



FINAL IRA REPORT

*Import Risk Analysis for the Importation of
bulk maize (Zea mays L.) from the United
States of America*



October 2002



Foreword

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The following is my determination in relation to Biosecurity Australia's policy on the importation of bulk maize (*Zea mays* L.) from the United States of America.

1. Importation of bulk maize from the USA will be permitted subject to the application of phytosanitary measures as specified in section 7 of this Final Import Risk Analysis (IRA) Report. These requirements maintain Australia's appropriate level of protection and accord with Australia's international rights and obligations under the WTO Agreement on the Application of Sanitary and Phytosanitary Measures. The import risk analysis has been conducted in accordance with *The AQIS Import Risk Analysis Process Handbook*.
2. This policy is to be applied in accordance with the *Quarantine Act 1908* and *Quarantine Proclamation 1998* as amended ('the Proclamation'). The phytosanitary measures specified in section 7 of this Final Import Risk Analysis (IRA) report are designed to limit the quarantine risk to a level, which is acceptably low, consistent with section 70 of the Proclamation.

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Disclaimer

This Import Risk Analysis was prepared on the basis of the best information available at the time of writing on the pest and disease status of the commodity in question. Information relating to the identity of the respondent and the substance of the comments received in response to the earlier draft of this document may be released to other respondents and to third parties unless a request for confidentiality was included in the response. Where a request for confidentiality was not made, a respondent will be taken to have consented to the release of information including the respondent's identity and the substance of the response for the purposes of the Information Privacy Principle 11 in section 14 of the *Privacy Act 1988*.

GLOSSARY OF TERMS AND ABBREVIATIONS

AFFA	Agriculture, Fisheries and Forestry - Australia
APHIS	Animal and Plant Health Inspection Service
AQIS	Australian Quarantine and Inspection Service
Area	an officially defined country, part of a country or all or parts of several countries
Biosecurity Australia	an agency within the Commonwealth Department of Agriculture, Fisheries and Forestry - Australia. Biosecurity Australia protects consumers and animal and plant health, and facilitates trade, by providing sound scientifically based and cost-effective quarantine policy
Control (of a pest)	suppression, containment or eradication of a pest population
DPIE	Department of Primary Industries and Energy (former name of AFFA)
Endangered area	an area where ecological factors favour the establishment of a pest whose presence in the area will result in economically important loss
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
Entry potential	likelihood of the entry of a pest
Establishment	the perpetuation, for the foreseeable future, of a pest within an area after entry
Establishment potential	likelihood of the establishment of a pest
FAO	Food and Agriculture Organization of the United Nations
FGIS	Federal Grain Inspection Service (USA)
Introduction potential	likelihood of the introduction of a pest
Introduction	entry of a pest resulting in its establishment
IPPC	International Plant Protection Convention, as deposited in 1951 with FAO in Rome and as subsequently amended
IRA	import risk analysis
ISPM	International Standard on Phytosanitary Measures
National Plant Protection organisation	official service established by a government to discharge the functions specified by IPPC
Non-quarantine pest	pest that is not a quarantine pest for an area
Official	established, authorised or performed by a National Plant Protection Organization
Official control (of a regulated pest)	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
OIE.....	International Office of Epizootics
Pathway.....	any means that allows the entry or spread of a pest
Pest.....	any species, strain or biotype of plant, animal, or pathogenic agent, injurious to plants or plant products
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
Pest free area.....	an area in which a specific pest does not occur as demonstrated by scientific evidence and in which, where appropriate, this condition is being officially maintained
Pest risk analysis.....	the process of evaluating biological or other scientific evidence to determine whether a pest should be regulated and the strength of any phytosanitary measures to be taken against it
Pest risk assessment.....	determination of whether a pest is a quarantine pest and evaluation of its introduction potential
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
Pest risk management.....	the decision-making process of reducing the risk of introduction of a quarantine pest
Pest risk management (for quarantine pests).....	evaluation and selection of options to reduce the risk of introduction and spread of a pest
Phytosanitary measure.....	any legislation, regulation or official procedure having the purpose to prevent the introduction and/or spread of quarantine pests
Phytosanitary regulation.....	official rule to prevent the introduction and/or spread of quarantine pests, by regulating the production, movement or existence of commodities or other articles, or the normal activity of persons, and by establishing schemes for phytosanitary certification
PRA.....	abbreviation for pest risk analysis
PRA area.....	area in relation to which a pest risk analysis is conducted
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
RAP.....	risk analysis panel
Regulated non- quarantine pest.....	a non-quarantine pest whose presence in plants for planting affects the intended use of those plants with an economically unacceptable impact and which is therefore regulated within the territory of the importing contracting party

Spread.....expansion of the geographical distribution of a pest within an area
Spread potential.....likelihood of the spread of a pest
SPS.....Sanitary and Phytosanitary
SPS Agreement.....WTO Agreement on the Application of Sanitary and Phytosanitary
Measures
TWG.....technical working group
USA.....United States of America
USDA.....United States Department of Agriculture
WTO.....World Trade Organization
WRA.....weed risk assessment

EXECUTIVE SUMMARY

An Import Risk Analysis (IRA) was conducted in response to an application to import bulk maize grain (*Zea mays* L.) from the United States of America (USA) for processing and use as animal feed in feedlots in Australia. This analysis was in accordance with International Standards, in particular the standard for Pest Risk Analysis (FAO 1996).

This final IRA report contains the following:

- information about Australia's biosecurity framework;
- pest risk analysis methodology;
- a summary stakeholders comments on the draft IRA; and
- details of risk management measures and quarantine conditions for the import of bulk maize from the USA.

Previous pest risk analyses have identified a number of diseases/arthropod pests and weeds of quarantine concern to Australia, and have considered risk management options. This IRA draws on previous work and new analysis to assess the risks to Australia of the proposal to import bulk maize from the USA. An evaluation of possible risk management measures is provided, with recommendations as to the measures that would be required to meet Australia's appropriate level of quarantine protection.

A number of pathogens, arthropod pests and weeds likely to be associated with bulk maize from the USA were identified. Of these, 17 pathogens, 14 arthropod pests and 80 weeds were determined to be capable of establishment in Australia via trade in bulk maize and have the potential to cause significant economic damage.

On the basis of a comparison of these phytosanitary risks with the action taken by AQIS on other imported commodities (e.g. other bulk commodities and seed for sowing) and the risks of entry via other pathways the RAP considers that the unrestricted import of bulk maize from the USA would not be consistent with Australia's appropriate level of protection.

Phytosanitary measures to meet Australia's appropriate level of protection against pests associated with maize from the USA were examined.

It was determined that any treatment, for which it was demonstrated to a high degree of certainty that maize was devitalised and pests destroyed, could achieve Australia's appropriate level of protection. At this time, steam heat treatment is a feasible option; however irradiation and infrared heat treatment are examples of other treatments that should be capable of achieving the desired level of phytosanitary protection for Australia. Offshore treatment of bulk maize using an approved method would be acceptable provided effective measures were taken to prevent post-treatment re-infection, re-infestation or contamination of the shipment.

Anyone who is of the opinion that the process outlined in *The AQIS Import Risk Analysis Process handbook* has not been properly followed, including that the risk analysis failed to consider a significant body of relevant scientific or technical information, may lodge an appeal to the Director of Animal and Plant Quarantine within 30 days of the release of this report.

1 BIOSECURITY FRAMEWORK

1.1 Biosecurity in Australia

1.1.1 Legislative framework

Agriculture Fisheries and Forestry - Australia's (AFFA) objective is to adopt biosecurity policies that provide the health safeguards required by government policy in the least trade-restrictive way and that are, where appropriate, based on international standards. In developing and reviewing quarantine (or biosecurity) policies, pest risks associated with importations may be analysed using import risk analysis — a structured, transparent and science-based process.

The *Quarantine Act* and its subordinate legislation, including the *Quarantine Proclamation 1998* (QP 1998), are the legislative basis of human, animal and plant biosecurity in Australia. The *Quarantine Amendment Act 1999*, which commenced in June/July 2000, incorporates major changes to the *Quarantine Act* as recommended in the report of the Australian Quarantine Review Committee (AQRC, 1996).

Section 4 of the *Quarantine Act* defines the scope of quarantine as follows:

In this Act, quarantine includes, but is not limited to, measures:

- *for, or in relation to, the examination, exclusion, detention, observation, segregation, isolation, protection, treatment and regulation of vessels, installations, human beings, animals, plants or other goods or things*
- *having as their object the prevention or control of the introduction, establishment or spread of diseases or pests that will or could cause significant damage to human beings, animals, plants, other aspects of the environment or economic activities*

Quarantine Risk

The concept of level of quarantine (or biosecurity) risk has been introduced as the basis of quarantine decision-making. When making decisions under the *Quarantine Act*, decision-makers must consider the level of quarantine risk and must take prescribed actions to manage the risk if it is unacceptably high. Section 5D of the *Quarantine Act* includes harm to the environment as a component of the level of quarantine risk.

Section 5D: level of quarantine risk

A 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 or the Cocos Islands; 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.*

Quarantine Proclamation

Subsection 13(1) of the *Quarantine Act* provides that the Governor-General in Executive Council may, by proclamation, prohibit the importation into Australia of any articles or things likely to introduce, establish or spread any disease or pest affecting people, animals or plants. The Governor-General may apply this power of prohibition generally or subject to any specified conditions or restrictions.

QP 1998 is the principal legal instrument used to control the importation into Australia of goods of quarantine (or biosecurity) interest. A wide range of goods is specified in *QP 1998* including animals, plants, animal and plant products, micro-organisms, and certain other goods, which carry a high risk if uncontrolled importation is allowed — e.g. soil, water, vaccines, feeds.

For articles or things prohibited by proclamation, the Director of Animal and Plant Quarantine may permit entry of products on an unrestricted basis or subject to compliance with conditions, which are normally specified on a permit. An import risk analysis provides the scientific and technical basis for biosecurity policies that determine whether an import may be permitted and, if so, the conditions to be applied.

The matters to be considered when deciding whether to issue a permit are set out in Section 70 of *QP 1998* as follows:

70 *Things a Director of Quarantine must take into account when deciding whether to grant a permit for importation into Australia*

(1) *In deciding whether to grant a permit to import a thing into Australia or the Cocos Islands, or for the removal of a thing from the Protected Zone or the Torres Strait Special Quarantine Zone to the rest of Australia, a Director of Quarantine:*

- (a) *must consider the level of quarantine risk if the permit were granted; and*
- (b) *must consider whether, if the permit were granted, the imposition of conditions on it would be necessary to limit the level of quarantine risk to one that is acceptably low; and*
- (c) *may take into account anything else that he or she knows that is relevant.*

The matters include the level of quarantine risk (see above), whether the imposition of conditions would be necessary to limit the quarantine risk to a level that would be acceptably low, and anything else known to the decision maker to be relevant.

Environment

While protection of the natural and built environment has always been an objective of Australian quarantine policy and practice, recent amendments to the *Quarantine Act 1908* make explicit the responsibility of quarantine officers to consider impact on the environment when making decisions. In particular, the scope of quarantine (as described in Section 4 of the *Quarantine Act*), and the level of quarantine risk (as described in Section 5D of the *Quarantine Act*), includes explicit reference to the environment.

Environment is defined in Section 5 of the *Quarantine Act* as:

... all aspects of the surroundings of human beings, whether natural surroundings or surroundings created by human beings themselves, and whether affecting them as individuals or in social groupings.

When undertaking an import risk analysis, Biosecurity Australia fully takes into account the risk of harm to the environment to ensure that the biosecurity policies developed reflect the Australian Government's approach to risk management. This is achieved through the involvement of Environment Australia in decisions on the import risk analysis work program and, for particular import risk analyses, discussions on the scope, the likely risks, and the expertise, which may be required to address those risks. Environment Australia may identify additional technical issues that it believes should be considered during an import risk analysis, and may nominate officers with relevant expertise who would be available to participate in the import risk analysis.

1.1.2 Policy framework

The primary purpose of biosecurity is to protect Australia from the entry, establishment or spread of unwanted pests and diseases that may cause social, economic or environmental damage, while minimising the restrictions on the entry of agricultural commodities.

Due to Australia's unique and diverse flora and fauna and the value of its agricultural industries, successive Australian Governments have maintained a highly conservative but not a zero-risk approach to the management of biosecurity risks. This approach is evident in the strictness of all biosecurity-related activities, including policies on imported commodities, procedures at the border and operations against incursions of pests and diseases.

Recent inquiries into Australia's biosecurity regime have recognised that it is impossible in practice to operate a zero-risk biosecurity regime. In 1979, the Senate Standing Committee on Natural Resources stressed that there is no such thing as a zero-risk quarantine policy, and it believed that Australia's approach should be better described as '*scientific evaluation of acceptable risk*'. In 1988, the Lindsay review of Australian quarantine concluded that '*a no risk policy is untenable and undesirable and should be formally rejected*'. In 1996, the Senate Rural and Regional Affairs and Transport Committee was of the view that a zero-risk approach was unrealistic and untenable, and that its currency only demonstrated that the concepts of risk assessment and risk management were widely misunderstood. These themes were repeated in the AQRC report. In its 1997 response to that report, the Government confirmed a managed risk approach.

Import risk analysis provides the basis for considering import applications for the importation of animals and animal-derived products, and plants and plant-derived products. In keeping with the scope of the *Quarantine Act* and Australia's international obligations, only factors relevant to the evaluation of quarantine risk (i.e. the risk associated with the entry, establishment or spread of unwanted pests and diseases) are considered in the import risk analysis. The potential competitive economic impact of prospective imports is not within the scope of the import risk analysis process, and any discussion on industry support mechanisms would need to remain quite separate from the import risk analysis.

1.2 WTO and Import Risk Analysis

One of the principal objectives in developing the administrative framework outlined for import risk analysis was to ensure that it complied with Australia's international rights and obligations.

These derive principally from the *WTO Agreement on the application of Sanitary and Phytosanitary Measures (SPS Agreement)*, although other WTO Agreements (including the *Agreement on Technical Barriers to Trade - the TBT Agreement*) may be relevant in certain circumstances. Specific international guidelines on risk analysis developed under IPPC and by International Office of Epizootics (OIE) are also relevant.

The *SPS Agreement* applies to measures designed to protect human, animal and plant life and health from pests and diseases, or a country from pests, and which may directly or indirectly affect international trade. It also recognises the right of WTO Member countries to determine the level of protection they deem appropriate and to take the necessary measures to achieve that protection. Sanitary (human and animal health) and phytosanitary (plant health) measures apply to trade in or movement of animal and plant based products within or between countries.

In the *SPS Agreement*, SPS measures are defined as any measures applied:

- *to protect animal or plant life or health within the territory of the Member from risks arising from the entry, establishment or spread of pests, diseases, disease-carrying organisms or disease-causing organisms;*
- *to protect human or animal life or health within the territory of the Member from risks arising from additives, contaminants, toxins or disease-causing organisms in foods, beverages or feed-stuffs;*
- *to protect human life or health within the territory of the Member from risks arising from diseases carried by animals, plants or products thereof, or from the entry, establishment or spread of pests; or*
- *to prevent or limit other damage within the territory of the Member from the entry, establishment or spread of pests*

The key provisions of the *SPS Agreement* are as follows:

- An importing country has the sovereign right to adopt measures to achieve the level of protection it deems appropriate (its appropriate level of protection, or ALOP) to protect human or animal life or health within its territory, but such a level of protection must be consistently applied in different situations.
- An SPS measure must be based on scientific principles and not be maintained without sufficient evidence.
- In applying SPS measures, an importing country must avoid arbitrary or unjustifiable distinctions in levels of protection, if such distinctions result in discrimination or a disguised restriction on international trade.
- An SPS measure must not be more trade restrictive than necessary to achieve an importing country's ALOP, taking into account technical and economic feasibility.

- An SPS measure should be based on an international standard, guideline or recommendation, where these exist, except to the extent that there is scientific justification for a more stringent measure which is necessary to achieve an importing country's ALOP.
- An SPS measure conforming to an international standard, guideline or recommendation is presumed to be necessary protect human, animal or plant life or health, and to be consistent with the *SPS Agreement*.
- Where an international standard, guideline or recommendation does not exist or where, in order to meet an importing country's ALOP, a measure needs to provide a higher level of protection than accorded by the relevant international standard, such a measure must be based on a risk assessment; the risk assessment must take into account available scientific evidence and relevant economic factors.
- When there is insufficient scientific evidence to complete a risk assessment, an importing country may adopt a provisional measure(s) by taking into account available pertinent information; additional information must be sought to allow a more objective assessment and the measure(s) reviewed within a reasonable period.
- An importing country must recognise the measures of other countries as equivalent, if it is objectively demonstrated that the measures meet the importing country's ALOP.

The rights and obligations in the *SPS Agreement* must be read as a whole. The articles must be interpreted in relation to each other. That is, the articles do not stand-alone.

In many instances, the biosecurity policies Biosecurity Australia develops are based on the relevant international standards, guidelines and recommendations. In certain instances and in conformity with rights under the *SPS Agreement*, Australia has not adopted such international norms because to do so would result in an unacceptably high level of risk of disease or pest entry and establishment. Instead, the policies are based on a risk analysis.

The text of the *SPS Agreement* can be found at the WTO Internet site.¹

The following issues are discussed in greater detail:

- notification obligations;
- use of international standards;
- equivalence;
- risk assessment;
- appropriate level of protection (ALOP); and
- consistency in risk management.

1.2.1 Notification obligations

The WTO SPS Committee has been established to oversee the implementation of the *SPS Agreement*, and to provide a forum for the discussion of any trade issues related to biosecurity policies. Like other WTO committees, all WTO Members have the right to participate in the work and decision making of the SPS Committee; decisions are taken by consensus. The SPS Committee has accepted, as observers, the Codex Alimentarius Commission (Codex), OIE

¹ Available at http://www.wto.org/english/docs_e/docs_e.htm

and IPPC, as well as other international and regional intergovernmental organisations with activities in food safety, animal health and plant protection to maximise knowledge of and participation in its work.

The SPS Committee normally meets three times a year at the WTO headquarters in Geneva, Switzerland.

In addition to considering any specific trade concerns raised by governments, the *SPS Agreement* has set specific tasks for the Committee. One of these is to monitor the extent to which governments are using internationally developed standards as the basis for their requirements for imported products. Countries identify cases where the non-use, or non-existence, of an appropriate international standard is causing difficulties for international trade. After consideration by the SPS Committee, these concerns may be brought to the attention of the relevant standard-setting organisations.

Under the *SPS Agreement*, Members are required to notify WTO of new sanitary or phytosanitary regulations or modifications to existing regulations that are not substantially the same as the content of an international standard and that may have a significant effect on international trade. Australia notifies new measures and comments on draft policies proposed by other countries through the SPS Notification Point in AFFA.

1.2.2 Use of international standards

The *SPS Agreement* has conferred special status on three international organisations by requiring WTO Members to harmonise their sanitary and phytosanitary measures on the standards, guidelines and recommendations produced by those organisations unless there is scientific justification for a more stringent measure.

The three international organisations are referenced in Annex A of the *SPS Agreement* as follows:

- for food safety, the standards, guidelines and recommendations established by the Codex Alimentarius Commission relating to food additives, veterinary drug and pesticide residues, contaminants, methods of analysis and sampling, and codes and guidelines of hygienic practice;
- for animal health and zoonoses, the standards, guidelines and recommendations developed under the auspices of the International Office of Epizootics; and
- for plant health, the international standards, guidelines and recommendations developed under the auspices of the Secretariat of the International Plant Protection Convention in co-operation with regional organizations operating within the framework of the International Plant Protection Convention.

International Plant Protection Convention

IPPC is a multilateral treaty deposited with the Director-General of the Food and Agriculture Organization of the United Nations. IPPC provides a framework and forum for international co-operation, standards harmonisation and information exchange on plant health in collaboration with regional and national plant protection organisations (RPPOs and NPPOs).

Its prime purpose is to secure common and effective action to prevent the spread and introduction of pests of plants and plant products and to promote measures for their control.

Currently, 117 governments are contracting parties to IPPC.

The New Revised Text of IPPC enabled the establishment of an Interim Commission on Phytosanitary Measures to serve as IPPC's new governing body. Membership in the Interim Commission is open to all contracting parties of IPPC. The Interim Commission meets annually to establish priorities for standard setting and harmonisation of phytosanitary measures in co-ordination with the IPPC Secretariat.

The functions of the Interim Commission are to provide direction to the work program of the IPPC Secretariat and promote the full implementation of the objectives of the Convention and, in particular, to:

- review the state of plant protection in the world and the need for action to control the international spread of pests and control their introduction into endangered areas;
- establish and keep under review the necessary institutional arrangements and procedures for the development and adoption of international standards, and to adopt international standards;
- establish rules and procedures for the resolution of disputes; and
- co-operate with other relevant international organisations.

The new IPPC and ISPM No 11 (*Pest Risk Analysis for Quarantine pests*) adopt a similar approach to that of OIE and note the importance of documenting all steps in the risk analysis process.

1.2.3 Equivalence

Article 4 of the *SPS Agreement* states that:

Members shall accept the sanitary or phytosanitary measures of other Members as equivalent, even if these measures differ from their own or from those used by other Members trading in the same product, if the exporting Member objectively demonstrates to the importing Member that its measures achieve the importing Member's appropriate level of sanitary or phytosanitary protection.

Members must accept the SPS measures of other Members, as equivalent to their own if the latter can demonstrate objectively that their measures provide the level of protection required by the importing country.

Article 5.6 of the *SPS Agreement* states that:

Often there are several alternative measures that may either singly or in combination achieve the ALOP. In choosing among such alternatives, a Member should apply measures that are not more trade-restrictive than necessary to achieve its ALOP, taking into account technical and economic feasibility.

1.2.4 Risk assessment

Articles 5.1 to 5.3 of the *SPS Agreement* outline the requirements that Members should follow when carrying out risk assessment.

Article 5.1 provides a basic statement of the obligation:

Members shall ensure that their sanitary or phytosanitary measures are based on an assessment, as appropriate to the circumstances, of the risks to human, animal or plant life or health, taking into account risk assessment techniques developed by the relevant international organisations.

Annex A of the *SPS Agreement* contains two definitions of risk assessment; the following is the definition applicable to biosecurity assessments:

The evaluation of the likelihood of entry, establishment or spread of a pest or disease within the territory of an importing Member according to the sanitary or phytosanitary measures which might be applied, and of the associated potential biological and economic consequences.

On the basis of this definition, the Appellate Body examining Australia's appeal against the dispute settlement panel's finding on Australia's prohibition of imports of Canadian salmon considered that a risk assessment within the meaning of Article 5.1 must:

- identify the hazards whose entry, establishment or spread within its territory a Member wants to prevent, as well as the associated potential biological and economic consequences;
- evaluate the likelihood of entry, establishment or spread of these hazards, as well as the associated potential biological and economic consequences; and
- evaluate the likelihood of entry, establishment or spread of these hazards according to the SPS measures that might be applied; measures which might be applied are those which reduce the risks to the appropriate level, with the aim of being least trade restrictive.

The Appellate Body believed that, for a risk assessment to fall within the meaning of Article 5.1 and the first definition in paragraph 4 of Annex A of the Agreement, it is not sufficient that it conclude that there is a 'possibility' of entry, establishment or spread of pests and their associated biological and economic consequences. That is, an assessment must evaluate the 'likelihood' (the 'probability') of entry, establishment or spread of diseases and their associated biological and economic consequences. Furthermore, likelihood should be evaluated without and then with any SPS measures that might be required.

Article 5.2 outlines factors that should be considered when assessing the risks associated with a proposed importation. Specifically, it states that:

In the assessment of risks Members shall take into account available scientific evidence; relevant processes and production methods; relevant inspection, sampling and testing methods; prevalence of specific diseases or pests; existence of pest- or disease-free areas; relevant ecological or environmental conditions; and quarantine or other treatment.

This paragraph emphasises the need to consider a wide range of factors in both the importing and exporting country.

Article 5.3 describes the need to include a consequence assessment in a risk assessment, and lists dimensions that should be considered when assessing ‘potential damage’ arising from a disease or pest incursion. Specifically, it states that:

Members shall take 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; the cost of control or eradication in the territory of the importing Member.

This list of ‘relevant economic factors’ may be viewed as the bare minimum that must be considered if an analysis is to comply with the terms of the *SPS Agreement*. In addition, both the *OIE Code* and IPPC standards for risk analysis have outlined factors that should be considered when assessing consequences. These two standards also stress the need to consider the ‘likely magnitude’ of consequences — that is, to base an assessment of consequences on the likelihood of various levels of damage in the importing country. Finally, Article 5.3 states that Members should consider ‘... *the relative cost-effectiveness of alternative approaches to limiting risks* ...’. This is an issue that should be explored during risk management. Among factors that may not be taken into account are those relating to import competition.

The environmental and ecological consequences of pest or disease introduction are legitimate considerations in a risk assessment. The *SPS Agreement* provides a basic right to take measures to protect animal or plant life or health (Article 2). In Annex A, ‘animal’ is defined to include fish and wild fauna; and ‘plant’ to include forests and wild flora.

Additional to the economic factors identified in Article 5.3, the definition of risk assessment in Annex A, paragraph 4 (‘... *evaluation of the likelihood of entry, establishment or spread of a pest or disease ... and of the associated potential biological and economic consequences* ...’) provides for general consideration of the biological consequences, including to the environment. The environment is included in paragraph 1(d), which states that an SPS measure is one that is applied to “ ... *prevent or limit other damage to a country from the entry, establishment or spread of pests* ...”.

1.2.5 Appropriate level of protection

The *SPS Agreement* defines ‘*appropriate level of sanitary or phytosanitary protection*’ as 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. The *SPS Agreement* notes that many Members also refer to this concept as the ‘*acceptable level of risk*’. In setting their ALOP, Members are to take into account the objective of minimising negative trade effects (Article 5.4).

Determination of Australia’s ALOP is an issue for government in consultation with the community — it is not a prerogative of WTO. ALOP reflects government policy that is affected by community expectations; it is a societal value judgement to which AFFA contributes by providing technical information and advice. It is important to note that the *SPS Agreement* does not require a Member to have a scientific basis for its ALOP determination.

ALOP can be illustrated using a *risk estimation matrix* (Table 1). The cells of this matrix describe the product of likelihood and consequences — termed ‘risk’.

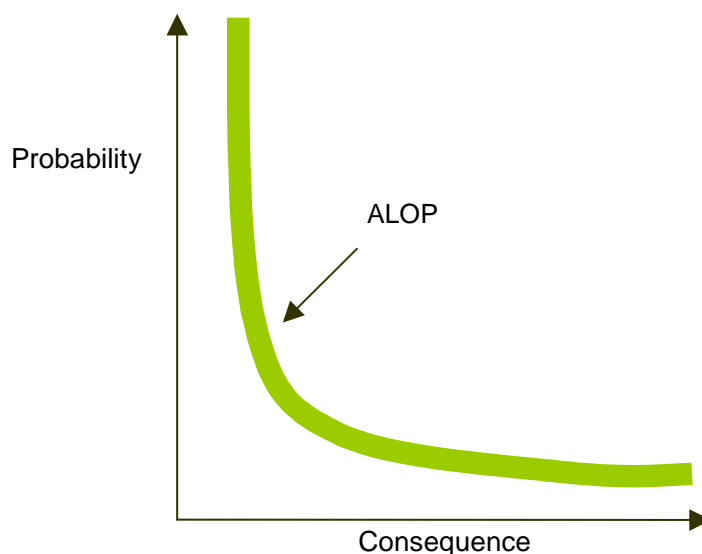
When interpreting the risk estimation matrix it should be remembered that the descriptors for each axis are similar (‘low’, ‘moderate’, ‘high’, etc), the vertical axis refers to *likelihood* and the horizontal axis refers to *consequences*.

One implication of this is that a ‘negligible’ probability combined with ‘extreme’ consequences, is not the same as an ‘extreme’ probability combined with ‘negligible’ consequences - that is, that the matrix is *not symmetrical*. Another implication is that ‘risk’ is expressed in the same units as are used to estimate consequences – that is, risk is *not* a likelihood.

Table 1: Risk estimation matrix

Likelihood of entry, establishment and spread	<i>High likelihood</i>	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
	<i>Moderate</i>	Negligible risk	Very low risk	Low risk	Moderate risk	High risk	Extreme risk
	<i>Low</i>	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk	High risk
	<i>Very low</i>	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk	Moderate risk
	<i>Extremely low</i>	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk	Low risk
	<i>Negligible likelihood</i>	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Negligible risk	Very low risk
		<i>Negligible impact</i>	<i>Very low</i>	<i>Low</i>	<i>Moderate</i>	<i>High</i>	<i>Extreme impact</i>
Consequences of entry, establishment and spread							

The band of cells in Table 1 marked ‘very low risk’ represents Australia's ALOP, or tolerance of loss. This band of cells represents an approximation of a continuous ‘iso-risk curve’ — a curve that will be asymptotic at the minimum level of consequences considered to be ‘acceptable’ (which, in Australia's case, is ‘very low’) and at a likelihood that tends toward zero. The principle of an iso-risk curve is illustrated in Figure 1.

Figure 1: Theoretical iso-risk curve

1.2.6 Consistency in risk management

Article 5.5 states:

With the objective of achieving consistency in the application of the concept of appropriate level of sanitary or phytosanitary protection against risks to human life or health, or to animal and plant life or health, each Member shall avoid arbitrary or unjustifiable distinctions in the levels it considers to be appropriate in different situations, if such distinctions result in discrimination or a disguised restriction on international trade

Members are obliged to avoid arbitrary or unjustifiable distinctions in the levels of protection applied in different situations, if such distinctions result in discrimination or a disguised restriction on international trade. This obligation reflects the objective of consistency in applying the concept of ALOP against risks to human, animal and plant life or health — that is, consistency in risk management. In other words, it is not open to a Member to arbitrarily vary its attitude to the acceptance of risk from one situation to another, where the situations are comparable.

Consistency in risk management is achieved in Biosecurity Australia's IRA process by using the risk estimation matrix (Table 1).

2 BACKGROUND TO THE BULK MAIZE IRA

The Australian Quarantine and Inspection Service (AQIS) received an application in June 1997 for permission to import bulk maize from “low risk areas of the USA” to Australia. The application specified that the imported maize was for direct delivery through conventional transport systems, without further AQIS intervention, to feedlots located inland for processing and use as animal feed.

Previous pest risk analyses (section 8.1) have identified a number of diseases/arthropod pests and weeds of quarantine concern to Australia, and have considered risk management options. This IRA draws on previous work and new analysis to assess the risks to Australia of the proposal to import bulk maize from the USA. An evaluation of possible risk management measures is provided, with recommendations on managing as to the measures that would be required to meet Australia’s appropriate level of quarantine protection.

AQIS wrote to stakeholders on 19 August 1997 and 5 September 1997 advising them that a request to import maize had been received and subsequently proposed that the non-routine process be used.

The Grains Council of Australia (GCA) considered that the priority given to the request was a valid issue for stakeholder consultation and appealed to the Director of Quarantine. The appeal was dismissed.

The non-routine process, involved the establishment of a risk analysis panel (RAP).

Timeline of major events

15 June 1998

RAP met for the first time, and decided on membership of technical working groups (TWGs).

6 July 1998

The RAP prepared and released an issues paper for stakeholders comment. The issues paper outlined the membership of technical working groups, provided information on the risk analysis process and provided technical information on the quarantine concerns that were identified in earlier risk analysis work.

23 July 1998

Workshop held for stakeholders to discuss the risk analysis process and to meet the RAP.

27 November 1998

RAP held a meeting to consider the draft reports submitted by technical working groups. Originally due for release in mid December 1998, the draft IRA was delayed to enable the RAP to consider a United States Department of Agriculture (USDA) Plant Health Inspection Service (APHIS) response to a number of technical questions raised by the TWGs. This response was received on 15 December 1998.

19 March 1999

Draft IRA for the importation of bulk maize from the USA was released for a 60-day consultation period. This document covered technical issues related to pest risk, risk

management options and a preliminary view on which option would achieve Australia's appropriate level of protection. The World Trade Organisation (WTO) was also notified of the release of this document.

Since release of the draft IRA in March 1999, RAP considered additional technical information provided by a number of stakeholders. The panel held a teleconference with Professor Denis McGee, a US maize expert who provided comments on behalf of ALFA to discuss technical concerns. The panel met with ALFA on 12 November 1999 to ensure that all relevant technical concerns had been discussed at the teleconference.

30 August 2000

After considering all technical issues and other comments received, the RAP released a revised draft in order that those stakeholders who provided comments could confirm that the issues raised had been addressed.

Changes to the internal structure of the Department of Agriculture, Fisheries and Forestry - Australia (AFFA) resulted in the formation of Biosecurity Australia on 6 October 2000. Biosecurity Australia is responsible for the IRA function that was formerly the responsibility of AQIS.

2.1 Administration

2.1.1 Scope

The scope of this analysis, as requested by the proponent, is to assess the phytosanitary risks associated with the importation of bulk maize originating from the USA and to examine means to manage all significant phytosanitary risks by measures applied (as necessary) outside Australia. The imported grain would be transported on arrival in Australia to rural areas for processing and use as animal feed with no further controls by AQIS once it leaves the port area. The hazards considered include spillage during transport into rural areas and during storage and handling at feedlots prior to processing.

In the USA, corn is defined as "Grain that consists of 50 percent or more of whole kernels of shelled dent corn and/or shelled flint corn (*Zea mays* L.) and may contain not more than 10.0 percent of other grains under Federal Grain Inspection Service (FGIS) standards, established under the United States Grain Standards Act". This definition establishes a minimum specification but there are a range of specific grades defined by FGIS. For example, the maximum percentage foreign matter that can be present ranges from 2% in US Grade 1 to 7% in US Grade 5. The grade standards also specify the allowable limits of damaged kernels. The foreign material content has clear implications for the presence of other seed-borne pathogens on grain admixture and makes the overall assessment of risk difficult. Damaged grain may also be of quarantine relevance depending on the reason for damage, which can include disease and other pest damage with implications for phytosanitary risk.

The potential volume of imports is not known, but for the purposes of the IRA it was assumed to be at least tens of thousands of tonnes per shipment, in contrast to imports of maize seed for sowing that would normally be less than 100 tonnes per year. In the light of experience gained from importations of maize in 1995, other factors that require consideration include soil, trash, weed seeds and admixtures of other grains (eg. barley, oats, millet, sorghum,

soybean, wheat, rice, beans, sunflower, peanut, linseed and chickpea) that could be present in substantial quantities in bulk maize imports.

There are existing arrangements for the importation of bulk grain for processing at the port of entry, or at approved premises in metropolitan areas. Approvals have included:

- steam heat treatment of whole grain at the port of entry to devitalise grain and any associated pests prior to transport to rural feedlots for use as animal feed;
- steam pelleting at approved premises in metropolitan areas for stock feed manufacture;
- destructive processing for extraction of amylopectin starch for industrial purposes; and
- processing for manufacture into products such as corn chips.

Subject to the existence of approved facilities and the ability to meet general quarantine conditions, AQIS will continue to approve applications to import maize for metropolitan processing on a case-by-case basis.

Processing of imported bulk grain at the port of entry is outside the scope of the request submitted to AFFA. Information relating to these existing arrangements has been considered in this risk analysis but not in detail.

A number of non-phytosanitary issues relevant to the importation of maize fall outside the scope of the risk analysis and have not been addressed. Examples include pesticide residues or the potential economic impact of competition on domestic producers from the importation of bulk maize grain. These issues are not relevant to the quarantine decision-making process but may be addressed, if necessary, by other areas of the Department of Agriculture, Fisheries and Forestry -Australia (AFFA).

2.1.2 Risk Analysis Panel

In accordance with the non-routine import risk analysis process described in *The AQIS Import Risk Analysis Process Handbook*, a risk analysis panel was established.

The RAP membership was:

Dr Bill Roberts (Chair)	Chief Plant Protection Officer, AFFA
Dr Bob Ikin	Private Consultant (Formerly Senior Manager, Plant Quarantine Policy Branch, Policy and International Division)
Mr Bill Magee	Senior Manager, Plant Biosecurity, Biosecurity Australia, AFFA
Mr Mev Connell	Private Consultant (formerly: member of the Advisory Committee to the Commonwealth Scientific and Industrial Research Organisation (CSIRO) Division of Entomology; Chief Executive Officer, Grain Elevators Board of Victoria; Director, Australian Wheat Board; Assistant General Manager, Australian Wheat Board)
Professor John Irwin	Professor and CEO, Cooperative Research Centre for Tropical Plant Protection, The University of Queensland

Technical Working Groups

The RAP established four Technical Working Groups (TWGs) to examine issues relevant to the risk analysis. A RAP member chaired each TWG. The TWGs considered specific aspects of the IRA as described below.

1. **Pathogen TWG:** Analysis of quarantine pathogens and nematodes likely to be associated with imports of bulk maize grain and assessment of the key disease risks associated with contamination of bulk maize shipments with seeds of other agricultural plant species such as barley, oat, millet, sorghum, soybean and wheat.
2. **Arthropod TWG:** Analysis of insect and mite pests potentially present in the bulk grain pathway (principally stored maize grain) in North America (Canada, USA and Mexico). This TWG also considered molluscs that might be associated with maize from the USA.
3. **Weeds TWG:** Analysis of quarantine weeds associated with proposed imports of bulk maize grain and consideration of different genotypes within species of common weeds already present in Australia. Herbicide resistant strains of weed species were included as potential quarantine pests.
4. **Operations TWG:** Analysis of operational issues relevant to the importation of bulk maize grain from the USA, including risk management options consistent with Australian Government policy, the SPS Agreement and relevant International Standards, and operational procedures for implementation of management options recommended by the other TWGs.

Each TWG was given terms of reference outlined by the RAP and was asked to submit findings in the form of a technical report. The RAP drew upon these reports and discussions with the TWG in producing this draft IRA.

Details of the membership and terms of reference of TWGs are given in Appendix - 3.

The TWG technical reports contain specific details of pests and diseases, both quarantine and non-regulated (non-quarantine), associated with the proposed importation of bulk maize sourced from the USA.

The TWGs were asked to draw upon all available information including international scientific literature and technical abstracts. The United States Department of Agriculture Animal and Plant Health Inspection Service (USDA/APHIS) was asked to comment on a number of issues identified by the TWGs. Although the USDA response was received after the TWG reports were finalised, the RAP considered the response in consultation with relevant TWG members. The RAP considered that the information provided by USDA was consistent with, and did not substantially alter, the findings of the TWG reports. Information provided by USDA is discussed, where appropriate, in this report. TWG members were also given an opportunity to consider stakeholder comment on the draft IRA. The RAP members who chaired each of the TWGs coordinated this discussion and reported back to the RAP.

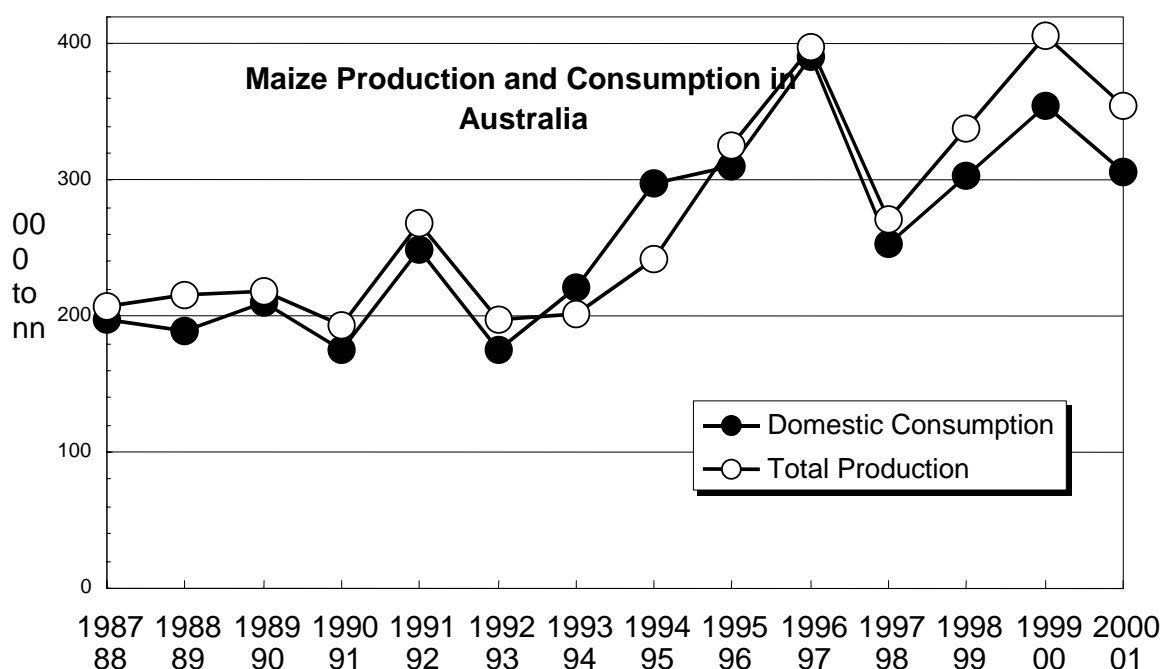
2.2 Australia's Current Quarantine Policy for Imports of Maize

Australia's current legislation prohibits the importation of maize seed and grain except in the circumstances where AQIS issues import permits that may specify phytosanitary measures to

effectively manage quarantine risks (Quarantine Proclamation 1998 made under the Quarantine Act 1908). Imports of maize seed for sowing include the requirement to grow imported seed in quarantine for one generation with release of progeny after disease screening. Bulk maize imports are currently permitted for processing in metropolitan areas at approved premises under quarantine supervision.

2.3 The Maize Industry in Australia

Maize is the second most important crop in the world in terms of total food production. It is the most widely distributed cereal crop in the tropics and is important in the Americas, Africa and Asia. Most of the maize produced in temperate areas is used for livestock feed and industrial products. Maize production in Australia is concentrated in New South Wales and Queensland, with smaller amounts produced in Western Australia and Victoria. Most of the maize produced in Australia is consumed domestically. Details of production and consumption are shown in the following figure.



Source: Australian Commodity Statistics, 2001. Australian Bureau of Agricultural and Resource Economics, Canberra.

Production has exceeded domestic consumption by an average of 10,000 tonnes per year over the ten years to 1997/98. Maize is a preferred feed grain for some intensive livestock industries and there has been significant interest in the importation of bulk maize from overseas, particularly in years when local supplies have been restricted by drought.

2.4 Stakeholder Comment on the Draft IRA

The draft IRA and revised draft IRA were sent to 393 stakeholders. Twenty-one sets of written comments were received on the draft IRA and a further six written comments were received on the revised draft (Appendix - 1). Nine stakeholders (three State Government departments, five industry groups and one private consultant) supported the position taken in

the draft IRA. Eleven stakeholders (all industry groups) did not support the position taken. The USDA provided technical comment and indicated that the proposed conditions for import may be impractical and uneconomic. Comments on the revised draft raised minor technical issues but did not challenge the outcome. The proponent, in correspondence received after close of the comment period, expressed dissatisfaction with the outcome.

Specialist technical reports commissioned by some stakeholders were included in their submissions. Professor Denis McGee and Dr Barry Jacobsen, based in the USA, provided technical comment on the quarantine pathogens identified in the draft IRA. ACIL Consulting provided a detailed analysis of the report from a procedural and economic standpoint. A technical report, prepared for the Meat Research Corporation in 1997, was referred to in comments by a number of stakeholders. After a request by AFFA this report was provided to the RAP on a Commercial in Confidence basis, and relevant issues raised were considered by the RAP and addressed in the IRA.

Three stakeholders who supported the position taken in the draft nevertheless emphasised that the efficacy of any devitalising treatment would need to be clearly demonstrated before imports were permitted. This view was restated in comments on the revised draft.

The view of a number of stakeholders disagreeing with the position taken in the draft IRA was that “the draft IRA did not adequately identify, measure and evaluate the quarantine risks associated with bulk maize imports from the USA”. Substantive issues raised included: that the pathogen risks were not correctly assessed; a complete economic analysis of costs and benefits was not undertaken; and the analysis was not sufficiently quantitative.

Stakeholders disagreeing with the draft IRA based their technical concerns largely on an assessment of the magnitude of the risk posed by the quarantine pathogens provided by Professor Denis McGee and Dr. Barry Jacobsen. To further clarify the quarantine pathogens issues raised by these experts, the RAP held a direct discussion with Professor Denis McGee.

There was little comment on the significant weed and possible arthropod risks identified in the draft IRA, except that one stakeholder identified an extra 6 weeds considered to be of quarantine concern. The RAP accepted the quarantine significance of these weeds and they have been dealt with in the appropriate sections of this report.

Some stakeholders commented that the draft IRA was not sufficiently quantitative. Although the RAP agrees that quantitative risk analysis is a desirable aim it considered that it is not technically feasible to undertake a quantitative analysis of the risk of establishment and spread of all relevant pests at the present time: there are gaps in understanding of the biology of these pests, and in many cases there is little quantitative data on the likelihood of key events that would be essential if a pest were to establish.

Nevertheless in response to stakeholder comments the RAP did explore the usefulness of a quantitative approach using weeds as a case study (Appendix - 4). Although this analysis supports the original draft conclusion that weed risks are significant and would require management, the RAP considers that given the lack of data caution should be used in relying on this analysis.

Some stakeholders provided specific technical comments about the risks of various pests, and in a number of these cases the RAP has accepted the view of stakeholders and modified

appropriate sections of this report. However, this has not altered the overall conclusion of the IRA that treatment is required to manage the risks posed by pests of quarantine concern.

Some stakeholders appear to have misunderstood the scope within which Biosecurity Australia can make an economic assessment. The SPS Agreement (Article 5.3) makes no allowance for consideration of the benefits of trade, as this is not a phytosanitary issue that can be considered in pest risk analysis. Managed risk is not about balancing costs against benefits. It is about using phytosanitary measures that are consistent with the analysis of risk that indicates a country's appropriate level of protection. However, the potential economic impacts of pests are a legitimate issue for risk analysis and this has been taken into account in the IRA.

Specific RAP responses to all significant issues raised by stakeholders are in Appendix - 1. Where relevant, specific stakeholders' comments are discussed throughout the text of this IRA.

2.5 Publications

An *Issues Paper*, outlining the technical issues considered during the risk analysis, was circulated for comment on 6 July 1998 and a draft version of this IRA was circulated for comment on 19 March 1999. These documents are available on the Biosecurity Australia Internet homepage at <http://www.affa.gov.au/biosecurityaustralia>.

A public file, containing the draft IRA, non-confidential stakeholder comments and technical documentation, was established. The public file is held at Biosecurity Australia headquarters in Canberra and is available to stakeholders during business hours for perusal and copying. Contact information for making appointments to gain access to this public file is at page 2 of this document.

The full reports of the TWGs, including data sheets for quarantine pests detailing their biological properties, extent of host range, potential impact and difficulty of detection, are available on the Biosecurity Australia Public File. The pathogen TWG report includes a world list of maize pathogens, the preliminary assessment of the risk from these pathogens, and other important quarantine pathogens that may be introduced in admixtures. These TWG reports were considered by the RAP in producing the draft IRA and have not been updated to reflect stakeholder comment provided in response to the draft. Therefore there may be minor technical differences between the TWG reports and the subsequent IRA documents.

3 METHOD FOR PEST RISK ANALYSIS

The technical component of an IRA for plants or plant products is termed a ‘pest risk analysis’, or PRA. In accordance with the ISPM *Pest Risk Analysis for Quarantine Pests*², a PRA comprises three discrete stages:

- Stage 1: initiation of the PRA
- Stage 2: risk assessment
 - pest categorisation
 - entry potential
 - establishment potential
 - spread potential
- Stage 3: risk management.

The *initiation* of a risk analysis involves the identification of pest(s) and pathways of concern that should be considered for analysis. *Risk assessment* comprises pest categorisation, assessment of the probability of introduction and spread, and assessment of the potential economic consequences (including environmental impacts). *Risk management* describes the evaluation and selection of measures to reduce the risk of introduction and spread of a pest.

3.1 Stage 1: Initiation of the PRA

According to the IPPC, the aim of the initiation stage is to identify the objectives of the PRA — in particular, to define the initiation point and the PRA area. The ‘initiation point’ describes the purpose or context in which the PRA was initiated. The ‘PRA area’ is the area in relation to which a PRA is conducted (officially defined country, part of a country or all or part of several countries).

Typical initiation points for the PRA process include:

- the identification of a pathway that presents a potential pest hazard
- the identification of a pathway that may require regulation
- the review or revision of phytosanitary policies and priorities.

From Biosecurity Australia’s perspective, the identification of a new pathway will be the most common and important means by which a PRA is initiated. This PRA was initiated because of the prospect of imports of bulk maize from the USA.

3.2 Stage 2: Method for Risk Assessment

Risk assessment describes the process of identifying pests of quarantine (or biosecurity) concern and estimating the risk (the probability of introduction and spread and the magnitude of the likely consequences) associated with each.

In accordance with the IPPC, this risk assessment was carried out and reported in the following steps:

- pest categorisation

² PRA is used throughout this document as an abbreviation of Pest Risk Analysis. AFFA uses the term PRA to describe the technical component of an import risk analysis.

-
- assessment of probability of entry, establishment and spread
 - assessment of potential consequences (including environmental impacts).

3.3 Stage 3: Method for Risk Management

The requirement for risk management was determined by comparing the unrestricted risk estimate with Australia's ALOP using the risk estimation matrix (Table 1). Australia's ALOP is represented in this matrix by the row of cells marked 'very low risk'. Where the estimate of unrestricted risk did not exceed Australia's ALOP, risk management was not required. Where the unrestricted risk estimate exceeded Australia's ALOP, risk management measures were required to reduce the risk to an acceptable level. Using this risk estimation matrix, risk management measures are required when the unrestricted risk estimate is low, moderate, high or extreme. Risk management measures are not required when the unrestricted risk estimate is very low or negligible.

4 PEST CATEGORIZATION

4.1 Pathogens

The assessment found at least 428 pathogens and nematodes associated with maize. These pests were assessed for their presence in the USA and Australia, their ability to be transported with bulk maize, and their ability to cause significant losses. The assessments for the 373 pests that have been reported in the USA are in Appendix – 2 (The full lists are in Appendix - 1 and Appendix - 2 of the Pathogen TWG Report).

Of the 428 pests identified, 55 were excluded, as they have not been recorded in the USA. A further 202 were excluded because they either occur in Australia, or are unlikely to enter Australia in bulk maize, while 106 were not examined in detail due to the lack of detailed information. The RAP considered that there was no information to indicate that these pests would meet the criterion for a quarantine pest.

A stakeholder was concerned that a decision to grant or refuse import cannot be made until the analysis on all pathogens is complete. Risk analyses have not been done on the 106 pathogens with insufficient data for judgement or quarantine pathogens of other crops potentially present in admixtures. However, the RAP considered that risks associated with these pathogens would be managed by treatments to control the major maize pathogens already considered.

Of the 65 potentially significant pathogens that occur in the USA but not in Australia and can occur in the pathway, 48 were excluded, as they are not reported to cause significant economic losses. Seventeen pathogens were identified that are present in the USA, could potentially occur in the pathway, are not present in Australia, and are capable of causing significant economic damage, and therefore meet the criteria for a quarantine pest.

There are many quarantine pathogens of other crops potentially present in admixtures likely to be in bulk maize. The RAP considered that there would be significant risk that these other pathogens could be introduced if untreated bulk maize of USA origin, containing significant admixture of other crops, were moved into agricultural areas of Australia.

Table 2 shows the seventeen organisms identified as potential quarantine pests ranked on their likelihood of entering and causing loss in Australia. Ten of these pests have a greater overall risk. Some have the capacity to cause serious losses on commodities of substantially higher economic value in Australia than maize. For example, *Peronosclerospora sorghi* can attack sorghum while High Plains *tenuivirus* and wheat streak mosaic *ymovirus* can damage wheat. Some of these high-risk pathogens have relatively wide host ranges, extending to sorghum, wheat and naturalised grasses such as Johnson grass. In Australia there are many situations where feedlots and crops of maize, sorghum and wheat are in close proximity to each other. These issues need to be considered when developing possible management options.

Nematodes are included as quarantine pests in table 2 at a lower risk rating because they are not seed-borne. Nevertheless, the nematodes can be present in soil and trash associated with bulk maize and one stakeholder emphasised this point. The stakeholder also noted that the root knot nematode, *Meloidogyne chitwoodi* should be given at least equal ranking to *Heterodera zae* because of the economic damage caused in the USA and Europe. In

consultation with members of the pathogen TWG, the RAP has reassessed this nematode as at least of equivalent concern to the others in table 2 and amended the table accordingly.

Table 2: A qualitative analysis of the relative³ risk to Australia of 17 quarantine pathogens associated with maize grain from the USA

Pathogen (hosts)	Disease Introduction Risks	Economic Damage Risks	Disease Management costs	Overall Risk
<i>Peronosclerospora sorghi</i> (downy mildew of maize, sorghum)	High	High	High	High
Maize dwarf mosaic <i>potyvirus</i> (maize)	High	Medium	Medium to high	Medium to high
High Plains <i>tenuivirus</i> (maize, wheat)	Medium	High	Low to medium	Medium to high
Wheat streak mosaic <i>rymovirus</i> (maize, wheat)	Medium	High	Low to medium	Medium to high
<i>Sclerospora graminicola</i> (maize, sorghum, pearl millet and many grasses)	Medium	High	Medium	Medium to high
<i>Phymatotrichopsis omnivora</i> (Texas root rot of cotton and other dicotyledonous plants)	Medium	High	Medium	Medium
Maize chlorotic mottle <i>machlomovirus</i> (maize)	Very high	Low to medium	Low	Medium
<i>Cercospora zeae-maydis</i> (grey leaf spot maize)	High	Low to medium	Low to medium	Medium
<i>Pantoea stewartii</i> subsp. <i>stewartii</i> (Stewart's wilt sweetcorn)	Low to medium	Medium	Low to medium	Medium
<i>Clavibacter michiganensis</i> subsp. <i>nebraskensis</i> (Goss's bacterial wilt of maize)	Medium	Low	Low to medium	Medium
<i>Heterodera zeae</i> (maize cyst nematode)	Low to medium	Low	Low	Low
<i>Ustilaginoidea virens</i> (false smut of maize)	Low to medium	Low	Low	Low
<i>Dolichodorus heterocephalus</i> (Awl nematode)	Low	Low	Low	Low
<i>Hoplolaimus columbus</i> (lance nematode)	Low	Low	Low	Low
<i>Longidorus breviannulatus</i> (needle nematode)	Low	Low	Low	Low
<i>Pratylenchus scribneri</i> (root lesion nematode)	Low	Low	Low	Low
<i>Meloidogyne chitwoodi</i> (root knot nematode)	Low	Low	Low	Low

Phymatotrichopsis omnivora, a minor pathogen of maize but serious on cotton and many other dicotyledons, was regarded as having a lower potential for establishment because it would be soil or trash-borne only. If an incursion did occur, however, and it became established, this pathogen would be extremely difficult to manage. Comments provided by

³ The risk estimates are relative to other pathogens in this table and are based on the collective judgement of the TWG members

Professor Denis McGee (a cereal pathologist based in the USA) indicated that maize is not grown with cotton in the USA Midwest. However, the RAP considered contamination remains a problem because of difficulties with identity preservation through the grain transport and consolidation systems in the USA. Feedlots in Australia are present in cotton growing areas so there is the potential for the disease to establish on cotton if it were to be introduced in imports of bulk maize.

Cercospora zea-maydis is a serious disease on maize in humid areas. However, it is regarded as less of an overall risk than some other fungal, bacterial and viral pathogens because it is likely to be only trash-borne and to be pathogenic only on maize. Professor McGee confirmed that this is a serious problem in the USA and is getting worse with the increasing adoption of stubble retention systems.

It is useful to compare the 10 highest risk pathogens in Table 2 with the work of Phillips (1994). This study lists six of these pathogens as quarantine pathogens but Phillips did not include High Plains virus, *Sclerospora graminicola* and *P. omnivora*. Since this study, High Plains virus has been shown to be seed-borne, which justifies its present inclusion. The scope of the Phillips (1994) study did not cover pathogens that are not seed-borne. *S. graminicola* and *P. omnivora* are trash and soil-borne, and therefore could be present as contaminants in bulk maize.

The Phillips (1994) study included *Ustilago zae*, *Sporisorium holci-sorghii* and *Claviceps gigantea*. The first two pathogens are present in Australia and the present risk analysis has not found sufficient data to justify their inclusion as quarantine pests on the basis of possible differences in strains between the USA and Australia. However, further work may show that strains in Australia differ from those in the USA, which would change the risk potential classification of *U. zae* and *S. holci-sorghii*, and justify Phillips' (1994) conclusion. Although *C. gigantea* has not been recorded in the USA it has been recorded in parts of Mexico. Risk management measures would need to ensure that shipments of bulk maize from the USA are not contaminated by maize from Mexico.

Stakeholders commenting on the draft IRA presented technical advice that the prevalence in the USA of some of the diseases in Table 2 is very low and that seed transmission is exceedingly unlikely. While accepting that the probability of transmission by maize seed of some of the pathogens identified was very low, risk of transmission by soil, trash and admixture remained a major concern for some pathogens such as *P. sorghii* and *C. zea-maydis*. Given the potential volume of bulk shipments and the likely level of soil and trash present (Section 4.1.1), the view of the RAP on the pathogen risks expressed in the draft IRA remains essentially unchanged.

A summary of the important features of three of the high-risk pathogens (*Peronosclerospora sorghii*, High Plains virus and Wheat streak mosaic rymovirus) follows, to illustrate the range of issues that arise in relation to quarantine pests.

4.1.1 *Peronosclerospora sorghii*

Peronosclerospora sorghii, the cause of sorghum downy mildew, presents one of the greatest quarantine risks to the Australian grains industry from the importation of bulk maize from the USA. The disease was first reported in the USA in Texas in 1961 (Keyes *et al.*, 1964). By the

early 1970s it had reached the corn-belt in the Ohio River Valley in Indiana and Illinois (Frederiksen, 1980).

There is recent evidence that *P. sorghi* consists of more than one species with some strains that occur on maize now recognised as a separate species, *P. zea*. Further work is needed to determine the distribution of this species (Jeger *et al.*, 1998). Until the situation in the USA is better defined, the strains have been considered as one species.

In response to a request for information from the RAP, APHIS cited a paper by Shivas (1989) in which this pathogen was recorded in Australia. This was based on a single doubtful record (Tweedie, 1970) that Ramsey and Jones (1988), after examining a herbarium specimen (Herb IMI 147292), considered to be *P. maydis* not *P. sorghi*. In view of this, and in the absence of any records subsequent to 1970, the RAP determined that it was valid to consider *P. sorghi* absent from Australia in accordance with ISPM No.8 (FAO, 1998), Determination of Pest Status in an Area.

The risks of introducing *Peronosclerospora sorghi* into Australia through bulk maize grain imports are summarised as follows:

- *P. sorghi* is likely to cause serious economic losses if introduced into Australia, particularly in grain sorghum, other Sorghum spp., sweet corn, maize, Panicum spp. and Pennisetum spp. The gross value of sorghum and maize produced in Australia in 1996/97 was \$225 million and \$75 million, respectively. Information from a USA expert supported the view that the disease was a serious problem in sorghum.
- *P. sorghi* is seed-borne (maize and sorghum admixture) and can also be carried in trash and soil. It is therefore in the pathway.
- *P. sorghi* is widely distributed in the USA from southern Texas to central Illinois, where it was reported on sweet corn in 1990 (Pataky & Pataky, 1990). It can infect wild sorghums and it would be expected to produce oospores in systemically infected maize (Bigeriwa *et al.*, 1998) that could form a pathway for seed transmission. Thus it would be difficult to source from maize-producing areas in the USA that are free of *P. sorghi*. Information from the USA indicated that the prevalence of *P. sorghi* in USA maize was low but the pathogen is prevalent on other grasses that can be amongst the trash in bulk maize.
- Many feedlots in Australia are in agricultural areas where maize and sorghum are grown. If untreated imported grain is transported to such feedlots, *P. sorghi* could be introduced through spillage of grain, soil or trash present in the bulk import. If spillage occurred, oospores of *P. sorghi* could be dispersed by wind. The wide distribution of Johnson grass in northern Australia would provide a perennial source of susceptible host material. A USA expert agreed that oospores in trash or soil associated with a maize consignment was a potential pathway for introducing the pathogen to Australia although he felt the degree of risk was low.

The systemic nature of *P. sorghi* could mean that it would remain undetected for a considerable period of time, particularly in an uneconomic and widespread host such as Johnson grass. Thus the pathogen could spread widely before being detected, reducing the likelihood of successful eradication. For this reason, a USA expert indicated that USA pathologists would be reluctant to give area freedom assurances.

4.1.2 High Plains *tenuivirus* (HPV)

HPV was first recognised in 1993 in the western plains of the USA in maize. The virus is transmitted between plants by the eriophyid mite *Aceria tosichella*, and can be lethal to maize, wheat, barley and other grasses.

The disease is known to be seed-transmitted, and can be recognised by the presence of a protein that is specific to HPV infection. A USA expert pointed out that the experimental evidence for seed transmission does not clearly demonstrate that seed transmission can occur under field conditions. He did accept that infected volunteer plants arising from spilt grain would present a risk if seed transmission does occur.

HPV has been positively identified in 10 States of the USA, from eastern Nebraska to western Idaho, and from Montana and South Dakota to the Texas panhandle. It has also been identified from sweet corn samples from Florida. Genetic variability exists in maize reactions to HPV but this variability has not yet been characterised (Marcon *et al.* 1997). The USA expert indicated that the disease, while widespread, had little economic consequence in the USA although it was a more serious problem in other countries.

Because HPV is only a relatively recently discovered virus (1993), there is still much to learn about its aetiology, distribution and management. Importantly, diagnostic tools have now been developed which will allow determination of its distribution and further clarification of its economic significance. This pathogen is regarded as a high risk to the Australian grains industry because:

- HPV could be seed-borne and seed-transmitted in maize.
- Yield losses of up to 75% have been reported in some parts of the USA in some seasons.
- The disease also significantly affects wheat and barley and thus must be regarded as a major threat to the \$5 billion Australian wheat industry.

Devitalisation of the seed by grinding or other means should be an effective management strategy for this pathogen, since there is no evidence it is capable of being mechanically transmitted.

4.1.3 Wheat streak mosaic *rymovirus* (WSMV)

WSMV causes a serious disease of wheat, particularly in the Great Plains region of the USA, where overall losses of up to 2% occur (Christian, 1993) and local losses can be 100% (McNeil *et al.*, 1996). WSMV is both seed-borne and seed-transmitted, and is transmitted by the wheat curl mite *Aceria tosichella*. High Plains virus is often found in association with WSMV, not surprisingly since they share a common vector. WSMV has also been found along with maize dwarf mosaic virus in the same maize plant (Hill *et al.*, 1974), and is seed-transmitted in maize.

WSMV has a relatively broad host range, encompassing many plants in the grass family. It infects wheat, barley, oats, maize and millets (*Panicum*, *Setaria* and *Echinochloa* spp.). It is the type member of the rymovirus group, whose members are all mite-transmitted.

WSMV was first recorded in 1932 (McKinney, 1937). There is considerable molecular diversity in the virus (McNeil, 1996), and it is thought molecular groups may correlate with host adaptation.

Its entry and establishment in Australia would pose a greater national economic risk to the \$5 billion wheat industry than to maize. In maize, it could also be expected to cause substantial losses but with a less significant national impact. Devitalisation of all seed should be an effective management strategy for this virus.

Comments were received from the USA on the low incidence of WSMV in maize and suggesting that risk of seed transmission of WSMV and HPV would be below 0.1%. The RAP accepts these comments and has modified the transmission risk ratings. However, WSMV and HPV have a common mode of transmission and there is evidence that they form a more virulent complex (Marcon *et al.* 1997). Given the uncertainty about the significance of HPV and possible interactions with WSMV, until the complex aetiology of these diseases is resolved the RAP considers that both these viruses are of significant quarantine concern.

4.2 Arthropods

The arthropod pest risk analysis covered potential insect, mite and mollusc pests present in the grain after harvest (principally stored maize grain) in North America (Canada, USA, and Mexico). Insect, mite and mollusc pests of the plant, associated with organs such as stems, leave and roots were not considered in the analysis. This was due to the different environments present between field and storage, and the fact that very few pests are capable of surviving in both environments. Those species that do exist in both field and storage environments were included in the analysis. Also included in the analysis are 19 arthropod pests identified by the Pathogen TWG that are present in North America and are known to vector maize diseases.

Due to the nature of trade in grain between Canada, USA, and Mexico, and the fact that common railcars and transport are used between all three countries, arthropod pests of stored maize grain for North America as a whole have been included in the analysis. In addition, the use of common railcars and storage facilities in North America increases the likelihood of admixture of other grain commodities. For this reason, common pests of possible admixture commodities have also been included. The risk analysis process took into account factors such as the biology, host range, distribution, entry potential, establishment potential, spread potential and economic damage potential of pests capable of feeding and breeding on stored grains in North America and Australia. Species and genera considered, their distribution in North America and Australia, and their quarantine status in Australia are listed in Appendix - 2. Table 3 shows quarantine pests for Australia with a significant risk of being associated with bulk maize grain from the USA.

Table 3: Quarantine pests for Australia with a significant risk of being associated with bulk maize grain from the USA

Scientific name	Common name
a: Pests that are capable of breeding in stored grain	
<i>Cathartus quadricollis</i> (Guérin-Méneville, 1829) [Coleoptera: Silvanidae]	Tropical warehouse moth
<i>Caulophilus oryzae</i> (Gyllenhal, 1838) [Coleoptera: Curculionidae]	Broad nosed grain weevil
<i>Cryptolestes turcicus</i> (Grouvelle, 1876) [Coleoptera: Laemophloeidae]	Flat grain beetle
<i>Cynaues angustus</i> (Le Conte, 1852) [Coleoptera: Tenebrionidae]	Large black flour beetle
<i>Pharaxanatha kirschi</i> Reitter, 1875 [Coleoptera: Languriidae]	Mexican grain weevil
<i>Prostephanus truncatus</i> (Horn, 1878) [Coleoptera: Bostrichidae]	Larger grain borer
<i>Tribolium audax</i> Halstead, 1969 [Coleoptera: Tenebrionidae]	American black flour beetle
<i>Tribolium brevicornis</i> (LeConte, 1859) [Coleoptera: Tenebrionidae]	Flour beetle
<i>Tribolium destructor</i> Uyttenboogaart, 1933 [Coleoptera: Tenebrionidae]	Large flour beetle
<i>Tribolium madens</i> (Charpentier, 1825) [Coleoptera: Tenebrionidae]	Black flour beetle
<i>Trogoderma glabrum</i> (Herbst, 1783) [Coleoptera: Dermestidae]	Glabrous cabinet beetle
<i>Trogoderma inclusum</i> LeConte, 1854 [Coleoptera: Dermestidae]	Large cabinet beetle
<i>Trogoderma ornatum</i> (Say, 1825) [Coleoptera: Dermestidae]	Ornate cabinet beetle
<i>Trogoderma variabile</i> Ballion 1878 [Coleoptera: Dermestidae]	Warehouse beetle
b. Pests associated with damp maize grain	
<i>Glischrochilus fasciatus</i> (Olivier, 1790) [Coleoptera: Nitidulidae]	Picnic beetle
<i>Glischrochilus quadrisignatus</i> (Say, 1835) [Coleoptera: Nitidulidae]	Four-spotted sap beetle
c. Pests associated with infestable pulses	
<i>Callosobruchus chinensis</i> (Linnaeus 1758) [Coleoptera: Bruchidae]	Cowpea weevil
<i>Zabrotes subfasciatus</i> (Boheman 1833) [Coleoptera: Bruchidae]	Mexican bean beetle
d. Additional pests of quarantine concern to Australia	
<i>Trogoderma granarium</i> Everts, 1898 [Coleoptera: Dermestidae]	Khapra beetle

4.2.1 Insects

Pest species identified ranged from little known pests of limited worldwide distribution, through to well-known and widespread pests such as *Prostephanus truncatus* and some *Trogoderma* species. As well as being pests associated with grain, all have the potential of establishing in natural habitats. Comments have been made in the data sheets (Arthropod pests TWG Report, Appendix - 1) as to some possible adverse consequences that introduction of these pests may have on the natural environment. Once established in natural habitats, official control and eradication is likely to be difficult or impossible to accomplish.

Information on the status and distribution of important insect pests of stored grain is relatively reliable both in North America and in Australia, allowing a reasonable comparison to be made between the faunas of Australia and the USA in order to identify the quarantine pests. However, in comparison, knowledge of many mould-feeding and minor genera is limited. Insufficient information is available to ascertain if such species known to occur in North America are present in Australia. Some mould feeders can survive for substantial periods in clean, dry grain but are unlikely to be able to feed or reproduce in it; these species were included in the analysis but none were classified as quarantine pests.

A wide range of incidental insects can also be harvested along with grain. These form a sample of the local fauna and may include many species not found in Australia. The likely

species involved are impossible to predict. Most of these incidental insects are unlikely to survive for significant periods in grain in storage, especially if it is clean with minimal admixture. No attempt was made to assess risks associated with parasites or predators that can be associated with pest species.

Measures that effectively control the identified quarantine arthropod pest species in maize grain can be expected to control other arthropod species, such as the mould feeding and incidental pests, contaminating the grain.

Most major economic pests of stored grain with the exception of those identified in Table 3, are common to both North America and Australia. While these species may be common, genotypes of a given species may be different in either continent. Strains in one place may be more resistant to pesticides and fumigants than elsewhere. Importation of such strains could cause problems with using control treatments. Currently, there is no information indicating that strains of major storage insects present in the USA and Canada are significantly more tolerant to pest control treatments than those known to occur in Australia. However, this may be due to lack of data as survey results in the USA and Canada, particularly for phosphine resistance, are rudimentary. In the absence of data and because of the widespread use of phosphine fumigation in the USA it should be assumed that some degree of phosphine resistance is likely to be present, at least in common stored product pests. Dosages will need to be targeted accordingly if phosphine is chosen as a disinfestant.

An additional pest, *Trogoderma granarium* Everts, the khapra beetle, was identified as being of concern to Australia (Table 3). *T. granarium* is not established in North America and is a legislated pest in the USA. However, this species has frequently been recorded in ships used for grain transport.

4.2.2 Mites

Our knowledge of the Australian mite fauna, native and exotic, associated with stored products is incomplete and no recent, in-depth surveys have been undertaken. It is not possible to assert that a given mite, not currently recorded here, is not present in Australia. No mite species listed by the USDA key (Smiley, 1991) and not recorded to date in Australia is known to be significantly destructive to well-stored grain. No assessment can be made as to the potential environmental impact of mites likely to be associated with stored maize, though some are likely to become established outside of grain stores, if not already present. However, well-managed clean, dry grain is unlikely to contain significant numbers of mites.

4.2.3 Molluscs

No specific references were found concerning snails as an agronomic problem associated with trade in maize grain in the USA and Canada. Snails may however be harvested as an incidental contaminant. As such they are likely to form a sample of the local fauna and may include species not found in Australia. Information does not appear to be available as to the ability of such species to survive in stored grain. Experience with the importation of bulk maize grain from the USA in 1995 indicates that the risk of importation of molluscs is low.

4.3 Weeds

To be classified as a quarantine pest, a weed taxon needs to meet the IPPC definition⁴. Being under “official control” in this context is taken to mean that they are on a published list of Declared or Noxious Plants or Prohibited Plants and are subject to control by or under the legislated instruction of a State or local government body in some part of Australia.

The matter is complicated by the presence of different genotypes within many species of common weeds. The approach taken by the Weed TWG, and supported by the RAP, was to consider those weeds present in both the USA and Australia as non-quarantine pests unless there are particular and identifiable genotypes of the weed in the USA that are not known to be present in Australia and which could be expected to be of economic importance if established here (eg. herbicide resistant strains).

Appendix - 2 lists the weed species recorded in fields of maize, sorghum and soybean in the USA and species recorded as contaminants in maize exported from the USA. Weed species found in sorghum and soybean crops are included, not only because they are likely to share the same fields as part of a rotational cropping system, but also to share post-harvest facilities. There is a high chance of cross contamination among these species with maize. The species are mostly common summer weeds found in the USA. However, winter weeds, and other species, found recorded as contaminants in US maize exports to other countries (Anon, 1994), are also listed. Quarantine weed pests are listed in Table 4.

4.3.1 Weed risk assessment

Biosecurity Australia uses a Weed Risk Assessment (WRA) system to assess the weed potential of new plant species for which applications for importation into Australia have been lodged. The system is a question based scoring system. The information required to input into the system includes knowledge of the species’ ability to adapt to Australian climates, noxious and beneficial characteristics, and the ability to spread, reproduce and persist. The score is positively correlated to weed potential with species scoring in excess of 5 likely to become weeds in Australia. The system is described on the AFFA website (<http://www.aqis.gov.au/docs/plpolicy/weeds1.htm>) and details of the assessments may be obtained from Biosecurity Australia.

Species from Appendix - 2, not recorded in Australia were assessed using the WRA system confirming that they have a high potential to establish, spread and become weeds in Australia, both in agricultural and environmental contexts.

In summary the risk analysis identified 80 weeds of quarantine concern to Australia that have a significant risk of being associated with bulk maize grain from the USA (Table 4). A number of these are herbicide resistant variants of species present in Australia. A stakeholder responding to the draft IRA submitted an additional 6 weed species that are quarantine pests. The RAP has confirmed the quarantine status of these weeds and they are included in Table 4. Following release of the draft, three species (*Daucus carota*, *Polygonum convolvulus* and *Senecio vulgaris*) have been reassessed as non-quarantine pests because the weeds are not under official control and are widely distributed in Australia. *Xanthium pensylvanicum* is not described separately as it is part of the *X. strumarium* complex. *Salsola kali* remains as a

⁴ 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 (Section 1, FAO 1999)

quarantine pest because although it is present in Australia, taxa described as a distinct species or subspecies of *S. kali* are present in the USA but not recorded in Australia. Data sheets for these pests detailing their biological properties, potential impact, and entry and establishment potential are given in Appendix - 1 of the Weed TWG report which is available from the public file.

Table 4: Quarantinable weed species associated with bulk maize grain imported from the USA

Weed species	QUARANTINE STATUS or WRA score ¹
<i>Abutilon theophrasti</i> (herbicide resistant)	Q
<i>Abutilon theophrasti</i> (herbicide resistant)	Q
<i>Acanthospermum hispidum</i>	Q
<i>Aeschynomene virginica</i>	17
<i>Amaranthus arenicola</i>	13
<i>Amaranthus chlorostachys</i>	14
<i>Amaranthus hybridus</i> (triazine resistant)	Q
<i>Amaranthus palmeri</i> (herbicide resistant)	11
<i>Amaranthus retroflexus</i> (triazine resistant)	Q
<i>Amaranthus rudis</i> (triazine resistance)	14
<i>Amaranthus tamariscinus</i>	10
<i>Ambrosia artemisiifolia</i>	Q
<i>Ambrosia grayi</i>	Q ²
<i>Ambrosia trifida</i>	Q
<i>Apocynum cannabinum</i>	13
<i>Asclepias syriaca</i>	Q
<i>Bassia scoparia</i>	Q ³
<i>Berteroa incana</i>	14
<i>Bidens aurea</i>	Q
<i>Brachiaria platyphylla</i>	15
<i>Brassica japonica</i>	10
<i>Bromus tectorum</i>	Q
<i>Brunnichia ovata</i>	13
<i>Cenchrus incertus</i>	Q
<i>Cenchrus longispinus</i>	Q
<i>Chamaesyce maculata</i>	Q ³
<i>Chenopodium album</i> (atrazine resistant)	Q
<i>Cirsium arvense</i>	Q
<i>Cocculus carolinus</i>	6
<i>Conringia orientalis</i>	Q
<i>Convolvulus arvensis</i> (herbicide resistant)	Q
<i>Cynanchum laeve</i>	15 ³
<i>Cyperus esculentus</i>	Q
<i>Cyperus rotundus</i>	Q
<i>Datura inoxia</i>	Q
<i>Datura inoxia</i> (resistant to ALS herbicides)	Q
<i>Datura stramonium</i>	Q

Weed species	QUARANTINE STATUS or WRA score ¹
<i>Echinochloa crus-galli</i> (herbicide resistant)	Q
<i>Equisetum arvense</i>	Q
<i>Erigeron annuus</i>	Q ²
<i>Eriochloa villosa</i>	17
<i>Eupatorium capillifolium</i>	19
<i>Helianthus annuus</i> (herbicide resistant)	Q
<i>Ipomoea hederacea</i> var. <i>integriuscula</i>	Q
<i>Ipomoea lacunosa</i>	12
<i>Ipomoea purpurea</i>	Q
<i>Ipomoea turbinata</i>	10
<i>Jacquemontia tamnifolia</i>	Q
<i>Lolium multiflorum</i> (herbicide resistant)	Q
<i>Muhlenbergia frondosa</i>	14
<i>Panicum capillare</i> (herbicide resistant)	Q
<i>Panicum dichotomiflorum</i>	16
<i>Panicum fasciculatum</i> var. <i>reticulatum</i>	Q
<i>Panicum ramosum</i>	14
<i>Panicum texanum</i>	16
<i>Paspalum boscianum</i>	Q ²
<i>Physalis heterophylla</i>	Q ²
<i>Polygonum aviculare</i>	Q
<i>Polygonum bungeanum</i>	Q ²
<i>Polygonum lapathifolium</i>	Q
<i>Polygonum pensylvanicum</i>	Q
<i>Raphanus raphanistrum</i>	Q
<i>Rubus allegheniensis</i>	19
<i>Rubus fruticosus</i>	Q
<i>Salsola collina</i>	17
<i>Salsola kali</i> (<i>Salsola kali</i> subsp. <i>ruthenica</i>)	17 ³
<i>Salvia reflexa</i>	Q
<i>Senna obtusifolia</i>	Q
<i>Setaria faberi</i>	Q
<i>Setaria lutescens</i> (herbicide resistant)	18
<i>Sicyos angulatus</i>	18
<i>Solanum ptychanthum</i>	13
<i>Sorghum halepense</i>	Q
<i>Sorghum x almum</i>	Q
<i>Striga asiatica</i>	Q
<i>Thlaspi arvense</i>	Q ²
<i>Verbesina encelioides</i>	Q
<i>Xanthium spinosum</i>	Q
<i>Xanthium strumarium</i>	Q
<i>Xanthium strumarium</i> (resistant to imidazolinone)	Q

¹ Weed Risk Assessments (WRA) were done for species (in boldface) not known to be present in Australia and not yet prohibited. Species with scores in excess of 5 are likely to become weeds

in Australia and are rejected by Biosecurity Australia. The WRA system is described on the AFFA website at http://www.affa.gov.au/docs/market_access/biosecurity/plant/weeds1.html. The remaining species (Q) are prohibited under Commonwealth legislation, noxious under State legislation or have herbicide resistant variants in the USA.

- 2 Additional weeds identified by Agriculture Western Australia in their response to the draft IRA.
- 3 Changed to preferred synonym

Appendix - 4 provides a numerical analysis of the probability of weed establishment via trade in bulk maize. A numerical analysis was not provided in the draft version of this risk analysis due to concerns of the RAP that there was insufficient data to allow this analysis to be done. However, the RAP has provided this numerical analysis in response to stakeholder comment.

In doing this analysis in the absence of a complete data set a number of assumptions have been made about the probability of various events in the pathways leading to weed establishment. The values of these probabilities are critical to the final outcome of the risk analysis. In simple terms this analysis is only as good as the assumptions used and, given the uncertainties, caution should be used in relying on the results.

This analysis supports the original conclusion that there was a significant risk of weed establishment via bulk imports of untreated maize. Nevertheless, the RAP considers that the strongest support for this conclusion is the abundant evidence for weed spread through movement of agricultural products and the firm data that indicates the potential weed contamination levels that could be present in bulk maize.

4.3.2 Risk assessment of herbicide resistant maize in bulk maize imported from the USA

The use of herbicide resistant maize varieties allows more effective weed control in crops by allowing application of a wider range of post-emergence herbicides without damaging the crop.

A number of maize hybrids with resistance to herbicides such as imidazolinone, sethoxydim and glufosinate ammonium, produced by Pioneer, ICI, and Cargill have been widely commercialised in the USA (Table 5). There is a significant risk that maize grain imports from the USA will contain a component of herbicide resistant varieties. Various activities during loading, transportation and processing of imported maize have the potential to unintentionally release genetically modified maize into the environment.

Table 5: Genetically modified herbicide resistant maize lines commercialised in the USA

Maize lines resistant to	Gene modification technique	Status in Australia
Acetyl coenzyme A carboxylase (ACCase) group: sethoxydim, haloxyfop, cycloxydim	Mutation, inbred lines developed in vitro selection and crossing with other lines to develop hybrid	Not yet present
Glufosinate ammonium	Gene transformation	Not yet present
Imidazolinone groups: imazethapyr, imazapyr, imazaquin, clomazone	Point mutation, inbred lines developed in vitro selection and crossing with other lines	Not yet present

The risk of herbicide resistant maize becoming weedy

Although maize carrying herbicide resistant genes could germinate along the roadside, the chance of survival until the reproductive stage is low. Generally, maize appears as a volunteer in some fields and roadsides, but it has never been shown to become established and reproduce in the wild (Gould, 1968). Maize is non-invasive in natural habitats and likely to be controlled by natural herbivores during early stages of growth. Shed pollen of maize can remain viable for 10-30 minutes (Coe *et al.*, 1988). If viable pollen of herbicide resistant maize were to be transferred by wind to any receptive maize stigma within the 30-minute period of pollen viability, an escape of genetic material could take place. This potential transfer is very unlikely at a distance beyond 200 m. There is only a small chance that volunteer maize will survive until the flowering stage and transfer genes to other maize varieties.

Even if genes do escape into other maize varieties, the added characteristic of herbicide resistance would still not significantly increase weediness provided that none of the reproductive or growth characteristics were modified. Maize seed has little or no dormancy and loses germinability within 2 years under natural conditions and therefore does not develop a soil seed bank. If accidentally introduced into cropping systems, there is a risk of herbicide resistant volunteer maize persisting, particularly in soybean crops or in crop rotation systems (Young & Hart, 1997; Vangessel *et al.*, 1996).

The risk of gene escape to wild relatives

No *Zea* species are either naturalised or recognised as weeds in Australia. However, there are wild relatives of maize imported from South America (Teosinte: *Euchlena mexicana*) whose distribution may overlap with that of cultivated maize. Teosinte is an ancient wild grass found in Mexico and Guatemala. Teosinte can be found in Queensland and Western Australia. Although teosinte has the ability to establish in the wild, it has no pronounced tendency to weediness (Gould, 1968). Cultivated maize and teosinte are sexually compatible and can produce fertile F1 hybrids. However, introgression between maize and teosinte rarely occurs naturally, probably because of the difference in flowering time. Related *Zea* species are geographically restricted and occur only in Mexico and Guatemala. There is low potential for interspecific gene flow to wild relatives to occur in Australia.

The importation of herbicide resistant maize in bulk feed grain for processing is therefore unlikely to present a significant risk to agricultural systems or the environment because it lacks other weedy characteristics, particularly the ability to naturalise in the wild. The risk of genes for herbicide resistance escaping from maize into agricultural and environmental areas is also low because sexually compatible species in Australia are rare.

4.3.3 Quarantine implications of *Striga asiatica* in the USA

Striga asiatica is the most serious root parasite of maize and other grass crops (including sorghum and sugarcane) in the world. Once established in an area it is extremely difficult (and expensive) to eradicate. Its seed size is very small (0.5x0.2 mm) and would be difficult to detect by normal sampling and analytical methods. The risk of it being imported into Australia with feed maize has been assessed.

The only *Striga* species present in Australia are 3 native species, *S. curviflora*, *S. multiflora* and *S. parviflora* (Hnatiuk, 1990). *S. curviflora* and *S. parviflora* are minor weeds in sugar cane in Queensland (Anon, 1989). *S. parviflora* has been recorded in maize crops in the Atherton tableland (Henderson, 1984). *S. asiatica* was previously reported from the North Kennedy Grazing District of Queensland (Hnatiuk, 1990), but is no longer considered to be present in Queensland (Phillips *et al.*, 1994; Hucks, 1999) since the herbarium record was shown to be a misidentification (Carter *et al.*, 1997).

S. asiatica was first recorded in North Carolina in 1956 (Sand, 1979), immediately triggering concerted efforts to limit its further spread and to eradicate it from the country; this program has continued over the last 48 years and is only now nearing completion.

The following advice was provided by Dr Robert Eplee, Senior Research Scientist and Director of the Raleigh Plant Protection Centre, North Carolina, USA (August, 1998):

“*Striga* has been under an intensive eradication program over the past years. All but about 10,000 acres of the original 435,000 infested acres has been declared eradicated. On the remaining infested areas, reproduction (seed production) is denied through the use of herbicides. Without seed production, it would only be possible to ‘export’ *Striga* seeds with the movement of soil. Movement of soil out of a maize field is inconsistent with our machine harvest methods. Our protocol requires that a site meet a set of conditions, accumulated over at least three years, before eradication can be declared. Nearly all of the infested acreage falls into this category.”

Although the risk of *S. asiatica* being present as a contaminant species in maize imported from the USA is very low, maize grain should not be sourced from any area infested or previously infested with this weed.

5 RISK MANAGEMENT OPTIONS

5.1 Pathogens

Evans *et al.* (1996) concluded that any spillage during transport to feedlots in Australia could be readily contained. However, it is evident from previous experience that spillage of grain and associated admixtures, soil and trash, and the discharge of dust into the air during loading, transport, unloading, storage prior to processing of grain, and in the event of processing plant breakdowns, are extremely difficult to control. Such spillage and discharge could provide opportunities for the establishment of pathogens. On the basis of the request of the proponent and the previous experience with grain spillage, control of spillage of untreated grain has not been considered in this risk analysis.

The RAP does not consider that early detection and eradication of pests is a feasible risk management option. Three recent incursions of quarantine pests show that it is difficult if not impossible to eradicate broad acre field pests once they are established:

- A major campaign in Western Australia failed to eradicate *Colletotrichum gloeosporioides*, the cause of lupin anthracnose.
- Efforts to prevent the spread of *Ascochyta rabiei* within chickpea-growing areas of eastern Australia have failed and a widespread epidemic of blight developed in 1998.
- *Sphacelia sorghi*, causing ergot of sorghum, spread rapidly throughout sorghum growing areas in 1996, making eradication impossible.

Possible options for managing the risk of entry of quarantine pathogens are sourcing grain from pest-free areas or sourcing resistant varieties, removal of soil and trash, devitalising seed by grinding, and pasteurising by heat or other treatments.

From assessment of the published literature, it may be possible to source seed from pest-free areas for each of the pathogens listed in Table 2. However, while some areas may be free of individual quarantine pathogens there are no obvious areas free of all quarantine pathogens. For example, humid areas in the southeastern USA have *Cercospora zeae-maydis* and arid regions in the southwestern USA have *Phymatotrichopsis omnivora*. The distribution of *Peronosclerospora sorghi* overlaps with *Phymatotrichopsis omnivora*, but would appear to extend further north to central Illinois. The bacterial pathogens *Pantoea stewartii* and *Clavibacter michiganensis* have a wider distribution, extending into northern USA. It is, therefore, unlikely that maize grain could be sourced from areas free of all of the quarantine pests contained in Table 2. Nevertheless, area freedom represents one possible risk management option if it can be adequately demonstrated that growing areas are free of diseases and the integrity of product sourced from such areas can be preserved in the transport chain. Advice provided by USDA, and confirmed by Professor McGee, is that under existing transport and storage systems in the USA, maize cannot be sourced exclusively from a specified area. Special arrangements would need to be developed for identity preservation of grain if an area free of quarantine pests could be identified.

Devitalisation of maize seed by grinding would be an effective strategy to prevent entry and establishment of the four viral diseases, as they require living tissue to survive. However, this

strategy alone would not be fully effective for management of quarantine bacterial and fungal pathogens associated with maize grain, which would be expected to largely survive mechanical processing.

Setting achievable maximum levels for trash, soil and admixtures may not effectively manage the risk for trash- and soil-borne pathogens, since substantial quantities of these materials are nevertheless likely to be present in bulk imports. Oospores of *Peronosclerospora sorghi* would be present in contaminated soil at levels of 1–95 propagules per gram and soil may be present, even in Grade 1 maize, at a level of up to 2%. Thus, there is a clear risk that soil or trash could provide a pathway for entry and establishment of pathogens such as *Peronosclerospora sorghi*, *Cercospora zea-maydis*, *Sclerospora graminicola*, *Phymatotrichopsis omnivora*.

Treatment of grain to devitalise quarantine pests that may be present on maize seed, soil, trash and other seed admixtures, appears to be the only suitable strategy for managing all pathogen risks. From the available data, heat treatment would appear to be the most effective mechanism. Work by AQIS associated with grain imports in 1995 established treatment conditions that met quarantine requirements for a number of specific shipments. These shipments were steam heat treated at 95°C for 10 minutes. The RAP considered that further work would be needed to optimise a heat treatment effective against all quarantine pathogens while maintaining grain quality.

Although the RAP considered that heat treatment could satisfactorily manage all the quarantine risks, any treatment that provided a high degree of reliability that all quarantine pathogens were killed would be acceptable. Choice of a suitable treatment would need to consider the risks posed by seed admixtures, trash and soil. Treatment could be done either at the port of entry to Australia, as is currently permitted, or offshore. If treatment were carried out offshore, procedures would be needed to prevent re-infection. Depending on the point of treatment, particular issues that need to be considered include:

- Cleanliness of rail cars used to freight the sourced bulk maize in the USA;
 - spores of the Karnal bunt fungus (*Tilletia indica*) and other pathogens could be present in freight cars used to transport the bulk maize.
- Cleanliness of handling and loading equipment.
- Cleanliness of ship holds used to transport the bulk maize.

5.2 Arthropods

5.2.1 Grain quality

Many insect species find it much easier to become established in grain consignments containing admixture and damaged grains. Risk of infestation increases with the decline in grain quality, measured in terms of its physical condition (eg. % broken, immature or mouldy grains), increase in temperature and moisture content, and increase in admixture of trash and other material. Risk of importation of species identified as of quarantine concern to Australia, with the exception of *Caulophilus oryzae* and *Prostephanus truncatus* that attack whole grains, would be reduced if only high-grade grain, in good condition with minimal admixture, was imported. Grain moisture content should be less than 14%, independent of grade. A

number of species including *C. oryzae* and *Glischrochilus* spp., are adversely affected by low moisture content. Complete removal of admixture of pulses from maize reduces the risk of species from Table 3 being imported to negligible levels.

Sieving and grain cleaning will remove most snails and other incidental contaminants. It may however be difficult to remove contaminants that are of similar size and density to maize grains, such as pulses.

Grain quality has a significant effect on the efficacy of fumigation. Lower grades of maize are difficult to fumigate as trash and fines tend to segregate during handling and transport of bulk grain and forms pockets and layers through which fumigants may have difficulty passing. This results in non-uniform distribution of gas and an increased risk of fumigant survivors. These problems are compounded if fumigation is undertaken in-ship (see later discussion on fumigation). Clean grain is much easier to fumigate properly.

5.2.2 Selection of grain from areas free of pests (area freedom)

Several species identified as being of quarantine concern to Australia appear to have restricted distributions in the USA. *Caulophilus oryzae*, *Prostephanus truncatus* and *Cathartus quadricollis* appear to be restricted to southern States and the latter two are much more widely distributed in Mexico. If it is possible to guarantee the source of grain, obtaining it from northern States will reduce but not completely eliminate the risk of importation of these species. Other species identified as being of quarantine concern, however, appear to be widely distributed and it will not be possible to identify maize producing regions free of these pests. In general, however, infestation pressure declines the further north the grain growing areas are. If maize were to be sourced using the principle of “Area Freedom”, this would require detection, monitoring and delimiting surveys for quarantine pests to be carried out annually, as well as the dedication and monitoring of rail cars. This is not normal practice in the USA.

5.2.3 Prevention of infestation during transportation, storage and handling

A number of species identified as being of quarantine concern, notably *Cryptolestes turcicus*, and the *Tribolium* and *Trogoderma* species, are not host specific and may infest residues present in grain handling systems. These species can infest maize grain when handled through contaminated facilities. Use of well-managed handling and transportation systems will reduce this risk. Fumigation of these facilities would provide control of insects but this is a non-residual treatment and will not confer protection of the grain during subsequent handling and transportation.

Ships used for the importation of bulk maize need to be ‘fit for purpose’. Vessels can become infested with insects of quarantine concern from previous cargoes and not necessarily only those associated with maize. This could often include species that are not established in North America including the khapra beetle, *Trogoderma granarium*. Prior to loading grain, ships must be clean and free of infestation, at least to the standard expected of vessels that handle Australian grain exports. This includes not only the hold, but also all other areas of the vessel including crew quarters, engine room and related areas from which infestation could arise.

5.2.4 Fumigation

There is little or no data available on the effects of fumigants, contact insecticides or other control measures on most of the pests identified as of quarantine concern. Nonetheless, most are unlikely to be more tolerant than *Tribolium castaneum* to methyl bromide (Bond, 1989), *Sitophilus oryzae* to phosphine (Anon 1997) or the lesser grain borer, *Rhyzopertha dominica* to heat (Banks & Fields, 1995). These are the most tolerant pests that the Australian dosage rates are aimed at. Exceptions are larvae of *Trogoderma* species in diapause, which are tolerant of methyl bromide (Rees & Banks, 1998), and species in the family Bruchidae, which can be tolerant of phosphine and many contact insecticides (Anon, 1997). The pesticide resistance status is unknown for all these pests from North America and would need to be investigated if fumigation were to be used as a primary risk management measure.

It is also noted that fumigation of bulk grain in ship is an uncertain process. It is difficult to ensure adequate gas distribution in the hold or any other part of a ship, even if the ship is stationary. The problem is further compounded by grain quality (section 5.2.1).

The normal practice used by the USA for grain shipments is for grain to be treated with phosphine at US label rates as an in-ship treatment for the duration of the voyage. The RAP does not consider this methodology to be adequate for phytosanitary purposes due to difficulties in achieving and assessing appropriate distribution of gas.

5.2.5 Devitalising treatments

Processing of maize prior to shipment can reduce the risk of importing the identified pest species of quarantine concern. The risk of importing species, such as *Caulophilus oryzae* and *Prostephanus truncatus* that infest whole grain, can be much reduced by milling the grain and other processing treatments such as steam pelleting. Other species present may be eliminated by the insecticidal nature of such processing.

Heat can be used for the processing or devitalisation of grain and may be insecticidal. Temperatures above 50°C are insecticidal, and become rapidly more so as temperatures increase above this. All storage pests are killed by a few seconds exposure to either wet or dry heat of 65°C (Field, 1992; Banks, 1998). Time allowance needs to be made for the heat to penetrate the grain kernel to this temperature.

However, after treatment, some species identified as of quarantine concern could reinfest, notably *Cryptolestes turcicus*, and the *Tribolium* and *Trogoderma* species. Therefore, if this option is adopted, continued phytosanitary security to prevent reinfestation must be assured.

5.3 Weeds

Weed risk identification and assessment confirmed the previous conclusion of Phillips (1994), Anon (1994) and Roberts *et al.* (1995) that bulk import of feed maize poses a significant risk of accidentally introducing a number of weed species into Australia. To reduce the risk to a manageable level, a number of phytosanitary management methods are reviewed (some of which have been proposed in the previous reviews of Roberts *et al.* 1995, and Evans *et al.* 1996).

5.3.1 Sourcing US maize from *Striga* free areas

Although it is concluded that the risk of exporting bulk grain contaminated by *S. asiatica* is low, consignments still may require phytosanitary certification declaring that the consignment of maize is bulked from maize grown in *S. asiatica* free areas. Relevant information in support of this declaration could include the source of maize, and a current map of *S. asiatica* infested or controlled areas.

5.3.2 Weed management in the field

A specific weed management program may have some capacity to significantly reduce the weed seed contamination in maize. However, given the large number of different weeds that could be present the RAP does not consider that a program based on weed management in the field would be a practical approach to managing all quarantine weeds risks.

5.3.3 Seed cleaning

According to previous reviews (Evans *et al.*, 1996), maize shipments contained a smaller number of contaminants than other imported grain. One of the reasons was that the size of maize seed is larger than that of most weed species and has a smooth surface. Consequently, appropriate screening and other seed cleaning treatments can exclude many weed seeds. In a technical report provided by a stakeholder, screening was considered to be an effective quarantine treatment.

A number of seed cleaning treatments are available which can exclude weed seed of different size, shape, texture or density to maize. Theoretically, if an intensive cleaning technique is adopted, many, but not all, quarantine weed seeds would be excluded. While these techniques are applicable and economically justified for the quantities of maize seed normally imported for sowing, for bulk volumes of low cost feed grain the technique may be impractical and a risk of introducing a significant number of new quarantine weed species into Australia would remain.

5.3.4 Seed sampling intensity

One risk management measure sometimes used in quarantine is to test or inspect the product at a particular sampling intensity on the basis that if no quarantine pests are found the shipment meets quarantine requirements.

Statistical advice was sought on the appropriate representative sample size of bulk maize grain in which a nil tolerance for quarantine weed seeds could be imposed. After mechanical reduction of the composite sample and submitted sample, practical operational constraints restrict the working sample to a maximum of 50 kg. Although this sample size is quite large seed technologists could use appropriate screening techniques to assist in isolating weed contaminants before performing identification of any seeds found. The statistical analysis indicated that up to 70 weed seeds could be present in each tonne of maize grain and have less than 5% probability of being detected in the 50 kg working sample (Roberts *et al.*, 1995). Extrapolating from this, if the bulk grain consignment size were 50,000 tonnes, up to 3,500,000 weed seeds could be present and not be detected.

It was concluded that an intensive sampling method for bulk grain shipments would be operationally difficult and costly to implement and would not provide sufficient assurance of

the absence of quarantine weeds in a shipment. A technical report provided in confidence by a stakeholder (Appendix - 1, table 2, ref 16b) also stated that phytosanitary certification based on representative seed samples would not be practical.

5.3.5 Devitalisation treatments

Steam heat treatments

Preliminary studies indicated that steam treatment at 95-100°C for 12-15 minutes killed the following species: *Ambrosia trifida*, *Abutilon* spp., *Amaranthus* spp., *Cirsium arvense*, *Setaria italica*, *Sorghum bicolor*, *Glycine max*, *Triticum* sp., *Chenopodium* sp., *Avena sativa*, *Raphanus raphanistrum*, *Hordeum* sp., *Xanthium spinosum*, *Xanthium strumarium*, *Secale cereale*, *Galium* sp., *Polygonum convolvulus*, *Brassica* spp., *Stellaria media*, *Spergula arvensis*, *Galeopsis bifida*, *Thlaspi arvense* and *Rapistrum rugosum* (Imported Grain Taskforce file, 1995).

Steam heat treatment of imported maize would manage the risk effectively, particularly if the treatment could be conducted at the port of entry or just prior to export, minimising the opportunities for post-treatment re-contamination. To optimise the temperature and time required to be effective for all weed species and admixtures, further work may be necessary. If the steam heat treatment is carried out at the point of export, additional operational requirements should include appropriate hygienic measures during the pre-entry handling process to avoid re-contamination.

Infrared energy management system

Infrared radiation converts to heat in an absorbent material. In contrast to microwave radiation, which is dependent to a large extent on sufficient moisture content in the material to be successful, infrared systems can effectively heat dry material. An infrared heat treatment facility for treatment of linseed has been approved by AQIS. Infrared heat has the potential to devitalise grain in a shorter time frame than steam heat treatment and may be less likely to damage grain but the treatment method needs further testing for efficacy against weed species of quarantine concern.

Fumigation

In 1995, CSIRO scientists, as AQIS consultants, undertook trials on devitalisation of maize using methyl bromide and chloropicrin (Cossells *et al.*, 1995). The results indicated that despite the very high dosage of methyl bromide used, all samples of maize maintained some viability after treatments. After five times the dosage and twice the exposure period normally specified by AQIS for disinfestation of consignments, more than 10% of the treated maize germinated. Chloropicrin at 4 times the commercial dosage was also found to be ineffective in devitalising maize, reducing germination by only few percent.

Extrapolating from these results, many weed seeds are likely to survive these fumigation treatments, and there would be practical difficulties in their use and chemical residue problems in the treated maize. Fumigation treatments are unlikely to be effective in killing weed contaminants in maize consignments.

5.4 Area Freedom and Identity Preservation

Freedom from relevant pests and diseases in the source area is an option if it can be demonstrated that the region in the USA has continuing area freedom and the integrity of the grain can be satisfactorily maintained in transporting the grain from this area to Australia. Maize sourced from areas free of quarantine pests would be acceptable to Biosecurity Australia, if appropriate phytosanitary measures are taken to prevent contamination during transport. Similarly, a sufficiently low incidence of a pest in areas from which the bulk maize is sourced could reduce the phytosanitary risk to a level acceptable to Biosecurity Australia.

While not all quarantine pests identified in this analysis are distributed evenly throughout the USA, pest distribution data indicate that no maize-producing state of the USA is free of all quarantine pests. In addition to this, there are considerable practical difficulties in preserving the identity of maize sourced from such areas. Given these difficulties, localised area freedom or low incidence for all quarantine pests has not been addressed in detail in this IRA. A proposal involving localised area freedom may be acceptable to Biosecurity Australia as a phytosanitary measure if current deficiencies are adequately addressed in the future.

A previous review (Evans, *et al.* 1996) examining risks associated with the importation of bulk grain considered a number of issues including sourcing from low risk areas and secure transport to feedlots. A number of stakeholders have used this report to support a range of arguments. Nevertheless, recommendations contained within that report are clear:

- Rec. 1. That AQIS reassess the likelihood of introducing exotic seed-borne and seed transmitted pests of maize, sorghum and barley taking account of the occurrence of pests of concern in exporting countries, the opportunities for obtaining grain from low risk sources and provisions for preserving the identity of grain in transit;*
- Rec. 6. That before considering applications for permits to import maize for processing in rural areas, AQIS seeks confirmation of the capacity of US authorities to preserve the identity of maize from low risk sources destined for Australia; and*
- Rec. 7. That the results of the transport trials be re-assessed on the understanding that any future approval to move imported grain into rural areas will be restricted to consignments originating from sources where risk can be managed offshore.*

This report implements the first recommendation for maize and the substance of recommendations 6 and 7 are addressed.

An analysis provided by a stakeholder in response to the draft IRA discussed grain transport arrangements in the USA under which the identity of grain sourced from a specified area could be preserved. The USDA response to the draft IRA, however, clearly stated that domestic grain transport arrangements were not suited for this purpose and Professor Denis McGee endorsed this view.

The RAP considers that area freedom is unlikely to be achievable for imports of bulk maize from the USA. Furthermore, if a low risk source could be found there may be significant difficulties in implementing adequate arrangements to preserve the identity and integrity of bulk grain sourced from a specific area.

5.5 Treatment

The TWGs proposed various treatments. The RAP considered that any treatment, in which it was demonstrated to a high degree of certainty that maize and potential admixtures were devitalised and pests destroyed, could achieve Australia's appropriate level of protection. On the basis of available information the RAP considered that the only likely candidate at this time is steam heat treatment. Irradiation and infrared heat treatment are examples of other treatments that should be capable of achieving the desired level of protection. However, given the lack of reliable efficacy data on these treatments more extensive development work may be required to demonstrate their efficacy.

Under WTO rules quarantine requirements must be the least restrictive measures necessary to manage the quarantine risk to an acceptably low level. On this basis, treatment efficacy may not need to be as high for grain that is sourced from lower risk areas, transported under identity preservation arrangements and subjected to detailed analysis to confirm the risk status of the grain compared to the efficacy of treatments applied to grain sourced from any area of the USA and potentially containing the full range of quarantine risks.

Offshore treatment of bulk maize would be acceptable provided effective measures were taken to prevent post-treatment infection, infestation or contamination of the shipment.

The common practice of grain drying has been proposed as a treatment for reducing quarantine risks. Commercial grain drying uses temperature and exposure periods aimed at conditioning the product for subsequent safe storage without damaging the viability of the grain or its processing qualities and characteristics. It follows that the viability of at least some of the potential weed seed contaminants would not be affected by this procedure. Furthermore, given that the dried maize may be stored for some time prior to transport from inland regions of the USA and shipment, the risk of reinfestation and cross-contamination would be a significant problem. On the basis of available information the RAP does not consider that conventional grain drying practices are likely to be adequate to manage all significant quarantine risks.

5.6 Analysis of operational Issues

The analyses of the pathogen, arthropod and weed risks have all indicated that bulk maize would need to be treated to reduce the risk to a level that meets Australia's appropriate level of protection. This section discusses a range of operational issues related to the application of a suitable treatment and maintenance of the integrity of the maize after treatment.

5.6.1 USA corn grades

Given the earlier conclusion (section 5.5) that grain must be rendered sterile and disinfected at the port of export in the USA, the likelihood of achieving this outcome is greater if a higher grade of corn is used, since a cleaner starting product provides greater confidence that the treatment will be effective. On the basis of USA Corn Grades and taking into account Australia's experience with previous shipments of bulk maize from the USA for animal feed, the RAP considers that Australia's grade specification for any future shipments of maize feed grain should be US No. 2 or better. It is noted however that if the process used to treat the grain can be shown to be equally effective on other grades of corn then lower grades may be an acceptable alternative.

5.6.2 Post treatment risk management options

There are a number of operational issues related to maintenance of the integrity of treated maize from the point of treatment to arrival in Australia.

5.6.3 Inspection agencies

The USA export grain industry is regulated by the Federal Government, which provides an infrastructure for Government Certification of documented quality grades. There is an accreditation and qualification system for individuals, agencies and certification companies to maintain certification integrity.

The following inspection agencies are involved in inspection and certification of grain in the USA:

- APHIS, the organisation responsible for the issuance of phytosanitary certificates. The Federal Seed Laboratory issues certificates on the basis of USA Federal Grain Inspection Service (FGIS) inspections and sampling, and analysis of the samples.
- FGIS, the role of FGIS and FGIS Agencies is primarily to maintain a recognised system of grading for commercial grain trading.
- State Departments of Agriculture. Many State Departments of Agriculture in the USA have a memorandum of understanding with APHIS. They conduct surveys for diseases in seed crops and specific pests and have a capacity to provide seed laboratory services.

The RAP considers that there is adequate infrastructure in the USA to provide reliable certification on grain shipments. However, specific arrangements would need to be negotiated with appropriate agencies.

5.6.4 Inspection standards

Some members of the Australian Grain Mission 1995 expressed the view that hygiene and operational standards were poor at some USA elevators (Roberts *et al.*, 1995 Report of Grain Mission). Unlike Australia, where hygiene standards are enforced by legislation and are a mandatory condition for the export of prescribed grains and prescribed goods, inspection and certification in the USA is based solely on inspection, sampling and analysis of the grain lot. The FGIS sample and inspection procedures as documented in their Grain Inspection Handbook therefore lack the second tier hygiene and treatment controls that underpin Australia's sample and inspection rates. Specific agreements on inspection standards would be needed if imports of bulk maize into Australia were to be permitted.

5.6.5 Export terminals

Grain is mainly transported by truck from farm/farm storage to elevator. Harvest and transport to storage is often performed by contractors who 'follow the season' from south to north. Transport from elevators to sub-terminals to export terminals in the Pacific Northwest and Texas Gulf is by rail. In addition, large quantities of grain are moved by barge down the Missouri/Mississippi River systems.

Export terminals are situated in the Pacific Northwest, Texas Gulf, Louisiana and California. They tend to operate on a 'just in time' principle with consolidated cargo moving from inland

elevators just prior to the vessel arrival at the port. The terminals visited by the Grain Mission 1995 were flow through systems with little buffer storage capacity.

The Grain Mission 1995 found that:

- Export Terminals have a capacity to blend grains and screenings similar to inland elevators and sub-terminals. This blending to achieve quality grades is normal practice in the USA grain market.
- Vessel loading is controlled by FGIS who release shipping bins for loading after grade standards have been checked.
- In relation to post treatment security of maize consolidated for export to Australia the following factors require consideration:
 - Management practices, particularly in usage of common elevators and flow paths, and segregation capacity of export terminals for storage of the treated lot.
 - Hygiene/pest control practices, especially the potential for inadequate treatments to mask infestations of quarantine pests or encourage insecticide resistant strains of cosmopolitan (non-regulated) pests, and the capacity of these pests to cross infest/infect post treatment.
 - Reject/treat/reinstate procedures for export grain, and capacity to inspect and if necessary divert grain from shipping bins.

Detailed procedures for storage, handling, hygiene and inspection/rejection of the treated maize and standards for pre loading verification of compliance will need to be supplied to the export terminal and to APHIS. In the absence of data, it is assumed that APHIS and/or FGIS do not have inspection/certification standards or accreditation training for acceptable procedures. An initial pre-clearance visit by an Australian inspector may be required to ensure correct interpretation of the procedures. In addition this visit could ensure that all stakeholders understand issues such as 'how clean is clean'. Subsequent shipments may be 'pre-cleared' on the basis of representative samples submitted for analysis prior to shipment, and a grain flow path hygiene condition certificate endorsed by APHIS or an approved certifier supplied.

5.6.6 Ship inspection

The Grain Mission 1995 reported that FGIS has responsibility for carrying out stowage examinations on vessels in accordance with the provisions of the USA Grain Standards Act.

Stowage space is examined for:

- Residues of previous cargoes
- Rust scale and paint scale
- Unsanitary conditions such as animal/rodent excreta or decaying matter
- Unknown substances
- Standing water in the hold
- Objectionable foreign odours
- Infestations with rodents or insects.

Holds that have been passed by FGIS as fit to load grain are listed on an Official Stowage Examination Certificate issued by FGIS. This certifies that the stowage areas were examined on a given date and found to be substantially clean, dry, free of insect infestation and suitable to carry grain or commodity.

Experience of residues in recent fertiliser vessels from the USA, that are required by AQIS to be free of infestation or contamination by live insects, seeds, soil and other plant or animal debris, suggest that USA certification bodies, particularly private surveyors, either have a different interpretation as to what constitutes 'substantially clean, dry, free from insect infestation' or their ship survey procedures are inadequate. Schedule 4 of the Australian Export Control Act, Grain, Plants and Plant Products Orders, made under the Export Control Act (1982) and the Ship Inspection section of the Field Crops Manual provide extensive instruction on the required ship survey standards and procedures used in Australia.

Experience from inspection of bulk carriers arriving in Australia and from the USA Grain Mission in 1995 has clearly shown that the interpretation of 'substantially clean' by FGIS is not as rigorously enforced as the Australian standards. This will require further clarification by AQIS to the USA authorities to ensure that ship inspection meets the AQIS export standard. In technical comment provided by a stakeholder, it was recommended that FGIS apply the USA Food Grade Standard for inspection of stowage space as this may minimise the inconsistencies between Australian and USA inspection requirements.

A protocol for offshore treatment of maize needs to include ship survey standards and procedures equivalent to the Australian standard. A pre-clearance visit by an Australian inspector would be required to ensure that the certification body understands the interpretation and application of these standards.

6 ENVIRONMENTAL IMPACT

Environmental concerns associated with the proposed trade are included amongst the issues covered in the preceeding analysis. Weed risk analysis includes specific consideration of environmental impact. Management of the identified risks to cereal production systems are considered adequate to also address any environmental risks, in accordance with obligations arising from the Administrative Procedures made under the Environment Protection and Biodiversity Conservation Act 1999. The requirement for an effective offshore treatment addresses the potential quarantine and environmental risk posed by imports of bulk maize.

7 CONDITIONS FOR IMPORT

Given the disease, arthropod and weed quarantine risk identified, and the practical problems associated with control measures, bulk maize permitted to be imported from the USA in accordance with the proponent's request that the risks be managed outside of Australia, must be subject to the conditions set out below.

The conditions are based on treatment in the USA and reflect the need for an integrated approach given the wide range of pests involved. However, it should be noted that these conditions represent the full range of measures that could be available. Specific conditions for individual shipments may vary depending on the configuration of sourcing, place of treatment and transport systems used.

7.1 Sourcing

To minimise the chance of post-treatment contamination, infection or infestation, the commodity should be sourced from the northern USA States in the maize growing areas, where the incidence of several of the more significant maize diseases is lower than in the southern States and from where Karnal bunt has not been detected in surveys of wheat crops. The northern States also have the advantage of a lower incidence of arthropod pests of concern compared to the southern States, and the weed, *Striga asiatica*, is not present. Note: This requirement may be varied depending on the demonstrated treatment efficacy and the ability to maintain the integrity of the grain after treatment.

7.2 Grade

The permitted maize grade standard should be US No. 2 Grade or better.

Note: Given the earlier conclusion that grain would need to be rendered sterile and disinfected at the port of export in the USA, the likelihood of achieving this outcome is greater if a higher grade of corn is used, since a cleaner starting product provides more latitude in the application of the treatment. It is noted however that if the process used to treat the grain can be shown to be equally effective on other grades of corn then lower grades may be an acceptable alternative.

7.3 Transportation

The selected maize should be transported, for subsequent shipment, to a port on the Pacific Northwest in a manner that preserves its identity.

Note: The USDA stated that grain transport arrangements in the USA are not suited to identity preservation. The RAP therefore considers that certification of source and transport arrangements may be adequate for grain being handled before treatment but would not be sufficient for dealing with grain that was being sourced from specific areas on the basis of area freedom or low prevalence as an alternative to treatment.

7.4 Treatment

The maize should be treated in a facility at the export port to provide a high degree of confidence that all seeds present (i.e. maize, other crop seed admixture and weed seeds) are rendered non-viable and all plant pathogens and arthropod pests present in the grain are killed.

7.5 Post-Treatment Conditioning

The treated maize should be conditioned immediately after treatment in a well cleaned plant to ensure that it is cooled to near ambient temperature and that its inherent moisture content is not more than 14% (wet basis).

Note: The requirement to condition grain to a moisture content of not more than 14% is primarily to maintain quality but does fall within sanitary and phytosanitary regulatory considerations, as it is essential to minimise heating of the grain to prevent the development of mycotoxin producing fungi in the maize, and to reduce the risk of re-infestation or re-infection.

7.6 Verification of Treatment Process

Samples of the treated maize should be collected by either FGIS authorised/licensed personnel or APHIS personnel and forwarded by secure express airfreight to AQIS for analysis to determine the efficacy of treatment. AQIS should also require documentary evidence of the treatment process such as records showing exposure period/temperature details for audit purposes.

Note: The tests for treatment efficacy could be carried out in the USA under FGIS or APHIS supervision subject to agreement with AQIS on conditions for carrying out and reporting these tests.

7.7 Storage Prior to Shipment

The treated and conditioned maize stocks should be stored in a well-cleaned, segregated facility to prevent any contact with untreated grain stocks or confusion as to the special status of the treated maize.

7.8 Loading Path to Export Vessel

The grain-loading path from the storage location to the ship must be thoroughly clean and free from residues from previous grain handling operations.

7.9 Phytosanitary Certification

AQIS would require a phytosanitary certificate issued by APHIS including the treatment details for the maize and certifying that no object of quarantine was detected in representative samples inspected during loading of the vessel. Alternatively, AQIS staff may pre-clear vessels.

7.10 Ship Hygiene

The ship to be loaded would require pre-inspection and certification by FGIS grain inspection staff that stowage space is free from previous cargo residues and live insects, in accordance with AQIS standards for inspection of export grain vessels.

Note: Standard stowage examination procedures are used by FGIS to certify all stowage space examined and result in the issuance of a certificate stating that: “Stowage space examined on the above date and found to be substantially clean, dry, free of insect infestation, and suitable to store or carry grain.”

7.11 On-arrival Inspection

On arrival of the ship in Australia, the treated maize cargo would be inspected by AQIS prior to and during discharge of the cargo, to verify that the condition of the cargo is consistent with the analysis conducted on pre-shipment samples and that the treated maize has not been infested or in any other way contaminated in post-treatment storage or from the ship. Following successful AQIS inspection and any other testing or analysis deemed necessary, the cargo would be released from quarantine for unrestricted movement.

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APPENDIX – 1

Analysis of Stakeholder Comment on
Draft IRA and Revised Draft IRA

1. Issues Raised by Stakeholders

Twenty-two stakeholders raised issues with respect to the draft IRA and 7 additional comments were made on the revised draft IRA. The following table addresses these issues, many of which were raised by more than one stakeholder. Numbers in brackets refer to stakeholders named in Table 1.

Table 1: Stakeholders responding to the draft and revised draft IRA

Stakeholder	Comments
1. Agriculture WA	
2. Australian Wheat Board	
3. Grains Council of Australia	
4. National Agricultural Commodities Marketing Association	
5. Natural Resources and Environment (Vic)	Comment on revised draft
6. Pacific Seeds	
6a. Comment on draft IRA	
6b. Comment on revised draft IRA	
7. Primary Industries and Resources SA	
8. Queensland Department of Primary Industries	
8a. Comment on draft IRA	
8b. Comment on revised draft IRA	
9. Weed Science Consultancy	
10. ALFA	Includes Technical Reviews by Professor Denis C. McGee, Iowa State University and Barry Jacobsen
10a. Comment on draft IRA	
10b. Comment on revised draft IRA	
11. Australian Chicken Meat Federation	
12. Australian Grain Exporters Association	Includes Technical Review by Professor Denis C. McGee, Iowa State University
13. Australian Meat Council	
14. Australian Meat Holdings	
15. Cargill	
16. Meat and Livestock Australia	Separately supplied ACIL Consulting submission was on behalf of MLA. Further comment made on revised draft
16a. ACIL Consulting	
16b. Corn Sourcing Evaluation Report	Corn Sourcing Evaluation Report supplied in confidence, following request from the RAP.
17. National Meat Association of Australia	Includes Technical Review by Professor Denis C. McGee, Iowa State University
18. Rangers Valley	
19. Red Meat Advisory Council Limited	Includes Technical Review by Professor Denis C. McGee, Iowa State University
20. Stock Feed Manufacturers' Association	
21. USDA	
22. South Pacific Trade Commission	
23. Peter Rothwell (Private Consultant)	Comment on revised draft only
24. NSW Farmers Federation	Late comment on revised draft

Issue No 1: A number of stakeholders, commenting that USA maize is or may be imported by Japan, India and Chile, considered that the conditions under which this trade is allowed should be taken into account (10a, 10b, 12, 16a, 17, 18, 19).

RAP response: The RAP does not know the conditions under which USA maize may be exported to these countries and is not aware of any published pest risk analysis in relation to such trade. Decisions made by other countries on maize imports from the USA would be based on risk profiles, pest status and the appropriate level of protection specific to those countries and therefore are not relevant for Australia.

Issue No 2: Economic benefits were not evaluated and weighted against costs to be incurred from an incursion of a quarantine pest (10a, 11, 12, 16, 16a, 17, 18, 19, 20). The RAP used a ‘nil risk’ approach (10a, 10b, 14, 15, 16a).

RAP response: The RAP does not know the conditions under which USA maize may be exported to these countries and is not aware of any published pest risk analysis in relation to such trade. Decisions made by other countries on maize imports from the USA would be based on risk profiles, pest status and the appropriate level of protection specific to those countries and therefore are not relevant for Australia.

Consistent with WTO rules, individual quarantine access decisions cannot take into account the economic benefits which might be derived from trade nor “social issues”. However, the potential impacts of pests are a legitimate issue for risk analysis and are the subject of this IRA. Economic considerations to be taken into account are set out in article 5.3 of the SPS Agreement.

Issue No 3: Economic and social issues were not addressed in accordance with the 1996 Review of Australian Quarantine (11, 16).

RAP response: While the level of risk that would be acceptable is not nil, the RAP determined that the acceptable level of risk was clearly exceeded by the risk associated with the proposed trade and that a sterilising treatment was necessary to reduce the risk to an acceptable level.

Issue No 4: Economic and social issues were not addressed in accordance with the 1996 review of Australian quarantine (11, 16).

RAP response: Pest Risk Analysis procedures recommended by the International Plant Protection Convention (IPPC) have been followed (see Annex 2, Part 2 of the AQIS Import Risk Analysis Process Handbook). These procedures set out the criteria for assessing economic importance based on establishment potential, spread potential and potential economic importance of a pest.

Issue No 5: Information contained in an international database on maize pathogens was not utilised (10a).

RAP response: The pathogen TWG undertook an exhaustive examination of the literature on maize pathogens, which did include the database alluded to. This resulted in the production of an annotated list of maize pathogens more comprehensive than any previously produced. Judgements were made on the basis on all available evidence.

Issue No 6: At least some of the 17 quarantine pathogens identified by the RAP had low prevalence in the USA and/or negligible chance of seed transmission (10a, 12, 13, 14, 17, 18, 19, 20).

RAP response: In general the RAP accepts this view; see specific comments on pathogens in Table 12.2. Low prevalence or low probability of seed transmission of a disease may be sufficient to reduce the risk associated with a specific pathogen to an acceptable level.

However there are at least 10 high-risk quarantine pathogens of serious economic concern and on the available data no area of the USA is known to be free of all of these pathogens. Furthermore, seed transmission is not the only potential route of introduction; the RAP regarded admixtures and soil and trash contamination to be a significant pathway for the introduction of several of the pathogens.

Issue No 7: As risk analysis has not been done on 106 pathogens of potential quarantine concern, the IRA is not complete and a decision to grant or refuse import cannot be made until the analysis on these pathogens is complete (2).

RAP response: Risk analyses have not been done on the 106 pathogens for which there are insufficient data for judgement or that are quarantine pathogens of other crops potentially present in admixtures. The technical literature does not contain evidence that any of these 106 pathogens are significant pathogens of maize. Moreover, the RAP considered that risks associated with these pathogens would be managed by treatments to control the major maize pathogens already considered.

Issue No 8: The presence of soil means that soil borne pests, such as nematodes, should be assessed. *Hoplolaimus galeatus* and *Meloidogyne chitwoodi* should have equivalent or greater ranking to those nematodes identified as quarantine pests (1).

RAP response: The RAP accepts this view, although there is some uncertainty that non-cyst forming nematodes would survive transport to Australia. The nematodes referred to in table 4.1 should be regarded as examples of low but real risks that would be managed by the disinfecting treatment protocol recommended in the IRA.

Issue No 9: Six additional weeds associated with maize in the USA were identified as quarantine pests (1).

RAP response: These have been noted and included in the IRA. The proposed phytosanitary measures would manage these additional weeds.

Issue No 10: A number of arthropod pests potentially associated with bulk maize from the USA but not identified in the IRA are declared in Western Australia (1).

RAP response: These insects would be managed by the disinfestation treatment protocol recommended in the IRA.

Issue No 11: The introduction of crops genetically modified for herbicide resistance presents a greater likelihood of transferring resistance into weeds present in Australia than as herbicide resistant biotypes of these weeds potentially present as contaminants of bulk maize imports (16a).

RAP response: The risks associated with the introduction of transgenic crops are subject to close scrutiny for various reasons including those raised by the stakeholder. The RAP is not aware of the release of propagable material in Australia containing genes, introduced by modern techniques, for herbicide resistance. Of the 80 weeds of quarantine concern identified in the IRA, 14 are weeds present in Australia for which resistance to herbicides has developed in the USA. This presents a significant and increased phytosanitary risk to Australia.

Issue No 12: Draft IRA contradicts findings of earlier BRS reports (10, 16a).

RAP response: Although earlier reports suggested that USA maize may present lower quarantine risk to Australia relative to other cereals, a detailed reassessment of the risks was

recommended. This IRA provides that detailed assessment but has a different approach insofar as the proposal under consideration involves the management of all quarantine risk outside of Australia so that transport of maize after arrival is assumed to occur without official supervision.

Issue No 13: No quantitative measurement of risk management options other than heat treatment (availability of more cost effective treatments) (12, 15, 16a, 17, 18, 19, 20).

RAP response: From the draft IRA: “The RAP considered that any treatment, in which it was demonstrated to a high degree of certainty that maize was devitalised and pathogens and pests destroyed, could achieve Australia’s appropriate level of protection.” Steam heat treatment was identified as a method, available with current technology, to achieve this. Biosecurity Australia would nevertheless consider any other technology shown to provide equivalent protection.

Issue No 14: Additional data are needed on the efficacy of grain treatment and testing (2, 4, 5).

RAP response: Biosecurity Australia will require technical data to demonstrate that an appropriate level of protection is achieved under specified conditions. This includes the need, in the case of heat treatment, to properly quantify the time (exposure period) and temperature required.

Issue No 15: There is no mechanism to ensure that appropriate measures specified in the conditions for import would actually be carried out, either in treatment or post treatment control (24).

RAP response: AQIS must be satisfied that all conditions are met before a permit is issued. This will include phytosanitary certification by APHIS and direct supervision and audits by AQIS as deemed necessary.

Issue No 16: As devitalisation is the principle management measure, verification of treatment efficacy, by on arrival testing is essential (6a, 6b).

RAP response: Condition 11, dealing with on arrival inspection, requires that any testing or analysis deemed necessary be conducted by AQIS. Testing for viability of the product would be a component of this.

Issue No 17: Decision is open to WTO challenge or USA retaliation (10b, 12, 13, 16a, 17, 18, 19).

RAP response: The RAP considers the decision is technically sound and conforms to the requirements of the SPS agreement and standards established under the IPPC.

Issue No 18: The IRA should take account of security of feed grain supply (4).

RAP response: This is not a phytosanitary issue.

Issue No 19: The term risk is not used consistently (11, 16, 16a, 20).

RAP response: Biosecurity Australia uses the term ‘risk’ to mean the combination of likelihood and consequences of an event. This is consistent with the normal usage of the term under the International Plant Protection Convention.

Issue No 20: The IRA identifies hazards but does not measure risk (11, 16, 16a, 20).

RAP response: Risk can be evaluated qualitatively, semi-quantitatively or quantitatively. The International Plant Protection Convention and associated standards recognise the validity

of both quantitative and qualitative risk analysis, as did the 1996 Review of Australian Quarantine.

Issue No 21: The draft IRA is not sufficiently quantitative (11, 16, 16a, 20).

Issue No 22: Equal emphasis is given to all pests (11, 16, 16a, 20).

RAP response: Quantitative risk assessment can be used to measure the level of risk, based on the probability of a pest establishment in combination with the cost of such an establishment. Such analysis depends upon the availability of reliable data.

Biosecurity Australia uses quantitative risk assessment wherever appropriate, provided that sufficient reliable data are available. However, as is often the case in such risk assessments, the necessary data are not available to permit quantitative risk assessment in the case of bulk maize from the USA except in relation to the risk presented by potential introduction of new weeds (see appendix - 4).

Issue No 23: Stakeholders did not have sufficient opportunity for comment during preparation of draft IRA or revised draft (10b, 11, 16).

RAP response: Stakeholder input was welcome at all times since the first notification of this IRA in August 1997. Stakeholders have had opportunities to formally comment on the issues paper, the draft IRA and a revised draft IRA. During the preparation of the IRA the RAP has consulted directly and received comment from a number of stakeholders and experts.

Issue No 24: Lack of economic expertise and overseas experience within TWGs (16a).

RAP response: The purpose of the IRA is to assess phytosanitary risk and risk management options and the skills contained within the TWGs were well suited to this task. The RAP sought comment from USDA on a range of technical issues raised by the TWGs and has received technical comment from USDA/ APHIS.

Issue No 25: Undue emphasis was placed on pests of lesser concern, such as Karnal bunt and *Striga* (16a).

RAP response: The RAP holds the view that the importance of these pests warrants consideration but the level of risk with bulk maize shipments was not overstated. For example, it was concluded that the *Striga* issue could be managed by not sourcing maize from the region in the USA in which it is known to be present. Management of the karnal bunt issue would require, *inter alia*, selection of maize from production regions in which this disease has not been found in wheat crops with careful attention to the hygiene of transport employed.

Issue No 26: Soil contamination risks are exaggerated (16a).

Issue No 27: Soil contamination is a serious concern; the list of nematodes of quarantine concern could be expanded because of this (1).

RAP response: Soil, trash and other plant seeds are extremely likely to be present in bulk maize from the USA, having regard to experience with imported grain in the past, direct observation of the USA grain system, and the USDA grains standards.

Issue No 28: One of the nominated pathogens rated as medium to high risk in the IRA has been reported only once in the US since 1928 (10b).

RAP response: The pathogen, *Sclerospora graminicola*, is common in the USA on other grass seeds such as sorghum, and millets that could be present as admixtures in consignments of bulk maize.

Issue No 29: Existing systems in the USA make it impractical and uneconomic to identity preserve bulk maize from specific areas (21).

RAP response: The RAP was unable to identify regions entirely free of all quarantine pests identified. Demonstrated area freedom remains a possible management option; however the USDA response to the draft IRA clearly indicated that the current grain transport and loading systems in the USA are not suited to ensuring identity preservation of bulk maize consignments.

Issue No 30: High reliance is placed on USA cooperation for offshore risk management that will require close scrutiny by AQIS (8a, 8b).

RAP response: Effective post treatment grain security against recontamination is essential. Security and hygiene standards during post treatment storage and transport must meet Australian standards. This minimum requirement is clearly set out under conditions 7-10 (**Section 11**) including the option of a preclearance arrangement if deemed necessary by AQIS.

Corn Sourcing Evaluation Report (16b)

Issue No 1: Commented on 10 pathogens.

RAP response: Addressed in table 2 (Appendix – 1).

Issue No 2: Commented on arthropod pests.

RAP response: Stored product pests are not included in this list of surveyed pests.

Issue No 3: Weed seed issues best addressed using screening equipment to remove contaminants.

RAP response: The Weed TWG determined that screening would not be sufficiently effective particularly as some of the weed seeds are similar to maize in size, and for seeds of any size, screening is not highly efficient.

Issue No 4: Of 13 weeds quarantine of concern listed by AQIS in earlier correspondence, APHIS indicated that 4 were present in Australia but at least 4 were a problem in US grains.

RAP response: The Weed TWG considered these weed species, in addition to many others associated with maize.

Issue No 5: Applying the highest-grade specification would provide additional assurance that the corn is free of weed seeds.

RAP response: The Operations TWG dealt at length with the issue of grade. High US grade specifications do not eliminate the risk.

Issue No 6: Overall view is that USA suppliers are reluctant to supply identity preserved low cost high volume grain.

RAP response: This view is confirmed by the USDA response to the draft IRA. In their response, ALFA accepts that the principle of area freedom may not be a viable option (this

concern is compounded by the possibility of grain originating from a third, unidentified country).

Issue No 7: Grain drying is a common practice. A determination should be made on the efficacy of the practice as a quarantine treatment.

RAP response: Commercial grain drying uses temperature and exposure periods aimed at conditioning the product for subsequent safe storage without adversely affecting the viability of the grain, its processing characteristics or its end use. Weed contaminants in particular are unlikely to be affected by this procedure. Furthermore, given that the dried maize may be stored for some time prior to transport from inland regions and shipment, the likelihood of infestation and cross contamination could be a significant problem.

Issue No 8: Inspection should be conducted by FGIS at Food Grade Standard.

RAP response: This is the only USA standard applied by FGIS that applies a nil tolerance to rust, scale and injurious insect pests. The RAP agrees that this would most closely correspond to Australian standards and should be the minimum standard applied for the inspection of ship stowage space.

Issue No 9: On board fumigation is an option for consignments failing inspection.

RAP response: The Arthropod TWG dealt this with. Ship fumigation cannot be carried out to a reasonable quarantine standard without exacting and inconvenient procedures and then only on certain types of ships.

2. Technical Comments on Pathogens

Specialist technical comment on pathogens identified as quarantine concerns in the draft IRA was commissioned by stakeholders. Additional technical comment provided by stakeholders is also noted in Table 2.

Table 2: Technical comments on pathogens

Specialists comment	RAP comment
<p><i>Peronosclerospora sorghi</i></p> <ul style="list-style-type: none">• Transmission will only occur in seed with moisture content greater than 20%⁶.• Rarely found in USA maize crops with exception of central Illinois. Infected plants are barren^{6, 8}.• Oospores are potentially wind-borne but dispersal depends on significant numbers of oospores from a spillage wind dispersed to a suitable site, incorporating into soil and infecting emerging host seedlings⁶.• Oospores in trash or soil is a legitimate, albeit low risk, pathway⁷.• A serious disease of sorghum that could be present in sorghum admixtures in maize consignments⁷.• Should the pathogen infect a plant, it could remain undetected until widespread; USA pathologists would be reluctant to provide area freedom assurances⁷.• Legitimate quarantine issue⁸.• Seed transmission in immature or freshly harvested seed only⁸.• Survives in soil⁸.	<ul style="list-style-type: none">• Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen (refer page 4 of pathogen TWG report).• Distribution of viable oospores is a risk. Wind dispersal of viable oospores from soil or trash is a particular concern; note detailed comments in Section 4.1.1 of the IRA.

Specialists comment	RAP comment
Maize dwarf mosaic <i>potyvirus</i> (MDMV) <ul style="list-style-type: none"> • A strain of sugarcane mosaic virus, already present in Australia⁶ • Extremely low rate of seed transmission⁶ • Seed transmission not recorded⁸ • Volunteer infected plants arising from spillage could be a risk⁷ • Widespread but of little economic consequence in USA although it causes severe damage in other countries such as Africa⁷ 	<ul style="list-style-type: none"> • Strains A, D, E & F are not recorded in Australia. • The virus is seed transmitted¹.
High Plains <i>tenuivirus</i> (HP) <ul style="list-style-type: none"> • Not recorded in maize east of the Missouri⁶ • No published evidence or unequivocal proof that it is transmitted from seed to seedlings^{7, 8} • Present in Australia?⁹ 	<ul style="list-style-type: none"> • With diagnostic tests only recently developed, the distribution is unclear. There are no confirmed records of this virus in Australia. • It is seed transmitted, according to at least one report². • The vector is in Australia.
Wheat streak mosaic <i>rymovirus</i> (WSMV) <ul style="list-style-type: none"> • Rarely found as a maize pathogen in USA⁶ • Seed transmission rate is < 0.1%⁶ • Seed transmission not recorded⁸ • Corn is bridging crop for this virus⁹ • Sweet corn is more susceptible than maize⁹ 	<ul style="list-style-type: none"> • There is convincing evidence that it is seed transmitted³ and the vector is in Australia. • WSMV and HPV have a common mode of transmission and there is evidence that they form a more virulent complex¹⁰.
<i>Sclerospora graminicola</i> <ul style="list-style-type: none"> • Reported just once in the USA on two plants in 1928^{6, 8} • Not shown to be seed-borne on maize⁶ 	<ul style="list-style-type: none"> • Agree that prevalence in maize is low. • Nevertheless, the pathogen is prevalent in other Poaceae such as Pennisetum and Sorghum that could be present as admixtures.
<i>Phymatotrichopsis omnivora</i> <ul style="list-style-type: none"> • Maize not shown to be a natural host⁶ • Maize and cotton growing areas distinct - Midwest sourced maize has no association with cotton⁷ • Common root pathogen of maize plants⁸ • Soil borne⁸ • No seed transmission⁸ 	<ul style="list-style-type: none"> • Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen. Sclerotia are long lived in soil. • Contamination remains a problem because of difficulties with identity preservation. • Feedlots are present in cotton growing areas in Australia.
Maize chlorotic mottle <i>machlomovirus</i> (MCMV) <ul style="list-style-type: none"> • Little economic impact⁶ • Seed transmitted at very low rate⁶ • Seed transmission not recorded⁸ 	<ul style="list-style-type: none"> • Agree the risk is lower for this pathogen. • The virus is seed transmitted⁴.
<i>Cercospora zeae-maydis</i> <ul style="list-style-type: none"> • No evidence for seed transmission^{6, 8}. • A serious and growing concern in the USA with quarantines on corn in place. This did constitute a real risk⁷. 	<ul style="list-style-type: none"> • Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen.
<i>Pantoea stewartii</i> subsp. <i>stewartii</i> <ul style="list-style-type: none"> • Occurs at low levels in inbred maize lines of seed production fields; rarely found in corn grain fields⁶. • Seed infected sufficiently to transmit pathogen could only arise from severely infected fields⁶. 	<ul style="list-style-type: none"> • Agree that maize resistance reduces risk; this is reflected in the lower ranking. • The pathogen can survive in trash

Specialists comment	RAP comment
<ul style="list-style-type: none"> Seed transmission not demonstrated under field conditions⁸. Seed transmission under lab conditions only for sweet corn⁸. Flea beetle vector required spreading this pathogen⁷. Dent corns highly resistant⁸. 	<p>and soil.</p> <ul style="list-style-type: none"> At least one known vector, <i>Delia platura</i>, is present in Australia.
<p><i>Clavibacter michiganensis</i> subsp. <i>nebraskensis</i></p> <ul style="list-style-type: none"> Rarely found in maize fields in USA⁶. Seed transmission only likely in highly infected (inoculated) seeds⁶. No evidence of seed transmission⁸. Detected at low rates in seed of susceptible germplasm⁸. Maize hybrids are highly resistant, accounting for the limited spread^{6,8}. 	<ul style="list-style-type: none"> Agree that maize resistance reduces risk; this is reflected in the lower ranking. The pathogen can survive in plant debris.
<p><i>Heterodera zeae</i></p> <ul style="list-style-type: none"> Soil inhabitant only⁸. 	<ul style="list-style-type: none"> Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen.
<p><i>Ustilaginoidea virens</i></p> <ul style="list-style-type: none"> Obscure disease, one unsubstantiated record in USA in 1929^{6,8}. No evidence that it is seed-borne or transmitted in maize^{6,8}. World wide on rice⁸. 	<ul style="list-style-type: none"> Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen. The pathogen is also seed borne⁵. The pathogen is present on other Poaceae such as <i>Oryza</i>, <i>Digitaria</i> and <i>Panicum</i> that could be present as admixtures.
<p><i>Dolichodorus heterocephalus</i></p> <ul style="list-style-type: none"> Soil inhabitant only⁸. 	<ul style="list-style-type: none"> Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen.
<p><i>Hoplolaimus columbus</i></p> <ul style="list-style-type: none"> Soil inhabitant only⁸. 	<ul style="list-style-type: none"> Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen.
<p><i>Longidorus breviannulatus</i></p> <ul style="list-style-type: none"> Soil inhabitant only⁸. 	<ul style="list-style-type: none"> Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen.
<p><i>Pratylenchus scribneri</i></p> <ul style="list-style-type: none"> Soil inhabitant only⁸. 	<ul style="list-style-type: none"> Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of this pathogen.
<p>General comments</p> <ul style="list-style-type: none"> The grain handling system in the USA is such that shipments would consist of a “cocktail of corn” with no control over origin⁷. Throughput pressures do not allow for delays during transport for pathogen testing⁷. Saprophytic fungi only recorded on stalks and decaying seed therefore unlikely to be associated with sound seed shipments⁸. 	<ul style="list-style-type: none"> Soil and trash are likely to be present in bulk maize consignments from the USA and provide a pathway for entry of pathogens that may not have a high risk of being seed borne or seed transmitted.

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2. Forster, R. P., Strausleugh, C. A., Jensen, S. G., Harvey T. & Seifers, D. L. (1996). Investigation of seed transmission of the High Plains disease in sweet corn. International Seed Testing Association Plant Disease Committee Symposium. Cambridge, England.
3. Hill, J. H., Martinson, C. A. & Russell W. A. (1974). Seed transmission of maize dwarf mosaic and wheat streak mosaic virus in maize and response of inbred lines. *Crop Science* 14: 232-5.
4. Jenson, S. G., Wysong, D. S., Ball, E. M. & Higley P. M. (1991). Seed transmission of maize chlorotic virus. *Plant Disease* 75: 497-8.
5. Richardson, M. J. (1990). An annotated list of seed-borne diseases. The International Seed Testing Association. Zurich. 335 pp.
6. McGee D. Written technical comment included in the submissions of several stakeholders (Table 12.1).
7. McGee, D. (1999). Telephone discussion with RAP, October 1999.
8. Jacobsen, B. Written technical comment included in the submission of a stakeholder (Table 12.1)
9. Other technical comment provided by stakeholders
10. Marcon, A., Kaeppler, S.M. & Jensen S.G. 1997. Genetic variability among maize inbred lines for resistance to the High Plains virus - wheat streak mosaic virus complex. *Plant Disease* 81: 195–198.

APPENDIX – 2

Quarantine status of pathogens, pests and weeds associated
with bulk grain imports from the USA

Table: 1A Quarantine status of pathogens associated with bulk grain imports from the USA

Pathogen	Disease	Present in USA	Present in Australia	Australian quarantine status	Present in pathway	Potential economic impact	Probability of introduction	Quarantine management required
BACTERIA								
<i>Acidovorax avenae</i> subsp. <i>avenae</i> (Manns) Willems <i>et al.</i>	Bacterial leaf blight	Yes	Yes	Races?	Yes	Yes		?
<i>Bacillus subtilis</i> (Ehrenberg) Cohn	Kernel rot; blight	Yes	Yes	Non-quarantine				
<i>Burkholderia andropogonis</i> (Smith) Gillis <i>et al.</i>	Bacterial stripe	Yes	Yes	Non-quarantine				
<i>Clavibacter michiganensis</i> subsp. <i>nebraskensis</i> (Vidaver & Mandel) Davis <i>et al.</i>	Goss's bacterial wilt and blight	Yes	No	Quarantine	Yes	Yes	Medium	Yes
<i>Erwinia carotovora</i> subsp. <i>carotovora</i> (Jones) Bergey <i>et al.</i>	Bacterial stalk and top rot	Yes	Yes	Non-quarantine				
<i>Erwinia chrysanthemi</i> pv. <i>zeae</i> (Sabet) Victoria <i>et al.</i>	Bacterial stalk and top rot	Yes	Yes	Non-quarantine				
<i>Erwinia dissolvens</i> (Rosen) Burkholder	Bacterial stalk rot	Yes	No	Quarantine	Yes	No		
<i>Erwinia herbicola</i> (Lohnis) Dye	Halo blight of corn	Yes	Yes	Non-quarantine				
<i>Pantoea stewartii</i> subsp. <i>stewartii</i> (Smith) Mergaert <i>et al.</i>	Stewart's bacterial wilt	Yes	No	Quarantine	Yes	Yes	Medium	Yes
<i>Pseudomonas syringae</i> pv. <i>lapse</i> (Ark) Young <i>et al.</i>	Bacterial stalk rot	Yes	No	Quarantine	Yes	No		
<i>Pseudomonas syringae</i> pv. <i>syringae</i> van Hall	Bacterial spot	Yes	Yes	Non-quarantine				
<i>Pseudomonas syringae</i> pv. <i>coronafaciens</i> (Elliott) Young <i>et al.</i>	Chocolate spot	Yes	Yes	Non-quarantine				
<i>Xanthomonas vasicola</i> pv. <i>holcicola</i> (Elliott) Vauterin <i>et al.</i>	Bacterial leaf spot	Yes	Yes	Non-quarantine				
FUNGI								
<i>Absidia corymbifera</i> (Cohan) Sacc. & Trott.		Yes	No	Quarantine	Yes	No		
<i>Absidia repens</i> Tiegh		Yes	No	Quarantine	Yes	No		
<i>Acremonium strictum</i> Gams	Black bundle	Yes	Yes	Non-quarantine				
<i>Acremonium zeae</i> Gams & Sumner	Acremonium stalk rot	Yes	Yes	Non-quarantine				
<i>Acrodictys erecta</i> (Ellis & Everh.) Ellis		Yes	No	Quarantine	Yes	No		

Pathogen	Disease	Present in USA	Present in Australia	Australian quarantine status	Present in pathway	Potential economic impact	Probability of introduction	Quarantine management required
<i>Actinomucor elegans</i> (Eidam) Benjamin & Hesseltine		Yes	Yes	Non-quarantine				
<i>Alternaria alternata</i> (Fr.:Fr.) Keissl.	Alternaria leaf blight	Yes	Yes	Non-quarantine				
<i>Alternaria longissima</i> Deighton & MacGarvie	Stalk rot	Yes	Yes	Non-quarantine				
<i>Ascochyta ischaemi</i> Sacc.	Yellow leaf blight	Yes	No	Quarantine	Yes	No		
<i>Ascochyta maydis</i> Stout.	Ascochyta leaf blight	Yes	No	Quarantine	Yes	No		
<i>Ascochyta tritici</i> Hori & Enjoji		Yes	No	Quarantine	Yes	No		
<i>Ascochyta zeicola</i> Ellis & Everh.	Ascochyta leaf spot	Yes	Yes	Non-quarantine				
<i>Aspergillus alliaceus</i> Thom & Church		Yes	Yes	Non-quarantine				
<i>Aspergillus caespitosus</i> Raper & Thom		Yes	No	Quarantine	Yes	No		
<i>Aspergillus candidus</i> Link		Yes	Yes	Non-quarantine				
<i>Aspergillus carbonarius</i> (Bainier) Thom		Yes	Yes	Non-quarantine				
<i>Aspergillus chevalieri</i> (Mangin) Thom & Church var. <i>intermedius</i>		Yes	No	Quarantine	Unknown			?
<i>Aspergillus clavatus</i> Desmaz.		Yes	Yes	Non-quarantine				
<i>Aspergillus echinulatus</i> (Delacr.) Thom & Church		Yes	No	Quarantine	Unknown			?
<i>Aspergillus elegans</i> Gasp.		Yes	No	Quarantine	Unknown			?
<i>Aspergillus equitis</i> Samson & Gams		Yes	Yes	Non-quarantine				
<i>Aspergillus flavipes</i> (Bainier & Sartory) Thom & Church		Yes	Yes	Non-quarantine				
<i>Aspergillus flavus</i> Link: Fr.		Yes	Yes	Non-quarantine				
<i>Aspergillus fumigatus</i> Fresen.		Yes	Yes	Non-quarantine				
<i>Aspergillus glaucus</i> Link: Fr.	Aspergillus ear rot; yellow mould	Yes	Yes	Non-quarantine				
<i>Aspergillus hollandicus</i> Samson & Gams		Yes	Yes	Non-quarantine				
<i>Aspergillus mangini</i> Thom & Raper		Yes	No	Quarantine	Unknown			?
<i>Aspergillus nidulellus</i> Samson & Gams		Yes	Yes	Non-quarantine				
<i>Aspergillus niger</i> Tiegh.	Aspergillus ear rot; black mould	Yes	Yes	Non-quarantine				
<i>Aspergillus ochraceus</i> Wilh.		Yes	Yes	Non-quarantine				

Pathogen	Disease	Present in USA	Present in Australia	Australian quarantine status	Present in pathway	Potential economic impact	Probability of introduction	Quarantine management required
<i>Aspergillus parasiticus</i> Speare		Yes	Yes	Non-quarantine				
<i>Aspergillus reptans</i> Samson & Gams		Yes	Yes	Non-quarantine				
<i>Aspergillus restrictus</i> Sm.		Yes	Yes	Non-quarantine				
<i>Aspergillus rubrobrunneus</i> Samson & Gams		Yes	No	Quarantine	Unknown			?
<i>Aspergillus stellifer</i> Samson & Gams		Yes	No	Quarantine	Unknown			?
<i>Aspergillus sulphureus</i> (Fresen.) Wehmer		Yes	No	Quarantine	Unknown			?
<i>Aspergillus sydowii</i> (Bainier & Startory) Thom & Church		Yes	Yes	Non-quarantine				
<i>Aspergillus tamaris</i> Kita		Yes	No	Quarantine	Unknown			?
<i>Aspergillus unguis</i> (EmilenoWeil & Gaudin) Thom & Raper		Yes	No	Quarantine	Unknown			?
<i>Aspergillus ustus</i> (Bainier) Thom & Raper		Yes	Yes	Non-quarantine				
<i>Aspergillus versicolor</i> (Vuill.) Tiraboschi		Yes	Yes	Non-quarantine				
<i>Aspergillus wentii</i> Wehmer		Yes	Yes	Non-quarantine				
<i>Aureobasidium pullulans</i> (de Bary) Arnaud	Brown spot	Yes	Yes	Non-quarantine				
<i>Aureobasidium zeae</i> (Narita & Hiratsuka) Dingley	Eye spot; brown spot	Yes	No	Quarantine	Unknown			?
<i>Basidiobotrys pallida</i> (Berk. & Curtis) Hughes		Yes	No	Quarantine	Unknown			?
<i>Bipolaris australiensis</i> (Ellis) Tsuda & Ueyama	Leaf spot	Yes	Yes	Non-quarantine				
<i>Bipolaris cynodontis</i> (Marig.) Shoemaker	Leaf spot	Yes	Yes	Non-quarantine				
<i>Bipolaris hawaiiensis</i> (Ellis) Uchida & Aragaki	Helminthosporium leaf spot	Yes	Yes	Non-quarantine				
<i>Bipolaris maydis</i> (Nisikadad Miyaka) Shoemaker	Southern leaf blight	Yes	Yes	Races?	Yes	Yes		?
<i>Bipolaris sacchari</i> (Butler) Shoemaker		Yes	Yes	Non-quarantine				
<i>Bipolaris setariae</i> (Sawada) Shoemaker	Spot blotch	Yes	Yes	Non-quarantine				
<i>Bipolaris sorghicola</i> (Lefebvre & Sherwin) Alcorn		Yes	Yes	Non-quarantine				
<i>Bipolaris sorokiniana</i> (Sacc.) Shoemaker	Helminthosporium root rot	Yes	Yes	Non-quarantine				
<i>Bipolaris urochloae</i> (Putterill) Shoemaker	Leaf spot	Yes	Yes	Non-quarantine				

Pathogen	Disease	Present in USA	Present in Australia	Australian quarantine status	Present in pathway	Potential economic impact	Probability of introduction	Quarantine management required
<i>Bipolaris victoriae</i> (Meehan & Murphy) Shoemaker		Yes	Yes	Non-quarantine				
<i>Bipolaris zeicola</i> (Stout) Shoemaker	Northern leaf blight	Yes	Yes	Races?	Yes	Yes		?
<i>Blakeslea trispora</i> Thaxt.		Yes	Yes	Non-quarantine				
<i>Botryosphaeria disrupta</i> (Berk. & Curtis) Arx & Mueller	Ear rot	Yes	No	Quarantine	Unknown			?
<i>Botryosphaeria festucae</i> (Lib.) Arx & Mueller	Ear rot	Yes	Yes	Non-quarantine				
<i>Botryosphaeria quercuum</i> (Schwein.) Sacc.	Ear rot	Yes	Yes	Non-quarantine				
<i>Botryosphaeria rhodina</i> (Cooke) Arx	Ear rot	Yes	No	Quarantine	Unknown			?
<i>Botryosphaeria zeae</i> (Fr.)	Grey ear rot	Yes	Yes	Non-quarantine				
<i>Botrytis cinerea</i> Pers.: Fr.	Botrytis stalk rot	Yes	Yes	Non-quarantine				
<i>Byssosclamyces nivea</i> Westling		Yes	No	Quarantine	Unknown			?
<i>Candida albicans</i> (robin) Berkhout		Yes	No	Quarantine	Unknown			?
<i>Candida guilliermondii</i> (Castellani) Langeron & Guerra		Yes	No	Quarantine	Unknown			?
<i>Candida intermedia</i> (Cif. & Ashford) Langeron & Guerra		Yes	No	Quarantine	Unknown			?
<i>Candida krusei</i> (Castellani) Berkhout		Yes	Yes	Non-quarantine				
<i>Candida parapsilosis</i> (Ashford) Langeron & Talice		Yes	No	Quarantine	Unknown			?
<i>Candida pseudotropicalis</i> (Castellani) Basgal		Yes	No	Quarantine	Unknown			?
<i>Ceratocystis paradoxa</i> (Dade) Moreau	Leaf spot	Yes	Yes	Non-quarantine				
<i>Cercospora sorghi</i> Ellis & Everh.	Grey leaf spot	Yes	Yes	Non-quarantine				
<i>Cercospora zeae-maydis</i> Tehon & Daniels	Grey leaf spot	Yes	No	Quarantine	Yes	Yes	Medium	Yes
<i>Chaetomium bostrychodes</i> Zopf		Yes	No	Quarantine	Unknown			?
<i>Chaetomium brasiliense</i> Batista & Pontual		Yes	No	Quarantine	Unknown			?
<i>Chaetomium dolichoptrichum</i> Ames		Yes	No	Quarantine	Unknown			?
<i>Chaetomium funicola</i> Cooke		Yes	Yes	Non-quarantine				
<i>Chaetomium globosum</i> Kunze: Fr.		Yes	Yes	Non-quarantine				
<i>Chaetomium indicum</i> Corda		Yes	Yes	Non-quarantine				
<i>Chaetomium murorum</i> Corda		Yes	No	Quarantine	Unknown			?

Pathogen	Disease	Present in USA	Present in Australia	Australian quarantine status	Present in pathway	Potential economic impact	Probability of introduction	Quarantine management required
<i>Chaetomium torulosum</i> Bainier		Yes	No	Quarantine	Unknown			?
<i>Chrysonilia sitophila</i> (Mont.) Arx		Yes	Yes	Non-quarantine				
<i>Ciccinella muscae</i> (Sorokin) Berl. & DE Toni		Yes	No	Quarantine	Unknown			?
<i>Cladosporium cladosporioides</i> (Fresen.) De Vries	Cladosporium rot	Yes	Yes	Non-quarantine				
<i>Cladosporium herbarum</i> (Pers.: Fr.) Link	Cob mould	Yes	Yes	Non-quarantine				
<i>Cladosporium macrocarpum</i> Preuss	Cob mould	Yes	Yes	Non-quarantine				
<i>Cladosporium tenuissimum</i> Cooke		Yes	Yes	Non-quarantine				
<i>Cladosporium zeae</i> Peck		Yes	No	Quarantine	Unknown			?
<i>Colletotrichum cereale</i> Manns in Selby & Manns		Yes	No	Quarantine	Unknown			?
<i>Colletotrichum graminicola</i> (Ces.) Wils.	Anthraxnose	Yes	Yes	Races?	Yes	Yes		?
<i>Coniothyrium scirpi</i> Trail	Leaf spot	Yes	Yes	Non-quarantine				
<i>Corynascus sepedonium</i> (Emmons) Arx		Yes	Yes	Non-quarantine				
<i>Cryptococcus laurentii</i> (Kuff.) Skinner		Yes	No	Quarantine	Unknown			?
<i>Curvularia brachyspora</i> Boedijn	Leaf spot	Yes	Yes	Non-quarantine				
<i>Curvularia clavata</i> P.C. Jain	Leaf spot	Yes	Yes	Non-quarantine				
<i>Curvularia eragrostidis</i> (Henn.) Meyer	Curvularia leaf spot	Yes	Yes	Non-quarantine				
<i>Curvularia geniculata</i> (Tracy & Earle) Boedijn	Curvularia leaf spot	Yes	Yes	Non-quarantine				
<i>Curvularia gudauskasii</i> (Morgan-Jones & Karr)	Leaf spot	Yes	Yes	Non-quarantine				
<i>Curvularia inequalis</i> (Shear) Boedijn	Curvularia leaf spot	Yes	Yes	Non-quarantine				
<i>Curvularia intermedia</i> Boedijn	Curvularia leaf spot	Yes	Yes	Non-quarantine				
<i>Curvularia lunata</i> (Wakk.) Boedijn	Curvularia leaf spot	Yes	Yes	Non-quarantine				
<i>Curvularia pallescens</i> Boedijn	Curvularia leaf spot	Yes	Yes	Non-quarantine				
<i>Curvularia senegalensis</i> (Speg.) Subramanian	Curvularia leaf spot	Yes	Yes	Non-quarantine				
<i>Curvularia tuberculata</i> P.C. Jain	Leaf spot	Yes	Yes	Non-quarantine				
<i>Dendrophoma zeae</i> Tehon		Yes	Yes	Non-quarantine				
<i>Diaporthe phaseolorum</i> (Cooke & Ellis) Sacc.	Seedling blight	Yes	Yes	Non-quarantine				
<i>Dictyochoeta fertilis</i> (Hughes & Kendrick) Holubova-Jechova	Root rot	Yes	Yes	Non-quarantine				

Pathogen	Disease	Present in USA	Present in Australia	Australian quarantine status	Present in pathway	Potential economic impact	Probability of introduction	Quarantine management required
<i>Dictyochora gambellii</i> Fairm.		Yes	No	Quarantine	Unknown			?
<i>Didymella exitialis</i> (Morini) Mueller	Didymella leaf spot	Yes	Yes	Non-quarantine				
<i>Didymium iridis</i> (Ditmar) Fr.		Yes	No	Quarantine	Unknown			?
<i>Didymosphaeria graminicola</i> Ellis & Everh.		Yes	No	Quarantine	Unknown			?
<i>Diplodia maydis</i> (Berk.) Sacc.	Diplodia ear and stalk rot	Yes	Yes	Non-quarantine				
<i>Doratomyces stemonitis</i> (Per.: Fr.) Morton & Sm.	Ear rot	Yes	Yes	Non-quarantine				
<i>Epicoccum nigrum</i> Link	Red kernel disease	Yes	Yes	Non-quarantine				
<i>Exserohilum monoceras</i> (Drechs.) Leonard & Suggs	Leaf blotch	Yes	Yes	Non-quarantine				
<i>Exserohilum pedicellatum</i> (Henry) Leonard & Suggs	Helminthosporium root rot	Yes	Yes	Non-quarantine				
<i>Exserohilum prolatum</i> Leonard & Suggs	Exserohilum leaf spot	Yes	Yes	Non-quarantine				
<i>Exserohilum rostratum</i> (Drechs.) Leonard & Suggs	Helminthosporium leaf disease	Yes	Yes	Non-quarantine				
<i>Exserohilum turcicum</i> (Pass.) Leonard & Suggs	Northern leaf blight	Yes	Yes	Races?	Yes	Yes	Medium	?
<i>Fusarium acuminatum</i> Ellis & Everh.	Root and stem rot	Yes	Yes	Non-quarantine				
<i>Fusarium avenaceum</i> (Fr.: Fr.) Sacc.	Stalk and root rot	Yes	Yes	Non-quarantine				
<i>Fusarium chlamydosporum</i> Wollenweb. & Reinking	Root rot	Yes	Yes	Non-quarantine				
<i>Fusarium crookwellense</i> Burgess <i>et al.</i>	Stem rot	Yes	Yes	Non-quarantine				
<i>Fusarium culmorum</i> (Wm. G. Sm.) Sacc.	Stalk rot	Yes	Yes	Non-quarantine				
<i>Fusarium episphaeria</i> (Tode) Snyder & Hans.	Stalk rot	Yes	Yes	Non-quarantine				
<i>Fusarium equiseti</i> (Corda) Sacc.	Stalk rot	Yes	Yes	Non-quarantine				
<i>Fusarium graminearum</i> Schwabe	Gibberella stalk rot	Yes	Yes	Non-quarantine				
<i>Fusarium merismoides</i> Corda	Stalk rot	Yes	Yes	Non-quarantine				
<i>Fusarium moniliforme</i> Sheld.	Fusarium ear and stalk rot	Yes	Yes	Non-quarantine				
<i>Fusarium oxysporum</i> Schlechtend.: Fr.	Root rot	Yes	Yes	Non-quarantine				

Pathogen	Disease	Present in USA	Present in Australia	Australian quarantine status	Present in pathway	Potential economic impact	Probability of introduction	Quarantine management required
<i>Fusarium pallidoroseum</i> (Cooke) Sacc.	Root rot	Yes	Yes	Non-quarantine				
<i>Fusarium poae</i> (Peck) Wollenweb.	White cob rot	Yes	Yes	Non-quarantine				
<i>Fusarium proliferatum</i> (Matsushima) Nirenberg	Root rot	Yes	Yes	Non-quarantine				
<i>Fusarium roseum</i> Link: Fr.	Root rot	Yes	Yes	Non-quarantine				
<i>Fusarium sacchari</i> (Butler) Gams	Root rot	Yes	No	Quarantine	Yes	No		
<i>Fusarium solani</i> (Mart.) Sacc.	Stalk rot	Yes	Yes	Non-quarantine				
<i>Fusarium subglutinans</i> (Wollenweb. & Reinking) Nelson <i>et al.</i>	Fusarium stalk and ear rot	Yes	Yes	Non-quarantine				
<i>Fusarium tricinctum</i> (Corda) Sacc	Root rot	Yes	Yes	Non-quarantine				
<i>Fusisporium cerealis</i> Cooke	Root rot	Yes	No	Quarantine	Unknown	No		
<i>Gaeumannomyces graminis</i> (Sacc.) Arx & Olivier	Root rot	Yes	Yes	Non-quarantine				
<i>Geotrichum candidum</i> Link	Stalk rot	Yes	Yes	Non-quarantine				
<i>Gibberella cyanogena</i> (Desmaz.) Sacc.	Root rot	Yes	Yes	Non- quarantine				
<i>Gibberella pulicaris</i> (Fr.: Fr.) Sacc.	Root rot	Yes	Yes	Non-quarantine				
<i>Glabrocyphella ellisiana</i> Cooke		Yes	No	Quarantine	Unknown			?
<i>Gloeocercospora sorghi</i> Bain & Edgerton ex Deighton	Zonate leaf spot	Yes	No	Quarantine	Unknown			?
<i>Glomerella tucumanensis</i> (Speg.) Arx & Mueller		Yes	Yes	Non-quarantine				
<i>Gonatobotrys simplex</i> Corda	Gonatobotrys seed rot	Yes	Yes	Non-quarantine				
<i>Gonatobotrys zeae</i> Futrell & Bain	Gonatobotrys seed rot	Yes	No	Quarantine	Yes	No		
<i>Graphium penicillioides</i> Corda	Leaf spot	Yes	No	Quarantine	Yes	No		
<i>Hansenula anomala</i> (Hans.) Syd. & Syd.		Yes	No	Quarantine	Yes	No		
<i>Harzia acremonioides</i> (Harz) Costantin		Yes	Yes	Non-quarantine				
<i>Helminthosporium ahmadii</i> Ellis	Leaf spot	Yes	No	Quarantine	Yes	No		
<i>Illosporium pallidum</i> Cooke		Yes	No	Quarantine	Unknown	No		
<i>Isariopsis subulata</i> Ellis & Everh.		Yes	No	Quarantine	Unknown	No		
<i>Lasioidiplodia theobromae</i> (Pat) Griffon &	Black kernel rot	Yes	Yes	Non-quarantine				

Pathogen	Disease	Present in USA	Present in Australia	Australian quarantine status	Present in pathway	Potential economic impact	Probability of introduction	Quarantine management required
Maubl.								
<i>Lecanidion atratum</i> (Hedw.) Rabenh.		Yes	Yes	Non- quarantine				
<i>Leptosphaeria macrospora</i> (Fuckel) Thuem.	Leaf spot	Yes	No	Quarantine	Yes	No		
<i>Leptosphaeria maydis</i> Stout	Leaf spot	Yes	No	Quarantine	Unknown	No		
<i>Leptosphaeria variisepta</i> Stout	Leaf spot	Yes	No	Quarantine	Yes	No		
<i>Leptosphaerulina trifolii</i> (Rostr.) Petr.		Yes	Yes	Non-quarantine				
<i>Leptothyrium zeae</i> Stout	Leaf spot	Yes	No	Quarantine	Yes	No		
<i>Ligniera junci</i> (Schwartz) Maire & Tison		Yes	No	Quarantine	Yes	No		
<i>Lophiosphaera zeicola</i> Ellis & Everh.		Yes	No	Quarantine	Unknown			?
<i>Lophiostoma arundinis</i> (Pers.: Fr.) Ces. & De Not)		Yes	No	Quarantine	Unknown			?
<i>Macrophomina phaseolina</i> (Tassi) Goidanich	Charcoal rot	Yes	Yes	Non-quarantine				
<i>Macrosporium maculatum</i> Cooke & Ellis in Sumstein, nom. nud.		Yes	No	Quarantine	Yes	No		
<i>Marasmius graminum</i> (Lib.) Berk.	Seedling and foot rot	Yes	Yes	Non-quarantine				
<i>Marasmius sacchari</i> Wakk.	Marasmius root and stalk rot	Yes	Yes	Non-quarantine				
<i>Mariannaea elegans</i> (Corda) Samson	Stalk rot	Yes	Yes	Non-quarantine				
<i>Massarina arundinacea</i> (Sowerby: Fr.) Leuchtmann		Yes	No	Quarantine	Yes	No		
<i>Melanospora zamiae</i> Corda		Yes	No	Quarantine	Unknown			?
<i>Microascus cinereus</i> (EmilenoWeil & Gaudin) Curzi		Yes	No	Quarantine	Yes	No		
<i>Microascus cirrosus</i> Curzi		Yes	No	Quarantine	Yes	No		
<i>Microascus desmosporus</i> (Lechmere) Curzi		Yes	No	Quarantine	Unknown			?
<i>Microascus longirostris</i> Zukal		Yes	No	Quarantine	Yes	No		
<i>Microdochium bolleyi</i> (Sprague) De Hoog & Hermanides-Nijhof	Microdochium root rot	Yes	Yes	Non-quarantine				
<i>Microdochium nivale</i> (Fr.) Samuels & Hallett	Microdochium root rot	Yes	Yes	Non-quarantine				
<i>Monascus purpureus</i> Went	Silage mould	Yes	No	Quarantine	Unknown			?
<i>Monascus ruber</i> Diegh.	Silage mould	Yes	No	Quarantine	Unknown			?

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<i>Mucor circinelloides</i> Teigh.		Yes	Yes	Non-quarantine				
<i>Mucor fragilis</i> Bainier	Seedling rot	Yes	Yes	Non-quarantine				
<i>Mucor heimalis</i> Wehmer		Yes	No	Quarantine	Yes	No		
<i>Mucor mucedo</i> Mich. Ex Saint-Amans		Yes	No	Quarantine	Yes	No		
<i>Mucor plumbeus</i> Bonord.		Yes	Yes	Non-quarantine				
<i>Mucor racemosus</i> Fresen.		Yes	Yes	Non-quarantine				
<i>Mycosphaerella zeae</i> (Sacc.) Woronow	Leaf blight	Yes	No	Quarantine	Yes	No		
<i>Myrothecium cinctum</i> (Corda) Sacc.	Root rot	Yes	Yes	Non-quarantine				
<i>Myrothecium gramineum</i> Lib.	Shuck rot	Yes	No	Quarantine	Yes	No		
<i>Myrothecium verrucaria</i> (Albertini & Schwein.) Ditmar.: Fr.	Root rot	Yes	Yes	Non-quarantine				
<i>Nigrospora oryzae</i> (Berk. & Broome) Petch	Nigrospora ear rot	Yes	Yes	Non-quarantine				
<i>Nigrospora sphaerica</i> (Sacc.) Mason	Stalk rot	Yes	Yes	Non-quarantine				
<i>Olpitrichum macrosporum</i> (Farl.) Sumstine		Yes	Yes	Non-quarantine				
<i>Olpitrichum tenellum</i> (Berk. & Curtis) Holubova-Jechova		Yes	No	Quarantine	Unknown			?
<i>Ophiliosphaerella herpotricha</i> (Fr.:Fr.) Walker		Yes	No	Quarantine	Unknown			?
<i>Paraphaeosphaeria michotii</i> (Westend.) Eriksson	Leaf spot	Yes	Yes	Non-quarantine				
<i>Penicillium aurantiogriseum</i> Dierckx		Yes	Yes	Non-quarantine				
<i>Penicillium brevicompactum</i> Dierckx		Yes	Yes	Non-quarantine				
<i>Penicillium canescens</i> Sopp		Yes	Yes	Non-quarantine				
<i>Penicillium chrysogenum</i> Thom		Yes	Yes	Non-quarantine				
<i>Penicillium citrinum</i> Thom		Yes	Yes	Non-quarantine				
<i>Penicillium clarviforne</i> Bainier		Yes	No	Quarantine	Unknown			?
<i>Penicillium crustosum</i> Thom		Yes	Yes	Non-quarantine				
<i>Penicillium expansum</i> Link	Penicillium ear rot	Yes	Yes	Non-quarantine	Unknown			?
<i>Penicillium felludanum</i> Biourge		Yes	No	Quarantine	Unknown			?
<i>Penicillium funiculosum</i> Thom		Yes	Yes	Non-quarantine				
<i>Penicillium glabrum</i> (Wehmer) Westling		Yes	No	Quarantine	Unknown			?

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<i>Penicillium granulatum</i> Bainier		Yes	No	Quarantine	Unknown			?
<i>Penicillium griseofulvum</i> Dierckx		Yes	No	Quarantine	Unknown			?
<i>Penicillium herquei</i> Bainier & Sartory		Yes	No	Quarantine	Unknown			?
<i>Penicillium implicatum</i> Biourge		Yes	No	Quarantine	Unknown			?
<i>Penicillium janthinellum</i> Biourge		Yes	No	Quarantine	Unknown			?
<i>Penicillium oxalicum</i> Currie & Thom		Yes	No	Quarantine	Unknown			?
<i>Penicillium puberulum</i> Bainier		Yes	No	Quarantine	Unknown			?
<i>Penicillium purpurogenum</i> Stoll		Yes	No	Quarantine	Unknown			?
<i>Penicillium roquefortii</i> Thom		Yes	No	Quarantine	Unknown			?
<i>Penicillium rugulosum</i> Thom		Yes	No	Quarantine	Unknown			?
<i>Penicillium sclerotiorum</i> Van Beyma		Yes	No	Quarantine	Unknown			?
<i>Penicillium thomii</i> Maire		Yes	No	Quarantine	Unknown			?
<i>Penicillium variabile</i> Sopp		Yes	No	Quarantine	Unknown			?
<i>Penicillium verrucosum</i> Dierckx		Yes	No	Quarantine	Unknown			?
<i>Penicillium viridicatum</i> Westling		Yes	No	Quarantine	Unknown			?
<i>Penicillium waksmanii</i> Zaleski		Yes	No	Quarantine	Unknown			?
<i>Perichaena vermicularis</i> (Schwein.) Rostr.		Yes	Yes	Non-quarantine				
<i>Periconia circinata</i> (Mangin) Sacc.	Root rot	Yes	Yes	Non-quarantine				
<i>Periconia macrospinosa</i> Lefebvre & Johnson in Lefebvre <i>et al.</i>		Yes	Yes	Non-quarantine				
<i>Perisporium zeae</i> Berk. & Curtis		Yes	No	Quarantine	Unknown			?
<i>Peronosclerospora sorghi</i> (Weston & Uppal) Shaw	Sorghum downy mildew	Yes	No	Quarantine	Yes	Yes	High	Yes
<i>Phaeocytostroma ambiguum</i> (Mont.) Petr. in Petr. & Syd.	Phaeocytostroma stalk infection	Yes	Yes	Non-quarantine				
<i>Phaeosphaeria eustoma</i> (Fuckel) Holm	Phaeosphaeria leaf spot	Yes	Yes	Non-quarantine				
<i>Phaeosphaeria herpotricha</i> (De Not) Holm	Phaeosphaeria leaf spot	Yes	Yes	Non-quarantine				
<i>Phaeotrichoconis crotalariae</i> (Salam & Rao) Subram.		Yes	Yes	Non-quarantine				

Pathogen	Disease	Present in USA	Present in Australia	Australian quarantine status	Present in pathway	Potential economic impact	Probability of introduction	Quarantine management required
<i>Phoma americana</i> Morgan-Jones & White	Root rot	Yes	No	Quarantine	Yes	No		
<i>Phoma terrestris</i> Hans.	Pink root; stalk rot	Yes	Yes	Non-quarantine				
<i>Phoma zeicola</i> Ellis & Everh.	Root rot	Yes	No	Quarantine	Yes	No		
<i>Phomopsis</i> sp.	Phomopsis seed rot	Yes	Yes	Non-quarantine				
<i>Phycomyces nitens</i> Kunze		Yes	Yes	Non-quarantine				
<i>Phyllosticta maydis</i> Arny & Nelson	Yellow leaf blight	Yes	No	Quarantine	Yes	No		
<i>Phyllosticta zeae</i> Stout	Phyllosticta leaf spot	Yes	No	Quarantine	Yes	No		
<i>Phymatotrichopsis omnivora</i> (Duggar) Hennebert	Root rot	Yes	No	Quarantine	Yes	Yes	Low	Yes
<i>Physalospora abdita</i> (Berk. & Curtis) Stevens in Voorhees		Yes	No	Quarantine	Unknown			?
<i>Physarum pusillum</i> (Berk. & Curtis) List.	Slime mould	Yes	Yes	Non-quarantine				
<i>Physoderma maydis</i> (Miyabe) Miyabe	Brown spot of maize	Yes	Yes	Non-quarantine				
<i>Physopella pallescens</i> (Arth.) Cummins & Ramachar	Leaf rust	Yes	No	Quarantine	Yes	No		
<i>Phytophthora cactorum</i> (Lebert & Cohn) Schroet.	Root rot	Yes	Yes	Non-quarantine				
<i>Phytophthora drechsleri</i> Tucker	Root rot	Yes	Yes	Non-quarantine				
<i>Phytophthora nicotianae</i> Breda de Haan var. <i>parasitica</i> (Dastur) Waterhouse	Root rot	Yes	Yes	Non-quarantine				
<i>Pithoascus intermedius</i> (Emmons & Dodge) Arx		Yes	No	Quarantine	Unknown			?
<i>Pithoascus schumachrei</i> (Hans.) Arx		Yes	No	Quarantine	Unknown			?
<i>Pithomyces maydicus</i> (Sacc.) Ellis	Ear rot	Yes	No	Quarantine	Yes	No		
<i>Pleospora straminis</i> Sacc. & Speg.		Yes	No	Quarantine	Unknown			?
<i>Podospora minor</i> Ellis & Everh.		Yes	No	Quarantine	Unknown			?
<i>Polyschema olivacea</i> (Ellis & Everh.) Ellis		Yes	No	Quarantine	Unknown			?
<i>Puccinia polysora</i> Underw.	Southern rust	Yes	Yes	Non-quarantine				
<i>Puccinia sorghi</i> Schwein.	Common maize rust	Yes	Yes	Non-quarantine				
<i>Pyricularia grisea</i> (Cooke) Sacc.	White leaf spot	Yes	Yes	Non-quarantine				
<i>Pyronema omphalodes</i> (Bull.: Fr.) Fuckel		Yes	Yes	Non-quarantine				

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<i>Pythium acanthicum</i> Drechs.	Root rot	Yes	No	Quarantine	Yes	No		
<i>Pythium adhaerens</i> Sparrow	Root rot	Yes	No	Quarantine	Yes	No		
<i>Pythium angustatum</i> Sparrow	Root rot	Yes	No	Quarantine	Yes	No		
<i>Pythium aphanidermatum</i> (Edson) Fitzp.	Pythium stalk rot	Yes	Yes	Non-quarantine				
<i>Pythium arrhenomanes</i> Drechs.	Root rot	Yes	Yes	Non-quarantine				
<i>Pythium graminicola</i> Subramanian	Root rot	Yes	Yes	Non-quarantine				
<i>Pythium irregulare</i> Buisman	Seedling blight	Yes	Yes	Non-quarantine				
<i>Pythium myriotylum</i> Drechs.	Root rot	Yes	Yes	Non-quarantine				
<i>Pythium paroeocandrum</i> Drechs.	Root rot	Yes	Yes	Non-quarantine				
<i>Pythium pulchrum</i> Minden	Root rot	Yes	No	Quarantine	Yes	No		
<i>Pythium rostratum</i> Butler	Root rot	Yes	Yes	Non-quarantine				
<i>Pythium splendens</i> Braun	Root rot	Yes	Yes	Non-quarantine				
<i>Pythium sylvaticum</i> Campbell & Hendrix	Seed rot	Yes	No	Quarantine	Yes	No		
<i>Pythium ultimum</i> Trow	Root rot	Yes	Yes	Non-quarantine				
<i>Ramulispora sorghi</i> (Ellis & Everh.) Olive & Lefebvre in Olive <i>et al.</i>	Brown leaf spot	Yes	Yes	Non-quarantine				
<i>Rhizoctonia solani</i> Kühn	Rhizoctonia root rot	Yes	Yes	Non-quarantine				
<i>Rhizoctonia zeae</i> Voorhees	Sclerotial rot	Yes	Yes	Non-quarantine				
<i>Rhizopus arrhizus</i> Fischer	Rhizopus ear rot	Yes	Yes	Non-quarantine				
<i>Rhizopus microsporus</i> Tiegh.	Rhizopus ear rot	Yes	No	Quarantine	Yes	No		
<i>Rhizopus microsporus</i> Tiegh. var. <i>rhizopodiformis</i> (Cohn) Schipper	Rhizopus ear rot	Yes	No	Quarantine	Yes	No		
<i>Rhizopus stolonifer</i> (Ehrenb.: Fr.) Vuill.	Rhizopus ear rot	Yes	Yes	Non-quarantine				
<i>Rhopoglyphus zeae</i> Pat.	Stalk rot	Yes	No	Quarantine	Yes	No		
<i>Sclerophthora macrospora</i> (Sacc.) Thirumalachar <i>et al.</i>	Crazy top	Yes	Yes	Non-quarantine				
<i>Sclerospora graminicola</i> (Sacc.) Schröt.	Graminicola downy mildew; green ear	Yes	No	Quarantine	Yes	Yes	Low	Yes
<i>Sclerotinia sclerotiorum</i> (Lib) de Bary	Sclerotinia stalk rot	Yes	Yes	Non-quarantine				
<i>Sclerotium rolfsii</i> Sacc.	Sclerotium ear rot	Yes	Yes	Non-quarantine				
<i>Scopulariopsis brevicaulis</i> (Sacc.) Bainier	Ear rot	Yes	Yes	Non-quarantine				

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<i>Scopulariopsis brumptii</i> Salvanet-Duval	Ear rot	Yes	Yes	Non-quarantine				
<i>Septoria zeae</i> Stout	Leaf spot	Yes	No	Quarantine	Yes	No		
<i>Septoria zeicola</i> Stout	Leaf spot	Yes	Yes	Non-quarantine				
<i>Septoria zeina</i> Stout	Leaf spot	Yes	No	Quarantine	Yes	No		
<i>Sphaerella paulula</i> Cooke		Yes	No	Quarantine	Unknown			?
<i>Sporidesmium folliculatum</i> (Corda) Mason & Hughes		Yes	No	Quarantine	Unknown			?
<i>Sporisorium holci-sorghii</i> (Rivolta) Vanky	Head smut	Yes	Yes	Races?	Yes	Yes	High	?
<i>Stachybotrys zeae</i> Morgan-Jones & Karr		Yes	No	Quarantine	Unknown			?
<i>Stauronema cruciferum</i> (Ellis) Syd et al.		Yes	No	Quarantine	Unknown			?
<i>Stenocarpella macrospora</i> (Earle) Sutton	Diplodia ear and stalk rot	Yes	Yes	Non-quarantine				
<i>Stenocarpella maydis</i> (Berk.) Sutton	Diplodia ear and stalk rot	Yes	Yes	Non-quarantine				
<i>Sterile white basidiomycete</i> (SWB)	SWB root rot	Yes	No	Quarantine	Yes	No		
<i>Stictis radiata</i> Pers.: Fr.		Yes	No	Quarantine	Unknown			?
<i>Stictis stellata</i> Schwein.		Yes	Yes	Non-quarantine				
<i>Syncephalastrum racemosum</i> Cohn ex Schroet		Yes	Yes	Non-quarantine				
<i>Talaromyces luteus</i> (Zukal) Benjamin		Yes	No	Quarantine	Unknown			?
<i>Talaromyces stipitatus</i> (Thom) Benjamin		Yes	No	Quarantine	Unknown			?
<i>Thamnidium elegans</i> Link: Fr		Yes	No	Quarantine	Unknown			?
<i>Trichoderma koningii</i> Oudem.		Yes	Yes	Non-quarantine				
<i>Trichoderma viride</i> Pers.: Fr.	Trichoderma ear rot	Yes	Yes	Non-quarantine				
<i>Trichothecium roseum</i> (Pers.: Fr.) Link	Pink mould	Yes	Yes	Non-quarantine				
<i>Tritirachium oryzae</i> (Vincens) De Hoog		Yes	No	Quarantine	Unknown	No		
<i>Tubeufia cylindrothecia</i> (Seaver) Höhn		Yes	No	Quarantine	Unknown			?
<i>Typhula phacorrhiza</i> (Reichard: Fr.) Fr.	Snow mould	Yes	No	Quarantine	Unknown			?
<i>Ulocladium lanuginosum</i> (Harz.) Simmons		Yes	No	Quarantine	Unknown			?
<i>Ustilaginoidea virens</i> (Cooke) Takah.	False smut	Yes	No	Quarantine	Yes	Yes	Low	Yes

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<i>Ustilago zeae</i> (Beckm.) Unger	Boil smut	Yes	Yes (under official control)	Quarantine	Unknown			?
<i>Verticillium tenerum</i> (Pers.: Fr.) Link		Yes	Yes	Non-quarantine				
<i>Wolfiporia cocos</i> (Wolf) Ryvarden & Gilbertson	Wood rot	Yes	No	Quarantine	Yes	No		
NEMATODES								
<i>Belonolaimus longicaudatus</i> Rau	Sting nematode	Yes	Yes	Non-quarantine				
<i>Criconea mutabile</i> (Taylor) Raski & Luc	Ring nematode	Yes	Yes	Non-quarantine				
<i>Ditylenchus dipsaci</i> (Kuhn) Filipjev	Bulb and stem nematode	Yes	Yes	Non-quarantine				
<i>Dolichodorus heterocephalus</i> Cobb,	Awl nematode	Yes	No	Quarantine	Yes	Yes	Low	Yes
<i>Filenchus exiguus</i> (de Man) Ebsary		Yes	Yes	Non-quarantine				
<i>Helicotylenchus multicinctus</i> (Cobb) Golden	Spiral nematode	Yes	Yes	Non-quarantine				
<i>Helicothus multicinctus</i> (Cobb) Sher	Spiral nematode	Yes	Yes	Non-quarantine				
<i>Helicotylenchus pseudorobustus</i> (Steiner) Golden	Spiral nematode	Yes	Yes	Non-quarantine				
<i>Heterodera avenae</i> Wollenweb	Cereal cyst nematode	Yes	Yes	Non-quarantine				
<i>Heterodera zeae</i> Koshy <i>et al.</i>	Corn cyst nematode	Yes	No	Quarantine	Yes	Yes	Low	Yes
<i>Hoplolaimus columbus</i> Sher	Lance nematode	Yes	No	Quarantine	Yes	Yes	Low	Yes
<i>Hoplolaimus galeatus</i> (Cobb) Thorne	Lance nematode	Yes	No	Quarantine	Yes	No		
<i>Longidorus breviannulatus</i> Norton & Hoffman	Needle nematode	Yes	No	Quarantine	Yes	Yes	Low	Yes
<i>Macroposthonia ornata</i> (Raski) de Grisse & Loof	Ring nematode	Yes	Yes	Non-quarantine				
<i>Meloidogyne arenaria</i> (Neal) Chitwood	Root-knot nematode	Yes	Yes	Non-quarantine				
<i>Meloidogyne chitwoodi</i> Golden <i>et al.</i>	Root-knot nematode	Yes	No	Quarantine	Yes	Yes	Low	Yes
<i>Meloidogyne incognita</i> (Kofold & White) Chitwood	Root-knot nematode	Yes	Yes	Non-quarantine				
<i>Meloidogyne javanica</i> (Treub) Chitwood	Root-knot nematode	Yes	Yes	Non-quarantine				
<i>Nacobbus dorsalis</i> Thorne & Allen		Yes	No	Quarantine	Yes	No	Low	
<i>Paratrichodorus christiei</i> (Allen) Siddiqi	Stubby-root	Yes	No	Quarantine	Yes	No		

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	nematode							
<i>Pratylenchus brachyurus</i> (Godfrey) Filipjev & Schuurmans Stekhoven	Root lesion nematode	Yes	Yes	Non-quarantine				
<i>Pratylenchus crenatus</i> Loof	Root lesion nematode	Yes	Yes	Non-quarantine				
<i>Pratylenchus hexincisus</i> Taylor & Jenkins	Root lesion nematode	Yes	Yes	Non-quarantine				
<i>Pratylenchus neglectus</i> (Rensch) Filipjev & Schuurmans Stekhoven	Root lesion nematode	Yes	Yes	Non-quarantine				
<i>Pratylenchus penetrans</i> (Cobb) Chitwood & Oteifa	Root lesion nematode	Yes	Yes	Non-quarantine				
<i>Pratylenchus scribneri</i> Steiner	Root lesion nematode	Yes	No	Quarantine	Yes	Yes	Low	Yes
<i>Pratylenchus thornei</i> Sher & Allen	Root lesion nematode	Yes	Yes	Non-quarantine				
<i>Pratylenchus zeae</i> Graham	Root lesion nematode	Yes	Yes	Non-quarantine				
<i>Quinislucius acutus</i> (Allen) Siddiqi	Stubby-root nematode	Yes	No	Quarantine	Yes	No		
<i>Radopholus similis</i> (Cobb) Thorne	Burrowing nematode	Yes	Yes	Non-quarantine				
<i>Rotylenchulus parvus</i> (Williams) Sher	Reniform nematode	Yes	Yes	Non-quarantine				
<i>Tylenchorhynchus dubius</i> (Butschli) Filipjev	Stunt nematode	Yes	Yes	Non-quarantine				
<i>Xiphinema americanum</i> Cobb	Dagger nematode	Yes	Yes	Non-quarantine				
PHYTOPLASMA								
Maize bushy stunt phytoplasma	Maize bush stunt	Yes	No	Quarantine	Unknown			?
<i>Spiroplasma kunkelii</i> Whitcomb <i>et al</i>	Corn stunt	Yes	No	Quarantine	Unknown			?
VIRUSES								
Barley yellow dwarf <i>luteovirus</i> (BSMV)	Barley yellow dwarf	Yes	Yes	Non-quarantine				
Brome mosaic <i>bromovirus</i> (BMV)	Brome mosaic	Yes	Yes	Non-quarantine				
Cucumber mosaic <i>cucumovirus</i> (CMV)	Cucumber mosaic	Yes	Yes	Non-quarantine				
High Plains <i>tenuivirus</i>	High Plains disorder	Yes	No	Quarantine	Yes	Yes	Medium	Yes
Johnson grass mosaic <i>potyvirus</i> (JGMV)	Johnson grass mosaic	Yes	Yes	Non-quarantine				
Maize chlorotic dwarf <i>waikavirus</i> (MCDV)	Maize chlorotic dwarf	Yes	No	Quarantine	Unknown			?

Pathogen	Disease	Present in USA	Present in Australia	Australian quarantine status	Present in pathway	Potential economic impact	Probability of introduction	Quarantine management required
Maize chlorotic mottle <i>maclomovirus</i> (MCMV)	Maize chlorotic mottle	Yes	No	Quarantine	Yes	Yes	High	Yes
Maize dwarf mosaic <i>potyvirus</i> (MDMV)	Maize dwarf mosaic	Yes	No	Quarantine	Yes	Yes	High	Yes
Maize mosaic <i>nucleorhabdovirus</i> (MMV)	Maize mosaic	Yes	No	Quarantine	Unknown			?
Maize rayado fino <i>marafivirus</i> (MRFV)	Maize rayado fino	Yes	No	Quarantine	Unknown	Yes		?
Maize stripe <i>tenuivirus</i> (MSpV)	Maize stripe	Yes	Yes	Non-quarantine	Unknown			?
Maize white line mosaic <i>satellivirus</i>	Maize white line mosaic	Yes	No	Quarantine	Unknown			?
Maize white line mosaic virus (MWLMV)	Maize white line mosaic	Yes	No	Quarantine	Unknown			
Wheat streak mosaic <i>rymovirus</i> (WSMV)	Wheat streak mosaic	Yes	No	Quarantine	Yes	Yes	Medium	Yes
Wheat striate virus (WStMV)	Wheat striate	Yes	No	Quarantine	No			

Table 1B Quarantine status of pests associated with stored maize grain and admixture grain commodities and arthropod pests known to vector maize diseases in North America.

Economic pests that either do not occur on stored maize grain in Australia or are under official control are quarantine pests in accordance with the FAO definition of a quarantine pest. Specific phytosanitary measures are only needed if the pest is associated with the part of the plant proposed to be imported, in this case the seeds. Taking account of this, the final column in the table below identifies those pests, which require quarantine management.

Pest	Common name/s	Present in North America	Present in Australia	Australian quarantine status	Present on pathway (seeds)	Potential economic impact	Probability of introduction	Quarantine management required ⁵
<i>Acanthoscelides obtectus</i>	Bean weevil	North America	Yes	Non-quarantine				
<i>Aceria tosichella</i>	Grass mite	USA	Yes	Non-Quarantine				
<i>Aglossa caprealis</i>	Murky meal moth	USA	Yes	Non-quarantine				
<i>Agriotes mancus</i>	Wheat wireworm	North America	No	Quarantine	No	Medium		
<i>Ahasverus advena</i>	Foreign grain beetle	Canada, USA	Yes	Non-quarantine				
<i>Alphitobius diaperinus</i>	Lesser mealworm	North America	Yes	Non-quarantine				
<i>Alphitobius laevigatus</i>	Black fungus beetle	North America	Yes	Non-quarantine				
<i>Alphitophagus bifasciatus</i>	Two-banded fungus beetle	Canada, USA	Yes	Non-quarantine				
<i>Anthicus</i> spp.	Ant beetles	North America	Yes	Non- quarantine				
<i>Anthrenus</i> spp.	Museum beetle	North America	Yes	Non-Quarantine				
<i>Attagenus</i> spp.	Black carpet beetle	North America	Yes	Non-quarantine				
<i>Bruchus pisorum</i>	Pea weevil	Canada, USA	Yes	Non-quarantine				
<i>Cadra cautella</i>	Tropical warehouse moth	North America	Yes	Non-quarantine				
<i>Cadra figulilella</i>	Raisin moth	USA	Yes	Non-quarantine				
<i>Callosobruchus chinensis</i>	Southern cowpea weevil	Possible in southern USA	No	Non-quarantine				
<i>Callosobruchus maculatus</i>	Cowpea weevil	USA	Yes	Non-quarantine				
<i>Carpophilus</i> spp.	Dried fruit beetles	North America	Yes	Non-quarantine				
<i>Cathartus quadricollis</i>	Square-necked flour beetle	USA-south, Mexico	No	Quarantine	Yes	High	High	Yes
<i>Caulophilus oryzae</i>	Broad nosed grain weevil	SE USA, Mexico	No	Quarantine	Yes	High	Medium	Yes

⁵ Pests assessed, as quarantine pests present in the pathway will be addressed by routine inspection procedures. The risks posed by these pests are reduced to negligibly low levels with a combination of inspection and management strategies, which are outlined in other parts of this document.

Pest	Common name/s	Present in North America	Present in Australia	Australian quarantine status	Present on pathway (seeds)	Potential economic impact	Probability of introduction	Quarantine management required ⁵
<i>Chaetocnema pulicaria</i>	Corn flea beetle	North America	No	Quarantine	No	High		
<i>Corcyra cephalonica</i>	Rice moth	USA, Mexico	Yes	Non-quarantine				
<i>Corticaria spp.</i>	Minute mould beetle	North America	Yes	Non-quarantine				
<i>Cryptolestes ferrugineus</i>	Rusty grain beetle	North America	Yes	Non-quarantine				
<i>Cryptolestes pusilleodes</i>	Flat grain beetle	Mexico	Yes	Non-quarantine				
<i>Cryptolestes pusillus</i>	Flat grain beetle	North America	Yes	Non-quarantine				
<i>Cryptolestes turcicus</i>	Flat grain beetle	Canada, USA	No	Quarantine	Yes	High	Medium	Yes
<i>Cryptophagus spp.</i>		USA, Canada	Yes	Non-quarantine				
<i>Cynaues angustus</i>	Large black flour beetle	Canada, Mexico, USA	No	Quarantine	Yes	High	Medium	Yes
<i>Dalbulus maidis</i>	Corn leafhopper	USA	No	Quarantine	No	Medium		
<i>Deinerella spp.</i>		North America	Yes	Non-quarantine				
<i>Delia platura</i>	Seed corn maggot	North America	Yes	Non-quarantine				
<i>Dermestes spp.</i>	Hide beetles	North America	Yes	Non-quarantine				
<i>Diabrotica sp.</i>	Corn rootworm	North America	Yes	Non-quarantine				
<i>Diabrotica longicornis</i>	Northern corn rootworm	Canada, USA	No	Quarantine	No	Medium		
<i>Diabrotica undecimpunctata</i>	Southern corn rootworm	Canada, USA	No	Quarantine	No	Medium		
<i>Diabrotica virgifera</i>	Western corn rootworm	USA	No	Quarantine	No	Medium		
<i>Dinoderus minutus</i>	Bamboo powder post beetle	North America	Yes	Non-quarantine				
<i>Endrosis sarcitrella</i>	White shouldered house moth	North America	Yes	Non-quarantine				
<i>Enicumus minutus</i>		USA, Canada	Yes	Non-quarantine				
<i>Ephestia elutella</i>	Tobacco moth	North America	Yes	Non-quarantine				
<i>Ephestia kuehniella</i>	Mediterranean flour moth	North America	Yes	Non-quarantine				
<i>Eriophyes tulipae</i>	Wheat curl mite	North America	Yes	Non-quarantine				
<i>Exitianus exitosus</i>	Leafhopper	USA	No	Quarantine	No	Medium		
<i>Gibbium aequinoctiale</i>	Spider beetle	North America	Yes	Non-quarantine				
<i>Gibbium psyllodes</i>	Spider beetle	USA, Mexico	Yes	Non-quarantine				
<i>Glischrochilus fasciatus</i>	Red spotted sap beetle	Canada, USA	No	Quarantine	Yes	High	Medium	Yes
<i>Glischrochilus quadrisignatus</i>	Four spotted sap beetle	Canada, USA	No	Quarantine	Yes	High	Medium	Yes
<i>Gnatocerus cornutus</i>	Broad horned four beetle	North America	Yes	Non-quarantine				

Pest	Common name/s	Present in North America	Present in Australia	Australian quarantine status	Present on pathway (seeds)	Potential economic impact	Probability of introduction	Quarantine management required ⁵
<i>Graminella nigrifrons</i>	Grass leafhopper	USA	No	Quarantine	No	Medium		
<i>Graminella sonora</i>	Grass leafhopper	USA	No	Quarantine	No	Medium		
<i>Henoticus spp.</i>		North America	Yes	Non-quarantine				
<i>Hofmannophila pseudospretella</i>	Brown house moth	North America	Yes	Non-quarantine				
<i>Lachesilla pedicularia</i>	Booklouse	North America	Yes	Non-quarantine				
<i>Lachesilla quercus</i>	Booklouse	North America	Yes	Non-quarantine				
<i>Lasioderma serricorne</i>	Cigarette beetle	North America	Yes	Non-quarantine				
<i>Latheticus oryzae</i>	Longheaded flour beetle	North America	Yes	Non-quarantine				
<i>Lathridius spp.</i>	Plaster beetle	North America	Yes	Non-quarantine				
<i>Lema melanopa</i>	Cereal beetle	Canada, USA	No	Quarantine	No	Medium		
<i>Lepinotus inquilinus</i>	Booklouse	USA	Yes	Non-quarantine				
<i>Lepinotus patruelis</i>	Booklouse	USA	Yes	Non-quarantine				
<i>Liposcelis bostrychophila</i>	Booklouse	North America	Yes	Non-quarantine				
<i>Liposcelis brunnea</i>	Booklouse	USA	Yes	Non-quarantine				
<i>Liposcelis corrosens</i>	Booklouse	USA	Yes	Non-quarantine				
<i>Liposcelis decolor</i>	Booklouse	USA	Yes	Non-quarantine				
<i>Liposcelis entomophila</i>	Booklouse	North America	Yes	Non-quarantine				
<i>Liposcelis paeta</i>	Booklouse	North America	Yes	Non-quarantine				
<i>Liposcelis rufa</i>	Booklouse	USA	Yes	Non-quarantine				
<i>Litargus balteatus</i>		Canada, USA	Yes	Non-quarantine				
<i>Mezium affine</i>	Spiny spider beetle	North America	Yes	Non-quarantine				
<i>Mezium americanum</i>	American spider beetle	North America	Yes	Non-quarantine				
<i>Murmidius ovalis</i>	Murmidius beetle	Canada, USA	Yes	Non-quarantine				
<i>Mycetophagus quadriguttatus</i>	Spotted hairy fungus beetle	Canada, USA	Yes	Non-quarantine				
<i>Nemapogon granella</i>	European grain moth	USA	Yes	Non-quarantine				
<i>Niptus hololeucus</i>	Golden spider beetle	Canada, USA	Yes	Non-quarantine				
<i>Oryzaephilus mercator</i>	Merchant grain beetle	North America	Yes	Non-quarantine				
<i>Oryzaephilus surinamensis</i>	Saw-toothed grain beetle	North America	Yes	Non-quarantine				
<i>Palorus ratzeburgii</i>	Broad horned flour beetle	North America	Yes	Non-quarantine				
<i>Palorus subdepressus</i>	Depressed flour beetle	North America	Yes	Non-quarantine				

Pest	Common name/s	Present in North America	Present in Australia	Australian quarantine status	Present on pathway (seeds)	Potential economic impact	Probability of introduction	Quarantine management required ⁵
<i>Peregrinus maidis</i>	Corn plant hopper	USA	Yes	Non-quarantine				
<i>Pharaxanota kirschi</i>	Mexican grain beetle	USA, Mexico	No	Quarantine	Yes	Low	Medium	Yes
<i>Phyllophaga</i> spp.	May beetle	North America	No	Quarantine	No	Medium		
<i>Plodia interpunctella</i>	Indian meal moth	North America	Yes	Non-quarantine				
<i>Prostephanus truncatus</i>	Larger grain borer, greater grain borer	USA-south, Mexico	No	Quarantine	Yes	High	Medium	Yes
<i>Pseudeurostus hilleri</i>		Canada, USA	Yes	Non-quarantine				
<i>Psocathropos microps</i>		USA	Yes	Non-quarantine				
<i>Ptinus</i> spp.	Spider beetles	North America (temperate regions)	Yes	Non-quarantine				
<i>Pyralis farinalis</i>	Meal moth	Canada, USA	Yes	Non-quarantine				
<i>Rhopalosiphum maidis</i>	Corn leaf aphid	North America	Yes	Non-quarantine				
<i>Rhopalosiphum padi</i>	Bird cherry-oat aphid	North America	Yes	Non-quarantine				
<i>Rhyzopertha dominica</i>	Lesser grain borer	North America	Yes	Non-quarantine				
<i>Sitophilus granarius</i>	Granary weevil	Canada, USA	Yes	Non-quarantine				
<i>Sitophilus oryzae</i>	Rice weevil	North America	Yes	Non-quarantine				
<i>Sitophilus zeamais</i>	Maize weevil	North America	Yes	Non-quarantine				
<i>Sitotroga cerealella</i>	Angoumois grain moth	USA, Mexico	Yes	Non-quarantine				
<i>Stegobium paniceum</i>	Drugstore beetle	North America	Yes	Non-quarantine				
<i>Tenebrio molitor</i>	Yellow mealworm	North America	Yes	Non-quarantine				
<i>Tenebrio obscurus</i>	Dark mealworm	North America	Yes	Non-quarantine				
<i>Tenebroides mauritanicus</i>	Cadelle	Canada, USA	Yes	Non-quarantine				
<i>Tineola bisselliella</i>	Common clothes moth	USA	Yes	Non-quarantine				
Tortricidae spp.	Budworm	North America	Yes	Non-quarantine				
<i>Tribolium audax</i>	American black flour beetle	Canada, USA	No	Quarantine	Yes	Medium	Medium	Yes
<i>Tribolium brevicorne</i>	Flour beetle	Canada, USA	No	Quarantine	Yes	Low	Medium	Yes
<i>Tribolium castaneum</i>	Red flour beetle	North America	Yes	Non-quarantine				
<i>Tribolium confusum</i>	Confused flour beetle	North America	Yes	Non-quarantine				
<i>Tribolium destructor</i>	Large flour beetle	Canada, USA	No	Quarantine	Yes	High	Medium	Yes
<i>Tribolium madens</i>	Black flour beetle	Canada, USA	No	Quarantine	Yes	High	Medium	Yes

Pest	Common name/s	Present in North America	Present in Australia	Australian quarantine status	Present on pathway (seeds)	Potential economic impact	Probability of introduction	Quarantine management required ⁵
<i>Trigonogenius globulus</i>	Globular spider beetle	Canada, USA	Yes	Non-quarantine				
<i>Trogoderma glabrum</i>	Glabrous cabinet beetle	Canada, Mexico, USA	No	Quarantine	Yes	Low	High	Yes
<i>Trogoderma granarium</i>	Khapra beetle	Only interceptions recorded	No	Quarantine	Yes	High	High	Yes
<i>Trogoderma inclusum</i>	Large cabinet beetle	Canada, USA	No	Quarantine	Yes	High	High	Yes
<i>Trogoderma ornatum</i>	Ornate cabinet beetle	USA	No	Quarantine	Yes	Low	High	Yes
<i>Trogoderma variabile</i>	Warehouse beetle	USA	Yes (under official control in WA)	Quarantine	Yes	High	High	Yes
<i>Typhaea stercorea</i>	Hairy fungus beetle	North America	Yes	Non-quarantine				
<i>Zabrotes subfasciatus</i>	Mexican bean beetle	Southern USA, Mexico	No	Non-quarantine			Low	Yes

Table 1C Quarantine status of weed species associated with maize grain imported from the USA.

Weed	Common name/s	Present in USA	Present in Australia	Australian quarantine status	Potential economic impact	Probability of introduction	Quarantine management required
<i>Abutilon theophrasti</i> (herbicide resistant)	Velvet leaf	Yes	No	Quarantine	High	Medium	Yes
<i>Acanthospermum hispidum</i>	Star burr, goat's head	Yes	Yes*	Quarantine	Medium-high	High	Yes
<i>Aeschynomene virginica</i>	Northern joint vetch	Yes	No	Quarantine	Medium-high	Medium	Yes
<i>Alopecurus myosuroides</i>	Slender foxtail	Yes	Yes	Non-quarantine			
<i>Amaranthus albus</i>	Tumble pigweed	Yes	Yes	Non-quarantine			
<i>Amaranthus arenicola</i>	Sandhill amaranth	Yes	No	Quarantine	High	Low	Yes
<i>Amaranthus chlorostachys</i>		Yes	No	Quarantine	High	Low	Yes
<i>Amaranthus hybridus</i>	Smooth pigweed	Yes	Yes	Non-quarantine			
<i>Amaranthus hybridus</i> (triazine resistant)	Smooth pigweed	Yes	No	Quarantine	High	High	Yes
<i>Amaranthus palmeri</i> (herbicide resistant)	Palmer amaranth	Yes	No	Quarantine	High	High	Yes
<i>Amaranthus retroflexus</i>	Redroot pigweed	Yes	Yes	Non-quarantine			
<i>Amaranthus retroflexus</i> (triazine resistant)	Redroot pigweed	Yes	No	Quarantine	High	High	Yes
<i>Amaranthus rudis</i> (triazine resistant)	Common water hemp	Yes	No	Quarantine	High	High	Yes
<i>Amaranthus tamariscinus</i>	Pigweed	Yes	No	Quarantine	High	Low	Yes
<i>Ambrosia artemisiifolia</i>	Common ragweed	Yes	Yes*	Quarantine	Low-medium	High	Yes
<i>Ambrosia grayi</i>	Woolly leaf bursage	Yes	No	Quarantine	Medium	Medium	Yes
<i>Ambrosia trifida</i>	Giant ragweed	Yes	No	Quarantine	Medium-high	High	Yes
<i>Anoda cristata</i>	Spurred anoda	Yes	Yes	Non-quarantine			
<i>Apocynum cannabinum</i>	Hemp dogbane	Yes	No	Quarantine	High	High	Yes
<i>Artemisia annua</i>	Wormwood	Yes	Yes	Non-quarantine			
<i>Asclepias syriaca</i>	Common milkweed	Yes	No	Quarantine	High	Medium	Yes
<i>Avena fatua</i>	Wild oat	Yes	Yes	Non-quarantine			
<i>Avena sativa</i>	Oat	Yes	Yes	Non-quarantine			
<i>Barbarea vulgaris</i>	Wintercress	Yes	Yes	Non-quarantine			
<i>Bassia scoparia</i> (<i>Kochia scoparia</i>)	Kochia	Yes	Yes*	Quarantine	Medium-high	High	Yes
<i>Berteroia incana</i>	Hoary Alison	Yes	No	Quarantine	Medium	Low	Yes

Weed	Common name/s	Present in USA	Present in Australia	Australian quarantine status	Potential economic impact	Probability of introduction	Quarantine management required
<i>Bidens aurea</i>		Yes	No	Quarantine	Low	Low	Yes
<i>Brachiaria platyphylla</i>	Broadleaf signal grass	Yes	No	Quarantine	High	High	Yes
<i>Brassica japonica</i>	Wild mustard	Yes	No	Quarantine	Medium	Low	Yes
<i>Brassica kaber</i>	Charlock	Yes	Yes	Non-quarantine			
<i>Brassica nigra</i>	Black mustard	Yes	Yes	Non-quarantine			
<i>Bromus tectorum</i>	Downy brome	Yes	No	Quarantine	Medium	High	Yes
<i>Brunnichia ovata</i>	Redvine	Yes	No	Quarantine	Medium	Medium	Yes
<i>Calystegia sepium</i>	Hedge bindweed	Yes	Yes	Non-quarantine			
<i>Campsis radicans</i>	Trumpet creeper	Yes	Yes	Non-quarantine			
<i>Cardiospermum halicacabum</i>	Balloonvine	Yes	Yes	Non-quarantine			
<i>Cenchrus incertus</i>	Spiny burrgrass	Yes	Yes*	Quarantine	Medium-high	Medium	Yes
<i>Cenchrus longispinus</i>	Longspine sandbur	Yes	Yes*	Quarantine	Medium-high	Medium	Yes
<i>Chamaesyce maculata</i> (<i>Euphorbia supina</i>)	Prostrate spurge	Yes	Yes*	Quarantine	Medium	Medium	Yes
<i>Chenopodium album</i>	Common lambs quarters	Yes	Yes	Non-quarantine			
<i>Chenopodium album</i> (atrazine resistant)	Fathen	Yes	No	Quarantine	Medium-high	High	Yes
<i>Cirsium arvense</i>	Canada thistle	Yes	Yes*	Quarantine	Medium-high	High	Yes
<i>Citrullus vulgaris</i> var. <i>citroides</i>	Wild watermelon	Yes	Yes	Non-quarantine			
<i>Cocculus carolinus</i>	Redberry moonseed	Yes	No	Quarantine	Medium	Low	Yes
<i>Conringia orientalis</i>	Hare's ear	Yes	Yes*	Quarantine	Medium	Low	Yes
<i>Convolvulus arvensis</i> (herbicide resistant)	Field bindweed	Yes	No	Quarantine	High	Medium	Yes
<i>Conyza canadensis</i>	Horseweed	Yes	Yes	Non-quarantine			
<i>Cynanchum laeve</i> (<i>Ampelamus albidus</i>)	Honeyvine milkweed	Yes	No	Quarantine	Medium	Medium	Yes
<i>Cynodon dactylon</i>	Bermuda grass	Yes	Yes	Non-quarantine			
<i>Cyperus esculentus</i>	Yellow nutgrass	Yes	Yes*	Quarantine	High	High	Yes
<i>Cyperus rotundus</i>	Purple nutsedge	Yes	Yes*	Quarantine	High	High	Yes
<i>Datura innoxia</i>	Downy thornapple	Yes	Yes*	Quarantine	Low-medium	Low	Yes

Weed	Common name/s	Present in USA	Present in Australia	Australian quarantine status	Potential economic impact	Probability of introduction	Quarantine management required
<i>Datura inoxia</i> (resistant to ALS herbicides)	Downy thornapple	Yes	No	Quarantine	Medium	Low	Yes
<i>Datura stramonium</i>	Jimsonweed	Yes	Yes*	Quarantine	High	High	Yes
<i>Daucus carota</i>	Wild carrot	Yes	Yes	Non-Quarantine			
<i>Desmodium tortuosum</i>	Florida beggarweed	Yes	Yes	Non-quarantine			
<i>Digitaria ischaemum</i>	Smooth summer grass	Yes	Yes	Non-quarantine			
<i>Digitaria sanguinalis</i>	Crabgrass	Yes	Yes	Non-quarantine			
<i>Echinochloa colonum</i>	Awnless barnyard grass	Yes	Yes	Non-quarantine			
<i>Echinochloa crus-galli</i>	Barnyard grass	Yes	Yes	Non-quarantine			
<i>Echinochloa crus-galli</i> (herbicide resistant)	Barnyard grass	Yes	No	Quarantine	High	High	Yes
<i>Eleusine indica</i>	Goosegrass	Yes	Yes	Non-quarantine			
<i>Equisetum arvense</i>	Common horsetail	Yes	Yes*	Quarantine	Medium	Medium	Yes
<i>Elytrigia repens</i>	Quackgrass	Yes	Yes	Non-quarantine			
<i>Eragrostis cilianensis</i>	Stinkgrass	Yes	Yes	Non-quarantine			
<i>Eriochloa villosa</i>	Woolly cupgrass	Yes	No	Quarantine	High	Medium	Yes
<i>Erigeron annuus</i>	Annual fleabane	Yes	No	Quarantine	Medium	Medium	Yes
<i>Eupatorium capillifolium</i>	Dog fennel	Yes	No	Quarantine	Low	Medium	Yes
<i>Helianthus annuus</i> (herbicide resistant)	Sunflower	Yes	No	Quarantine	Low	Medium	Yes
<i>Hibiscus trionum</i>	Venice mallow	Yes	Yes	Non-quarantine			
<i>Ipomoea hederacea</i>	Entireleaf morningglory	Yes	Yes*	Quarantine	High	High	Yes
<i>Ipomoea lacunosa</i>	Morningglory	Yes	No	Quarantine	High	High	Yes
<i>Ipomoea purpurea</i>	Tall morningglory	Yes	Yes*	Quarantine	High	High	Yes
<i>Ipomoea turbinata</i>	Morningglory	Yes	No	Quarantine	High	Low	Yes
<i>Jacquemontia tamnifolia</i>	Morningglory	Yes	No	Quarantine	Medium	Low	Yes
<i>Lamium amplexicaule</i>	Hen bit	Yes	Yes	Non-quarantine			

Weed	Common name/s	Present in USA	Present in Australia	Australian quarantine status	Potential economic impact	Probability of introduction	Quarantine management required
<i>Lolium multiflorum</i> (herbicide resistant)	Italian ryegrass	Yes	No	Quarantine	High	Medium	Yes
<i>Lychnis alba</i>	White campion	Yes	Yes	Non-quarantine			
<i>Malva neglecta</i>	Dwarf mallow	Yes	Yes	Non-quarantine			
<i>Melochia corchorifolia</i>	Redweed	Yes	Yes	Non-quarantine			
<i>Mollugo verticillata</i>	Indian chickweed	Yes	Yes	Non-quarantine			
<i>Muhlenbergia frondosa</i>	Wire stem muhlys	Yes	No	Quarantine	Medium	Low	Yes
<i>Panicum capillare</i>	Witchgrass	Yes	Yes	Non-quarantine			
<i>Panicum capillare</i> (herbicide resistant)	Witchgrass	Yes	No	Quarantine	Medium	Medium	Yes
<i>Panicum dichotomiflorum</i>	Fall panicum	Yes	No	Quarantine	Medium	High	Yes
<i>Panicum fasciculatum</i>		Yes	No	Quarantine	Medium	Medium	Yes
<i>Panicum miliaceum</i>	Wild proso millet	Yes	Yes	Non-quarantine			
<i>Panicum racemosum</i>		Yes	Yes	Non-quarantine			
<i>Panicum ramosum</i>		Yes	No	Quarantine	Medium	Low	Yes
<i>Panicum texanum</i>	Texas Panicum	Yes	No	Quarantine	Medium	Medium	Yes
<i>Paspalum boscianum</i>		Yes	No	Quarantine	Medium	Medium	Yes
<i>Paspalum ciliatifolium</i>		Yes	Yes	Non-quarantine			
<i>Paspalum dilatatum</i>	Paspalum	Yes	Yes	Non-quarantine			
<i>Passiflora incarnata</i>	Mayhop passionfruit	Yes	Yes	Non-quarantine			
<i>Physalis heterophylla</i>	Clammy ground-cherry	Yes	No	Quarantine	Medium	Medium	Yes
<i>Poa pratensis</i>	Kentucky bluegrass	Yes	Yes	Non-quarantine			
<i>Polygonum aviculare</i>	Knotweed	Yes	Yes*	Quarantine	Medium-high	Medium	Yes
<i>Polygonum bungeanum</i>		Yes	No	Quarantine	Medium	Medium	Yes
<i>Polygonum convolvulus</i> (AQIS status changed to permitted since release of draft)	Knotweed	Yes	Yes	Non-quarantine			
<i>Polygonum lapathifolium</i>	Knotweed	Yes	Yes*	Quarantine	Medium-high	Low	Yes
<i>Polygonum pensylvanicum</i>	Pennsylvania smartweed	Yes	Yes*	Quarantine	High	High	Yes
<i>Portulaca oleracea</i>	Pigweed	Yes	Yes	Non-quarantine			

Weed	Common name/s	Present in USA	Present in Australia	Australian quarantine status	Potential economic impact	Probability of introduction	Quarantine management required
<i>Raphanus raphanistrum</i>	Wild radish	Yes	Yes*	Quarantine	High	High	Yes
<i>Richardia scabra</i>		Yes	Yes	Non-quarantine			
<i>Rottboellia cochinchinensis</i>	Itchgrass	Yes	Yes	Non-quarantine			
<i>Rubus allegheniensis</i>	Wild blackberry	Yes	No	Quarantine	Medium	Low	Yes
<i>Rubus fruticosus</i>	Blackberry	Yes	Yes*	Quarantine	Medium	Low	Yes
<i>Rumex crispus</i>	Curled dock	Yes	Yes	Non-quarantine			
<i>Salsola collina</i>	Tumble thistle	Yes	No	Quarantine	Medium-high	Low	Yes
<i>Salsola kali</i> (<i>Salsola kali</i> subsp. <i>ruthenica</i>)	Russian thistle	Yes	Yes	Quarantine	Medium high	High	Yes
<i>Salvia reflexa</i>	Mintweed	Yes	Yes*	Quarantine	Low-medium	Low	Yes
<i>Senecio vulgaris</i> (revised to non-quarantine following release of draft)	Common groundsel	Yes	Yes	Non-quarantine			
<i>Senna obtusifolia</i>	Java bean	Yes	Yes*	Quarantine	High	High	Yes
<i>Senna occidentalis</i>		Yes	Yes	Non-quarantine			
<i>Sesbania exaltata</i>	Hemp sesbania	Yes	Yes	Non-quarantine			
<i>Setaria faberi</i>	Giant foxtail	Yes	No	Quarantine	Medium	High	Yes
<i>Setaria glauca</i>	Yellow foxtail	Yes	Yes	Non-quarantine			
<i>Setaria italica</i>	Foxtail	Yes	Yes	Non-quarantine			
<i>Setaria lutescens</i> (herbicide resistant)	Foxtail	Yes	No	Quarantine	Medium	Medium	Yes
<i>Setaria verticillata</i>	Foxtail	Yes	Yes*	Quarantine	Medium	Low	Yes
<i>Setaria viridis</i>	Foxtail	Yes	Yes	Non-quarantine			
<i>Sicyos angulatus</i>	Burcucumber	Yes	No	Quarantine	High	High	Yes
<i>Sida spinosa</i>	Prickly sida	Yes	Yes	Non-quarantine			
<i>Sinapis arvensis</i>	Charlock	Yes	Yes	Non-quarantine			
<i>Solanun nigrum</i>	Black nightshade	Yes	Yes	Non-quarantine			
<i>Solanum sarrachoides</i>	Nightshade	Yes	Yes	Non-quarantine			
<i>Solanum ptycanthum</i>	Eastern black nightshade	Yes	No	Quarantine	Medium-high	High	Yes
<i>Sorghum x alnum</i>	Columbus grass	Yes	Yes*	Quarantine	Medium	Low	Yes

Weed	Common name/s	Present in USA	Present in Australia	Australian quarantine status	Potential economic impact	Probability of introduction	Quarantine management required
<i>Sorghum bicolor</i>	Shattercane	Yes	Yes	Non-quarantine			
<i>Sorghum halepense</i>	Johnson grass	Yes	No	Quarantine	High	High	Yes
<i>Stellaria media</i>	Common chickweed	Yes	Yes	Non-quarantine			
<i>Striga asiatica</i>	Witchweed	Yes	No	Quarantine	High	Low	Yes
<i>Taraxacum officinale</i>	Dandelion	Yes	Yes	Non-quarantine			
<i>Thlaspi arvense</i>	Penny cress	Yes	Yes*	Quarantine	High	Medium	Yes
<i>Verbesina encelioides</i>	Crownbeard	Yes	Yes*	Quarantine	Medium	Low	Yes
<i>Xanthium spinosum</i>	Common cocklebur	Yes	Yes*	Quarantine	High	High	Yes
<i>Xanthium strumarium</i> (complex that includes <i>X. pensylvanicum</i>)	Noogoora burr	Yes	Yes*	Quarantine	High	High	Yes
<i>Xanthium strumarium</i> (resistant to imidazolinone)	Noogoora burr	Yes	No	Quarantine	High	Medium	Yes

* Regulated taxa in Australia under AQIS or State legislation

APPENDIX – 3

Technical Working Group Membership and Terms of Reference

Technical Working Group 1

Disease Risk Analysis

Membership

Professor John Irwin (Chair)	Professor and CEO Cooperative Research Centre for Tropical Plant Protection University in Queensland
Dr Sharan Singh	Manager Plant Biosecurity Biosecurity Australia Agriculture, Fisheries and Forestry - Australia
Dr Joe Kochman	Principal Plant Pathologist Queensland Department of Primary Industries
Dr Gordon Murray	Plant Pathologist (Crops & Pastures) NSW Agriculture

Terms of reference

- Identify quarantine diseases associated with imports of maize grain from the USA consistent with the International Standard for Phytosanitary Measures (ISPM), Guidelines for Pest Risk Analysis, developed under the auspices of the International Plant Protection Convention (IPPC), and in particular assess the potential of these diseases to
 - enter, establish and spread in Australia and,
 - cause economic damage, including crop losses and loss of export markets.
- Consider various risk management options consistent with the Australian government policy, the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) and relevant international standards, including the International Standards for Phytosanitary Measures (ISPMs).
- Liaise on relevant issues with other Technical Working Groups (TWGs) established under the Risk Analysis Panel (RAP) on the import of maize grain from the USA, and other national and international technical experts, as necessary.
- Assess the key disease risks associated with contamination of bulk maize shipments with seeds of other agricultural plant species such as barley, oat, millet, sorghum, soybean and wheat.
- Report the findings of the working group to the RAP.

Technical Working Group 2

Arthropod Pest Risk Analysis

Membership

Dr Bob Ikin (Chair)	Senior Manager (retired) Plant Quarantine Policy Branch Policy and International Division Australian Quarantine and Inspection Service
Dr Jonathan Banks	Stored Grain Research Laboratory,
Mr David Rees	CSIRO Division of Entomology
Ms Alison Roach	Professional Officer Plant Biosecurity Biosecurity Australia Agriculture, Fisheries and Forestry - Australia

Terms of reference

- Identify quarantine arthropod pests associated with imports of maize grain from the USA consistent with the International Standard for Phytosanitary Measures (ISPM), Guidelines for Pest Risk Analysis, developed by the Food and Agriculture Organization of the United Nations (FAO), and in particular assess the potential of these pests to
 - enter, establish and spread in Australia and,
 - cause economic damage, including crop losses and loss of export markets.
- Consider various risk management options consistent with the Australian government policy, the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) and relevant international standards, including the International Standards for Phytosanitary Measures (ISPMs).
- Liaise on relevant issues with other Technical Working Groups (TWGs) established under the Risk Analysis Panel (RAP) on the import of maize grain from the USA, and other national and international technical experts, as necessary.
- Report the findings of the working group to the RAP.

Technical Working Group 3

Weed Risk Analysis

Membership

Dr Bill Roberts (Chair)	Chief Plant Protection Officer Office of the Chief Plant Protection Officer Agriculture, Forestry and Fisheries, Australia
Dr Acharee Pheloung	Professional Officer Plant Biosecurity Biosecurity Australia Agriculture, Fisheries and Forestry - Australia
Mr. John Swarbrick	Weed Science Consultant (Formerly Associate Professor of Weed Science, University of Queensland)

Terms of reference

- Identify quarantine weeds associated with imports of maize grain from the USA consistent with the International Standard for Phytosanitary Measures (ISPM), Guidelines for Pest Risk Analysis, developed by the Food and Agriculture Organization of the United Nations (FAO), and in particular assess the potential of these weeds to
 - enter, establish and spread in Australia and,
 - cause economic damage, including crop losses and loss of export markets.
- Consider various risk management options consistent with the Australian government policy, the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) and relevant international standards, including the International Standards for Phytosanitary Measures (ISPMs).
- Liaise on relevant issues with other Technical Working Groups (TWGs) established under the Risk Analysis Panel (RAP) on the import of maize grain from the USA, and other national and international technical experts, as necessary.
- Report the findings of the working group to the RAP.

Technical Working Group 4

Operational Issues

Membership

Mr Mev Connell (Chair)	Private Consultant
Mr Bill Magee	Senior Manager
	Plant Biosecurity
	Biosecurity Australia
	Agriculture, Fisheries and Forestry - Australia
Mr Mike Robbins	Manager
	Plant Programs
	Australian Quarantine and Inspection Service

Terms of reference

- Identify operational issues relevant to the importation of maize grain from the USA.
- Consider various risk management options consistent with the Australian government policy, the World Trade Organization (WTO) Agreement on the Application of Sanitary and Phytosanitary Measures (the SPS Agreement) and relevant international standards, including the International Standards for Phytosanitary Measures (ISPMs).
- Liaise with other Technical Working Groups (TWGs) and national and international technical experts, as necessary, on relevant issues identified by other TWGs and this working group.
- Develop and assess operational procedures for implementation of management options recommended by other TWGs.
- Report the findings of the working group to the Risk Analysis Panel (RAP).

APPENDIX – 4

Impact of management options on maximum weed seed number in maize shipments and potential for establishment

Impact of management options on maximum weed seed number in maize shipments and potential for establishment

Acharee Pheloung and Bill Roberts
Technical Working Group (Weeds) for bulk maize IRA

SUMMARY

A quantitative model based on available weed contamination data was developed to explore different strategies for managing the risk of weed introduction. Without management options to reduce weed seeds in a maize consignment, the model indicated that there will be the potential of 123–441 quarantine weed establishments per shipment depending on the level of contamination. The results support the previous conclusions that devitalisation treatment is the most effective treatment for reducing weed establishment potential. The second best option was to increase sample size, in which a nil tolerance for weed seeds is required, to 10 kg. This option would reduce establishment potential to 5 weed seed establishments per shipment. Screening at 70% efficiency reduced weed establishment potential to 37 per shipment. Integration of sampling and screening did not reduce weed risk as much as devitalisation treatment alone. If the level of quarantine weed seed contamination is at 0 seed/kg of maize (in the sample tested) then devitalisation at 99% efficacy can reduce weed establishment potential to less than 1 per shipment.

1. Purpose

- To compare the effect of management options on the number of quarantine weed seeds in a shipment and in spilt maize.
- To predict the establishment of quarantine weeds after spillage during transport and storage in Australia.

2. Background

2.1 Qualitative weed risk analysis

The qualitative weed risk analysis of bulk maize grain imported from the USA indicated a high risk of introducing quarantine weeds as contaminants. The Bulk Maize Import Risk Analysis Technical Working Group (TWG) on weeds examined three major management options to reduce the risk to an acceptable level:

- Basic screening
- Increased sample size in which a nil tolerance for quarantine weed contaminants in grain shipment is imposed
- Devitalisation treatments

The efficacy of these management options will affect the number of viable quarantine weed seeds that could be present in shipments of maize to be imported, and the probability that some of these weed seeds would be spilt and establish in Australia.

2.2 Estimating the proportion of grain spillage

A high level of grain spillage during loading, storage and transportation was found from survey data in farms on the Darling Downs, Queensland (Sinclair, 1982). Transportation of maize imported in 1994-1995 was conducted under a stringent protocol to minimise spillage; the trucks were sealed with plastic. There was, however, evidence of spillage during loading and unloading in the feedlots and processing plants, many of which were situated close to agricultural fields. The amount of spilt grain was estimated to be 500-1000 kg per shipment of 30,000 tonnes (Phillips *et al.*, 1994).

3. Quantitative Analysis

The efficiency of management options was compared to determine the number of viable weed seeds that may be present in spilt grain.

3.1 Management Option 1. Basic seed cleaning

Effect of basic screening method on weed seed number in bulk maize

The efficacy of basic seed cleaning procedures was estimated to be 70-95%. The efficiency of screening depends on the type of screen used and the seed size of grain and weeds. These range from a single screen with or without a small fan to six or seven screens with multiple fans (Linnett, 1981). Based on our previous analysis, there were 22 out of 72 weed species, which are similar in seed size to that of maize. These seeds may not be easily separated from maize by basic screening techniques.

Table 1. Estimation of quarantine weeds expected to remain as contaminants after basic seed cleaning methods

Weed species found in sample of grain	Before screening		After screening	
	Weed seed* (No/kg)	Weed seed (No/tonne)	70% efficiency Weed seed (No./tonne)	95% efficiency Weed seed (No./tonne)
<i>Abutilon theophrasti</i>	10	10,000	3,000	500
<i>Amaranthus</i> spp.	314	314,000	94,200	15,700
<i>Ambrosia</i> spp.	6	6,000	1,800	300
<i>Ipomoea</i> spp	1	1,000	300	50
<i>Bassia</i> sp	29	29,000	8,700	1,450
<i>Panicum</i> spp.	62	62,000	18,600	3,100
<i>Polygonum pensylvanicum</i>	4.4	4,400	1,320	220
<i>Setaria</i> spp.	201	201,000	60,300	10,050
<i>Sorghum halepense</i>	100	100,000	50,000	5,000
<i>Xanthium</i> spp.	4	4,000	1,200	200

* Data from seed analysis of grains imported from the USA, Source: Grain Taskforce file (1995)

3.2 Management Option 2: Requirement of nil tolerance for quarantine weed seeds in a larger sample size

Effect of sample size on weed seed number in 1 tonne of spilt maize

AQIS routinely uses ISTA sampling guidelines, which require a 1 kg working sample for maize in which a nil tolerance for quarantine weed seeds is imposed. From the sample size

used and number of weed seeds found (if any) in the sample the maximum number of weed seeds that could be present in a maize shipment can be predicted (Cannon & Roe, 1982; Roberts, *et al*, 1995). This approach is also described in the TWG (Weeds) report. The expected number of weed seeds present in 1 tonne of grain, when no weed seeds are detected in various sample sizes is shown in Table 2.

Table 2 The maximum number of weed seeds that could be present if no quarantine weeds are found in samples of varying sizes. These figures are based on a ninety five percent confidence level and a shipment size of 30,000 tonnes

Total maize shipment (tonnes)	Total maize working sample size (kg)	Maximum weed seeds (No/kg)	Maximum weed number (in shipment)	Maximum weed seed number in 1 tonne
50,000	1	3.64	109,200,000	3,640
	2	1.82	54,600,000	1,820
	5	0.73	21,900,000	730
	10	0.36	10,800,000	360
	20	0.18	5,400,000	180
	50	0.07	2,100,000	70

3.3 Management Option 3: Devitalisation of grain shipment

Effect of devitalisation on weed seed number in spilt maize

Devitalisation by steam heat treatment at 95-100°C for 10-30 min was found to be 93-100% effective in killing weed seeds (Grain Taskforce File, 1994-1995). The efficiency of this treatment alone or combined with other management options is shown in Table 3a, b and c.

Table 3a. Effect of devitalisation treatments with varying efficacy on weed seed number in bulk maize with and without cleaning at 70 and 90% efficiency. This example uses *Xanthium*, which has been found in imported maize at 4 seeds/kg

Treatment	Expected <i>Xanthium</i> seeds/tonne		
	No cleaning	Cleaning at 70 % efficiency	Cleaning at 90% efficiency
No devitalisation treatment	4,000	1,200	400
Devitalisation (99% efficacy)	40	12	4
Devitalisation (99.99% efficacy)	0.4	0.12	0.04

Table 3b. Effect of devitalisation treatments with varying efficacy on weed seed number in spilt maize with and without cleaning at 70% and 90% efficiency. This example uses *Bassia*, which has been found in imported grain at 29 seeds/kg.

Treatment	Expected viable <i>Bassia</i> seeds/tonne		
	No cleaning	Cleaning at 70% efficiency	Cleaning at 90 % efficiency
No devitalisation treatment	29,000	8,700	2,900
Devitalisation treatment (99% efficacy)	290	87	29
Devitalisation treatment (99.99% efficacy)	2.9	0.87	0.29

Table 3c. Effect of varying sampling intensity and varying devitalisation treatments on viable weed seed number in maize

Treatment	Maximum number of viable weed seeds/tonne where no seed is found when using a sample size of:			
	1 kg	2 kg	5 kg	20 kg
No devitalisation treatment	3640	1820	730	180
Devitalisation treatment (99% efficacy)	36.4	18.2	7.3	1.8
Devitalisation treatment (99.99% efficacy)	0.364	0.182	0.073	0.018

3.4 Prediction of weed seed establishment as affected by various management strategies

Phillips *et al.* (1994) identified three key factors for which information is needed for quarantine decision-making on the probability of pest establishment:

- a particular pest is likely to present in the shipment;
- it is likely to pass the quarantine barrier (i.e. undetected by conventional sampling procedures) and;
- the pest has a high potential to establish and spread in Australia.

In the current analysis, the presence of these factors have been established and supported by published data. Some other parameters that would affect the establishment potential of quarantine weeds are reviewed below.

The analysis in the previous section focused on weed seeds that have been detected using the conventional sampling methods. However, previous reports identified a number of other quarantine weed species that were likely to be contaminants in bulk maize grain imported from the USA. Many of these species would not be detected, particularly when present at lower than 1 seed/kg. Based on a sample size of 1 kg quarantine weed seeds could be present at up to 3640 seeds in 1 tonne of maize grain and have less than 5% probability of being detected (Table 2).

3.4.1 Estimate of seed germination and seedling survival

The probability that spilt weed seed would establish and spread in Australia depends on many biological factors. These include seed viability, persistence (seed dormancy, drought tolerance or ability to adapt to a broad range of climates, unpalatability, absence of natural enemies etc.), and the ability to produce many viable seed, particularly by self-pollination. The identified quarantine weeds have many of these characteristics and were assessed as presenting a high risk of becoming established in the Australian environment.

Germination ability of maize grain imported from the USA during 1994-1995 was found to be around 70-80%. After cracking, imported maize grain remained viable with a germination ability of 55% (Grain Taskforce file, 1995). This suggests that even mechanical processing such as cracking is unlikely to destroy the viability of weed seeds. A number of weed contaminants were identified during seed analysis and generally their viability, tested before heat treatment trials, was high (90-98%) indicating that if weed seeds are present they are likely to be viable. Many experiments indicate that quarantine weed seeds such as *Bassia*,

Xanthium, *Ipomoea*, *Panicum*, *Ampelamus*, *Apocynum* and *Amaranthus* remained highly viable in the environment for more than 3 years (Evetts & Burnside, 1972; Egley & Chandler, 1978; Zorner *et al.*, 1980). After being buried for 10 years, germination ability of *Amaranthus* spp., *Ampelamus* sp. and *Panicum* sp. did not decrease (Burnside *et al.*, 1981).

Spillage along roadsides, railways or feedlots often does not provide suitable conditions for seed to germinate. In this analysis, the chance of a weed seed being spilt in an environment suitable for germination was estimated at 10%. Of the weed seed that did germinate a further assumption was made that only 10% of the germinating weed seeds would reach a reproductive stage and produce another generation. This gives a probability of 1% that a weed seed that was spilt would establish and reproduce. These estimates are based on published data on weed establishment capability (Louda *et al.*, 1990; Piggin, 1976; Johnson & Thomas, 1978). Climate similarity analysis (Pheloung, 1990) also indicates that the climate in Australian production areas is suited to the establishment of quarantine weeds identified in the TWG (Weeds) report.

3.4.2 Model developed to predict potential weed seed establishment

Based on above information and assumptions, a simple mathematical model was developed to predict the chance of quarantine weed establishment under different management options. The calculation may be collectively applied to all weed species in a shipment, or applied to each of weed seed species individually, if required.

Sample Size

Total weed seeds in shipment estimated from the number of weed seeds found in a 1 kg sample. This step allows the estimation of weed seeds present in a shipment before management is applied.

$$W = C * L_x * 1000 \dots\dots\dots \text{(Equation 1)}$$

Where:

- W is the estimated total weed seed in a maize shipment;
- C is the shipment size (tonnes);
- L_x is the expected maximum quarantine weed seed number in x kg of maize before application of management options (derived from the number of quarantine weed seeds found in a sample of x kg; Appendix 2)

If a conventional sampling system is applied, the shipment is required to be cleaned to a level such that no quarantine weeds are found in a 1 kg sample size. This is the current requirement for seed/grain imported into Australia.

Alternatively, if the required sample size in which no quarantine weed seeds are to be found were increased to 10 kg, the maximum expected weed seeds in the whole shipment would be reduced. The maximum number of weed seed in the shipment is calculated as in equation 1 by altering the sample size (x). The expected maximum seed number in 1 kg of maize where no weed seeds was found in a given sample size is shown at Appendix 2.

Screening and devitalisation

Having calculated the maximum level of weed seed contamination in a shipment, the effect of screening and devitalisation on weed seed number can be calculated. The required treatment efficacy may be varied depending on the level of quarantine weed seeds found in a shipment and the practicality of treatments applied.

Management options may be incorporated into the equation:

$$T = 1 - (1 - F)(1 - D) \dots\dots\dots \text{(Equation 2)}$$

Where:

- T is overall management efficiency (%)
- F is screening efficiency (%)
- D is devitalisation efficiency (%)

Where either screening or devitalisation is not applied, the respective parameters, F or D, are set to 0.

Example: When two management options are combined, if the efficacy of F is 80% and the efficacy of D is 90%, then T efficacy will be 98%.

Weed Establishment

The potential for weed establishment is dependent on how much grain is spilt and the capacity of weed seed in the spilt grain to establish under a range of conditions. Establishment potential may be predicted by incorporating these parameters into the model. In this analysis, the establishment is based on two parameters, the probability of weed seed germinating and then surviving until the reproductive stage and producing seed in subsequent generations. To predict potential weed establishment, these parameters can be incorporated into either of the above equations.

Potential weed establishment may be predicted as follows:

$$G = S * V * R \dots\dots\dots \text{(Equation 3)}$$

Where:

- G is probability of weed seed being spilt, germinating and reproducing (%)
- S is the rate of maize spillage per shipment (in this analysis set at 0.003% of a shipment)
- V is the estimate of weed seed germination (%) (in this analysis estimated at 10%)
- R is seedling survival (in this analysis estimated at 10%)

Incorporating all the components

Incorporation of shipment levels of weed seed, management and establishment is achieved as follows:

$$E = W * (1 - T) * G \dots\dots\dots \text{(equation 4)}$$

Where

- E is the overall weed establishment potential (plants per shipment)

The use of several management options may be useful when the practical efficacy of each option applied alone is insufficient. For example, the basic cleaning technique may not be sufficient on its own to eliminate quarantine weed seeds, a severe heat treatment may cause adverse effects to maize nutrition quality or storage ability or the sample size required to effectively reduce the chance of weed establishment is too high and not practical.

Using this equation, the parameters can be varied to predict potential of weed establishment. Varying efficiency of management options and other parameters in the model may facilitate decision making on implementing an appropriate management strategy. Examples of how to

generate management options and parameters using an excel spreadsheet to calculate the results are shown at Appendix 1.

Model Outcomes

Table 4a-d shows various scenarios to estimate the likelihood of weed establishment based on efficiency of management options at different sampling regimes.

Table 4. Predicted number of weed seed in spilt grain and establishment potential as influenced by different management options; based on a shipment size (C) of 50,000 tonnes, spillage (S) of 0.003%

A: Four quarantine weed seeds found¹ in 1 kg sample with screening (F) at 70% efficiency and devitalization treatment (D) 99% efficiency

Management option	Predicted potential viable number of weed seed		
	In shipment	In split grain	Establishment per shipment
No management	410,666,060	12320	123.2
Screening	123199818	3696	36.95
Devitalisation	4106661	123.2	1.232
Devitalization and screening	1231998	36.960	0.3696

B: Twenty-nine quarantine weed seeds found¹ in 1 kg sample with screening at (F) 90% efficiency and devitalisation treatment at (D) 99% efficiency

Management option	Viable seed in		Potential seed establishment per shipment
	Shipment	Split grain	
No management	1,470,843,326	44,125.300	441.25
Screening	147,084,333	4,412.530	44.125
Devitalisation	14,708,433	441.253	4.412
Devitalization and screening	1,470,843	44.125	0.4412

C: No quarantine weed seed found in 1 kg sample with screening at (F) 70% efficiency and devitalisation treatment at (D) 99% efficiency

Management option	Viable seed in		Potential seed establishment per shipment
	Shipment	Split grain	
No management	18,1823,268	5455	54.54
Screening	54,546,980	1636.409	16.364
Devitalisation	1,818,233	54.547	0.5455
Devitalization and screening	545,470	16.364	0.1636

D: No quarantine weed seed found in 10 kg sample with screening (F) at 70% efficiency and devitalisation treatment (D) at 99% efficiency

Management option	Viable seed in		Potential seed establishment per shipment
	Shipment	Split grain	
No management	18,183,831	546	5.45
Screening	5,455,149	164	1.63
Devitalisation	181,838	5.455	0.0546
Devitalization and screening	54,551	1.637	0.0164

1. Based on averaged results from samples of grain shipments imported to Australia

4. DISCUSSION

This quantitative risk analysis of management options supports the previous qualitative analysis that an effective devitalisation treatment is the best option to reduce the risk of quarantine weeds establishing in Australia. This is a consequence of the significant number and range of weed seeds that would be present in imported grain. Devitalisation at 99% efficiency could reduce weed establishment potential to 1.23 per shipment when contamination level was at 4 seeds/kg of maize (Table 4a) and to 4.412 when contamination level was higher (Table 4b). Using a conventional sampling requirement of nil tolerance in 1 kg of maize combined with a devitalisation treatment could reduce weed establishment potential to 0.545 (Table 4c). Further increasing sampling intensity from 1 kg to 10 kg combined with a devitalisation treatment could reduce the chance of weed establishment to 0.0546 (Table 4d). Sampling at 10 kg and screening at efficiency of 70% reduced the establishment potential to 1.63 per shipment (Table 4d).

The calculation in Table 4a was based on 4 quarantine weed seeds being found in one kg sample of maize, which is the working sample size, required based on ISTA sample guidelines. This sample size is currently being used to detect quarantine weed seeds. Often, there may be more than 4 quarantine weed seeds found in a 1 kg working sample of maize before screening or without management procedures. If there were higher numbers of quarantine weed seeds found in 1 kg of maize, particularly likely in lower grades of grain, the risk of weed establishment would be higher when based on similar management efficacy. Therefore, the efficiency of devitalisation would need to be higher than 99% when lower grade grain consignments were imported.

The calculation is based on a shipment of 50,000 tonnes, as was recorded for one of the shipments in 1995. To predict the likelihood of quarantine weed establishment per year, the total annual tonnage of maize imported would need to be considered. The analysis showed that if no quarantine weed seeds are found in a 1 kg sample from a shipment size of 50,000 tonnes, a 99% effective devitalisation treatment is sufficient to reduce the risk to less than 1 weed establishment.

5. REFERENCES

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Appendix 1. Spreadsheet used to calculate the establishment potential of weed seeds

Each parameter in Equation 1 can be varied and input into the excel spreadsheet to generate the output which is the prediction of weed establishment. The maximum seed number for the sample size specified is derived from Table 2; only sample size was required as input into spreadsheet.

Example 1 *Xanthium* spp.

Contaminant calculator	
Weed:	<i>Xanthium</i>
Contaminants in consignment (#/kg)	4
X: Sample size (nil tolerance in # kg):	10
F: Screening efficiency (%)	70%
D: Devitalisation efficiency (%)	99%
S: Spillage (%)	0.003%
V: Seed germination (%)	10%
R: Seedling survival (%)	10%
C: Shipment size	50 000

Number of weeds:

Management	/tonne	in consignment	spilled	established
No management	8213	410 666 060	12320	123
Sampling	364	18 183 831	546	5.5
Screening	2464	123 199 818	3 696	40
Sampling & Screening	109.10	5 455 149	164	1.6
Treatment	82.13	4 106 661	123	1.2
Sampling and Treatment	3.64	181 838	5.5	0.055
Treatment and Screening	24.64	1 231 998	37	0.37
Sampling, Treatment and Screening	1.09	54 551	1.64	0.016

Example 2 *Bassia* sp.

Contaminant calculator

Weed:	<i>Bassia</i>
Contaminants in consignment (#/kg)	29
X: Sample size (nil tolerance in # kg):	10
F: Screening efficiency (%)	90%
D: Devitalisation efficiency (%)	99%
S: Spillage (%)	0.003%
V: Seed germination (%)	10%
R: Seedling survival (%)	10%
C: Shipment size	50 000

Number of weeds:

Management	/tonne	in consignment	Spilled	established
No management	29417	1 470 843 326	44125	441
Sampling	364	18 183 831	546	5.5
Screening	2942	147084 333	4413	44
Sampling & Screening	37	1 818 383	55	0.55
Treatment	294	14 708 433	441	4.4
Treatment and Sampling	3.6	181 838	5.5	0.055
Treatment and Screening	29	1 470 843	44	0.44
Treatment and Sampling and Screening	0.36	18 184	0.55	0.0055

Appendix 2. Maximum number of weed seeds per kg of grain (95% confidence) for a given number found in a given sample size

Sample size (kg)	Number of weed seeds found in the sample							
	0	1	2	3	5	10	20	50
0.25	14.54	21.11	27.13	32.84	43.74	69.37	117.61	254.23
0.5	7.27	10.56	13.57	16.42	21.88	34.69	58.82	127.18
0.75	4.85	7.04	9.04	10.95	14.59	23.13	39.22	84.80
1	3.64	5.28	6.78	8.21	10.94	17.35	29.42	63.60
2	1.82	2.64	3.39	4.11	5.47	8.68	14.71	31.81
3	1.21	1.76	2.26	2.74	3.65	5.78	9.81	21.20
4	0.91	1.32	1.70	2.05	2.74	4.34	7.36	15.90
5	0.73	1.06	1.36	1.64	2.19	3.47	5.88	12.72
10	0.36	0.53	0.68	0.82	1.09	1.74	2.94	6.36
20	0.18	0.26	0.34	0.41	0.55	0.87	1.47	3.18
50	0.07	0.11	0.14	0.16	0.22	0.35	0.59	1.27