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Containment zones for control of transboundary animal diseases

An assessment of the practical application of the expanded definition of a containment zone to facilitate rapid return to trade in the face of a disease outbreak

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Acronyms

AAHL	Australian Animal Health Laboratory
AADIS	Australian Animal Disease Spread Model
ARP	At-risk premises
CA	Control area
CCEAD	Committee on Emergency Animal Health Diseases
CSF	Classical Swine Fever
CVO	Chief Veterinary Officer
DCP	Dangerous contact premises
DCPF	Dangerous contact processing facility
EAD	Emergency animal disease
FMD	Foot and Mouth Disease
HPAI	Highly Pathogenic Avian Influenza
IP	Infected premises
LCC	Local Control Centres
ND	Newcastle Disease
NMG	National Management Group
OIE	The World Organisation for Animal Health
SCC	State Control Centres
SP	Suspect premises
TaS	Tracing and surveillance
TP	Trace premises
OA	Outside area
POR	Premises of relevance
PVS	Performance of veterinary services
RA	Restricted area
RP	Resolved premises
UP	Unknown status premises
USA	United States of America
ZP	Zero susceptible stock premises

Executive summary

To reduce unnecessary economic impacts associated with the loss of market access for an entire nation during an emergency animal disease (EAD) outbreak, the current OIE Terrestrial Animal Health Code (the Code) allows for the establishment of a 'containment zone' for the purposes of resuming trade in the event of 'limited outbreaks' of a disease in a country or zone previously free from disease (Chapter 4.3). Under the current OIE Code, Member Countries can establish a containment zone to maintain their free status outside that zone and resume trade accordingly; however, trade cannot resume until there are no new cases for a minimum of two incubation periods from the last detected case within the zone.

In recent months, the OIE Terrestrial Animal Health Standards Commission (Code Commission) and Member Countries have refined draft changes to chapter 4.3 of the Code. The proposed changes would introduce an expansion to the current concept of containment zones to include the use of 'infected zones' and 'protection zones'. A containment zone could be established whilst active cases are occurring within the infected zone, as long as it is surrounded by a protection zone, where no outbreaks have occurred for at least two incubation periods and which separates the infected zone from the rest of the country or zone (in the case where a zone within a country has free status). Potentially, this could result in quicker establishment of containment zones and earlier resumption of trade outside those zones.

Whilst these changes have the potential to reduce unnecessary economic losses, they come with significant implications for disease surveillance and control, particularly in relation to assuring the integrity of the containment zone.

Firstly, any country that intends to implement a containment zone will require the core competencies necessary to manage an EAD outbreak effectively. Essential prerequisites include pre-defined governance and funding arrangements, supporting documentation for outbreak response implementation, and a trained and competent veterinary service.

Secondly, countries intending to establish a containment zone will also require substantial capacity for disease surveillance. Surveillance enablers including a tracing and surveillance plan, strong local and regional networks, reliable data sources, and defined control and coordination centres with clear roles, responsibilities and resourcing—these are all essential for the effective control of EAD outbreaks. Implementation of surveillance should include efforts to classify premises and regions based on risk, implement active surveillance at premises most at-risk, communicate clearly with the general public to improve passive surveillance and use data to monitor control efforts. Eventually surveillance data should also be used to support demonstration of freedom. Core control activities during an EAD include stamping out, movement control, vaccination, treatment of infected animals, enhanced biosecurity, appropriate disposal of carcasses, control of wild, feral or vector species when appropriate and effective public awareness campaigns.

In Australia, these fundamental control and surveillance measures are guided by AUSTVETPLAN and have been implemented to successfully control several EAD outbreaks in the past. Australia has contained multiple outbreaks of virulent Newcastle Disease (ND) and Highly Pathogenic Avian Influenza (HPAI), confining outbreaks to a few neighbouring properties in a small geographic region and then successfully eradicating the diseases. More recently, Australia eradicated Equine Influenza (EI) following a large outbreak.

In addition to the core activities required in EAD outbreak response, there are a number of additional measures that are necessary to establish an effective containment zone. These include selecting an appropriate time to define the containment zone (i.e. when the extent of the outbreak is fully understood), defining a suitable size and shape for the containment zone (with consideration of a number of factors), conducting appropriate surveillance and control measures within and outside the zone and implementing activities to reduce risk beyond the zone.

When core EAD outbreak competencies are implemented, along with special measures relating to containment zones, countries will need to actively demonstrate the integrity of their zone to trading partners. Detailed information on the quality and competence of the Veterinary Service and other supporting elements of response is likely to be required, along with the results of surveillance and contextual data. Information that justifies the proposed boundaries of the containment zone will be critical. In Australia's case, the distribution of livestock industries is likely to be relevant, as patchy distributions of some species have proved useful in containing disease outbreaks in the past.

It is important to note that a key benefit of containment zones is that the free zone maintains the same advantages as a country that is already recognised as free of the disease by the OIE. The OIE requirements for maintaining disease freedom recognition are always less than those required to regain OIE disease freedom recognition. However, in reality, trading partners are likely to demand a greater level of evidence of freedom from the free zone when a containment zone is implemented than would be required from a country that is completely disease free. Therefore, it might be necessary to demonstrate disease freedom in the free zone with greater rigour during an outbreak (when a containment zone has been established) than would otherwise be required. There are several approaches to demonstration of freedom. Depending on the nature of the disease and outbreak, Australia is most likely to use a combination of traditional and more complex methodologies to demonstrate disease freedom within the free zone when the outbreak is ongoing, and within the containment zone following the eradication of disease.

The characteristics of the disease incursion will influence a country's approach to control and surveillance, as well as to the establishment of a containment zone. In Australia's case, responses to specific disease outbreaks are guided by AUSVETPLAN disease strategies. An outbreak of Foot and Mouth Disease (FMD) will initiate a heavily resourced response with an immediate livestock movement standstill, rapid typing of the virus and stamping out (along with other standard measures typical of any EAD response such as tracing and property classification). Implementation of a containment zone would be highly desirable when the extent of the outbreak is well understood. An outbreak of Classical Swine Fever (CSF) would result in movement control of pigs, pig products and potentially contaminated fomites and stamping out. A modified stamping out approach—where slaughter for human consumption is permitted—may be considered should the outbreak become widespread. A containment zone may be implemented when the extent of the outbreak is well known. An outbreak of an emergency poultry disease such as ND or HPAI will initiate rapid stamping out on infected properties. However, given the limited export market for Australian poultry, implementing a containment zone may not be economically beneficial. Zoning efforts are more likely to concentrate solely on controlling the disease to protect domestic producers, rather than on establishing a containment zone for trade purposes.

1 Background and context

EADs have a significant impact on food security and international trade (Domenech et al., 2006). In addition, globalisation means that persistence of transboundary disease anywhere poses a serious risk to global agriculture and international trade (Zepeda, 1998). Protection of trade provides a strong incentive for many countries to prevent and control EADs, particularly given the enormous economic consequences of losing market access, even if only for a short period (Domenech et al., 2006). However, outbreaks of EADs can cause excessive economics impacts where the scale of loss is unnecessary given the scale of the outbreak.

To reduce unnecessary economic impacts associated with the loss of market access for an entire nation during a EAD outbreak, the current OIE Code allows for the establishment of a 'containment zone' for the purposes of resuming trade in the event of 'limited outbreaks' of a disease in a country or zone previously free from disease (Chapter 4.3). A containment zone is described as 'a defined zone around and including suspected or infected establishments, taking into account the epidemiological factors and results of investigations, where control measures to prevent the spread of the infection are applied'. Under the current code, member countries can establish a containment zone to maintain their free status outside that zone and resume trade accordingly. However, trade cannot resume until there are no new cases for a minimum of two incubation periods from the last detected case within the zone.

Although relatively new, containment zones have already been applied. On October 19, 2016 Russia reported an FMD outbreak in the Vladimirskaya Oblast. Ninety animals showed clinical signs with a total of 797 presumed to be susceptible. Russia established a containment zone around the affected area and submitted detailed documentation to the OIE on December 5, 2016. The OIE accepted the documentation as complying with Article 8.8.6 of the OIE Code (the Foot and Mouth specific chapter) and reinstated Russia's status as an FMD free zone where vaccination is not practised, except for the territory of the containment zone, effective from January 13, 2017.

In recent months, the OIE Code Commission and Member Countries have refined draft changes to Chapter 4.3 of the OIE Code. The proposed changes would introduce an expansion to the current concept of containment zones to include the use of 'infected zones' and 'protection zones'. Under the proposed draft, a containment zone can also be established if it is comprised of an infected zone (where new cases continue to be detected) surrounded by a protection zone, where no outbreaks have occurred for at least two incubation periods and which separates the infected zone from the rest of the country or zone (in the case where a zone within a country has free status). Potentially, this could result in quicker establishment of containment zones and earlier resumption of trade outside those zones. In addition, the country or zone would still retain its free status, even when outbreaks continue to occur within the infected zone (if the protection zone remains free).

Whilst these changes are yet to be finalised, there are recent examples of importing countries choosing to continue to trade in the face of ongoing disease outbreaks, following the presentation of evidence from exporting countries that an outbreak is geographically limited. In 2014–2015 HPAI affected 211 commercial operations, 21 backyard flocks, 75 wild birds and four captive raptors across 21 states of America (Swayne et al., 2017; USDA, 2016). The stamping-out policy that followed resulted in the culling of over 50.4 million poultry at a cost of USD $850 million (Swayne et al., 2017). Seventeen trading partners suspended all poultry imports from the United States of America (USA), while 38 trading partners recognised regionalisation and allowed import of poultry and poultry products from unaffected zones of the country (Swayne et al., 2017).

Prior to the outbreak, the USA and Canada had established bird health zoning arrangements and agreed to limit trade restrictions to affected geographical zones only should bird disease outbreaks occur (Harchaoui, 2015). During the outbreak, the USA presented trading partners with comprehensive surveillance data for the affected and surveillance zones and data from the National Poultry Improvement Plan to support the claim that outbreaks were geographically limited, providing a scientific justification for resuming trade with unaffected areas. 38 countries accepted this evidence and resumed trade (Swayne et al., 2017). The exports to these countries make up 69% of the total value of US poultry exports (Swayne et al., 2017). Hence, the zoning principles applied during this outbreak resulted in a significant reduction in the economic burden of the outbreak.

Whilst these changes have the potential to reduce unnecessary economic losses, they come with significant implications for disease surveillance, particularly in relation to assuring the integrity of established containment zones. Firstly, any country that intends to implement a containment zone will require the core competencies necessary to manage an EAD outbreak effectively. These are discussed at length in Section 0. Secondly, a number of additional control, management and surveillance activities will be required, specifically related to implementation of a containment zone. These are discussed at length in Section 2.5. Demonstrating the integrity of an established containment zone under the new code will require both core competencies and extra activities, but will also be effected by a number of additional factors such as the disease in question and the distribution of livestock industries in the geographical region experiencing the outbreak. Section 0 describes these additional factors with a focus on four key diseases in an Australian context.

2 Core competencies and surveillance activities during EAD outbreaks

There are a number of core competencies that are necessary to control any EAD outbreak. Without these, implementation of an effective containment zone is not feasible. This section outlines these core competencies, drawing on examples from Australia's 'gold standard' EAD response approach.

2.1 Key pre-existing arrangements

2.1.1 Appropriate and clear governance arrangements

Control of a major EAD event is an intricate process requiring timely mobilisation of resources and effective coordination of a range of people and resources. This demands a whole-of-government response, operating across all levels of government and involving multiple government departments and industry bodies. Managing a rapid response effectively therefore necessitates predefined and mature governance arrangements where the role of each stakeholder is clearly defined prior to the outbreak.

In countries with the core competencies to control EAD outbreaks, there will be typically two interrelated governance structures. The first is the overall organisational structure of animal health and will generally consist of organisations, specialist groups, industry groups and government departments that operate at all times and have a role in EAD response planning. It is critical that the roles and responsibilities of each of these groups to plan for EAD outbreaks and their relationship to each other is clear.

In Australia, the overall organisation of animal health is shown in Figure 1, extracted from the 2016 Animal Health in Australia report (Animal Health Australia, 2017). Details on the role of each of these organisations is provided in the full Animal Health in Australia report.

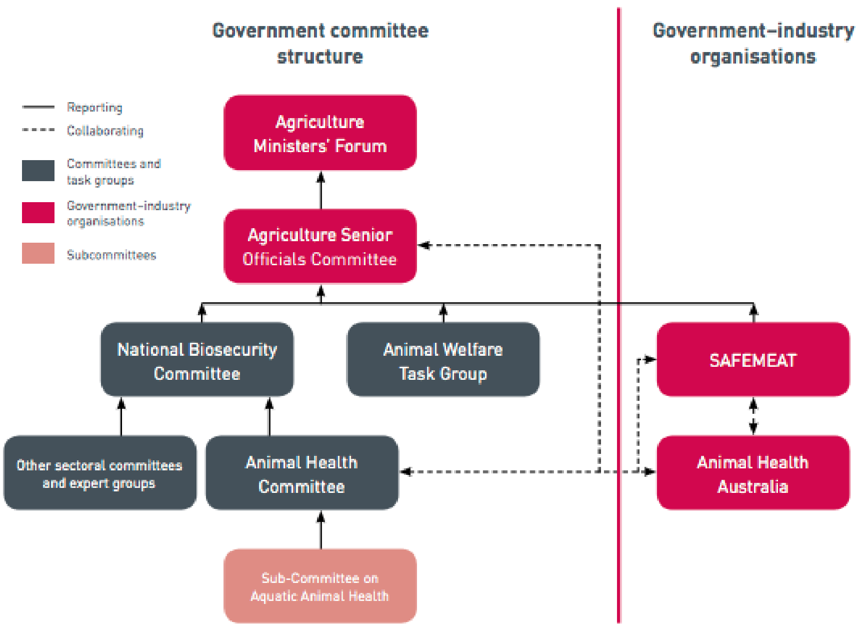

Figure 1: The organisation of animal health in Australia (reproduced from the 2016 Animal Health in Australia report)

The second critical governance structure for EAD management is the arrangement instigated when an EAD outbreak is detected. Many of the stakeholders involved in the general organisation of animal health in a country will also have a critical role when an EAD outbreak is detected. In addition, there will be committees and other advisory bodies that are rapidly established following an outbreak and disbanded when the outbreak has ceased. As is the case for the general organisation of animal health, it is critical that the roles and responsibilities of each group in the event of an EAD outbreak—and their relationship to each other—is clear.

In Australia, state and territory governments have legislative and operational responsibility for control and eradication of EADs within their borders. The Australian Government also has powers to support states and territories where appropriate. The Chief Veterinary Officer (CVO) of the state or territory where an EAD is occurring is ultimately responsible for implementing control measures in accordance with legislation and for providing the Australian Animal Health Laboratory (AAHL) with samples for diagnosis.

Without clear governance arrangements for both general EAD preparation and EAD outbreak response (such as those in place in Australia), a country is unlikely to be able to control a disease sufficiently and the establishment of an effective containment zone is unlikely to be feasible.

2.1.2 Predefined funding agreements

EAD outbreak response is potentially expensive and rapid response depends on there being a clear understanding of the bodies responsible for funding EAD response before an outbreak occurs. In Australia, The Government and Livestock Cost Sharing Deed in Respect to Emergency Animal Disease Response (EAD Response Agreement, EADRA) is signed by the Australian Government, state and territory governments and all major livestock industry organisations, and describes cost-sharing arrangements for the initial response to an EAD incursion or outbreak in Australia.

Without a predefined funding agreement, a country is unlikely to be able mount a rapid and effective control program following an EAD outbreak and hence will be unable to establish an effective containment zone.

2.1.3 Supporting documentation to ensure coherent operations and procedures

As described earlier, control of a major EAD is complex process that requires a rapid and coherent response. It is impossible to implement this response if documentation outlining a nationally-agreed upon approach and supporting information on key diseases is not readily available.

To ensure coherent operations and procedures in response to outbreaks, Australia is guided by the Australian Veterinary Emergency Plan (AUSVETPLAN), a nationally-agreed approach for response to EAD incidents. The plan is described through a series of manuals and supporting documentation. The AUSVETPLAN summary document describes the components of AUSVETPLAN and their relationship to each other. Disease strategies (available for 35 important EAD that are subject to cost-sharing arrangements) provide detailed information about the nature of particular diseases, the principles of their control and eradication, policies and strategies, and recommendations for control and management. Response policy briefs (available for 27 EADs subject to cost-sharing arrangements but with a lower likelihood of incursion and less severe consequences) provide useful information on the nature of particular diseases, and principles and policies for control. Operational procedures manuals outline the recommended processes for different components of EAD response such as destruction of animals and decontamination of public sites. Management manuals provide useful information on the management of control centres and laboratories. Lastly, enterprise manuals provide guidance for specific types of enterprises that may be involved in EAD outbreaks: these are targeted at both government staff and industry personnel. These core documents are supported by other resources such as training materials, agency support plans and diagnostic guides.

2.1.4 Trained and competent veterinary and support services

Effective EAD response requires trained and competent veterinary and support services. Strong veterinary services should be independent and objective, making decisions based on science rather than political pressure (OIE, 2018). The OIE defines four key components of effective veterinary services:

- the human, physical and financial resources to attract resources and retain professionals with technical and leadership skills,
- the technical authority and capability to address current and new issues including prevention and control of biological disasters based on scientific principles,
- the sustained interaction with interested parties in order to stay on course and carry out relevant joint programmes and services,
- the ability to access markets through compliance with existing standards and the implementation of new disciplines such as the harmonisation of standards, equivalence and zoning

Based on these components, the OIE has developed a Performance of Veterinary Services (PVS) evaluation tool (OIE PVS tool) and a corresponding PVS Pathway to assist with the sustainable development of a country's veterinary services.

PVS evaluation reports can be used as an independent resource to assess the capacity of a veterinary service to respond to EAD outbreaks. If a country has inadequate veterinary services, they are unlikely to be able to control EAD outbreaks and even less likely to be able to implement an effective containment zone. Some of these reports are publically available whilst others can be viewed on request.

A PVS evaluation report on Australia's veterinary services can be downloaded from the OIE website.

2.2 Core surveillance activities during an EAD outbreak

2.2.1 Surveillance enablers

Gold standard surveillance is of critical importance during EAD outbreak response and requires an enabling environment. Core components of optimal surveillance cannot be implemented without the following enabling factors.

A tracing and surveillance plan

Surveillance during EAD outbreak response is a complex process and needs to be guided by a clear plan. In most cases, surveillance is likely to be undertaken through both regional and local control centres and may involve hundreds or thousands of individuals. A tracing and surveillance (TaS) plan should be developed rapidly in response to an EAD outbreak, utilising guidelines already available but adapted for the particular disease and circumstances. In Australia, AUSVETPLAN includes three key components that aid in the rapid development of an effective TaS plan following an EAD outbreak: a guidance document on TaS, sections on TaS in each individual disease strategy and control centre management manuals that clearly define the roles and responsibilities of key personnel. The process for developing and approving the plan should be clearly defined and the plan should include details on the aim of TaS, the TaS objectives and the details on how to implement the activities required.

Local and regional networks and data sources

Tracing and surveillance requires high quality data sources and networks. For example, tracing relies on knowledge of animal movements. In some countries, this information is not available. In Australia, producers must submit movement records when stock such as cattle and sheep are transported from one property. These movement records are critical for rapid tracing during an EAD outbreak. Other examples of critical data sources and networks that allow for effective surveillance and tracing include agricultural property databases, vector monitoring information, trade records and laboratory records. Many countries do not have the basic data required to implement effective TaS during EAD outbreaks.

Defined control and coordination centres with clear roles, responsibilities and resourcing

TaS in an effective EAD outbreak response will be coordinated through multiple centres, located in different geographical locations and operating at different levels. The roles and responsibilities of these different centres in relation to TaS must be clear prior to an EAD incursion; however, the organisational structure is likely to vary depending on the scale and complexity of the incident. Control and coordination centres should be supported by policies, documentation and resources (both financial and human) that allow for coherent implementation of the TaS plan, delivered through contemporary emergency response management practices.

In Australia, AUSVETPLAN includes two manuals on the management of control centres. Most TaS activities are coordinated by State Control Centres (SCC) and Local Control Centres (LCC). A National Coordination Centre is used to ensure a consistent approach across the country. Each SCC and LCC develops their own TaS plan, guided by the TaS guidance document in AUSVETPLAN and the control centre manuals. Funding arrangements are described in the **EAD Response Agreement.**

2.2.2 Core components of tracing and surveillance

TaS has several core purposes. In the context of EAD outbreak response, TaS should aim to:

- detect new cases rapidly
- define the extent of an outbreak
- monitor progress against response objectives
- demonstrate freedom from disease in particular areas.

TaS may also help to describe the extent and characteristic of disease, including risk factors for transmission and spread. However, this is likely to be less important when the disease in question is already well understood.

Core components of TaS that allow these objectives to be met and minimise disease spread are described below.

Classifying premises and regions and concentrating resources in accordance with risk

Effective TaS requires prioritisation. EAD outbreak response therefore should involve classification of premises and regions based on their likelihood of harbouring infected animals so that surveillance can be concentrated on properties most at risk of infection. This necessitates a disease case definition, data on agricultural properties and risk pathways (including movement records) and trained professionals who can allocate a classification to premises and regions, based on risk assessment from the data available. Lastly, all properties with susceptible species within at-risk regions need to be recorded in an appropriate information management system.

In Australia, AUSVETPLAN disease strategies contain a case definition and details of premises and regional classification. For example, in the case of foot and mouth disease (FMD), a premise can be classified as an infected premises (IP), a dangerous contact premises (DCP), a dangerous contact processing facility (DCPF), an approved processing facility (APF), a suspect premises (SP), a trace premises (TP), an at-risk premises (ARP), a premises of relevance (POR), a resolved premises (RP), an unknown status premises (UP) or a zero susceptible stock premises (ZP). Areas can be classified as a restricted area (RA), control area (CA) or outside area (OA). Further details on the definition of each of these classifications and the surveillance activities for each can be found in the AUSVETPLAN disease strategy for FMD.

Premises are assigned a classification based on risk assessments conducted by trained professionals (including tracing back and forward). These professionals rely on numerous data sources including agricultural property data and livestock movement records.

Active surveillance of premises most at-risk

Active surveillance requires a high level of resourcing and should be concentrated on premises most likely to be harbouring infected animals. These should be identified through classification processes as described above. Surveillance activities can spread disease because they involve the movement of people and vehicles between properties. To avoid this, surveillance teams should only consist of trained professionals who can implement appropriate biosecurity and are coordinated by dedicated control centres.

In Australia, AUSVETPLAN disease strategies provide guidelines on active surveillance. In the case of FMD, surveillance teams initially concentrate on SPs, TPs and DCPs as these are the premises where new infections are most likely to be detected. ARPs in the RA are inspected by both owners and control centre veterinarians. Surveillance within the CA is less intensive. AUSVETPLAN disease-specific strategies also contain information on how particular diseases are transmitted and appropriate biosecurity measures to avoid their transmission. Enterprise manuals contain details on appropriate biosecurity measures for specific enterprise types.

A communication plan and improved passive surveillance

Passive surveillance plays a critical role in EAD outbreaks. Generally, improved passive surveillance requires communication strategies targeted at veterinarians, livestock owners and the general public. Any effective EAD outbreak response will have a communications plan that is implemented rapidly and effectively.

In Australia, AUSVETPLAN disease strategies refer to the development of a communications plan. The Australian Government Department of Agriculture and Water Resources has also developed a Biosecurity Incident Public Information Manual that provides guidance to enable Australian biosecurity and agricultural agencies to apply a nationally consistent communication response to biosecurity emergencies, such as EAD outbreaks.

Monitoring progress

One of the primary purposes of surveillance during an EAD outbreak is to monitor progress against the outbreak response objectives and provide data for disease control operations. In many cases, the overarching objective of an EAD outbreak response will be to control and then eradicate the disease. Therefore, surveillance during an EAD outbreak should answer the question: 'Is the disease being controlled?'

In Australia, response progress is monitored at a national, state/territory and local level. TaS data are therefore included in reports to the National Coordination Centre and must conform to nationally agreed data standards. On the basis of available data, the case definition and premises status definitions may change throughout the course of the outbreak (for example, in response to change in the relative importance of false-negative and false-positive classifications at different stages of the outbreak).

Demonstrating freedom

When the aim of an EAD response is to eradicate disease and regain free status, the demonstration of disease freedom marks the finale of the response effort. The TaS data collected in the early stages of a response can significantly reduce the time and cost associated with demonstrating freedom. In an effective response, infected premises or those found to be at high risk during classifying processes will need to demonstrate property freedom from disease to return to their free status and this will eventually lead to contraction of declared areas and national freedom.

In Australia, AUSVETPLAN disease strategies provide information on 'proof of freedom' surveillance. Most of this is derived from, and refers to, the OIE TAHC disease-specific chapters. For many diseases, proof of freedom will require both clinical and additional serological or molecular surveillance.

2.3 Core control activities during an EAD outbreak

There are a number of activities that are critical to controlling disease during an EAD outbreak. In most cases, the most appropriate control measures and how these should be applied is dependent on the nature of the disease and other factors unique to the outbreak (such as the location of the outbreak and the livestock systems operating in that area).

In Australia, AUSVETPLAN disease strategies contain recommendations on appropriate control measures for specific diseases. These recommendations provide a good summary of the core control activities that would be expected to be included in EAD outbreak response in any country where the implementation of effective containment zones could conceivably occur and are summarised below. This section summarises the core control activities that would be expected to be implemented in any EAD outbreak. Section 2.4 examines control activities that would be specifically expected in response to EAD outbreaks of four key diseases.

2.3.1 Movement controls and quarantine

For most EAD outbreaks, containment and eventual eradication of the disease are of the highest priority, so 'normal business movements' of susceptible livestock should cease immediately. Live animals usually pose the greatest risk of disease spread and hence their movement should be most strictly controlled. The severity of movement restrictions may depend on the disease status of areas and premises, so an appropriate classification methodology and supporting TaS activities are required (See Section 2.2.2). In general, areas with infected premises (in Australia, these are usually referred to as RAs) and areas immediately surrounding those (in Australia, these are referred to as CAs) should be subject to restrictive movement controls where producers are not allowed to move their livestock without a permit. In some cases, movement will be required to relocate infected or in-contact animals to an appropriate facility for slaughter and this should be conducted under permit. Initially, the whole country may be placed under movement controls until an EAD outbreak response plan is formulated and the extent of the outbreak is determined.

Careful consideration also needs to be given to the movement of animal products such as embryos, semen, meat, milk and effluent, and equipment such as vehicles. The movement and quarantine imposed on products and equipment will depend entirely on the nature of the pathogen. In Australia, AUSVETPLAN disease strategies provide detailed information on the nature of each disease and recommendations for movement and quarantine restrictions for both live animals and products and equipment.

2.3.2 Stamping out

In many EAD outbreak situations, stamping out is considered the most efficient and cost-effective way of eradicating the disease. Implementation requires effective classification methodology, supporting TaS activities (See Section 2.2.2) along with well-resourced, trained and coordinated depopulation teams. Stamping out should be completed as soon as possible and infected properties marked for depopulation should be effectively quarantined until susceptible animals are destroyed. Lastly, stamping out requires effective and efficient processes for carcass disposal. If a country cannot implement stamping out effectively, then establishing an effective containment zone is unlikely to be feasible.

In Australia, stamping out is guided by a series of operational manuals including 'Destruction of animals', 'Disposal Procedures' and 'Livestock Welfare and Management' and AUSVETPLAN disease strategies. All of these are available publically on the Animal Health Australia website.

2.3.3 Vaccination

For some diseases and in certain circumstances, vaccinations may be used. In most cases, the decision to vaccinate requires careful consideration of factors such as whether the country intends to regain OIE status as a country free from disease without vaccination (in the case of FMD) and whether animals that are vaccinated can easily be distinguished from animals that are infected by the disease agent itself.

In Australia, AUSVETPLAN disease strategies include information on vaccination when applicable. However, the decision to vaccinate or not is usually taken during the EAD outbreak response when the extent of the outbreak is known with reasonable confidence and the likelihood of controlling it without vaccination is well understood.

2.3.4 Treatment of infected animal and products

For many EADs of livestock, treatment of infected animals will be ineffective and cost-prohibitive compared to stamping out or contrary to disease control objectives. However, for some EADs—namely, those with no long-term carrier state where animals can be conceivably quarantined until they recover—stamping out could be considered inappropriate and unnecessary. This is the case for diseases such as EI. In these cases, animals may be treated during this period to potentially reduce the clinical course and spread of disease and to relieve animals of unnecessary pain or suffering.

For many diseases, treatment may also be appropriate for potentially infected animal products such as milk or meat. Countries should take a risk-based approach to the use of animal products and by-products that are potentially infected; for example, through use of premises and area classifications and supporting surveillance information (including tracing).

In Australia, AUSVETPLAN disease strategies contain information about the treatment of animals for diseases where treatment is preferable to stamping out. They also provide information on the treatment of potentially infected animal products.

2.3.5 Biosecurity of products, personnel and equipment

All effective EAD outbreak responses should include the implementation of increased biosecurity measures and standards immediately following the incursion. In Australia, AUSVETPLAN enterprise manuals provide detailed guidelines on appropriate biosecurity for different enterprise types.

2.3.6 Disposal of animals and products, decontamination and restocking

In any EAD outbreak response, infected animal carcasses and products need to be disposed of appropriately to minimise potential for disease spread. There are many ways to dispose of infected animals and products and the method selected will depend on multiple factors including the nature of the disease, cost, safety and timeliness. In Australia, AUSVETPLAN disease strategies contain information on possible methods for disposal for particular diseases. The operational manual 'Disposal Procedures' contains more detailed information on disposal options, factors to consider when choosing a disposal option and a decision-making framework.

Likewise, animal products, equipment, materials and buildings that may be contaminated during an EAD outbreak need to be thoroughly decontaminated as part of the response. In Australia, AUSVETPLAN disease strategies provide information on agents that destroy specific diseases. The operational manual 'Decontamination' provides more detailed information on classes of disinfectants and procedures for decontaminating different materials.

Lastly, in some cases, it may be appropriate for sentinel animals to be placed on infected premises or properties that were considered likely to be infected. The purpose of this is to monitor these animals as a potential pathway to resolving the free status of the premises. Sentinel animal placement should only commence after decontamination and should be monitored closely. Complete restocking should only commence when the free status of the premises is resolved and should be conditional on high level government approval.

2.3.7 Wild, feral and vector control

Some diseases are carried by wild animals, feral animals or vectors and their control can be critical in containing the EAD in question. The potential for this should be considered in every EAD outbreak. In Australia, AUSVETPLAN disease strategies provide information on the potential for specific diseases to be carried by wild animals, feral animals or vectors. The operational manual 'Wild Animal Response Strategy' provides more detailed guidelines on controlling wild and feral animals in the event that they are potential carriers for an EAD.

2.3.8 Public awareness

Public awareness is critical during an EAD outbreak response. Relevant industries, the media and the public should always remain fully informed on the nature of disease and the control programs being implemented. In some cases, particular control strategies like stamping out are likely to cause public concern and this can be exacerbated by poor communication or messaging. In most cases, awareness of clinical signs amongst producers and encouragement to report disease is of paramount importance. Any effective EAD outbreak response will include a carefully considered communications strategy.

2.4 Core surveillance and control measures for specific diseases

2.4.1 Foot and Mouth Disease

FMD is a highly contagious disease that can cause significant social and economic disruption when an incursion occurs in a previously free country. Many of the control and surveillance activities discussed in Sections 2.1, 2.2 and 2.3 apply to FMD. However, the following specific core surveillance and control activities should be implemented during an incursion of FMD:

- an immediate livestock movement standstill due to the highly contagious nature of the disease and capacity to infect multiple species
- immediate laboratory confirmation due to a number of diseases presenting with the same clinical signs
- timely typing of the virus so that appropriate vaccines can be ordered should vaccination be chosen as a tool for control
- tracing and surveillance including in feral or wild animals that are known hosts
- stamping out and appropriate disposal of animal carcasses and products and decontamination of destocked premises
- recall of animal products (including dairy for animal consumption) that are likely to be contaminated
- relief and recovery programs that minimise animal and human welfare concerns.

Additional measures that could be implemented if appropriate in the circumstances include:

- vaccination to reduce susceptibility of animals to infection and reduce viral excretion
- pre-emptive destruction of susceptible animals
- risk-based movement controls.

In Australia, AUSVETPLAN disease strategy for FMD outlines Australia's preferred approach to controlling and eradicating FMD.

2.4.2 Classical Swine Fever

Classical Swine Fever (CSF) is a highly contagious disease with potential for rapid spread and significant production losses. Many of the control and surveillance activities discussed in 2.1, 2.2 and 2.3 apply to CSF. However, the following specific core surveillance and control activities should be implemented during an incursion of CSF:

- early laboratory confirmation of cases
- rapid movement controls over pigs, pig product and potentially contaminated fomites
- rapid tracing and surveillance
- stamping out and appropriate disposal of pig carcasses and potentially infected pig products
- decontamination of infected premises and fomites
- recall of suspect pig products (meat and offal).

Additional measures that could be implemented if appropriate in the circumstances include:

- vaccination
- modified stamping out where slaughter for human consumption is considered
- a long-term control strategy should the outbreak become widespread.

In Australia, AUSVETPLAN disease strategy for CSF outlines Australia's preferred approach to controlling and eradicating CSF.

2.4.3 Highly Pathogenic Avian Influenza

HPAI is a highly contagious and lethal disease of poultry that (like influenza viruses in general) may have the potential to spread to humans. It can also infect wild birds, caged birds and zoo species and an uncontrolled outbreak would cause severe economic losses. Many of the control and surveillance activities discussed in Sections 2.1, 2.2 and 2.3 apply to HPAI. However, the following specific core surveillance and control activities should be implemented during an incursion of HPAI:

- rapid stamping out of all birds on premises known to be infected and disposal of destroyed birds and contaminated products
- consideration of pre-emptive slaughter on premises identified as high risk by tracing and surveillance activities
- rapid tracing and surveillance including consideration of wild birds
- localised quarantine and movement control on birds and avian products
- decontamination of infected premises and enhanced biosecurity on all poultry establishments or premises holding caged or zoo birds, including measures to disallow contact with wild birds
- a large public awareness campaign that communicates risk and encourages cooperation from the entire community (including zoos, cage bird owners etc)

- vaccination, protective clothing and antivirals (when appropriate) provided to personnel engaged in eradication activities

Vaccination of birds may be considered if the outbreak is becoming difficult to control.

In Australia, AUSVETPLAN disease strategy for Avian Influenza outlines Australia's preferred approach to controlling and eradicating HPAI.

2.4.4 Newcastle disease

ND is a highly contagious disease that has significant consequences for trade of poultry. Many of the control and surveillance activities discussed in Sections 2.1, 2.2 and 2.3 apply to ND. However, the following specific core surveillance and control activities should be implemented during an incursion of ND:

- rapid stamping out of all birds on properties suspected of being infected with appropriate disposal of carcasses and products
- decontamination of infected premises following depopulation
- localised movement controls on birds, avian products and potential fomites
- pathotyping of ND virus isolates to determine their virulence
- rapid tracing and surveillance

Additional measures that could be implemented if appropriate in the circumstances include:

- vaccination
- long term control strategies (especially for low virulence strains)

In Australia, AUSVETPLAN disease strategy for ND outlines Australia's preferred approach to controlling and eradicating ND.

2.5 Examples of EAD response in Australia

When the competencies described above exist, EADs can be effectively controlled and eradicated. Australia has a proud history of controlling EAD outbreaks through the application of AUSVETPLAN and its predecessors. The following section provides some examples of where 'best practice' outbreak response was applied to successfully control and eradicate an EAD in Australia. These examples suggest that containment zones could be applied in Australia to resume trade more rapidly.

2.5.1 Highly pathogenic avian influenza outbreaks

Australia has had seven outbreaks of HPAI: five between 1976 and 1997 in Victoria, New South Wales (NSW) and Queensland, one in NSW in 2012 and one in NSW in 2013. In all cases, eradication was achieved by a stamping out program and confirmed by local, state and national surveillance (OCVO, 2010; Queensland Department of Agriculture and Fisheries, 2013). In all outbreaks, spread was limited to three premises or less, demonstrating that the EAD outbreak response implemented was ultimately successful in containing and eradicating the disease (OCVO, 2010; Queensland Department of Agriculture and Fisheries, 2013). Containment zones for more rapid return to trade would have been effective in all these outbreaks because the infected properties were limited to a very small geographical area.

2.5.2 Newcastle disease outbreaks from 1998–2002

Australia is free from virulent ND but avirulent strains are actively circulating.

In 1998, a virulent ND virus emerged in NSW with genetic sequencing indicating that it had originated from an avirulent ND virus of Australian origin. Further outbreaks occurred in different areas of NSW in 1999 and again in 2000.

In response to these outbreaks, a national representative survey for ND virus distribution was completed in late 2000 and did not detect any isolates of virulent ND or isolates with gene sequences related to the recent NSW outbreaks. By 2001, all properties with the virulent ND had been depopulated and Australia met the international standards for freedom from virulent ND virus.

In 2002, virulent ND was confirmed on a single property in Victoria and (later in 2002) was detected in NSW. In both instances, the AUSVETPLAN disease controls strategy for ND was applied and the disease was effectively controlled.

In all these cases, ND was restricted to a handful of premises and did not spread rapidly across a wide geographic area. This indicates that containment zones for prompter return to trade would have been likely to have been successful with no diseased products or animals exported.

2.5.3 Equine influenza outbreak in 2007

Australia is one of the only countries across the world to be free of EI (Cowled et al., 2009). However, in August 2007 a large outbreak associated with imported horses occurred in NSW and Queensland, with nearly 10,000 premises infected (Cowled et al., 2009). Despite the large number of horses infected, the disease was successfully controlled and Australia regained its EI free status in December 2008.

Analysis conducted after the event identified an epidemic of three key phases (Cowled et al., 2009). In the first phase, significant spatial dispersion of disease occurred through relatively few horses prior to disease detection (Cowled et al., 2009). The second phase was characterised by local spread and the final phase by epidemic phase out (Cowled et al., 2009). Movement restrictions were implemented on 25 August, 2007 and were immediately followed by a rapid decrease in spatial dispersion (phase two), suggesting that movement restrictions were critical to the successful control of disease (Cowled et al., 2009).

Whilst thousands of premises were infected during this outbreak, long distance spread was effectively stopped by movement restrictions. This suggests that a containment zone established after the extent of the outbreak was well understood (after phase one) would have most likely been successful with infection continuing with the zone but not advancing into the free zone.

3 Additional requirements to establish a containment zone

The objective of a containment zone should be to contain the disease within a specified area, such that importing countries can have confidence that the product they import from outside the containment zone doesn't contain the disease agent. A containment zone should be considered 'successful' if no cases occur outside the infected zone.

Section 0 outlines a number of core competencies for surveillance and disease that are necessary to control any EAD outbreak, although the activities will vary with the specific EAD event. These should be considered as core prerequisites for the establishment of a containment zone and without which an effective containment zone is not feasible. This section summarises the additional or different activities —i.e. above and beyond core activities—that are required to implement an effective containment zone.

3.1 Implementing a containment zone

3.1.1 Time from detection to establishment of a containment zone

The timing of establishment of a containment zone must balance the desire to re-establish trade as soon as possible with the need to meet conditions required of a containment zone and provide reasonable assurance that the zone will be successful.

Preliminary TaS including activities relating to initial trace back, trace forward and risk analysis should be completed prior to defining a containment zone, so that the extent of the outbreak is well understood. If a containment zone is defined prematurely—i.e. before the extent of the outbreak is well understood and when the disease is still spreading rapidly—it is likely to fail, bringing significant reputational consequences. On the other hand, the longer the time between confirmation of the outbreak and the establishment of a containment zone, the longer the disruption to trade and greater the associated economic and social impacts.

The new OIE Code Article prescribes that the protection zone must be free of new cases for a period equivalent to two incubation periods. Therefore, if a containment zone (with an infected and protection zone) was drawn on the first day of the outbreak and there were no cases detected in the protection zone thereafter, then the OIE could theoretically recognise the containment zone as early as two incubation periods after Day One of the outbreak. However, in reality, the boundaries of the containment zone are more likely to be drawn when the extent of the outbreak is well understood and effective control interventions are in place, with a view to the criteria of the protection zone being reaffirmed two incubation periods later. This could take many weeks in the event of a large outbreak where disease continues to spread in the early stages of the response.

3.1.2 Size and shape of the containment zone

Should Australia choose to establish a containment zone during an EAD outbreak, the smallest 'infected zone' would consist of the area defined by a convex hull around the infected premises with a specified buffer of distance *x*. The boundary of the infection zone might take into account natural or production-system features that provide a barrier to disease spread (e.g. mountain ranges or the absence of susceptible species) but should avoid using boundaries of large administrative area such as states or territories. See Figure 2. Local administrative boundaries or property boundaries may be sued to define the zone at a local level, and may be useful in clearly defining the status of every property with respect to its zone. The use of property boundaries cannot be see on the scope of Figure 2 but could be determined at higher resolution. This would form the 'infected zone' in OIE terms.

There would then be a protection zone drawn around the infected zone with a specified minimum buffer of distance y and most likely defined by local administrative or property boundaries (see **Error! Not a valid bookmark self-reference.**).

In some cases, it may be reasonable to establish multiple containment zones; for example, if there are two foci of disease with no signs of disease in the areas in between. This could occur if, for example, a consignment of infected animals were moved from northern Queensland to northern Western Australia (WA), resulting in outbreaks in both jurisdictions but with no cases occurring in the Northern Territory.

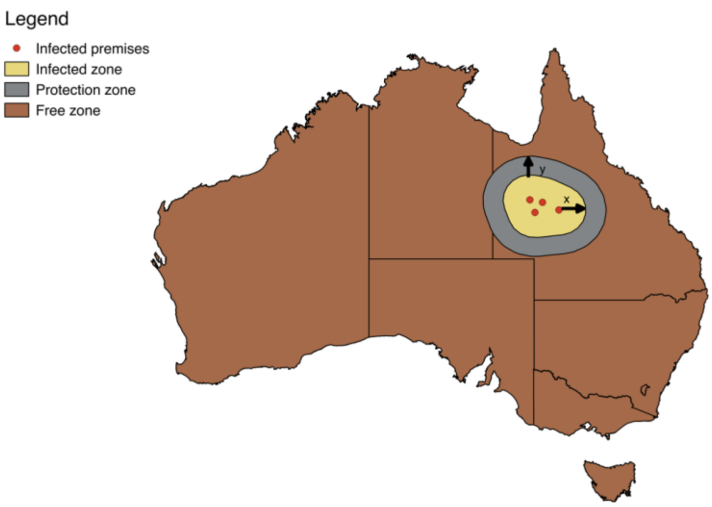

Figure 2: Map of a hypothetical containment zone

If there is further local spread within the infected zone such that the distance from the closest infected premises to the infected zone boundary becomes less than x (as originally specified), this will not invalidate the zone—indeed, this is the purpose of including (as part of the infected zone) a buffer around the known infected premises. The zoning only becomes invalid ('fails'), if infected premises are detected within the protection zone.

Just as the *time* to establishment of the containment zone needed to balance expedience with the likelihood of success (hence confidence in the zone), so too does the determination of the *buffer distances* x and y. The appropriate value of x and y will vary depending on the circumstances but the following factors that influence the success of a containment zone[1] should be considered:

- in general, the greater the values of x and y, the greater the number (and proportion) of trade-restricted producers and the greater the economic and social impacts of the outbreak

[1] These factors are proposed by the authors

- in general, the greater the value of x, the lesser the likelihood that cases will occur outside the infected zone
- in general, the greater the value of y, the lesser the likelihood that cases will occur outside the protection zone
- in some situations, smaller values of x and y could actually *reduce* the risk of cases occurring outside the protection zone because available surveillance and control resources can be concentrated where they are most needed
- small x or y values will not necessarily result in a high risk of infected products being exported; especially if no exporting properties are close to the containment zone
- Smaller values of x and y may be justified if there is strong evidence that the outbreak is under control and there is robust surveillance evidence to support presumptions about the extent of the outbreak.
- larger values of x and y will not always have a proportionally greater economic and social impact; for example, if the location is such that few properties are included in the (larger) infected and protection zones
- small values of x and y may still have a significant economic and social impact if many export-focussed properties are included in the infected and protection zones
- the values of x and y are not the only determinants of a successful containment zone.

Multiple factors influence the temporal and spatial dynamics of infectious diseases (including in the face of a control program) and it is therefore impossible to propose single or precise values for x and y that ensure success of a containment zone. However, the value of x is unlikely to be set at any less than 30km or (in the case of very large properties) a property boundary.

Regardless of the value of x and y, it is possible to outline the surveillance that is required within the different zones to maintain high confidence that the objectives are being met.

In an Australian context, the following general rules would be appropriate:

1. In the remote north of the country where agricultural properties are large, livestock systems are extensive and intensive surveillance is challenging, x would be at least one entire neighbouring property and y at least one more, with a minimum of x = 50km and y = 50km
2. In areas of intensive production where intensive active and passive surveillance is possible, such as the south-east or south-west, x could be a minimum of 30km and y a minimum of 10km with boundaries defined by properties or Local Government Areas.

3.2 Surveillance and control when a containment zone is implemented

3.2.1 Within the infected zone and protection zone

The objective of surveillance within the infected zone should be to detect any new cases rapidly so that control efforts can be prioritised the progress of disease spread can be monitored. In the protection zone, the objective is early detection of cases, should any occur in this zone (which is considered to be free of disease). Eventually, surveillance information collected here will also contribute to demonstrating freedom from disease

The infected and protection zones should be areas of high activity and resourced appropriately. As is the case with standard EAD response, premises should be classified based on their known or probably likelihood of harbouring infected animals so that surveillance can be concentrated on properties most at risk of infection. Active surveillance would be prioritised according to risk. Passive surveillance efforts should be enhanced by public awareness campaigns and other means (for example, the removal of disincentives to report). Results from these TaS activities would guide the implementation of the core control activities described in detail in section 2.3.

If there is the possibility that the disease may be spread by, or maintained in, feral animals or wildlife, then risk assessment and/or surveillance in these populations will be required.

Regions within the infected zone and protection zone may carry two classifications; one for internal disease control purposes and aligned with existing conventions in the country and one that denotes their inclusion in the infected zone, for trade purposes. For example, in Australia premises within the infected zone could also be defined as being within the RA whilst premises in the protection zone may be defined as being within the CA. In some cases, authorities may align their own existing control conventions with the OIE terminology for containment zones. If this was adopted in Australia, the RA would have the same boundaries as the infected zone and the CA would have the same boundaries as the protection zone.

Obviously, properties within the infected zone would not be able to trade or move their animals or animal products without restriction. Trade and movement from the protection zone into the free zone would be restricted; however, movement within the protection zone may be allowed.

3.2.2 Beyond the containment zone

The objective of surveillance beyond the zone should be to demonstrate freedom from disease or detect any new cases should they occur. This is a normal requirement for surveillance for any country claiming freedom from a particular disease. To illustrate this point: if there happened to be an international boundary near the edge of the protection zone, then no additional requirements for disease freedom would be placed on the neighbouring country. However, it would be expected that the neighbouring country adopt precautionary measures to ensure increased vigilance through enhanced passive surveillance and possibly other measures. Precautionary risk management measures might include improved biosecurity practices.

Trade and movement may be allowed in the free zone. Movement or trade with the infected or protection zones will be prohibited.

3.3 Reducing risk beyond the containment zone

Containment zones with appropriate surveillance and control measures should manage risk to a very large extent, but 'zero risk' is impossible to guarantee (and the pursuit of zero risk in the establishment of a containment zone may well defeat the purpose of establishing the zone). Consequently, the zone should not be expected to provide 100% confidence that infected animals or products will not get outside the containment zone. This premise has implications both for risk management outside the containment zone and for consequences should disease be detected outside the containment zone.

If disease is detected outside the zone, then for all intents and purposes the containment zone has failed: disease has not in fact been contained and the reasons for this (whether through premature or optimistic definition of boundaries, or ineffective control measures) are irrelevant. In this case, the notion of a containment zone *in that particular situation* is rightly discredited and the country should not be allowed a 'second chance' to implement a containment zone for that outbreak—it is not appropriate to simply revise the containment zone boundaries.

Given the very low (but non-zero) risk of disease spreading beyond the containment zone, some additional risk-mitigation measures may be taken for animals/products exported from the free zone during the outbreak. The purpose of additional risk management is to further reduce risk and improve confidence that infected products will not be exported, even if the containment zone fails. Additional surveillance in the free zone should be risk-based, on the basis of likelihood of infection (e.g. proximity to the containment zone or through other risk pathways) and consequences (i.e. properties or origin and supply chains of animals/products destined for export). Additional activities that could manage the risk of infected products being exported (even if the zone fails to contain the spread) that should be considered include:

3.3.1 Live export chain surveillance

Live export chains from point of departure to arrival at destination port can be several days long. In many countries, veterinarians are legally obliged to be present on live export shipments and conduct regular clinical examinations. Veterinarians are also present at feedlots prior to the loading of shipments and complete a loading inspection. In the event of an EAD outbreak, live export shipment veterinarians should be briefed to take extra care assessing animals for the clinical signs of the EAD that has recently entered Australia. Extra active surveillance at ports could also be implemented.

3.3.2 Abattoir ante-mortem and post-mortem inspection

For meat products destined for export, abattoir ante-mortem inspections provide an additional opportunity to conduct surveillance and increase confidence that infected products will not be exported with post-mortem examination providing a further opportunity. In many countries, every export abattoir must employ an on-plant veterinarian. The on-plant veterinarian is responsible for conducting ante-mortem inspections and overseeing post-mortem inspections. If the time between infection and slaughter is more than the incubation period and the disease has clearly distinguishable clinical signs, then the on-plant veterinarian would be expected to detect the disease and stop the export of associated products.

3.3.3 Enhanced surveillance of animal product

If the time between infection and slaughter (or collection of products) is more than the incubation period and the disease in question can be transmitted through infected products, PCR batch testing could be considered. For example, real time polymerase chain reaction (RT PCR) is known to be an effective way of detecting FMD in milk and could be considered as an additional measure to ensure infected milk is not exported from the free zone, should the containment zone fail (Reid et al., 2006).

4 Demonstrating the integrity of a containment zone

To allow for continued trade from the free zone, the integrity of a containment zone must be clearly demonstrated to trading partners. Ultimately, trading partners will require assurance that the extent of the outbreak is known and the outbreak is under control. This section focusses on how Australia could demonstrate the integrity of an implemented containment zone. In addition to this section, Appendix 1 provides recommendations on demonstrating the integrity of a containment zone, presented as a checklist for countries planning on implementing a zone.

4.1 Providing detailed information on the Australian system and response

The first priority of Australia during the implementation of a containment zone would be to provide detailed information to trading partners on the quality and competence of the Veterinary Service and other supporting elements of response. This would include details of the groups involved in the response, their specific roles and the activities implemented to date. Many of these potential activities have been described in earlier sections. The results of surveillance and contextual data would be provided and used to justify the proposed boundaries of the containment zone.

4.2 The distribution of Australian livestock industries

Australia is a large country and many of its livestock industries have patchy distributions that lend themselves to effective containment of disease. When there are large gaps of low livestock density between areas of higher density, control of disease through zoning is most effective because there are limited opportunities for disease to move from one densely populated area to another, when movement controls are enforced. It would be expected that any containment zone established in Australia following an EAD outbreak could utilise the natural barriers created by areas of low livestock and human density.

The bulk of the Australian poultry industry is established around capital cities or major provincial centres where they are close to cereal grain cropping areas (see Figure 3) (Scolexia Animal and Avian Health Consultancy, 2005).

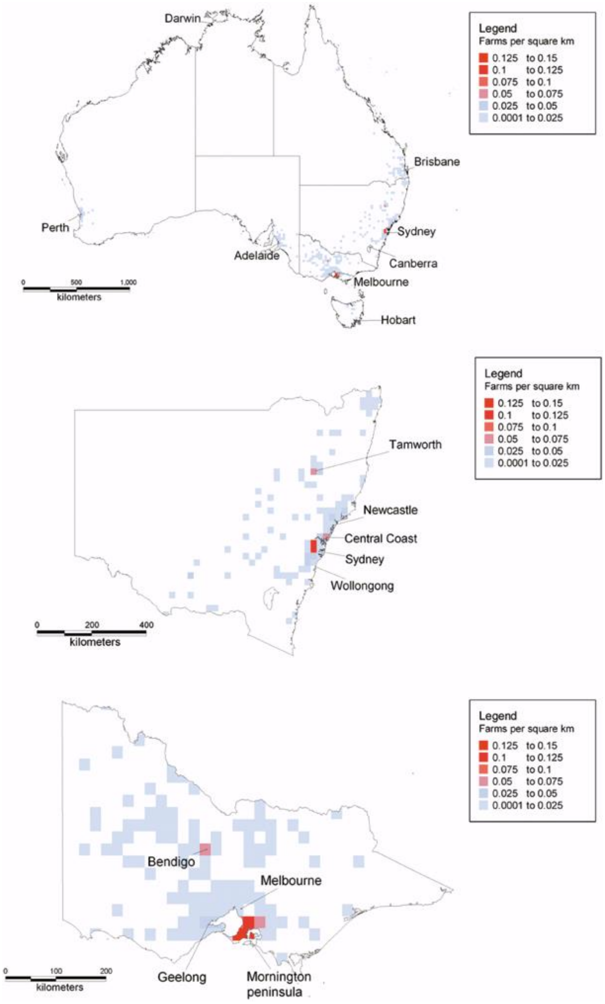

Figure 3: Density of Australian poultry farms (Hamilton et al., 2009)

Between these main areas, there are very few poultry. Hence, in the past outbreaks of HPAI and ND have been effectively contained to a small number of premises, primarily by instigating TaS, stamping out and implementing strict movement controls to prevent further disease spread (see Section 2.5). In hindsight, a containment zone established around the small number of infected premises would have been successful: disease was restricted to a few premises within the infected zone whilst trade would have been able to continue safely within the free zone.

The distribution of the Australian sheep industry is driven more by environmental factors that influence the quality of pastures (Hassal and Associates, 2006). For production systems that rely on lamb production to derive the majority of income, productive, high protein pastures are critical to rapid growth (Hassal and Associates, 2006). Hence, sheep are most densely populated in regions with reasonable rainfall (or access to irrigation) and relatively productive soils (Hassal and Associates, 2006). High sheep density is therefore restricted mainly to the south-east and to the south-west (see Figure 3). In addition, the majority of the national flock is involved in self replacing breeding systems where the only movement of animals is stud rams, cull for age animals and surplus younger animals (Hassal and Associates, 2006). Approximately 75% of sheep movements occur over distances of less than 200km and on 79% of properties movement of sheep is limited to the introduction of less than 50 stud rams annually (East and

Foreman, 2011). If containment zones were applied following an EAD outbreak where sheep are susceptible, it is unlikely that disease would spread from the eastern states to WA or from WA to the eastern states. It is more likely that the disease would be successfully contained on the seaboard where the first incursion occurred, following movement restrictions and other control measures.

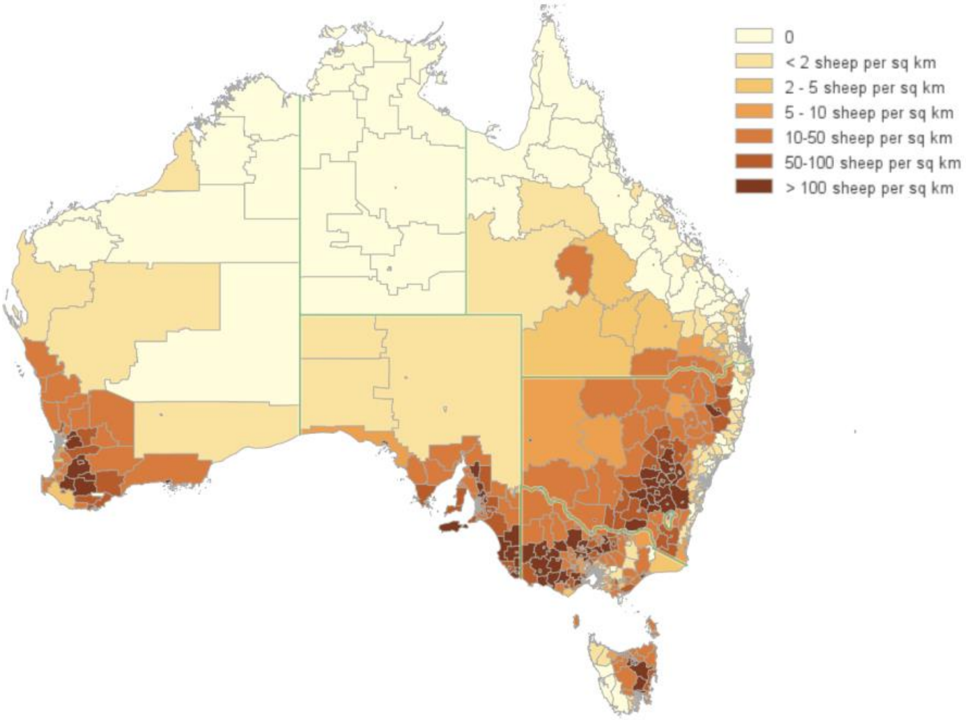

Figure 4: Australian sheep density (data source: ABS 2011)

The distribution of the Australian dairy cattle herd is also driven by environmental factors, primarily rainfall. In general, pasture-based dairying requires irrigation when rainfall is less than 800mm per annum (AusVet Animal Health Services, 2005). Dryland dairy farms with seasonal rainfall require calving patterns that prevent large numbers of cattle lactating in dry periods (AusVet Animal Health Services, 2005). Because of these requirements, dairy cattle populations are limited to the coastal strip and winter rainfall areas of southern Australia and the major irrigation areas of inland NSW and northern Victoria (AusVet Animal Health Services, 2005). Beef cattle production is more adaptable to variations in climate and hence beef cattle are found in all Australian states and territories. However, high rainfall areas still support a greater density of animals while some arid areas are essentially free of cattle (see Figure 5).

Whilst significant movement of cattle occurs regularly in Australia, the majority of cattle movements remain within a single livestock production region and most within the same state or territory (Iglesias and East, 2015).

Following an EAD outbreak where cattle were susceptible, containment zones could be established which take advantage of the fact that patches of zero to very low density could act as natural barriers against the spread of disease. For example, an outbreak occurring in Victoria is unlikely to cross the Nullarbor plain, where there is a large area of land with no cattle to spread the disease to animals in Western Australia.

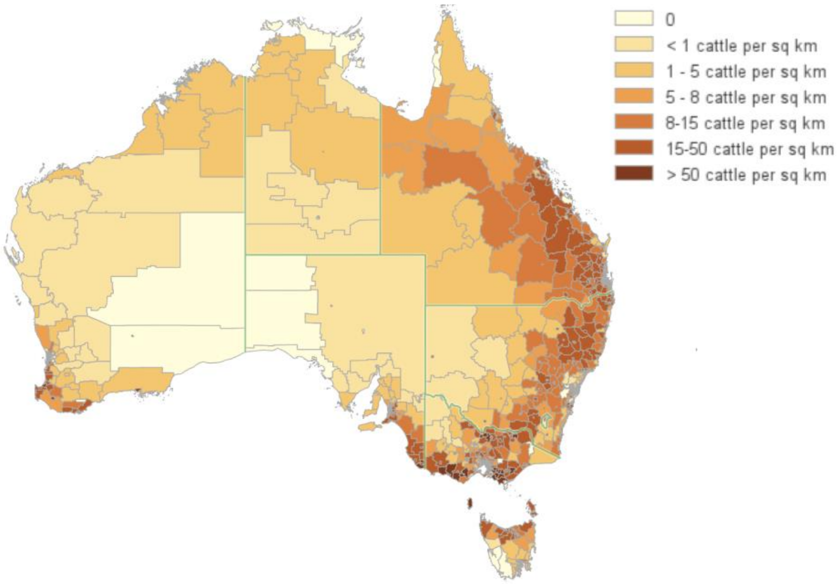

Figure 5: Australian cattle density (data source: ABS 2011)

The Australian pig herd is relatively small compared to the national sheep and cattle herds. The majority of piggeries are located in southern Queensland, central NSW, northern Victoria, south-east South Australia (SA) and south-west WA (see Figure 6 and Figure 7). Two main types of pig herds persist in Australia: large commercial herds and small producers. However, pig ownership is becoming increasingly concentrated and the role of saleyards in pig trading appears to be declining, as major producers trend towards maintaining closed herds. (East et al., 2014). A reduction in pig trade through saleyards has effectively divided the Australian pig herd into a number of small compartments (East et al., 2014). If containment zones were applied following an EAD of pigs, this industry compartmentalisation is likely to assist significantly in ensuring disease does not spread beyond the containment zone, especially with the added implementation of strict movement controls.

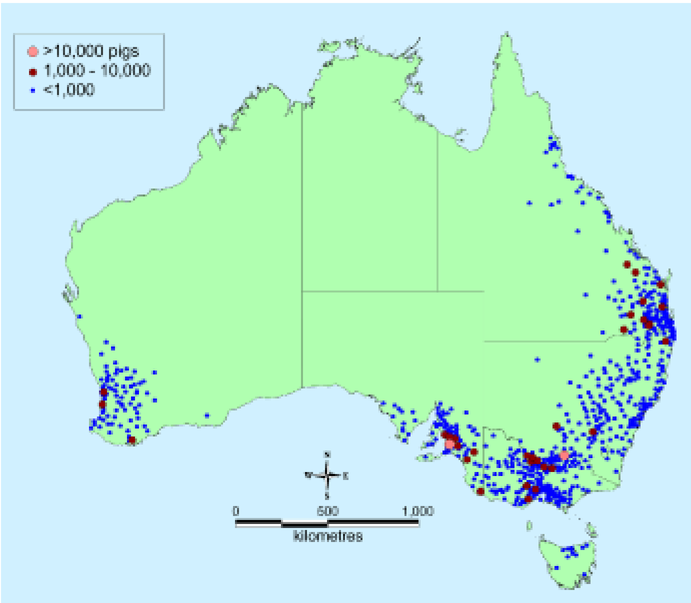

Figure 6: Location and size of pig farms registered on the PigPass database (from East et al., 2014)

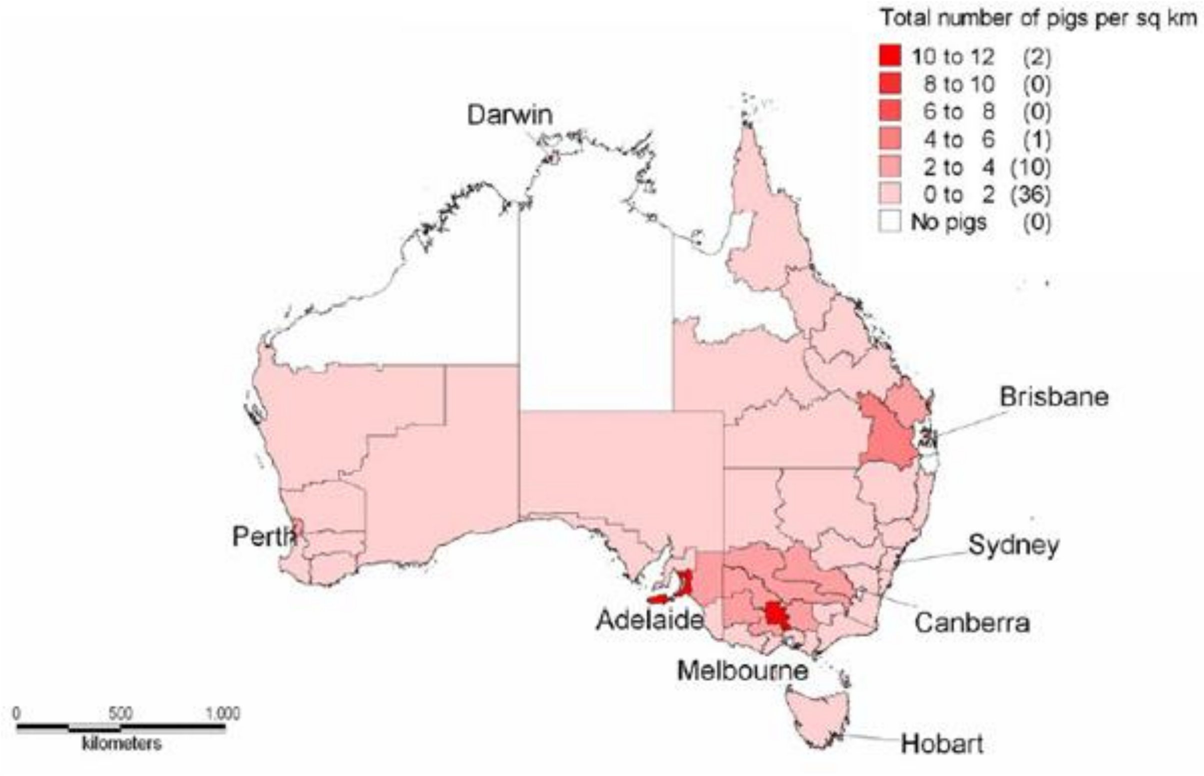

Figure 7: Pig density in Australia from Department of Agriculture and Water Resources, (undated)

4.3 Demonstration of freedom

In the early stages of an EAD outbreak in Australia, resources will be heavily focused on controlling disease in the infected and protected areas. In preparation for the establishment of a containment zone, it will be necessary to demonstrate freedom from disease in the proposed protection zone. This will require application of methods to demonstrate disease freedom. These methods will be supported by TaS efforts instigated at the beginning of the outbreak. Eventually, these methodologies will also be applied to the previously infected zone to regain recognition of national disease freedom once the disease is eradicated.

It is important to note that a key benefit of containment zones is that the free zone maintains the same advantages as a country that is already recognised as free of the disease by the OIE. The OIE requirements for maintaining disease freedom recognition are always less than those required to regain OIE disease freedom recognition. However, in reality, trading partners are likely to demand a greater level of evidence of freedom from the free zone when a containment zone is implemented than would be required from a country that is completely disease free. Therefore, it might be necessary to demonstrate disease freedom in the free zone with greater rigour during an outbreak (when a containment zone has been established) than would otherwise be required.

There are several approaches to demonstration of freedom. In the most basic approach, a random sample of animals can be selected from a population and tested for disease. If no animals test positive, or all test-positive animals are subsequently shown not to be infected with disease, then the probability that the population (in this case all animals in the free zone) are free can be quantified, based on the:

- number of animals tested
- diagnostic sensitivity of the test used

- specified design prevalence (expected prevalence of the disease if it were present in the population)
- population size.

There are methodologies for calculating the number of animals to be tested to ensure the desired probability of detecting disease can be reached[2]. Proof of freedom through representative sampling can fail to be cost-effective if a high level of confidence is required.

Other approaches to demonstrate freedom from disease can be substantially more efficient. Risk-based sampling is one approach, whereby surveillance targets sub-populations most likely to be infected if disease were present. This is more efficient than representative sampling, but requires that risk factors are known, rationale is clearly described and data is available to differentiate animals with respect to their risk status. A second approach is to use scenario tree modelling to combine information from multiple sources to quantify the sensitivity of surveillance the probability of disease freedom, given negative surveillance results. This method has been described by Martin et al., 2007b, and has since been used in numerous situations

Depending on the nature of the disease and outbreak, Australia is most likely to use a combination of traditional and complex methodologies to demonstrate disease freedom within the free zone when the outbreak is ongoing, and within the containment zone following the eradication of disease.

4.4 Ensuring and demonstrating containment zone integrity for specific diseases

Specific disease factors will influence Australia's approach to containment zones. The table below presents these factors and subsequent additional measures to address some of these. The measures listed are in in addition to those discussed at length in Sections 0 and 0 and consequently are very few.

Table 1. Disease-specific factors and additional measures to address these.

	FMD	CSF	ND	HPAI
Disease characteristics				
Highly contagious	✓	✓	✓	✓
Windborne spread	✓			
Survival within animal products	✓	✓	✓	✓
Capacity to infect multiple species (including feral and wild)	✓	✓	✓	✓
Risk of amplification through certain production systems	✓			
Persistence through chronic infection and different pathotypes		✓ *(no pathotypes)*	✓ *Only in non-velogenic strains*	*(doesn't include low pathogenic strains)*

[2] See http://epitools.ausvet.com.au/content.php?page=FreedomFinitePop

Variable or absent clinical signs	✓ *Variable clinical signs in sheep and goats*	✓ *Chronic and active forms*	✓ *Several forms of varying virulence*	*(doesn't include low pathogenic strains)*
Limited export markets for the effected industries			✓	✓
Measures to be implemented in addition to those outlined in Sections 0 and 0				
In defining the boundaries of a containment zone, consider insights provided by models such as the Australian Animal Disease Spread Model (AADIS) for example for windborne spread.	✓			
Additional biosecurity to minimise contact between pigs destined for export (following slaughter) and potential feral pig carriers.		✓		
Increased biosecurity to prevent transmission of virus between wild birds and domestic poultry.				✓
Increased pathotyping of ND virus isolates in exporting flocks			✓	

5 Conclusion

Following EAD outbreaks, restrictions on trade frequently come with an unnecessary magnitude of economic and social cost. A large nation's trade may be restricted, despite an outbreak being relatively small and successfully contained by appropriate control and surveillance activities. In recognition of this, the OIE is moving towards guidelines that allow countries to establish a containment zone where cases are still actively occurring but where the outbreak is considered to be confined to a limited geographical area.

Before considering how the integrity of containment zones can be demonstrated, it is important to acknowledge that there are a number of core competencies required to control any EAD outbreak, regardless of whether a zone is implemented. Only countries capable of demonstrating these core competencies will be able to successfully contain a disease to the point where an effective containment zone could be implemented. This report outlines those core competencies, drawing heavily on Australia as an example of a country that is capable of controlling EAD outbreaks and has demonstrated this through successful eradication campaigns in the past.

In addition to core competencies, there are extra requirements that would be expected to implement an effective containment zone. This report discusses what these requirements are, using Australia as an example and specifically examining four key diseases.

Appendix 1: Checklist for demonstrating the containment zones

To demonstrate the integrity of a containment zone, the implementing country should provide the following:

Evidence of core competencies

☐ Detail on the governance and funding arrangements in place to manage EAD outbreaks including those where a containment zone has been implemented

☐ Supporting documentation that outlines operations and procedures for EAD outbreak response

☐ Evidence of trained and competent veterinary support services

☐ A TaS plan including information on potential data sources

☐ Information on control and coordination centres including their roles and responsibilities

☐ Evidence of classification of properties based on risk

☐ Surveillance results from high-risk properties where active surveillance is occurring

☐ Results from passive surveillance

☐ Evidence of efforts to monitor progress through surveillance

☐ Evidence of efforts to demonstrate freedom in allegedly free areas

☐ Evidence that effective movement controls and quarantine practices are in place

☐ Information on stamping out activities

☐ Information on vaccination if it is being used

☐ Information on the treatment of animals or their products if animals are being treated for the disease

☐ Information of the biosecurity practices in place

☐ Details of disposal, decontamination and restocking practices

☐ Evidence of wild, feral or vector control when it is relevant

☐ Information on public awareness campaigns

Evidence of activities specific to implementing a containment zone

☐ A timeline outlining when disease was first detected and when the containment zone boundaries were defined

☐ A preliminary epidemiological report and justification for the date that the containment zone boundaries were defined

☐ Detailed geospatial information that demonstrates the size and shape of the infected zone and protection zone

☐ Justification for the size and shape of the containment zone including information on the distribution of affected industries

☐ Results of all surveillance from within the containment zone

☐ Results of all surveillance from the free zone

☐ Evidence of efforts to reduce the risk of exporting infected products beyond the containment zone, such as:

- movement controls and quarantine
- stamping out
- vaccination (if appropriate)
  treatment of infected animal and products
- enhanced biosecurity
- appropriate disposal of animals and products
- appropriate decontamination and restocking
- wild, feral and vector control (if appropriate)
- public awareness efforts.

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