for a 60 day stakeholder comment period on 19 October 2011. During this period on 25 November 2011, DAFF Biosecurity met again with the industry stakeholders.

Two submissions on the draft IRA report were received, from the pineapple industry representative body, Growcom, and from the Queensland Department of Employment, Economic Development and Innovation (now Queensland Department of Agriculture Fisheries and Forestry (DAFF)).

1.2.6 Next Steps

The regulated timeframe for an IRA ends when a provisional final IRA report is issued.

Stakeholders who believe there was a significant deviation from the IRA process set out in the *Import Risk Analysis Handbook 2011* that adversely affected their interests may appeal to the Import Risk Analysis Appeals Panel (IRAAP). Appeals must be lodged within 30 days of the publication of the provisional final IRA report.

The appeals process is independent of DAFF Biosecurity. It is a non-judicial review that is not part of the regulated process.

Further details of the appeal process may be found at Annex 6 of the IRA Handbook.

At the conclusion of the appeal process and after any issues arising from the IRAAP process have been addressed, DAFF Biosecurity will provide the final IRA report and a recommendation for a policy determination to the Director of Animal and Plant Quarantine.

The Director of Animal and Plant Quarantine will then make a determination. The determination provides a policy framework for decisions on whether or not to grant an import permit and any conditions that may be attached to a permit.

A policy determination represents the completion of the IRA process.

The Director of Animal and Plant Quarantine notifies DAFF Biosecurity of the policy determination. In turn, DAFF Biosecurity notifies the proposer and registered stakeholders, and DAFF notifies the WTO Secretariat, of the determination. The determination will also be placed on the public file and on the DAFF website.

2 Method for pest risk analysis

This section sets out the method used for the pest risk analysis (PRA) in this report. DAFF Biosecurity has conducted this PRA in accordance with the International Standards for Phytosanitary Measures (ISPMs), including ISPM 2: *Framework for pest risk analysis* (FAO 2007) and ISPM 11: *Pest risk analysis for quarantine pests, including analysis of environmental risks and living modified organisms* (FAO 2004).

A PRA is 'the process of evaluating biological or other scientific and economic evidence to determine whether a pest should be regulated and the strength of any phytosanitary measures to be taken against it' (FAO 2009). A pest is 'any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products' (FAO 2009).

Quarantine risk consists of two major components: the probability of a pest entering, establishing and spreading in Australia from imports; and the consequences should this happen. These two components are combined to give an overall estimate of the risk.

Unrestricted risk is estimated taking into account the existing commercial production practices of the exporting country and that, on arrival in Australia, DAFF Biosecurity will verify that the consignment received is as described on the commercial documents and its integrity has been maintained.

Restricted risk is estimated with phytosanitary measure(s) applied. A phytosanitary measure is 'any legislation, regulation or official procedure having the purpose to prevent the introduction and spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests' (FAO 2009).

A glossary of the terms used is provided at the back of this IRA report.

PRAs are conducted in three consecutive stages: initiation, pest risk assessment and pest risk management.

2.1 Stage 1: Initiation

Initiation identifies the pest(s) and pathway(s) that are of quarantine concern and should be considered for risk analysis in relation to the identified PRA area.

The pests assessed for their potential to be on the exported commodity (produced using commercial production and packing procedures) are listed in column 1 of Appendix A. Appendix A does not present a comprehensive list of all the pests associated with the entire plant, but concentrates on the pests that could be on the assessed commodity. Pests that are determined to not be associated with the commodity in column 3 are not considered further in the PRA. Contaminating pests that have no specific relation to the commodity or the export pathway have not been listed and would be addressed by Australia's current approach to contaminating pests.

The identity of the pests is given in Appendix A. The species name is used in most instances but a lower taxonomic level is used where appropriate. Synonyms are provided where the current scientific name differs from that provided by the exporting country's NPPO or where the cited literature uses a different scientific name.

For this PRA, the ‘PRA area’ is defined as Australia for pests that are absent, or of limited distribution and under official control. For areas with regional freedom from a pest, the ‘PRA area’ may be defined on the basis of a state or territory of Australia or may be defined as a region of Australia consisting of parts of a state or territory or several states or territories.

For pests that had been considered by DAFF Biosecurity in other risk assessments and for which import policies already exist, a judgement based on the specific circumstances was made on the likelihood of entry of pests on the commodity and whether existing policy is adequate to manage the risks associated with its import. Where appropriate, the previous risk assessment was taken into consideration when developing the new policy.

2.2 Stage 2: Pest risk assessment

A pest risk assessment (for quarantine pests) is: ‘the evaluation of the probability of the introduction and spread of a pest and of the likelihood of associated potential economic consequences’ (FAO 2009).

In this PRA, pest risk assessment was divided into the following interrelated processes:

2.2.1 Pest categorisation

Pest categorisation identifies which of the pests with the potential to be on the commodity are quarantine pests for Australia and require pest risk assessment. A ‘quarantine pest’ is a pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled, as defined in ISPM 5: *Glossary of phytosanitary terms* (FAO 2009).

The pests identified in Stage 1 were categorised using the following primary elements to identify the quarantine pests for the commodity being assessed:

- presence or absence in the PRA area
- regulatory status
- potential for establishment and spread in the PRA area
- potential for economic consequences (including environmental consequences) in the PRA area.

The results of pest categorisation are set out in columns 4–7 in Appendix A. The steps in the categorisation process are considered sequentially, with the assessment terminating with a ‘Yes’ in column 4 or the first ‘No’ in columns 5 or 6. The quarantine pests identified during pest categorisation were carried forward for pest risk assessment and are listed in Table 4.1.

2.2.2 Assessment of the probability of entry, establishment and spread

Details of how to assess the ‘probability of entry’, ‘probability of establishment’ and ‘probability of spread’ of a pest are given in ISPM 11 (FAO 2004). A summary of this process is given below, followed by a description of the qualitative methodology used in this IRA.

Probability of entry

The probability of entry describes the probability that a quarantine pest will enter Australia as a result of trade in a given commodity, be distributed in a viable state in the PRA area and subsequently be transferred to a host. It is based on pathway scenarios depicting necessary steps in the sourcing of the commodity for export, its processing, transport and storage, its use in Australia and the generation and disposal of waste. In particular, the ability of the pest to survive is considered for each of these various stages.

The probability of entry estimates for the quarantine pests for a commodity are based on the use of the existing commercial production, packaging and shipping practices of the exporting country. Details of the existing commercial production practices for the commodity are set out in Section 3. These practices are taken into consideration by DAFF Biosecurity when estimating the probability of entry.

For the purpose of considering the probability of entry, DAFF Biosecurity divides this step of this stage of the PRA into two components:

- **Probability of importation**: the probability that a pest will arrive in Australia when a given commodity is imported.
- **Probability of distribution**: the probability that the pest will be distributed, as a result of the processing, sale or disposal of the commodity, in the PRA area and subsequently transfer to a susceptible part of a host.

Factors considered in the probability of importation include:

- distribution and incidence of the pest in the source area
- occurrence of the pest in a life-stage that would be associated with the commodity
- mode of trade (e.g. bulk, packed)
- volume and frequency of movement of the commodity along each pathway
- seasonal timing of imports
- pest management, cultural and commercial procedures applied at the place of origin
- speed of transport and conditions of storage compared with the duration of the lifecycle of the pest
- vulnerability of the life-stages of the pest during transport or storage
- incidence of the pest likely to be associated with a consignment
- commercial procedures (e.g. refrigeration) applied to consignments during transport and storage in the country of origin, and during transport to Australia.

Factors considered in the probability of distribution include:

- commercial procedures (e.g. refrigeration) applied to consignments during distribution in Australia
- dispersal mechanisms of the pest, including vectors, to allow movement from the pathway to a host
- whether the imported commodity is to be sent to a few or many destination points in the PRA area
- proximity of entry, transit and destination points to hosts
- time of year at which import takes place
- intended use of the commodity (e.g. for planting, processing or consumption)
- risks from by-products and waste

Probability of establishment

Establishment is defined as the 'perpetuation for the foreseeable future, of a pest within an area after entry' (FAO 2004). In order to estimate the probability of establishment of a pest, reliable biological information (lifecycle, host range, epidemiology, survival, etc.) is obtained from the areas where the pest currently occurs. The situation in the PRA area can then be compared with that in the areas where it currently occurs and expert judgement used to assess the probability of establishment.

Factors considered in the probability of establishment in the PRA area include:

- availability of hosts, alternative hosts and vectors
- suitability of the environment
- reproductive strategy and potential for adaptation
- minimum population needed for establishment
- cultural practices and control measures

Probability of spread

Spread is defined as 'the expansion of the geographical distribution of a pest within an area' (FAO 2004). The probability of spread considers the factors relevant to the movement of the pest, after establishment on a host plant or plants, to other susceptible host plants of the same or different species in other areas. In order to estimate the probability of spread of the pest, reliable biological information is obtained from areas where the pest currently occurs. The situation in the PRA area is then carefully compared with that in the areas where the pest currently occurs and expert judgement used to assess the probability of spread.

Factors considered in the probability of spread include:

- suitability of the natural and/or managed environment for natural spread of the pest
- presence of natural barriers
- potential for movement with commodities, conveyances or by vectors
- intended use of the commodity
- potential vectors of the pest in the PRA area
- potential natural enemies of the pest in the PRA area

Assigning qualitative likelihoods for the probability of entry, establishment and spread

In its qualitative PRAs, DAFF Biosecurity uses the term 'likelihood' for the descriptors it uses for its estimates of probability of entry, establishment and spread. Qualitative likelihoods are assigned to each step of entry, establishment and spread. Six descriptors are used: high; moderate; low; very low; extremely low; and negligible (Table 2.1). Descriptive definitions for these descriptors are given in Table 2.1. The standardised likelihood descriptors provide guidance to the risk analyst and promote consistency between different risk analyses.

Table 2.1 Nomenclature for qualitative likelihoods

Likelihood	Descriptive definition
High	The event would be very likely to occur
Moderate	The event would occur with an even probability
Low	The event would be unlikely to occur
Very low	The event would be very unlikely to occur
Extremely low	The event would be extremely unlikely to occur
Negligible	The event would almost certainly not occur

The likelihood of entry is determined by combining the likelihood that the pest will be imported into the PRA area and the likelihood that the pest will be distributed within the PRA area, using a matrix of rules (Table 2.2). This matrix is then used to combine the likelihood of entry and the likelihood of establishment, and the likelihood of entry and establishment is then combined with the likelihood of spread to determine the overall likelihood of entry, establishment and spread.

For example, if the probability of importation is assigned a likelihood of 'low' and the probability of distribution is assigned a likelihood of 'moderate', then they are combined to give a likelihood of 'low' for the probability of entry. The likelihood for the probability of entry is then combined with the likelihood assigned to the probability of establishment (e.g. 'high') to give a likelihood for the probability of entry and establishment of 'low'. The likelihood for the probability of entry and establishment is then combined with the likelihood assigned to the probability of spread (e.g. 'very low') to give the overall likelihood for the probability of entry, establishment and spread of 'very low'. A working example is provided below;

P [importation] x *P* [distribution] = *P* [**entry**] e.g. **low x moderate = low**

P [entry] x *P* [establishment] = *P* [**EE**] e.g. **low x high = low**

P [**EE**] x [spread] = ***P* [EES]** e.g. **low x very low = very low**

Table 2.2 Matrix of rules for combining qualitative likelihoods

	High	**Moderate**	**Low**	**Very low**	**Extremely low**	**Negligible**
High	High	Moderate	Low	Very low	Extremely low	Negligible
Moderate		Low	Low	Very low	Extremely low	Negligible
Low			Very low	Very low	Extremely low	Negligible
Very low				Extremely low	Extremely low	Negligible
Extremely low					Negligible	Negligible
Negligible						Negligible

Time and volume of trade

One factor affecting the likelihood of entry is the volume and duration of trade. If all other conditions remain the same, the overall likelihood of entry will increase as time passes and the overall volume of trade increases.

DAFF Biosecurity normally considers the likelihood of entry on the basis of the estimated volume of one year's trade. This is a convenient value for the analysis that is relatively easy to estimate and allows for expert consideration of seasonal variations in pest presence, incidence and behaviour to be taken into account.

The consideration of the likelihood of entry, establishment and spread and subsequent consequences takes into account events that might happen over a number of years even though only one year's volume of trade is being considered. This difference reflects biological and ecological facts, for example where a pest or disease may establish in the year of import but spread may take many years.

The use of a one year volume of trade has been taken into account when setting up the matrix that is used to estimate the risk and therefore any policy based on this analysis does not simply apply to one year of trade. Policy decisions that are based on DAFF Biosecurity's method that uses the estimated volume of one year's trade are consistent with Australia's policy on appropriate level of protection and meet the Australian Government's requirement for ongoing quarantine protection. Of course, if there are substantial changes in the volume and nature of the trade in specific commodities then DAFF Biosecurity has an obligation to review the risk analysis and, if necessary, provide updated policy advice.

In assessing the volume of trade in this PRA, DAFF Biosecurity assumed that a small volume of trade will occur (refer to Section 3).

2.2.3 Assessment of potential consequences

The objective of the consequence assessment is to provide a structured and transparent analysis of the likely consequences if the pests or disease agents were to enter, establish and spread in Australia. The assessment considers direct and indirect pest effects and their economic and environmental consequences. The requirements for assessing potential consequences are given in Article 5.3 of the SPS Agreement (WTO 1995), ISPM 5 (FAO 2009) and ISPM 11 (FAO 2004).

Direct pest effects are considered in the context of the effects on:

- plant life or health
- other aspects of the environment.

Indirect pest effects are considered in the context of the effects on:

- eradication, control, etc
- domestic trade
- international trade
- environment.

For each of these six criteria, the consequences were estimated over four geographic levels, defined as:

- **Local**: an aggregate of households or enterprises (a rural community, a town or a local government area).

- **District**: a geographically or geopolitically associated collection of aggregates (generally a recognised section of a state or territory, such as 'Far North Queensland').
- **Regional**: a geographically or geopolitically associated collection of districts in a geographic area (generally a state or territory, although there may be exceptions with larger states such as Western Australia).
- **National**: Australia wide (Australian mainland states and territories and Tasmania).

For each criterion, the magnitude of the potential consequence at each of these levels was described using four categories, defined as:

- **Indiscernible**: pest impact unlikely to be noticeable.
- **Minor significance**: expected to lead to a minor increase in mortality/morbidity of hosts or a minor decrease in production but not expected to threaten the economic viability of production. Expected to decrease the value of non-commercial criteria but not threaten the criterion's intrinsic value. Effects would generally be reversible.
- **Significant**: expected to threaten the economic viability of production through a moderate increase in mortality/morbidity of hosts, or a moderate decrease in production. Expected to significantly diminish or threaten the intrinsic value of non-commercial criteria. Effects may not be reversible.
- **Major significance**: expected to threaten the economic viability through a large increase in mortality/morbidity of hosts, or a large decrease in production. Expected to severely or irreversibly damage the intrinsic 'value' of non-commercial criteria.

The estimates of the magnitude of the potential consequences over the four geographic levels were translated into a qualitative impact score (A-G)[2] using table 2.3[3]. For example, a consequence with a magnitude of 'significant' at the 'district' level will have a consequence impact score of D.

Table 2.3 Decision rules for determining the consequence impact score based on the magnitude of consequences at four geographic scales

		Geographic scale			
		Local	**District**	**Region**	**Nation**
Magnitude	Indiscernible	A	A	A	A
	Minor significance	B	C	D	E
	Significant	C	D	E	F
	Major significance	D	E	F	G

The overall consequence for each pest is achieved by combining the qualitative impact scores (A–G) for each direct and indirect consequence using a series of decision rules (Table 2.4). These rules are mutually exclusive, and are assessed in numerical order until one applies.

[2] In earlier qualitative IRAs, the scale for the impact scores went from A to F and did not explicitly allow for the rating 'indiscernible' at all four levels. This combination might be applicable for some criteria. In this report, the impact scale of A-F has changed to become B-G and a new lowest category A ('indiscernible' at all four levels) was added. The rules for combining impacts in Table 2.4 were adjusted accordingly.
[3] The decision rules for determining the consequence impact score are presented in a simpler form in Table 2.3 from earlier IRAs, to make the table easier to use. The outcome of the decision rules is the same as the previous table and makes no difference to the final impact score.

Table 2.4 Decision rules for determining the overall consequence rating for each pest

Rule	The impact scores for consequences of direct and indirect criteria	Overall consequence rating
1	Any criterion has an impact of ‘G’; or more than one criterion has an impact of ‘F’; or a single criterion has an impact of ‘F’ and each remaining criterion an ‘E’.	Extreme
2	A single criterion has an impact of ‘F’; or all criteria have an impact of ‘E’.	High
3	One or more criteria have an impact of ‘E’; or all criteria have an impact of ‘D’.	Moderate
4	One or more criteria have an impact of ‘D’; or all criteria have an impact of ‘C’.	Low
5	One or more criteria have an impact of ‘C’; or all criteria have an impact of ‘B’.	Very Low
6	One or more but not all criteria have an impact of ‘B’, and all remaining criteria have an impact of ‘A’.	Negligible

2.2.4 Estimation of the unrestricted risk

Once the above assessments are completed, the unrestricted risk can be determined for each pest or groups of pests. This is determined by using a risk estimation matrix (Table 2.5) to combine the estimates of the probability of entry, establishment and spread and the overall consequences of pest establishment and spread. Therefore, risk is the product of likelihood and consequence.

When interpreting the risk estimation matrix, note the descriptors for each axis are similar (e.g. low, moderate, high) but the vertical axis refers to likelihood and the horizontal axis refers to consequences. Accordingly, a ‘low’ likelihood combined with ‘high’ consequences, is not the same as a ‘high’ likelihood combined with ‘low’ consequences – the matrix is not symmetrical. For example, the former combination would give an unrestricted risk rating of ‘moderate’, whereas, the latter would be rated as a ‘low’ unrestricted risk.

Table 2.5 Risk estimation matrix

Likelihood of pest entry, establishment and spread	Consequences of pest entry, establishment and spread: Negligible	Very low	Low	Moderate	High	Extreme
High	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Moderate	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
Low	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk	High risk
Very low	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk
Extremely low	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk
Negligible	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk

2.2.5 Australia's appropriate level of protection (ALOP)

The SPS Agreement defines the concept of an 'appropriate level of sanitary or phytosanitary protection (ALOP)' as the level of protection deemed appropriate by the WTO Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory.

Australia expresses its ALOP in qualitative terms. Australia's ALOP, which reflects community expectations through government policy, is currently expressed as providing a high level of sanitary or phytosanitary protection aimed at reducing risk to a very low level, but not to zero. The band of cells in Table 2.5 marked 'very low risk' represents Australia's ALOP.

2.3 Stage 3: Pest risk management

Pest risk management describes the process of identifying and implementing phytosanitary measures to manage risks to achieve Australia's ALOP, while ensuring that any negative effects on trade are minimised.

The conclusions from pest risk assessment are used to decide whether risk management is required and if so, the appropriate measures to be used. Where the unrestricted risk estimate exceeds Australia's ALOP, risk management measures are required to reduce this risk to a very low level. The guiding principle for risk management is to manage risk to achieve Australia's ALOP. The effectiveness of any proposed phytosanitary measure (or combination of measures) is evaluated, using the same approach as used to evaluate the unrestricted risk, to ensure it reduces the restricted risk for the relevant pest or pests to meet Australia's ALOP.

ISPM 11 (FAO 2004) provides details on the identification and selection of appropriate risk management options and notes that the choice of measures should be based on their effectiveness in reducing the probability of entry of the pest.

Examples given of measures commonly applied to traded commodities include:

- options for consignments – e.g., inspection or testing for freedom from pests, prohibition of parts of the host, a pre-entry or post-entry quarantine system, specified conditions on preparation of the consignment, specified treatment of the consignment, restrictions on end-use, distribution and periods of entry of the commodity

- options preventing or reducing infestation in the crop – e.g., treatment of the crop, restriction on the composition of a consignment so it is composed of plants belonging to resistant or less susceptible species, harvesting of plants at a certain age or specified time of the year, production in a certification scheme
- options ensuring that the area, place or site of production or crop is free from the pest – e.g., pest-free area, pest-free place of production or pest-free production site
- options for other types of pathways – e.g., consider natural spread, measures for human travellers and their baggage, cleaning or disinfestations of contaminated machinery
- options within the importing country – e.g., surveillance and eradication programs
- prohibition of commodities – if no satisfactory measure can be found

Risk management measures are identified for each quarantine pest where the risk exceeds Australia's ALOP. These are presented in the 'Pest Risk Management' section of this report.

3 Malaysia's commercial production practices for fresh pineapple fruit

This section provides information on the pre-harvest, harvest and post-harvest practices in Malaysia for fresh pineapple fruit considered to be commercial production practices. The export capability of Malaysia is also outlined.

3.1 Assumptions used in estimating unrestricted risk

Malaysia provided Australia with information on the standard commercial practices adopted in the production of pineapples in the different regions and for all the commercially-produced pineapple varieties in Malaysia. This information was complemented with data from other sources and was taken into account when estimating the unrestricted risk of pests that may be associated with the import of this commodity.

DAFF Biosecurity visited pineapple production areas in Johor on 28–30 April 2010 to verify pest status and observe the harvest, processing and packing procedures for export of pineapples. DAFF Biosecurity's observations and additional information provided during the visit confirmed the production and processing procedures described in this section as standard commercial production practices for pineapples for export.

In estimating the likelihood of pest introduction it was assumed that the pre-harvest, harvest and post-harvest production practices for pineapples as described in this section are implemented for all regions and for all pineapple varieties within the scope of this analysis. Where a specific practice described in this section is not taken into account to estimate the unrestricted risk, it is clearly identified and explained in Section 4.

3.2 Production areas

3.2.1 Production areas

The main pineapple production areas in Malaysia are in the states of Johor, Selangor, Pahang, Terengganu, Kelantan and Sarawak as shown in Figure 5.

3.2.2 Climate in production areas

Located near the equator, Malaysia's climate is categorised as equatorial, being hot and humid throughout the year. Annual average rainfall exceeds 2000 mm a year and the average temperature is 27 °C. Malaysia faces two monsoon seasons—the south-west monsoon from late May to September and the north-east monsoon from November to March. The north-east monsoon brings in more rainfall compared to the south-west monsoon.

Figure 5   Map of Malaysia

3.3 Pre-harvest

3.3.1 Cultivars

Commercial pineapple cultivars belong to five main groups, i.e. Cayenne, Queen, Spanish, Pernambuco and Mordilona. Cultivars of the first three groups are of commercial importance to Malaysia (MTFIS 2004).

Smooth Cayenne cultivars: are the most important globally. Malaysian clones of this cultivar are ‘Sarawak’ (grown in Peninsular Malaysia), ‘Samarahan’, ‘Nanas Durian’ and ‘Nanas Paun’ (grown in Sarawak) and ‘Babagon’ (grown in Sabah).

Queen cultivars: are extensively cultivated globally, for the fresh fruit market. It is commonly called ‘Nanas Moris’ (i.e. Mauritian pineapple) in Peninsular Malaysia, and ‘Sarikei’ in Sarawak.

Spanish cultivars: are not widely cultivated globally, but are well adapted to the coastal peat soils of Malaysia. They are mainly produced for canning and Spanish cultivars with improved canning qualities, such as ‘Masmera’h and ‘Gandu’l have been developed.

Currently, the most common varieties within these three cultivar groups grown in Malaysia are ‘Sarawak’, ‘Gandol’, ‘Mauritius’ and hybrids ‘N36’ and ‘Josapine’. The characteristics of the each of these varieties are shown in Table 3.1.

Table 3.1 Characteristics of common Malaysian pineapple varieties

Varieties		Fruit weight (kg)	General characteristics
Sarawak		2–4	▪ Used for canning as well as table ▪ Vigorous plant, grows up to 120cm high with 60–80 leaves at flowering ▪ Leaves are spiny at the tip ▪ Fruits are green to copper in colour ▪ Flesh is pale yellow. ▪ Brix: 14–17%
Gandol		1.5	▪ Plants are medium size with erect leaves and sparsely spiny towards the tip ▪ Fruit are dark purple in colour ▪ Flesh is golden and translucent ▪ Brix: 8–15%
Mauritius		0.5–1.5	▪ Plants are small with dark bluish-green spiny leaves ▪ Fruits are dark green in colour ▪ Flesh is yellow ▪ Brix: 15–17%
N36		1.5–2	▪ Hybrid between Gandul (Spanish) and Smooth Cayenne ▪ Robust cultivar with large crown ▪ Flesh is pale yellow ▪ Brix: 14%
Josapine		1.2–1.5	▪ Hybrid between Johor (Spanish) and Sarawak (Smooth Cayenne) ▪ Leaves are light purple-tinged with spineless margins ▪ Crown is medium size ▪ Fruits are cylindrical in shape with dark purple peel ripening to attractive orange-red ▪ Flesh is deep golden yellow ▪ Brix: 17–22%

3.3.2 Cultivation practices

In Malaysia, pineapple is typically propagated vegetatively using crowns (tops), slips (rudimentary fruits with an exaggerated crown formed from buds within the axils of leaves borne on the peduncle) and suckers (ratooning). An overview of the anatomical features and cultivation of pineapple is given by Bartholomew *et al.* (2002).

The time taken from planting to harvest is, 18–24 months from crowns, 15–20 months from slips, and, 14–17 months from suckers. Planting is staggered year-round. Plants are typically spaced at a distance of 30 cm x 60 cm, giving a planting density of approximately 37 000 plants per hectare.

Figure 6 Freshly planted Malaysian pineapple field (DoA 2009)

The pineapple industry in Malaysia is unique compared with other countries as much of the annual production is cultivated on peat soil. This type of soil is not suited for many other agricultural crops and has been classified within Malaysia as 'marginal soil' (Chan 2000). One of the most significant problems facing cultivation on peat is the soft ground conditions which cannot support the use of heavy equipment. It is for this reason that many of the field operations which are mechanised in large-scale operation elsewhere in the world such as planting (Figure 6), weeding (Figure 7) harvesting and application of fertilisers and flowering hormones have to be carried out manually in Malaysia.

Irrigation of production areas is not commonly practiced due to the nature of the production area (soil type and high annual rainfall) complimented by the fact pineapples are relatively drought tolerant species.

Fertilisation is an essential process used to increase fruit size and total yield. Fertiliser is applied periodically in the form of foliar sprays and also as a ground broadcast up to six months post-planting. Depending on soil types, nitrogen and magnesium are used to increase fruit size, whilst iron is important where soils have a high pH.

The plant growth regulator ethephon or naphthalene acetic acid (NAA) is commonly used to promote flowering and crop synchrony, usually at the 32–35 leaf stage (approx. 9 months post-planting, depending on cultivar).

Manual and chemical weed controls are combined for six months post-planting. Once the pineapple plants are established, the weeds tend to be shaded out and less weeding is typically required.

Figure 7 Manual weeding of the pineapple field being undertaken in Malaysia

3.3.3 Pest management

The following information on pest and disease management in the field was provided by Malaysia's Department of Agriculture (DoA 2009). Fresh pineapples are only sourced from farms registered by Malaysia's Department of Agriculture and are certified to practice in accordance with Malaysia's farm certification scheme for Good Agricultural Practice.

Table 3.2 details pests targeted, management activities and, where applicable, chemicals used.

Table 3.2 Pest and disease control in Malaysian pineapple production systems

Pest/disease	Common name	Malaysia's control proposals
Dysmicoccus brevipes	mealybug	▪ Use healthy suckers free of mealybug. ▪ Prior to planting, suckers are dipped in a 0.15% malathion solutions for 24 hours. ▪ Spray 0.15% malathion or 0.1% dimethoate.
Diaspis bromeliae	scales	▪ Spray insecticides such as 0.15% malathion or 2.0% white oil.
Dolichotetranychus floridanus	mites	▪ Spray miticides such as amitraz or dimethoate at the rate of 0.1%.
Thielaviopsis paradoxa	butt rot	▪ Practice farm sanitation and good cultural practices. ▪ Proper farm drainage system.
Erwinia chysanthemi (pineapple strain *Dickeya sp.*)	Bacterial fruit collapse and heart rot	▪ Remove and destroy all infected plants. ▪ Ant control in the farm to check spread of disease to healthy plants. ▪ Planting resistant variety.
Penicillium funiculosum	interfruitlet corking	▪ Control flies with pesticide during flowering stage. ▪ Reduce application of nitrogen fertiliser. ▪ Spraying Bordeaux mixture on plants which show symptoms of copper deficiency.

3.4 Harvesting and handling procedures

Pineapple is a non-climacteric fruit and therefore following harvest, will not improve in quality, accumulate sugars, or respond well to ethylene-induced artificial ripening. Pineapple fruit ripened on the plant develop better flavour and sweetness. The Codex Alimentarius Standard 182 for Fresh Pineapple (FAO 2005) requires a total soluble solid content in fruits for harvesting of 12° Brix.

Pineapple can be harvested between 115 and 117 days after flowering depending on the variety, and market destination. As Malaysian pineapple is mostly cultivated on soft peat (low pH) soils, which cannot support heavy mechanised equipment; harvesting is typically done manually using a sharp knife. Once picked, up to 350 fruit are placed in baskets on the back of the small tractor for transport to the packhouse or distribution centre.

3.5 Post-harvest

3.5.1 Packing house

The Malaysian Department of Agriculture (DOA) have identified two packaging houses for the export of fresh pineapple to Australia which have been registered under DOA Malaysia as having been certified to practice Good Agriculture Practices (GAP). Any fumigation treatment required would be provided by fumigation providers registered under the Australian Fumigation Accreditation Scheme (AFAS).

Malaysian pineapple cultivars can theoretically be stored for 4–5 weeks at 8–10 °C. However, chilling injury (black heart) may occur within this temperature range (5–20 °C) (Rohrbach and Schmitt 2003), being expressed in fruit when they are returned to ambient conditions. This factor and other post-harvest diseases may reduce storage life and influence the transport and storage conditions chosen. Chilling injury typically occurs in the pineapple cultivars, ‘Moris’, ‘Sarawak’ and ‘Gandul’, while the Spanish cultivar crosses, ‘Hybrid 36’ and ‘Josapine’ have demonstrated to be less susceptible (MTFIS 2004).

3.5.2 Post-harvest processing

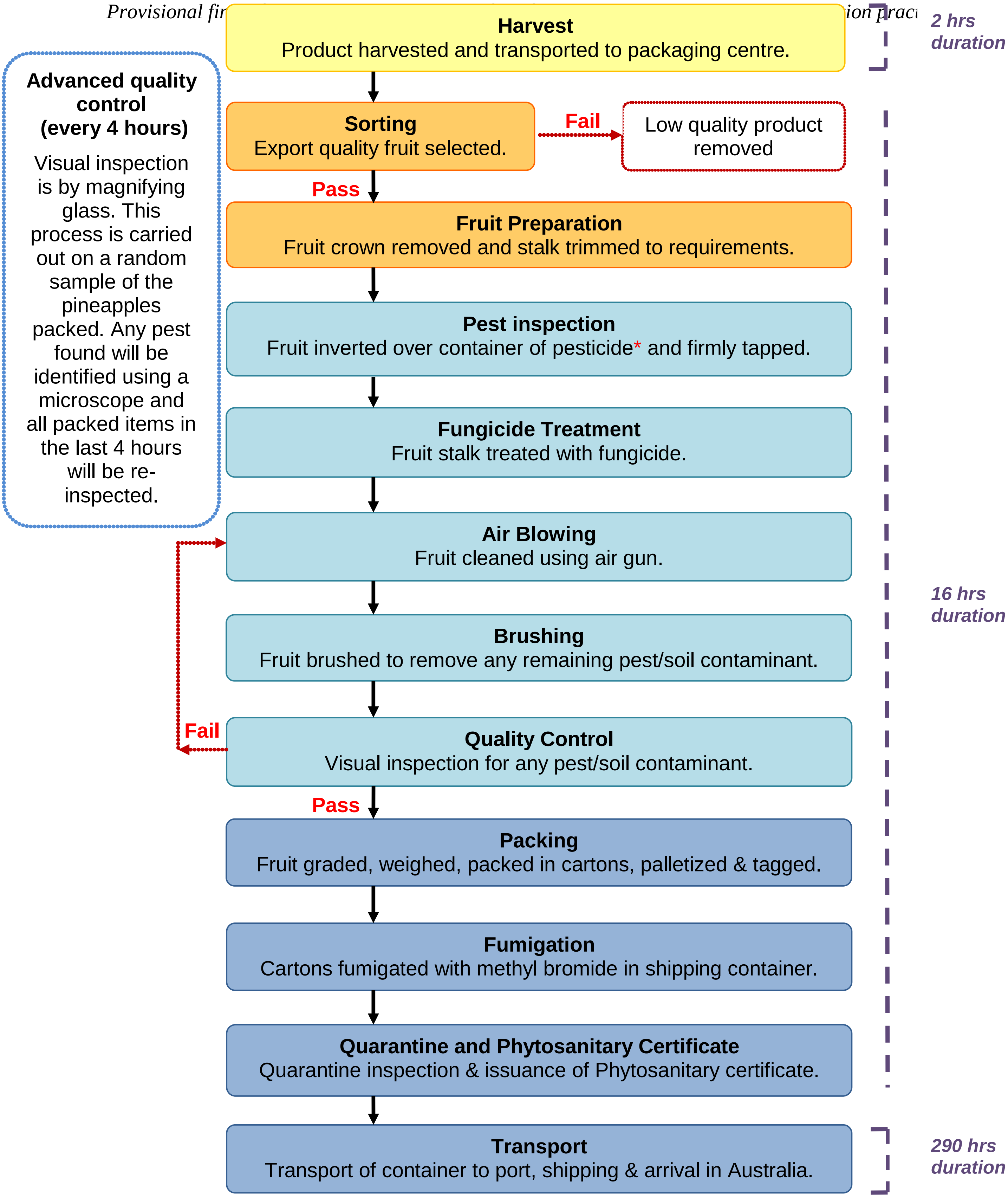
The process of cleaning, sorting, fungicide treatment, weighing, grading and packaging is carried out manually.

- **Sorting and decrowning**: fruit is sorted manually into export quality and other fruit. Fruit that is rotten or heavily infested is discarded. The pineapple crown is removed and the stalk is trimmed to meet the importing country’s conditions.
- **Pest inspection**: fruit is inverted over a container of pesticide Decis 205 (active ingredient *deltamethrin 2.8%*) and tapped firmly to remove any pest contaminant.
- **Fungicide treatment**: fruit stems are treated immediately after sorting and pest inspection with an anti-fungal treatment.
- **Cleaning**: fruit is cleaned using an air blower to remove any remaining pest or soil debris (Figure 8).
- **Grading and packing**: suitable fruit are selected for export, weighed and packed into corrugated fibreboard cartons. Cartons are placed on pallets inside containers.

- **Fumigation/post harvest treatment**: fruit would be treated using an approved product/methodology. Fumigation treatments can only be conducted by providers registered under the Australian Fumigation Accreditation Scheme (AFAS).

Figure 8 Fruit cleaning being undertaken at the packing house using an air blower

Malaysia estimates that the whole process from farm to consumer in Australia to take approximately 13 days. A flowchart of the process from harvest to export is provided in Figure 9.



* Decis 250 active ingredient *deltamethrin* 2.8% w/w.

Process takes approximately 13 days (308 hr)

Figure 9 **Exportation activities of fresh pineapple to Australia (based on a consignment with a 30 tonne capacity)**

3.5.3 Export packaging

Corrugated fibreboard boxes, containing 10 kg net weight of pineapples, are typically used by Malaysia for fresh pineapple exports (Figure 10).

Figure 10 10 kg corrugated fibre board boxes currently utilised by the Malaysian pineapple industry for exports to Dubai

3.5.4 Transport

Malaysia has advised that the preferred export system to Australia would be through the use of sea freight in refrigerated shipping containers. Transport to the port from the packing house will be through the use of a refrigerated shipping container. Air freight, although not preferred, may also be used for export to Australia.

3.6 Export capability

Although most commercial pineapple production in Malaysia is canned prior to export, there is a growing demand for both fresh pineapple and pineapple juice.

3.6.1 Production statistics

Pineapple is widely grown in the states of Johor, Selangor, Kelantan, Sarawak and Penang. Malaysia is ranked as the world's seventeenth largest producer of pineapple fruit, with 1–2% of the global market (MTFIS 2004). In 2009, Malaysia produced 170 021 metric tonne of pineapples, of which 59.40% were produced by small farmers and the other 40.60% produced by large commercial estates.

3.6.2 Export statistics

In 2008, Malaysia's exports of pineapple fruit was 17 743 tonnes. The major export destinations of Malaysian pineapples are summarised in Table 3.3.

Table 3.3 Major export destination of Malaysian pineapples

Country	2003		2004		2005		2006		2007		2008	
	Qty (tonne)	Value (RM)	Qty (tonne)	Value (RM)	Qty (tonne)	Value (RM)	Qty (tonne)	Value (RM)	Qty (tonne)	Value (RM)	Qty (tonne)	Value (RM)
Singapore	11562.94	6621042	11085.07	6499167	11959.84	7282665	12712.18	8201117	12631.74	7640157	12930.41	7630580
UAE	1249.51	1934225	870.46	1079128	1338.98	1319849	2345.82	2462061	45489.03	3073187	2500.73	3671754
Brunei	193.90	205272	101.00	149065	93.40	150220	5619.44	162404	157.37	134206	24.26	23750
Iran	380.00	288800	1558.00	1151463	2020.00	1626618	843.56	1030941	421.10	510637	692.87	671987
Japan	3.65	9444	18.72	51376			1559.46	11057	1.51	4829		
Turkey					115.62	99394	634.00	624371	756.54	1120338	899.1	1432788
Indonesia	258.57	116950	2.00	2400	24.60	16770	67.85	57675	154.89	154693	49.02	38320
Egypt			9.00	10260	48.48	56678	120.25	120633	314.59	284372	438.91	424993
Saudi Arabia	77.83	96881			20.00	15200	67.80	204657	288.63	750011	186.52	184610
Kuwait							47.31	143083	181.42	299455	22	22000
Total	13726.40	9272614	13644.25	8942859	15620.92	10567394	24017.67	13017999	60396.82	13971885	17743.82	14100782

3.6.3 Export season

Flower induction is commonly practiced in Malaysian pineapple production. Commercially produced pineapples are induced to flower in synchrony so that harvesting can be done in one operation. As a result, Malaysian pineapples are not subject to an annual fruiting period and can be produced year round.

3.6.4 Export to Australia

Malaysia has indicated a potential capacity to export 200 tonnes of fresh decrowned pineapple fruit to Australia per annum (DoA 2012).

4 Pest risk assessments for quarantine pests

Quarantine pests associated with decrowned pineapple fruit from Malaysia are identified in Appendix A. This section assesses the probability of the entry, establishment and spread of these pests and the likelihood of associated potential economic, including environmental, consequences.

Pest categorisation identified eight quarantine pests associated with decrowned pineapple fruit from Malaysia. Full details of the pest categorisation are provided in Appendix A. Of these quarantine pests, six are of national concern and two are of regional concern. Table 4.1 identifies these quarantine pests. Assessments of risks associated with these pests are presented in this section. Pests are listed or grouped according to their taxonomic classification, consistent with Appendix A.

Table 4.1 Quarantine pests for decrowned pineapple fruit from Malaysia

Pest	Common name
Armoured scales [Hemiptera: Diaspididae]	
Melanaspis bromiliae[EP] (Leonardi, 1899)	brown pineapple scale
Unaspis citri[WA, SA] (Comstock, 1883)	citrus snow scale
Mealybugs [Hemiptera: Pseudococcidae]	
Dysmicoccus grassii[EP] (Leonadi, 1913)	mealybug
Dysmicoccus neobrevipes[EP] Beardsley, 1959	grey pineapple mealybug
Planococcus minor[WA] (Maskill, 1897)	Pacific mealybug
Pseudococcus jackbeardsleyi[EP] Gimpel and Miller, 1996	Jack Beardsley mealybug
Bacteria	
Erwinia chrysanthemi (Burkholder *et al.* 1953) (pineapple strain, *Dickeya* sp.)	bacterial fruit collapse and heart rot of pineapple
Straminopila	
Phytophthora meadii McRae	rubber leaf drop

Pest risk assessments were completed to determine whether the risk posed by each pest exceeds Australia's ALOP and thus whether phytosanitary measures are required to manage the risk. In this import risk analysis the superscript '**EP**' (existing policy) is used for pests that have previously been assessed and a policy already exists.

Some pests identified in this assessment have been recorded in some regions of Australia, and due to interstate quarantine regulations are considered pests of regional concern. These organisms are identified with a superscript, such as '**WA**', for the state for which the regional pest status is considered.

Pineapples harvested, packed, stored and transported for export to Australia may need to travel variable distances to ports. Depending on the port of departure and arrival it could take two to three weeks for general sea freight from Malaysia to Australia. Pineapple fruit could also potentially be air freighted from Malaysia to Australia within about a week from harvest. While the unrestricted risk assessments undertaken in this risk analysis do not impose any mandatory measures during storage and transport, common commercial practices may impact on the survival of some pests. If these conditions are applied to all consignments for a minimum period of time, then those conditions can be considered as part of the unrestricted risk assessment.

4.1 Armoured scales [Hemiptera: Diaspididae]

Melanaspis bromiliae; Unaspis citri WA, SA

4.1.1 Introduction

Armoured scales, as the group Diaspididae, have previously been assessed in a number of IRAs. Most recently; the final import risk analysis report for fresh apple fruit from the People's Republic of China (Biosecurity Australia 2010a), the final import risk analysis report for fresh unshu mandarin fruit from Shizuoka Prefecture in Japan (Biosecurity Australia 2009) and the final import risk analysis report for fresh mango fruit from India (Biosecurity Australia 2008).

The assessment in this policy builds upon these previous assessments and takes into account differences in production practices, climatic conditions and the prevalence of the pest on the commodity.

Armoured scales construct a wax-like, fibrous 'scale' that covers the insect (Carver *et al.* 1991). This 'scale' forms a protective barrier against physical and chemical attack (Foldi 1990), and strongly affixes the insect to the plants on which they occur (Burger and Ulenberg 1990).

Scale insects are primarily sedentary, small and often inconspicuous and occur widely on plants and plant products. Armoured scales are unlikely to be killed by any washing solution, even if insecticidal, as the physical properties of their protective covers provide an effective barrier against contact toxicants (Foldi 1990).

Female armoured scales have thee instars; the first is the only one that is mobile (Williams and Watson 1988a). Male armoured scales have five instars. The adult male is capable of flight, but they are weak, have no mouthparts and are short lived (Beardsley and Gonzalez 1975; Hely *et al.* 1982; Williams and Watson 1988a).

The first instar is the primary dispersal stage of the armoured scale. The larvae emerge as 'crawlers' which are able to wander before finding a suitable place to settle (Beardsley and Gonzalez 1975; Hely *et al.* 1982).

The armoured scale *Melanaspis bromiliae* was assessed in previous policy developed for the importation of pineapples from the Philippines, Thailand, Sri Lanka and the Solomon Islands (Biosecurity Australia 2002). That assessment has been reviewed for decrowned pineapple fruit from Malaysia.

The armoured scales considered in this import risk assessment are *Melanaspis bromiliae* and *Unaspis citri*.

Unaspis citri is not present in the states of Western Australia and South Australia and is a pest of regional concern for those states (DAWA 2005; PIRSA 2011).

Melanaspis bromiliae and *Unaspis citri* have been grouped together due to their similar biology and taxonomy. In this assessment, the term 'armoured scale' is used to refer to these species, unless otherwise specified.

4.1.2 Probability of entry

Probability of importation

The likelihood that armoured scales will arrive in Australia with the importation of decrowned pineapple fruit from Malaysia is: **HIGH**.

Association of the pest with the pathway

- Armoured scales occur in Malaysia (CIE 1962; Ben-Dov *et al.* 2010) and pineapple is a known host (Deitz and Davidson 1986; Watson 2005; CAB International 2010).
- First instar nymphs (or crawlers) of armoured scales can move onto fruit, attach permanently and commence feeding (Beardsley and Gonzalez 1975; Dreistadt *et al.* 1994). Subsequent instars are sessile and usually remain attached to their host (CAB International 2010).

Ability of the pest to survive existing pest management procedures

- Armoured scales have a relatively hard, impermeable, external covering or 'scale' (Foldi 1990) that can protect them from physical and chemical damage (Foldi 1990). Commercial fruit cleaning procedures undertaken as part of Malaysia's standard production practices may not remove all viable scales present on the fruit surface (Armstrong 2001).
- Armoured scales may be inconspicuous on pineapple fruit because of their limited mobility, size (*U. citri* adult female is approximately 2 mm (Smith *et al*. 1997)) and the textured surface of pineapple fruit. Therefore these species are likely to escape detection during routine visual inspection.

Ability of the pest to survive transport and storage

- Given that fruit would provide an ample food supply during transit, adults and crawlers are likely to survive storage and transport at 8–10 °C.

Summary

The small size, sessile nature of most life stages and that they are unlikely to be removed from the fruit surface through standard cleaning, all support a likelihood estimate for importation of 'high'.

Probability of distribution

The likelihood that armoured scales will be distributed within Australia in a viable state as a result of the processing, sale or disposal of decrowned pineapple fruit from Malaysia and subsequently transfer to a susceptible part of a host is: **LOW**.

Distribution of the imported commodity in Australia

- Imported fresh pineapple fruit is intended for human consumption in Australia. It is expected that once the fresh pineapple fruit has arrived in Australia, it will be distributed throughout Australia for wholesale or retail sale.

Risks from by-products and waste

- Due to the physical size of scales, infested fruit is still likely to be consumed, and disposal of fruit skin may further aid distribution of viable scales. Disposal of infested fruit is likely to be via commercial or domestic rubbish systems. While this reduces the chances of successful transmission, any susceptible hosts in the vicinity of the rubbish systems may be exposed.

- Consumers will discard small quantities of fruit waste in urban, rural and natural localities. Small amounts may be discarded in domestic compost.

Ability of the pest to move from the pathway to a suitable host

- Adult armoured scales lack a natural dispersal mechanism that allows for their movement from discarded fruit waste to a suitable host.
- First-instar nymphs are the primary dispersal phase in the life-cycle of armoured scales. They need to be present for dispersal from waste material to a host plant.
- There are two principal ways that first-instar nymphs may transfer to a suitable host; active dispersal of crawlers and the action of wind (Beardsley and Gonzalez 1975).
- Birds, insects, and other animals including human activities may also serve as accidental carriers (Beardsley and Gonzalez 1975).

Summary

The possibility of dispersal near suitable hosts by crawlers associated with discarded fruit, moderated by the limited mobility of adult armoured scales and the disposal of most waste via commercial or domestic rubbish systems, supports a likelihood estimate for distribution of 'low'.

Overall probability of entry (importation × distribution)

The overall probability of entry is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2.

The likelihood that armoured scales will enter Australia as a result of trade in decrowned pineapple fruit from Malaysia and be distributed in a viable state to a susceptible host is: **LOW.**

4.1.3 Probability of establishment

The likelihood that armoured scales will establish in Australia, based on a comparison of factors in the source and destination areas considered pertinent to its survival and reproduction, is: **HIGH**.

Availability of suitable hosts, alternative hosts and vectors in the PRA area

- *Melanaspis bromiliae* has a narrow host range and has only been reported on *Ananas* spp., *Bromelia* spp., *Cocos nucifera*, *Neoglaziovia variegata* and *Pandanus* spp. (Deitz and Davidson 1986; Ben-Dov *et al.* 2010). All these host species occur in Australia within a climatic area that would be similar to climatic conditions in Malaysian pineapple production areas.
- Despite a wide potential host range (Davidson and Miller 1990; Watson 2005), *U. citri* has primarily been recorded on citrus species within Australia (Hely *et al*. 1982; Smith *et al.* 1997; APPD 2011). Citrus species are widely distributed in Australia.

Suitability of the environment

- Climatic conditions in parts of Australia are conducive to the establishment of armoured scales.

- Environmental conditions greatly influence the survival and dispersal of first-instar nymphs (Watson 2005). Moderate to high humidity, without precipitation, favours survival of first-instar nymphs (Watson 2005).
- Moderate to high humidity coastal regions favour the survival of *U. citri* (Watson 2005), however infestation rates in coastal regions of NSW are higher in the dry season (Hely *et al.* 1982). In Australia, this species is confined to humid, coastal regions of Queensland and New South Wales and has not colonized semi-arid inland areas (Maelzer 1979; ABRS 2009). Narrow climate tolerances are likely to moderate the potential of *U. citri* to establish in other Australian regions.

The reproductive strategy and survival of the pest

- Armoured scales have a relatively high reproductive rate resulting largely from the longevity and fecundity of the adult female. Diaspidids are sexually dimorphic.
- *Unaspis citri* produces several overlapping generations throughout the year (Hely *et al.* 1982; Watson 2005) with largest populations in late autumn (Smith *et al.* 1997). The number of generations produced per year is typically four in citrus-growing areas (Brooks 1977), but 3–4 are produced in NSW and 5–6 are possible in Queensland and the Northern Territory (Smith *et al.* 1997). Smith *et al.* (1997) reported production of 150 eggs per female and a life-cycle of approximately 8 weeks, when hosted on Australian citrus. Cooler weather usually extends the life-cycle duration (CAB International 2010).

Summary

Adaptation to climatic conditions occurring in Australia and the high reproductive rate of armoured scales support a likelihood estimate for establishment of 'high'.

4.1.4 Probability of spread

The likelihood that armoured scales will spread within Australia, based on a comparison of those factors in the source and destination areas considered pertinent to the expansion of the geographic distribution of the pest, is: **MODERATE**.

Suitability of the natural or managed environment for natural spread

- In Australia, *U. citri* is confined to humid, coastal regions of the Northern Territory, Queensland and New South Wales and has not colonized semi-arid inland areas (Maelzer 1979; ABRS 2009). Narrow climate tolerances are likely to moderate the potential of *U. citri* to spread within the PRA area.
- *Unaspis citri* is polyphagous (Watson 2005), although in Australia it has primarily been recorded on citrus species (Hely *et al.* 1982; Smith *et al.* 1997; APPD 2011).
- *Melanaspis bromiliae* has a limited host range and has only been reported on *Ananas* spp, *Bromelia* spp, *Cocos nucifera*, *Neoglaziovia variegata* and *Pandanus* spp.
- Mortality due to abiotic factors is high for first instar nymphs, hazards include fluctuation in temperature, low humidity, rain and lack of suitable settling sites (Beardsley and Gonzalez 1975).

Presence of natural barriers

- The presence of natural barriers will prevent the long range spread of these scales.
- Crawlers are the primary dispersal stage and move short distance by active wandering (Beardsley and Gonzalez 1975).

- Crawlers can also be dispersed locally by wind currents, by birds, insects or other animals. Dispersal, particularly over long distances, of sessile adults and eggs occurs almost entirely through human transport of infested plant material (Beardsley and Gonzalez 1975).

Potential enemies

- Predation is a key factor known to moderate the rate of spread of armoured scales where they occur. In Australia, predatory caterpillars (*Batrachedra* spp.) have been demonstrated to significantly reduce population density (Hely *et al.* 1982) of *U. citri*. Additionally, a number of beetles (*Chilocorus* spp. *Telsimia* spp., *Rhizobius* spp., and *Cybocephalus* spp.), mites (*Hemisarcoptes* spp) and a fungus (*Fusarium coccophilum*) are also known to help control armoured scales (Smith *et al.* 1997).

Summary

The mobility of crawlers and potential for passive dispersal and demonstrated prior history of spread in some Australian states, moderated by the limited host range, support a likelihood estimate for spread of ‘moderate’.

4.1.5 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The likelihood that armoured scales will be imported as a result of trade in decrowned pineapple fruit from Malaysia, be distributed in a viable state to a susceptible host, establish and spread within Australia is: **LOW**.

4.1.6 Consequences

The consequences of the establishment of armoured scales in Australia have been estimated according to the methods described in Table 2.3.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are **‘D’**, the overall consequences are estimated to be: **LOW**.

Reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D** – Significant at district level. Armoured scales can cause direct harm to a wide range of host plants, affecting fruit quality and plant health (Dreistadt *et al*. 1994). Miller and Davidson (1990) list *U. citri* as a serious and widespread agricultural pest. Feeding by *U. citri* usually occurs on the trunk and main limbs of trees, but spreads to the twigs, leaves and fruit when infestations are heavy (CAB International 2010). Several species of *Melanaspis* are considered economically important pests (Deitz and Davidson 1986). Damage caused to plants includes yellow spotting to the underside of leaves, premature leaf loss, branch dieback and, in some instances, extensive drying and splitting of the bark on the trunk and main limbs (Smith *et al*. 1997). Infested hosts are often susceptible to secondary attack by fungi and wood-boring insects (CAB International 2010). Members of the Diaspididae do not excrete honeydew and there is no issue with associated sooty mould or ants (Foldi 1990).
Other aspects of the environment	**B –** Minor significance at local level. Armoured scales introduced into a new environment may compete for resources with native species.

Indirect	
Eradication, control etc.	**D** – Significant at district level. Additional programs to minimise the impact of armoured scales of are likely to be costly and include pesticide applications and crop monitoring. For some hosts, existing control programs, for example broad spectrum pesticide applications, can be effective. For other hosts, existing control programs, for example specific integrated pest management or organic systems, may not be effective. Insecticides do not always provide adequate control of armoured scales. The waxy surfaces, sessile nature, intermittent feeding and overlapping generations of armoured scales may make them difficult to control (Foldi 1990; CAB International 2010). In Australian citrus production areas, trees are inspected regularly for scale insects; when 20–30% of orchard trees are infested, they are sprayed. Monitoring of pest development is vital to the effective timing of oil sprays because the young crawler stage is most vulnerable (Moulds and Tugwell 1999). Biological control is likely to be an effective long term strategy. *Chilocorus circumdatus* (a ladybird, Coccinellidae) provides effective biological control for *U. citri* in citrus production areas of Queensland and northern New South Wales (Smith *et al.* 1997).
Domestic trade	**C** – Significant at local level. The presence of armoured scales in commercial production areas is likely to have a significant effect at the local level due to interstate trade restrictions on some commodities. These restrictions may lead to a loss of markets and industry adjustment.
International trade	**D** – Significant at district level. The presence of armoured scales in commercial production areas of export commodities (e.g. citrus) may have an effect on international trade due to restrictions on access to overseas markets where these pests are absent.
Environmental and non-commercial	**B** – Minor significance at local level. Additional pesticide applications or other control activities would be required to control these pests on susceptible crops. Any additional insecticide usage may affect the environment.

4.1.7 Unrestricted risk estimate

The unrestricted risk estimate for *Melanaspis bromiliae* and *Unaspis citri* is: **VERY LOW**.

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

The unrestricted risk estimate for armoured scales of ‘very low’ is below Australia’s ALOP. Therefore, no specific risk management measures are required for these pests.

4.2 Mealybugs [Hemiptera: Pseudococcidae]

Dysmicoccus grassii; Dysmicoccus neobrevipes; Pseudococcus jackbeardsleyi; *Planococcus minor* WA

4.2.1 Introduction

Mealybugs, as the group Pseudococcidae, have previously been assessed in a number of IRAs. Most recently; the final import risk analysis report for table grapes from the People's Republic of China (Biosecurity Australia 2011), the final import risk analysis report for fresh apple fruit from the People's Republic of China (Biosecurity Australia 2010a), the final import risk analysis report for fresh stone fruit from California, Idaho, Oregon and Washington (Biosecurity Australia 2010b) and the final import risk analysis report for fresh unshu mandarin fruit from Shizuoka Prefecture in Japan (Biosecurity Australia 2009).

The assessment in this policy builds upon these previous assessments and takes into account differences in production practices, climatic conditions and the prevalence of the pest on the commodity.

Mealybugs are small, oval, soft-bodied, slow moving insects that are covered with white wax (Furness and Charles 1994). They are sucking insects that injure plants by extracting large quantities of sap. They also produce honeydew, which serves as food for ants or as a substrate for the development of sooty mould. Many mealybug species pose serious problems for agriculture, particularly when introduced into new areas of the world where their natural enemies are not present (Miller *et al.* 2002).

Mealybugs develop through a number of nymphal (immature instar) stages before undergoing a final moult into the adult form. Female mealybugs have four instars and the male has five instars (Williams 2004). Reproduction in mealybugs is parthenogenic or sexual and there may be multiple generations per year. After mating, mealybugs produce between 300 and 1000 offspring (eggs or live young). There are two groups of mealybugs: short-tailed mealybugs, which produce eggs (e.g. *Pseudococcus jackbeardsleyi*), and long-tailed mealybugs, which are ovoviviparous that hatch eggs within the female and give birth to live young (e.g. *Dysmicoccus neobrevipes*) (Mau and Kessing 1993; Kessing and Mau 2007).

The mealybugs *Dysmicoccus grassii*, *D. neobrevipes* and *Pseudococcus jackbeardsleyi* were assessed in previous policy developed for the importation of pineapples from the Philippines, Thailand, Sri Lanka and the Solomon Islands (Biosecurity Australia 2002). Those assessments have been reviewed for decrowned pineapple fruit from Malaysia.

The additional mealybug considered further in this import risk analysis for decrowned pineapple fruit is *Planococcus minor*. Planococcus minor is not present in the state of Western Australia and is a pest of regional quarantine concern for that state. The four species have been grouped together because of their related biology and taxonomy. They are predicted to pose a similar risk and require similar mitigation measures. In this assessment the term 'mealybugs' is used to refer to these species unless otherwise specified.

4.2.2 Probability of entry

Probability of importation

The likelihood that mealybugs will arrive in Australia with the importation of decrowned pineapple fruit from Malaysia is: **HIGH**.

Association of the pest with the pathway

- Mealybugs are present on the importation pathway. They occur in Malaysia and pineapple is a known host (Williams 2004; Ben-Dov *et al.* 2010).
- Mealybugs may be inconspicuous and not detected because of their small size (0.5–4.5 mm), immobility and the textured surface of pineapple fruit.

Ability of the pest to survive fruit processing procedures

- Mealybugs are likely to resist commercial cleaning of fruit as they have a protective coating.

Ability of the pest to survive transport and storage

- Mealybugs can hibernate in cold conditions (Hoy and Whiting 1997). They are likely to survive both the temperatures and duration of importation and subsequent distribution processes.

Summary

The association of mealybugs with fruit, their inconspicuousness, resistance to standard post-harvest treatments and capacity for surviving adverse environmental conditions all support a likelihood estimate for importation of ‘high’.

Probability of distribution

The likelihood that mealybugs will be distributed within Australia in a viable state as a result of processing, sale or disposal of decrowned pineapple fruit from Malaysia and subsequently transfer to a susceptible part of a host is: **MODERATE**.

Distribution of the imported commodity in Australia

- Imported fresh pineapple fruit is intended for human consumption in Australia. It is expected that once the fresh pineapple fruit has arrived in Australia, it will be distributed throughout Australia for wholesale or retail sale.

Risks from by-products and waste

- Infested fruit is still likely to be consumed, and disposal of fruit skin may further aid distribution of viable mealybugs. Disposal of infested fruit is likely to be via commercial or domestic rubbish systems. While this reduces the chances of successful transmission, any susceptible hosts in the vicinity of the rubbish systems may be exposed.
- Consumers will discard small quantities of fruit waste in urban, rural and natural localities. Small amounts may be discarded in domestic compost.

Ability of the pest to move from the pathway to a suitable host

- Crawlers are the primary dispersal phase in the mealybugs life-cycle. They are capable of active dispersal by crawling and passive dispersal by wind currents (Hely *et al.* 1982; Rohrbach *et al*. 1988). Mealybugs may migrate from fruit waste to adjacent vegetation.

- Mealybugs are polyphagous. A range of plants that are widely distributed in Australia can act as hosts (see Appendix B).
- Lack of active (by flight) long distance dispersal mechanisms may moderate the rate of distribution of these species.

Summary

The possibility of dispersal by crawlers near suitable hosts, the wide availability of hosts, moderated by the lack of long distance dispersal, support a likelihood estimate for distribution of 'moderate'.

Overall probability of entry (importation × distribution)

The overall probability of entry is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2.

The likelihood that mealybugs will enter Australia as a result of trade in decrowned pineapple fruit from Malaysia and be distributed in a viable state to a susceptible host is: **MODERATE.**

4.2.3 Probability of establishment

The likelihood that mealybugs will establish in Australia, based on a comparison of factors in the source and destination areas considered pertinent to its survival and reproduction, is: **HIGH**.

Availability of suitable hosts in the PRA area

- The identified species are polyphagous and therefore there is a high probability that dispersing mealybugs will find a suitable host.
- Hosts of *Pl. minor* include wild and cultivated plants (Venette and Davis 2004) comprising over 250 species in 80 families (Ben-Dov *et al.* 2010).

Reproductive strategy and survival of the pest

- Mealybugs have a relatively high reproductive rate, providing the capacity to rapidly establish a significant population after incursion. Adult females are generally long-lived and fecund.

Suitability of the environment

- Many species of mealybugs are considered invasive (Miller *et al.* 2002); rapidly becoming established when introduced into new areas. These mealybug species have shown the ability to establish after being introduced into new environments. For example *Ps. jackbeardsleyi* has been introduced into Hawaii and Florida in the United States and is now considered a pest (Mau and Kessing 1993; Miller *et al.* 2002).
- Demonstrating this capacity in Australia *Pl. minor* is established within New South Wales, Queensland, South Australia and the Northern Territory (Ben-Dov *et al.* 2010).

Summary

The generalist feeding behaviour, high fecundity and past invasive history of mealybugs all support a likelihood estimate for establishment of 'high'.

4.2.4 Probability of spread

The likelihood that mealybugs will spread within Australia, based on comparison of factors in the source and destination areas considered pertinent to the expansion of the geographic distribution of the pest, is: **HIGH**.

The suitability of the environment

- The identified species are polyphagous and therefore there is a high probability that dispersing mealybugs will find a suitable host. Susceptible hosts are likely to be available adjacent to sites of establishment and therefore increase the potential for spread.
- Once second and subsequent generations of mealybugs have become established on susceptible commercial, household and wild host plants, mealybugs are likely to persist indefinitely and to spread progressively overtime.

Presence of natural barriers

- Lack of a longer range active dispersal mechanism may moderate the rate at which mealybugs spread. Although adult males are winged, they are fragile, do not feed and are short-lived (Mau and Kessing 1993; Kessing and Mau 2007).
- Crawlers, the primary dispersal phase within the mealybug's life-cycle, are capable of active dispersal by crawling and passive dispersal by wind currents (Hely *et al.* 1982; Rohrbach *et al*. 1988). Movement of adults or nymphs can occur on infected plant material or on animals (Hely *et al.* 1982; Williams 2004).

Summary

The broad host range, active and passive dispersal of crawlers and adult females and past history of establishment all support a likelihood estimate for spread of 'high'.

4.2.5 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The likelihood that these mealybugs will enter Australia as a result of trade in decrowned pineapple fruit from Malaysia, be distributed in a viable state to a susceptible host, establish and spread within Australia is: **MODERATE**.

4.2.6 Consequences

The consequences of the establishment of these mealybugs in Australia have been estimated according to the methods described in Table 2.3.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**D**', the overall consequences are estimated to be: **LOW**.

Reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D** – Significant at the district level. Internationally *D. grassii, D. Neobrevipes, Ps. jackbeardsleyi and Pl. minor* are economically significant pests of many crops (Miller *et al.* 2002; Venette and Davis 2004; Williams 2004; Ben-Dov *et al.* 2010). Mealybugs cause direct harm to hosts by sucking and depleting sap and secreting honeydew (Williams 2004). Honeydew provides a substrate for sooty mould to grow which can reduce fruit quality, photosynthesis, tree vigour and productivity (Williams 2004). The mealybug's proboscis rarely penetrates beyond the fruits epidermis, but spotting at feeding sites and distortion of fruit can occur and attacked fruit is considered of low quality and is often unmarketable (Ooi *et al.* 2002). Mealybugs can act as disease vectors. *Dysmicoccus neobrevipes* is known to vector pineapple mealybug wilt virus (Rohrbach *et al.* 1988), which is present in parts of Australia. All four species have a wide host range and are likely to find suitable hosts (commercial and native) in Australia.
Other aspects of the environment	**B** – Minor significant at the local level. Mealybugs may compete for resources with native species, especially in the absence of predation.
Indirect	
Eradication, control etc.	**D –** Significant at the district level. Programs to contain, eradicate and/or minimise the impact of these pests are likely to be costly and include pesticide application and crop monitoring. Existing controls (e.g. specific integrated pest management or organic systems) may be ineffective and compromised.
Domestic trade	**D –** Significant at the district level**.** Trade restrictions may be applied by states that lack these mealybugs. In states where the pests exist there may be losses if restrictions are placed on interstate trade in association with containment and eradication of the pests.
International trade	**D –** Significant at the district level**.** The presence of these pests in commercial production areas of a range of commodities that are hosts to these mealybugs may restrict access to overseas markets where these pests are absent.
Environmental and non-commercial	**B –** Minor significance at local level. Additional pesticide applications would be required to control these pests on susceptible crops. Any additional insecticide usage may affect the environment. However, any impact on the environment is likely to be minor at the local level.

4.2.7 Unrestricted risk estimate

The unrestricted risk for mealybugs is: **LOW**.

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in table 2.5.

The unrestricted risk estimate for mealybugs of 'low' is above Australia's ALOP. Therefore, specific risk management measures are required for this pest.

4.3 Bacterial fruit collapse of pineapple [Enterobacteriales: Enterobacteriaceae]

Erwinia chrysanthemi (pineapple strain, *Dickeya* sp.)

4.3.1 Introduction

The bacterial species *Erwinia chrysanthemi* was first proposed in 1953 for the agent causing blight in chrysanthemums (Burkholder *et al.* 1953). Similar bacteria were subsequently isolated from soft rots and wilts of numerous diseased plant species. After extensive biochemical studies all isolates were finally gathered into the single species *Erwinia chrysanthemi* (syn. *Pectobacterium chrysanthemi*) in the Approved list of bacterial names (Skerman *et al.* 1980). The genus *Pectobacterium* (Waldee 1945) has been included within the genus *Erwinia* (Burkholder *et al.* 1957; Lelliott and Dickey 1984). For convenience, phytobacteriologists divided *E. chrysanthemi* into six pathovars, pv. *chrysanthemi*, pv. *dianthicola*, pv. *dieffenbachiae*, pv. *paradisiaca*, pv. *parthenii*, and pv. *zeae* (Dye *et al.*1980). However, using pathogenicity tests to define the affiliation of a strain to a given pathovar proved difficult to implement (Dickey 1981; Janse and Ruissen 1988). Hence at that time it was proposed (Dickey 1981; Lim and Lowings 1983) that the pineapple strain be known as *E. chrysanthemi* (pineapple strain). Subsequently, as an alternative to the pathovar concept, nine biovars were proposed to characterise all strains of the complex by unambiguous differential biochemical tests (Samson and Nassan-Agha 1978; Samson *et al.* 1989; Ngwira and Samson 1990).

Samson *et al.* (2005) proposed a new genus *Dickeya* to accommodate bacterial species previously assigned to *E. chrysanthemi* and *P. chrysanthemi* and proposed six species of *Dickeya* (*D. zeae*, *D. dadantii*, *D. chrysanthemi*, *D. dieffenbachiae*, *D. dianthicola*, and *D. paradisiaca*). However in that study, the status of pineapple infecting strains was unclear. They placed a strain isolated from pineapples in Martinique (France) under *Dickeya zeae* and the strain isolated from pineapples from Malaysia under *Dickeya* sp., without being able to allocate it into any of the other six *Dickeya* species. Further, they listed pineapple as a host in the species description of *Dickeya dadantii*. There were only two strains placed under *Dickeya* sp, namely the Malaysian pineapple strain and the Australian sugarcane strain and they too were different to each other in serological and phenotypic characteristics.

Findings of Samson *et al.* (2005) that the Malaysian pineapple strain is distinct is supported by previous work of Nassar *et al.* (1994) and Avrova *et al.* (2002). Based on rRNA patterns, Nassar *et al.* (1994) found Malaysian pineapple strains to occupy a discrete group (cluster 6) to all other isolates tested. Avrova *et al.* (2002) found Malaysian pineapple infecting strains to have a different amplified fragment length polymorphism pattern from other *E. chrysanthemi* strains.

Parkinson *et al.* (2009) attributed the Malaysian pineapple infecting strain to *D. zeae* but that study used the gene sequence at one locus and limitations of such an approach have been highlighted (Growcom 2011).

Kaneshiro *et al.* (2008) decided to refer to the pathogen affecting pineapple as *E. chrysanthemi* until sufficient taxonomic studies on a larger collection of pineapple strains had been performed that could place the strains more definitely under the new nomenclature. Peckham *et al.* (2010) argued that until the pineapple strains are genetically characterised, the strains infecting pineapples must be referred to as unclassified *Dickeya* sp. Marrero *et al.* (2009; 2010) argued that the pathogen infecting pineapple warrants classification as a new species or a subspecies of *D. zeae*. Most recently, Marrero and Alvarez (2011) used the name *E. chrysanthemi* (*Dickeya* sp.).

As seen, even after several decades of work, the position of the Malaysian pineapple affecting strains has not been resolved satisfactorily. International guidelines for Pest Risk Analysis (PRA) require that the identity of the pest be clearly defined to ensure that the assessment is being performed on a distinct organism and that the biological and other information used in the assessment is relevant to the organism in question (FAO 2004). Therefore, to avoid any confusion and for the purposes of completing this assessment, the pineapple affecting strain in Malaysia is referred to as ***Erwinia chysanthemi* (pineapple strain, *Dickeya* sp.)** although *E. chrysanthemi* will be maintained in citing literature where this name has been used.

The strain of the gram negative bacterium *E. chrysanthemi* infecting pineapple in Malaysia is specific to pineapple (Lim and Lowings 1983) and recent molecular studies support that the Malaysian pineapple strain is distinct (Samson *et al.* 2005).

The bacterium causes two diseases in pineapple; a fruit disease called fruit collapse and a stem and leaf disease called bacterial heart rot. Both diseases have been known in the Malaysian pineapple industry from around 1937 (Lim 1986). According to Rohrbach and Schmitt (2003), both diseases are now present in Costa Rica, Philippines and Brazil. Recently bacterial heart rot, suspected to have entered with pineapple planting material imported from Central America or Philippines, has been reported in Hawaii (Vine *et al*. 2005; Kaneshiro *et al.* 2008). Neither disease has been reported in Australia. Although strains of *E. chrysanthemi* infecting several other hosts including corn, potato, banana, ginger and *Dieffenbachia* are present in Australia (APPD 2011; CABI/EPPO 2011; CAB International 2012), the specific strain infecting pineapple in Malaysia is considered absent.

In fruit collapse the bacterium enters through the flower. Ants and insects are considered to carry the bacterium into flowers. The bacterium remains latent as the fruit matures and develops symptoms about 2–3 weeks before ripening. The break in latency is believed to be caused by a reduction in polyphenoloxidase level coupled with a sharp increase in sugar (Lim 1978). Symptoms of fruit collapse include copious exudation of fluid accompanied by bubbles of gas and the skin of the infected fruit changing from dark purple to olive green.

In bacterial heart rot the infection usually occurs on young plants four to eight months after planting. Older plants are affected rarely. Infection takes place through the stomata at the base of young leaves (Lim 1986). Symptoms first appear as water-soaked lesions arising from the base of the central whorl of leaves. These lesions may spread to the green portion of the leaf, turning it olive green and the leaf appears bloated due to accumulation of gas within. Sometimes the entire length of the leaf becomes infected. Disease symptoms usually only progress to the stem at the apical region. A few days after the initial infection, the whole 'heart' can be easily detached from the plant by a gentle tug. Heart rot is commonly produced in vegetative plants before flowering but leaves of the crown can also show signs of infection.

The source of inoculum for both diseases is freshly collapsed fruits, plants infected with heart rot or bases of leaves where exudate collects. Fruit collapse is the more serious of the two diseases (Lim 1986).

The risk scenario with respect to *Erwinia chysanthemi* (pineapple strain, *Dickeya* sp.) when importing pineapple fruit with the crown intact is that any infection in the flesh of the fruit and infected leaves in the crown or at the bottom of the fruit may not be detected during harvest and processing in the packing house. However, in the current IRA the scope is for fresh decrowned pineapples from which the crown and all basal leaves have been removed (section

1.2.2). This greatly minimises the risk with infected leaves and heart rot. The main risk scenario in the current situation is therefore infections from fruit collapse, latent or otherwise, that may be associated with the exported fruit.

4.3.2 Probability of entry

Probability of importation

The likelihood that the pineapple fruit collapse and heart rot pathogen *Erwinia chrysanthemi* (pineapple strain, *Dickeya* sp.) will arrive in Australia with the importation of decrowned pineapple fruit from Malaysia is: **LOW**.

Association of the pest with the pathway

- The strain of *Erwinia chrysanthemi* infecting pineapple in Malaysia causes two diseases in pineapple; a fruit disease called 'fruit collapse' and a leaf and stem disease called 'bacterial heart rot' (Lim 1986). In fruit collapse the bacterium enters mainly through the flower, remains latent as the fruit matures and develops symptoms about 2–3 weeks before ripening.
- In bacterial heart rot, the pathogen infects the central whorl of leaves in young plants spreading to the stem at the apical region (Lim 1986). Rohrbach (1983) states that crowns growing above the fruit are much less likely to be infested than slips or suckers which occur below the rotting fruit. However, Lim (1986) outlines that some crowns from healthy fruit can appear twisted because of early infection by the pathogen at the base of some of the crown leaves.
- Malaysia has indicated that exports of fresh pineapples to Australia will include hybrid varieties 'Josapine' and 'N36' (DoA 2009). 'Josapine' is the most popular variety in Malaysia (Ibrahim *et al*. 2009) and is highly susceptible to bacterial heart rot (Rozeita and Kogeetha 2010). Although it is a hybrid between 'Johor' ('Spanish', highly susceptible (Lim and Lowings 1979)) and 'Sarawak' ('Smooth Cayenne', relatively resistant (Lim and Lowings 1979)), the highly susceptible character of 'Spanish' seems to have prevailed in the hybrid. Similarly, N36 is a hybrid between 'Gandul' ('Spanish') and 'Smooth Cayenne'.
- The scope of Malaysia's request is for decrowned pineapple fruit with crowns and all basal leaves removed (section 1.2.2). Association of the pest with the pathway would only be through any infections in the fruit and not through infected leaves.

Prevalence of the pest in plantations in the exporting country

- The prevalence of the pathogen causing fruit collapse in Malaysian pineapple production systems has been reported at various levels ranging from 0 to 40% over the past 50 years (Lim 1979; Lim 1986). While no specific figures were available reporting the incidence of fruit collapse in the new 'Josapine' and 'N36' varieties, the incidence of heart rot has been demonstrated to cause losses as high as 64% in the 'Josapine' variety (Rozeita and Kogeetha 2010).
- A number of disease management procedures to reduce the incidence of fruit collapse are recommended to growers in Malaysia and these have been briefly outlined in section 3 of this IRA. The measures include:
    - removal and destruction of all infected plants

- the use of insecticides to control vectors, particularly ants (DoA 2009), which has been demonstrated to be extremely effective in reducing the incidence of fruit collapse in the field (Lim and Lowings 1982)
- planting resistant varieties (DoA 2009).

Likelihood of harvested fruit being infected

Latency in the fruit

- In fruit collapse, the pathogen enters the plant through the flower and remains latent in the developing fruit for over 2 months. Then as the fruit matures, latency is broken and the bacteria begin multiplying and infecting the fruit as it matures, producing symptoms 2–3 weeks before ripening (Lim and Lowings 1978; Lim and Lowings 1979; Lim 1986; Rohrbach 1989). Symptoms include copious exudation of fluid from the interfruitlet fissures, accompanied by bubbles of gas, and the skin of the infected fruit changing from dark purple to olivaceous green (Lim 1986).
- Expression of symptoms 2–3 weeks before ripening, coupled with the rapid collapse of infected fruit at ambient temperatures ensures the detection and exclusion of infected fruit from harvest to a high degree (Rohrbach 1983). However, while the greatest incidence of fruit collapse can be observed in the field and such fruit excluded from harvest, data in Lim (1986) and Lim and Lowings (1979) indicate that small percentages (up to 2%) of fruit can remain as undetected latent infections beyond the initial picking phase.
- Stakeholders have argued that there is no credible basis for the possible 2% infection in harvested fruit cited in the draft IRA because although the draft IRA report was citing Lim (1986) and Lim and Lowings (1979) to support this figure it was drawing conclusions from Thompson (1937) paper. However, Lim (1986) which is a review paper cites the Thompson (1937) observation that the level of fruit collapse in harvested fruit arriving at the cannery was estimated at 2%. Further, the claim that the draft IRA report was making conclusions using Thompson (1937) alone is incorrect. Figure 1 of Lim and Lowings (1979) had actual field data, showing the possibility of about 2% latent infection remaining at harvest and supporting the figure of Thompson (1937). Hence, the 2% figure in the draft IRA is not arbitrary but substantiated by two published reports 40 years apart.
- Stakeholders have also argued that since the pathogen was not known when Thompson (1937) was published it is possible that some of the 2% rejections reported in that paper were due to other diseases such as yeast rot. However, it is clear from the symptom descriptions of the disease in Thompson (1937) such as “sudden collapse of a mature fruit which does not appear to have ripened” and “apparently healthy, growing fruit may become entirely decayed with a soft rot within 24 hours, or, if picked when apparently sound may decay during the journey to the factory”, etc., that the author is talking of the same fruit collapse disease we know today. Johnston (1957a; 1957b) concluded the bacterium responsible for fruit collapse and heart rot in pineapple to be *E. caratovora* but Lim (1974a) confirmed that was not *E. caratovora*, but *E. chrysanthemi*. More recent reviews such as Rohrbach (1983) also accept that the first reports of the diseases fruit collapse and heart rot were caused by *E. chrysanthemi*. Furthermore, if some of the 2% rejections reported in Thompson (1937) could be due to other diseases such as yeast rot as the stakeholders claim then the rot at harvest due to *E. chrysanthemi* (pineapple strain, *Dickeya* sp.) has to be lower than 2%.
- Stakeholders have argued that there is no known way to measure at which point latency will break in any individual fruit. However, Lim and Lowings (1978) have reviewed the

findings that latency is associated with the physiological status of the developing fruit and that latency breaks 2–3 weeks from ripening and harvest when polyphenoloxidase activity decreases and sugar levels increase to a level conducive for invasion. This allows the symptoms to express starting from 2–3 weeks before harvest. According to Figure 1 of Lim and Lowings (1979) the percentage of fruit collapse is highest 2–3 weeks before harvest. DAFF Biosecurity agrees, like any other biological process, latency break and symptom expression times are variable and as seen from Lim and Lowings (1979), up to about 2% of fruit may not have expressed symptoms at harvest and may still have latent infection.

- The Department of Agriculture, Malaysia provided some preliminary unpublished results from a field and packing house survey conducted in April 2012, to evaluate current rates of infection of pineapple fruit with the fruit collapse bacterium *E. chrysanthemi* and latency in export production systems (DoA 2012). The results based on pineapples sampled from several fields and several packing houses during the export packing process, in general support the possibility of fruit carrying lower levels of latent infection at harvest than indicated in the Lim and Lowings papers in the 1970's. However, DAFF Biosecurity is unable to fully assess this survey and trial with the limited methodological details and data provided.
- Apart from the pathway of latent infection in fruit resulting from the entry of the pathogen through the flowers, stakeholders proposed two other pathways by which the pathogen may enter Australia: limited decay resulting from surface contamination of fruit and entry through growth cracks (eye (fruitlet) rot); and (b) as latent infection in basal leaves.

Surface contamination of fruit

- In infected fruit expressing symptoms, gas bubbles escaping through crevices in infected fruit can be distinctly heard (Johnston 1957b; Growcom 2011). During this process exudates containing bacteria can be splashed from infected fruit to other healthy fruit nearby (Lim 1974b). Such splashed inoculum or that brought to the fruit surface by agents such as insects, wind or rain may have the potential to infect mature fruit by entry through small wounds and cracks on the surface. Lim and Lowings (1978) carried out experiments specifically to investigate all potential pathways of entry of the pathogen into the fruit. Natural or shallow artificial cracks on the skin, bracts, and even decrowning wounds were not found to act as points of entry. Entry was only at the open flower stage and not through withered flowers or any time after. These observations indicate that infections resulting from surface contamination of fruit and entry through cracks are not substantiated by any data and they are extremely low probability events.
- In the studies of Lim and Lowings (1978) infection was produced when deep wounds made in mature fruit one month from ripening were inoculated with cocktail sticks dipped in a high concentration of bacterial suspension. Johnston (1957b) also reported that disease was produced by wounding healthy fruits and inoculating them with diseased material. These were again deep wounds inoculated with high concentrations of bacteria. This situation is very unlikely in the field and in particular with export quality fruit.
- Johnston (1957a) states that although heart rot affects mostly young plants it can sometimes affect older plants, even when they are bearing fruit. The bases of leaves can rot as in young plants and the rot can extend up into the stem (peduncle) of the fruit. This suggests that fruit infection through the stem rather than through the flower or wounds on the fruit surface may also be possible, if rare.

- The important point to note is that the observed average figure of 2% of harvested fruit carrying infection (Thompson 1937; Lim and Lowings 1979) would include entry of the pest into the fruit through all routes, the flower, fruit surface and stem.

Latent infection in basal leaves

- Stakeholders have argued that it is impossible to remove all basal leaves without chopping into the actual fruit and therefore the likelihood of the pest entering as infection in parts of leaves attached to the fruit should also be considered.
- An infected fruit already secreting exudates and with disease extending down the peduncle could contaminate the basal leaves (Lim 1978). However, such fruit with visible exudates secretion will not be harvested for export.
- There is potential for any basal leaves remaining at the base of the fruit to carry exudates splashed by infected fruits nearby. However, current import policy for pineapples has no tolerance for basal leaves.
- Epiphytic survival of the bacterium on basal leaves would be very short except where the rot and the resulting exudate was allowed to flow into the leaf axils below where low populations of the bacterium can survive for over three weeks (Lim 1978). Such fruit with exudates flowing into basal leaves would not be harvested or exported; therefore the likelihood of the pathogen entering on infected leaves would be extremely low. This would also be ensured by the lack of tolerance for any leaves on the individual fruit at the Australian border.

Resistant and susceptible varieties

- Stakeholders have raised the possibility that resistant varieties could potentially be carriers of the bacteria.
- Commercially important varieties of pineapple grown in Malaysia belong to four groups: Cayenne, Spanish, Queen and New Hybrids. The Cayenne varieties such as ‘Smooth Cayenne’ and ‘Sarawak’ are resistant to infection; Spanish varieties such as ‘Singapore Spanish’, ‘Gandol’, and ‘Masmerah’ are highly susceptible; and Queen varieties such as ‘Mauritius’ are moderately susceptible (Lim and Lowings 1979). Hybrids between ‘Smooth Cayenne’ and Spanish varieties such as ‘Josapine’ and ‘N36’ appear to maintain the highly susceptible characteristics of the Spanish varieties as indicated by the high susceptibility of ‘Josapine’ to heart rot (Rozeita and Kogeetha 2010).
- Lim and Lowings (1979) found that when harvested fruit was artificially inoculated with the fruit rot pathogen, Cayenne varieties showed on average about 10% disease severity (based on percentage of the flesh in the fruit infected), Spanish varieties showed 90–100% disease severity and Queen variety, ‘Mauritius’, showed a 48% disease severity (Lim and Lowings 1979). When intact fruit in the field was artificially inoculated, the Cayenne variety ‘Sarawak’ showed around 20% fruit collapse whereas Spanish varieties showed about 50% (Lim and Lowings 1979).
- Therefore, resistant varieties with low disease severity may carry some infection but they too express symptoms (Lim and Lowings 1979) and the observed rate of about 2% of fruit infection at harvest should include all such infections.

Ability of the pest to survive fruit processing procedures

- Malaysia has indicated that harvest dates are generally 115–117 days after flowering but can change depending on variety and market destination, although as a non-climacteric fruit harvesting pineapples too early i.e. before ripening is not desirable and is unlikely to occur.
- Rohrbach (1983) considered that sorting, grading and quality control would not eliminate the possibility of small amounts of infected fruit being included in commercial shipments. Although infected fruit collapses rapidly at ambient temperatures, any fruit with latent or visually undetectable infection harvested the previous day is unlikely to express symptoms during the short processing step in the packing house.
- Fruit will be packed into the container for transport to the port within 24–48 hours of harvesting (DoA 2009).
- Malaysia plans to sea freight pineapple exports to Australia, which will take a minimum of 13 days from harvesting in the field to arrival in the retail market in Australia (DoA 2009).

Ability of the pest to survive transport and storage

- Storage life of pineapple is about 4–5 days at ambient temperatures (25–35 °C). Chilling injury occurs in pineapple fruit at temperatures below 7 °C. Some varieties may suffer chilling injury under 15 °C (Wills *et al*. 2007). Transport of fruit to Australia by sea is expected to be at about 8–12 °C to maintain shelf life up to about 3 weeks (Growcom 2011), although some transport companies claim transport at this temperature could extend storage life up to 4–5 weeks (TIS 2011).
- Transportation temperatures are considered likely to slow down the multiplication of bacteria and symptom development, and favour the survival of bacteria as latent infections.

Summary

As the exported fruit will be without crowns and all basal leaves, the association of the pest with the pathway would be only as the fruit collapse disease and not as the heart rot disease.

Although the incidence of fruit collapse in Malaysian pineapple plantations can sometimes be as high as 40%, the biology of the disease is such that infected fruit can be easily detected before or at harvest and inclusion of infected fruit in exports will be reduced to a high degree. However, a small volume (estimated as up to 2%) of export fruit may contain latent or visibly undetectable infection. Therefore the likelihood estimate for importation is ‘low’.

Probability of distribution

The likelihood that the pineapple heart rot and fruit collapse pathogen *Erwinia chrysanthemi* (pineapple strain, *Dickeya* sp.) will be distributed within Australia in a viable state as a result of the processing, sale or disposal of decrowned pineapple fruit from Malaysia and subsequently transfer to a susceptible part of a host is: **LOW**.

Distribution of the imported commodity in Australia and waste generation

- After arrival in Australia pineapples will be distributed throughout the country.
- As shown earlier, evidence from the literature indicates that a small volume of fruit from susceptible cultivars such as ‘Josapine’ could carry latent infection. These will develop symptoms when displayed for sale or directed for processing in Australia at ambient temperatures and will be discarded mostly into municipal waste by retailers, consumers, or processing plants.

Transfer of the pest from waste to a suitable host

- The transfer of the pathogen from infected fruit in waste to a susceptible host plant is a complex variable, dependent on a number of critical factors including: the location of the bacteria; survival in waste and viability; survival in water; survival in soil; transfer mechanisms; availability of hosts; host susceptibility and entry points; and inoculum source, dose, and host proximity. These factors are discussed in further details below.

Location of the bacteria

- Juice exudate from fruit is considered a major source of inoculum for starting both fruit collapse and heart rot diseases in healthy pineapple plants (Lim 1974b).
- Infected fruit, whether intact on the plant or harvested, produce exudates and a diseased fruit could exude on average 360 ml of juice containing 10^{13} bacterial cells/ml at peak exudation (Lim 1974b).
- After arrival in Australia, fruit that begin producing fruit collapse symptoms will most likely be discarded into waste. The surface and internal tissue of these fruits would be expected to support viable bacteria.

Survival in waste and viability

- The facts that fluid secreted by collapsed fruit can be the inoculum for both heart rot and fruit collapse phases (Lim 1986) and that fluid is secreted over about 10 days (Lim 1974b) suggest that the bacteria remain viable in the fluid for some time, although the literature does not indicate the exact time period of survival.
- In the environment or on leaf surfaces bacterium does not survive long (Lim 1986), perhaps due to lack of nutrients and/or desiccation. Within the infected fruit, the reduced polyphenoloxidase and increased sugar levels associated with ripening enable the bacterium to multiply (Lim and Lowings 1978). The bacterium will likely survive in fruit tissue discarded to waste as long as sugars are available and the tissue remains moist. As the fruit tissue gets colonised by other saprophytic organisms and the sugars get used up, the population of *E. chrysanthemi* (pineapple strain, *Dickeya* sp.) will decline rapidly.
- Bacteria from waste fruit discarded in the environment may contaminate water and soil. The likelihood of survival of the bacterium in water and soil is discussed below.

Survival in water

- Lim (1974b), citing his earlier unpublished work, claims the pathogen was unable to survive in water. Therefore this does not play an important role in the spread of the disease.
- The introduction in Lim (1978) indicates that drain water tested in his earlier unpublished work was from peat soil where the pathogen survived for only four days. Drainage from peat soil is likely to be more acidic than from mineral soils. The survival of the pathogen in drainage water from mineral soils is unknown.
- Stakeholders have cited Cother and Gilbert (1990), Cother *et al.* (1992) and Toth *et al.* (2011) as evidence supporting the survival of *E. chrysanthemi* in soil and water. Cother and Gilbert (1990) and Cother *et al.* (1992) are studies detecting *E. chrysanthemi* strains in river waters in Australia. However, these references do not provide evidence for the survival of the pineapple infecting strain of *E. chrysanthemi* (pineapple strain, *Dickeya* sp.) in water and they refer in general to strains of the bacterium infecting other hosts.
- Stakeholders have reviewed the literature and support that Australian strains of *E. chrysanthemi* are different from the strain infecting pineapples in Malaysia (Growcom

2011). It is difficult to apply the findings of Cother and Gilbert (1990) and Cother *et al.* (1992) to the pineapple infecting strain, particularly given there is literature that states the Malaysian pineapple infecting strain per se, does not survive in water (Lim 1974b and references therein).

- This is also supported by the recent observations that *E. chrysanthemi* (*Dickeya* sp.) strains isolated from irrigation water were non-pathogenic on pineapples in Hawaii (Kaneshiro *et al.* 2008) and the *Dickeya* sp. strains isolated from Hawaiian pineapple clustered separately from strains isolated from irrigation water (Marrero *et al.* 2009; Peckham *et al.* 2009; Peckham *et al.* 2010; Marrero and Alvarez 2011).

Survival in soil

- Current import conditions for the import of pineapples into Australia state that they must be free of soil (ICON 2011). Soil is a regulated article and considered as contaminating trash. The scope of this IRA is decrowned pineapple, free of contaminants. Therefore soil from Malaysian pineapple plantations is not considered to be associated with infected fruit or waste.
- The survival in soil under consideration is the possibility of bacteria surving in soil after contamination of the soil through infested fruit or waste.
- Lim (1975) tested the survival of the pathogen in unsterilised mineral and peat soils inoculated with bacterium from the laboratory. The results showed that the pathogen does not survive in unsterilised peat soil but can survive up to 7 days in unsterilised mineral soil. Lim (1975) also tested for the presence of the bacterium in soil from pineapple fields with high disease incidence in the crop. The pathogen could not be detected in those soils. Stakeholders comment that this study should not be used to understand the field behaviour of the bacterium because the authors used artificial contamination of sterile soil. However, as discussed above, in addition to artificial contamination of sterile soil the authors also tested the survival in unsterilised soil under artificial inoculation and survival in field soil with high disease incidence. From those results it appears that the bacterium does not survive long in natural field soil or unsterilised soil. Shorter survival in unsterilised soil than in sterilised soil (Lim 1975) provides indirect evidence that the pathogen population declines rapidly in unsterilised soil due to competition from other soil microorganisms.
- The rapid decline of soft rot erwinia populations in unsterilised soil at high temperature is thought to be caused by antagonists such as other bacteria and fungi (Pérombelon and Kelman 1980).
- Australian pineapples are not grown in peat soil and therefore the ability of the bacterium to survive for short periods in mineral soils has some significance for the probability of distribution and transfer. Rohrbach (1983) considers that the short survival in mineral soil may be an important factor to consider for soil contamination on vegetative propagative material. This may also be relevant for contaminated waste fruit located in the vicinity of pineapple plants.
- Questions have been raised about the conclusions of Malaysian scientists in the early 1970s on the poor survival of the bacterium in water and soil. However, DAFF Biosecurity considers that the comprehensive studies of Lim in the 1970s are relevant. It is acknowledged that DNA based methods have not yet entirely replaced traditional culture and phenotypic methods in plant pathology (Alvarez 2004).
- Stakeholders have noted that according to recent information from the University of Hawaii, when corn (*Zea mays*) was grown in soil transported from contaminated pineapple

fields, it became infected with a *Dickeya* species with the same genome as the pineapple pathogen producing corn stalk rot symptoms, suggesting that the pineapple pathogen may have survived in the soil. However, the strain of *E. chrysanthemi* causing corn stalk rot is present in Hawaii and there is the possibility that the infested soil may have had two strains of *Dickeya* (Growcom 2011).

- Stakeholders have also noted that at least in the Australian situation the strains infecting non-pineapple hosts such as corn in Australia are different (Growcom 2011). Thus, given that the Hawaii work is not confirmed, DAFF Biosecurity is required to consider the comprehensive published works of Lim (1974b; 1975; 1986) that conclude that this strain survives only for short periods of up to about 7 days in mineral soils.
- Toth *et al.* (2003) state that erwinia soft rots in general appear to survive in soil and ground water when not causing disease but little is known about these alternative life-styles. Toth *et al.* (2011) state survival studies reported in the scientific literature often fail to specify the *Dickeya* spp. involved and in general it appears unlikely that the pathogen can overwinter freely in soils.
- Perombelon and Hyman (1989) state that having adapted to grow in nutrient-rich plant tissues, soft rot erwinias will die more or less rapidly in a low nutrient environment. Poor survival of the pineapple infecting strain discussed here in drain water and soil (Lim 1974b; Lim 1975) seem to agree with this.
- Overall, the information above suggests that the pineapple infecting strain of this pathogen survives only for very short periods in peat soils or drainage from such soils and slightly longer, up to about seven days in mineral soils (Lim 1974b; Lim 1975; Lim 1978).

Transfer mechanisms

- In pineapple plantations in Malaysia, numerous insects, including ants, beetles and flies, have been associated with fruit infected by bacterial fruit collapse, plants infected with heart rot, and inflorescences (Lim and Lowings 1977).
- Within this group, ants e.g. *Iridomyrmex* spp. and *Pheidole* spp. are considered to be the main vectors of the pathogen (Lim and Lowings 1977; Lim and Lowings 1982; Lim 1986). Ants were the only group observed to be visiting both collapsed fruits and inflorescences in significant numbers (Lim and Lowings 1977).
- Species of *Iridomyrmex* and *Pheidole* ants are wide-spread in Australia (APPD 2011).
- Several species of souring beetles, such as *Haptoncus* (=*Epuraea*) *ocularis, H. luteolus, Carpophilus* (=*Urophorus*) *humeralis* (=*C. foveicollis*), *C. hemipterus, C. mutilates* and *C. maculates,* have been reported visiting collapsed fruit (Lim and Lowings 1977; Rohrbach and Johnson 2003). In Malaysian pineapple fields *H. luteolus* and *C. foveicollis* are the most predominant (Lim and Lowings 1977). According to Rohrbach and Johnson (2003), *H. ocularis, C. humeralis* (pineapple beetle) and *C. hemipterus* (dried fruit beetle) are most common in pineapple fields in general.
- All of the aforementioned souring beetle species are present in Australia (APPD 2011).
- Wee and Rao (1974) claimed that these souring beetles (Nitidulids) are involved in cross pollination of pineapples. Although high numbers of souring beetle species have been collected from collapsed fruits, the numbers collected on inflorescences were very low (Lim and Lowings 1977). Therefore, the likelihood of souring beetles transferring the pathogen to pineapple flowers to initiate fruit collapse was considered to be low (Lim and Lowings 1977).

- Lim and Lowings (1982) found a highly significant reduction in fruit collapse incidence brought about by ant control indicating unimportance of insects such as souring beetles acting as a vector for fruit collapse.
- Ripe fruit and collapsed fruit is the most attractive food source for the pineapple beetle, *C. humeralis*, and they swarm around such fruit (Tan *et al*. 1969) and adults may inhabit pineapple plants at various stages of growth (Hinton 1945). Therefore, although their role in transferring the pathogen to flowers to initiate fruit collapse is low as suggested by Lim and Lowings (1977; 1982), there is a greater possibility of them transferring the pathogen from waste fruit to leaves or the heart of the pineapple plants to initiate heart rot.
- Lim and Lowings (1982) note that souring beetles are strong flying insects; they have been found to carry the pathogen and may account for the random distribution of the disease. While there appears to be no direct reports of flying distances of these souring beetles in pineapple fields, the dried fruit beetle, *C. hemipterus*, is a strong flier and can travel several kilometres in search of hosts and has no native enemies in Australia (Steiner *et al.* 1999). The dried fruit beetle and pineapple beetle could be effective vectors for initial transfer of the pathogen from infected pineapple waste to nearby susceptible pineapple plants.
- Flies, although observed visiting collapsed fruits, were least associated with inflorescences (Lim and Lowings 1977) and are not considered important vectors.
- Rohrbach and Johnson (2003) state that the pineapple tarsonemid mite (*Steneotarsonemus ananas*) has been associated with bacterial heart rot in the Philippines, but reference to a detailed study is not given. *Steneotarsonemus ananas* is present in pineapple growing areas of Australia (Waite 1993). It feeds by sucking the contents of plant cells, especially trichomes on heart leaves (Waite 1993) and flower bracts and sepals, and internal flower parts in the inflorescence (Rohrbach and Johnson 2003). Hence, the likelihood of this mite visiting discarded infected fruit, picking up the bacterium and transferring it to initiate heart rot or fruit collapse on a pineapple plant in plantations would be very low.
- Stakeholders have pointed out that native bees and birds may act as agents of transfer of the pathogen from infected waste to a pineapple plant, however there is no published evidence to support this.
- Sanewski (2007) studied the role of insects acting as pollinators of pineapple in Australia. The author found honey bees, native bees (*Trigona* sp.), the noisy miner bird (*Manorina melanocephala*) and a small number of other insect species (including ants and flies) visited pineapple flowers. However, except for ants and flies that have been shown to visit infected fruits and have already been considered as possible vectors, the other nectar feeding organisms listed above have not been shown to visit infected fruit waste or carry the inoculum.
- Bacteria from the heart rot disease can be transmitted by rain splash (Lim 1986) and technically the same could potentially apply to the bacteria on collapsed fruit discarded in waste. However, a host plant would need to be very close to the infected fruit in waste for a transfer of this nature to be successful.
- Specific studies giving distances to which agents may carry the pathogen are limited. Lim and Lowings (1982) carried out a field study involving two adjacent 0.8 ha pineapple fields. The study was based on hot spots at two corners of one of the fields where large numbers of diseased and rejected fruits from other fields were dumped. Lim and Lowings (1982) concluded that ants were responsible for transmission within the immediate environment; the strong-flying souring beetles may be responsible for random distribution in the field and

wind for transmitting the disease to distant fields. Such hot spots with very high inoculum doses are unlikely to be created in a single spot with any imported infected fruit discarded close to the pineapple growing areas of Australia.

- Stakeholders have argued that the pathogen has been recovered from irrigation water in Hawaii and the pathogen may be transferred if susceptible host plants are irrigated with water contaminated through infected waste. However, as stated previously, a number of studies have confirmed that the strain recovered from irrigation water in Hawaii is distinct from the strains isolated from pineapples (Marrero *et al.* 2009; Peckham *et al.* 2009; Peckham *et al.* 2010; Marrero and Alvarez 2011) and it is non pathogenic on pineapple (Kaneshiro *et al.* 2008) and the strain infecting Malaysian pineapples does not survive long in drainage water (Lim 1974b).

Availability of hosts

- The strain of *E. chrysanthemi* (pineapple strain, *Dickeya* sp.) infecting pineapple appears to be highly specific to pineapple (Lim and Lowings 1983).
- Some data sheets (DoA 2004; CABI/EPPO 2011) list a large number of hosts but these are for all strains of *E. chrysanthemi* infecting various plants. With recent molecular work demonstrating the pineapple infecting strain of *E. chrysanthemi* (*Dickeys* sp.) to be a unique strain (Nassar *et al.* 1994; Avrova *et al.* 2002; Samson *et al.* 2005; Marrero *et al.* 2009; Marrero *et al.* 2010), it has not been convincingly demonstrated whether this strain can infect any other hosts.
- Different *E. chrysanthemi* strains causing corn stalk rot and infecting many other hosts such as corn, potato, banana, ginger, *Dieffenbachia*, etc., have been reported in Australia (APPD 2011). Appendix 1 of Growcom (2011) has reviewed the information indicating how the Australian strains of *E. chrysanthemi* infecting other crops are different to the pineapple infecting strain in Malaysia.
- Marrero and Alvarez (2011) recently reported that a strain of *E. chrysanthemi* (*Dickeya* sp.) with genetic characteristics similar to that responsible for pineapple heart rot in Hawaii has been isolated from ornamental plants, taro germplasm and corn hybrids showing severe symptoms of stalk rot. The genetic relationships between these strains are still being investigated (Alvarez, pers.comm. 2012).
- A number of previous studies also indicate that the strain causing corn stalk rot to be different to the pineapple infecting strain. In Malaysia the strains causing stalk rot in corn were only weakly pathogenic to pineapple, suggesting that it may be a distinct pathovar of the bacterium (Hiryati 1982). Sabet *et al.* (1964) compared strains causing corn stalk rot with a strain from Malaysia (which Lim and Lowings (1983) considered as the pineapple strain) and found only the former to be capable of inducing stalk rot in corn.
- Lim and Lowings (1983) conducted pathogenic comparisons of *E. chrysanthemi* strains from pineapple with strains from other hosts and concluded that the pineapple strain is distinct from all other strains tested and should be distinguished from them by designating the name as *E. chrysanthemi* (pineapple strain). They found that when corn was inoculated with the pineapple strain of the pathogen using stem prick method it did not produce symptoms. When whorl inoculation method was used it produced symptoms in corn but the authors concluded that whorl inoculation method is not suitable for distinguishing strains. When pineapple fruits were inoculated with several strains of *E. chrysanthemi* from different hosts, only the pineapple strain was able to cause extensive fruit rotting typical of the fruit collapse disease.

- The suggestion of Merrero and Alvarez (2011) that corn may be an alternative host of the pathogen is based partly on their observation that when corn was grown in a soil that was transported to a distant place from a pineapple field previously infected with the heart rot disease, the corn developed symptoms of corn stalk rot. However, *Erwinia chrysanthemi* was reported on numerous crops and ornamentals in Hawaii before the introduction of the strain of *E. chrysanthemi* infecting pineapple in 2003, including *Zea mays*, *Grammatophyllum* spp., *Syngonium podophyllum* and *Dendrobium* spp. (Raabe 1981; Bradshaw-Rouse *et al.* 1988; Kaneshiro *et al.* 2008). Stakeholders have queried whether there could have been two strains of *E. chrysanthemi* in the soil transported (Growcom 2011), suggesting that the corn and pineapple strains may be different.
- Janse and Ruissen (1988) isolated an *E. chrysanthemi* strain belonging to biovar 3 from the bromeliad *Achemea fasciata* in the Netherlands. This bromeliad is widely used in the nursery industry in Australia. However, there is no evidence in Janse and Ruissen (1988) to consider that the strain isolated is the same as the *Dickeya* sp. isolated from Malaysian pineapples in Samson *et al*. (2005).
- There are also no reports indicating that the Malaysian pineapple strain infects other closely related bromeliad species in Malaysia.
- Parkinson *et al*. (2009) studying strain relatedness using sequences from a single gene locus (recA) has observed the strain of *E. chrysanthemi* infecting pineapple to be closely related to a strain from a *Brassica* species in Malaysia. However, this relatedness is using only one locus and there are no reports of the pineapple strain infecting *Brassica* species in Malaysia.
- In over sixty years of research on this pathogen in Malaysia and in other countries, including molecular approaches in recent years, no group has convincingly demonstrated other alternative hosts of this pineapple pathogen. In Malaysia the disease has spread over the years from the state of Johor to all other pineapple growing areas but there are no reports of the pineapple strain infecting any other hosts. With no clear demonstration of any other hosts for the pineapple infecting strain DAFF Biosecurity is required to consider only the currently available literature which does not convincingly support a host range other than pineapple.
- Given that there are no confirmed reports of other hosts at the present time, for the purposes of this assessment, the only known host available in Australia for the initial transfer of the pest is considered to be pineapple.

Host susceptibility and entry points

- Pineapple is grown mainly in the narrow coastal strip in Queensland from Cairns to Brisbane with only small commercial fields in the Northern Territory (ABS 2006; ABS 2008a; ABS 2008b), northern New South Wales and Western Australia (OGTR 2003; McMahon 2005). Approximately 60% of Australia’s total production occurs within the Cooloola-Sunshine Coast Region (PHA 2008).
- Approximately 60% of pineapple plantings in Australia are ‘Smooth Cayenne’ and ‘Queen’ varieties, and 40% of plantings are of hybrid varieties (OGTR 2003; McMahon 2005; HAL 2011). The main variety, ‘Smooth Cayenne’, is reported as being highly resistant to the disease (Lim and Lowings 1979). While this would significantly reduce the likelihood of initial transfer to a host in Australia it is also noted that the Australia industry has indicated a move towards planting more susceptible hybrids for the fresh pineapple market (Growcom 2011).

- The entry points for the fruit collapse disease are pineapple flowers. In Australia pineapple production occurs year round. Typically, pineapple flowering is irregular but chemical methods are used to regulate flowering to ensure uniform maturity and harvest throughout the year. Pineapple plants ratoon crop, where harvesting of one fruit triggers the production of a new fruit. When an inflorescence has emerged, about 5–10 flowers open daily (each flower lasts for one day) and the flowering lasts for 10–15 days (OGTR 2003). Therefore entry points through flowers would be available most of the year.
- The entry points for the bacterial heart rot disease are stomata at the base of young leaves (Lim 1986) and perhaps injured leaves (Rohrbach and Schmitt 2003). Rohrbach and Johnson (2003) cite a personal observation that in Australia, urease activity in dirty water breaks urea down to ammonium hydroxide, which causes burn and may provide additional potential entry points for bacteria in general.
- Heart rot infection usually occurs on young plants at 4–8 months after planting (Lim 1986). Young plants would be available year round and there is some likelihood of the transfer agents, particularly the adult souring beetles that are known to inhabit pineapple plants at various stages of growth (Hinton 1945), transferring the pathogen from waste fruit to enable entry through stomata or sites of injury on young leaves.

Inoculum source, dose and host proximity

- The exact number of bacteria required to initiate infection as fruit collapse or heart rot, has not been precisely determined. However, juice secreted by infected fruit, which is the source of inoculum for both diseases, contain high numbers of bacteria, up to 10^{13} bacterial cells/ml, and an average infected fruit can exude up to 360 ml of juice (Lim 1986). Again, the natural spread of the disease through exudates from infected fruit indicates that the inoculum dose required to initiate infection in healthy plants is being transferred by biotic and/or abiotic agents.
- A large proportion of the Malaysian pineapples imported into Australia will be utilised in metropolitan areas away from commercial pineapple plantations. The coastal strip of Queensland from Brisbane to Cairns, where pineapples are grown commercially, is close to the major population centres of Brisbane, Rockhampton and Townsville. The Sunshine Coast, with a current population of more than 300,000, is a rapidly expanding area in close proximity to 60% of production areas. More than 74% of consumers purchase their fruit and vegetables in supermarkets (Growcom 2011).
- Based on Australian population distribution statistics for 2008 (ABS 2008c), about 8% of the Australian population can be estimated to be in regional and remote areas of Queensland. Of this 8% only a small proportion would be in pineapple growing areas and thus the number of fruit distributed to this population would be limited. Therefore a relatively small proportion of imported pineapples could be distributed to areas in the vicinity of pineapple growing regions of Queensland.
- It is not possible to assume that imported pineapples will be less likely to be consumed in pineapple growing areas. The distribution and consumption of pineapples within Australia will be driven by commercial factors and market forces.
- Apart from commercial plantations, many households in Queensland may have pineapple plants in their backyards. These plants may be in close proximity to discarded fruit or skins from imported product (DEEDI 2011) so that initial transfer could occur in a household backyard.

- Although there is potential for an individual consumer to discard pineapple waste on properties adjacent to pineapple farms, most retail and household waste will go to municipal landfills where the waste is buried.
- The possibility of some imported fruit being used for production of fresh cut pineapple in processing facilities located in pineapple production areas cannot be ruled out. Some of these processing facilities transport their waste in open trucks to cattle farms throughout the South-east Queensland region. Some of these farms could be close to pineapple farms (Growcom 2011).

Summary

As outlined above, with a host range limited to pineapple, a number of factors would need to align in order to facilitate a successful transfer of this pathogen to a susceptible host. A freshly discarded infected fruit or infected waste would need to be in close proximity to a susceptible pineapple plant, with suitable vectors in the direct vicinity. This scenario could occur in an infected plantation chiefly because of the significant number of inoculum points available. In introducing the disease to a new area from waste fruit, the pathway is limited by the number of inoculum points in proximity.

Although there is an increased tendency to grow new more susceptible pineapple varieties in Australia, host proximity is geographically restricted. Potential vectors and agents of transfer are available; however, the transfer opportunity for ants and beetles and the viability of the bacterium in soil and water is short. Considering the low volume of fruit expected to be imported into Australia and distributed to and potentially disposed of in areas near pineapple production, the number of infected fruit that are likely to come in close proximity to susceptible pineapple plants would be limited. This will minimise the likelihood of achieving all the necessary factors for a successful transfer. Therefore the likelihood estimate for distribution is ‘low’.

Overall probability of entry (importation × distribution)

The overall probability of entry is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2.

The likelihood that *Erwinia chrysanthemi* (pineapple strain, *Dickeya* sp.) will enter Australia as a result of trade in decrowned pineapple fruit from Malaysia and be distributed in a viable state to a susceptible host is: **VERY LOW**.

4.3.3 Probability of establishment

The likelihood that *Erwinia chrysanthemi* (pineapple strain, *Dickeya* sp.) will establish in Australia, based on a comparison of factors in the source and destination areas considered pertinent to its survival and reproduction, is: **HIGH.**

Availability of suitable hosts, alternate hosts and vectors in the PRA area

- Although there are many strains of *E. chrysanthemi* infecting a large number of other hosts, the pineapple strain is considered to be specific to that host. Any other hosts including alternate hosts that this strain can infect have not been systematically demonstrated. There are no reports of the pineapple strain infecting bromeliads. Pathogenicity of the pineapple strain on bromeliads has not been demonstrated and whether the strain isolated from ornamentals (supposedly bromeliads (Growcom 2011)) in Hawaii (Marrero and Alvarez

2011) is the same infecting pineapple has not been confirmed. Therefore, based on the currently available literature, the only susceptible host in Australia is pineapple and that host is available in plantations largely in Queensland and to a smaller degree in the Northern Territory, northern New South Wales and Western Australia.

- Stakeholders have stated that the issue of alternate hosts has high significance in terms of likelihood of establishment and spread. However, this issue is still unresolved (Marrero and Alvarez 2011; Alvarez, pers.comm. 2012) and, even in Malaysia where the pathogen has existed for the longest time and spread to all pineapple growing regions in that country, there are no reports of any other hosts affected by this pathogen. Many reports including one from the Australian pineapple industry (Growcom 2011) argue the strains infecting other hosts are different.
- The fact that the moderately resistant 'Smooth Cayenne' variety is still the most widely grown variety in Australia limits the availability of susceptible hosts but a significant proportion of susceptible 'Queen' and hybrid varieties are grown in Australia.
- Species of ants e.g. *Iridomyrmex* spp. and *Pheidole* spp. are considered to be vectors of the pest (Lim 1986) and they are wide-spread in pineapple growing areas of Australia including the key growing areas of Queensland (APPD 2011). Species of souring beetles (e.g. *Haptoncus* and *Carpophilus*) are thought to play minor roles as vectors for the fruit collapse disease (Lim 1986) but may have a role in establishing the heart rot disease and are also present in Australian pineapple production areas (APPD 2011).
- Although bees and birds were considered to have a minimum role in the transfer from waste to hosts within the distribution step, they can play a role in establishment by transferring the pathogen from inflorescence to inflorescence given that they are involved in pineapple pollination in Australia (Sanewski 2007).
- The pineapple tarsonemid mite, *Steneotarsonemus ananas* is reported to be associated with bacterial heart rot in the Philippines (Rohrbach and Johnson 2003) but no detailed studies are available. *Steneotarsonemus ananas* is a pest of pineapples in Australia and the organism feeds by sucking the contents of plant cells, especially trichomes including those on heart leaves (Waite 1993). Therefore, this mite may assist in the establishment of bacterial heart rot and fruit collapse if the bacterium gets transferred to an initial host plant.

Suitability of the environment

- The pineapple infecting strain of *Erwinia chrysanthemi* has established in pineapple plantations under tropical environmental conditions in Malaysia, Costa Rica, Philippines, Brazil (Rohrbach and Schmitt 2003) and more recently Hawaii (Kaneshiro *et al*. 2008). The pineapple growing areas of Australia have environmental conditions similar to these countries. Therefore the environment in Australia, particularly in the pineapple growing areas, is suitable for the establishment of the pest.
- In Malaysia disease levels are lower in peat soils but higher in mineral soils (Johnston 1957a). Australian pineapples are not grown in peat soils and therefore the soils are likely to be more favourable for establishment.

Reproductive strategy of the pest

- The ability to multiply and cause two diseases in pineapple, heart rot by entry through stomata and minute wounds on leaves, and fruit collapse by entry through flowers, is indicative of a strong reproductive capacity.
- The ability of the bacterium to remain latent in the developing fruit for several months after entry through the flower (Lim 1986; Rohrbach 1989), until the sugar levels increase and polyphenoloxidase levels decrease with maturity (Lim 1986), is again indicative of a strong reproductive capacity.
- Secretion of up to 360 ml of exudates per infected fruit, containing 10^{13} bacterial cells/ml at peak production shows the alibility of the bacterium to multiply rapidly and exponentially under high sugar and low polyphenoloxidase conditions.

Minimum population needed for establishment

- The minimum population needed for establishment on a host has not been precisely determined. Artificial inoculation by placing cotton balls soaked in a solution of 2.8×10^7 cells/ml inside holes made in fruit has effectively produced disease symptoms (Lim and Lowings 1979). This concentration is significantly less than the 10^9–10^{13} cells/ml observed in the liquid oozing 6–7 days after inoculation of healthy intact fruit in the field (Lim 1974b). Ooze from infected fruit is considered to be a main source of inoculum for infecting new hosts.

Method of pest survival

- The current knowledge on the survival of this pathogen is that it sits primarily within the host tissue. Its ability to survive epiphytically on the host or in the outside environment is recognised as being limited to a short time (Lim 1986).
- After entry through pineapple flowers the bacterium remains latent inside the developing fruit until 2–3 weeks before ripening (Lim 1986). This appears to be a specialised survival strategy.

Cultural practices and control measures

- Maintenance of good orchard hygiene by removing and destroying infected plant material and planting resistant varieties are two cultural practices recommended. The majority of pineapples grown in Australia are moderately resistant varieties although there is a move towards varieties that may be more susceptible.
- Ant control is used to minimise the spread of the disease from infected to healthy plants in the fields in Malaysia. Field ant control is not standard practice in Australian pineapple production, except in the event of an exotic ant incursion under quarantine control.
- The incidence of 0–40% of the two diseases in Malaysia and the establishment in all pineapple growing areas of that country, in spite of these cultural practices and control measures, indicates that these measures are not able to fully prevent establishment in new locations.

Summary

The presence of the vectors of the disease and suitable environmental conditions in Australia, the strong reproductive and survival characteristics of the pest within pineapple plants, and a lack of fully effective cultural practices and control measures, all support a likelihood estimation for establishment of ‘high’.

4.3.4 Probability of spread

The likelihood that *Erwinia chrysanthemi* (pineapple strain, *Dickeya* sp.) will spread within Australia, based on a comparison of those factors in source and destination areas considered pertinent to the expansion of the geographic distribution of the pest, is: **HIGH.**

Suitability of the natural and/or managed environment

- The environment, particularly the temperature, rainfall and soil conditions in the pineapple growing areas of Australia is broadly similar to that of other pineapple growing areas of the world. Australia does not grow pineapple in peat soils like in Malaysia. Australian soils would be more favourable for the spread of disease, as survival of the pathogen in mineral soil is recognised as being more conducive than the very acidic peat soils of Malaysia (Lim 1975).
- Rain splash and wind are considered to assist in the spread of the disease. Exudation of juice from infected fruits is usually accompanied by the escape of bubbles of gas from the inter-fruitlet fissures and it has been suggested that minute droplets that are a result of gas bubbles bursting may be carried by wind (Lim 1974b). Seasonal rains that occur in the pineapple growing areas in Queensland will also favour the spread of this pathogen.

Presence of natural barriers

- There are no significant natural barriers for the spread of the pathogen along the main pineapple growing stretch from the south to the north of Queensland. Potential natural spread between Queensland and other minor pineapple production areas is likely to be moderated by the large dry land masses between production areas.

Potential movement of pest with commodities or conveyances

- As the fruit collapse phase infects fruits including peduncles and the heart rot phase infects leaves and stems, the pathogen once established in Australia could spread with the movement of infected pineapple leaves, stems and to a lesser extent fruit.
- Movement of infected planting material in Australia could facilitate the long distance spread of the pathogen. The pathogen's entry into Hawaii is suspected to be through pineapple suckers imported from Costa Rica, Honduras or Philippines for propagation purposes (Kaneshiro *et al*. 2008; Peckham *et al*. 2010).
- Infected fruit has not been demonstrated to be associated with long distance spread but is associated with short distance spread between pineapple fields within a district (Lim and Lowing 1982).
- Exudates from infected fruits and leaves contain high bacterial numbers. Therefore any conveyances such as boxes and vehicles contaminated with such exudates have the potential to spread the pathogen to a new area. However, the spread by this means will be limited as the survival of the pathogen outside the host is short.
- Exudates containing the bacterium secreted from infected tissues could flow into the soil, where it can survive for up to seven days (Lim 1979). Therefore, the movement of contaminated soil through agricultural machinery and equipment has some potential to spread the pathogen.
- Soil, runoff and drainage water are not considered to play an important role in the spread of the disease (Lim 1974b, 1975, 1978 and references therein).

Intended use of the commodity

- Pineapples produced in Australia would be used for fresh human consumption or processing. Fresh produce may be distributed throughout the country although this would likely be in proportion to population distribution, and therefore largely to metropolitan areas.

Potential vectors of the pest

- Ants (e.g. *Iridomyrmex* spp. and *Pheidole* spp.) have been identified as the main vectors of the pathogen within the immediate environment. Souring beetles such as *Carpophilus* spp. and *Haptoncus* spp. although considered unimportant as vectors for fruit collapse (Lim and Lowings 1982; Lim 1986) may play a role as vectors for heart rot. Species belonging to all four of these genera are present in Australia (APPD 2011).
- As discussed under the probability of establishment, bees and birds that visit pineapple flowers can play a role in spread. The pineapple tarsonemid mite, *Steneotarsonemus ananas*, is present in Australian pineapple plantations (Waite 1993) and may assist in the spread of the two bacterial diseases after establishment.

Summary

Suitable environmental conditions and the presence of vectors in Australia, the intended use of the commodity, short distance movement with fruit and long distance movement with infected planting material, all support a likelihood estimate for spread of 'high'.

4.3.5 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The overall likelihood that *Erwinia chrysanthemi* (pineapple strain, *Dickeya* sp.) will be imported as a result of trade in decrowned pineapple fruit from Malaysia, be distributed in a viable state to a susceptible host, establish and spread within Australia is: **VERY LOW**.

4.3.6 Consequences

The consequences of the establishment of the pineapple heart rot and fruit collapse pathogen *Erwinia chrysanthemi* (pineapple strain, *Dickeya* sp.) in Australia have been estimated according to the methods described in Table 2.3.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**E**', the overall consequences are estimated to be: **MODERATE**.

Reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**E –** Significant at regional level. Impact of the pineapple strain of *E. chrysanthemi* (pineapple strain, *Dickeya sp.*) on plant life or health in Australia would only be on Australian pineapples, grown mainly in regional Queensland. Host range and susceptibility of other plant species to the pineapple strain of *E. chrysanthemi* are not known. At present the strain appears to be specific to pineapple. There are no reports of the pineapple strain infecting other species within the pineapple family including other bromeliads. Therefore impact on other plant species in Australia is considered to be minimal. Where they are known to occur, the diseases bacterial fruit collapse and heart rot are of major economic importance to pineapple producers (Rohrbach 1983). Fruit collapse of pineapple is considered the most serious pineapple disease in Malaysia. Malaysian surveys indicate field losses due to fruit collapse ranging from 0% to 40% (Lim 1986). Reporting the detection of bacterial heart rot in Costa Rica, Chinchilla *et al.* (1979) considered it a severe disease causing losses of up to 50% in some plantations. With the tropical climate in the pineapple growing areas of Queensland and Northern Territory of Australia, similar damage levels could be expected with an associated loss of production. Susceptibility of pineapple varieties vary with 'Smooth Cayenne' varieties relatively resistant; 'Spanish' varieties and most crosses between 'Smooth Cayenne' and 'Spanish' varieties highly susceptible and 'Queen' varieties moderately susceptible (Lim and Lowings 1979). Currently about 60% of pineapple plantings in Australia are 'Smooth Cayenne' and 'Queen' varieties and 40% of plantings are of hybrid varieties. However, the incidence rates of the two diseases in Malaysia reported above are also for a mixture of varieties and therefore similar disease incidences and losses are likely in Australia. Impact of the disease although low in peat soils is higher in mineral soils (Johnston 1957a; Lim and Lowings, 1979). Australian pineapples are not grown in peat soils so disease levels could be higher if the strain established in Australian pineapples. In the event of disease establishment in Australia, the Australian pineapple industry will likely incur costs associated with loss of production.
Other aspects of the environment	**A** – indiscernible at local level There are no known other direct impacts of *E. chrysanthemi* (pineapple strain, *Dickeya* sp.) on the environment.
Indirect	
Eradication, control etc.	**D** – significant at district level. In the event of disease establishment in Australia, the Australian pineapple industry, and government agencies will incur substantial costs, associated with regulatory enforcement and implementation of the contingency plan for control/eradication and surveillance/monitoring. It is a destructive pest affecting leaves, stems and fruits of pineapple. Copper and antibiotics are ineffective as control measures. As observed in Malaysia it will be impossible to eradicate the pest once established.

Criterion	Estimate and rationale
Domestic trade	**D** – significant at district level. Given that spread of the pathogen between regions is primarily thought to have occurred through infected planting material, restrictions on movement and trade of planting material between production areas may be required. Restrictions on movement of fruit between production areas/states will be subject to state and territory legislation but may not be required, as infected fruit expresses symptoms 2–3 weeks before harvest and can be easily identified in picking and packing processes. With reported field losses up to 40% due to fruit collapse (Lim 1986), and just one state (Queensland) having to provide all the pineapples to the rest of Australia, there will be significant impact on domestic trade at district level with a minor impact at regional level. Viability of several other sectors associated with pineapple production such as packing houses, transport operators, packing suppliers, agricultural suppliers, the banking and financial sector and retail industry in general would be affected if there is wide spread pineapple fruit collapse or heart rot disease in Australia.
International trade	**C** – significant at local level. Although the majority of pineapples produced in Australia are sold domestically, a small volume (less than 60 tonnes per annum) is exported to a number of Asian and Oceanian horticulture markets. The presence of fruit collapse or heart rot or disease may restrict access to overseas markets where this pest is absent.
Environmental and non-commercial	**C** – significant at local level. Ants are the primary agent responsible for the spread of the pathogen (Lim and Lowings 1982). Australia will likely have to embark on a chemical ant control program in the event of disease establishing pineapple production areas. This may have undesirable flow on effects on the local environment.

4.3.7 Unrestricted risk estimate

The unrestricted risk estimate for *Erwinia chrysanthemi* (pineapple strain, *Dickeya* sp.) is: **VERY LOW**.

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

The unrestricted risk estimate for *Erwinia chrysanthemi* (pineapple strain, *Dickeya* sp.) of 'very low' is below Australia's ALOP. Therefore, no specific risk management measures are required for this pest.

4.4 Rubber leaf drop [Pythiales: Pythiaceae]

Phytophthora meadii

4.4.1 Introduction

Rubber (*Heavea brasiliensis*) is the principal host of *Phytophthora meadii*. It has a limited host range and has been recorded on other crops including: pineapple (*Ananas comosus*); cocoa (*Theobroma cacao*), arecanuts (*Areca catechu*), cardamoms (*Elettaria cardamomum*), aubergines (*Solanum melongena*), Indian holly (*Leea coccinea*); black pepper (*Piper nigrum*), arum lily (*Zantedeschia aethiopic*) and *Acacia mearnsii* (Erwin and Ribeiro 1996; Roux and Wingfield 1997; Farr and Rossman 2010).

Phytophthora meadii was isolated at very low levels in a disease survey of *Acacia mearnsii* in commercial wattle growing areas in South Africa and was reported to cause lesions in pathogencity testing (Roux and Wingfield 1997).

Disease symptoms on pineapple fruit appear as a brown spot on green immature fruit which gradually extends to cover the whole fruit (Erwin and Ribeiro 1996). In rubber plantations this fungus is spread mainly through the dispersal of sporangia by rain splash from infected pods and petioles in the canopy (Erwin and Ribeiro 1996). *Phytophthora meadii* grows well from 25 to 30 °C (minimum 5 °C, maximum 33 °C) (Erwin and Ribeiro 1996). Fungal growth, reproduction (sporulation), spread and infection are all favoured by moisture and suppressed by dry weather (Erwin and Ribeiro 1996; Peries and Fernando 1966).

4.4.2 Probability of entry

Probability of importation

The likelihood that *P. meadii* will arrive in Australia with the importation of decrowned pineapple fruit from Malaysia is: **VERY LOW**.

Association of the pest with the pathway

- Rubber is the main host of *P. meadii*. It has been reported to occasionally cause top rot of pineapple fruit (Erwin and Ribeiro 1996), stem and heart rot (Sideris and Paxton 1930) and root rot (Sideris and Paxton 1931) of pineapple in Hawaii. However, there are limited worldwide records for pineapple as a host. It is present in Malaysia (Lee and Lum 2004) where it occurs on rubber, cocoa, betel and *Dioscorea* sp. (Farr and Rossman 2011). No records have been found of this species on pineapple in Malaysia.
- Erwin and Ribeiro (1996) report disease symptoms on pineapple fruit as a brown spot on green immature fruit which gradually extends to cover the whole fruit. Symptoms may be readily visible, but may develop during transportation.

Ability of the pest to survive transport and storage

- *Phytophthora meadii* may survive importation and subsequent distribution in a viable state. *Phytophthora meadii* produce oospores and chlamydospores that can survive adverse conditions, including absence of a suitable host and poor environmental conditions (George and Edathil 1974; Liyanage and Wheeler 1991).

- Growth of *P. meadii* occurs in a temperature range from 5 °C to 33 °C, and is optimal between 25 and 30 °C (Erwin and Ribeiro 1996). Peries and Fernando (1966) reported maximal survival *in vitro* at 36 °C for 96 hours. Temperatures below the minimal for *P. meadii* growth are not routinely used for transport of pineapple fruit, as it may result in physiological chill injury, and it is unlikely that fruit will be exposed to temperatures that exceed those at which this pathogen grows.

Ability of the pest to survive existing pest management procedures

- Symptomatic fruit is likely to be removed during routine harvesting operations due to distinct symptoms. However, commercial cleaning activities may not eliminate all viable spores from the textured surface of pineapple fruit.

Summary

Its limited association with pineapple, lack of reports on pineapple in Malaysia and the occurrence of visible disease symptoms on the fruit all support a likelihood for importation of 'very low'.

Probability of distribution

The likelihood that *P. meadii* will be distributed within Australia in a viable state as a result of the processing, sale or disposal of decrowned pineapple fruit from Malaysia and subsequently transfer to a susceptible part of a host is: **LOW**.

Distribution of the imported commodity in Australia

- Imported fresh pineapple fruit is intended for human consumption in Australia. It is expected that once the fresh pineapple fruit has arrived in Australia, it will be distributed throughout Australia for wholesale or retail sale.
- If not fully developed at the time of importation, external disease symptoms may develop later and restrict circulation for sale. Disposal of infected fruit is likely to be via the commercial or domestic rubbish systems.
- External disease symptoms may develop after sale of infected fruit. Infected fruit is not expected to be consumed and it is likely that it will be disposed of via commercial or domestic rubbish systems. While this reduces the chances of successful transmission, any susceptible hosts in the vicinity of the rubbish systems may be exposed.
- Consumers will discard small quantities of fruit waste in urban, rural and natural localities. Small amounts may be discarded in domestic compost.

Transfer of the pest from waste to a suitable host

- *Phytophthora meadii* produce oospores and chlamydospores that can survive adverse conditions, including absence of a suitable host and poor environmental conditions (George and Edathil 1974; Liyanage and Wheeler 1991).
- Mycelium and sporangia and zoospores may survive for shorter periods on discarded fruit or in the absence of a host (Liyanage and Wheeler 1991).
- Temperature, low humidity, drying and antagonistic organisms are the limiting factors to survival (Weste 1983). If optimal environmental conditions occur, oospores and chlamydospores may produce sporangia (Erwin and Ribeiro 1996; Drenth and Guest 2004). Sporangia can be dislodged by water, wind or vertebrate or invertebrate vectors (Drenth and Guest 2004).

- The primary host of *P. meadii, Hevea brasiliensis* has a limited distribution in Australia. However, other possible hosts may be available in Australia including *Allium cepa*, *Acacia mearnsii*, *Ananas comosus*, *Prunus persica*, *Solanum melongena* and *Theobroma cacao* (Burt 2000; Wicks 2003; PHA 2007; APC 2011; Florabank 2011; RIRDC 2011). The narrow host range decreases the probability of the pathogen being spread to a suitable host when conditions are favourable for infection.

Summary

The possibility that *P. meadii* may enter the environment via association with discarded fruit, wind or rain-splash dispersal of whole sporangia, spores carried on animals or soil contaminated equipment, moderated by the climatic conditions that limit survival of this pathogen and its limited host range and distribution of these species, support a likelihood estimate for distribution of ‘low’.

Overall probability of entry (importation × distribution)

The overall probability of entry is determined by combining the probability of importation with the probability of distribution using the matrix of rules shown in Table 2.2.

The likelihood that *P. meadii* will enter Australia as a result of trade in decrowned pineapple fruit from Malaysia and be distributed in a viable state to a susceptible host is: **VERY LOW**.

4.4.3 Probability of establishment

The likelihood that *P. meadii* will establish in Australia, based on a comparison of factors in the source and destination areas considered pertinent to its survival and reproduction, is: **MODERATE**.

Availability of suitable hosts in Australia

- The primary host of *P. meadii*, *Hevea brasiliensis* has a limited distribution in Australia. However, other possible hosts may be available to aid establishment in Australia including *Allium cepa, Acacia mearnsii, Ananas comosus, Prunus persica, Solanum melongena and Theobroma cacao* (Wicks 2003; Burt 2000; PHA 2007; APC 2011; Florabank 2011; RIRDC 2011).

Suitability of the environment

- Erwin and Ribeiro (1996) report the incidence of disease on pineapple caused by *P. meadii* is greatest in areas with maximum temperature ranges from 22 to 26 °C and high rainfall. These parameters indicate that the climatic conditions within parts of Australia would be favourable to the establishment of *P. meadii*.

The reproductive strategy and survival of the pest

- *Phytophthora meadii* is capable of rapid population growth. After heavy rain, sporangia can develop on diseased tissue (Erwin and Ribeiro 1996).
- Peries and Fernando (1966) reported that for *P. meadii* the optimal temperature is 28 °C for production of sporangia, and 26 °C for zoospore liberation. Free water is also required in order for *P. meadii* to germinate (Peries and Fernando 1966).
- *Phytophthora meadii* may persist in the environment as chlamydospores or oospores awaiting favourable conditions or hosts (George and Edathil 1975; Liyanage and Wheeler

1991). Inoculum may germinate once conditions are conducive and establish an infection on a suitable host.

Summary

The presence of some suitable hosts and favourable climate conditions for *P. meadii* and its favourable life-cycle and reproductive strategies all support a likelihood estimate for establishment of 'moderate'.

4.4.4 Probability of spread

The likelihood that *P. meadii* will spread in Australia, based on a comparison of those factors in source and destination areas considered pertinent to the expansion of the geographic distribution of the pest, is: **MODERATE.**

The suitability of the natural or managed environment for spread

- *Phytophthora meadii* may persist in latent forms or as saprophytic colonizers of dead organic material in the environment (Erwin and Ribeiro 1996). This provides a reservoir for infection when susceptible hosts are available and/or favourable conditions occur and may promote spread.
- Peries and Fernando (1966) note that *Phytophthora meadii* is likely to spread during extended periods of overcast rainy weather where there is limited sunlight and high atmospheric humidity.
- Zoospores of phytophthora are able to swim and may remain active for hours. However, they generally encyst within 30 minutes (Drenth and Guest 2004). *Phytophthora meadii* zoospore germination and growth can be inhibited by dry surfaces, low humidity and sunlight (Peries and Fernando 1966).

Potential movement of the pest with commodities or conveyances

- *Phytophthora meadii* spores may be transferred to suitable hosts by wind and rain, cultivating implements, water-splash, vertebrate and invertebrate activity and by infected plant material (Cahill 1999; Drenth and Guest 2004). In Taiwan, Ann *et al.* (2003) determined that there was potential for transmission of *P. meadii* via contaminated ground water, as peaches cleaned with this water became infected post-harvest.
- The potential to spread may be moderated by the availability of suitable hosts.

Summary

The ability of *P. meadii* to persist in latent and saprophytic forms and for spores to be dispersed by wind, water and other vectors, moderated by specific climatic conditions required for germination, support a likelihood estimate for spread of 'moderate'.

4.4.5 Overall probability of entry, establishment and spread

The overall probability of entry, establishment and spread is determined by combining the probabilities of entry, of establishment and of spread using the matrix of rules shown in Table 2.2.

The likelihood that *P. meadii* will be imported as a result of trade in decrowned pineapple fruit from Malaysia, be distributed in a viable state to a susceptible host, establish and spread within Australia is: **VERY LOW**.

4.4.6 Consequences

The consequences of the establishment of *P. meadii* in Australia have been estimated according to the methods described in Table 2.3.

Based on the decision rules described in Table 2.4, that is, where the consequences of a pest with respect to one or more criteria are '**D**', the overall consequences are estimated to be: **LOW.**

Reasoning for these ratings is provided below:

Criterion	Estimate and rationale
Direct	
Plant life or health	**D** – Significant at district level. *Hevea brasiliensis* (rubber) is the principle economic host of *P. meadii*, on which the pathogen causes leaf fall, pod rot and black stripe (Erwin and Ribeiro 1996). In India and Sri Lanka, losses from *P. meadii* are significant. In Sri Lanka the pathogen has led to cessation of rubber tapping in the monsoon season (CAB International 2010). However, *H. brasiliensis* has a limited distribution in Australia (APC 2011). Yield and quality may be affected on other crop hosts including *Ananas comosus*, *Theobroma cacao and Solanum melongena*. *Phytophthora meadii* was isolated at low levels in a disease survey of *Acacia mearnsii* in commercial wattle growing areas in South Africa (Roux and Wingfield 1997). *Acacia mearnsii* is native to Australia. The distribution of *A. mearnsii* in Australia is limited to south-eastern and south-western Australia (Spooner 2007; Florabank 2011). Erwin and Ribeiro (1996) report the incidence of disease caused by *P. meadii* is greatest in areas with a maximum air temperature ranging from 22 to 26 °C and high rainfall, therefore establishment of the pathogen on this species may be limited. There are a number of *Leea* and *Piper* species in northern Australia which may be potential hosts of *P. meadii* (APC 2011).
Other aspects of the environment	**A** – Indiscernible at local level. There is no known impact of this pathogen on other aspects of the environment.
Indirect	
Eradication, control etc.	**D** – Significant at district level. Programs to minimise the impact of *P. meadii* are likely to be costly and include fungicide applications and crop monitoring. For some hosts existing control programs may be effective. For other hosts, existing control programs, for example specific integrated pest management or organic systems, may not be effective.
Domestic trade	**D** – Significant at district level. If *P. meadii* became established some losses may occur if restrictions are placed on interstate trade in association with containment and eradication of this pathogen.
International trade	**B** – Minor significance at local level. The presence of *P. meadii* in pineapple production areas or on other hosts may restrict access to overseas markets where this pest is absent. For example, *P. meadii* is considered a regulated pest by New Zealand for pineapple fruit imports from Ecuador (NZ MAF 1999).
Environmental and non-commercial	**B** – Minor significance at local level. Additional fungicide applications would be required in any containment and/or eradication programs and possibly, subsequently to control this pathogen on susceptible crops. This may have minor impact on the environment.

4.4.7 Unrestricted risk estimates

The unrestricted risk estimate for *P. meadii*: **NEGLIGIBLE**.

Unrestricted risk is the result of combining the probability of entry, establishment and spread with the outcome of overall consequences. Probabilities and consequences are combined using the risk estimation matrix shown in Table 2.5.

The unrestricted risk estimate for *P. meadii* of 'negligible' is below Australia's ALOP. Therefore, no specific risk management measures are required for this pest.

4.5 Pest risk assessment conclusions

Key to table 4.2

Genus species [EP]	pests for which policy already exists. The outcomes of previous assessments and/or reassessments in this IRA are presented in table 4.2
Genus species [state/territory]	state/territory in which regional quarantine pests have been identified

Likelihoods for entry, establishment and spread

N	negligible
EL	extremely low
VL	very low
L	low
M	moderate
H	high
P[EES]	overall probability of entry, establishment and spread

Assessment of consequences from pest entry, establishment and spread

PLH	plant life or health
OE	other aspects of the environment
EC	eradication control etc
DT	domestic trade
IT	international trade
ENC	environmental and non-commercial
A-G	consequence impact scores are detailed in section 2.2.3
URE	unrestricted risk estimate. This is expressed on an ascending scale from negligible to extreme.

Table 4.2 Summary of unrestricted risk estimates for quarantine pests associated with decrowned pineapple fruit from Malaysia

Pest name	Likelihood of						Consequences							URE
	Entry			Establishment	Spread	P[EES]	Direct		Indirect				Overall	
	Importation	Distribution	Overall				PLH	OE	EC	DT	IT	ENC		
Armoured scales [Hemiptera: Diaspididae]														
Melanaspis bromeliae EP	High	Low	Low	High	Moderate	Low	D	B	D	C	D	B	Low	**Very Low**
Unapsis citri WA, SA														
Mealybugs [Hemiptera: Pseudococcidae]														
Dysmicoccus grassii	High	Moderate	Moderate	High	High	Moderate	D	B	D	D	D	B	Low	**Low**
Dysmicoccus neobrevipes														
Planococcus minor WA														
Pseudococcus jackbeardsleyi														
Bacteria														
Erwinia chrysanthemi (pineapple strain, *Dickeya sp.)*	Low	Low	Very Low	High	High	Very Low	E	A	D	D	C	C	Moderate	**Very Low**
Stramanopila														
Phytophthora meadii	Very Low	Low	Very Low	Moderate	Moderate	Very Low	D	A	D	D	B	B	Low	**Negligible**

5 Pest risk management

This section provides information on the management of quarantine pests identified with an unrestricted risk exceeding Australia's appropriate level of protection (ALOP). The recommended phytosanitary measures are described below.

5.1 Pest risk management measures and phytosanitary procedures

Pest risk management evaluates and selects options for measures to reduce the risk of entry, establishment or spread of quarantine pests for Australia where they have been assessed to have an unrestricted risk above Australia's ALOP. In calculating the unrestricted risk, existing commercial production practices in Malaysia have been considered, as have post-harvest procedures and packing of fruit.

In addition to Malaysia's existing commercial production practices for the production of decrowned pineapple fruit and minimum border procedures in Australia, specific pest risk management measures, including operational systems, are recommended to achieve Australia's ALOP.

In this section, DAFF Biosecurity has identified risk management measures that may be applied to consignments of decrowned pineapple fruit sourced from Malaysia. Finalisation of the quarantine conditions may be undertaken with input from the Australian states and territories as appropriate.

The following measures will form the basis of the import conditions for decrowned pineapple fruit from Malaysia. However, DAFF Biosecurity does recognise that other risk management measures may be suitable to manage the identified risks. Australia will consider any measure proposed by Malaysia consistent with the principle of equivalence detailed in ISPM 11: *Pest risk analysis for quarantine pests including analysis of environmental risks and living modified organisms* (FAO 2004), providing that it achieves an equivalent level of quarantine protection. Evaluation of such measures or treatments will require a technical submission from Malaysia that details the proposed treatment including data from suitable trials to demonstrate the efficacy.

5.1.1 Pest risk management for pests

The pest risk analysis identified the quarantine pests listed in Table 5.1 as having an unrestricted risk above Australia's ALOP.

This report recommends that when the following pest management practices are followed, the restricted risk for all identified quarantine pests assessed achieves ALOP.

Table 5.1 Phytosanitary measures recommended for quarantine pests of decrowned pineapple fruit from Malaysia

Pest	Common name	Measures
Arthropods		
Dysmicoccus grassii	mealybug	Methyl bromide fumigation or an alternative post harvest phytosanitary treatment as approved by DAFF.
Dysmicoccus neobrevipes	grey pineapple mealybug	
Planococcus minor (WA)	Pacific mealybug	
Psedococcus jackbeardsleyi	Jack Beardsley mealybug	
Australian regional quarantine pests are indicated with the region(s) concerned in parentheses		

Management for mealybugs

The mealybugs identified as quarantine pests for Australia in this IRA report are *Dysmicoccus grassii*, *D. neobrevipes*, *Planococcus minor* (WA only) and *Pseudococcus jackbeardsleyi*. The term 'mealybugs' is used to refer to these species unless otherwise specified.

Visual inspection alone is not considered to be an acceptable measure to verify the level of infestation of decrowned pineapple fruit with mealybugs. Due to the rough surface texture of pineapple fruit and the small size of pest species, infestation may be difficult to detect during inspection, therefore additional measures are required.

The risks of entry, establishment and spread of mealybugs associated with the importation of decrowned pineapple fruit from Malaysia would not achieve Australia's ALOP if visual inspection was the only measure applied. Inspection alone would not provide sufficient confidence that unacceptable levels of these pests are not present on decrowned pineapple fruit.

The *Import risk analysis (IRA) for the importation of fresh pineapple fruit: final IRA report* (Philippines, Thailand, Sri Lanka and the Solomon Islands) (Biosecurity Australia 2002) recommended methyl bromide fumigation and an operational system for the maintenance and verification of phytosanitary status as risk management measures for mealybugs.

Australia has discussed with Malaysia the above risk management measures for mealybugs and also other phytosanitary treatments such as vapour heat treatment and an alternative fumigant, namely ethyl formate/carbon dioxide (trade name Vapormate®).

DAFF Biosecurity considers that methyl bromide fumigation at the recommended dose rate (outlined below), implemented in conjunction with an operational system for the maintenance and verification of the quarantine status of decrowned pineapple fruit, will achieve Australia's ALOP.

Risk management measures for the mealybugs identified as quarantine pests for Australia in this IRA report, *D. grassii*, *D. neobrevipes*, *Pl. minor* (WA only) and *Ps. jackbeardsleyi* must be put in place pre-export and/or on-arrival.

All decrowned pineapple fruit imported into Australia must undergo mandatory fumigation with methyl bromide. Fumigation may be undertaken either prior to export, or on arrival in Australia after the pre-export phytosanitary inspection by the Malaysian DoA. If fumigation is performed on arrival, the security of the pineapples must be maintained at all times during the transport from the port/airport to the fumigation facility, and during transfer of the pineapples from the container to the fumigation chamber to ensure the exit of pests is minimised.

Fumigation with methyl bromide must be carried out for 2 hours according to the specification below:

a) 32g/m³ at an air and pulp temperature of 21 °C or above

b) 40g/m³ at an air and pulp temperature of 16–20 °C

c) 48g/m³ at an air and pulp temperature of 11–15 °C

d) 64g/m³ at an air and pulp temperature of 10 °C[*].

Decrowned pineapple fruit must not be fumigated if the fruit pulp temperature is below 10 °C. Loading ratio for the fumigation chamber must not exceed 80%.

Conclusion

The objective of this measure is to reduce the likelihood of importation for the listed mealybug species to at least 'moderate'. The restricted risk would then be reduced to at least 'very low' which would achieve Australia's ALOP.

5.1.2 Operational system for the maintenance and verification of phytosanitary status

A system of operational procedures is necessary to maintain and verify the phytosanitary status of decrowned pineapple fruit from Malaysia. This is to ensure that the recommended risk management measures have been met and are maintained.

Details of the operational system, or equivalent, will be determined by agreement between DAFF Biosecurity and the Malaysian DoA.

The components of the recommended operational systems are described below.

Provisions of traceability

Registration of export plantations by the Malaysian DoA.

The objectives of this recommended procedure are to ensure that:

- decrowned pineapples are sourced from export plantations registered by the Malaysian DoA producing export quality fruit and are certified to practice in accordance with Malaysia's farm certification scheme for Good Agricultural Practice, as the pest risk assessments are based on existing commercial production practices
- export plantations from which decrowned pineapples are sourced can be identified so investigation and corrective action can be targeted rather than applying it to all contributing export plantations in the event that live pests are regularly intercepted during on-arrival inspection.

Registration of packing house and treatment facilities and auditing of procedures

The objectives of this recommended procedure are to ensure that:

- decrowned pineapples are sourced only from Malaysian DoA-registered packing houses, processing export quality fruit, as the pest risk assessments are based on existing commercial packing activities

[*] Under Australian requirements methyl bromide fumigation cannot be carried out below 11 °C.

- reference to the packing house and the plantation source (by name or registration number code) are clearly stated on cartons destined for export of decrowned pineapple fruit to Australia for trace back and auditing purposes.

It is recommended that the Malaysian DoA registers the packing houses before commencement of harvest each season. The list of registered packing houses must be kept by the Malaysian DoA and made available to DAFF, if requested.

Registration of packing houses and treatment facilities in the initial export season would include an audit program conducted by DAFF before exports commence to verify that the operational system meets Australian requirements. After the initial approval, the Malaysian DoA would be required to audit facilities at the beginning of each season to ensure that packing houses and treatment facilities are suitably equipped to carry out the specified phytosanitary tasks and treatments. Records of the Malaysian DoA audits would be made available to DAFF on request.

Packing houses will be required to identify individual plantations with a unique identifying system and identify fruit from individual plantations by marking cartons or pallets (i.e. one plantation per pallet) with a unique plantation number or identification provided by the Malaysian DoA.

Treatment

Where decrowned pineapple fruit is fumigated prior to export, fumigation must occur in facilities registered and audited by the Malaysian DoA for that purpose. The Malaysian DoA is required to register all export fumigators before their export activity commences. Registered fumigators must comply with the current Malaysian DoA standards for export grade facilities, and must also comply with Australian Fumigation Accreditation Scheme (AFAS) standards for off-shore fumigators. Records of registration and fumigation chamber tests must be made available to DAFF on request.

Packaging and labelling

The objectives of this recommended procedure are to ensure that:

- decrowned pineapples proposed for export to Australia are not contaminated by quarantine pests or regulated articles (e.g. leaf material, trash, soil and weed seeds).
- to maintain quarantine integrity until arrival in Australia and undergoes on-arrival phytosanitary inspection and clearance by DAFF Biosecurity.

Treated and inspected fruit is required to be packed using clean, new materials.

All wood material used in packaging of the commodity must comply with DAFF Biosecurity conditions (see DAFF Biosecurity publication ‘Cargo Containers: Quarantine aspects and procedures’).

Secure packaging must be used if consignments are not transported in sealed containers directly to Australia.

Where boxes are on pallets, the pallets must be securely strapped following post-harvest treatments and export phytosanitary inspection.

The packaged decrowned pineapples must be labelled with the plantation registration number or code and the packing shed reference number or name for the purposes of trace back to registered plantations.

Specific conditions for storage and movement

The objectives of this recommended procedure are to ensure that:

- product for export to Australia that has been treated and/or inspected is kept secure and segregated at all times from any fruit for domestic or other markets and untreated product, to prevent product mixing or cross-contamination
- the quarantine integrity of the commodity during storage and movement is maintained.

Freedom from trash

All decrowned pineapple fruit for export must be free from pests of quarantine concern to Australia and other regulated articles. Regulated articles are defined as any items other than the decrowned pineapple fruit. This may include leaf material, woody plant material, weeds, weed seeds, soil or any other contaminant, often referred as to as 'trash'. Freedom from trash will be confirmed by the inspection procedures. DoA must provide details on how inspection for trash will occur before trade commences.

Pre-export phytosanitary inspection and certification

The objectives of this recommended procedure are to ensure that:

- all consignments are inspected by the Malaysian DoA in accordance with official procedures for all visually detectable quarantine pests and other regulated articles (including soil, animal and plant debris) on a 600 unit sample that is a representative sample of the consignment where one unit is one decrowned pineapple
- if mealybugs are detected on consignments undergoing on-arrival methyl bromide fumigation in Australia consignments may still enter Australia. If pests of quarantine concern other than mealybugs are intercepted, consignments must not enter Australia and remedial action must be taken (refer to section below on actions for non-compliance)
- an international phytosanitary certificate (IPC) is issued for each consignment upon completion of pre-export inspection and treatment to verify that the relevant measures have been undertaken offshore
- each IPC includes:
  - a description of the consignment (including plantation number and packing house details)
  - treatments: details of disinfestation treatments (methyl bromide fumigation (if off-shore methyl bromide fumigation option has been undertaken)), including date, concentration, temperature, duration, and packing house/treatment facility number (as appropriate)

and

  - an additional declaration that *'The fruit in this consignment has been produced in Malaysia in accordance with the conditions governing entry of decrowned* *pineapple fruit to Australia and inspected and found free of quarantine pests and regulated articles'*.

– Where fumigation is to be performed on-arrival in Australia, a further declaration stating: *'Subject to on-arrival methyl bromide fumigation in Australia'* must be added.

A consignment is the quantity of decrowned pineapple fruit covered by one IPC that arrives at one port in one shipment. Consignments need to be shipped directly from one port or city in Malaysia to a designated port or city in Australia, or transhipped, in sealed containers.

On-arrival phytosanitary inspection and clearance by DAFF Biosecurity

DAFF Biosecurity will undertake inspection of all imported consignments on-arrival in Australia.

Consignments must undergo appropriate quarantine inspection on-arrival in Australia. Where fumigation has not been carried out pre-shipment, inspection will be undertaken after on-arrival fumigation.

Each consignment is required to be free of quarantine pests, based on finding no live quarantine pests in a sample of 600 units (single decrowned pineapple fruit) from each inspection lot[4] from a consignment. No detection of pests resulting from the inspection of 600 units achieves a confidence level of 95% that not more than 0.5% of the units in the inspection lot are infested or infected.

Actions for non-compliance

The objectives of the recommended requirements for remedial action(s) for non-compliance are to ensure that:

- any quarantine risk is addressed by remedial action, as appropriate
- non-compliance with import requirements is addressed, as appropriate.

The detection of live quarantine pests or regulated articles during an inspection will result in the failure of the entire consignment during on-arrival inspection.

Where inspection lots are found to be non-compliant with Australian requirements, remedial action must be taken. The remedial actions for consignments where quarantine pests are detected will depend on the type of pest and the mitigation measure that the risk assessment has determined for that specific pest.

Remedial actions could include:

During pre-export phytosanitary inspection and certification

- withdrawing the consignment from export (if quarantine pests are detected during the pre-export phytosanitary inspection after fumigation where fumigation has occurred offshore)

[4] An inspection lot is defined as 'the quantity of product from which the NPPO draws its sample of units for inspection from a consignment or part of a consignment'.

- withdrawing the consignment from export (if pests of quarantine concern other than mealybugs are detected during the pre-export phytosanitary inspection, where consignments will undergo methyl bromide fumigation on-arrival in Australia)

During on-arrival phytosanitary inspection

- re-export of the consignment (if quarantine pests are detected during on-arrival inspection after fumigation)
- destruction of the consignment (if quarantine pests are detected during on-arrival inspection after fumigation)

or

- re-treatment of the consignment.

Separate to the corrective measures mentioned above, there may be other breach actions necessary depending on the specific pest intercepted and the risk management strategy put in place against that pest in the protocol.

DAFF Biosecurity will provide feedback to the Malaysian DoA if there are significant issues with the product at inspection. If product continually fails inspection, DAFF Biosecurity reserves the right to suspend the export program and conduct an audit of the risk management systems in Malaysia. The program will recommence only after DAFF Biosecurity (in consultation with the relevant state departments if required) is satisfied that appropriate corrective action has been taken.

5.2 Responsibility of competent authority

The Malaysian DoA is the designated NPPO under the International Plant Protection Convention (IPPC).

The NPPO's responsibilities include:

- inspecting plants and plant products moving in international trade
- issuing certificates relating to phytosanitary condition and origin of consignments of plants and plant products
- ensuring that all relevant agencies participating in this program meet the proposed service and certification standards and proposed work plan procedures
- ensuring that administrative processes are established to meet the requirements of the program.

5.3 Review of processes

5.3.1 Audit of protocol

DAFF Biosecurity reserves the right to audit the entire phytosanitary system for pineapple imports from Malaysia, including packing house processing, mandatory methyl bromide fumigation and pre-export inspection and certification. DAFF Biosecurity reserves the right to conduct these audits before issuing import permits and at any time during the entire production cycle.

5.3.2 Review of policy

DAFF Biosecurity reserves the right to review the import policy after the first year of trade or when there is reason to believe that the pest and phytosanitary status in Malaysia has changed.

The Malaysian DoA must inform DAFF Biosecurity immediately on detection in Malaysia of any new pests of decrowned pineapple fruit that are of potential quarantine concern to Australia.

5.4 Uncategorised pests

If an organism is detected on decrowned pineapple fruit during the pre-clearance inspection that has not been categorised, it will require assessment by DAFF Biosecurity to determine its quarantine status and if phytosanitary action is required. Assessment is also required if the detected species was categorised as not likely to be on the import pathway. If the detected species was categorised as on the pathway but assessed as having an unrestricted risk that achieves Australia's ALOP due to the rating for likelihood of importation, then it would require reassessment. The detection of any pests of quarantine concern not already identified in the analysis may result in remedial action and/or temporary suspension of trade while a review is conducted to ensure that existing measures continue to provide the appropriate level of protection for Australia.

Appendices

Appendix A Initiation and categorisation for pests of fresh decrowned pineapple fruit from Malaysia[5]

Table A Initiation and pest categorisation

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
DOMAIN BACTERIA						
Gammaproteobacteria						
Enterobacteriales						
Pectobacterium carotovorum (Jones 1901) Waldee 1945 emend. Gardan *et al*. 2003 Syn: *Erwinia carotovora* (Jones 1901) Bergey *et al*. 1923. [Enterobacteriaceae] fruit collapse	Yes (Williams and Liu 1976; Rahman 1992)	Not assessed	Yes (Chandrashekar and Diriwaechter 1984)	Not assessed	Not assessed	No
Erwinia chrysanthemi (pineapple strain, *Dickeya* sp.) (Burkholder *et al.* 1953) Syn: *Dickeya chrysanthemi* (Burkholder *et al*. 1953) Samson *et al*. 2005 [Enterobacteriaceae] bacterial fruit collapse, bacterial heart rot	Yes (Lim 1986)	Yes Fruit and leaves (Lim 1986)	No Although strains of *Erwinia chrysanthemi* (pineapple strain, *Dickeya* sp.) are present in Australia (APPD 2011), the strain infecting pineapple in Malaysia appears to be highly specific pineapple (Lim and Lowings 1983) and has not been recorded in Australia.	Yes *Erwinia chrysanthemi* (pineapple strain, *Dickeya* sp.) has established is pineapple plantations under tropical environmental conditions in Malaysia, Costa Rica, Philippines, Brazil (Rohrbach and Schmitt 2003) and Hawaii (Kaneshiro *et al.* 2008). The pineapple growing areas of Australia have environmental conditions similar to these countries. Therefore the environment in Australia, particularly in the pineapple growing areas, is suitable for the establishment of the pest.	Yes Bacterial heart rot and fruit collapse caused by *Erwinia chrysanthemi* (pineapple strain, *Dickeya* sp.) are of economic importance to pineapple producers where this pathogen is known to occur.	Yes

[5] This pest categorisation table does not represent a comprehensive list of all the pests associated with the entire plant of an imported commodity. Reference to soilborne nematodes, soilborne pathogens, wood borer pests, root pests or pathogens, and secondary pests have not been listed or have been deleted from the table, as they are not directly related to the export pathway of fresh decrowned pineapple fruit and would be addressed by Australia's current approach to contaminating pests.

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Pantoea agglomerans (Ewing and Fife 1972) Gavini *et al*. 1989 Syn*: Erwinia herbicola* (Lohnis 1911) Dye 1964 [Enterobacteriaceae] pink disease	Yes (Liu 1977)	Not assessed	Yes (Pegg *et al.* 1995; APPD 2011)	Not assessed	Not assessed	No
Pantoea ananatis corrig. (Serrano 1928) Mergaert *et al.* 1993 Syn: *Erwinia ananas* Serrano 1928; *Erwinia ananatis* corrig. Serrano 1928; *Pseudomonas ananas* (Serrano 1928) Mergaert, Verdonck and Kersters 1993 [Enterobacteriaceae] bacterial fruitlet brown rot	Yes (Bradbury 1986)	Not assessed	Yes (Bradbury 1986; Pegg 1993; Pegg and Anderson 2009) Not in WA (DAWA 2005). Although DAWA (2005) states this species is not in WA, as no effective control measures are currently being exercised to prevent interstate transfer of this pathogen, the pathogen cannot be considered as a quarantine pest for WA.	Not assessed	Not assessed	No
DOMAIN EUKARYA						
ANIMALIA						
ARTHROPODA: Arachnidia: Acari						
Dolichotetranychus floridanus (Banks, 1900) [Tenuipalpidae] pineapple false mite	Yes (Yunus and Ho 1980)	Not assessed	Yes (Waite 1993; Petty *et al*. 2002; ABRS 2009)	Not assessed	Not assessed	No
Dolichotetranychus vandergooti (Oudemans, 1927) [Tenuipalpidae] perianth mite	Yes (Yunus and Ho 1980)	No Leaves (Yunus and Ho 1980).	No records found (APPD 2011)	Not assessed	Not assessed	No
Eutetranychus orientalis (Klein, 1936) [Tetranychidae] citrus brown mite	Yes (Bolland *et al.* 1998)	Not assessed	Yes (Bolland *et al.* 1998; CABI/EPPO 2007)	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
*Tyrophagus putrescentiae (*Schrank, 1781) [Acaridae] cereal mite	Yes (Colloff 2009)	Not assessed	Yes (ABRS 2009)	Not assessed	Not assessed	No
ARTHROPODA: Insecta						
Coleoptera						
Adoretus sinicus Burmeister, 1855 [Scarabaeidae] Chinese rose beetle	Yes (Waterhouse 1993)	No Larvae are found in the soil and are detritus feeders (Williams 1931; Mau and Kessing 1991). Adults feed on leaves and roots (Rohrbach 1983; Petty *et al.* 2002).	No records found (APPD 2011)	Not assessed	Not assessed	No
Ahasverus advena (Waltl, 1832) [Silvanidae] foreign grain beetle	Yes (Yunus and Ho 1980)	Not assessed	Yes (Greening 1973; Naumann 1993)	Not assessed	Not assessed	No
Araecerus fasciculatus (De Geer, 1775) [Anthribidae] coffee bean weevil	Yes (Corbett 1929; Waller 2007)	Not assessed	Yes (Waller 2007; Walker 2008)	Not assessed	Not assessed	No
Carpophilus dimidiatus (Fabricius, 1792) [Nitidulidae] pineapple sap beetle	Yes (Yunus and Ho 1980)	Not assessed	Yes (Barrer 1983)	Not assessed	Not assessed	No
Carpophilus humeralis (Fabricius, 1798) [Nitidulidae] dried fruit beetle	Yes (Connell 1981; Morton 1987)	Not assessed	Yes (James *et al.* 1995; Walker 2007a)	Not assessed	Not assessed	No
Carpophilus obsoletus Erichson, 1843 [Nitidulidae] dried fruit beetle	Yes (Hinton 1945; Kalshoven 1981)	No *Carpophilus obsoletus* is a pest of corn and dried fruit commodities (Stanaway *et al*. 2001; Walker 2007b).	Yes (Walker 2007b; APPD 2011) Not in WA (Poole 2010).	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Dactylosternum abdominal (Fabricius, 1792) [Hydrophilidae] beetle	Yes (Yunus and Ho 1980)	Not assessed	Yes (Newton 1989)	Not assessed	Not assessed	No
Glycyphana quadricolor sinuata (Wallace, 1867) Syn: *Glycyphana sinuata* (Wallace, 1867 [Scarabaeidae] flower beetle	Yes (Yunus and Ho 1980)	No Although Yunus and Ho (1980) have reported *Glycyphana quadricolor sinuata* on flowers and fruit, there has been no other record found for this pest on pineapple fruit. Cetoniinae have weak mouthparts that typically feed on nectar, pollen, and soft overripe fruits (Richards and Davies 1977; Hill 1994). Other *Glycyphana* species have been recorded feeding on nectar and pollen and their larvae have been found in rotten wood (Cassis *et al*. 1992).	No records found (APPD 2011)	Not assessed	Not assessed	No
Haptoncus luteolus (Erichson, 1843) Syn: *Epuraea luteola* Erichson, 1843 [Nitidulidae]	Yes (Yunus and Ho 1980)	No *Haptoncus luteolus* is a pest of dried fruit and has also been collected from decaying fruit (Ewing 2004; Myers 2004).	Status uncertain. Two records in APPD listed as *Epuraea luteola* in NSW (APPD 2011)	Not assessed	Not assessed	No
Haptoncus ocularis (Fairmaire, 1849) Syn: *Epuraea ocularis* Fairmaire, 1849 [Nitidulidae] pineapple sap beetle	Yes (Yunus and Ho 1980)	No *Haptoncus ocularis* develop on dead and souring plant material and pupate in soil (Chang and Jensen 1974).	Yes (Blanche and Cunningham 2005; APPD 2011) Not in WA (DAWA 2005).	Not assessed	Not assessed	No
Lasiodites pictus (Macleay, 1825) [Nitidulidae] sap beetle	Yes (Yunus and Ho 1980)	No Although Yunus and Ho (1980) have reported *Lasiodites pictus* on fruit, there have been no other records found for this pest on pineapple fruit. Nitidulidae are typically attracted to soft ripe fruit, damaged fruit, overripe fruit and fermenting juice (Nielsen 2003b).	No records found (APPD 2011)	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Oryctes rhinoceros (Linnaeus, 1758) [Scarabaeidae] rhinoceros beetle	Yes (Bedford 1980)	No *Oryctes rhinoceros* is a pest of coconut and oil palm, which has occasionally been reported on pineapple (Khoo *et al*.1991). Eggs are laid in rotting organic matter; adults feed on leaves (Bedford 1980; Khoo *et al*.1991).	No records found (APPD 2011)	Not assessed	Not assessed	No
Tribolium castaneum (Herbst, 1797) [Tenebrionidae] red flour beetle	Yes (Yunus and Ho 1980)	Not assessed	Yes (Wallbank and Greening 1976; APPD 2011)	Not assessed	Not assessed	No
Diptera						
Atherigona orientalis Schiner, 1868 [Muscidae] pepper fruit fly	Yes (Pont 1992)	Not assessed	Yes (Pont 1992)	Not assessed	Not assessed	No
Drosophila ananassae Doleschall 1858 [Drosophilidae] vinegar fly	Yes (Yunus and Ho 1980)	No Although reported as being associated with pineapple fruit by Yunus and Ho (1980), the condition of the fruit was not described. It is considered an improbable association with the pathway as *Drosophila* species deposit their eggs on or near the surface of rotting or fermenting (over-ripe) fruit and vegetable matter (Nielsen 2003a). Larvae of most *Drosophila* species are also associated with decaying fruit and fungi (Nielsen 2003a). *Drosophila ananassae* is reported on rotting fruit (Brncic 1987; McEvey *et al.* 1987).	Yes (Evenhuis and Okada 2008) Not present in WA (DAWA 2005).	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Gymnonerius fuscus (Wiedemann, 1824) [Neriidae] stilt fly	Yes (Yunus and Ho 1980)	No Yunus and Ho (1980) have reported this species on pineapple fruit. However no further records have been found to show *Gymnonerius fuscus* as a pest of on pineapple or other crops. Known larvae of this family are saprophagous and feed on decaying plant material (Oosterbroek 1998; Zumbado 2006). Identified as not being a quarantine pest (Biosecurity Australia 2002). Potential for establishment and spread was considered not feasible.	No records found (Pitkin 1986)	Not assessed	Not assessed	No
Lamprolonchaea smaragdi (Walker, 1849) Syn: *Lonchaea aurea* Macquart, 1851 [Lonchaeidae] lance fly	Yes (Yunus and Ho 1980)	No Fruit (Yunus and Ho 1980). However, considered an improbable association with the pathway as the immature stages of most species of the Lonchaeidae family are considered secondary invaders in diseased or injured plant material. Larvae of this species are reported living in damaged tomatoes within Australia (Pitkin 1989).	Yes (Pitkin 1989) Not present in WA (DAWA 2005).	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Mimegralla albitarsis Wiedemann, 1819 (cited as *Mimegralla leucopeza albitarsis* Wiedemann in BA 2002) [Micropezidae] stilt fly	Yes (Yunus and Ho 1980)	No Yunus and Ho (1980) have reported *Mimegralla albitarsis* on fruit. However, it is considered an improbable association with the pathway as adults are reported as either predaceous on small insects or are attracted to decaying fruit and excrement (Evenhuis 1998). The larvae of Micropezidae are reported to live in decaying wood and other vegetable matter (Colless and McAlpine 1991).	No records found (Evenhuis 1998)	Not assessed	Not assessed	No
Hemiptera						
Aonidiella aurantii (Maskell, 1879) [Diaspididae] California red scale	Yes (IIE 1996)	Not assessed	Yes (Smith *et al.* 1997; APPD 2011)	Not assessed	Not assessed	No
Aspidiotus destructor Signoret, 1869 [Diaspididae] coconut scale	Yes (CIE 1966)	Not assessed	Yes (CIE 1966; Naumann 1993; APPD 2011)	Not assessed	Not assessed	No
Coccus hesperidum hesperidum Linnaeus, 1758 Syn: *Coccus hesperidum* Linnaeus, 1758 [Coccidae] soft brown scale	Yes (Ben-Dov *et al.* 2010)	Not assessed	Yes (Smith *et al.* 1997)	Not assessed	Not assessed	No
Diaspis bromeliae (Kerner, 1778) [Diaspididae] pineapple scale	Yes (Yunus and Ho 1980)	Not assessed	Yes (CIE 1973a; Petty *et al.* 2002)	Not assessed	Not assessed	No
Diaspis boisduvalii Signoret, 1869 [Diaspididae] orchid scale	Yes (Yunus and Ho 1980)	Not assessed	Yes (Naumann 1993)	Not assessed	Not assessed	No
Dysmicoccus boninsis (Kuwana, 1909) [Pseudococcidae] grey sugarcane mealybug	Yes (Williams 2004; Ben-Dov *et al.* 2010)	Not assessed	Yes (Williams 1985; Ben-Dov 1994)	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Dysmicoccus brevipes (Cockerell, 1893) [Pseudococcidae] pineapple mealybug	Yes (Yunus and Balasubramaniam 1975; Yunus and Ho 1980; Williams 2004)	Not assessed	Yes (Williams 1985; Waite 1993)	Not assessed	Not assessed	No
Dysmicoccus grassii (Leonardi, 1913) [Pseudococcidae] mealybug	Yes (Williams 2004; Ben-Dov *et al.* 2010)	Yes Pineapple has been reported as a host plant (Ben-Dov 1994).	No records found (Ben-Dov *et al*. 2010)	Yes *Dysmicoccus grassii* is highly polyphagous attacking broad range of plant genera (Ben-Dov 1994). Susceptible hosts are freely available in the protected area suggesting a high probability that a suitable host would be found.	Yes Fruit quality can be reduced by the presence of secondary sooty mould (fungus) growing on honeydew expelled by these species (Smith *el al.* 1997)	Yes
Dysmicoccus neobrevipes Beardsley 1959 [Pseudococcidae] grey pineapple mealybug	Yes (Petty *et al.* 2002; Williams 2004; Ben-Dov *et al.* 2010)	Yes Fruit and leaves (Beardsley 1993; Petty *et al.* 2002; Williams 2004).	No records found (Ben-Dov *et al*. 2010)	Yes *Dysmicoccus neobrevipes* is highly polyphagous attacking broad range of plant genera (Williams 2004). Susceptible hosts are freely available in the protected area suggesting a high probability that a suitable host would be found.	Yes Mealybugs can cause direct harm to a wide range of plant hosts and have also been reported as disease vectors. Fruit quality can be reduced by the presence of secondary sooty mould. In Hawaii, *D. neobrevipes* is ranked as an important pest of pineapples where it is associated with pineapple wilt disease (Beardsley 1993; Williams 2004). It has potential to cause economic damage if introduced into the protected area.	Yes
Ferrisia virgata (Cockerell, 1893) [Pseudococcidae] striped mealybug	Yes (Williams 2004; Ben-Dov *et al.* 2010)	Not assessed	Yes (Williams 1985; Ben-Dov *et al*. 2010; Poole 2010)	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Geococcus coffeae Green, 1933 [Pseudococcidae] coffee root mealybug	Yes (Williams 2004; Ben-Dov *et al.* 2010)	No Roots (Petty *et al.* 2002).	Yes (Williams 1985; Ben-Dov *et al*. 2010) Not present in WA (DAWA 2005).	Not assessed	Not assessed	No
Kilifia acuminata (Signoret, 1873) [Coccidae] acuminate scale	Yes (Ben-Dov *et al.* 2010)	No Leaves (Williams and Watson 1990).	No records found (Ben-Dov *et al.* 2010)	Not assessed	Not assessed	No
Leptocorisa acuta (Thunberg, 1783) [Alydidae] rice bug	Yes (Singh 1971)	Not assessed	Yes (Kay *et al.* 1993)	Not assessed	Not assessed	No
Melanaspis bromiliae (Leonardi, 1899) Note: *Melanaspis smilacis* closely resembles *M. bromiliae* and *M. marlatti* which were previously considered to be synonyms of *M. smilacis* (Deitz & Davidson 1986). However, *M. bromiliae* is now recognised as a valid and separate species from *M. smilacis.* [Diaspididae] ananas scale	Yes (Ben-Dov *et al.* 2010)	Yes Fruit and leaves (Dekle 1965).	No records found (Ben-Dov *et al.* 2010)	Yes Based on family characteristics, adults and crawlers may survive storage and transport (Beardsley and Gonzalez 1975). First instar nymphs (or crawlers) of armoured scales can move onto fruit, attach and commence feeding (Beardsley and Gonzalez 1975; Dreistadt *et al.* 1994). Dispersal of armoured scales may occur on discarded fruit or they may be dispersed on wind currents or by birds, insects or other animals (Beardsley and Gonzalez 1975). *Melanaspis bromiliae* is reported on pineapple*, Cocos nusifera* (coconut palm) and species of *Pandanus* and *Neoglaziovia* (Ben-Dov *et al.* 2010). Armoured scales can produce several overlapping generations per year (Beardsley and Gonzalez 1975; Dreistadt *et al.* 1994).	Yes *Melanaspis bromiliae* was reported by Sipes (2000) as a pest of pineapple. Other species of scale are capable of causing significant damage to pineapples (*Diaspis bromeliae*) (Petty *et al.* 2002). Several species of *Melanaspis* are considered economically important pests (Deitz and Davidson 1986).	Yes

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Parasaissetia nigra (Nietner 1861) [Coccidae] pomegranate scale	Yes (Ben-Dov *et al.* 2010)	Not assessed	Yes (Ben-Dov *et al*. 2010)	Not assessed	Not assessed	No
Pinnaspis buxi (Bouché, 1851) [Diaspididae] scale	Yes (Ben-Dov *et al.* 2010)	Not assessed	Yes (Williams and Watson 1988a)	Not assessed	Not assessed	No
Pinnaspis strachani (Cooley 1899) (Cited as *Chionaspis minor* Maskell in Biosecurity Australia 2002). [Diaspididae] cotton white scale	Yes (Watson 2005)	Not assessed	Yes (APPD 2011; Ben-Dov *et al.* 2010)	Not assessed	Not assessed	No
Planococcus citri (Risso 1813) [Pseudococcidae] citrus mealybug	Yes (Williams 2004; Ben-Dov *et al.* 2010)	Not assessed	Yes (Williams 1985; Ben-Dov *et al*. 2010)	Not assessed	Not assessed	No
*Planococcus minor (*Maskell 1897) [Pseudococcidae] Pacific mealybug	Yes (Williams 2004; Ben-Dov *et al.* 2010)	Yes Fruit (Williams and Watson 1988b; Williams 2004; Ben-Dov *et al.* 2010).	Yes (Ben-Dov *et al.* 2010) Not present in WA (DAWA 2005). WA regional freedom warrants further assessment of this species.	Yes *Planococcus minor* is polyphagous attacking many wild and cultivated susceptible species; 250 host species in nearly 80 families are reported as hosts (Sugimoto 1994; Lit *et al.* 1998; Venette and Davis 2004; Ben-Dov *et al*. 2010). Susceptible hosts are freely available within the protected area suggesting a high probability that a suitable host would be found. Many species of mealybugs are considered invasive, rapidly becoming established when introduced into new areas (Miller *et al.* 2002).	Yes *Planococcus minor* is a pest of many economically important species (Venette and Davis 2004; Ben-Dov *et al.* 2010). It has potential to cause economic damage if introduced into the protected area.	Yes [WA]

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Pseudococcus jackbeardsleyi Gimpel & Miller, 1996 [Pseudococcidae] Jack Beardsley mealybug	Yes (Williams 2004; Ben-Dov 2010)	Yes Fruit (MTFIS 2004).	No records found (Ben-Dov *et al*. 2010) Although detected in the Torres Strait Islands in 2010, there are quarantine operation measures in place to prevent its spread into mainland Australia, one of the important roles played by the Northern Australia Quarantine Strategy (NAQS 2012).	Yes Reported on pineapple (Ben-Dov *et al*. 2010; CAB International 2010). *Pseudococcus jackbeardsleyi* is polyphagous (Ben-Dov *et al.* 2010) and a number of host plants are present in Australia. Many mealybugs are considered invasive with a history of establishment in new areas (Miller *et al*. 2002).	Yes Reported on a diverse array of fruits, vegetables, and ornamentals from 88 genera in 38 plant families (Ben-Dov *et al*. 2010; CAB International 2010). Mealybugs can directly harm hosts by feeding damage, and are reported as disease vectors (Smith *et al.* 1997; Pandey and Johnson 2005). Fruit quality can be reduced by the presence of secondary sooty mould (fungus) growing on honeydew expelled by these species; photosynthesis, tree vigour and productivity may also be reduced (Smith *et al.* 1997).	Yes
Pseudococcus longispinus (Targioni-Tozzetti, 1867) [Pseudococcidae] long-tailed mealybug	Yes (Williams 2004; Ben-Dov *et al.* 2010)	Not assessed	Yes (Williams 1985; Ben-Dov *et al*. 2010)	Not assessed	Not assessed	No
Rhopalosiphum rufiabdominale (Sasaki, 1899) [Aphididae] rice root aphid	Yes (CAB International 2010)	Not assessed	Yes (Berlandier 1997; ABRS 2009)	Not assessed	Not assessed	No
Saccharicoccus sacchari (Cockerell, 1895) [Pseudococcidae] pink sugarcane mealybug	Yes (Williams 2004; Ben-Dov *et al.* 2010)	Not assessed	Yes (Williams 1985; Allsopp *et al.* 1993; Ben-Dov *et al*. 2010)	Not assessed	Not assessed	No
Stephanitis typica (Distant, 1903) [Tingidae] banana lace-wing bug	Yes (CIE 1973b; Khoo *et al.* 1991)	No Leaves (Khoo *et al.* 1991; CAB International 2010).	No records found	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Unaspis citri (Comstock, 1883) [Diaspididae] citrus snow scale	Yes (CIE 1962; Ben-Dov *et al.* 2010)	Yes Fruit (Watson 2005; CABI/EPPO 2010).	Yes (Smith and Papacek 1990) Not present in WA (DAWA 2005) nor in SA (PIRSA 2011).	*Yes* *Unaspis citri* is polyphagous. The host species include the families Anacardiaceae, Musaceae, Myrtaceae and Rutaceae (Davidson and Miller 1990; Ben-Dov *et al.* 2010). Many of the host species are common in Australia (e.g. citrus and mango) suggesting a high probability that a suitable host would be found by actively or passively dispersed scales. First instar nymphs (or crawlers) of armoured scales are capable of movement onto fruit where they attach and commence feeding (Beardsley and Gonzalez 1975). Therefore, they may be difficult to remove by cleaning (Armstrong 2001). *Unaspis citri* can produce several overlapping generations per year (Watson 2005).	Armoured scales can cause direct harm to a wide range of host plants, affecting fruit quality and plant health. Miller and Davidson (1990) list *U. citri* as a serious and widespread pest worldwide. On citrus *U. citri* causes yellow spotting on the underside of leaves, premature leaf fall, branch dieback, and promote secondary attack by fungus and wood-boring insects (CAB International 2010). There is significant potential that the protected area for *U. citri* may be adversely affected by its introduction. The presence of this species in commercial production areas of a wide range of commodities (e.g. citrus, mango, and grapevine) may limit access to overseas markets where this pest is absent.	Yes[WA, SA]
Lepidoptera						
Assara albicostalis Walker 1863 [Pyralidae] pyralid moth	Yes (Robinson *et al.* 1994)	No Whilst this species has been reported on pineapple in Malaysia (Robinson *et al.* 1994), specific details on plant part affected were not provided. There are no other reports of this species being associated with pineapple fruit in Malaysia.	No records found (APPD 2011)	Not assessed	Not assessed	No
Eudocima fullonia (Clerck, [1764]) [Noctuidae] fruit-piercing moth	Yes (CABI/EPPO 2001a)	Not assessed	Yes (Nielsen *et al.* 1996; CABI/EPPO 2001a)	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Melanitis leda ismene Cramer, 1775 [Nymphalidae] rice butterfly; green horned caterpillar	Yes (Dale 1994; CAB International 2010)	Not assessed	Yes (Grist and Lever 1969)	Not assessed	Not assessed	No
Parasa lepida Cramer 1799 [Limacodidae] blue-striped nettle grub	Yes (CIE 1986)	No Larvae feed on the leaves of a variety of plant species (Butani 1975; Wakamura *et al*. 2007).	No records found	Not assessed	Not assessed	No
Spodoptera exempta Walker 1856 [Noctuidae] day feeding armyworm	Yes (CIE 1972a)	Not assessed	Yes (CIE 1972a; Ironside 1979; Nielsen *et al.* 1996)	Not assessed	Not assessed	No
Spodoptera exigua (Hübner 1808) [Noctuidae] lesser armyworm	Yes (Waterhouse 1993)	Not assessed	Yes (CIE 1972b; Nielsen *et al.* 1996; APPD 2011)	Not assessed	Not assessed	No
Orthoptera						
Locusta migratoria (Linnaeus, 1758) [Acrididae] migratory locust	Yes (Yunus and Ho 1980)	Not assessed	Yes (APPD 2011; Roberts 2010)	Not assessed	Not assessed	No
Stenocatantops splendens (Thunberg, 1815) [Acrididae]	Yes (Willemse 1968)	No Leaves (Willemse 1968).	No records found	Not assessed	Not assessed	No
Valanga nigricornis (Burmeister, 1838) [Acrididae] grasshopper	Yes (Yunus and Ho 1980; Waterhouse 1993)	No Leaves (Yunus and Ho 1980).	No records found (APPD 2011)	Not assessed	Not assessed	No
Thysanoptera						
Frankliniella schultzei (Trybom, 1910) [Thripidae] cotton thrips	Yes (CABI/EPPO 1999a)	Not assessed	Yes (Mound 1996)	Not assessed	Not assessed	No
Thrips hawaiiensis (Morgan, 1913) [Thripidae] banana flower thrips	Yes (Waterhouse 1993)	Not assessed	Yes (Mound 1996)	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
DOMAIN FUNGI						
Agaricales						
Marasmius palmivorus Sharples [Marasmiaceae] oil palm bunch rot	Yes (Singh 1980; DoA 2004; Farr and Rossman 2010)	No Although Singh (1980) notes this cause's fruitlet brown rot, further investigation by Malaysian DoA found no further records of this species affecting pineapples in Malaysia (DoA 2009).	No records found (CAB International 2010)	Not assessed	Not assessed	No
Marasmiellus scandens (Massee) Dennis & D.A. Reid Syn: *Marasmius scandens* Massee [Marasmiaceae] white thread blight	Yes (Turner 1971; Singh 1980; Lim and Sangchote 2003)	No Leaves (Lim and Sangchote 2003; CAB International 2010).	No records found (CAB International 2010)	Not assessed	Not assessed	No
Marasmius crinis-equi F. Muell. ex Kalchbr Syn: *Marasmius equicrinis* F. Muell. ex Berk [Marasmiaceae] horse hair blight	Yes (Turner 1971; Singh 1980)	No Leaves (Lim and Sangchote 2003; CAB International 2010).	Yes (Cairney 1991; Young 2005; CAB International 2010) Not in WA (DAWA 2005).	Not assessed	Not assessed	No
Atheliales						
Athelia rolfsii (Curzi) C.C. Tu & Kimbr Anamorph: *Sclerotium rolfsii* Sacc [Atheliaceae] Rolf's disease	Yes (Farr and Rossman 2010)	Not assessed	Yes (Pegg *et al.* 1974; APPD 2011)	Not assessed	Not assessed	No
Botryosphaeriales						
Lasiodiplodia theobromae (Pat) Griffon & Maubl Syn: *Botryodiplodia theobromae* Pat [Botryosphaeriaceae] botryodiplodia rot	Yes (Williams and Liu 1976; CMI 1985)	Not assessed	Yes (Simmonds 1966; CMI 1985; Shivas 1989; CAB International 2010)	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Neoscytalidium dimidiatum (Penz.) Crous & Slippers Syn: *Fusicoccum dimidiatum* (Penz.) D.F. Farr; *Hendersonula toruloidea* Natrass Botryosphaeriaceae hendersonula fruit rot	Yes (Singh 1980)	Not assessed	Yes (APPD 2011; Ray *et al*. 2010; Sakalidis *et al*. 2011)	Not assessed	Not assessed	No
Macrophomina phaseolina (Tassi) Goid Syn: *Macrophoma phaseoli* Maubl [Botryosphaeriaceae] charcoal root rot	Yes (Singh 1980)	Not assessed	Yes (Shivas 1989; Ali and Dennis 1992)	Not assessed	Not assessed	No
Calosphaeriales						
Pleurostomophora richardsiae (Nannf.) L. Mostert, W Cams & Crous Syn: *Phialophora richardsiae* (Nannf.) Conant [Pleurostomataceae]	Yes (Williams 1991)	No Considered an improbable association with the pathway as this species is reported as being associated with dead and decaying wood (Han and Yuan 2000).	Yes (Williams 1991) Not in WA (DAWA 2005).	Not assessed	Not assessed	No
Capnodiales						
Passalora fulva (Cooke) U. Braun & Crous Syn: *Fulvia fulva* (Cooke) Cif [Mycosphaerellaceae]	Yes (Farr and Rossman 2010)	Not assessed	Yes (CMI 1983; Shivas 1989; APPD 2011)	Not assessed	Not assessed	No
Eurotiales						
Penicillium dangeardii Pitt Teleomorph: *Talaromyces flavus* (Klocker) Stolk & Samson [Trichocomaceae]	Yes (Farr and Rossman 2010)	No Roots (Farr and Rossman 2010).	No records found	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Penicillium funiculosum Thom [Trichocomaceae] black spot of pineapple	Yes (Rohrbach 1983; Rohrbach and Schmitt 2003; MTFIS 2004)	Not assessed	Yes (Simmonds 1966; Rohrbach 1983; Pegg 1993; Pegg *et al*. 1995) Not in WA (DAWA 2005). Although DAWA (2005) states this species is not in WA, as no effective control measures are currently being exercised to prevent interstate transfer of this pathogen, the pathogen cannot be considered as a quarantine pest for WA.	Not assessed	Not assessed	No
Hypocreales						
Fusarium moniliforme J. Sheldon This species is part of the *Gibberella fujikuroi* species complex. It is distinct from *Fusarium guttiforme* the cause of Fusariosis which is known only to occur in South America (Rohrbach & Schmitt 1994, Kvas *et al*. 2009). [Nectriaceae] fruitlet core rot	Yes (DoA 2004)	Not assessed	Yes (Simmonds 1966; Pegg 1993; APPD 2011)	Not assessed	Not assessed	No
Gliomastix luzulae (Fuckel) E.W. Mason ex S. Hughes [Incertae sedis]	Yes (Singh 1980)	No Leaves and dead and decaying material (Ellis 1971; Williams and Liu 1976).	No records found	Not assessed	Not assessed	No
Mariannaea elegans var. elegans (Corda) Samson Syn: *Paecilomyces elegans* (Corda) E.W. Mason & S. Hughes [Nectriaceae] basal leaf rot	Yes (Johnston 1960)	No Reported as basal leaf rot on pineapple and on decaying wood and soil (Johnston 1960; Farr and Rossman 2010).	Yes Limited records found (McCredie and Sivasithamparam 1985; APPD 2011).	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Myrothecium roridum Tode [Incertae sedis]	Yes (Farr and Rossman 2010)	Not assessed	Yes (APPD 2011)	Not assessed	Not assessed	No
Stachybotrys parvispora S. Hughes [Incertae sedis]	Yes (Farr and Rossman 2010)	No This species is reported in soil and decaying leaves (Kirk 1994; Whitton *et al.* 2001; Qureshi *et al.* 2004).	No records found	Not assessed	Not assessed	No
Stilbella annulata (Berk. & M.A. Curtis) Siefert Syn: *Stilbum annulatum* Berk. & M.A. Curtis [Incertae sedis]	Yes (Singh 1980)	No This species is reported on leaves and dead and decaying plant material (Sigh 1980; Farr and Rossman 2010).	No records found	Not assessed	Not assessed	No
Microascales						
Ceratocystis paradoxa (Dade) C. Moreau Anamorph: *Thielaviopsis paradoxa* (De Seynes) Hohn [Ceratocystidaceae] <u>base rot</u>	Yes (Singh 1980; CMI 1981)	Not assessed	Yes (Simmonds 1966; Pegg 1993; APPD 2011)	Not assessed	Not assessed	No
Microthyriales						
Asterinella stuhlmannii (Henn.) Theiss [Microthyriaceae] <u>leaf spot</u>	Yes (Singh 1980)	No This species is reported on decaying leaves of pineapple (Stevenson 1975; Singh 1980).	No records found	Not assessed	Not assessed	No
Mucorales						
Rhizopus stolonifer (Ehrenb.) Vuill [Mucoraceae] <u>rhizopus soft rot</u>	Yes (Farr and Rossman 2010)	Not assessed	Yes (Persley *et al*. 2009; APPD 2011)	Not assessed	Not assessed	No
Pleosporales						
Cochliobolus geniculatus R.R. Nelson Anamorph: *Curvularia geniculata* (Tracy & Earle) Boedijn [Pleosporaceae]	Yes (Singh 1980)	Not assessed	Yes (Shivas 1989; APPD 2011)	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Periconia byssoides Pers [Incertae sedis]	Yes (Peregrine and Ahmad 1982; Farr and Rossman 2010)	No Leaves and stems (Ellis 1971; Peregrine and Ahmad 1982).	Yes Not in WA (DAWA 2005).	Not assessed	Not assessed	No
Pseudocochliobolus eragrostidis Tsuda & Ueyama Syn. *Cochliobolus eragrostidis* (Tsuda & Ueyama Anamorph: Curvularia eragrostidis (Henn.) J.A. Mey. [Pleosporaceae] leaf rot	Yes (Singh 1980; Sivanesan 1990; Liu 1977)	Not assessed	Yes (Shivas 1989; Duff and Daly 2002; APPD 2011)	Not assessed	Not assessed	No
Trichosphaeriales						
Nigrospora sphaerica (Sacc.) E.W. Mason [Incertae sedis] storage fruit rot	Yes (Peregrine and Ahmad 1982)	Not assessed	Yes (Simmonds 1966; Trimboli and Burgess 1985; APPD 2011)	Not assessed	Not assessed	No
Unassigned						
Beltrania rhombica Penz Syn: *Beltrania indica* [Incertae sedis] leaf spot	Yes (Singh 1980)	No This species is reported on leaves of pineapple (Ellis 1971; Farr and Rossman 2010).	Yes (Paulus *et al*. 2006; APPD 2011) Not in WA (DAWA 2005).	Not assessed	Not assessed	No
Colletotrichum sp. [Glomerellaceae] leaf tip dieback	Yes (DoA 2009)	No This species is reported on leaves of pineapple seedlings (DoA 2011).	Uncertain	Not assessed	Not assessed	
Corynespora cassiicola (Berk. & M.A. Curtis) C.T. Wei [Glomerellaceae] leaf spot	Yes (Ellis and Holliday 1971)	No Leaves and stems (Ellis and Holliday 1971; Farr and Rossman 2010).	Yes (Simmonds 1966; Ellis and Holliday 1971) Not in WA (DAWA 2005).	Not assessed	Not assessed	No
Spegazzinia tessarthra (Berk. & M.A. Curtis) Sacc. [Incertae sedis]	Yes (Ellis 1971)	Not assessed	Yes (Ellis 1971; APPD 2011)	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Stachylidium bicolor Link [Incertae sedis]	Yes (Singh 1980)	No *Stachylidium bicolor* is reported on dead leaves and stems of various species (Ellis 1971; Farr and Rossman 2010).	Yes Limited distribution – SA (APPD 2011). Not in WA (DAWA 2005).	Not assessed	Not assessed	No
Xylariales						
Pestalotiopsis theae (Sawada) Steyaert [Amphisphaeriaceae]	Yes (Farr and Rossman 2010)	No Leaves (Lang *et al*. 1998; Chang *et al*. 1999; Farr and Rossman 2010).	Yes Limited distribution – NT (APPD 2011).	Not assessed	Not assessed	No
KINGDOM CHROMALVEOLATA						
Peronosporales						
Phytophthora cinnamomi Rands [Pythiaceae] <u>green fruit rot</u>	Yes (Lee and Lum 2004; CAB International 2010)	Not assessed	Yes (Pegg 1993; Pegg and Anderson 2009; APPD 2011)	Not assessed	Not assessed	No
Phytophthora meadii McRae [Pythiaceae] <u>heart rot</u>	Yes (Liu 1977; Lee and Lum 2004)	Yes *Phytophthora meadii* is reported to cause fruit (top) rot (Sideris 1929), stem (heart rot) (Sideris and Paxton 1930) and root rot (Sideris and Paxton 1931) of pineapple in Hawaii. It is present in Malaysia (CMI 1982; Farr and Rossman 2010); however, no primary reference associates this organism with pineapple fruit in Malaysia. This may be indicative of insignificant economic impact as other *Phytophthora* species are present.	Uncertain. No records found in APPD 2011. Limited records of a *Phytophthora sp*. near *meadii* were reported in Brown (1999) in Northern Queensland.	*Phytophthora* species have a life-cycle and reproductive strategies that enable them to reproduce, be disseminated, and remain viable within a diverse range of environments (Weste 1983). Promoting spread potential, *P. meadii* may persist as latent forms, or as saprophytic colonizers of dead organic material in the environment, to act as a reservoir for infection when susceptible hosts are available and/or favourable conditions occur (Weste 1983).	*Phytophthora meadii* has a host range that includes a number of commercial crops (e.g. eggplant, onion, peach) produced in Australia (Collins *et al*. 2004). The introduction of this species into Australian commercial production areas of a wide range of commodities (e.g. eggplant, onion, peach) may limit their access to overseas markets where this pest is absent.	Yes
Phytophthora nicotianae Breda de Haan [Pythiaceae] <u>heart rot</u>	Yes (Lee and Lum 2004)	Not assessed	Yes (Pegg 1993; Walker and Morey 1999; APPD 2011)	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
Phytophthora palmivora (E.J. Butler) E.J. Butler [Pythiaceae] phytophthora heart rot; root rot	Yes (Lee and Lum 2004; CAB International 2010)	No *Phytophthora palmivora* is associated with pineapple in Malaysia (Farr and Rossman 2010), but considered an improbable association with the pathway as it causes stem (heart) and root rots of the pineapple plant. No primary references found that associated this organism with pineapple fruit (e.g. Mehrlich 1934; Suzui *et al*. 1979; Gonsalves and Ferreira 1994; Erwin and Ribeiro 1996).	Yes (Teakle 1957; Hamill 1987; CAB International 2010; APPD 2011) Not in WA (DAWA 2005).	Not assessed	Not assessed	No
Pythium aphanidermatum (Edson) Fitzp [Pythiaceae] cottony leak; heart rot	Yes (Liu 1977; CMI 1978)	Not assessed	Yes (Simmonds 1966; Bumbieris 1972; CMI 1978)	Not assessed	Not assessed	No
Pythium arrhenomanes Drechsler [Pythiaceae] root rot	Yes (CMI 1976)	Not assessed	Yes (Holliday 1980; Cother and Gilbert 1992)	Not assessed	Not assessed	No
Pythium myriotylum Drechsler [Pythiaceae] brown rot of groundnut	Yes (Liu 1977; CAB International 2010)	Not assessed	Yes (Croft 1988; Shivas 1989; CAB International 2010)	Not assessed	Not assessed	No
Pythium splendens Hans Braun [Pythiaceae]	Yes (Liu 1977; CMI 1979)	Not assessed	Yes (CMI 1979; Shivas 1989; APPD 2011)	Not assessed	Not assessed	No
Pythium vexans de Bary [Pythiaceae]	Yes (Liu 1977; CMI 1980)	Not assessed	Yes (Simmonds 1966; CMI 1980; Shivas 1989; APPD 2011)	Not assessed	Not assessed	No

Pest	Present in Malaysia	Potential to be on the pathway	Present within Australia	Potential for establishment and spread	Potential for economic consequences	Consider further in PRA
DOMAIN VIRUSES						
Pineapple mealybug wilt-associated virus [Closteroviridae: Ampelovirus] mealybug wilt of pineapple (MWP) The Malaysian DoA reference this virus as pineapple wilt (pineapple mealybug wilt) (DoA 2009). This virus is referred to as *pineapple mealybug wilt-associated virus* (PMWaV), however PMWaV is a complex of closteroviruses (PMWaV-1, PMWaV-2, PMWaV-3, PMWaV-4, PMWaV-5).	Yes (Walkman *et al.* 1995; DoA 2009) Sether and Hu (2002) have reported *pineapple mealybug wilt-associated virus-2* as the causal agent of MWP on pineapples in Malaysia.	Not assessed	Yes Widespread in eastern Australia (Pegg 1993). PMWaV-1, PMWaV-2, PMWaV-3, PMWaV-5 have been reported in QLD (Gambley *et al* 2008). Not in WA (DAWA 2005). Although DAWA (2005) states this species is not in WA, as no effective control measures are currently being exercised to prevent interstate transfer of this pathogen, the pathogen cannot be considered as a quarantine pest for WA.	Not assessed	Not assessed	No
Tomato spotted wilt virus [Bunyaviridae: Tospovirus] pineapple yellow spot virus	Yes (Green 1993; CABI/EPPO 1999b)	Not assessed	Yes (Simmonds 1966; Pegg 1993; Brunt *et al.* 1996; CABI/EPPO 1999b)	Not assessed	Not assessed	No

Appendix B Additional quarantine pest data

Quarantine pest	***Melanaspis bromiliae*** **(Leonardi, 1899)**
Synonyms	*Aspidiotus bromiliae* Newstead, 1901 *Aonidiella bromiliae* Leonardi, 1899
Common name(s)	brown pineapple scale
Main hosts	*Cocos nucifera*; *Ananas*; *Ananas comosus*; *Ananas bracteatus*; *Bromelia* spp.; *Neoglaziovia variegata*; *Pandanus* spp. (Ben-Dov *et al*. 2010).
Distribution	Azores; Bahamas; Bermuda; Brazil; Cameroon; Canary Islands; Colombia; Costa Rica; Cote d'Ivoire; Cuba; Dominican Republic; Ecuador; Federated States of Micronesia; Guam; Guatemala; Guinea; Hawaiian Islands; Honduras; India; Italy; Jamaica; Japan; Malaysia; Martinique; Mexico; Netherlands; Panama Canal Zone; Philippines; Portugal; Puerto Rico & Vieques Island; Seychelles; Singapore; South Africa; Togo and USA (Ben-Dov *et al*. 2010).
Quarantine pest	***Unaspis citri*** **Comstock, 1883**
Synonyms	*Chionaspis euonymi* Comstock, 1881 *Chionaspis citri* Comstock, 1883
Common name(s)	citrus snow scale
Main hosts	*Acacia* spp.; *Ananas* spp.; *Annona muricata*; *Chalcas exotica*; *Citrus aurantifolia*; *Citrus aurantium*; *Citrus decumana*; *Citrus deliciosa*; *Citrus grandis*; *Citrus limon*; *Citrus maxima*; *Citrus medica acida*; *Citrus nobilis*; *Citrus paradise*; *Citrus reticulate*; *Citrus sinensis*; *Cocos* spp.; *Euonymus japonicas*; *Euonymus latifolia*; *Fortunella* spp.; *Glycosmis parviflora; Hibiscus* spp.; *Inga* spp.; *Mangifera indica*; *Murraya paniculata*; *Musa* spp.; *Osmanthus* spp.; *Persea Americana*; *Pittosporum* spp.; *Poncirus* spp.; *Psidium guajava*; *Severina* spp.; *Tillandsia usneoides* (Ben-Dov *et al*. 2010).
Distribution	Algeria; American Samoa; Antigua and Barbuda; Argentina; Australia (NSW, QLD); Barbados; Benin; Bermuda; Bolivia; Brazil (Rio de Janeiro, Sao Paulo); California; Cameroon; China; Colombia; Comoros; Cuba; Dominican Republic; Ecuador; Egypt; El Salvador; Federated States of Micronesia; Fiji; Florida; Georgia; Greece; Grenada; Guinea; Hawaiian Island; Hong Kong; Indonesia; Jamaica; Japan; Kiribati; Liberia; Louisiana; Madagascar; Malaysia; Mauritius; Mexico; Mississippi; New Caledonia; New Zealand; Nigeria; Papua New Guinea; Peru; Philippines; Puerto Rico & Vieques Island; Singapore; Solomon Islands; South Africa; Taiwan; Thailand; Togo; Tonga; Uruguay; Vanuatu; Veracruz; Vietnam; Virginia; Wallis and Futuna Islands; Western Samoa; Zaire (Ben-Dov *et al*. 2010).
Quarantine pest	***Dysmicoccus neobrevipes*** **Beardsley, 1959**
Synonyms	
Common name(s)	gray pineapple mealybug
Main hosts	*Acacia farnesiana*; *Acacia koa*; *Achras zapota*; *Albizia saman*; *Agave sisalana*; *Allium cepa*; *Alpinia purpurata*; *Ananas comosus*; *Ananas sativus*; *Annona reticulate*; *Arachis hypogaea*; *Barringtonia speciosa*; *Brassica olearacea*; *Citrus aurantifolia*; *Citrus limon*; *Citrus sinensis*; *Cocos nucifera*; *Coffea* spp; *Garcinia mangostana*; *Ficus* spp.; *Lycopersicon esculentum*; *Musa* spp; *Opuntia megacantha*; *Pandanus* spp.; *Pinus* spp.; *Pipturus argentea*; *Piscidia piscipula*; *Samanea saman*; *Solanum melongena*; *Syzygium malaccensis*; *Theobroma cacao* (Ben-Dov *et al.* 2010).
Distribution	American Samoa; Antigua and Barbuda; Bahamas; Brazil; Colombia; Cook Islands; Costa Rica; Dominican Republic; Ecuador; Fiji; Guam; Guatemala; Haiti; Hawaiian Islands; Honduras; India; Italy; Jamaica; Kiribati; Malaysia; Marshall Islands; Mexico; Northern Mariana Islands; Pakistan; Panama; Peru; Philippines; Puerto Rico & Vieques Island; Sicily; Singapore; Suriname; Thailand; Trinidad and Tobago; U.S. Virgin Islands; Vietnam; Western Samoa (Ben-Dov *et al*. 2010).
Quarantine pest	***Dysmicoccus grassii*** **(Leonardi, 1913)**
Synonyms	*Pseudococcus grassii Leonardi, 1913* *Dysmicoccus alazon Williams, 1960*
Common name(s)	mealybug
Main hosts	*Acacia* spp; *Ananas comosus*; *Andrea inermis*; *Annona squamosa*; *Artocarpus spp*; *Asparagus* spp; *Carica papaya*; *Coccoloba uvifera*; *Codiaeum spp*; *Coffea arabica*; *Crescentia cujete*; *Dasylirion longissimum*; *Ficus benjamina*; *Guazuma tomentose*; *Mangifera indica*; *Melastoma* spp.; *Musa acuminata*; *Musa sapientum*; *Passiflora edulis*; *Punica granatum*; *Sechium edule*; *Tectona grandis*; *Terminalia catappa*; *Theobroma cacao* (Ben-Dov *et al.* 2010).
Distribution	Bahamas; Belize; Brazil; Canary Islands; Colombia; Costa Rica; Cuba; Dominican Republic; Haiti; Honduras; Italy; Malaysia; Mexico; Nigeria; Panama; Peru; Puerto Rico & Vieques Island; Sicily; Trinidad and Tobago (Ben-Dov *et al*. 2010).

Quarantine pest	***Planococcus minor* (Maskell, 1897)**
Synonyms	*Dactylopius calceolariae* var. *minor* Maskell 1897 *Planococcus pacificus* Cox 1981 *Pseudococcus calceolariae* var. *minor* (Maskell) *Planococcus psidii* Cox 1989 Fernald 1903 (Williams and Willink, 1992)
Common name(s)	Pacific mealybug
Main hosts	*Planococcus minor* is a significant pest of more than 250 host plants. Banana, citrus, cocoa, coffee, corn, grape, mango, potato and soybean are among the notable crops that may be affected by this pest (Venette and Davis 2004) (More information can found in Ben-Dov *et al*. 2010).
Distribution	American Samoa; Andaman Islands; Antigua and Barbuda; Argentina; Australia (NSW, NT, SA, QLD); Bangladesh; Bermuda; Brazil; British Indian Ocean Territories; Brunei; Bruma; Christmas Island; Columbia; Comoros; Cook Islands; Costa Rica; Cuba; Dominica; Fiji; French Polynesia; Galapagos Islands; Grenada; Guatemala; Guyana; Haiti; Honduras; India; Indonesia; Jamaica; Kampuchea; Kiribati; Madagascar; Malaysia; Maldives; Mauritius; Mexico;New Caledonia; Niue; Papua New Guinea; Philippines; Rodriques Island; Saint Lucia; Seychelles; Singapore; Solomon Islands; Sri Lanka; Suriname; Taiwan; Thailand; Tokelau; Tonga; Trinidad and Tobago; U.S Virgin Islands; Uruguay; Vanuatu; Vietnam; Western Samoa (Ben-Dov *et al.* 2010).
Quarantine pest	***Pseudococcus jackbeardsleyi* Gimpel & Miller 1996**
Synonyms	*Pseudococcus elisae*
Common name(s)	Jack Beardsley mealybug
Main hosts	*Acacia* spp.; *Acalypha wilkesiana*; *Acrotrema cestatum*; *Aeschynomene Americana*; *Agave* spp; *Aglaonema* spp.; *Ananas comosus*; *Annona* spp.; *Anthurium* spp.; *Aporusa aurita*; *Begonia* spp.; *Bidens bipinnata*; *Cajanus cajan*; *Cajanus indicus*; *Carica papaya*; *Cereus peruvianus*; *Coccinia grandis*; *Cocos* spp.; *Coleus* spp.; *Cordia curassavica*; *Coryphanta cubensis*; *Cucumis melo*; *Cucurbita pepo*; *Dieffenbachia* spp.; *Dracaena* spp.; *Eupatorium odoratum*; *Euphorbia* spp; *Gossypium barbadense*; *Haematoxylum campechianum*; *Heliconia* spp.; *Hibiscus cannabinus*; *Hoya carnosa* spp; *Hura crepitans*; *Ipomoea batatas*; *Jatropha curca*; *Mangifera indica*; *Manihot esculenta*; *Melocactus* spp; *Nerium oleander*; *Pelargonium* spp.; *Phaseolus limensis*; *Plumeria* spp; *Pueraria javanica*; *Rhipsalis mesembrianthemoides*; *Salvia* spp.; *Sechium edule*; *Spondias* spp.; *Tamarindus indica*; *Trichosanthes cumumesina*; *Yucca* spp.; *Hibiscus exculentus*; *Ficus decora*; *Ficus tricolor*; *Moringa oleifera*; *Musa paradasiaca*; *Musa sapientum*; *Eucalyptus* spp.; *Bougainvillea* spp.; *Dendrobium tortile*; *Mormolyca balsamina*; *Piper nigrum*; *Cymbopogon citrates*; *Zea mays*; *Macadamia* spp.; *Punica granatum*; *Coffea Arabica*; *Gardenia jasminoides*; *Citrus aurantiifolia*; *Citrus aurantium*; *Citrus paradise*; *Blighia sapida*; *Litchi chinensis*; *Nephelium lappaceum*; *Chrysophyllum cainito*; *Capsicum annuum*; *Capsicum fructescens*; *Lycopersicon esculentum*; *Physalis peruviana*; *Physalis pubescens*; *Solanum melongena*; *Solanum tuberosum*; *Melochia tomentose*; *Theobroma cacao*; *Apium graveolens*; *Lantana camara*; *Vitis* spp.; *Alpinia purpurata*; *Zingiber officinale* (Ben-Dov *et al.* 2010).
Distribution	Bahamas; Barbados; Belize; Brazil; Brunei; Canada; Colombia; Costa Rica; Cuba; Dominican Republic; El Salvador; Federated States of Micronesia; Galapagos Islands; Guatemala; Hawaiian Islands; Honduras; Indonesia; Jamaica; Malaysia; Maldives; Martinique; Mexico; Panama; Philippines ; Puerto Rico & Vieques Island; Rio; Seychelles; Singapore; Taiwan; Texas; Thailand; Trinidad and Tobago; U.S. Virgin Islands; United States of America; Venezuela; Vietnam (Ben-Dov *et al.* 2010).
Quarantine pest	***Erwinia chrysanthemi* (pineapple strain, *Dickeya* sp.,) (Burkholder *et al.* 1953)**
Synonyms	*Pectobacterium chrysanthemi* (Burkholder *et al*. 1953) Brenner *et al*. 1973 *Dickeya chrysanthemi* (Burkholder *et al*. 1953) Samson *et al.* 2005. *Dickeya* sp.
Common name(s)	Bacterial fruit collapse of pineapple, bacterial heart rot of pineapple
Main hosts	*Ananas comosus* var. *comosus*
Distribution	Brazil; Costa Rica; Malaysia; Philippines (Rohrbach and Johnson 2003) and Hawaii, USA (Kaneshiro *et al*. 2008).
Quarantine pest	***Phytophthora meadii* McRae**
Synonyms	
Common name(s)	rubber leaf drop

Main hosts	*Allium cepa*; *Acacia mearnsii*; *Ananas comosus* (pineapple); *Elettaria cardamomum* (cardamom); *Hevea brasiliensis* (rubber); *Leea coccinea* (Indian holly); *Piper nigrum* (black pepper); *Prunus persica*; *Solanum melongena* (aubergines); *Theobroma cacao* (cocoa) and *Zantedeschia aethiopica* (arum lily) (Erwin and Ribeiro 1996; Roux and Wingfield 1997; Burt 2000; Wicks 2003; PHA 2007; CAB International 2010; Farr and Rossman 2010; APC 2011; Florabank 2011; RIRDC 2011)
Distribution	China; India; Iran; Malaysia; Myanmar; Sri Lanka; Thailand; Vietnam; Hawaii; South Africa (Roux and Wingfield 1997; CAB International 2010).

Appendix C Scientific issues raised in stakeholder comments

A summary of major stakeholder issues and how they were considered in the provisional final report is given below:

Issue 1: Post-harvest chemicals not registered in Australia may be used in Malaysia.

Australian law requires that all food, including imported food, meets the food safety standards set out in the Australia New Zealand Food Standards Code. Imported foods are tested for compliance and Malaysia will have to meet these requirements.

Issue 2: The post-harvest processing regime detailed in the IRA report might not be followed.

Malaysia's Department of Agriculture will be required to demonstrate that their commercial production practices and recommended systems and/or measures are in place to achieve the required level of protection for Australia prior to export commencing.

Issue 3: The taxonomy of the bacterial heart rot and fruit collapse pathogen on pineapple is uncertain.

The draft IRA report included discussion on the taxonomy of *Erwinia chrysanthemi* (pineapple strain, *Dickeya* sp.) and additional text has been incorporated into section 4.3.1 (Introduction) to further clarify this issue. The risk assessment has been based on the most up to date information on this pathogen and its biology.

Issue 4: DAFF Biosecurity has relied on out of date research on Erwinia chrysanthemi.

Section 4.3.2 of the draft IRA report included a literature review by Lim (1986) citing research conducted in 1937. Those results were confirmed by leading experts in the field Lim & Lowings (1979) and Lim (1986) and this information was also cited in the assessment. Additional information has been included in section 4.3.2 (Probability of importation, *Likelihood of harvested fruit being infected–Latency in the fruit*) to clarify the use of this data.

Issue 5: Ongoing research into Erwinia chysanthemi (pineapple strain, Dickeya sp.) *in Hawaii has not been taken into account.*

DAFF Biosecurity has reviewed all scientific literature and stakeholder comments on the ongoing research regarding *Erwinia chysanthemi* (pineapple strain, *Dickeya sp.*) in Hawaii and has also corresponded with the Hawaiian research group working on the pathogen and has taken all information into account in the provisional final IRA report.

Issue 6: The host range for the pineapple infecting strain of Erwinia chrysanthemi (pineapple strain, Dickeya sp.) may be broader than just pineapples.

Research into this pathogen over the past sixty years has not demonstrated other hosts of this pineapple infecting strain. This includes work in Malaysia and other countries, and more recently molecular approaches. Additional discussion of this issue has been included in section 4.3.2 (Probability of distribution, *Transfer of the pest from waste to a suitable host–Availability of hosts*).

Issue 7: Flowering of pineapples is not restricted to a few days per year but is a few days, several times a year.

It is understood that flowering can be induced throughout the year to produce pineapples all year round in Queensland. Section 4.3.2 (Probability of distribution, *Transfer of the pest from waste to a* *suitable host–Host susceptibility and entry points*) in the provisional final IRA report has been amended to reflect this practice.

Issue 8: Symptoms of infection by Erwinia chrysanthemi (pineapple strain, Dickeya sp.) may not be detected during sorting and early harvest would reduce the number of fruit with visible symptoms.

Malaysia has indicated that harvest dates are generally 115–117 days after flowering but can change depending on variety and market destination. As a non-climacteric fruit, pineapples do not ripen after harvest and therefore early harvest is not considered desirable. Section 4.3.2 (Probability of importation, *Ability of the pest to survive fruit processing procedures*) has been amended to clarify that sorting and grading processes would only identify infections if latency had broken.

Issue 9: The figure of 2% for latent infection in the packing house is not scientifically valid and should not be used as the potential level of latent and visually undetectable infection could be higher.

The draft IRA report considered all available scientific literature and information for the purpose of completing the assessment. Additional text has been included in section 4.3.2 (Probability of importation, *Likelihood of harvested fruit being infected–Latency in the fruit*) to clarify and support that the observed rate of up to 2% of latent fruit infection at harvest is valid.

Issue 10: The draft IRA report did not consider waste handling by pineapple processors or that pineapple waste may be composted on peri-urban properties adjacent to pineapple farms.

Information about waste handling by pineapple processors and disposed waste as a source of infection near pineapple plants on properties has been incorporated into section 4.3.2 (Probability of distribution, *Transfer of the pest from waste to a suitable host–Inoculum source, dose and host proximity)* of the provisional final IRA report and considered in the assessment.

Issue 11: The bacterium may survive in soil/water/the environment longer than indicated in the draft risk assessment.

The draft IRA report considered survival of the bacterium in soil/water/the environment. Additional information, including information provided by stakeholders, has been included in section 4.3.2 (Probability of distribution, *Transfer of the pest from waste to a suitable host– Survival in waste and viability/ Survival in water/ Survival in soil*) to clarify this issue.

Issue 12: Possible vectors in Australia e.g. native bees and birds have not been considered in the draft risk assessment.

There is no evidence to support native bees and birds acting as agents of transfer of the pathogen from infected waste to a susceptible pineapple plant. Native bees and birds may play a greater role in the subsequent establishment and spread. Additional text has been included at section 4.3.2 (Probability of distribution, *Transfer of the pest from waste to a suitable host–Transfer mechanisms*) and section 4.3.3 (Probability of establishment, *Availability of suitable hosts, alternate hosts and vectors in the PRA area*) and section 4.3.4 (Probability of Spread, *Potential vectors of the pest*) to clarify this issue in the risk assessment.

Issue 13: Souring beetles (Carpophilus spp.) are a high risk vector.

The draft IRA report considered these vectors and additional text has been added to section 4.3.2 (Probability of distribution, *Transfer of the pest from waste to a suitable host–Transfer mechanisms*) and section 4.3.3 (Probability of establishment, *Availability of suitable hosts, alternate hosts and vectors in the PRA area*) and section 4.3.4 (Probability of Spread, *Potential vectors of the pest*) of the provisional final IRA report to explain their potential role as vectors in the distribution, establishment and spread of *Erwinia chysanthemi* (pineapple strain, *Dickeya sp*.).

Issue 14: Napthalene acetic acid is not an effective treatment for Erwinia chrysanthemi (pineapple strain, Dickeya sp.).

Naphthalene acetic acid (NAA) is not used by Malaysia as a treatment for *Erwinia chrysanthemi* (pineapple strain, *Dickeya* sp.). NAA is used for the purpose of inducing uniform flowering time for pineapples. The text in section 3.3.2 (Cultivation practices) has been amended to accurately reflect this use.

Issue 15: Growing regions are close to major population centres in Queensland.

Section 4.3.2 (Probability of distribution, *Transfer of the pest from waste to a suitable host–Host susceptibility and entry points*) of the provisional final IRA report has incorporated the information from stakeholders about proximity of major population centres to pineapple growing regions, consumer trends and household pineapple plantings into the risk assessment in the context of the transfer of the pest to a suitable host.

Issue 16: Imports of pineapples from Malaysia should be restricted until more scientific evidence to assess the risk of Erwinia chysanthemi (pineapple strain, Dickeya sp.) is known.

DAFF Biosecurity conducts risk assessments using the scientific information available at the time of assessment consistent with Australia's responsibilities and obligations under the WTO's SPS Agreement and guidelines of the IPPC. The additional information included in the provisional final IRA was sufficient to adequately assess the risk of *Erwinia chysanthemi* (pineapple strain, *Dickeya* sp.).

Appendix D Biosecurity framework

Australia's biosecurity policies

The objective of Australia's biosecurity policies and risk management measures is the prevention or control of the entry, establishment or spread of pests and diseases that could cause significant harm to people, animals, plants and other aspects of the environment.

Australia has diverse native flora and fauna and a large agricultural sector, and is relatively free from the more significant pests and diseases present in other countries. Therefore, successive Australian Governments have maintained a conservative, but not a zero-risk, approach to the management of biosecurity risks. This approach is consistent with the World Trade Organization's (WTO's) Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement).

The SPS Agreement defines the concept of an 'appropriate level of protection' (ALOP) as the level of protection deemed appropriate by a WTO Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory. Among a number of obligations, a WTO Member should take into account the objective of minimising negative trade effects in setting its ALOP.

Like many other countries, Australia expresses its ALOP in qualitative terms. Our ALOP, which reflects community expectations through Australian Government policy, is currently expressed as providing a high level of sanitary and phytosanitary protection, aimed at reducing risk to a very low level, but not to zero.

Consistent with the SPS Agreement, in conducting risk analyses Australia takes into account as relevant economic factors:

- the potential damage in terms of loss of production or sales in the event of the entry, establishment or spread of a pest or disease in the territory of Australia
- the costs of control or eradication of a pest or disease
- and the relative cost-effectiveness of alternative approaches to limiting risks.

Roles and responsibilities within Australia's quarantine system

Australia protects its human[6], animal and plant life or health through a comprehensive quarantine system that covers the quarantine continuum, from pre-border to border and post-border activities.

Pre-border, Australia participates in international standard-setting bodies, undertakes risk analyses, develops offshore quarantine arrangements where appropriate, and engages with our neighbours to counter the spread of exotic pests and diseases.

At the border, Australia screens vessels (including aircraft), people and goods entering the country to detect potential threats to Australian human, animal and plant health.

[6] The Australian Government Department of Health and Ageing is responsible for human health aspects of quarantine.

The Australian Government also undertakes targeted measures at the immediate post-border level within Australia. This includes national co-ordination of emergency responses to pest and disease incursions. The movement of goods of quarantine concern within Australia's border is the responsibility of relevant state and territory authorities, which undertake inter- and intra-state quarantine operations that reflect regional differences in pest and disease status, as a part of their wider plant and animal health responsibilities.

Roles and responsibilities within the Department

The Australian Government Department of Agriculture, Fisheries and Forestry is responsible for the Australian Government's animal and plant biosecurity policy development and the establishment of risk management measures. The Secretary of the Department is appointed as the Director of Animal and Plant Quarantine under the *Quarantine Act 1908* (the Act).

The Department takes the lead in biosecurity and quarantine policy development and the establishment and implementation of risk management measures across the biosecurity continuum, and:

- **Pre-border** conducts risk analyses, including IRAs, and develops recommendations for biosecurity policy as well as providing quarantine policy advice to the Director of Animal and Plant Quarantine
- **At the border** develops operational procedures, makes a range of quarantine decisions under the Act (including import permit decisions under delegation from the Director of Animal and Plant Quarantine) and delivers quarantine services
- **Post-border** coordinates pest and disease preparedness, emergency responses and liaison on inter- and intra-state quarantine arrangements for the Australian Government, in conjunction with Australia's state and territory governments.

Roles and responsibilities of other government agencies

State and territory governments play a vital role in the quarantine continuum. The Department works in partnership with state and territory governments to address regional differences in pest and disease status and risk within Australia, and develops appropriate sanitary and phytosanitary measures to account for those differences. Australia's partnership approach to quarantine is supported by a formal Memorandum of Understanding that provides for consultation between the Australian Government and the state and territory governments.

Depending on the nature of the good being imported or proposed for importation, DAFF Biosecurity may consult other Australian Government authorities or agencies in developing its recommendations and providing advice.

As well as a Director of Animal and Plant Quarantine, the Act provides for a Director of Human Quarantine. The Australian Government Department of Health and Ageing is responsible for human health aspects of quarantine and Australia's Chief Medical Officer within that Department holds the position of Director of Human Quarantine. DAFF Biosecurity may, where appropriate, consult with that Department on relevant matters that may have implications for human health.

The Act also requires the Director of Animal and Plant Quarantine, before making certain decisions, to request advice from the Environment Minister and to take the advice into account when making those decisions. The Australian Government Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC) is responsible under the *Environment Protection and Biodiversity Conservation Act 1999* for assessing the environmental impact associated with proposals to import live species. Anyone proposing to import such material should contact DSEWPaC directly for further information.

When undertaking risk analyses, DAFF Biosecurity consults with DSEWPaC about environmental issues and may use or refer to DSEWPaC's assessment.

Australian quarantine legislation

The Australian quarantine system is supported by Commonwealth, state and territory quarantine laws. Under the Australian Constitution, the Commonwealth Government does not have exclusive power to make laws in relation to quarantine, and as a result, Commonwealth and state quarantine laws can co-exist.

Commonwealth quarantine laws are contained in the *Quarantine Act 1908* and subordinate legislation including the Quarantine Regulations 2000, the Quarantine Proclamation 1998, the Quarantine (Cocos Islands) Proclamation 2004 and the Quarantine (Christmas Island) Proclamation 2004.

The quarantine proclamations identify goods, which cannot be imported into Australia, the Cocos Islands and or Christmas Island unless the Director of Animal and Plant Quarantine or delegate grants an import permit or unless they comply with other conditions specified in the proclamations. Section 70 of the Quarantine Proclamation 1998, section 34 of the Quarantine (Cocos Islands) Proclamation 2004 and section 34 of the Quarantine (Christmas Island) Proclamation 2004 specify the things a Director of Animal and Plant Quarantine must take into account when deciding whether to grant a permit.

In particular, a Director of Animal and Plant Quarantine (or delegate):

- must consider the level of quarantine risk if the permit were granted, and
- must consider whether, if the permit were granted, the imposition of conditions would be necessary to limit the level of quarantine risk to one that is acceptably low, and
- for a permit to import a seed of a plant that was produced by genetic manipulation, must take into account any risk assessment prepared, and any decision made, in relation to the seed under the Gene Technology Act, and
- may take into account anything else that he or she knows is relevant.

The level of quarantine risk is defined in section 5D of the *Quarantine Act 1908*. The definition is as follows:

> reference in this Act to a *level of quarantine risk* is a reference to:
>
> (a) the probability of:
>
> (i) a disease or pest being introduced, established or spread in Australia, the Cocos Islands or Christmas Island; and
>
> (ii) the disease or pest causing harm to human beings, animals, plants, other aspects of the environment, or economic activities; and
>
> (b) the probable extent of the harm.

The Quarantine Regulations 2000 were amended in 2007 to regulate keys steps of the import risk analysis process. The Regulations:

- define both a standard and an expanded IRA;
- identify certain steps, which must be included in each type of IRA;
- specify time limits for certain steps and overall timeframes for the completion of IRAs (up to 24 months for a standard IRA and up to 30 months for an expanded IRA);
- specify publication requirements;
- make provision for termination of an IRA
- allow for a partially completed risk analysis to be completed as an IRA under the Regulations.

The Regulations are available at http://www.comlaw.gov.au

International agreements and standards

The process set out in the *Import Risk Analysis Handbook 2011* is consistent with Australia's international obligations under the SPS Agreement. It also takes into account relevant international standards on risk assessment developed under the International Plant Protection Convention (IPPC) and by the World Organisation for Animal Health (OIE).

Australia bases its national risk management measures on international standards where they exist and when they achieve Australia's ALOP. Otherwise, Australia exercises its right under the SPS Agreement to apply science-based sanitary and phytosanitary measures that are not more trade restrictive than required to achieve Australia's ALOP.

Notification obligations

Under the transparency provisions of the SPS Agreement, WTO Members are required, among other things, to notify other members of proposed sanitary or phytosanitary regulations, or changes to existing regulations, that are not substantially the same as the content of an international standard and that may have a significant effect on trade of other WTO Members.

Risk analysis

Within Australia's quarantine framework, the Australian Government uses risk analyses to assist it in considering the level of quarantine risk that may be associated with the importation or proposed importation of animals, plants or other goods.

In conducting a risk analysis, DAFF Biosecurity:

- identifies the pests and diseases of quarantine concern that may be carried by the good
- assesses the likelihood that an identified pest or disease or pest would enter, establish or spread, and
- assesses the probable extent of the harm that would result.

If the assessed level of quarantine risk exceeds Australia's ALOP, DAFF Biosecurity will consider whether there are any risk management measures that will reduce quarantine risk to achieve the ALOP. If there are no risk management measures that reduce the risk to that level, trade will not be allowed.

Risk analyses may be carried out by DAFF Biosecurity's specialists, but may also involve relevant experts from state and territory agencies, the Commonwealth Scientific and Industrial Research Organisation (CSIRO), universities and industry to access the technical expertise needed for a particular analysis.

Risk analyses are conducted across a spectrum of scientific complexity and available scientific information. An IRA is a type of risk analysis with key steps regulated under the Quarantine Regulations 2000. DAFF Biosecurity's assessment of risk may also take the form of a non-regulated analysis of existing policy or technical advice. Further information on the types of risk analysis is provided in the *Import Risk Analysis Handbook 2011*.

Glossary

Term or abbreviation	Definition
Additional declaration	A statement that is required by an importing country to be entered on a phytosanitary certificate and which provides specific additional information on a consignment in relation to regulated pests (FAO 2009).
Appropriate level of protection (ALOP)	The level of protection deemed appropriate by the Member establishing a sanitary or phytosanitary measure to protect human, animal or plant life or health within its territory (WTO 1995).
Area	An officially defined country, part of a country or all or parts of several countries (FAO 2009).
Certificate	An official document which attests to the phytosanitary status of any consignment affected by phytosanitary regulations (FAO 2009).
Consignment	A quantity of plants, plant products and/or other articles being moved from one country to another and covered, when required, by a single phytosanitary certificate (a consignment may be composed of one or more commodities or lots) (FAO 2009).
Control (of a pest)	Suppression, containment or eradication of a pest population (FAO 2009).
DAFF Biosecurity	The unit responsible for recommendations for the development of Australia's biosecurity policy.
Endangered area	An area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss (FAO 2009).
Entry (of a pest)	Movement of a pest into an area where it is not yet present, or present but not widely distributed and being officially controlled (FAO 2009).
Establishment	Perpetuation, for the foreseeable future, of a pest within an area after entry (FAO 2009).
Fresh	Living; not dried, deep-frozen or otherwise conserved (FAO 2009).
Host range	Species capable, under natural conditions, of sustaining a specific pest or other organism (FAO 2009).
Import permit	Official document authorising importation of a commodity in accordance with specified phytosanitary import requirements (FAO 2009).
Import risk analysis	An administrative process through which quarantine policy is developed or reviewed, incorporating risk assessment, risk management and risk communication.
Infestation (of a commodity)	Presence in a commodity of a living pest of the plant or plant product concerned. Infestation includes infection (FAO 2009).
Inspection	Official visual examination of plants, plant products or other regulated articles to determine if pests are present and/or to determine compliance with phytosanitary regulations (FAO 2009).
Intended use	Declared purpose for which plants, plant products, or other regulated articles are imported, produced, or used (FAO 2009).
Interception (of a pest)	The detection of a pest during inspection or testing of an imported consignment (FAO 2011).
International Standard for Phytosanitary Measures (ISPM)	An international standard adopted by the Conference of the Food and Agriculture Organization, the Interim Commission on phytosanitary measures or the Commission on phytosanitary measures, established under the IPCC (FAO 2009).
Introduction	The entry of a pest resulting in its establishment (FAO 2009).
Lot	A number of units of a single commodity, identifiable by its homogeneity of composition, origin etc., forming part of a consignment (FAO 2009).
National Plant Protection Organization (NPPO)	Official service established by a government to discharge the functions specified by the IPPC (FAO 2009).
Official control	The active enforcement of mandatory phytosanitary regulations and the application of mandatory phytosanitary procedures with the objective of eradication or containment of quarantine pests or for the management of regulated non-quarantine pests (FAO 2009).
Pathway	Any means that allows the entry or spread of a pest (FAO 2009).
Pest	Any species, strain or biotype of plant, animal, or pathogenic agent injurious to plants or plant products (FAO 2009).

Term or abbreviation	Definition
Pest categorisation	The process for determining whether a pest has or has not the characteristics of a quarantine pest or those of a regulated non-quarantine pest (FAO 2009).
Pest risk analysis (PRA)	The process of evaluating biological or other scientific and economic evidence to determine whether an organism is a pest, whether it should be regulated, and the strength of any phytosanitary measures to be taken against it (FAO 2009).
Pest risk assessment (for quarantine pests)	Evaluation of the probability of the introduction and spread of a pest and of the associated potential economic consequences (FAO 2009).
Pest risk management (for quarantine pests)	Evaluation and selection of options to reduce the risk of introduction and spread of a pest (FAO 2009).
Phytosanitary certificate	Certificate patterned after the model certificates of the IPPC (FAO 2009).
Phytosanitary measure	Any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO 2009).
Phytosanitary regulation	Official rule to prevent the introduction and/or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests, including establishment of procedures for phytosanitary certification (FAO 2009).
Polyphagous	Feeding on a relatively large number of hosts from different genera.
PRA area	Area in relation to which a pest risk analysis is conducted (FAO 2009).
Quarantine pest	A pest of potential economic importance to the area endangered thereby and not yet present there, or present but not widely distributed and being officially controlled (FAO 2009).
Regulated article	Any plant, plant product, storage place, packing, conveyance, container, soil and any other organism, object or material capable of harbouring or spreading pests, deemed to require phytosanitary measures, particularly where international transportation is involved (FAO 2009).
Restricted risk	Risk estimate with phytosanitary measure(s) applied.
Spread	Expansion of the geographical distribution of a pest within an area (FAO 2009).
SPS Agreement	WTO Agreement on the Application of Sanitary and Phytosanitary Measures (WTO 1995).
Stakeholders	Government agencies, individuals, community or industry groups or organizations, whether in Australia or overseas, including the proponent/applicant for a specific proposal, who have an interest in the policy issues.
Unrestricted risk	Unrestricted risk estimates apply in the absence of risk mitigation measures.

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