Australian Government

Department of Agriculture, Fisheries and Forestry

# ASSESSING MANAGEMENT OPTIONS FOR PIG FARMS THAT DEVELOP WELFARE PROBLEMS IN AN EMERGENCY DISEASE RESPONSE

*Final Report for Animal Health Australia*

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# 1 Foreword

In responding to an emergency animal disease (EAD) outbreak, it is generally acknowledged that the welfare of animals is an important consideration. In recent overseas responses aimed at disease eradication, it has been necessary to devote significant resources to the management of welfare issues. In Australia, it is recognised that such commitment of resources is necessary and appropriate, given the need to act responsibly and ethically in an animal disease emergency.

This collaborative study between officers of the Australian Government Department of Agriculture, Fisheries and Forestry and the pig industry, which was facilitated by Animal Health Australia (AHA), has important findings for animal welfare management during a response to an incursion of foot-and-mouth disease (FMD) in Australia. AHA members had previously agreed to the principles for animal welfare management during an EAD response.

The purpose of this study was to develop guidance for Chief Veterinary Officers relating to animal welfare compensation, and to further investigate the implementation of disease control principles and their effect on animal welfare and its management. The work was greatly assisted by the information and advice provided by Australian Pork Limited and key industry personnel.

This study explores the extent to which pig properties are at risk of encountering welfare problems in response to an FMD incursion in Australia and assesses the effects and impacts of implementing different welfare management strategies on farms. It also considers potential effects on the overall disease control response, because limited resources may need to be diverted from control activities to manage animal welfare problems.

The aim of animal welfare management during an EAD response is to ensure:

1. destruction of the minimum number of non-infected animals
2. maintenance of acceptable animal welfare standards for all livestock species, without compromising disease control and eradication efforts
3. effective management of animals within restricted areas and elsewhere, based on sound risk assessment, to avoid later welfare problems
4. best use of available resources (finances, personnel, infrastructure, feed and water)
5. movement and other disease control measures are applied to minimise the likelihood of slaughter being necessary due to animal welfare issues.

The study has helped test the proposed principles for animal welfare management in an EAD response; such a response will be managed according to the terms of the Emergency Animal Disease Response Agreement (EADRA). Under EADRA arrangements, this will enable the alleviation of animal welfare issues that might occur as a consequence of restrictions imposed for disease control. The authors and respective industry contributors are to be commended for the quality and usefulness of this study which represents a valuable addition to Australia's EAD preparedness arrangements.

Mike Bond
CHIEF EXECUTIVE OFFICER

## 2 Executive summary

Animal welfare is increasingly becoming a topic of interest to a range of stakeholders, including governments, veterinarians, livestock industries and the broader community. As part of the regular review of AUSVETPLAN, AHA identified the potential for animal welfare problems to emerge in intensive livestock enterprises due to movement restrictions imposed during an EAD response. Specifically, there was concern that interruption to the regular movement of animals off farms as part of normal management and marketing practices could lead to overcrowding and serious animal welfare problems. Intensive pig farms are likely to be at high risk of developing welfare problems given their limited capacity to house growing pigs. This study was designed to investigate the possible extent of animal welfare problems on intensive pig farms in the event of a FMD outbreak.

A modelling study using DAFF's *AusSpread* model was undertaken to assess welfare compensation issues and costs that may arise during an outbreak of FMD in Australia. FMD outbreaks were simulated in two intensive major livestock production regions. For each region, moderate and severe outbreak scenarios, and four control strategies involving stamping out, pre-emptive slaughter or vaccination were assessed.

Industry consultation was sought on the most realistic and feasible welfare management strategies for pig enterprises encountering welfare problems during an EAD. It was decided that dwindling space allowances on intensive pig farms would rapidly lead to overcrowding and welfare compromise due to the restrictions imposed on the regular movement of marketable pigs off farm. It was also agreed that restricting the nutrition of growing pigs was not practically possible, of little overall consequence for the emerging space issue, and was ethically unacceptable. Three welfare management strategies were evaluated, including the full culling of all grower and finisher pigs on farms, partial culling of finisher pigs only on farms, and controlled movement of finisher pigs to slaughter. Finally, the results of the modelling study were used in an economic analysis to look at the comparative cost implications of the various welfare management strategies. The economic analysis included the direct control costs, losses in export earnings, and compensation costs for slaughtered animals and farms that developed welfare problems.

Results suggested that in moderate sized outbreaks available resources were adequate to maintain an effective stamping out strategy under the scenarios modeled. For these outbreaks, pre-emptive culling of dangerous contact premises, pre-emptive culling of premises contiguous to infected premises, or ring vaccination did not offer any significant gains in terms of size or duration of an outbreak. Welfare management strategies did not significantly increase the length or size of these outbreaks and welfare problems were adequately addressed.

In the more severe outbreaks (Region 9 severe outbreak), resources were insufficient to control disease under a stamping out policy alone. In these situations, the size and duration of the outbreaks quickly built up, to the extent that most of the outbreaks were not eradicated by 150 days. Under some circumstances the contiguous cull strategy could reduce the size of the outbreak but at the expense of removing more herds in total and increasing the uncertainty of the outcome. Vaccination was the most effective strategy to reduce both the size of the outbreak and its variability so that eradication was more likely to be achieved in a shorter period.

The most effective control strategy will be determined by the nature of the outbreak, available resources to control it, and socio-economic factors. A contiguous culling policy is likely to be most effective in high density situations where significant local spread of FMD occurs. It has the potential to decrease the duration of the outbreak with the ability to return to trade sooner. It is likely to be less desirable in small to moderate sized outbreaks due to the larger number of farms culled in total, in exchange for minimal gains in terms of the overall duration of the outbreak. This would result in greater compensation liabilities, and may be less readily accepted by the public. In large outbreaks, this policy can result in more rapid depletion of stamping out resources with increased risk of disease escaping containment. Vaccination is likely to be most effective in situations where disease is widespread, high rates of spread can be expected or authorities anticipate significant resource issues. Under these circumstances it is unlikely that an outbreak would be contained through stamping out on its own. Additionally, socio-political factors are likely to play a large part in the decision to vaccinate, and subsequent decisions on management of vaccinated animals.

The effectiveness of the welfare management strategies depended on the severity of the outbreak and available resources to control it. In the moderate outbreaks, partial culling strategies were more effective than the full culling strategy, since fewer animals were culled and these strategies did not impact on resources required to adequately control the outbreak. In the more severe outbreaks, welfare problems were unlikely to be addressed as resources were insufficient to manage the disease response and welfare problems were considered second priority. In these outbreaks sending pigs direct to slaughter was the most effective option since the scarce resources required for control efforts were not required.

The vast majority of costs estimated for an outbreak of FMD were from export losses due to market trade restrictions. Any control strategy that prolonged the period before trade could resume resulted in the largest economic impacts. For the moderate outbreaks, vaccination resulted in the largest economic losses when it was associated with delays in regaining market access. For Region 9 severe outbreak, non-vaccination strategies (stamping out and pre-emptive culling) are more likely to result in longer outbreaks compared to vaccination and may result in larger economic losses when outbreaks last in excess of 150 days. The welfare compensation costs comprised a fraction of the overall costs of the control response.

Given that the findings reported in this study are very dependent on assumptions about resource availability and given reductions in jurisdictional workforces, a more thorough examination of resource capacity to manage an FMD incursion is considered essential. The choice of strategy for managing animal welfare problems during an EAD is best tailored to the nature of the outbreak and resources available to control it.

# 3 Background

Foot and mouth disease (FMD) is a major livestock disease that could seriously impact Australia's livestock sector and economy as a whole. Potential consequences of a disease outbreak include the immediate loss of international market access, disruption of the domestic market in the major livestock industries, severe production and income losses in livestock and related industries, and the slaughter of thousands of animals.

As a country free from FMD, Australia has developed comprehensive contingency plans through AUSVETPLAN to manage and control emergency animal disease (EADs) such as FMD in the event of an incursion. Whilst AUSVETPLAN provides comprehensive details on the control of FMD in susceptible species including slaughter, movement restrictions and zoo-sanitary measures, there are limited guidelines on how to manage enterprises that develop welfare problems in their livestock as a direct result of the movement restrictions imposed during an EAD response. The AUSVETPLAN Livestock Welfare and Management manual identifies space/stocking density in conventional indoor pig grower units as the key concern. For an incursion of FMD, it is likely that intensive pig farms are at the greatest risk of developing welfare problems given their limited capacity to house growing pigs.

AHA requested AHPB assistance to assess welfare compensation issues in an EAD response. It was agreed that the best way to develop further guidance relating to welfare compensation would be to simulate disease outbreaks for FMD. DAFF's FMD model *AusSpread* was used to simulate FMD outbreaks in two Regions of Australia to gain a better understanding of the number of pig farms at risk of developing welfare problems under different control strategies. Different welfare management strategies were identified and their effects compared. The model was informed by a detailed study of welfare management in typical production units for pigs. The study has not included or attempted to measure the impact of unexpected 'black swan' events on piggeries arising from the disruption of an EAD response. The model outputs were then used in an economic analysis to look at the cost implications of the various welfare management strategies.

This study explores the extent to which pig farms are at risk of developing welfare problems in response to a FMD incursion in Australia, and assesses the effects and impacts of implementing different welfare management strategies on these farms and on the overall control response since limited resources may need to be diverted from control activities to manage welfare problems.

# 4 Methods

A detailed description of the materials and methods are provided in the Appendix section 7.4 and 7.5.

## 4.1 FMD Modelling

The study uses DAFF's FMD stochastic spatial simulation model, *AusSpread,* to simulate outbreaks of FMD in two Regions with large livestock populations, including intensive livestock production[1]. The model was run for Region six (southern Queensland and northern NSW), which contains a large feedlot beef cattle population, and Region nine (southern NSW and northern Victoria) an important dairying Region (Figure 1 and Table 1). Both of these regions are important pig production areas. Two outbreak scenarios (moderate and severe) were assessed per region, and four control strategies assessed per outbreak scenario. Finally three welfare management strategies were assessed for each control strategy. An outline of the approach taken in this study is provided in Figure 2.

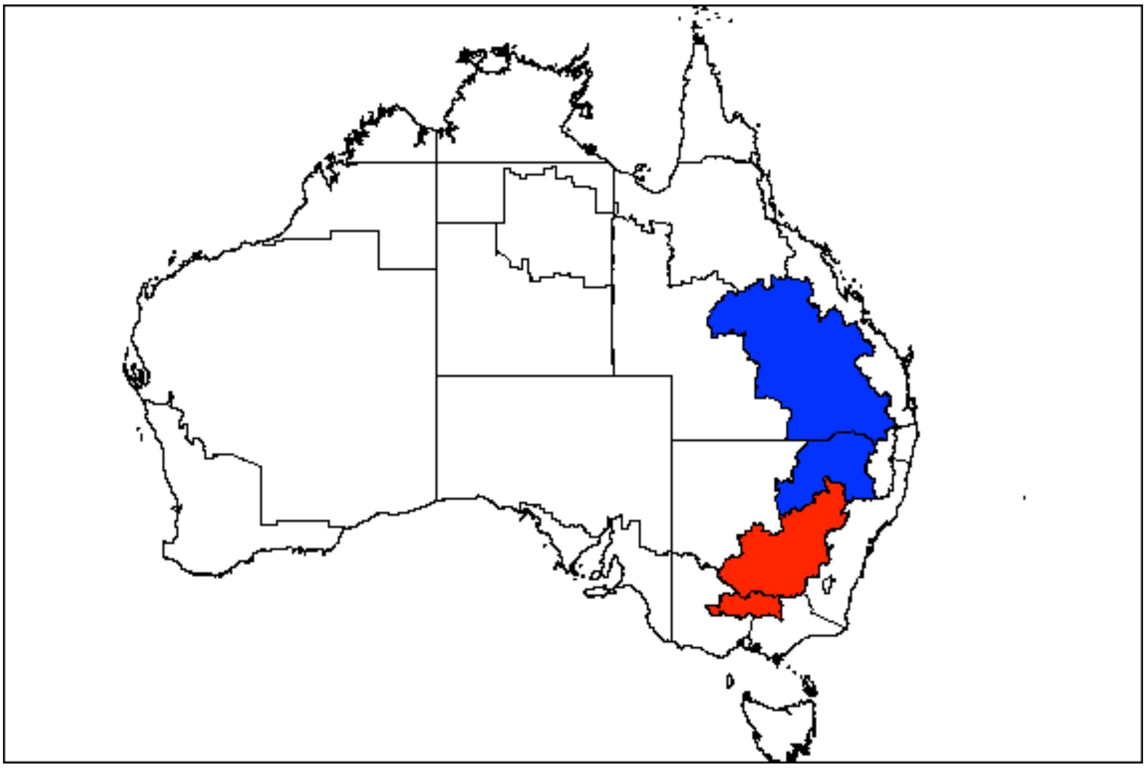

Figure 1: Location of Region 6 (blue) and Region 9 (red).

A meeting between AHA, DAFF and APL representatives on 27 April 2011 recognised that welfare problems on intensive pig farms could be expected after two weeks of movement bans. Consultation with industry during the AUSVETPLAN pig disease movement control workshops and the January-February 2011 floods in Victoria and Queensland, set a maximum of 2 weeks before welfare problems could develop on an intensive pig farm following movement restrictions. After this time, dwindling space allowance will severely impact on the welfare of the intensively housed pigs. It was

[1] Australia has been divided into 12 livestock production Regions based on geography, environment and livestock production and marketing characteristics.

also agreed that restricting the nutrition of growing pigs was not practically possible, of little overall consequence for the emerging space issue likely to result in pig welfare problems, and is ethically unacceptable.

The current draft guidelines for control and movement restrictions as identified by AUSVETPLAN were used to identify the farms that are likely to develop welfare problems. Under AUSVETPLAN, all premises in the RA are designated as 'at risk premises' (ARPs) and are subject to movement restrictions, potentially creating animal welfare issues. Premises outside the RA, including the CA, may be able to move livestock off premises under permit and therefore should be able to avoid welfare problems. Additionally, premises with sufficient space, such as free-range piggeries, are less likely to develop welfare problems.

Table 1: Number of farms by farm type for each region used in the study.

| | Region 6 | Region 9 |
|---|---:|---:|
| **Beef** | 5190 | 2000 |
| **Dairy** | 302 | 2559 |
| **Sheep** | 622 | 2302 |
| **Pig** | 326 | 417 |
| **Beef-sheep** | 3132 | 5142 |
| **Small-holder** | 6081 | 9321 |
| **Feedlot** | 268 | 2364 |
| **Total** | **15921** | **24105** |

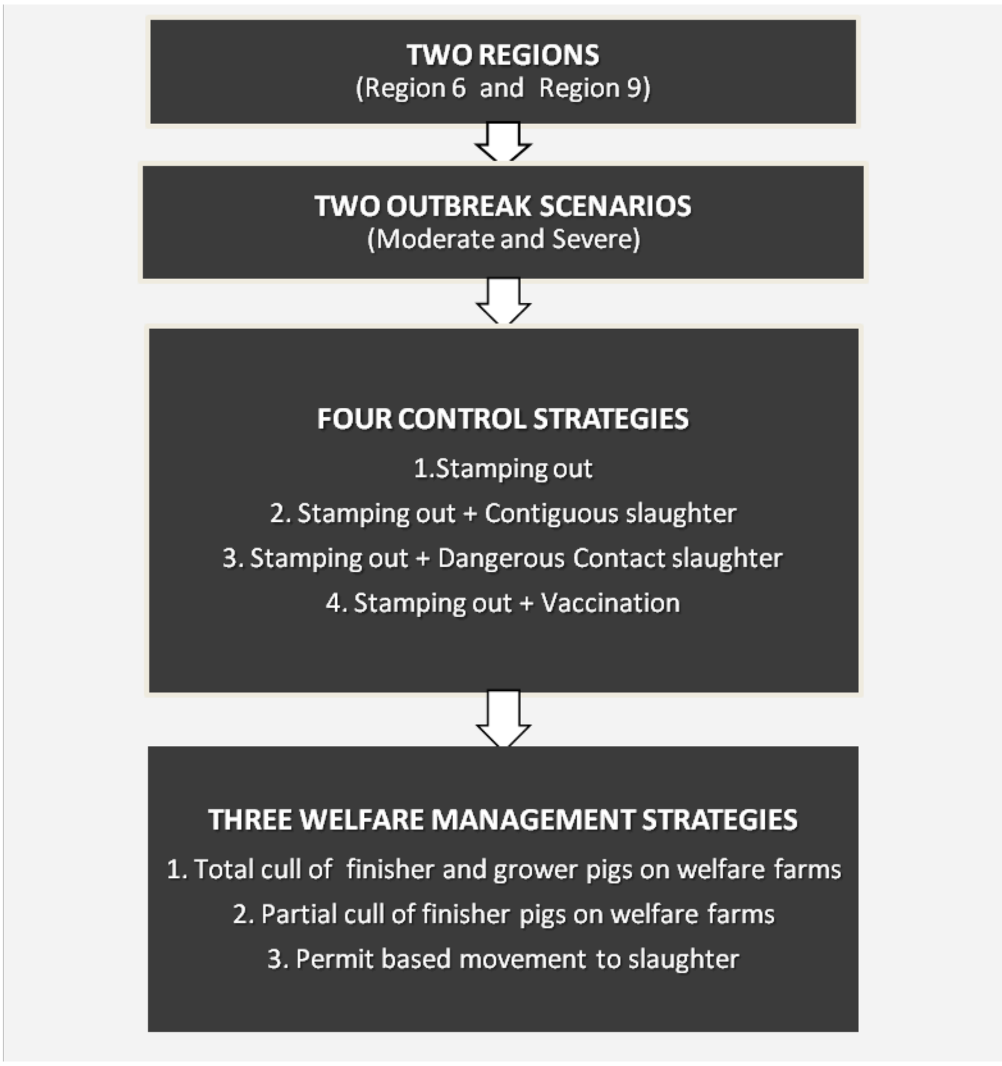

Figure 2: Model approach for the study of pig farms at risk of developing welfare problems.

The objectives of this study were to

1. define the extent of an outbreak in terms of the duration of the outbreak, number of IPs (infected premises that contain susceptible species), number of pig farms that develop welfare problems (welfare farms), and total number of farms culled (including IPs, DCPs, and welfare farms that have had all pigs culled) for different control strategies
2. assess the effects of instituting different welfare management strategies on farms that develop welfare problems
3. provide an indication of the likely costs associated with the management strategies
4. compare these outcomes between strategies and outbreaks to test the 'robustness' of the welfare management strategies under different animal and farming demographics and agricultural practices.

### 4.1.1 Modelling approach

For each Region the study was conducted in two phases. The first phase, representing the outbreak scenario, modelled a moderate outbreak of FMD following entry of the virus into one piggery. In this scenario it will take 21 days for the disease to be detected and control policies implemented. This is based on previous experiences in the UK, Japan, and Korea (Mansley et al, 2011; Nishiura and Omori, 2010). This time frame provides plausible scenarios with sufficiently large numbers of pig farms to become infected to discriminate any differences between the welfare management strategies.

At a meeting with AHA on 28 July 2011, the size of the RA zone was discussed given its relevance to the number of welfare farms that could arise. In AUSVETPLAN the minimum size for a RA is 3km around all IPs and DCPs. In reality, it is more likely a much larger RA will be declared in the initial phase of an outbreak given the uncertainty of the size and magnitude of the spread during this early period. It was decided that local government areas (LGA) will form the RA within the first 2 weeks of the control response, so that any LGA containing IPs and became an RA. The whole of the rest of study Region will constitute the CA. Following this initial 2 week period, all new IPs and DCPs will have RAs designated on a radius of 3km placed around them.

AUSVETPLAN does not provide any information on when movement restrictions in the RA may be removed. Following discussions with AHA, the agreed default (minimum) is that at risk premises (ARPs) will be restricted for 14 days after the last IP is declared in a given area (this is consistent with European Union policy). If another nearby premise becomes an IP, the 14 day restriction period will start again. This means that restrictions are lifted 14 days after the last IP is declared in an area.

It was agreed that two levels of outbreak would be simulated – a moderate and a severe outbreak in each Region. The approach used for Region 6 is explained to show how this was done, with a similar approach used for Region 9. For Region 6, FMD is assumed to begin on a single randomly selected pig farm during winter with 21 days elapsing before a diagnosis of FMD is made. The model was run 100 times to generate a distribution of possible Outbreak Situations at the time of detection. At the end of this 'silent spread' phase, there were 1-95 (27 ± 25, mean ± standard deviation) infected farms in the population. The median and 95% probability interval were 18 and 2-88 respectively. To represent a moderate outbreak a single run, consistent with the average with 27 infected farms present in the population after the 21 day silent spread period, was chosen as the moderate outbreak (**Outbreak M**). To represent a more severe scenario a single run, consistent with 90$^{th}$ percentile with 67 infected farms, was chosen as the severe scenario (**Outbreak S**). The population structures for these runs were saved and used in this study as the starting points for subsequent simulations starting at day 1 of a control program. This enabled outbreak sizes and number of welfare cases to be compared under different control strategies and settings assuming the same starting conditions.

**KEY ASSUMPTIONS USED IN THE MODELLING STUDY**

- An initial 3 day livestock standstill is applied following confirmation of the first IP.
- There is good compliance with movement restrictions (90% reduction in direct contacts, 70% reduction in indirect contacts)
- There is a 30% probability that an infected sheep flock would not be recognised and reported through passive surveillance, 10% probability of infection in a backyard herd not being reported. All other infected herd types assumed that they will be recognised and reported although time to report will vary.
- The control program involves quarantine of infected, suspect and dangerous contact premises, movement controls, stamping out of IPs, tracing, active surveillance around IPs with options to consider pre-emptive culling of DCPs or contiguous premises, suppressive or protective vaccination.
- The resources for stamping out are one team on day one of the control program, ramping up to 35 teams by three weeks into the control program.
- If vaccination is used, it begins seven days into the control program with 3 km suppressive ring vaccination around IPs and all susceptible species are vaccinated. The resourcing for vaccination are ten teams at the start ramping up to 30 teams after three weeks.
- The resources for surveillance are two teams on day one of the control program, ramping up to 60 teams by three weeks into the control program.
- In the first 2 weeks of the control response the RA will comprise any LGA containing an IP. Following this, all new IPs will have a designated radius of 3km placed around them to represent the RA. The whole of the study area will represent a CA. Refer to Section 3.1.1.
- The time period until an RA can be reclassified and movement restrictions lifted is 14 days (see Section 3.1.1).
- Properties in the CA are able to move animals under permit and are therefore not at risk of developing welfare problems (see section 3.1.1).
- Of the various pig production systems in Australia grower-finisher pig farms and farrow-to-finish farms are at the greatest risk of developing welfare problems. This is assumed to occur after 2 weeks of movement restrictions. See Section 3.1.1.
- The culling of welfare farms was a once-off activity. See Section 2.3.
- For all strategies except the severe outbreak in Region 9, the model was set to run until disease was eradicated. For the severe outbreak in Region 9, it was not uncommon for outbreaks to last in excess of 1.5 years. This was computationally demanding and time consuming, so the model was set to run until the outbreak was eradicated or for a maximum of 150 days, whichever came first.

## 4.2 Control strategies

The size and duration of a disease outbreak is heavily influenced by the approach to control. Four control strategies were considered including stamping out of IPs, pre-emptive culling of DCPs or contiguous herds, and suppressive ring vaccination as detailed below.

### 4.2.1 Stamping out strategy (baseline) (SO)

A stamping out response is the baseline control strategy. This is consistent with AUSVETPLAN and involves the quarantine of infected, suspect and DCPs, stamping out of IPs, movement controls (initial 3-day national standstill followed by declared RA and CA), tracing of DCPs (which are subject to surveillance/investigation), and active surveillance around IPs.

### 4.2.2 Stamping out and dangerous contact slaughter (SODC)

The same as SO except that high risk dangerous contact premises are pre-emptively culled.

### 4.2.3 Stamping out and contiguous farm culling (SOCS)

The same as SO except that all susceptible livestock on premises contiguous to IPs (defined as within 1.5 km) are pre-emptively culled[2].

### 4.2.4 Stamping out and suppressive ring vaccination (SORV)

As for strategy SO except that all holdings excluding IPs, DCPs and SPs in a 3 km radius around IPs are vaccinated, with vaccination beginning 7 days into the control program.

### 4.2.5 Sensitivity analysis

Because the number of farms at risk of welfare problems will be affected by both the size of the designated areas and the time ARPs are under restrictions a sensitivity analysis was done where the time before movement restrictions are lifted was increased to 21 and 28 days. This was applied to the baseline control strategy of stamping out only (SO) in Region 6 Outbreak M.

## 4.3 Welfare management strategies

Through industry consultation it was agreed that pig farms will start to develop welfare problems (and specifically will not be able to house growing pigs) following 2 weeks of continuous movement restrictions. Pig farms were classified into five categories (see Table x1 in Appendix Section 7.4.3.1). Based on discussions with industry and AHA, pig farms in the farrow-to-finish and grower-finisher categories were considered at greatest risk of developing welfare problems. Following consultation three welfare management strategies were identified.

### 4.3.1 Full cull of all welfare cases on welfare farms (WS1)

[2] Added in recognition that together local spread and wind-borne spread on-average account for 82% of the new infections

This involved the culling of all **grower and finisher pigs** on farrow-to-finish farms (farm category 1) and grower-finisher farms (farm category 2). This was a once-off activity and meant that farrow-to-finish farms were partially culled and grower-finisher farms were fully culled.

#### 4.3.2 Partial cull of welfare cases on welfare farms (WS2)

This involved the culling of **finisher pigs** on farrow-to-finish farms and grower-finisher farms. It was expected that these farms would have a 4 week period before welfare problems could re-emerge. Although a second cull may be required in pig farms subjected to extended periods of movement restrictions, this was not modeled in this study.

#### 4.3.3 Permit-based movement to slaughter on welfare farms (WS3)

This involved the movement of **finisher pigs** from welfare farms direct to slaughter at abattoirs located within RAs. This strategy is based on guidelines under consideration for a new edition of AUSVETPLAN (refer to Appendix section 7.7). A farm would only be eligible for a movement permit if:

- Animals were inspected and found free of clinical signs of FMD prior to and on the day of travel
- It was not contiguous to an IP or DCP
- The destination abattoir was within the associated RA, and could demonstrate appropriate biosecurity standards
- Appropriate decontamination of equipment and vehicles could be assured

This strategy assumes abattoirs are located within RAs and the slaughtering of pigs is acceptable and possible. The strategy is unlikely to be relevant in some Regions of Australia due to the large distance of abattoirs from pig farms. However, it is included for completeness and consideration in Regions where abattoirs are located in high pig production areas. Figure x1 (Appendix Section 7.4.3) provides a description of the abattoir locations in Australia based on APL data for 2011 (Salter and Mitchell, APL, pers. comm., 2011).

### 4.4 Economic evaluation

The economic impacts of an outbreak of FMD would be expected to vary considerably depending on the management strategy employed and the nature of the outbreak. There is a considerable degree of uncertainty over the cost estimates for controlling a potential FMD outbreak in Australia given our lack of experience with this disease in Australia. To provide an indication of comparative costs incurred from implementing the various welfare management strategies, an economic assessment was performed utilising the results from the simulations. This evaluation is a simplified economic analysis, and provides an indication of costs rather than a complete economic assessment. The results will provide a comparative assessment of the **relative** costs of the different strategies rather than **absolute** costs.

For this study, the costs associated with an outbreak of FMD can be divided into four broad categories:

■ **Direct control costs** — those designed to avoid, eliminate or reduce the impacts of the disease and associated production losses. These costs include operational costs associated with decontamination of infected properties, slaughter and disposal of infected animals, and the cost of both professional and nonprofessional labour involved in administering the control strategies.

■ **Export losses** — costs associated with revenue forgone from international trade in livestock and their products.

■ **Compensation costs** — costs associated with the compensation of culling animals on IPs and DCPs.

■ **Welfare costs** — costs associated with the compensation of culling or slaughtering welfare cases and the operational costs associated with the culling and disposal of pigs on welfare farm.

The analysis utilises a similar approach to the one performed by Abdalla et. al., 2005 and is detailed in the Appendix under Section 7.5. All costs and prices in this analysis are in 2010-11 Australian dollars. A list of the key assumptions used in the economic evaluation is provided in the box below.

**KEY ASSUMPTIONS USED IN THE ECONOMIC EVALUATION**

- There is a national ban on exports for the duration of the outbreak and variable period afterwards depending on strategy (no zoning occurs) (see section 7.5.3).
- Compensation costs and herd sizes are based on average values.
- For any given region, there are two SDCHQs and two LDCCs representing two affected jurisdictions per region.
- Proof of freedom will take three months following the last confirmed case. This is in accordance with OIE guidelines where a stamping out policy requires a minimum of 3 months before international market access may be regained.
- More serological sampling for proof of freedom would be required in a vaccinated population compared to a non-vaccinated population (because of the expected lower within-herd prevalence).
- For welfare cases (pigs) sent to slaughter (Welfare Strategy 3) 100% of their market value is paid in compensation. For details see Appendix Section 7.5.5.
- For emergency animal vaccination, animals receive a single dose of vaccine. For details see Appendix Section 7.5.2.3.
- Under a vaccination control strategy where vaccinates are slaughtered following the outbreak, it is assumed this will take an additional month to remove them from the population so that four months elapses before market access can resume.
- Under a vaccination control strategy where vaccinates are not slaughtered following the outbreak, it is assumed that it will be 6 months before market access resumes (in accordance

with OIE guidelines).

- Vaccinated animals are assumed to retain full market value and therefore no compensation is paid. For details see Appendix Section 7.5.4.

# 5 Results

The outputs of interest are the duration of the outbreak (days), the number of IPs (any infected premises that contain susceptible species), the **total farms culled (including IPs, DCPs, and welfare farms that have had all pigs culled)**, and the **number of welfare farms (pig farms that develop welfare problems)**. Results are quoted as median values with 90% probability intervals ($5^{th}$ and $95^{th}$ percentiles) to represent the bulk of spread in values for 100 simulations (potential outcomes). Where an extreme event or 'run' occurs, maximum figures are quoted for this 'worst case' scenario. Simulations were run until eradication or for 6 months, whichever came first.

## 5.1 Control strategies

### 5.1.1 Moderate outbreaks (Outbreak M)

#### *5.1.1.1 Region 6*

There were relatively small differences in the size and duration of the outbreaks by strategy , suggesting that despite some initial shortfalls, available resources were adequate to maintain an effective stamping out strategy for the moderate outbreak scenario. Given that most of the new cases were due to local spread and wind-borne spread (on average these two routes accounted for 82% of new infections) pre-emptive culling of dangerous contact premises (SODC) (i.e. premises associated with longer distance direct and indirect contacts) did not show any significant benefits for the moderate outbreak either in terms of reduction in the duration of the outbreak or in number of IPs.

In contrast, pre-emptive culling of contiguous herds (SOCS) was effective in reducing the median number of IPs by almost half, but at the cost of culling almost double the number of farms in total. A contiguous culling strategy also results in a large amount of variation (or uncertainty) in the size of the outbreak and has the potential to create very large outbreaks under a worst-case scenario (Fig. 3).

There was no significant difference in the number of welfare farms for the four control strategies considered. A median of 19-24 welfare farms could be expected under Outbreak M.

#### *5.1.1.2 Region 9*

Outbreak sizes and durations for Region 9 were similar to those for Region 6, indicating once again that resources were adequate to maintain an effective stamping out strategy under this scenario . Unlike Region 6, the variation (or uncertainty) in the length and severity of the outbreak under a SO strategy is large compared to the other strategies (Fig. 4). These results suggest that while most of the time an outbreak can be successfully contained by strategy SO, on some occasions more extensive spread can occur. From a risk management perspective, pre-emptive culling of contiguous herds (SOCS) may represent a more effective strategy in Region 9. This strategy reduces the median length and severity of the outbreak, and the potential for a worst-case scenario to occur compared to other strategies. However, this does come at a cost of more than doubling the number of farms culled.

There was no significant difference in the number of welfare farms for the four control strategies considered. A median of 22-26 welfare farms could be expected in Region 9.

### 5.1.2 Severe outbreaks (Outbreak S)

#### *5.1.2.1 Region 6*

The severe outbreak can be expected to provide a more challenging test of resources. As for the pattern seen with moderate outbreaks in Regions 6 and 9, there were relatively small differences between strategies in terms of the size and duration of the outbreak . However, there was considerable variability in the results with any given strategy. Vaccination was the most effective at reducing the variation (or uncertainty) in outcome (Fig. 5). This suggests that vaccination is likely to be useful when resources to effectively implement stamping out are stretched (due to the size of the outbreak or high rates of spread) and risk mitigation is prioritized to reduce the likelihood of a large outbreak occurring.

As for the moderate outbreak scenarios, pre-emptive culling of contiguous herds was effective in reducing the number of IPs but at the cost of culling significantly more farms in total. The SODC strategy appears to offer little advantage over other strategies in this Region both in terms of the outbreak size and length.

As for the other outbreak scenarios, there was no significant difference in the number of welfare farms between the four control strategies. A median of 73-80 welfare farms could be expected under a severe outbreak.

#### *5.1.2.2 Region 9*

Outbreak sizes in Region 9 are significantly larger than they are for other outbreak scenarios, as resources to manage the situation quickly become stretched and some very large outbreaks would occur. We set a limit of 150 days for modeling purposes, and in fact, in Region 9 most of the time the outbreaks were still active at the end of the simulation. In this outbreak the differences between the control strategies are more apparent ( Fig. 6). Significantly, vaccination and contiguous culling strategies resulted in the least severe outbreaks in terms of the size and likelihood the outbreak would be eradicated within 150 days, with strategy SORV being the most effective. In contrast, SO and SODC strategies resulted in very large outbreaks that in most cases were not eradicated within the 150 day simulation period.

As most outbreaks were still active at the end of the simulation it is not possible to provide figures on the total welfare farms that would occur in Region 9 under the different control strategies. By 150 days a median of 35-37 welfare farms could be expected under a severe outbreak.

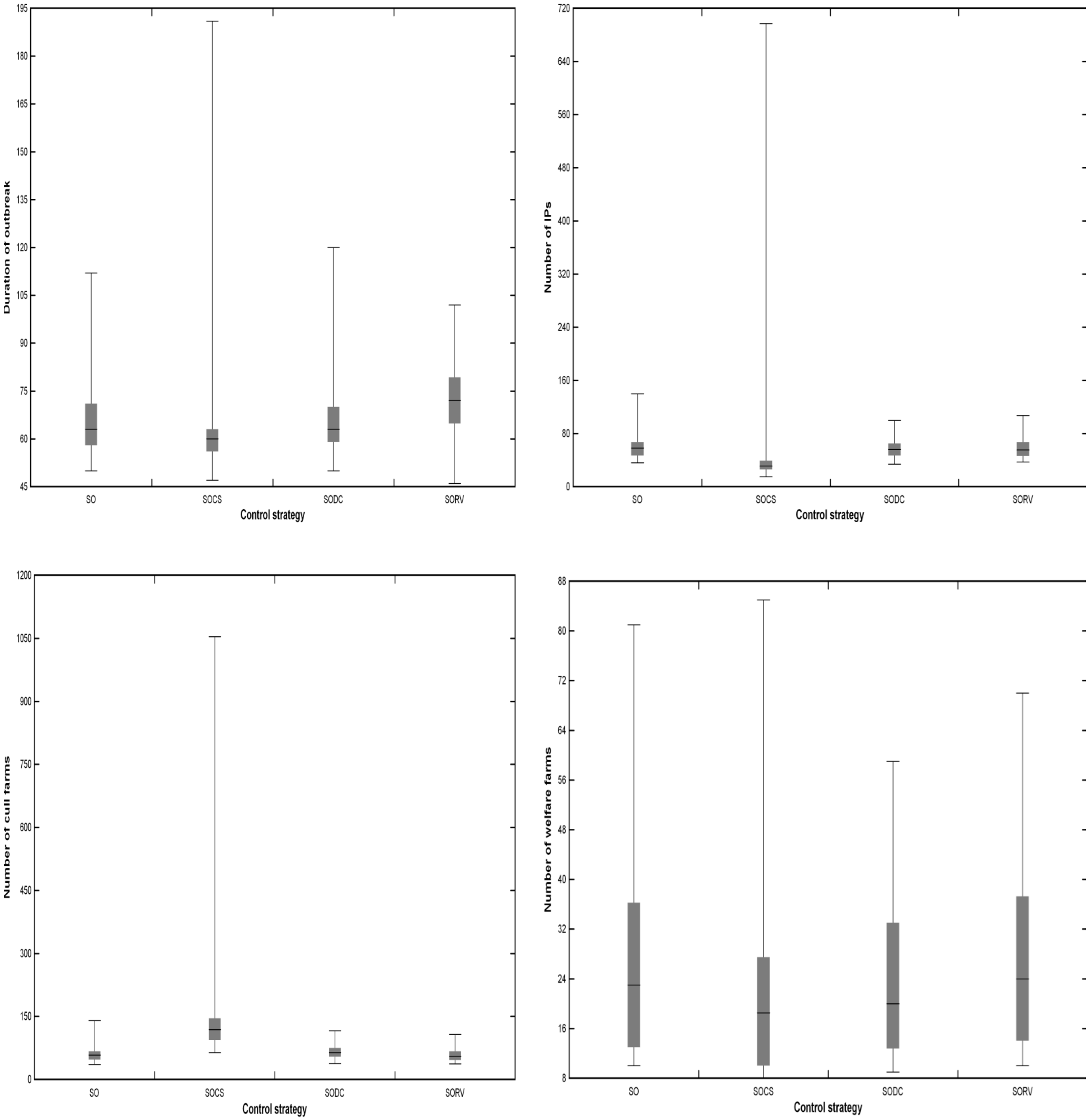


Figure 3: Median and range of the duration, number of IPs, number of farms culled, and number of welfare farms for **Outbreak M in Region 6** for the four control strategies.

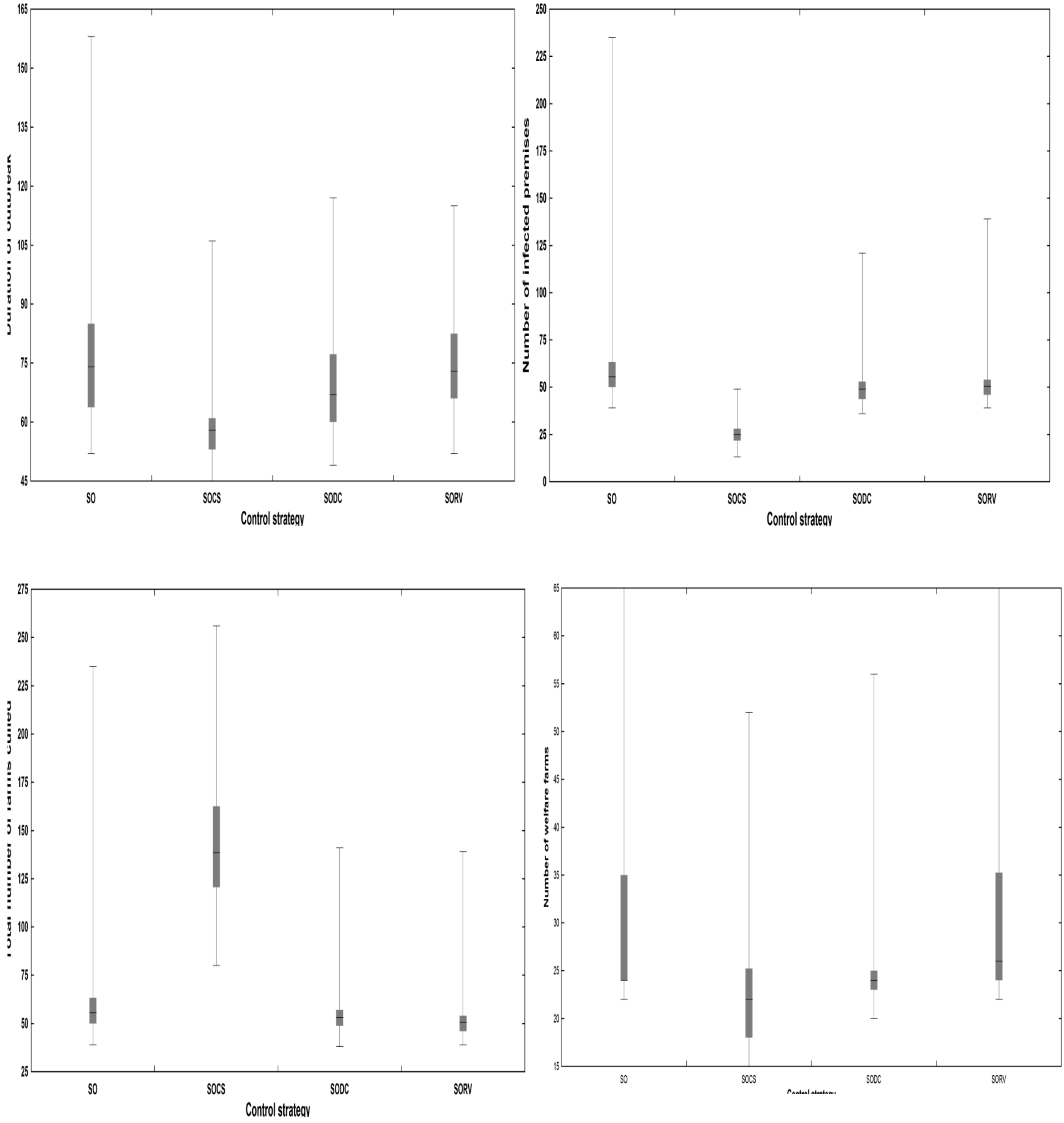


Figure 4: Median and range of the duration, number of IPs, number of farms culled, and number of welfare farms for **Outbreak M in Region 9** for the four control strategies.

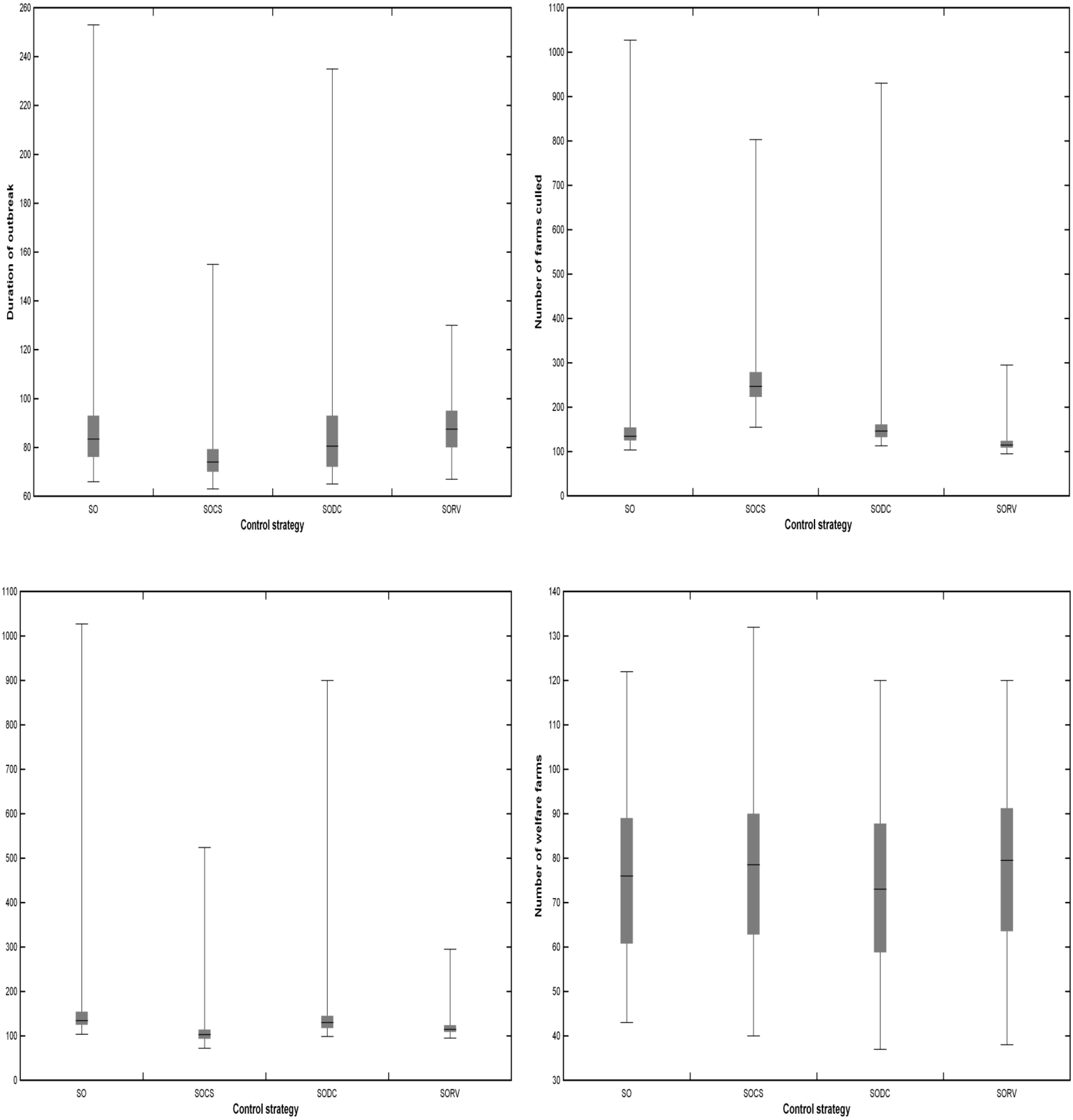


Figure 5: Median and range of the duration, number of IPs, Number of farms culled, and number of welfare farms for **Outbreak S in Region 6** for the four control strategies.

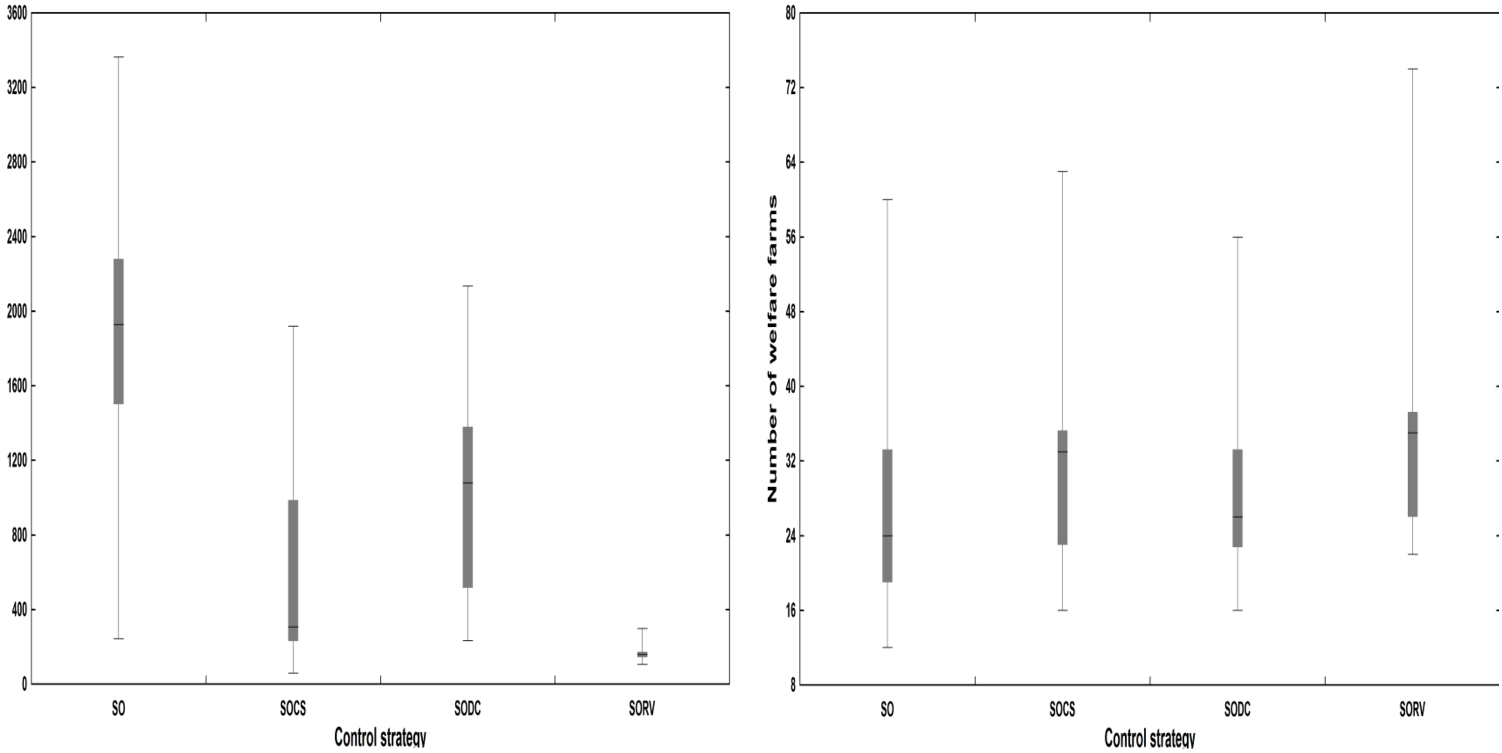


Figure 6: Median and range for the number of IPs and number of welfare farms for **Outbreak S in Region 9** for the four control strategies.

### 5.1.3 Sensitivity analysis

The results of increasing the time before movement restrictions can be lifted in RAs from the baseline 14 day period are presented for Outbreak M and S in Region 6 (Figure x4 in Appendix Section 7.6.1.2). In both outbreak scenarios, increasing these periods makes no difference to the average minimum and maximum number of IPs, number of farms culled and duration of the outbreak. However, increasing the period of movement restrictions significantly increases the average number of welfare farms that develop as more ARPs are placed under restriction. The number of welfare farms plateau when increases to movement restrictions occur beyond 21 days. This is likely to be due to 'saturation' in the number of ARPs susceptible to welfare problems. In conclusion, maintaining movement restrictions for 14 days, compared to 21 or 28 days, results in fewer welfare farms without compromising the duration of the outbreak or the number of IPS and farms culled.

## 5.2 Welfare management strategies

For all outbreaks except Outbreak S in Region 9, welfare management strategies did not significantly increase the length or size of the outbreak for the control strategies considered (Fig. 7). This suggests that resources were sufficient to carry out culling on welfare farms without compromising overall control efforts. For Outbreak S in Region 9, welfare management strategies also had minimal impact on the number of IPs. This was because of the prioritisation of culling IPs over welfare farms. However, the cost of this prioritisation was that many welfare farms were not culled at all (Table 5), so that in a more severe outbreak, welfare problems were not able to be addressed due to the limited resources. The exception to this was WS3 (permit to slaughter) as welfare pigs were permitted to move to slaughter without needing to divert limited resources from the control effort.

For a given outbreak, the number of welfare farms culled was very similar between strategies (Tables 2-5). This is not surprising as the size of the outbreaks was similar (see previous section). For the moderate outbreaks this ranged from a median of 15-25 and 18-26 welfare farms culled in Regions 6 and 9 respectively, to 64-80 in Outbreak S Region 6.

For Region 9 Outbreak S, it is not possible to give figures on the total number of farms culled because in most cases the outbreak was still active at the end of the simulation period. Up to 150 days the median number of welfare farms culled ranged from 0-44 across control strategies. It should be remembered that this understates the number of welfare farms because IPs are prioritised for culling over welfare farms and when resources were inadequate the culling and disposal of pigs on welfare farms (WS1 and 2) was not possible in many instances. Of the welfare farms identified in this outbreak, a higher proportion were culled under WS3 compared to WS1 and WS2, and ranged from 71-100% across control strategies (Table 5). For vaccination and contiguous culling strategies, a higher proportion of welfare farms were culled compared to a stamping out strategy, with a median of 72-100% compared to 0-71%.

Not surprisingly, the number of welfare pigs culled was highest under a full cull strategy of grower and finisher pigs (WS1), with approximately half the number of welfare cases removed under the partial cull strategy finisher pigs only (WS2 and WS3) for any given control strategy. The exception to this was in Outbreak S Region 9 where resources were inadequate to carry out culling and disposal of pigs on welfare farms.

For all outbreaks except Outbreak S Region 9 the more desirable welfare management strategies are WS2 and WS3 as fewer pigs are culled and efforts do not impact on the control response. For Outbreak S Region 9 the only feasible welfare strategy is WS3, as the scarce resources required for control efforts are not utilized in this strategy.

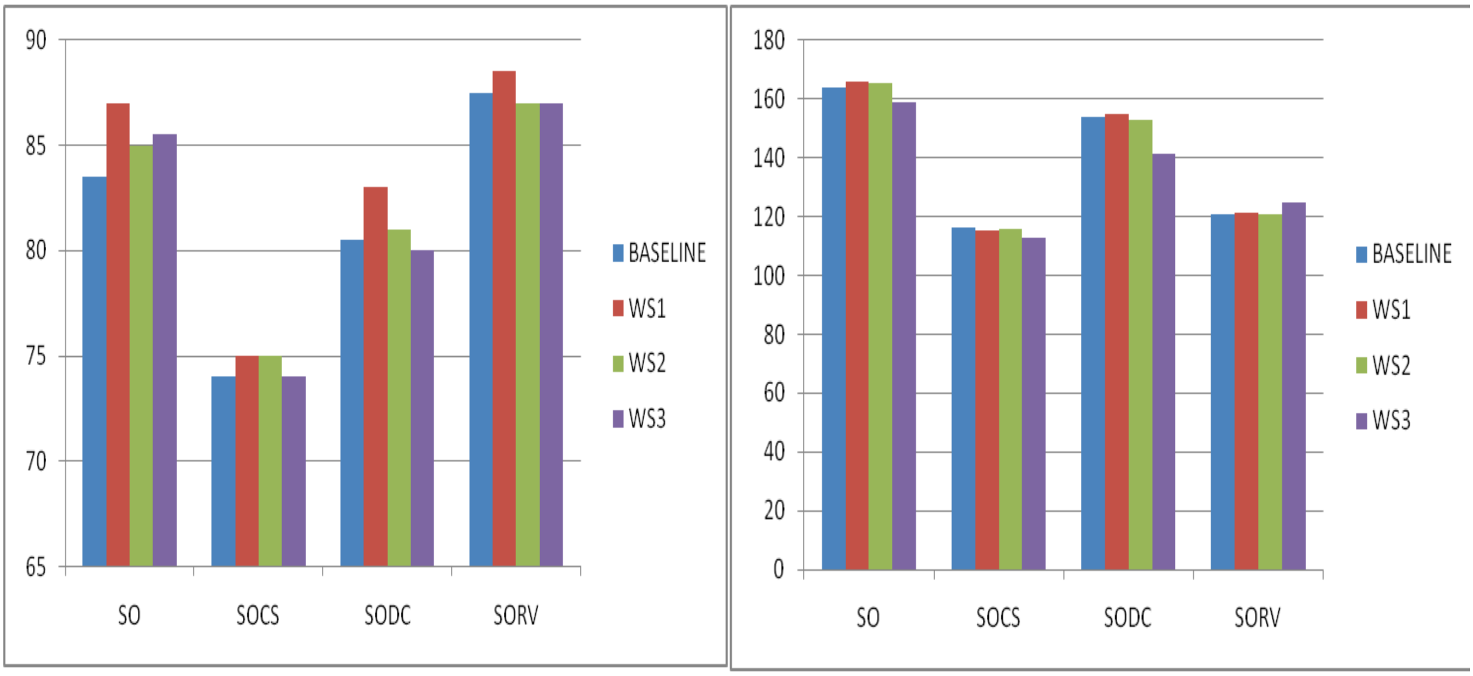


Figure 7: Comparison of the average duration of outbreak (LEFT) and average number of IPs (RIGHT) when the three welfare strategies are implemented for **Outbreak S Region 6**. Similar comparisons were evident in the other outbreaks (results not presented).

Table 2: Results for the median (5th and 95th percentiles; maximum*) number of welfare farms and pigs culled for **Outbreak M in Region 6** by welfare management strategy.

| Strategy | Number of culled welfare farms | Number of culled welfare pigs |
|---|---|---|
| **SOWS1** | 23 (11-55) | 7,204 (1,214-61,082) |
| **SOWS2** | 23 (11-55) | 3,597 (604-30,535) |
| **SOWS3** | 24 (11-55) | 3,597 (604-30,281) |
| **SOCSWS1** | 15 (8-43; 85) | 2,890 (224-54,329) |
| **SOCSWS2** | 17 (8-51; 85) | 1,443 (110-27,154) |
| **SOCSWS3** | 18 (8-47; 79) | 1,558 (110-27,154) |
| **SODCWS1** | 17 (10-44) | 7,871 (1,214-60,578) |
| **SODCWS2** | 20 (10-50) | 3,531 (604-27,765) |
| **SODCWS3** | 20 (10-50) | 3,531 (604-27,784) |
| **SORVWS1** | 24 (11-55) | 7,871 (1,214-60,578) |
| **SORVWS2** | 24 (11-55) | 3,931 (604-30,285) |
| **SORVWS3** | 25 (11-53) | 3,926 (604-30,081) |

* maximum values quoted for outlier values.

Table 3: Results for the median (5th and 95th percentiles; maximum*) number of welfare farms and pigs culled for **Outbreak S in Region 6** by welfare management strategy.

| Strategy | Number of culled welfare farms | Number of culled welfare pigs |
|---|---|---|
| **SOWS1** | 61 (41-90) | 77,191 (24,290-129,916) |
| **SOWS2** | 76 (46-105) | 38,589 (12,139-64,953) |
| **SOWS3** | 78 (45-107) | 38,190 (12,139-65,018) |
| **SOCSWS1** | 62 (36-89) | 77,191 (24,290-129,916) |
| **SOCSWS2** | 72 (41-100) | 37,512 (11,929-64,590) |
| **SOCSWS3** | 72 (41-100) | 38,087 (11,929-64,402) |
| **SODCWS1** | 64 (39-89; 104) | 77,191 (24,290-129,916) |
| **SODCWS2** | 73 (44-101; 120) | 35,689 (12,073-67,790) |
| **SODCWS3** | 73 (44-102; 116) | 35,746 (12,073-62,649) |
| **SORVWS1** | 69 (41-91) | 78,837 (25,822-136,186) |
| **SORVWS2** | 80 (46-104) | 38,589 (12,139-64,953) |
| **SORVWS3** | 78 (45-106) | 38,675 (14,587-70,221) |

*maximum values quoted for outlier values.

Table 4: Results for the median (5th and 95th percentiles; maximum*) number of welfare farms and pigs culled for **Outbreak M in Region 9** by welfare management strategy.

| Strategy | Number of culled welfare farms | Number of culled welfare pigs |
|---|---|---|
| **SOWS1** | 21 (19-55) | 8,345 (8,280-35,534) |
| **SOWS2** | 24 (22-62) | 4,172 (4,140-17,765) |
| **SOWS3** | 24 (23-36) | 4,166 (4,140-7,915) |
| **SOCSWS1** | 18 (12-41) | 8,267 (7,484-29,712) |
| **SOCSWS2** | 22 (16-47) | 4,134 (3,743-14,856) |
| **SOCSWS3** | 22 (16-47) | 4,134 (3,743-14,856) |
| **SODCWS1** | 20 (19-47) | 8,332 (8,280-30,445) |
| **SODCWS2** | 20 (19-47) | 4,166 (4,140-15,222) |
| **SODCWS3** | 24 (23-53) | 4,166 (4,140-15,222) |
| **SORVWS1** | 22 (19-50) | 7,871 (1,214-60,578) |
| **SORVWS2** | 26 (23-56) | 4,686 (4,140-15,774) |
| **SORVWS3** | 26 (23-55) | 4,672 (4,140-15,748) |

Table 5: Results for the median (5th and 95th percentiles; maximum*) number of welfare farms and pigs culled for **Outbreak S in Region 9** by welfare management strategy over a 150 day simulation period *(note that the outbreak in most instances was not eradicated by day 150).*

| Strategy | Number of culled welfare farms | Number of welfare farms | Proportion of welfare farms culled (%) | Number of culled welfare pigs |
|---|---|---|---|---|
| **SOWS1** | 0 (0-29) | 62 (26-102) | 0 (0-72) | 0 (0-15476) |
| **SOWS2** | 0 (0-34) | 36 (25-67) | 0 (0-95) | 6964 (3599-7641) |
| **SOWS3** | 25 (16-48) | 36 (24-66) | 71 (58-93) | 7014 (3642-18088) |
| **SOCSWS1** | 20 (0-43) | 37 (25-66) | 72 (0-81) | 7239 (0-28944) |
| **SOCSWS2** | 23 (0-48) | 37 (25-66) | 85 (0-94) | 3619 (0-14470) |
| **SOCSWS3** | 31 (20-51) | 37 (25-65) | 84 (61-94) | 4166 (4140-15222) |
| **SODCWS1** | 0 (0-28) | 36 (25-65) | 0 (0-81) | 0 (0-13978) |
| **SODCWS2** | 0 (0-34) | 36 (25-68) | 0 (0-92) | 0 (0-7354) |
| **SODCWS3** | 26 (17-48) | 36 (25-66) | 72 (54-94) | 7014 (3647-18091) |
| **SORVWS1** | 37 (21-61) | 44 (24-70) | 87 (82-90) | 19150 (7287-38486) |
| **SORVWS2** | 44 (24-69) | 44 (24-70) | 100 (96-100) | 9572 (3643-19240) |
| **SORVWS3** | 35 (23-65) | 35 (24-65) | 100 (95-100) | 7008 (3627-18088) |

## 5.3 Economic evaluation

Comparative costs estimated for the various outbreaks are provided in Table 6 and the Appendix (Section 7.6.4)[3]. By far the most significant costs are due to export market losses, so that strategies with the longest outbreaks had the greatest influence on the overall economic impacts. Consequently, the greatest costs were evident when a vaccination strategy was implemented, due to the longer periods before market access could be regained.

Similarly, the overall costs were lowest when a pre-emptive culling strategy was adopted, due to the shorter outbreak duration compared to other strategies. However, in some outbreaks such as Outbreak M Region 6, the large uncertainty in the length of the outbreaks meant that costs could blow out to double that of other strategies (Table 6).

Welfare compensation comprises a fraction of the total costs of the outbreak (less than 1%). When considering welfare compensation alone, it is unsurprising that these costs double when culling and disposing all pigs on welfare farms (WS1) compared to partial culling and disposal (WS2). WS3 is the most cost effective strategy given pigs sent to slaughter retain their market value and resources are not re-directed away from the control efforts. This is particularly the case in more severe outbreaks such as Outbreak S Region 9 where resources are insufficient to control the outbreak and welfare problems are inadequately addressed under the other welfare management options.

From a cost perspective, the choice of welfare strategy is immaterial in the smaller outbreaks (all outbreaks except Outbreak S Region 9), since the bulk of the total costs are derived from export losses, and consequently outbreak length and resources can cope with the welfare problems. However, for the large outbreaks where control resources are a problem (Outbreak S Region 9), WS3 is the most desirable welfare management option since welfare problems are addressed without the need to divert scarce resources required for control efforts.

[3] The costing of Outbreak S Region 9 is not presented as most outbreaks were not eradicated so that a direct comparison of costs between strategies was not possible.

Table 6: Total costs in millions (average, minimum and maximum) estimated for **Outbreak M in Region 6**. In strategies where vaccination is used (SORVWS1-3), vaccinated animals are either slaughtered following the last case (_D) or not (_L).

| Strategy | During outbreak | | Post outbreak | Overall costs*** |
|---|---|---|---|---|
| | Welfare costs* | Total costs** | Export losses | |
| **SOWS1** | 3.85(0.13-17.31) | 2809(2809-5817) | 2729 | 5117(4508-9366) |
| **SOWS2** | 1.94(0.08-8.67) | 2721(2721-4872) | 2729 | 5104(4507-9783) |
| **SOWS3** | 1.95(0.05-8.64) | 1800(1800-2528) | 2729 | 5040(4507-9944) |
| **SOCSWS1** | 2.53(0.07-17.23) | 1967(1967-2690) | 2729 | 4909(4385-12027) |
| **SOCSWS2** | 1.28(0.05-8.63) | 1967(1967-2687) | 2729 | 4956(4413-12282) |
| **SOCSWS3** | 1.25(0.02-8.6) | 2001(2001-2848) | 2729 | 4977(4413-11718) |
| **SODCWS1** | 3.85(0.29-15.23) | 2572(2572-3868) | 2729 | 5295(4425-8431) |
| **SODCWS2** | 1.94(0.16-7.63) | 2592(2592-4324) | 2729 | 5297(4425-8719) |
| **SODCWS3** | 1.87(0.13-7.28) | 2527(2527-4175) | 2729 | 5304(4493-9535) |
| **SORVWS1_D** | 3.85(0.29-15.23) | 2572(2572-3868) | 2729 | 8023(7154-11160) |
| **SORVWS2_D** | 1.94(0.16-7.63) | 2592(2592-4324) | 2729 | 8026(7153-11447) |
| **SORVWS3_D** | 1.87(0.13-7.28) | 2527(2527-4175) | 2729 | 8033(7222-12264) |
| **SORVWS1_L** | 3.85(0.29-15.23) | 2737(2737-6674) | 5457 | 5056(4519-9420) |
| **SORVWS2_L** | 1.5(0.08-7.08) | 2737(2737-6673) | 5457 | 5056(4513-9280) |
| **SORVWS3_L** | 1.47(0.05-7.05) | 2453(2453-4187) | 5457 | 5061(4540-8935) |

*Welfare costs=compensation costs for culling welfare pigs +operational costs for slaughter and disposal of welfare pigs on welfare farms (fixed per farm)

**Total costs=welfare costs + direct control costs + compensation costs + export losses (latter three not shown)

***Overall costs = total costs + export losses post outbreak + direct control costs post outbreak (latter two not shown)

# 6 Discussion

This study considered a range of options for the management of farms that develop welfare problems due to movement restrictions during an EAD response for a variety of control strategies. The utility of each strategy was examined under a range of outbreak conditions, including two different livestock Regions, two different sized outbreaks, and a range of control activities. Finally an economic evaluation was performed to assess the impact of these strategies under various outbreak scenarios.

For all outbreaks except the severe outbreak in Region 9, there were sufficient resources for a stamping out strategy to perform well without the need to implement pre-emptive culling or vaccination. In these outbreaks resources were adequate to effectively implement surveillance and stamping out, the number of farms that experienced welfare problems did not vary significantly between the control strategies used in the study. Additionally, each of the control strategies resulted in outbreaks of similar duration and severity. There were some notable exceptions to these patterns. In Region 6, the contiguous cull strategy in Outbreak M resulted in half the number of IPs compared to stamping out alone, although this was at the cost of almost doubling the number of farms culled in total and was associated with increased variability in the length and severity of the outbreak. This is because while on average contiguous slaughter was associated with small outbreaks, in some case more extensive spread could occur, overwhelming resources and lead to a large outbreak. Ring vaccination in Outbreak S was the other exception, where the uncertainty and range in potential outbreak duration and severity was significantly reduced compared to other strategies. Consequently, ring vaccination may offer advantages in larger outbreaks.

The severe outbreak in Region 9 was significantly larger than the other outbreaks. This was due to the nature of livestock production and high farm densities in this region. The resources allocated in the model for disease control quickly became overwhelmed as disease spread resulted in large buildups of infected farms designated for culling. A ring vaccination strategy was more effective in containing disease and thus able to significantly reduce the number of IPs, and increased the probability the outbreak was eradicated within the 150 day simulation period. The 'buffer' zones created by vaccination reduce the number of susceptible animals and subsequent rate of disease spread. The findings suggest that vaccination is likely to be effective if early indications are that there are a particularly large number of infected properties, high spread rates are anticipated, and/or resources for control may be inadequate.

In Region 6 outbreaks and Region 9 moderate outbreaks, resources were sufficient to carry out culling on welfare farms without compromising overall control efforts. Not surprisingly, the number of welfare cases (pigs) culled was highest under a full cull strategy (WS1), with approximately half the number of welfare cases removed under the partial cull strategies (WS2 and WS3) for all strategies in these outbreaks.

Under more severe outbreak scenarios as demonstrated in Region 9 Outbreak S, the welfare management strategies based on culling were frequently not able to be implemented due to resource shortages. The prioritisation of culling of IPs over culling of welfare farms and the growing number of IPs meant that culling teams never became available for the culling of pigs in welfare farms. In reality, one would expect authorities to adapt policies to deal with emerging problems rather than allow them to continue to get out of control.

Given that the findings reported in this study are very dependent on assumptions about resource availability and given reductions in jurisdictional workforces, a more thorough examination of resource capacity to manage an FMD incursion is considered essential. The authors note that the Matthews Review of foot and mouth disease preparedness has identified capacity to respond as a critical issue and understand that NBC has requested AHC to report on this.

The vast majority of costs estimated for an outbreak of FMD are from export losses due to market trade restrictions. Any control strategy that prolongs the period before trade can resume will result in the greatest economic impacts. For a 'vaccinate to live' policy this resulted in the longest period before export markets could resume (six months post-outbreak). In the moderate outbreaks, vaccination resulted in the largest economic losses when it was associated with delays in regaining market access. This makes vaccination a much less desirable option in small to moderate outbreaks of FMD. However, it should be remembered that the period before market access is regained is based on OIE guidelines and represents the 'best case scenario' in terms of resuming trade with international trading partners. In reality regaining market access will depend on attitudes and requirements of trading partners which may reduce or exacerbate the differences between vaccination or non-vaccination approaches.

For Region 9 severe outbreak, non-vaccination strategies (stamping out and pre-emptive culling) are more likely to result in longer outbreaks compared to vaccination and may result in larger economic losses when outbreaks last in excess of 150 days. However, it was not possible to directly compare costs, since most outbreaks were not eradicated within the 150 day simulation period.

As discussed above, vaccination is likely to be most effective in situations where disease is widespread, high rates of spread can be expected or authorities anticipate significant resource issues. A contiguous culling policy is likely to be most effective in high density situations where significant local spread of FMD occurs. It has the potential to decrease the duration of the outbreak with the ability to return to trade sooner. It is likely to be less desirable in small to moderate sized outbreaks due to the larger number of farms culled in total, in exchange for minimal gains in terms of the overall duration of the outbreak. This would result in greater compensation liabilities, and may be less readily accepted by the public. In large outbreaks, this policy can result in more rapid depletion of stamping out resources with increased risk of disease escaping containment. Additionally, socio-political factors are likely to play a large part in the decision to vaccinate, and which policy to adopt (vaccinate to live or die).

The welfare compensation costs comprised a fraction of the overall costs of the control response (less than 1%). Consequently the choice of welfare management strategy should be determined by the available resources. In severe outbreaks where resources are insufficient to control disease, welfare problems are unlikely to be addressed through strategies based on culling. Therefore sending pigs direct to slaughter (WS3) is likely to be the most effective strategy as resources are not available due to the prioritisation of control activities.

When the relative costs of each welfare management strategy are considered, WS3 (movement to slaughter under permit) is generally the most cost effective strategy. This is due to the reduced number of pig's slaughtered and subsequent compensation paid, and the lack of operational costs for slaughter and disposal. For this analysis it was assumed that there are limited or no markets for the product of welfare pigs slaughtered at abattoirs, and therefore full compensation would be paid to owners. It may be the case that product retains some or all of its market value, in which case compensation would only make up the difference in the market price of the product. This would make WS3 an even more desirable strategy from a cost perspective. However, it must be noted that other costs associated with implementing WS3, such as transporting pigs to abattoirs, were not included in this analysis. A more thorough evaluation would need to consider these costs, and would be dependent upon the various cost sharing arrangements laid out in EADRA. Welfare Strategy 1 (complete cull of all grower and finisher pigs on farm) is the most expensive as greater numbers of animals are culled and higher compensation costs result. However, in this study the culling of welfare farms was a once-off activity for all welfare strategies considered. In longer and more severe outbreaks, welfare strategy 2 may result in comparable or higher costs as the need to cull welfare farms on multiple occasions would need to be considered and costs appropriately calculated.

Although WS3 appears the most desirable welfare management strategy as it does not utilize disease control resources and is generally associated with lower costs, there are practical limitations to implementing this strategy. The movement permit that would allow movements to slaughter only enables movement within the same RA. There are only a small number of pig abattoirs in Australia (Figure x1), which limits the number of farms that would be close enough to send pigs to an abattoir within the same RA. In addition, not all pig producers typically send pigs to the nearest abattoir, due to the presence of vertically integrated companies or negotiated supply contracts with abattoirs. To implement this strategy, the abattoir would need to be willing to accept pigs from producers that are not normally within their 'catchment', and be willing to accept pigs from the RA, and comply with the required decontamination procedures afterwards. There would also need to be a facility for storing or moving the product, either within or out of the RA, as on-site storage is likely to be rapidly filled. It is also possible that the product would not be able to be moved from the RA without treatment such as rendering. This would make the product unfit for human consumption and limit its value. Due to the market closure for animal products internationally and disruptions to markets domestically, abattoirs within the RA may also just simply closedown. The use of abattoir facilities and staff for culling healthy animals on welfare grounds during an EAD may be able to be negotiated for a fee, however this has not been investigated in this study.

It should be noted that the conclusions made in this study depend on the assumptions used. Because this study was limited to particular age cohorts on particular farm types within the intensive pig industry, the estimates of costs and evaluation of management strategies apply only within these limitations. The occurrence of welfare problems on other types of farm, within other age cohorts, or within other industries is not being ruled out, but is expected to be an infrequent problem compared to the enterprises considered in this study.

The assumption of a two week period from decontamination to the lifting of the RA classification and associated movement restrictions does limit the apparent number of farms affected by welfare problems. A sensitivity analysis showed that this assumption was sensitive to increasing the period to 21 or 28 days. However, in the absence of more definitive guidelines in AUSVETPLAN, no further accuracy can be achieved.

Another assumption that may have effects on the results is the single partial cull for welfare farms. In Region 6, where the outbreak is generally resolved within 8-12 weeks, it is unlikely that any individual pig farm would remain under movement restrictions for long enough to justify a second partial cull. However, in Region 9, where a severe outbreak May last for over 5 months, farms may remain under movement restrictions for extended periods, which may require further intervention after a single partial cull. This serves as a reminder of the additional considerations that may arise in a severe and poorly controlled outbreak. In particular, the additional costs that could arise from the need to cull these farms multiple times.

The economic analysis used in this study was a simplified model and did not attempt to identify and cost every possible expense in the event of an outbreak. This study provides a comparative evaluation of costs between strategies. It is by no means a complete evaluation, and figures are indicative only. A number of costs were not accounted for in the evaluation, such as the costs of conducting serological surveys for proof of freedom, the costs of identifying vaccinated animals etc, and would be required for a more in depth analysis. Additionally, some of the costs estimated for direct control were based on estimates sourced from a number of years ago and may not accurately reflect present day costs. This evaluation highlights the uncertainty and lack of knowledge in costing various aspects of a response, particularly one as severe as FMD. More research is required to complete a more thorough economic evaluation.

The estimates of cost were largely based on analogy with previous EAD response programs, which may not be applicable to an outbreak of a disease such as FMD, which has a wider host range and affects multiple industries. As Australia has not had an incursion of FMD since the 19$^{th}$ century, the actual costs of an outbreak are difficult to determine. Some other assumptions were made in the economic analysis which may affect the findings of this study. The most important of these is the assumption relating to the farms that are eligible or not eligible for compensation, as has been discussed above.

The other is the time from resolution of the outbreak to the reopening of export markets. For the purposes of this study, the time required for OIE recognition of 'free' status has been used to estimate the time to regain market access. In reality, each receiving country will make their own assessment, and may place additional requirements on high risk consignments from Australia. This may result in a far longer period from resolution to regaining market access or additional costs in surveillance or pre-export testing requirements.

A final area of interest is the 'stepped' occurrence of welfare farms at roughly two week intervals seen in this study. This is due to the assessment that the average piggery will develop welfare problems after two weeks of movement restrictions. However, it provides a convenient guide for those managing disease control programs, to consider the animal welfare situation on intensive properties within the RA at roughly 2-3 week intervals throughout the control program. The strategy for managing any animal welfare problems will probably best be decided based on the circumstances of the particular outbreak. A combination of the strategies considered in this report will probably be adopted, to best tailor the solution to the affected farm. At the very least, managers should give serious consideration to any requests for Special Permits which would allow animals to move off affected farms and mitigate animal welfare problems. It is clear that a more thorough examination of risk based movements off properties within restricted areas is required to assist in the management of welfare problems during an EAD.

# 7 Key findings

The findings from this study are summarized in the following points. It is important to note that these findings are based on the assumptions outlined in the study and may vary under different circumstances.

1. In the moderate sized outbreaks available resources were adequate to maintain an effective stamping out strategy. Pre-emptive culling or vaccination did not offer any significant gains in terms of size or duration of an outbreak.
2. For severe sized outbreaks (Region 9 outbreak S), resources were insufficient to control disease under a stamping policy. In these situations, the size and duration of the outbreaks quickly built up, to the extent that most of the outbreaks were not eradicated by 150 days. Under some circumstances contiguous cull strategy could reduce the size of the outbreak but at the expense of removing more herds in total and increasing the uncertainty of the outcome. Vaccination was the most effective strategy to reduce both the size of the outbreak and its variability so that eradication was more likely to be achieved in a shorter period.
3. The effectiveness of the welfare management strategies depends on the severity of the outbreak and available resources to control it.
    i. In moderate outbreaks welfare management strategies did not significantly increase the length or size of the outbreak for the control strategies considered and welfare problems were able to be adequately addressed. The more effective strategies were the partial culling strategies where finisher pigs are culled and disposed of on welfare farms (WS2) or sent to slaughter at abattoirs (WS3). These strategies resulted in fewer animals culled and did not impact on the control response.
    ii. For the severe outbreaks, welfare problems are unlikely to be addressed as resources were insufficient to manage the disease response and welfare problems were considered second priority. In these outbreaks sending pigs direct to slaughter (WS3) was the most effective option since scarce resources required for control efforts were not required.
4. The vast majority of costs estimated for an outbreak of FMD are from export losses due to market trade restrictions. Any control strategy that prolongs the period before trade can resume will result in the greatest economic impacts. Vaccination will result in the largest economic losses when it is associated with delays in regaining market access.
5. The welfare compensation costs comprised a fraction of the overall costs of the control response. Consequently the choice of welfare management strategy should be determined by the available resources. In severe outbreaks where resources are insufficient to control disease, welfare problems are unlikely to be addressed through strategies based on culling. Therefore sending pigs direct to slaughter (WS3) is likely to be the most effective strategy as resources are not available due to the prioritisation of control activities.

# 8 Acknowledgements

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# 9 Appendix

## 9.1 Abbreviations

ABARE Australian Bureau of Agricultural and Resource Economics

ABS Australian Bureau of Statistics

AHA Animal Health Australia

AHPB Animal Health Policy Branch, DAFF

AHC Animal Health Committee

APL Australian Pork Limited

DAFF Department of Agriculture, Fisheries, and Forestry

EAD Emergency Animal Diseases

EADRA Emergency Animal Disease Response Agreement

DPI Department of Primary Industries

FMD Foot and Mouth Disease

LGA Local Government Area

NBC National Biosecurity Council

OIE Office International Des Epizooties

EU European Union

## 9.2 Glossary

**AUSVETPLAN**
A nationally agreed approach for responding to exotic animal disease emergencies developed by Commonwealth and State animal health authorities and the Natural Disasters Organisation, linking Australia's animal disease policy, strategies, implementation, coordination and counter-disaster plans.

**Disease control centre (DCC)**
An emergency operations centre responsible for the command and control of field operations in a defined area.

**Infected Premises (IP)**
A defined area (which may be all or part of a property) in which an emergency disease meeting the case definition exists or is believed to exist, or in which the causative agent or that emergency disease exists or is believed to exist.

**Dangerous Contact Premises (DCP)**
Premises that contain susceptible animals(s) not showing clinical signs but that, following a risk assessment, are considered highly likely to contain an infected animal(s) or contaminated animal products, wastes or things that present an unacceptable risk to the response if not addressed.

**Suspect Premises (SP)**
Temporary classification of premises that contain susceptible animal(s) not known to have been exposed to the disease agent but showing clinical signs that require investigation.

**Trace Premise (TP)**
Temporary classification of premises that contain susceptible animal(s) that tracing indicates, may have been exposed to an infected animal(s), or contaminated animal products, wastes or things, and that require investigation.

**At risk Premises (ARP)**
Premises in a Restricted Area that contain susceptible animal(s) but are not considered at the time of designation to be an SP, DCP, IP or TP.

**Restricted Area (RA)**
An initial RA will have at least a 3-km radius drawn around all IPs and DCPs, including as many SPs and TPS as practical, and some processing establishments to enable processing and trade to continue where possible. Actual distance will depend on the epidemiology of the pathogen. A high level of movement control and surveillance will apply.
*For this study Local Government Areas (LGA) were designated as the RA for the initial two weeks of the EAD response. After two weeks the above applies, i.e. 3km radius around all IPs and DCPs.*

**Control Area (CA)**
An initial CA will be based on jurisdictional borders. These boundaries will be reviewed as epidemiological information becomes available, but will probably still be based on LGAs. The CA will have a minimum of 10 km, including the RA.
*For this study the study Regions were designated as the CA.*

## 9.3 Background

In discussions with AHA, it was agreed that the livestock enterprises most at risk of developing welfare problems during an EAD are the intensive industries. For an incursion of FMD, it is likely that intensive pig farms are at the greatest risk given their limited capacity to house and husband growing pigs. In modern intensive pig production systems any disruption to normal husbandry and marketing processes may lead to welfare problems on-farm. Production systems rely on regular movement of animal's off-farm and 'held' animals will soon outgrow available space on-farm. Consequently, intensive pig farms are the focus of this study.

Under AUSVETPLAN, all premises in the RA are designated as 'at risk premises' (ARPs) and subject to movement restrictions, potentially creating animal welfare issues. Premises outside the RA, including the CA, may be able to move livestock off premises under permit and therefore should be able to avoid welfare problems. Additionally, premises with sufficient space, such as free-range piggeries and dedicated farrowing or weaning systems are less likely to develop welfare problems. A meeting between AHA, DAFF and APL representatives on 27 April 2011 recognised that welfare problems on intensive pig farms could be expected after two weeks of movement bans. Consultation with industry during the AUSVETPLAN pig disease movement control workshops and the January-February 2011 floods in Victoria and Queensland set a maximum of 2 weeks before welfare problems could develop on an intensive pig farm following movement restrictions. After this time, dwindling space allowance will severely impact on the welfare of the intensively housed pigs. It was also agreed that restricting the nutrition of growing pigs was not practically possible, of little overall consequence for the emerging space issue likely to result in pig welfare problems, and is ethically unacceptable.

## 9.4 FMD modelling

DAFF's Regional FMD model *AusSpread* (Garner and Beckett 2005, Beckett and Garner 2007) was used for this study. *AusSpread* is a stochastic spatial simulation model developed to study spread and control of FMD in livestock populations. It uses the farm as its unit of interest and simulates disease spread in daily time steps, allowing for interactions between farms with different animal species, and of different production types, and incorporating the role that such interactions might play in the epidemiology of an outbreak of FMD. The model allows for the spread of disease through animal movements, local spread, indirect contacts, through sale yards and by windborne spread. The attributes and spatial locations of individual farms, sale yards, weather stations, local government areas and various other features of the Regional environment, are incorporated into the model.

The model population contains the following farm types:

1. Beef cattle
2. Dairy
3. Sheep
4. Pig
5. Mixed beef/sheep
6. Smallholder

7. Feedlot

For this study the model was initially set up to represent Region 6, a study area that has been previously used to assess vaccination requirements in an FMD outbreak. Using the beef cattle industry as the basis, DAFF has divided Australia into twelve livestock production Regions taking into account environmental, production and marketing factors (Figure 1). These Regions are based on the Australian Bureau of Agriculture and Resource Economics (ABARE) farm survey Regions. The work was replicated in Region 9.

The study proceeded in a series of stages:

*Stage 1: Scenario development*

Scenarios were developed to model and analyse including which Regions, control strategies, pig welfare management strategies, and pig production systems to incorporate into the model.

*Stage 2: Data collection and collation*

Data was collected and collated including which input parameters and values are required for the model in consultation with AHA and APL. Pig population data, including up-to-date information on location and types of pig farms in the study Regions were provided to OCVO by APL on 11 August 2011.

*Stage 3*: *Refinement of the model*

The *AusSpread* model was adapted and modified for this study to reflect the various farming characteristics and strategies under assessment.

*Stage 4: Execution of the model*

The model was 'run' for the various outbreak scenarios and control and welfare management strategies.

*Stage 5: Indicative costing*

Results from the model were used in an economic analysis to provide indicative costs of the various welfare management strategies.

### 9.4.1 Outbreak scenarios

In simulating disease outbreaks, the size of an epidemic will depend on:

- Where and when the disease is first introduced
- How long it takes until the disease is first recognised and reported
- The type of control measures applied
- The availability of resources to implement the control measures
- Chance events

At the 28 July 2011 meeting with AHA, the size of the RA zone was discussed given its relevance to the number of welfare farms that could arise. In AUSVETPLAN the minimum size for a RA is 3km around all IPs and DCPs. In reality, it is more likely a much larger RA will be declared in the initial phase of an outbreak given the uncertainty of the size and magnitude of the spread during this early period. It was decided that for the baseline control strategy a LGA will form the RA within the first 2 weeks of an outbreak, so that any LGA containing IPs will become a RA. Additionally, the whole of the study Region will represent the CA. Following this 2 week period, all new IPs and DCPs will have a designated radius of 3km placed around them to represent the RA.

AUSVETPLAN does not provide any information on when movement restrictions in the RA may be removed. Following discussions with AHA, the agreed default (minimum) is that at risk premises (ARPs) will be restricted for 14 days after the last IP is declared in a given area (based on EU policy). If another nearby premise becomes an IP, the 14 day restriction period will start again. This means that restrictions are lifted 14 days after the last IP is declared in an area.

For pig producers, welfare impacts can be expected after 2 weeks of restrictions. In the simulation, whenever a new IP is declared all farms within the 3km RA (excluding IP, DCP, TP or SP) will be designated as an ARP, and will be flagged and subject to movement restrictions. The day a farm is restricted is recorded and time under restrictions is set to 14 days. If subsequently another close by farm becomes an IP, the time under restrictions will be reset back to 14 days. Each day the model will check ARPs. Once a pig farm has been under restrictions continuously for >14 days it will be flagged as a potential welfare case.

It was agreed that two levels of outbreak would be simulated – a moderate and a severe outbreak in each Region. The approach used for Region 6 is explained to show how this was done, with a similar approach used for Region 9. For Region 6, FMD is assumed to begin on a single randomly selected pig farm (#15738 — a 150 head grower farm) during winter with a 21 days elapsing before a diagnosis of FMD is made. The model was run 100 times to generate a distribution of possible outbreak situations at the time of detection. At the end of this 'silent spread' phase, there were 1-95 (27 ± 25, mean ± standard deviation) infected farms in the population. The median and 95% probability interval were 18 and 2-88 respectively. To represent a moderate outbreak a single run (#37), consistent with the average (with 27 infected farms present in the population after the 21 day silent spread period), was chosen (**Outbreak M**). To represent a more severe scenario a single run (#23), consistent with $90^{th}$ percentile with 67 infected farms was chosen as the severe scenario (**Outbreak S**). The population structures for these runs were saved and used in this study as the starting points for subsequent simulations starting at day 1 of a control program. This enabled outbreak sizes and number of welfare cases to be compared under different control strategies and settings assuming the same starting conditions.

### 9.4.2 Study Regions

#### *9.4.2.1 Region 6*

Region 6 (Fig. 1), an area covering southern Queensland and northern New South Wales, represents one of the best agricultural production areas in Australia with good soils and an equitable climate. It takes in the Darling Downs, which is one of the major intensive livestock producing areas in Australia. The Region has a large livestock population. Based on the last agricultural census in 2006 there are approximately 16 million head of commercial livestock. The area is noted for cattle breeding, growing and finishing and accounts for 24% of the national herd. It represents Australia's major lot feeding area, producing cattle for the domestic, and export (especially Japanese and Korean) markets. There are also sizeable populations of pigs, poultry, dairy cattle and sheep.

#### *9.4.2.2 Region 9*

This Region covers NSW and Victoria (Fig. 1). It encompasses temperate inland areas with hot, dry summers and generally unpredictable rainfall, although some areas have access to irrigation. Livestock industries include beef, dairy, sheep, poultry and pigs. The beef industry is varied with some extensive rearing, and some feedlot finishing, as well as specialist breeding enterprises. Many beef producers are also involved in other industries. Dairy is a large industry within this Region although water supply may be unreliable, putting pressure on this industry. Pig production is a significant industry in parts of this Region, particularly in the south along the NSW-Vic border. Sheep are raised for both meat and wool production in this Region. Moderate to high stocking densities can be achieved. Significant live stock movements may occur due to numerous feedlots, saleyards and abattoirs in the Region. Based on the last agricultural census in 2006 there are approximately 2.7 million beef cattle, 20 million sheep, and close to 1 million pigs.

### 9.4.3 Study population

The farm and livestock population used for this study was based on a combination of 2006 Bureau of Statistics Agricultural Census data, industry data and a small number of specific studies. As information on smallholder populations was scarce or unreliable, a synthetic dataset was created for this study using available data (published and unpublished) from other sites.

Based on this data, the numbers of farms by farm type for each region used in this study are provided in Table 1. In Region 6 there were approximately 5.7 million cattle, 9 million sheep, and half million pigs. In Region 9 there were approximately 2.8 million cattle, 23 million sheep, and 0.9 million pigs.

#### *9.4.3.1 Pig production systems*

A number of different pig production systems exist in Australia, and the information provided in this report has been derived from industry data, reports and expert opinion. Pig population data was supplied by APL in September 2011 on pig production types, herd sizes and farm locations by postcode for NSW, Queensland, and Victoria. Pig farms were classified into five categories (Table x1). Only farms in the farrow-to-finish and grower-finisher categories are considered at risk of developing welfare problems. Most of the APL data provided records with sow and/or grower numbers. Records with missing pig data were populated by randomly allocating values from log normal distributions using those records with data. Total pig numbers on farrow-to-finish farms were calculated by assuming that for each sow there was an average of 10 additional pigs (Pat Mitchell, 2011, pers. comm.). To estimate the numbers of growing pigs on grower-finisher farms, the proportion of pigs by growth category was calculated where growers and finishers each represent 24% of the growing herd (this is adjusted for the total farm size ~20-21%) (Pat Mitchell pers. comm.). These figures are similar to previous studies where a 550 sow herd is likely to produce 200 pigs per week (Cutler and Holyoake, 2007).

APL was concerned that individual farm details would not be made available. A randomisation process was used to generate farm locations, where pig farms were geo-located using postcode. An agricultural land use mask was created from the BRS National Land Use data. This was used along with a 2007 postcode boundary map to ensure farms were located within the given postcode and placed on suitable 'agricultural' land. Due to scale issues, some areas such as urban/peri-urban postal areas had no 'agricultural' land so farms were randomly allocated within the postcode area.

Table x1: Pig farm categories used in the model based on 2011 APL data.

| Category | Type | Proportion of producers where pig numbers were not recorded to those that were | Welfare farm? | Description |
|---|---|---|---|---|
| 1 | Farrow-to-finish | 13/1018 | Yes | This is the predominant pig enterprise in Australia and represents the conventional intensive piggery. |
| 2 | Grower-finisher | 144/228 | Yes | Pig enterprises that house either grower or finisher pigs. |
| 3 | Breeder-weaner | 10/364 | No | |
| 4 | Free-range | 1/4 | No | |
| 5 | Other | | No | |

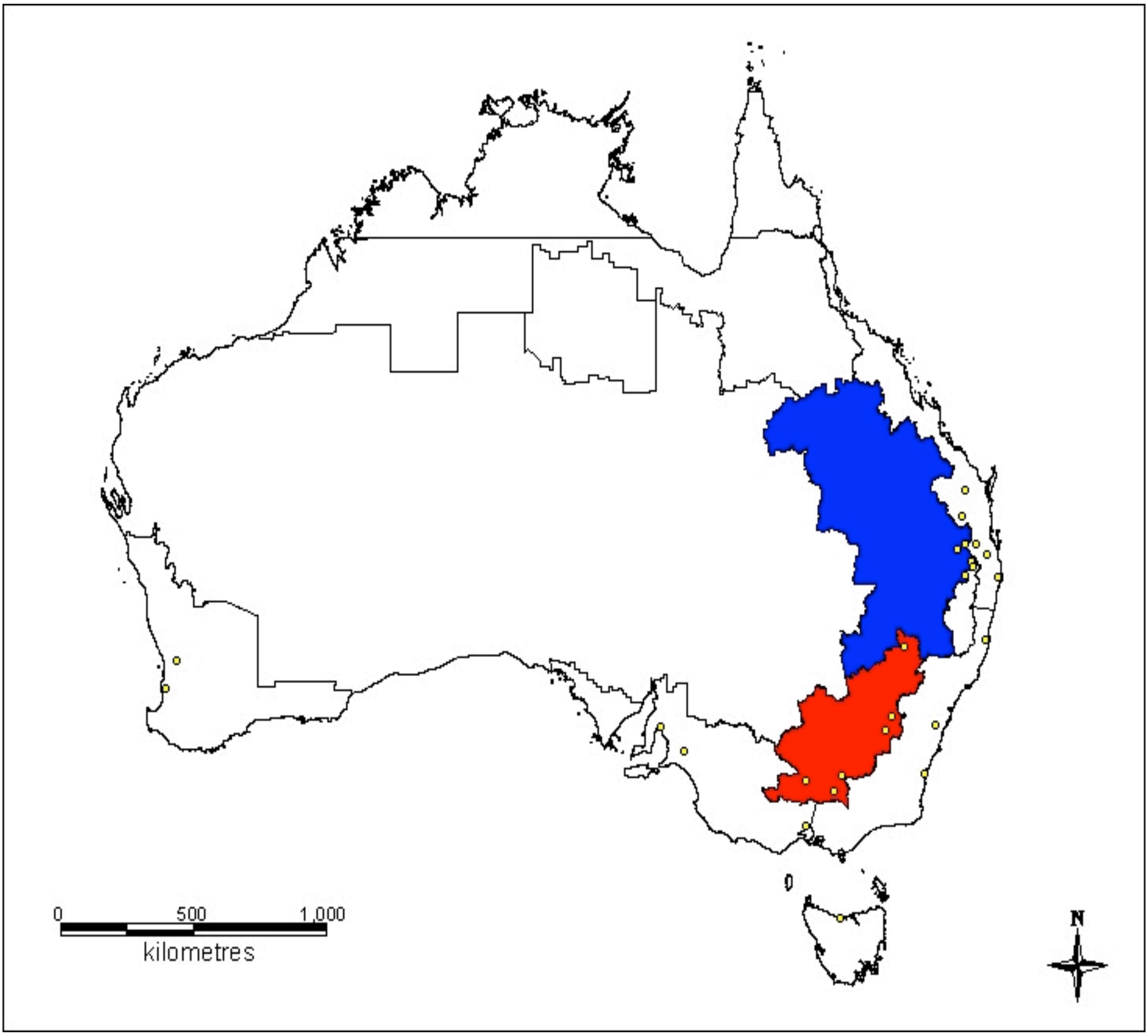



Figure x1: Geographical distribution of abattoirs (yellow dots) slaughtering pigs in Australia. The location of the study areas, Region 6 (blue) and Region 9 (red) are also provided.

### 9.4.4 Resourcing

During an EAD response resources are limited and the challenge for decision-makers is prioritizing these resources for optimal disease control and management. Of importance in this study is the extent to which welfare management strategies will consume resources used for disease control. Specifically, welfare culling (WS1 and 2) competes for available resources for stamping out activities, and the assessment of welfare cases suitable for slaughter (WS3) will detract from resources available for undertaking surveillance activities.

To accommodate these changes in the *AusSpread* model, each day herds scheduled for culling will be identified and listed in an order of priority. From a fixed resource base, culling teams will be allocated, while they are available, in the following order of priority:

1. IPs
2. Welfare cases
3. DCPs/CPs

In deciding these priorities it was acknowledged that in a large outbreak where resources are inadequate, the allocation of welfare cases to the lowest priority may mean these cases never get done and the welfare problem is never addressed. Additionally, in contrast to IPs and DCPs, welfare cases will take less time for culling operations to be completed because there is no need to do full cleaning, disinfection and decontamination. Surveillance teams can be allocated visits for the assessment of welfare cases suitable for slaughter in a similar way. In reality it is likely that these priorities will be managed on a case by case basis. The outcome of this is that in some circumstances implementing welfare management strategies can have a negative feedback on the control program due to using up (limited) resources.

## 9.5 Economic evaluation

The economic impacts of an outbreak of FMD would be expected to vary considerably depending on the management strategy employed and the nature of the outbreak. To provide an indication of comparative costs incurred from implementing the various welfare management strategies, an economic assessment was performed utilising the results from the simulations and published literature. The assessment estimates the possible direct and market costs of each strategy to provide a comparison between strategies. There is a considerable degree of uncertainty over the cost estimates for controlling a potential FMD outbreak in Australia given our lack of experience in having this disease in Australia. As such, the results drawn from this evaluation will be useful comparative indicators of the costs of the different welfare management strategies, rather than providing absolute estimates of economic impact.

The gross value of Australian farm production of livestock products was around $21.1 billion in 2010-11 (ABARE, 2011). In that year, exports of cattle, sheep and pig meat, live cattle and sheep, and dairy products earned around $9.1 billion and accounted for 61% of the total value of livestock exports. With such high value exports at risk, closure of international markets to Australian product would alone lead to substantial economic costs.

The majority of the costs associated with a potential FMD outbreak would be derived from the consequent loss of market access. In particular, as identified by Abdalla et. al. (2005), "the suspension of exports to the high returning Pacific Rim markets could have a substantial impact on livestock industries and the Australian economy as all exports of cloven hoofed animals and their products would cease for an undetermined period of time. The extent of the impact would depend on the proportion of domestic production excluded from trade and the period of time before access to export markets could be regained".

In turn, the extent and duration of the outbreak would be influenced by the strategy implemented to eradicate the disease. The duration of closure to trading markets would also depend on the management strategy chosen and would be governed by international rules specifying the criteria for regaining freedom of disease status (OIE, 2011). Consequently, choosing an FMD management strategy would involve several tradeoffs as the strategy employed would have implications for the extent of the operational costs, duration of the outbreak and, perhaps most importantly, duration of export market access restrictions.

### 9.5.1 Model inputs

For this study, the costs associated with an outbreak of FMD can be divided into four broad categories:

■ **Direct control costs** — those designed to avoid, eliminate or reduce the impacts of the disease and associated production losses. These costs include operational costs associated with decontamination of infected properties, slaughter and disposal of infected animals, and the cost of both professional and nonprofessional labour involved in administering the control strategies.

■ **Export losses** — costs associated with revenue forgone from international trade in livestock and their products.

■ **Compensation costs** — costs associated with the compensation of culling animals on IPs and DCPs.

■ **Welfare costs** — costs associated with the compensation of culling or slaughtering welfare cases and the operational costs associated with the culling and disposal of pigs on welfare farm.

This analysis utilises a similar approach to the one performed by Abdalla et. al., 2005. This analysis provides an indication of costs, rather than as a comprehensive economic evaluation, which is beyond the scope of this study. All costs and prices in this analysis are in 2010-11 Australian dollars. Where it was not possible to obtain present day values for all costing, figures were multiplied by the average consumer price index (0.03) (ABS, 2011) over the elapsed time period in years according to the formula:

$$\text{Present value} = \text{Past value}\ (1.03)^{\text{number years elapsed}}$$

A list of the costs used in this evaluation is provided in Table 10.

### 9.5.2 Direct control costs

The operational control costs considered in this evaluation included the cost of running a disease control centre and the costs of slaughter, disposal, and decontaminating IPs and DCPs. This will include the costs for labour, decontamination, slaughter and disposal, hire of equipment and facilities, and vaccine.

#### *9.5.2.1 Decontamination, slaughter, and disposal costs*

Decontamination costs were estimated based on labour requirements and equipment hire. The costs of farm decontamination were estimated for each industry using wage rates and estimates of the number of work days required plus the hire of necessary equipment for operations. The costs differ between industries to reflect the different design of premises in each industry. Decontamination would be undertaken on all properties where infected, contiguous and dangerous contact herds were to be slaughtered. Abdalla et. al. (2005) provided decontamination costs in 2001 prices for beef and sheep ($20 000 each), pigs ($50 000), and dairy ($35 000). Based on design and size of premises, it was assumed the cost to decontaminate a smallholder property would be one quarter that of a beef property, and for a feedlot would be the same cost as a dairy property.

Slaughter and disposal of infected and dangerous contact animals was considered to take place on farm. From Abdalla et. al. (2005), slaughter and disposal of infected and dangerous contact animals was estimated to cost around $15 000 for a herd of 4000 animals for sheep and pigs, and a similar amount for a herd of 400 animals for beef and dairy cattle in 2001 dollars. Given the comparative size of feedlots to beef properties it was assumed the costs of slaughter and disposal was four fold that of beef, and for smallholders one tenth that of beef. The cost estimates for decontamination, slaughter and disposal used in this study were priced using these figures as a baseline, and rounded up to present day values (Table x3).

#### *9.5.2.2 Control centre costs*

Estimates of the total cost of labour required for the administration of the control strategies, which includes the costs of administration, monitoring, surveillance activities and running local disease control centres, were based on estimates provided by NSW DPI (2012) and figures estimated from the Equine Influenza (EI) outbreak in 2007-08. It was assumed that each Region would set up two local disease control centres (LDCC) and two state disease control headquarters (SDCHQ).

The costs associated with the operation of a disease control centre include labour costs for operational activities and incidentals. NSW DPI (Kevin Cooper, pers. comm., 2012) estimate the costs of running a LDCC are approximately $100,000 per day plus staffing costs. This includes staffing of 200-800 people in the field and at the centre. Staffing costs for specialist staff (i.e. those with technical skills such as veterinarians and scientists) were derived from contract rates paid during the EI outbreak in NSW in 2007-08 at $1000 per day (Therese Wright, NSW DPI, pers. comm., 2012). Support staff (such as administrative staff and animal handlers) were assumed to be half these costs. For a FMD outbreak it is assumed each centre would require a large number of people per centre (400), and the proportion of specialist to non-specialist staff is estimated to be 20:80 based on the average proportion of specialist staff required for the EI outbreak in NSW and Qld in 2007 (Webster, 2011). The total control centre costs per region were calculated to be $680,000 per day (Table x2). It was assumed the control centre's would continue to operate at these costs over the surveillance phase for proof of freedom from infection, and will remain operational for three months following the last confirmed case (Therese Wright, DPI NSW, 2012). Under a vaccination control strategy it was assumed control centre's will remain operational for an additional month to allow for extra time to conduct surveillance on vaccinated herds.

Table x2. Total labour and operational costs per day for each region.

| | Total costs |
|---|---|
| Number staff per disease control centre | 200 |
| Number of disease control centres (2 LDCCs and 2 SDCHQs) | 4 |
| Cost per control centre/day ($) | 100,000 |
| Cost of specialist staff/day ($) | 1000 |
| Cost of non-specialist staff/day ($) | 500 |
| Proportion of specialist staff: non-specialist per control centre | 20:80 |
| Total cost per control centre ($) | 220,000 |
| **Total control centre costs ($)** | 880,000 |

### *9.5.2.3 Vaccination costs*

Under the vaccination strategy all susceptible animals are vaccinated within a 3 km radius of an IP. The costs of vaccination include the costs of the vaccine and labour costs. FMD vaccine is estimated to cost $0.60/ml, and cattle and pigs require a 2ml dose and sheep half this dose. Additional costs for the cold storage, consumable items and delivery are estimated to be $0.80/dose based on costs from the EI outbreak in 2007 (Kevin de Witte, AHA, pers. comm., 2011, Abdalla et al, 2005). It is assumed two people will average 500 head per day at $1500, or $3/dose in labour costs. For emergency vaccination, such as the case under consideration here, a single dose would be adequate and subsequent vaccination rounds would not be necessary. Therefore the total costs for vaccinating cattle and pigs are $5/head, and sheep is $4.40/head.

*9.5.2.4 Serosurveillance*

Surveillance costs comprise the costs of detecting disease during the outbreak and surveillance for proof of freedom following the epidemic. It is difficult to determine what level of proof would be required for Australia to substantiate its claim it was free of FMD. The level and degree of sampling and surveillance required to prove freedom from disease will depend on epidemiological factors and the level of statistical confidence to demonstrate freedom from disease according to OIE guidelines. It is beyond the scope of this study to provide an in-depth analysis of the serosurveillance requirements following the outbreak to prove freedom of disease. For simplicity, we assume each Region represents one stratum and there are a large number of herds within each Region. Assuming a perfect test, we would need to sample 458 herds to be 99% confident we would detect FMD if it were present in 1% of herds (Win Episcope, v2.0, 2000). For the purposes of this comparative evaluation the surveillance costs are assumed to be the same between control strategies. The exception is when vaccination is used as a control strategy. It is expected that more within herd sampling will be required to demonstrate freedom from infection in a vaccinated population, as the within-herd prevalence of infection would be lower than in a fully susceptible (non-vaccinated) population. If a herd is infected, the assumed sero-prevalence is 30%. This is considered a conservative estimate as FMD is a highly contagious disease and will readily spread through a highly susceptible Australian population. This is expected to result in high within-herd infection rates (Garner et. al., 1997). Based on OIE guidelines, the assumed seroprevalence in a non-vaccinated herd is 1%. If we assume a test specificity and sensitivity of 100% and 95% respectively (Engel, 2008), an average herd size of 1000, then we need to sample 17 and 389 individuals per herd in a non-vaccinated and vaccinated population respectively, to be 99% confident that at least one individual from the herd is detected if FMD is present in the herd (Ausvet, Epitools, http://epitools.ausvet.com.au/content.php?page=Freedom, 2012). The number of vaccinated herds was derived from the model. The costs of the ELISA tests are similar whether testing for non-structural proteins (for a non-vaccinated population) or structural proteins (for a vaccinated population), and are estimated to be $29/test (James Watson, AAHL, pers. comm., 2012). Therefore the *additional* costs of surveillance for a vaccinated population were estimated to be 29*(389-17)*number vaccinated herds.

### 9.5.3 Export losses

The loss in revenue from export earnings includes a nationwide ban on the export of live cattle (beef and dairy), sheep, and pigs, and their products. Animal products include meat, dairy products (butter, cheese, powdered milk, casein and other dairy products), wool and skins. It is assumed there is a suspension on all Australian exports to any country for the entire period of the market closure. Although zoning[4] is an integral component of Australia's FMD response so access to export markets could be retained or regained for product from designated disease free areas, it is beyond the scope of this study to assess these effects. Additionally, the primary focus of this analysis is to compare the costs of the welfare strategies, rather than assess differences in costs associated with variable zoning options.

[4] Zoning allows a country to demarcate Regions into FMD infected and free areas. The conditions under which zoning for FMD can be established are defined by the OIE (2011).

Under international guidelines, using all strategies where vaccine is not used, a period of three months must elapse after the last case of infection is eradicated before market access can be regained (OIE, 2011). For this analysis, it is assumed this is the shortest period of market closure following removal of the last case under strategies where vaccination is not used. In a 'vaccinate to die' policy, where vaccination is used with stamping out of infected herds and all vaccinated animals are slaughtered at the end of the outbreak, a period of three months after the last vaccinated animal is slaughtered must elapse before disease free status could be regained. For this study, it is assumed it will take an extra month to slaughter vaccinates compared to strategies where vaccination is not used, so that trade will not resume until four months following the last confirmed case. Under OIE guidelines, in a 'vaccinate to live' policy, where vaccinated animals are not slaughtered, it will take 6 months before disease free status is regained. In reality, it is unlikely market closure under any strategy will resume for some time, and it could be expected to take up to or longer than twelve months before trading partner confidence in the FMD free status is restored.

### 9.5.4 Compensation costs

Compensation costs comprise the costs of compensating animals slaughtered in the control response of the outbreak. Under AUSVETPLAN, farmers are fully compensated for the slaughter of infected and dangerous contact animals and for vaccinated animals (vaccinates) in cases where there is no market returns from their slaughter. For the purposes of this study it is assumed that vaccinates retain their full market value so no compensation is paid. It may be the case that producers receive a proportion of the value of the animal if vaccinated as described in Garner et. al. (1997), or no market exists for vaccinates. In these situations the overall costs of a vaccination strategy would be expected to be higher than the figures quoted in this study, and for the latter situation additional costs for the slaughter and disposal of vaccinates would also need to be included.

Compensation payouts would initially be provided according to prevailing market prices for each animal type and category. Average prices for each animal in the industry were obtained from ABARE's annual agricultural and grazing industries survey for 2011 (Table x8). For smallholders, compensation costs were assumed to be the average market value of sheep, beef, and pigs.

### 9.5.5 Welfare costs

Welfare costs comprise the costs of compensating pigs culled on welfare farms and sent to slaughter, and the operational costs associated with the culling and disposal of pigs on welfare farms. For the purposes of this study it is assumed that pigs culled for welfare reasons (for all welfare strategies) do not retain their market value and full compensation is paid. Compensation payouts for welfare pigs were based on the average market value of finisher pigs for the year 2010 (APL, 2010) (Table x3). Operational costs associated with the culling and disposal of pigs on welfare farms (WS1 and WS2) were assumed to be fixed at 40% of the costs of slaughter, disposal and decontamination of an average sized pig farm on infected premises (Table x3). There are no operational costs associated with WS3.

Table x3: Input values used in the economic evaluation of different welfare management strategies. Figures highlighted in **bold** are fixed costs for each strategy. For the fixed costs, average values were used.

| Input | Value | Reference |
|---|---|---|
| **Total disease control centre costs/day ($)** | 1,160,000 | NSW DPI 2012, Webster 2012 |
| **National export losses/day ($m)** | 32.48 | ABARE 2011 |
| Number of culled farms | | Simulation |
| Length of outbreak (days) | | Simulation |
| Number of welfare cases (welfare pigs slaughtered) | | Simulation |
| **Vaccine costs/head ($)** | | AHA 2011 |
| ▪ **Cattle, pigs** | 5.00 | |
| ▪ **Sheep** | 4.40 | |
| **Decontamination, slaughter, and disposal costs on farm type ($):** | | Abdalla et al 2005 |
| ▪ **Beef** | 45,667 | |
| ▪ **Dairy** | 65,239 | |
| ▪ **Sheep** | 45,667 | |
| ▪ **Pig** | 84,810 | |
| ▪ **Mixed beef/sheep** | 45,667 | |
| ▪ **Small holder** | 7,502 | |
| ▪ **Feedlot** | 202,240 | |
| **Average number of animals on farm type:** | | Simulation |
| ▪ **Beef** | 700 | |
| ▪ **Dairy** | 231 | |
| ▪ **Sheep** | 2,491 | |
| ▪ **Pig** | 1,542 | |
| ▪ **Mixed beef/sheep** | 2,879 | |
| ▪ **Small holder** | 15 | |
| ▪ **Feedlot** | 1,941 | |
| **Average compensation cost/head for farm type ($):** | | |
| ▪ **Beef** | 742.50 | ABARE 2011 |
| ▪ **Dairy** | 742.50 | ABARE 2011 |
| ▪ **Sheep** | 69.00 | ABARE 2011 |
| ▪ **Pig** | 222.50 | AUSVETPLAN 2006 |
| ▪ **Mixed beef/sheep** | 742.50 | ABARE 2011 |
| ▪ **Small holder** | 344.67 | |
| ▪ **Feedlot** | 872.00 | ABARE 2011 |
| **Compensation costs for welfare cases* ($)** | 223.20 | APL 2010 |
| **Serological cost/test ($)** | 29 | AHL 2012 |
| **Slaughter and disposal cost/welfare farm ($)** | 33,924 | Abdalla et al 2005 |

*The average value paid for compensation of slaughter of welfare pigs (finisher pigs) is different to the average value of slaughtering pigs on infected premises where a range of different pig classes exist including weaners, sows, and grower pigs.

## 9.6 Results

### 9.6.1 Control strategies

*9.6.1.1 Region 6 Outbreak M*

There were relatively small differences in the size and duration of the outbreaks by strategy (Table x4), suggesting that despite some initial shortfalls, available resources were adequate to maintain an effective stamping out strategy for the moderate outbreak scenario. Given that most of the new cases were due to local spread and wind-borne spread (on average these two routes accounted for 82% of new infections) pre-emptive culling of dangerous contact premises (i.e. premises associated with longer distance direct and indirect contacts) did not show any significant benefits for the moderate outbreak either in terms of reduction in the duration of the outbreak or number of IPs. Similarly, there was no significant difference in the duration or number of IPs under strategy SORV but on average 169 farms (range 58-372) would be vaccinated. On the other hand pre-emptive culling of contiguous herds was effective in reducing the median number of IPS by almost 50% (from 58 to 31) but at the cost of culling almost double the number of farms (a median of 119 farms culled versus 58). In contrast to the other control strategies assessed, a SOCS strategy has the potential to create a very large outbreak under a worst case scenario.

There was no significant difference in the number of welfare farms for the four control strategies considered (Friedman statistic=6.43, P=0.092) (Table x4). A median of 19-24 welfare farms could be expected under this outbreak. Most of the welfare farms occur in discrete “steps” at 2 week intervals 2-6 weeks into the control program (see Figure x2) reflecting the two week restriction period that apply to farms in RAs around new diagnoses.

As a comparison, the simulation was run for the stamping out strategy using 3km restricted areas rather than LGA-sized RAs. It is interesting to note that using the smaller restricted areas has not significantly altered the duration or size of the outbreak. It could be expected that larger RAs means the majority of infected farms (whether recognised or not) are quickly put under stringent restrictions limiting the subsequent opportunity to spread infection. In the moderate outbreak this is not evident, and maybe because the outbreak is of limited size and spread is limited. However, the number of welfare farms are significantly reduced with the smaller restricted areas, where the median number of welfare farms fell from 28 to 2 (Table x4). This is to be expected as fewer pig farms are placed under movement restrictions.

Table x4: Results for the median (5th and 95th percentiles; maximum*) number of IPs, number of welfare farms, duration of outbreak, and number of farms culled for Outbreak M in Region 6 by control strategy following 100 simulations (run Dec 2011).

| Strategy | SO 3km RA | SO (baseline) | SOCS | SODC | SORV |
|---|---|---|---|---|---|
| **Duration(days)** | 66 (55-90) | 63 (52-83) | 60 (51-71; 191) | 63 (53-89) | 72 (54-88) |
| **Number of IPs** | 63 (43-99) | 58 (40-89) | 31 (18-60; 697) | 56 (36-87) | 56 (39-77) |
| **Number of welfare farms** | 2 (1-4) | 23 (11-55) | 19 (9-53; 85) | 20 (10-50) | 24 (11-55) |
| **Number of farms culled** | 63 (43-99) | 58 (40-89) | 119 (69-200; 1054) | 64 (44-102) | 56 (39-77) |

* maximum values quoted for outlier values.

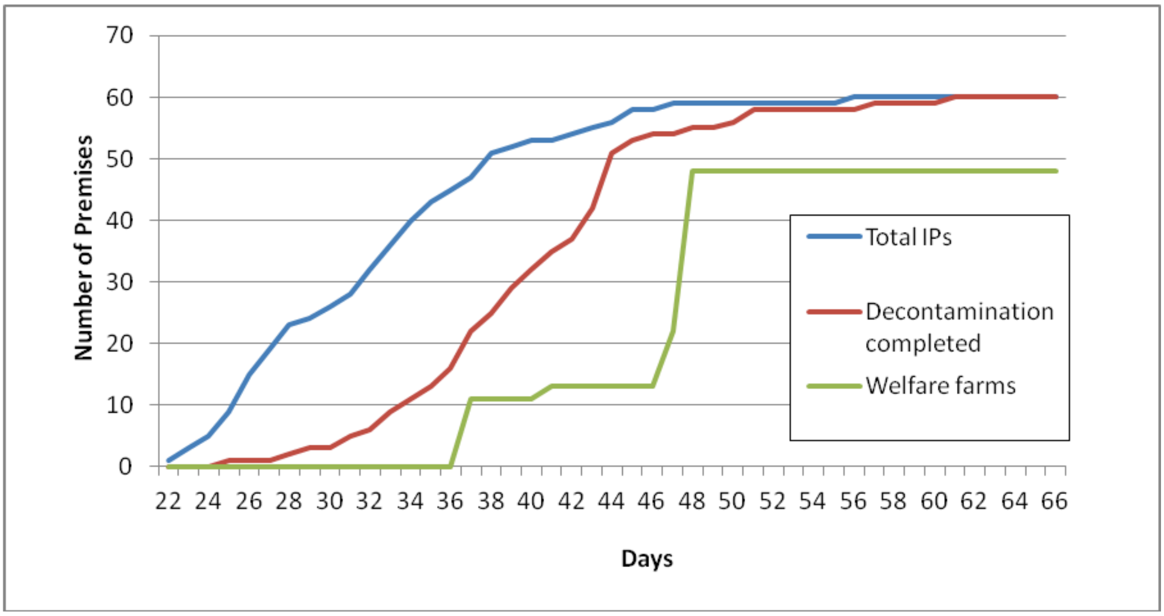



Figure x2: Sample simulation run showing cumulative IPs, number of premises decontaminated, and number of welfare farms over time for Outbreak M in Region 6.

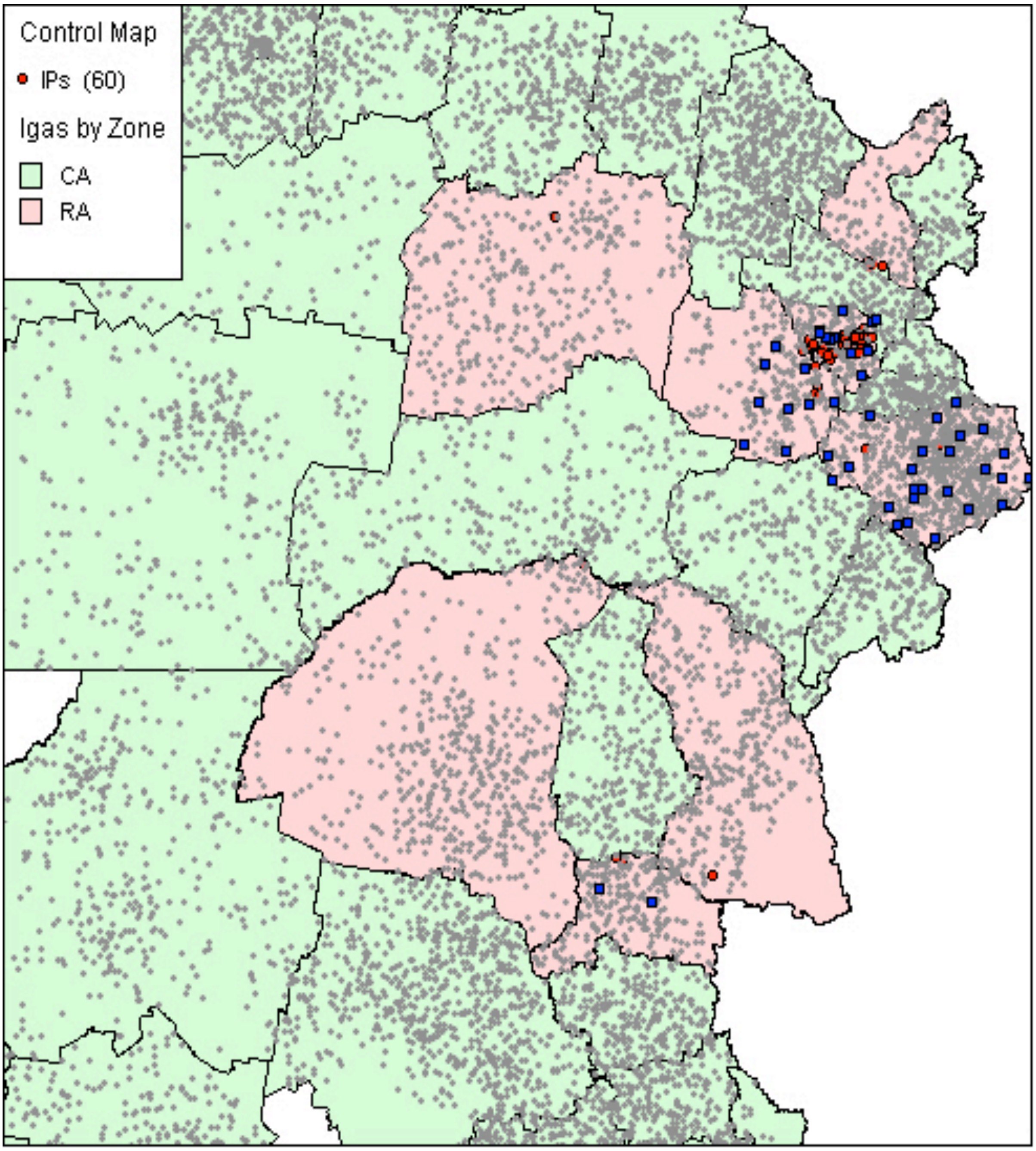



Figure x3: Distribution of IPs (red) and welfare farms (blue) in a sample simulation run for control strategy SO (Outbreak M).

*9.6.1.2 Sensitivity analysis*

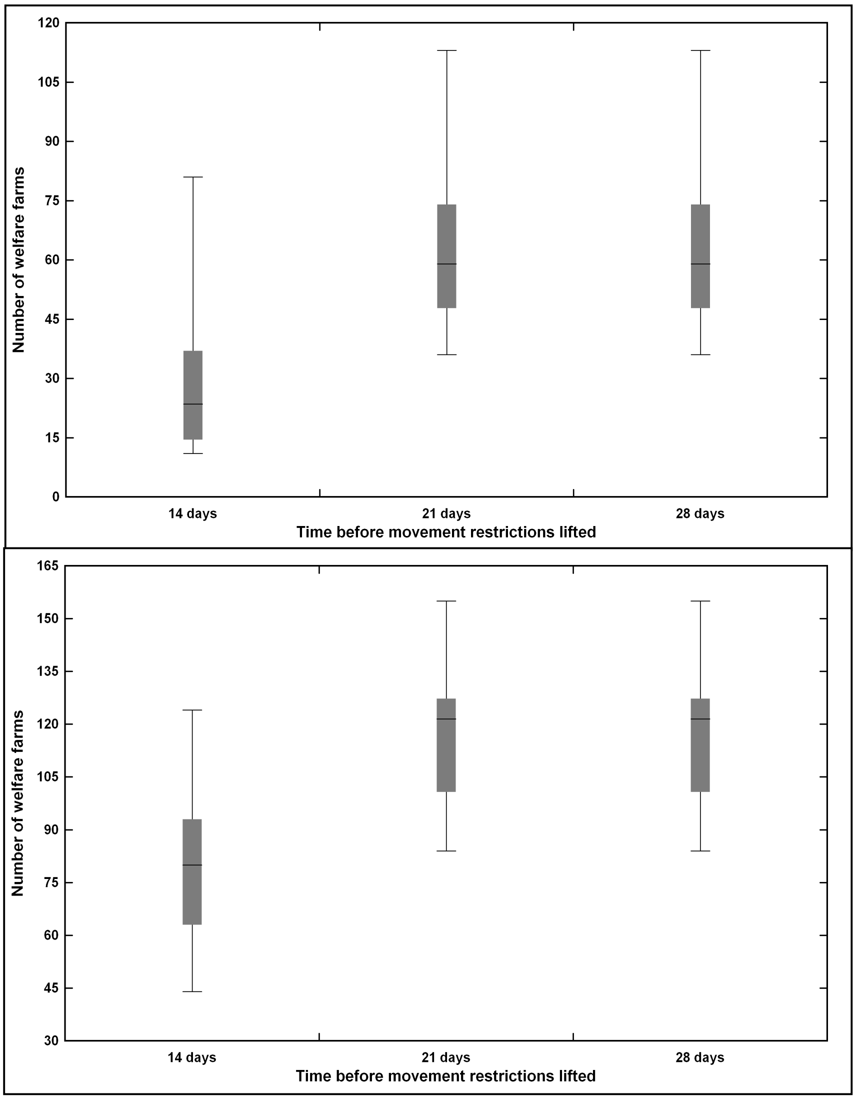



Figure x4: The number of welfare farms that result when increasing the time when movement restrictions apply in RAs for Outbreak M (top plot) and Outbreak S (bottom plot) in Region 6.

### 9.6.2 Welfare management strategies

Table x5: Results for the median (5th and 95th percentiles; maximum*), number of welfare pigs and farms culled for **Outbreak M in Region 6** by welfare management strategy following 100 simulations.

| Strategy | Number of welfare farms | Number of welfare pigs |
|---|---|---|
| **SOWS1** | 23 (11-55) | 7,204 (1,214-61,082) |
| **SOWS2** | 23 (11-55) | 3,597 (604-30,535) |
| **SOWS3** | 24 (11-55) | 3,597 (604-30,281) |
| **SOCSWS1** | 19 (9-54; 85) | 2,890 (224-54,329) |
| **SOCSWS2** | 19 (9-54; 85) | 1,443 (110-27,154) |
| **SOCSWS3** | 19 (9-54; 85) | 1,558 (110-27,154) |
| **SODCWS1** | 20 (11-58) | 7,871 (1,214-60,578) |
| **SODCWS2** | 20 (11-50) | 3,531 (604-27,765) |
| **SODCWS3** | 20 (11-50) | 3,531 (604-27,784) |
| **SORVWS1** | 24 (11-55) | 7,871 (1,214-60,578) |
| **SORVWS2** | 24 (11-55) | 3,931 (604-30,285) |
| **SORVWS3** | 25 (11-53) | 3,926 (604-30,081) |

* Maximum values quoted for outlier values.

Table x6: Results for the median (5th and 95th percentiles; maximum*) , number of welfare pigs and farms culled for **Outbreak S in Region 6** by welfare management strategy following 100 simulations.

| Strategy | Number of welfare farms | Number of welfare pigs |
|---|---|---|
| **SOWS1** | 80 (46-108) | 77,191 (24,290-129,916) |
| **SOWS2** | 80 (46-108) | 38,589 (12,139-64,953) |
| **SOWS3** | 80 (46-108) | 38,190 (12,139-65,018) |
| **SOCSWS1** | 80 (48-111) | 77,191 (24,290-129,916) |
| **SOCSWS2** | 80 (48-111) | 37,512 (11,929-64,590) |
| **SOCSWS3** | 80 (47-108) | 38,087 (11,929-64,402) |
| **SODCWS1** | 75 (46-104) | 77,191 (24,290-129,916) |
| **SODCWS2** | 75 (46-104) | 35,689 (12,073-67,790) |
| **SODCWS3** | 75 (46-104) | 35,746 (12,073-62,649) |
| **SORVWS1** | 80 (46-106) | 78,837 (25,822-136,186) |
| **SORVWS2** | 80 (46-106) | 38,589 (12,139-64,953) |
| **SORVWS3** | 79 (46-106) | 38,675 (14,587-70,221) |

*Maximum values quoted for outlier values.

Table x7: Results for the median (5th and 95th percentiles; maximum) , number of welfare pigs and farms culled for **Outbreak M in Region 9** by welfare management strategy following 100 simulations. Simulations were run for a maximum of 150 days.

| Strategy | Number of culled welfare farms | Number of welfare pigs |
|---|---|---|
| **SOWS1** | 25 (23-63) | 8,345 (8,280-35,534) |
| **SOWS2** | 25 (23-63) | 4,172 (4,140-17,765) |
| **SOWS3** | 25 (22-25) | 4,166 (4,140-7,915) |
| **SOCSWS1** | 22 (17-49) | 8,267 (7,484-29,712) |
| **SOCSWS2** | 22 (17-49) | 4,134 (3,743-14,856) |
| **SOCSWS3** | 22 (17-49) | 4,134 (3,743-14,856) |
| **SODCWS1** | 24 (23-27) | 8,332 (8,280-30,445) |
| **SODCWS2** | 24 (23-53) | 4,166 (4,140-15,222) |
| **SODCWS3** | 24 (23-53) | 4,166 (4,140-15,222) |
| **SORVWS1** | 26 (23-56) | 7,871 (1,214-60,578) |
| **SORVWS2** | 26 (23-56) | 4,686 (4,140-15,774) |
| **SORVWS3** | 26 (23-55) | 4,672 (4,140-15,748) |

Table x8: Results for the median (5th and 95th percentiles; maximum), number of welfare pigs and farms culled for **Outbreak S in Region 9** by welfare management strategy following 100 simulations. Simulations were run for a maximum of 150 days.

| Strategy | Number of culled welfare farms | Number of welfare pigs |
|---|---|---|
| **SOWS1** | 0 (0-29) | 0 (0-15476) |
| **SOWS2** | 0 (0-34) | 6964 (3599-7641) |
| **SOWS3** | 25 (16-48) | 7014 (3642-18088) |
| **SOCSWS1** | 20 (0-43) | 7239 (0-28944) |
| **SOCSWS2** | 23 (0-48) | 3619 (0-14470) |
| **SOCSWS3** | 31 (20-51) | 4166 (4140-15222) |
| **SODCWS1** | 0 (0-28) | 0 (0-13978) |
| **SODCWS2** | 0 (0-34) | 0 (0-7354) |
| **SODCWS3** | 27 (17-49) | 7014 (3647-18091) |
| **SORVWS1** | 37 (21-61) | 19150 (7287-38486) |
| **SORVWS2** | 44 (24-69) | 9572 (3643-19240) |
| **SORVWS3** | 35 (23-65) | 7008 (3627-18088) |

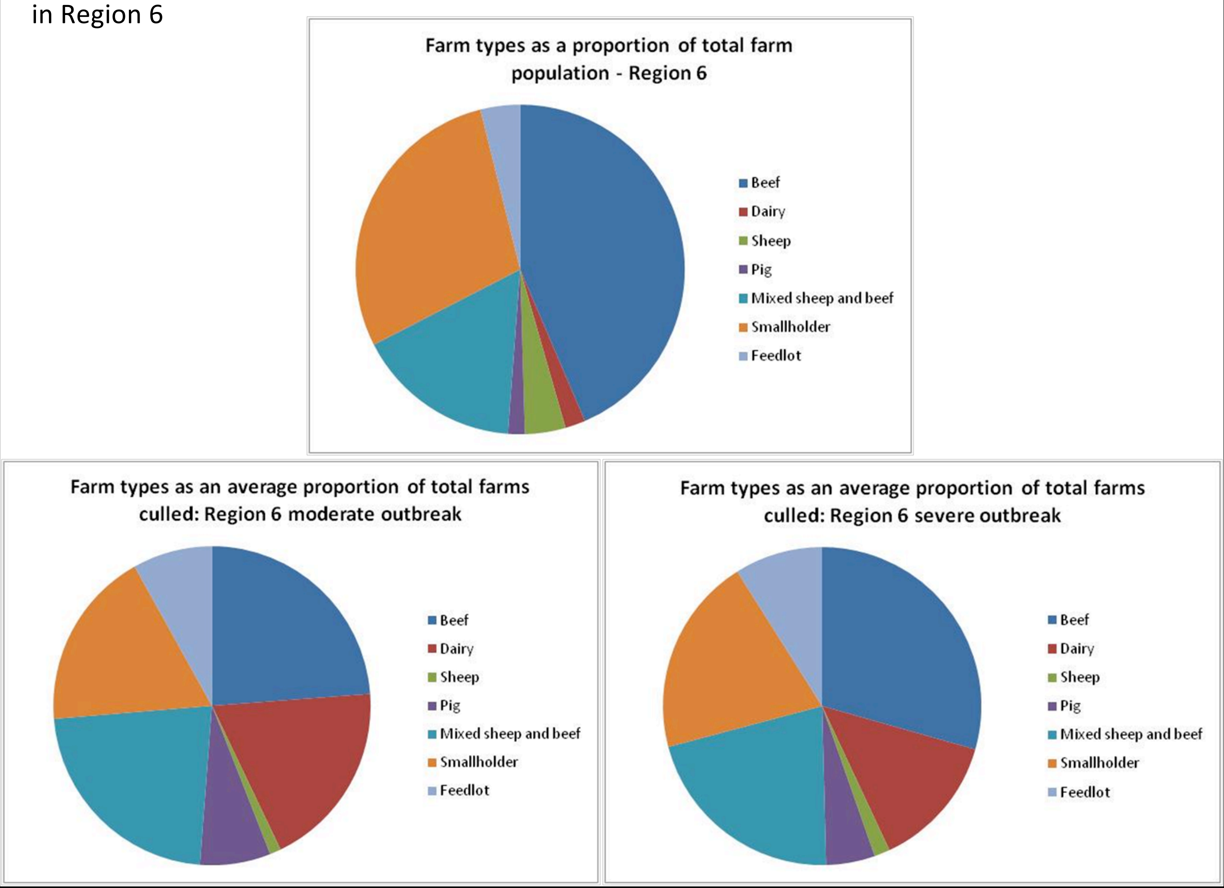
### 9.6.3 Breakdown of outbreak by farm type

#### *9.6.3.1 Region 6*

The contribution of different farm types to the outbreak can be crudely assessed by comparing the proportion of farms that became infected with the overall farm population in the Region (Fig. x9). This was assessed for the two Regions in this study, using data from the baseline strategy (stamping out only).

Of the total farms infected (culled), beef, dairy, mixed beef-sheep, and smallholder farms comprised the greatest proportion (Fig x9). This may reflect their increased susceptibility to infection or their representation in the total farm population. When accounting for the contribution each farm type makes to the total farm population, dairy, pig, mixed beef-sheep, and feedlot farms were over-represented among the infected (culled) farms, suggesting that these types of enterprise are at a higher risk of becoming infected. In contrast, beef, sheep, and smallholder farms were under-represented among the infected farms, suggesting that these types of enterprise are at a lower risk of becoming infected.

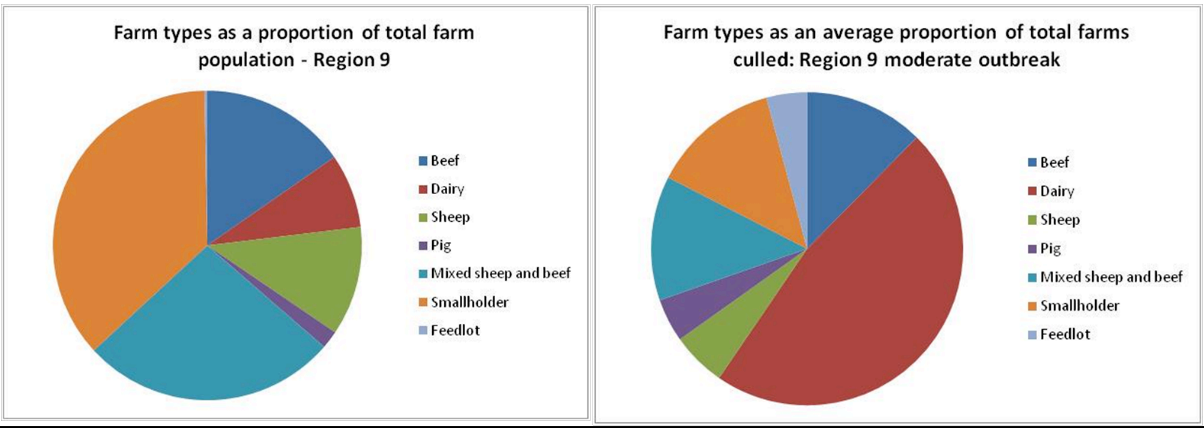
Figure x9: Comparison of farm types in the population with farm types culled during an outbreak in Region 6



*9.6.3.2 Region 9*

A similar pattern was observed in Region 9 (Figure x10), except that in this Region mixed beef-sheep farms appeared to be at a lower risk of becoming infected. This may be due to different management practices between Regions. Dairy farms appear to be at the greatest risk of becoming infected.

Figure x10: Comparison of farm types in the population with farm types culled during an outbreak in Region 9




For both Regions, despite their relatively large contributions to the total farm population, smallholders are less likely to become infected (and therefore contribute to the control response in terms of culling) compared to other farm types.

### 9.6.4 Economic evaluation

Table x9: Total costs in millions (average, minimum and maximum) estimated for **Outbreak S in Region 6**. For Tables x9-10, in strategies where vaccination is used (SORVWS1-3) vaccinated animals are either slaughtered following the last case (_D) or not (_L).

| Strategy | During outbreak | | Overall costs*** |
|---|---|---|---|
| | Welfare costs* | Total costs** | |
| **SOWS1** | 16.8(5.39-32.07) | 3280(2262-9482) | 6066(5047-15548) |
| **SOWS2** | 8.42(2.71-16.05) | 3258(2258-9525) | 6044(5044-15568) |
| **SOWS3** | 8.52(2.68-16.02) | 3144(2222-8989) | 5930(5008-14919) |
| **SOCSWS1** | 16.91(5.27-31.93) | 2774(2216-5774) | 5560(5002-11334) |
| **SOCSWS2** | 8.47(2.65-15.98) | 2769(2212-5761) | 5555(4997-11316) |
| **SOCSWS3** | 8.43(2.53-15.95) | 2735(2218-4588) | 5521(5003-10109) |
| **SORVWS1_D** | 17.63(5.32-32.65) | 3121(2325-4801) | 5926(5130-10726) |
| **SORVWS2_D** | 8.83(2.67-16.34) | 3072(2315-4570) | 5877(5120-10447) |
| **SORVWS3_D** | 8.79(2.64-16.99) | 3067(2417-5240) | 5872(5222-11113) |
| **SORVWS1_L** | 17.63(5.32-32.65) | 3121(2325-4801) | 8654(7859-13455) |
| **SORVWS2_L** | 8.83(2.67-16.34) | 3072(2315-4570) | 8606(7849-13176) |
| **SORVWS3_L** | 8.79(2.64-16.99) | 3067(2417-5240) | 8601(7951-13841) |
| **SODCWS1** | 17.63(5.32-32.65) | 3037(2384-8595) | 5823(5170-14418) |
| **SODCWS2** | 8.83(2.67-16.34) | 3037(2253-8050) | 5823(5039-13873) |
| **SODCWS3** | 8.79(2.64-16.99) | 2958(2236-5618) | 5744(5022-11362) |

*Welfare costs=compensation costs for culling welfare pigs +operational costs for slaughter and disposal of welfare pigs on welfare farms. **Total costs=welfare costs + direct control costs + compensation costs + export losses (latter three not shown). ***Overall costs = total costs + export losses post outbreak + direct control costs post outbreak (latter two not shown)

Table x10: Total costs in millions (average, minimum and maximum) estimated for **Outbreak M in Region 9**.

| Strategy | During outbreak | | Overall costs*** |
|---|---|---|---|
| | Welfare costs* | Total costs** | |
| **SOWS1** | 3.06(1.75-8.33) | 2809(2809-5817) | 5612(4495-11429) |
| **SOWS2** | 1.55(0.89-4.18) | 2721(2721-4872) | 5524(4494-10396) |
| **SOWS3** | 1.13(0.74-4.15) | 1800(1800-2528) | 4602(4306-7130) |
| **SOCSWS1** | 2.49(1.32-6.81) | 1967(1967-2690) | 4770(4311-7460) |
| **SOCSWS2** | 1.26(0.68-3.42) | 1967(1967-2687) | 4769(4310-7456) |
| **SOCSWS3** | 1.23(0.65-3.39) | 2001(2001-2848) | 4804(4360-7652) |
| **SORVWS1_D** | 3.85(0.29-15.23) | 2572(2572-3868) | 5399(4649-9267) |
| **SORVWS2_D** | 1.66(0.62-4.3) | 2592(2592-4324) | 5420(4649-9743) |
| **SORVWS3_D** | 1.61(0.74-4.27) | 2527(2527-4175) | 5355(4483-9530) |
| **SORVWS1_L** | 3.85(0.29-15.23) | 2572(2572-3868) | 8128(7377-11996) |
| **SORVWS2_L** | 1.66(0.62-4.3) | 2592(2592-4324) | 8148(7378-12472) |
| **SORVWS3_L** | 1.61(0.74-4.27) | 2527(2527-4175) | 8083(7211-12259) |
| **SODCWS1** | 2.69(1.75-8.16) | 2737(2737-6674) | 5540(4461-12214) |
| **SODCWS2** | 1.36(0.89-4.1) | 2737(2737-6673) | 5540(4460-12213) |

| | | | |
|---|---|---|---|
| **SODCWS3** | 1.33(0.86-4.04) | 2453(2453-4187) | 5256(4460-9443) |

## 9.7 AUSVETPLAN FMD

This section (FMD Section 4) was taken from a recent draft version of the AUSVETPLAN (25 September 2011) and used for the purposes of this study.

The following table describes the movements of live pigs permitted within and between declared areas. All movements of live pigs out of an RA are prohibited. The only allowed movements within the RA would be for pigs either going to slaughter, or following a risk assessment, to another ARP, primarily for welfare reasons.

### 9.7.1 Movement controls for live pigs

| From \ To | | RA | CA | OA |
|---|---|---|---|---|
| RA | **IP, DCP, SP, TP** | **Prohibited** | **Prohibited** | **Prohibited** |
| RA | **ARP** | **Prohibited, except under SpP1** | **Prohibited** | **Prohibited** |
| CA | DCP, SP, TP | Prohibited | Prohibited | Prohibited |
| CA | POR | Prohibited, except under SpP2 | Prohibited, except under SpP3 | Prohibited |
| OA | | Prohibited, except under SpP2 | Prohibited, except under SpP3 | Allowed |

ARP = at-risk premises; CA = control area; DCP = dangerous contact premises; GP = general permit; IP = infected premises; OA = outside area; POR = premises of relevance; RA = restricted area; SP = suspect premises; SpP = specific permit; TP = trace premises

**SpP1 conditions:**

- For slaughter, or to an ARP for other movements if a risk analysis indicates that the risk associated with movement is acceptable within the response.
- Travel by approved route only and no stopping en route.
- Appropriate biosecurity standard at receiving premises.
- Appropriate decontamination of equipment and vehicles.
- Absence of clinical signs prior to and on day of travel.
- Single consignment per load.
- Individual or group animal identification (eg National Vendor Declaration, waybill, PigPass).

**SpP2 conditions - for slaughter only, if the RA contains the only available abattoir:**

- Travel by approved route only and no stopping en route.
- Appropriate biosecurity standard at receiving premises.
- Appropriate decontamination of equipment and vehicles.
- Absence of clinical signs prior to and on day of travel.
- Single consignment per load.
- Individual or group animal identification (eg National Vendor Declaration, waybill, PigPass).

**SpP3 conditions:**

- Travel by approved route only and no stopping en route.
- Appropriate decontamination of equipment and vehicles.
- Absence of clinical signs prior to and on day of travel.
- Single consignment per load.
- Individual or group animal identification (eg National Vendor Declaration, waybill, PigPass).

### 9.7.2 Movement controls for fresh and frozen meat and carcases of pigs

The table below describes the movements of fresh and frozen meat[5] and carcases of pigs permitted within and between declared areas. Movements of fresh and frozen meat and carcases of pigs from registered commercial abattoirs only.

| From \ To | | RA | CA | OA |
|---|---|---|---|---|
| RA | IP, DCP, SP, TP | Prohibited | Prohibited | Prohibited |
| RA | ARP | Allowed | Allowed | Allowed |
| CA | DCP, SP, TP | Prohibited | Prohibited | Prohibited |
| CA | POR | Allowed | Allowed | Prohibited |
| OA | | Allowed | Allowed | Allowed |

ARP = at-risk premises; CA = control area; DCP = dangerous contact premises; GP = general permit; IP = infected premises; OA = outside area; POR = premises of relevance; RA = restricted area; SP = suspect premises; SpP = specific permit; TP = trace premises

[5] May include offal for human consumption

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