final report

Project code: P.PSH.0194

Prepared by: Michael Ward

The University of Sydney

Date published: January 2012

PUBLISHED BY
Meat & Livestock Australia
Locked Bag 991
NORTH SYDNEY NSW 2059

Chair in Veterinary Public Health at the University of Sydney

Meat & Livestock Australia acknowledges the matching funds provided by the Australian Government to support the research and development detailed in this publication.

Abstract

The Australian red meat industry's market access is dependent on both its actual and perceived health status. Healthy livestock and a healthy product commands a premium. To maintain a healthy sector, veterinary public health skills are critical for controlling and minimizing the impact of hazards on product integrity.

This project was undertaken to address the impact a lack of veterinary public health skills can have on the competitiveness of the Australian red meat industry. It aimed to capitalize on the established partnership between the University of Sydney and MLA through additional co-investment, specifically to address the pressing needs in veterinary public health and food safety which underpin international market access and competitiveness of Australian red meat.

With co-funding from Meat & Livestock Australia, a new unit in Veterinary Public Health and Food Safety in the Faculty of Veterinary Science was established in 2006. Following an international search and interviews in 2007, Professor Ward commenced as Chair, Veterinary Public Health and Food Safety in January 2008 and has led this new unit since that time.

Some of the major outcomes from this project include the consolidation of the Veterinary Public Health Management coursework Master's degree as a world class online program for advanced training in veterinary public health; the recruitment and training of 18 postgraduate research students and 4 postdoctoral fellows in veterinary public health; securing > $2.7M in funding to support a major research program in veterinary public health addressing issues such as bluetongue disease risk, responses to exotic animal disease incursions, risk assessment and modelling of emerging disease threats and improving product integrity via on-farm control of foodborne pathogens; revitalisation of undergraduate teaching to produce graduates with the skills, knowledge and confidence to address current and future industry needs in veterinary public health; creation of a new faculty position in Food Security; and enhancement of the ability and reputation of the Australian red meat sector to develop and implement animal health programs.

This MLA project has immediately benefited the industry via improved training of undergraduate veterinary and bioscience students to recognise and address industry issues, the training and mentoring of a large group of postgraduate students who will continue to work in animal health in this country, and the creation of local and international networks to benefit the industry and its attempts to maintain market competitiveness. The beneficiaries of this MLA project are livestock producers, processors and associated interests throughout Australia.

It is recommended that MLA – in partnership with the Faculty of Veterinary Science − seek industry support for continued investment in training and research in veterinary public health and food safety via specific research and experiential projects that deliver immediate outcomes to the industry and support the development of human capital – graduates and postgraduates with highly developed skills in veterinary public health. It is also recommended that MLA – together with other agencies and organisations – develop a strategy to promote the public good of veterinary public health. Finally, it is recommended that MLA invest more in developing and assessing methods to anticipate the risk to the red meat sector posed by emerging disease issues.

Executive Summary

The Australian red meat sector derives most of its income from the export of its product. This sector, and a large part of rural Australia, derives income from such trade. Underpinning this trade is market access. Australia is able to export red meat to most markets in the world, without restriction (except for those barriers that result from politics and economics). The health status of our animal industries provides the confidence that markets increasingly demand.

Thus, the Australian red meat industry's market access is dependent on both it's actual and perceived health status. Healthy livestock and a healthy product commands a premium. To maintain a healthy sector, veterinary public health skills are critical for controlling and minimizing the impact of hazards on product integrity. Examples in the past include bovine spongiform encephalopathy; current examples include antimicrobial resistance, enteropathogenic *E.coli*.and bluetongue virus.

This project was undertaken to address the impact a lack of veterinary public health skills can have on the competitiveness of the Australian red meat industry. It aimed to capitalize on the established partnership between the University of Sydney and MLA through additional co-investment, specifically to address the pressing needs in veterinary public health and food safety which underpin international market access and competitiveness of Australian red meat.

With co-funding from Meat & Livestock Australia, a new unit in Veterinary Public Health and Food Safety in the Faculty of Veterinary Science was established in 2006. Following an international search and interviews in 2007, Professor Ward commenced as Chair, Veterinary Public Health and Food Safety in January 2008 and has led this new unit since that time.

This new unit in Veterinary Public Health and Food Safety has produced a range of major outcomes, including:

- consolidation of the Veterinary Public Health Management coursework Master's degree as a world class online program for advanced training in veterinary public health;
- the recruitment and training of 18 postgraduate research students and 4 postdoctoral fellows in veterinary public health;
- securing > $2.7M in funding to support a major research program in veterinary public health addressing issues such as bluetongue disease risk, responses to exotic animal disease incursions, risk assessment and modelling of emerging disease threats and improving product integrity via on-farm control of foodborne pathogens;
- revitalisation of undergraduate teaching to produce graduates with the skills, knowledge and confidence to address current and future industry needs in veterinary public health;
- creation of a new faculty position in Food Security; and
- enhancement of the ability and reputation of the Australian red meat sector to develop and implement animal health programs.

This MLA project has immediately benefited the industry via improved training of undergraduate veterinary and bioscience students to recognise and address industry issues, the training and mentoring of a large group of postgraduate students who will continue to work in animal health in this country, and the creation of local and international networks to benefit the industry and its attempts to maintain market competitiveness. The beneficiaries of this MLA project are livestock producers, processors and associated interests throughout Australia.

Irrespective of the above physical outcomes, the greatest outcome from this project has been the creation of human capital. Professor Ward (originally trained at the University of California-Davis with support from MLA) returned from the United States to lead this unit and has attracted a large group of young, enthusiastic students and faculty committed to the development of veterinary public health in Australia for the benefit of the red meat sector, other livestock industries, animal populations, government and society. This group will have a lasting impact well into the future.

However, the job is not complete. There remain some substantial challenges.

It is recommended that MLA – in partnership with the Faculty of Veterinary Science − seek industry support for continued investment in training and research in veterinary public health and food safety via specific research and experiential projects that deliver immediate outcomes to the industry and support the development of human capital – graduates and postgraduates with highly developed skills in veterinary public health. It is also recommended that MLA – together with other agencies and organisations – develop a strategy to promote the public good of veterinary public health. Finally, it is recommended that MLA invest more in developing and assessing methods to anticipate the risk to the red meat sector posed by emerging disease issues.

It is important for the prosperity of the Australian red meat industry to maintain its market access. Regardless of day-to-day, year-to-year issues and emerging threats this sector needs to invest in veterinary public health as an insurance policy. Such investment needs to be a partnership between MLA, governments and academia. Veterinary Public Health is a public good. Healthy livestock benefits all of us – producers, processors, consumers. Veterinary Public Health provides the skills, knowledge and approaches to ensure that such benefits are realised. This project has laid the foundation for the realisation of these benefits.

Contents

1 Background

There is a national deficiency in capacity to predict, prevent and manage emerging product integrity threats to the red meat sector. The current project aimed to capitalize on the established partnership between the University of Sydney and MLA through additional co-investment, specifically to address the pressing needs in veterinary public health and food safety which underpin international market access and competitiveness of Australian red meat.

While effort is made in Australia to respond to threats, it is fragmented across jurisdictions and constrained by both manpower and mandate issues within the various agencies. Consequently there is risk of system failure in the event of concurrent threats or rapidly changing market requirements. It is estimated that 97% of Australia's red meat exports currently supply key, high value, Pacific Rim markets where prices are maintained through consumer expectations of product safety, as well as taste and tenderness. Consequently the gross value of product of Australia's red meat sector is highly sensitive to threats to product integrity. National preparedness to meet current and future threats may be insufficient to guarantee continued access to these markets. Overseas countries who are competitors or potential competitors for market access have invested heavily in research and training in the university sector, specifically in the areas of veterinary public health and food safety and in Australia may not be sufficient to meet the ongoing routine demands of importing countries.

Australia has enjoyed ready access to overseas markets for its livestock and livestock products as a consequence, in part, of freedom from important epidemic diseases of livestock and its ability to demonstrate its status in this regard. However, our favoured trading status cannot be taken for granted and it is likely to be subject to considerable challenges in the next 10 to 20 years.

The perceived or real presence in Australia of an exotic disease closes our access to foreign markets, and sometimes endemic diseases can have impact in this regard. In the past, live sheep exports to Saudi Arabia have been stopped by inadequate management of scabby mouth and the impact of finding bluetongue virus 25 years ago was costly to redress. Similarly, chemical residues in livestock products have seriously disrupted exports. Should Foot and Mouth Disease (FMD) occur in this country, ABARE has estimated that market closures will reduce average broad-acre farm income by $30,000 in the first year.

Maintenance of Australia's favoured trading position cannot be taken for granted. In the past decade we have been increasingly asked to defend our import restrictions and demonstrate our animal health status (eg transmissible spongiform encephalopathies) and the capacity of our animal health services. We have also had to deal successfully with "new" infections such as Hendra virus and bat lyssavirus. Food safety issues remain critical to the export of red meat and domestic consumption. Emerging issues include *E.coli* O157 and antimicrobial resistance.

A sound understanding of our animal health situation, underpinned by solid data analysis and information that we can use to develop international protocols and our own import/export agreements, is becoming critical to maintaining and enhancing our trading position. In turn, the profitability of our livestock production, processing and marketing sectors depend on this. We must also maintain a capacity to identify, investigate and efficiently control exotic and emerging diseases that could otherwise severely affect production and marketing of our animal products or potentially human health.

To address the range of animal health issues confronting the red meat industry, veterinary public health skills are critical. During the last 2-3 decades, Federal and State government animal health services have increasingly reduced their support for training in veterinary public health. The decline in field and laboratory animal health staff with expertise in veterinary public health is a threat to Australia's surveillance, response and research capacity. This is turn threatens the competitiveness of Australia's red meat sector.

The University of Sydney's Veterinary Faculty is acutely aware of the challenge and is keen to contribute to addressing the needs presented by Australia's trading relationships. The Faculty is proud of the excellent contributions that its graduates have made, and continue to make, to the livestock industries and their health status. However it is also well aware that these graduates are aging and that comparatively few new graduates are developing skills and careers in veterinary public health.

The Faculty sought the financial support of Meat & Livestock Australia (MLA) to create a veterinary public health research and training unit within the Faculty of Veterinary Science. The following report outlines efforts to address veterinary public health skills in Australia and the competitiveness of Australia's red meat sector.

2 Project Objectives

1. Established a new unit in Veterinary Public Health and Food Safety in the Faculty of Veterinary Science

2. Appointed a new Chair to lead the unit

3. Delivered broad outcomes for the red meat industry through research and training including:

    - Decreasing production costs
    - Maintaining market access
    - Reducing risks of loss of export market access
    - Increasing microbiological safety of product
    - Advancing technology to maintain competitiveness
    - Promoting research activity
    - Educating to increase human resource capacity
    - Advocacy
    - Change management and planning for future change

3 Implementation

With sponsorship and funding from Meat & Livestock Australia, a Chair of Veterinary Public Health and Food Safety was established in 2006. Interviews were conducted in February 2007, and Dr. Michael Ward (Professor of Epidemiology, Texas A&M University) was offered the position. Dr. Ward subsequently commenced employment in January 2008.

4 Outcomes

4.1 Strategic Plan

Professor Ward, together with Professors Whittington (Farm Animal Health) and Windsor (Animal Production and Welfare), developed a strategic plan to promote Farm Animal and Veterinary Public Health.

Our vision is to be recognised as a ***vibrant, innovative, world class teaching and research unit in Veterinary Public Health and Food Safety***.

Opportunities that have been identified include:

- increasing importance of veterinary public health and food safety to society;
- creation of additional veterinary schools in Australia;
- veterinary school accreditation;
- the 1:5:40 program (the University of Sydney to be the best university in Australia, among the top 5 in Asia and within the top 40 globally); and
- the Bachelor of Animal and Veterinary Biosciences degree.

Impediments include subgroups that can discourage sharing of resources and reduce opportunities for interaction, lack of time and resources, and a split campus.

Strengths of veterinary public health and food safety within the Faculty of Veterinary Science include analytical skills (modeling, risk analysis, geographic information systems and biostatistics), integration of education, clinical and applied on-farm research, training and extension, international engagement, interdisciplinary research, networks and industry linkages.

Gaps include constraints in animal holding and housing, constraints in laboratory and safe working environments, lack of diagnostic laboratory capacity, declining opportunities for engagement with local rural communities (urbanization).

The gaps identified can be met through several strategies

1. **Collaboration and linkages**

   These have the capacity to provide short term complementation of staff and facilities. Potential linkages to be explored include the NSW Centre for Plant and Animal Biosecurity, EMAI; the Australian Biosecurity CRC; Australian DAFF; the Wildlife Health and Conservation Centre (University of Sydney), veterinary public health Faculty at Charles Sturt and James Cook Universities. Within the Faculty, collaborations have already been discussed with staff within applied microbiology, pathology and livestock services.

2. **Facilities upgrades**

   Facilities are needed to allow conduct of controlled field trials (pasture subdivided and fenced, and the appropriate animal handling facilities. Animal accommodation for a wide range of species in several specific animal houses within a complex is required. Overall design must be Good Clinical Practice capable and include a PC2 livestock animal house to enable disease

transmission trials to inform pathogenesis, vaccine and therapeutic efficacy trials and infectious disease modelling studies. General containment animal housing for small laboratory animals is also required. New laboratories (PC2 and PC3) will be required to accommodate ambitions in clinical trials and food safety.

3. Teaching

To achieve balance in the curriculum and resource allocation consistent with need we will continue to make contributions to teaching in years 1 to 3 of the BVSc and BAnVetBioSci degree programs and to support location of the whole of year 4 of these degrees at Camden. Benchmarking veterinary education, sharing ideas and resources, distinguishing our Faculty through new initiative and leadership).

The current project has delivered on collaboration and linkage, and teaching, gaps.

4.2 Improve Undergraduate Outcomes in Veterinary Public Health

" In a rapidly changing world, veterinary education must face new challenges and continually evolve to meet societal demands in the field of prevention and control of diseases food security, food safety, public health and animal welfare. Appropriate education and training have a direct effect on the quality and performance of public and private components of Veterinary Services; therefore, the World Organisation for Animal Health (OIE) is considering the issue of initial and continuous veterinary education as part of its commitment to encouraging its Members to strengthen the animal health policies and activities of their national Veterinary Services. Well-educated public and private veterinarians who have received appropriate training will help the OIE to fulfil its global mission: improve animal health worldwide. "

Evolving veterinary education for a safer world
World Organisation for Animal Health
October 2009

Veterinary Public Health unit of study

Prior to and including 2008, Veterinary Public Health (VETS3035) was taught in Year 3 of the veterinary curriculum. At this point, it was juxtaposed between the preclinical (Years 1 and 2) and the clinical units of study (Years 4 and 5).

The Veterinary Public Health course was not taught in 2009, but rather it was taught to 4th year veterinary students in 2010 (and again in 2011) at the Camden Campus (previously it was taught at the Camperdown Campus). As part of this change, Professor Ward led a review of Veterinary Public Health teaching to make this course more relevant, and to integrate it with other courses taught in the 4th year of the veterinary degree. This activity was the second objective of an action plan for learning and teaching targets within the Faculty of Veterinary Science, to address the growing international call for veterinarians to take a greater role in public health.

Within the Veterinary Public Health unit, students have core information presented in microbiology, parasitology and pathology which is integrated with topics in epidemiology, food safety and zoonoses. This then is reinforced within concurrent or later clinical units in cattle, sheep, pig and poultry health

and production. This way allows students to expand their views of their professional role outside the narrow confines of clinical medicine and surgery.

The veterinary curriculum is structured to ensure our graduates meet a series of predetermined Graduate Attributes. At the end of the Unit of Study graduates will:

1. understand the role of veterinarians in maintaining human and animal health through identifying specific components of human-animal interactions
2. be able to outline the corresponding responsibility and inputs by the profession to these components
3. understand the key concepts from the interrelated disciplines of veterinary epidemiology, zoonotic disease and food safety by applying them to:
   - the investigation of health, production and performance problems in production animals
   - make clinical decisions in companion and production animal practice
4. recognise the economically or socially important zoonotic diseases in Australia overseas and be able to give accurate advice to clients regarding the source, transmission, diagnosis, treatment and control of these diseases
5. provide accurate advice on the control and prevention of foodborne diseases and residues associated with animal products
6. consider some of the social, legal and economic implications of pet/animal ownership in Australia
7. critically evaluate the research literature

Veterinary Public Health is presented as a combination of didactic lectures, online material, tutorials and case studies. Case studies are designed to integrate epidemiologic and public health principals with real-life problem solving situations. Case studies have been developed on current issues such as BSE, equine influenza, Hendra virus and foodborne disease outbreak scenarios.

In addition to lectures from specialist staff within the Faculty of Veterinary Science, students are presented lectures by external specialists recognised nationally and internationally in epidemiology, herd medicine and production, food safety, food microbiology and chemical residues. The inclusion of these external experts reinforces the global view of the role of the profession not only in animal health but also the important role of veterinarians in the maintenance of human health.

As part of the re-design of the Veterinary Public Health unit of study, between 23 September and 30 October 2009 Professor Ward conducted an online survey of stakeholders in Veterinary Public Health Training. A total of 19 responses were received – 74% Government, 10% Industry, 16% Other.

The attributes valued in veterinary graduates that were most commonly cited were:

- problem solving
- inquiring
- initiative
- creativity
- “big picture”
- enthusiasm
- willingness to learn
- team member

- work ethic
- positive attitude

Skills expected in veterinary graduates included:

- strong investigation and problem-solving skills
- ability to investigate disease outbreaks using first principles
- Basic understanding of epidemiology
- basic research skills

Most (77%) of the respondents agreed that the structure of undergraduate VPH should be epidemiology, zoonoses and food safety, and the same proportion considered that VPH should be taught at the undergraduate (versus postgraduate) level.

Professor Ward represented the Faculty at the World Organisation for Animal Health (OIE) conference, *Evolving veterinary education for a safer world*, held in October 2009. This was an opportunity for Deans and Directors of veterinary training institutions and key national veterinary education policy makers from all over the world to exchange views on priorities for the content of academic courses. About 350 delegates attended the 2 and 1/2 day meeting, many of whom were Deans. Sessions were held on transboundary diseases, zoonoses and emerging infections; early detection, notification and surveillance; veterinary public health and 'Veterinary Services' concept; Food safety; animal welfare; basic global needs for veterinary education; and global harmonisation and evaluation of the veterinary curriculum. The meeting made 28 recommendations (http://www.oie.int/eng/A_DEANS2009/Conclusions_and_recommendations_FINAL_30_novembre_09_ANG.pdf). Recommendations that are relevant for Veterinary Public Health at The University of Sydney and within Australia include:

- develop a basic core curriculum, to be implemented by Veterinary Education Establishments
- initial and continuing education: VPH, production, trade, social values, basic sciences, wildlife, aquaculture, OIE codes …
- new IT technologies for distance learning
- twinning programmes
- VBS adopt the PVS evaluation model for VEE assessment
- harmonization and veterinarian mobility

Professor Ward was invited to participate in the Education Day at the AVA Annual Conference (Darwin, May 19, 2008). He presented on *Career Paths (Other Than Practice) for New Graduates: Opportunities in Veterinary Public Health*. An accompanying paper was published in the conference proceedings. The key points of this presentation were:

Many issues currently face veterinary education in Australia, including the delivery of rural veterinary services, companion versus production and wildlife medicine, and veterinary workforce supply versus demand. Now more than ever, graduating veterinarians need to consider career paths other than traditional veterinary practice. This paper addresses some of those options, and the skills needed in our graduates in the 21st centaury.

The issues (at least some):

During the past 20-30 years, there has been a dramatic shift in the employment of veterinarians in Australia: the employment of veterinarians in rural practice has decreased, and government veterinary services within the livestock industries have been scaled back. Some of the drivers of this shift include the intensification of livestock production, the move towards applying the user-pays principle to veterinary public health and the rationalization of government services, the economy and personal wealth, and the expectations and lifestyle desires of veterinary graduates. More recently, we are experiencing in Australia an increase in the number graduating veterinarians. In addition, globally there is a movement towards the harmonisation of the skills of veterinarians worldwide. The issues outlined above have also become apparent in other developed countries, even without the same oversupply concerns.

There is little doubt that the veterinary profession in Australia finds itself within a period of rapid change. There is a need to consider and respond to employment capacity and opportunities. We must also be cognizant of societal expectations. As a profession, we must define what type of veterinarian is needed for the 21st centaury. Although veterinary schools are ultimately the institutions with responsibility for training veterinarians, the profession as a whole is responsible for articulating what skills that 21st centaury graduate should possess.

The solutions (at least one):

There is a concern that we will soon (if not already) face an oversupply of veterinarians. Essentially, this means that there will be too many veterinarians seeking employment in traditional veterinary practice, which is dominated by small animal medical practice. In other words, the pet dog and cat population in Australia is not substantially increasing, and the disposable income that Australians are prepared to spend on the care of their pets is unlikely to increase dramatically. If we view this as a simple supply and demand problem, there is limited future demand in traditional veterinary practice and we are entering an era of oversupply of veterinarians. Again using the supply and demand model, the solution is either to reduce supply (an unlikely course of action), or to increase the demand for veterinary services.

Using a market-driven model, veterinary education within Australia has responded to a perceived shift in the market by emphasizing the clinical disciplines. It has then been argued that markets other than traditional companion animal practice are unable to absorb the interested veterinary workforce. However, an alternative view is that the profession creates a market in the non-practice areas by enhancing the skills of our graduates to exploit the opportunities offered in such non-traditional areas. Thus, veterinarians with skills in biosecurity and biodefense, food safety, regulatory medicine, research methodology, biotechnology, welfare, epidemiology and public health, ecosystem health, wildlife medicine, biostatistics, and policy (to list just a few), if promoted appropriately by the profession, might just be one of the solutions to the changing situation in career opportunities. This fits well within the concept of One Medicine − One Health: graduating veterinarians should have the skills for employment in a range of areas outside of traditional veterinary practice which makes them valued by society. Improving the health of both animal and human populations is perhaps the ultimate service we can offer to society.

Once the profession agrees that diversification of the skill-base is the best course of action to ensure long-term sustainability, then the training needed to develop such a veterinarian becomes a relatively straightforward exercise in curriculum development. This should be based on an understanding of the needs of potential employers, to help create a picture of the ideal modern

veterinarian. The mechanism to achieve this change could be accreditation. Ultimately, the profession would become more relevant to society.

Based on the online survey, and ideas presented at the OIE and AVA education conferences, a VPH scoping meeting was held on 4 November 2009. The objectives of this workshop were to:

1. Review results of stakeholder survey
2. Hear outcomes of OIE conference *Evolving veterinary education for a safer world*
3. Review results of TIES VPH focus groups with Year 4 and Year 5 vet students
4. Agree on general structure and learning objectives of VETS4232
5. Define opportunities for vertical and horizontal alignment with other units
6. Agree on needs and timeline for development of teaching resources
7. Discuss TIES small project application to support development of new online cases
8. Consider plan for maintaining an academic position at Camden that includes responsibility for abattoir placement from 2011.

Outcomes from this workshop included the following:

1. Challenge to Faculty to consider strategic direction in relation to VPH
2. Recognition of stakeholder view of the importance of VPH training at undergraduate and postgraduate levels – international OIE and national government and industry
3. Recognition of the need for more integrated and case-based approach to VPH training – stated by national stakeholders and by students
4. Need to review identified gaps in UG training to achieve graduate attributes – including exotic diseases, animal welfare and occupational health & safety.
5. Extramural Abattoir Program – academic support and unit status
6. Veterinary Public Health unit − revised learning outcomes and implementation of a more integrated course that includes the presentation of two detailed cases running across several sessions

VETS4232 Veterinary Public Health was presented in 2010 and in 2011. Within the current Veterinary Public Health unit, Professor Ward introduces the unit and provides an overview of Veterinary Public Health, lectures on Emerging Diseases, Global and Transboundary Diseases, and Disease Control, as well as conducting the foodborne outbreak investigation exercise.

Compared to VETS3025 taught in 2008, USE results for VETS4232 in 2010 were substantially improved.

Food Safety Assessment and Management unit of study

Discussions were held during 2008 regarding introduction of a new unit of study within the Animal and Veterinary Bioscience degree program, Food Safety (AVBS4004), The unit was introduced in 2009, with Dr. Gary Muscatello (Lecturer, Applied Animal Microbiology) acting as the unit of study coordinator.

This unit of study is presented as a final year elective course. It focuses on the issues and practices in the animal industry relevant to food safety and zoonotic disease. It covers general food safety issues, including risk assessment and hazard analysis of microbes and chemicals. Food-borne diseases of animal origin and their impact on public heath will be explored through the examination of zoonotic diseases in scenario-based learning activities. In these processes diagnostic and strategic methods of investigating, controlling and preventing food-borne disease outbreaks will be examined.

Students are introduced to national and international animal and human health policy relevant to food safety regulations, and to surveillance initiatives and strategies that underpin these policies. Students in this unit are also exposed to emerging food-borne pathogen issues and current industry driven topics. On completion of the unit, students have a global and local perspective on the major food-borne diseases, surveillance and control programs.

Topics covered within this unit include:

- Principles of food safety
- Introduction to food microbiology
- Global diseases of production animals
- Food safety regulations
- Principles of zoonoses
- Production animal derived zoonoses
- Epidemiology of food-borne disease
- Drug use in food production animals
- Chemical residues in food of animal origin and public health
- Food production animals and antimicrobial resistance, HACCP,
- Microbial hazards in food
- Microbial diagnostics in food safety
- Important food-borne zoonotic diseases – prevention and control strategies
- Management of antimicrobial resistance
- Emerging food-borne pathogens of production animal origin
- Disease control programs – “gate to plate”

After completing this Unit of Study, students are expected to be able to:

- Apply the principles of veterinary epidemiology, pathogenesis and zoonoses to investigate food-borne diseases.
- Evaluate the key elements in food safety risk assessment and management as part of a total quality management food safety system.
- Design and critique hazard analysis and critical control point (HACCP) intervention in food safety systems.
- Advise the animal industry on the control and prevention of drug residues and chemical contaminant in food of animal origin.
- Recognise and evaluate the various chemical and biological surveillance systems used in food safety systems.
- Characterize the microbial hazards in food of animal origin and the means by which they affect humans.
- Apply and evaluate microbiological diagnostic tools used in food safety programs.
- Propose and evaluate measures to control and prevent zoonotic diseases acquired by humans through exposure to animal products.
- Recognise emerging food-borne pathogens of animal origin and evaluate the risk to public health.
- Describe the global trends in food-borne disease distribution.
- Recognise the respective roles and recent initiatives in food safety of the various government and industry organisations that form the global, national and regional regulatory system for the safety of food of animal origin and critically evaluate the health, welfare, surveillance and political ramifications.

- Advise on the safe production of animal products for human consumption.

Lecture topics cover the various components and concepts of food safety. The small class sizes encourage facilitators to move away from tradition didactic teaching and incorporate student-centric small group teaching activities to illustrate key concepts and encourage understanding through active application of knowledge and principles in food safety.

Tutorial and practical classes are designed such that students have the opportunity to reinforce and scaffold acquired knowledge and concepts through the use of problem based learning tools in the form of case studies. Reflection and discussion activities of key concepts and topics in food safety also aid and encourage deeper understanding and critical thinking. A microbiological diagnostic practical activity, foodborne disease outbreak investigation, HACCP case study and field trips to a milk processing plant, domestic abattoir, are part of this unit.

Besides members of the Faculty of Veterinary Science, collaborators from Meat and Livestock Australia, the NSW Food Authority and the Australian Department of Agriculture, Fisheries and Forestry also contribute to this course.

Abattoir Placements and Meat Inspection

Several decades ago the Faculty of Veterinary Science at the University of Sydney timetabled 5 days of compulsory abattoir visit into the extramural component of the curriculum. However, by 2000 the formal abattoir extramural program had been abandoned because of the failure to provide an appropriate, relevant, high quality learning experience that achieved required outcomes, the failure of some students and abattoirs to comply with the requirements and the increased pressure on students to have paid employment in non-semester time.

A previous review within the Faculty identified a number of constraints to reinstating this program: the need for pedagogically sound activities that had been missing from the previous student abattoir experiences; the need to provide this abattoir experience during semester time; the requirement for abattoir locations to be close to Sydney as the visits are conducted during semester; the lack of suitable abattoirs within 3 hours of Sydney. These are the only abattoirs that have a supervising veterinarian. The closest non-export abattoir is still over 90 minutes away and does not have a veterinarian. The Faculty developed a different approach to provide for a meaningful abattoir experience and exposure of students to important concepts in food hygiene and safety.

However, the Faculty was advised by the Royal College of Veterinary Surgeons in October 2006 that abattoir experience will need to be reintroduced into the curriculum to meet RCVS and therefore EU guidelines for accreditation. This required an urgent response.

The issue of abattoir placements and meat inspection instruction for University of Sydney B.V.Sc. students have been addressed through meetings with the Australian Quarantine and Inspection Service (Carol Sheridan) and the Faculty.

Professor Ward led the development and adoption of common standard for the abattoir student experience and meat inspection. This was achieved via the Public Health University Network (PHUN). These guidelines were endorsed by the Veterinary Science Deans in 2009, providing a framework for the development of a new protocol for *Extramural Students in Meat Processing Plants* program. This new program consists of an online component, pre-abattoir training session and practical teaching in small groups at commercial slaughterhouses. A new video-assisted training module is currently being developed via a TIES project.

4.3 Improve Postgraduate Coursework Outcomes in Veterinary Public Health

On commencement, Professor Ward took over leadership of the Veterinary Public Health Management (VPHMgt) postgraduate program (http://www.vetsci.usyd.edu.au/publichealth_management/index.shtml).
The impetus for establishment of a new postgraduate program in the Faculty of Veterinary Science at the University of Sydney was recognition of the changing landscape in relation to the needs of the veterinary profession, industry and animal health professionals wishing to pursue postgraduate education. The identified trends were:

- Critical lack of veterinary expertise in livestock medicine and production particularly in the disciplines of epidemiology and pathology, (Rose, 2000) with a substantial percentage of veterinarians working in this sector approaching retirement age
- Change in the services required by the livestock industries with increasing emphasis on issues such as market assurance, product integrity, sound government policy, economic assessment, risk analysis, environmental management and public health
- Increased demand for postgraduate education opportunities within Australia suitable for working professionals.

In addition extensive consultation with key stakeholders identified a consistent demand for animal health professionals with technical skills able to work effectively in multidisciplinary teams and manage projects ranging from emergency response to large-scale research programs. This requirement for effective application of technical and managerial skills in an age of increasingly complex animal and human health issues was strongly supported subsequently by expert opinion (Heuston, 2003).

In response, the Faculty of Veterinary Science launched an innovative postgraduate program in Veterinary Public Health Management (VPHMgt) in February 2003. The vision of this program is to produce leaders in veterinary public health. The VPHMgt program, consisting of three articulated award courses at Graduate Certificate, Graduate Diploma and Masters levels, ensures that graduates are equipped with technical and managerial skills that enable them to manage complex issues in the national and international animal health arena.

Veterinary Public Health Management is a postgraduate distance program, delivered online with short residential sessions, directed towards career enhancement for animal health professionals.

Integrating scientific skill and leadership competence, the program has been created to address the increasing need for veterinarians and animal scientists with developed skills to benefit the health of the whole community.

The vision of the VPHMgt program is:

An innovative world-class program, training veterinary public health leaders.

This program aims to educate and graduate leaders in veterinary public health management, to work with the livestock industries to provide outstanding veterinary public health professionals to meet

their needs, and to partner with other outstanding educational programs in veterinary and human public health management.

The VPHMgt program is designed to deliver high quality education to students who are working full time and are able to apply their learning in real time.

The program allocates equal credit points to technical and managerial learning in the first year of the program, demonstrating the importance of skill development in both areas.

Managerial capabilities are a central, unique attribute of our graduates and core units in leadership and project management feature. The leadership units have been purpose designed from existing course materials used in the Executive Masters of Business Administration degree program to identify linkages between veterinary contexts and organisational behaviour, management and leadership perspectives.

The project management unit, also taught via a residential workshop and online class with emphasis on veterinary applications, was modelled on units in the highly successful online Master of Project Management offered through the Department of Civil Engineering at the University of Sydney.

VPHMgt students are provided with access to a wide range of externally contracted facilitators – suitably qualified experts working in the area in which they teach. Online spaces are created for discussion in every unit of study. There is a requirement to work together.

Face to face study at short residential sessions enables deep, experiential learning in management/leadership and also provides valuable opportunities for networking and socialising amongst fellow students, external industry experts and Faculty staff.
To aid student progression through the award courses, students can choose to complete a degree in the minimum time required (for example, 2 years for the Masters) or to stagger unit enrolment in line with work and personal commitments. Non-award enrolment in individual units is also encouraged for professionals who need to gain skills in a particular area but do not wish to complete a full degree. Core courses for the Masters award include the following:

VETS7004 Veterinary Epidemiology 1
VETS7005 Veterinary Epidemiology 2
VETS7008 Hazards to Human and Animal Health
VETS7009 Animal Health Economics
VETS7010 Animal Health Policy Development
VETS7011 Data Analysis for Policy Making
VETS7018 Research Paper A
VETS7025 Leadership, People & Organisations
VETS7026 Leadership: Managing Change
VETS7027 Project Management

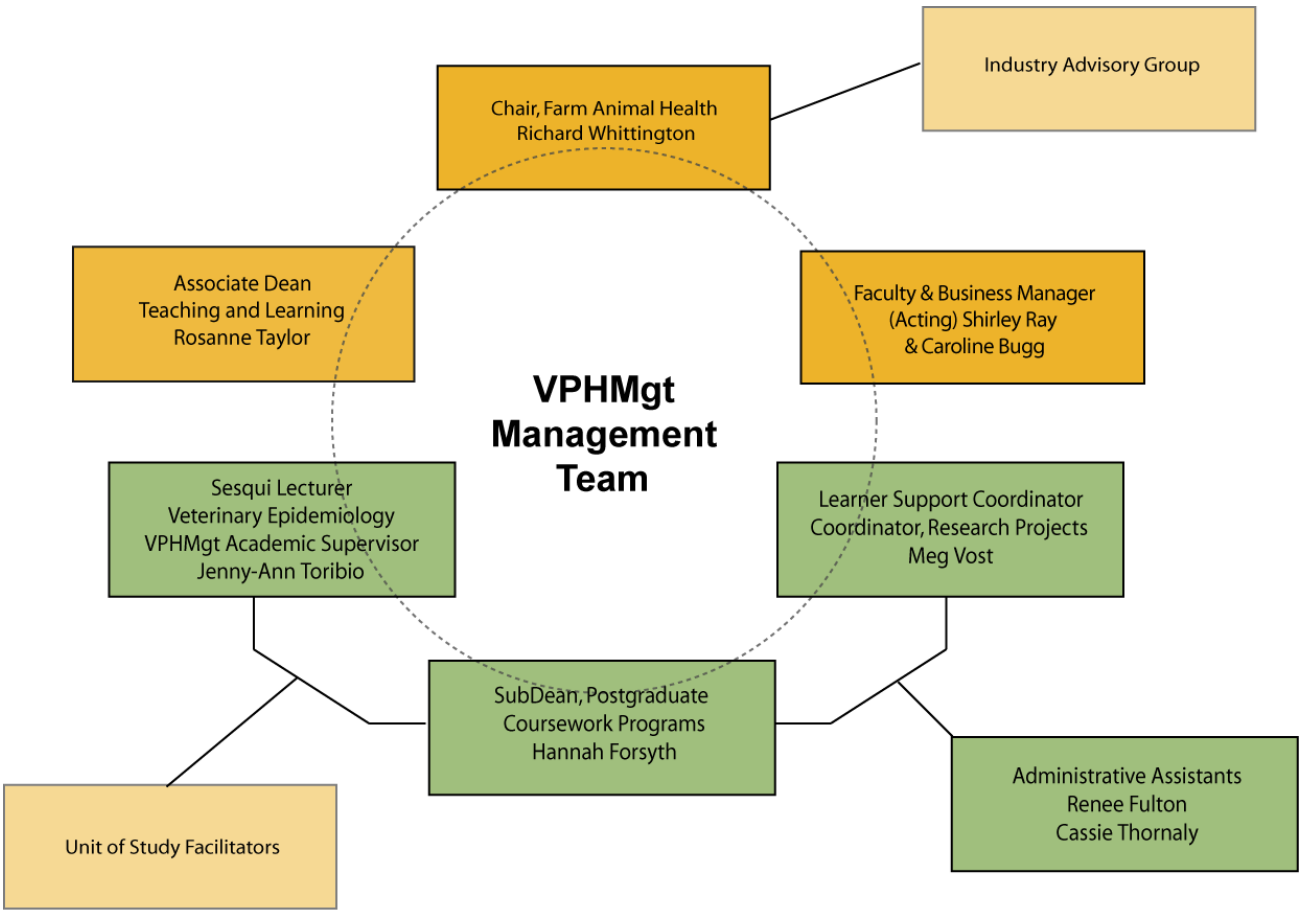
Graduates of this program are better equipped to contribute as professionals to the field of animal health at regional, national and international levels. Graduates possess generic attributes (communication, thinking, personal and practical skills) of all graduates at The University of Sydney. In addition, VPHMgt graduates possess the following specific technical attributes and research skills:

- apply understanding of specific topics in the program (including epidemiological principles, zoonoses, food safety, animal health economics and policy development) to existing and emerging issues in animal health;

- apply skills in leadership and project management effectively in a work context;
- apply detailed knowledge and understanding of each selected elective topic by application to current issues in the relevant field and to problem solving within their work setting;
- work with others across disciplines, workplaces and across geographies to create an ongoing learning environment;
- conduct veterinary research in a highly professional and ethical manner; and
- write, publish and report research methods and results, either collaboratively or individually, across disciplines and across geographical boundaries.

The VPHMgt program ensures quality curriculum design and content by a variety of means, such as development of graduate attributes in consultation with industry and the profession, contracting of an Educational Design consultant, consultation and collaboration with educational experts, and via surveys of students in every unit of study and across the program.

Professor Ward supplies leadership and strategic direction for the postgraduate VPH / VPHMgt programs. He advises program management on academic development, research projects and financial management. He secured funds ($15,000) from the Veterinary Science Faculty via a Learning & Teaching grant to conduct an external review of the VPHMgt program, and to make recommendations regarding future directions. This review was needed to keep the program on track with growing international competition.



Dr. Jeff Bender (http://www.vdl.umn.edu/aboutVDL/_staff/bender/_home.html) was selected as the consultant to conduct this review. Dr. Bender is Associate Professor of Veterinary Public Health and Director, Center for Animal Health & Food Safety (CAHFS), College of Veterinary Medicine, The University of Minnesota. He is a Diplomate of the American College of Veterinary Preventive Medicine. Dr. Bender's research interests include zoonoses and emerging diseases, food safety, antimicrobial resistance and infectious disease surveillance. He teaches *Veterinary Public Health* to 3rd and 4th year DVM students and postgraduates, and also teaches within the University of Minnesota's Public Health Institute (*World Food Problems*; *Epidemiology of Foodborne Pathogens*; *Use of Epi Info in Epidemiologic Investigations*; and *Understanding the Emergence of Zoonotic Diseases*).

The University of Minnesota has a combined DVM/MPH program that is growing and is unique in North America (http://cpheo.sph.umn.edu/cpheo/institute/home.html). There is some institutional familiarity with veterinary public health online learning.

Professor Ward was successful in securing additional funding for VPHMgt Scholarships through to the end of 2012.

Within the VPHMgt program, Professor Ward has acted as unit of study facilitator for VETS 7004 Veterinary Epidemiology I (2009; 21 students) and VETS 7005 Veterinary Epidemiology 2 (2011; 22 students), and has participated in VETS 7017 Food Safety, VETS7015 Surveillance, Preparedness and Response and Research Seminars. He also regularly attends residential courses (VETS7025 Leadership, people and Organisations; VETS7026 Leadership: Managing Change; VETS7027 Project Management. He has assessed several MVPHMgt dissertations.

To date, Professor Ward organised, coordinated or taught 7 short courses between 2008 and 2010.

1. **Disease Mapping**

   Training tailored to Faculty and Postgraduate students within the Farm Animal and Veterinary Public Health and the Livestock Services groups at The University of Sydney on disease mapping was provided during 4 three-hour sessions in April and May, 2008. Participants were trained in the use of geographic information system (GIS) software and explored potential sources of spatial data and statistics. Future access to software is being coordinated by Professor Ward. Similar training was provided to a visiting group of Indonesian veterinarians, funded by AusAID's Australian Leadership Award – Fellowship program.

2. **Logistic Regression**

   A short course on logistic regression modelling, *Logistic regression model building as an analytic technique for identification of risk factors for animal disease*, was conducted in June, 2008. The course was led by Dr. Ashley Hill, Assistant Professor (Epidemiology), College of Veterinary Medicine and Biomedical Sciences, Colorado State University. Dr. Hill's visit was sponsored by a University of Sydney International Visiting Research Fellowship Scheme. Dr. Hill is the current facilitator for our on-line Veterinary Public Health Management course VETS7005, Veterinary Epidemiology 2.

   A total of 27 faculty and students attended the course that included University of Sydney participants from Farm Animal Health, Veterinary Public Health and Food Safety, Reproduction and Genetics, Parasitology and Livestock Services. In addition, five PhD students (University of

Queensland, Murdoch University) from the Australian Biosecurity Cooperative Research Centre participated in the course.

3. Import Risk Analysis

In partnership with Massey University, New Zealand, a three day introductory course on import risk analysis for animal and animal products was presented in September, 2008. The lead instructor was Dr. Naomi Cogger, a lecturer in veterinary epidemiology from Massey University. Naomi has a close relationship with The University of Sydney and Camden: she completed a PhD in 2006 investigating the epidemiology of musculoskeletal injuries in two and three year old Australian thoroughbred racehorses. Naomi was assisted by Dr. Marta Hernandez-Jover. Marta is currently Research Fellow at The University of Sydney and is working on an Australian Biosecurity CRC project evaluating the biosecurity risks posed by small landholders. Fifteen students attended this course. They came from Federal (Biosecurity Australia, Australian Quarantine and Inspection Service, Department of Agriculture, Forestry and Fisheries, and the Australian Pesticides and Veterinary Medicines Authority) and State (Victorian and Queensland DPIs) governments, Universities (Murdoch, Queensland and Sydney) and the Australian Biosecurity CRC, and private consultancy. Several University of Sydney Veterinary Public Health Management (VPHMgt) students attended the course.

Day one of the course focused on the policy and international conventions underpinning import risk analysis for animal products that are of interest to regulators and risk analysts alike. The remaining two days covered the technical aspects of import risk analysis. Students were taught probability theory and developed skills in quantitative risk assessment. Several cases studies were used, and the issue of equine influenza provoked animated discussions.

4. Application of Bayesian Methods in Animal Health

A 3-day short course, run in December 2008, explored the application of Bayesian methods in animal health. This course was led by Professor Wes Johnson from the Department of Statistics, The University of California, Irvine.

Professor Johnson is famous in the animal health community for his pioneering research in the field of Bayesian methods and diagnostic test evaluation. His main research interests are in developing Bayesian statistical methods for biostatistical and epidemiologic applications. He is currently involved with collaborative efforts to develop asymptotic posterior distribution theory for mixed models, Bayesian methods for assessing diagnostic test accuracy and for estimating prevalence when no gold standard is available. Professor Johnson was assisted by Dr. Navneet Dhand and Associate Professor Peter Thompson from The University of Sydney Faculty of Veterinary Science.

The course was presented as a combination of lecture, workshop and practical sessions. On day 1, course participants were introduced to probability theory and Bayesian methods. On day 2, the application of Bayesian methods to diagnostic test evaluation was covered. During the final day, participants explored advanced methods, including demonstration of freedom from disease, and became comfortable using software programs (including WinBugs).

5. Spatial Analysis for Public Health

Professor Ward taught a course on spatial analysis in Valdivia, Chile (2009) as part of the 2nd International Summer School in Public Health and Food Safety. Students were trained in

disease map making techniques, statistical cluster analysis and risk factor analysis. The objective of the courses was to provide students with a strong knowledge base in the application of methods to describe, display and analyze spatial disease information. Learning outcomes included:

- Design a scientific study in which spatial data is integral
- Gain experience in the use of geographic information systems
- Display disease data using a variety of methods
- Be aware of data sources in landscape epidemiology
- Know how to locate and describe disease and covariate attributes
- Identify disease clustering
- Smooth spatial disease data
- Model spatial disease distributions
- Critically evaluate journal articles concerning spatial epidemiology

6. Network Analysis

A course on *Network Analysis* was presented by visiting international scholar, Dr. Rob Christly, was presented in April 2009. Dr. Christly is a Senior Lecturer at the University of Liverpool and an internationally recognized expert in social network analysis. He is a University of Sydney alumnus. His visit to The University of Sydney was supported by the International Visiting Research Fellowship Scheme. There were 25 course participants from Australia and New Zealand.

The course introduced the terminology, methods and some of the software available to analyse networks. The workshop was a combination of short lectures, discussions and hands-on analysis. At the end of the workshop participants were able to design and undertake studies appropriate for the collection of network data, and use such data to create network images, describe important features of the network and identify important individuals and subgroups within the network. In addition, and covered aspects of the statistical analysis of network data and the impact of networks on infectious disease dynamics.

7. Geographic Information Systems and Spatial Epidemiology

Professor Ward taught this 4-day course in May 2010 by invitation from CIRAD (the French Overseas Agency for Agricultural Research). The course was held at CIRAD's Headquarters, in Montpellier, France.

This course is an intermediate-level postgraduate course in the application of methods for displaying, describing and analyzing spatial environmental exposure and disease data. The course is suited for students in any field with an interest in the application of spatial methods to exposure data and disease data, and for public health officials needing to develop and extend their skills in spatial analysis of epidemiologic and public health data. The course focused on both veterinary and human health related examples, primarily on the spatial distribution of infectious diseases.

In addition, Professor Ward organized and presented an international conference and 3 short courses – *GEOVET 2010* – between 29 November and 5 December. GEOVET brought together > 100 international scientists and policy advisors (including MLA) to showcase the latest techniques

for examining and understanding how disease spreads across the landscape. The scientific program included 6 keynote and 11 senior presentations by scientists from Australia, the United Kingdom, the United States, Germany, Argentina, Chile, New Zealand, Denmark, China and Russia. The conference was opened by Dr. Andy Carroll, Australia's Chief Veterinary Officer, who highlighted the need to understand how diseases emerge and spread, in order to protect Australia's livestock health status and to protect humans from diseases that might be transmitted from animal populations, such as Hendra virus and bird flu.

Faculty from the Veterinary Public Health unit made 9 presentations at GEOVET 2010 on subjects ranging from disease surveillance in dogs and cats, to diseases affecting our native fish stocks, to the recent equine influenza outbreak and diseases with international biosecurity implications – West Nile virus, bird flu, rabies, classical swine fever and foot-and-mouth disease.

One study presented highlights the issue of disease emergence, *What role does wildlife play in emergency disease? The case of the feral pig*. This project aims to provide a better understanding of how endemic diseases are transmitted within populations of feral pigs. Based on such understanding, the potential spread of exotic diseases in feral pigs and cattle can be inferred, allowing effective surveillance and mitigation strategies to be developed.

Another study examined the risk of West Nile virus entering Australia via infected mosquitoes introduced at Sydney International Airport. The spread of West Nile around Australia was modeled based on experience from the United States during 1999–2005. The potential number of human and equine deaths and sickness were then calculated. Future work will look at the economics of surveillance strategies – how much should be spent to prevent an incursion of West Nile virus.

The 3 short courses presented were *Application of Molecular Methods in Spatial Epidemiology* (Petra Müllner, Andres Perez, Fernando Madones), *Introduction to GIS Using QuantumGIS* (Ben Madin, Jenny Hutchison) and *Introduction to Bayesian Disease Mapping* (Andrew Lawson).

The field of spatial methods for examining and understanding how disease spreads across the landscape is developing quickly, with new analytical and visualization techniques becoming available. A challenge is to communicate findings to decision- and policy-makers so that the impact of emerging diseases on animal and human health can be minimized.

Keynote and senior presentations were published in two journal volumes, in *Preventive Veterinary Medicine* and *Spatial and Spatio-temporal Epidemiology*.

4.4 Improve Research Opportunities in Veterinary Public Health

The creation of the new unit has enabled the development of a world class research program to benefit the livestock sector. Highlights include:

- four young post doctoral fellows (Marta Hernandez-Jover, Brendan Cowled, Priti Goswami, Sharon Roche) employed and engaged to solve problems for the livestock sector
- twelve future researchers trained at PhD , Masters and Hons degree levels
- scientific publications, industry reports and consultancies
- industry and networking workshops and agreements
- research projects funded by a range of agencies, including MLA, DAFF, ARC and APL

- greater credibility of primary production issues in general and the livestock sector in particular within the University and within the Faculty, enabling on-going activity and future investment in personnel and infrastructure

During the period 2008–2011 the Chair of Veterinary Public Health and Food Safety has lead, either directly or indirect, several major projects that provide whole of sector, on-farm, processor and product research outcomes. As part of the Farm Animal and Veterinary Public Health group within The University of Sydney's Faculty of Veterinary Science, this position has also contributed to a number of broader research programs. Ten specific projects, representing total funding of $2,797,833 and supporting three Postdoctoral Fellows, one technician and 8 Postgraduate students, are described below.

1. Risk assessment: Animal diseases as they relate to food safety

Funding agency: Meat & Livestock Australia
Period: 2008–2009

This study was funded within MLA's Off-farm research and development food safety program plan (2006–2009). MLA identified the need for a risk profile to be conducted in the area of "animal diseases (as they relate to food safety)". The study was conducted in conjunction with MLA's Scientific Risk Assessment Panel, which supplied advice and guidance in the areas of public health, risk assessment, and food microbiology.

The project involved developing an approach for assessing the potential for emerging animal diseases to be transmitted to man by products of cattle, sheep or goats (specifically, meat). Completing a risk profile in this area provides the red meat industry with an understanding of current and potential risks, and the ability to identify possible management options and ensure that it stays "ahead of the play" in the area of international animal diseases that may affect food safety.

Risk assessment algorithms have been proposed for the assessment of emerging animal diseases for their zoonotic potential. A considerable body of work has led to guidelines for risk assessment for microbiological food safety risk assessment. However, the red meat industry required the ability to rapidly assess emerging animal disease not only for their impact on farm animal species, or for their zoonotic potential, but also for their potential to affect the safety of meat traded nationally and internationally.

The project objectives were:

1. Review the literature available on appropriate risk assessment approaches and algorithms available for assessment of known zoonoses and food safety. Develop (with assistance from an expert panel), using existing literature / models a defensible risk assessment model for zoonoses potentially transmitted through meat.
2. Identify animal diseases that represent a food safety hazard, which may enter any point of the food chain for beef, sheep or goat products produced in Australia and rank them in terms of risk.
3. Identify potential management strategies for the hazards.
4. Identify areas where further information may be required to effectively assess or manage significant risks.

The project was conducted by Master of Veterinary Public Health Management candidate, Dr. Elizabeth Parker. The project provided Dr. Parker with the opportunity to gain experience in the area

of risk assessment and food safety. A dissertation was submitted and passed in 2009. The project was presented at the International Symposium on Veterinary Epidemiology and Economics (ISVEE), Durban 2009 and has been published in the international journal, *Zoonoses and Public Health*.

2. A framework for evaluating the economics of the control and prevention of animal health emergencies

Funding agency:	Commonwealth Dept. of Agriculture, Fisheries & Forestry
Period:	2008–2011

There is a lack of application of economic methods to animal health issues, particularly regarding the allocation of resources to prevent and respond to incursions of animal diseases. This project aims to improve the situation by producing a framework that can be applied to address the threats to Australia posed by transboundary diseases. Project outputs will result in better disease control and response policy and plans:

1. A conceptual framework (approach) for addressing the economic impacts of preventing, versus responding to, transboundary diseases;
2. New methods, or integration of existing methods, for analysing the potential impacts of transboundary disease incursions;
3. Cases studies of selected disease threats that represent a range of commercial, trade, species, and intangible benefit issues; and
4. Increase capacity and expertise within Australia to analyse and address economic aspects of animal health.

Decisions regarding the control and prevention of animal health emergencies − incursions of transboundary diseases that can cause severe impacts on regions free of disease − are usually based on economic considerations. However, methods specifically designed for estimating the economic benefit of different control strategies and different strategies to prevent such disease incursions in general are lacking. Most of the methods available are based on traditional micro-economic theory. Those methods based on macro-economic theory have been borrowed from traditional economic theory and their application to animal health emergencies is problematic because of intangibles benefits. Even in the case of trade-related diseases, the trade affects of an incursion can be uncertain. Whilst epidemiological methods have advanced considerably during the past 20 years, there has been a corresponding lack of progress in developing new methods for animal health economic analysis.

Economic models applicable to animal health include benefit-cost analysis (BCA), linear programming (LP), partial equilibrium analysis, input-output (I-O) models and social accounting matrices (SAMs), multimarket models, and computable general equilibrium (CGE) models. Multiple economic models are available for any scale of analysis and for each type of information requested, but none is universally appropriate. BCA, SAMs and CGE models have been applied to FMD.

Economics offers a range of tools, with divergent strengths and weakness, that can be applied to measure the impacts of animal disease. BCA, for example, offers precise specification of the immediate impact of a disease outbreak on herd-level costs, but little insight into longer term effects throughout the economy. By contrast, multi-market or CGE models can provide information on wider impacts over different time frames, but obscure details of more immediate effects. With the exception of benefit-cost analysis, most economic methods remain under-used. Greater use of other methods could enhance the applicability of economics to a variety of questions that need to be addressed in the context of animal disease and its evaluation. At the same time, the complexity of

the tools suggests a strong need to cultivate multi-disciplinary collaboration in the planning process for disease evaluation, data collection, and subsequent data analyses.

A framework that can be applied to assess both the economic costs and benefits of disease control and disease prevention for transboundary diseases will be developed. This framework will incorporate some methodologies already applied to assessing the economic impact of animal health emergencies, but will investigate under what circumstances which methodologies – or combination of methodologies are most appropriate. Guidelines will be developed for which methodologies should be used in which situation.

The approach to developing the economic framework will firstly be to review the methods that are currently available and that have been applied in animal health during the past 50 years. The strengths and weaknesses of each method will be determined. Second, other methods for economic analysis that have not been applied to animal health issues will be reviewed and similarly strengths and weaknesses will be determined. Third, based on those methodologies reviewed, a multistage process will be developed in which strengths are maximized and weaknesses are reduced for given generic scenarios. Finally, the framework will be assessed by using it to analyse specific scenarios.

The framework will be developed by applying a range of economic analysis methods to 3 case studies that represent diseases with and without substantial trade-related issues, direct and indirect costs and benefits, tangible and intangible benefits, and which represent a range of potential disease control and prevention strategies. These 3 case studies are foot-and-mouth disease, Hendra virus, and the Asian honeybee mite (*Varroa destructor*).

3. Arbovirus surveillance needs and the National Animal Monitoring Program

Funding agency: Animal Health Australia
Period: 2008–2009

Arboviral diseases impact Australia in several ways: they reduce the efficiency of livestock production, restrict trade access, and pose a risk to human health and animal welfare. Monitoring and surveillance systems aim to reliably and rapidly detect emerging and re-emerging diseases and document disease freedom. Monitoring and surveillance underpins the validity of claims of disease freedom, and increase the sensitivity of detection of emerging and re-emerging diseases.

The National Arbovirus Monitoring Program (NAMP) is a specific program of Animal Health Australia, and is part of the National Animal Health Surveillance Strategy (NAHSS). This provides the framework for animal disease surveillance in Australia, and focuses on impacts to human health, food safety, the environment, productivity and market access.

A review of future national arbovirus surveillance needs for public, livestock and wildlife health was undertaken by a risk-based assessment, focused on key stakeholders. Based on the range of risks identified and the ranking of these risks, the contemporary relevance of the four current objectives of the NAMP was assessed.

The appropriateness of the NAMP to deliver on future national needs was assessed by focusing on those current objectives that do not address perceived future risks, and those future risks that are not addressed by current NAMP (and other NAHSS) objectives. An evaluation method applicable to NAMP and other targeted national animal disease surveillance programs was recommended.

Current collaborations in arbovirus surveillance with public health and environment agencies were documented, and potential collaborations identified.

4. Technical merits of introducing mandatory mob-based movement recording, and the use of transaction tags for sheep and goat movements

Funding agency: Animal Health Australia
Period: 2008–2009

The aims of this project were to assess the:

1. risks posed by sheep movements along the industry supply chain;
2. scope for effective tracing of movements under current arrangements (measured against the requirements of the national performance standards);
3. scope for improving traceability if mandatory mob based movement recording and transactions tags are introduced

Primary Industries Standing Committee and SAFEMEAT Partners endorsed the introduction of mandatory mob based movement recording for all sheep and goat saleyard transactions, commencing 1 July 2009. This involves the collection, collation and the electronic submission of specified data to a central database. There was also agreement to introduce the mandatory use of transaction tags on sheep and goats, to commence from 1 July 2009.

These decisions followed an assessment of the current system via “Exercise Sheepcatcher” and ongoing saleyard monitoring. SAFEMEAT Partners supported undertaking a risk based assessment of the need to extend the mob based movement recording to all transactions.

To assist industry and government, two complementary studies were undertaken to assist the implementation of the above decisions:

1. An assessment of the need to extend the mob based movement recording requirement beyond saleyard transactions by undertaking a risk assessment of all movements representative of the sheep and goat industries.
2. A risk assessment of the need for transaction tags for a range of movements (e.g. movements where ownership does not change) before a final decision is made on the scope of the mandatory transaction tag program.

Typical sheep movements (e.g. property of birth to abattoir, property of birth to live export depot to ship, property of birth to a second property to a saleyard to a feedlot to abattoir) were assessed. The risks against which these movements were assessed included:

- risk of coming into contact with an infectious disease
- risk of these movements contributing to the spread of the disease
- risk of compromised product integrity (e.g. chemical residue violation)
- effectiveness of the current traceability arrangements in the context of an outbreak of an exotic disease such as FMD, or a disease such as scrapie.

The study then assessed the technical merits of applying mandatory mob based movement recording, and mandatory use of transaction tags to these movements (in conjunction and

separately). The study assessed the gains in terms of the speed of traceability, and the risk of not requiring the recording of the movement.

Project activities included providing expertise in the application of risk analysis methodology; working with a team of industry and government representatives who provided advice on the data and assumptions that were included in the assessment; and undertaking the risk assessment based on the data provided by the above group. A report detailing the risk assessments for each of the nominated sheep movements, including an explanation of the methodology used, the performance criteria and the data and assumptions used for the purposes of the assessment was produced.

5. *Campylobacter jejuni* through the food chain: from range through processing

Funding agency: United States Department of Agriculture NRI
Period: 2008–2011

In 2009 there were 6,033 laboratory confirmed human cases of *Campylobacter jejuni* identified in the U.S. *C. jejuni* infection in humans is most often attributed to undercooked poultry. However, since 1999, the Centers for Disease Control (CDC) has confirmed 5 outbreaks of campylobacteriosis due to ground beef products affecting 199 people, and cattle isolates have been linked to human infection. Because *Campylobacter* infection is generally sporadic, the prevalence of illness due to contaminated beef may be underestimated.

A potential risk factor for feedlot cattle to acquire *C. jejuni* is the presence of fecal droppings from birds. Feedlots become a haven for local and migratory birds because of the ample supply of grain. Doves, pigeons and migratory birds are colonized with *C. jejuni* and shed the bacterium in their feces, contaminating feed bunks and pens. Cattle may then become infected when they consume the contaminated feed.

This project includes the following specific aims:

- Isolation of *C. jejuni* from the feedlot environment and beef cattle from range to slaughter
- Determine the genetic diversity of *C. jejuni* isolates.
- Assess the antibiotic susceptibilities and virulence properties of bovine *C. jejuni* isolates.

In preliminary studies, *C. jejuni* was detected in 94% of the carcasses sampled along the ventral midline cut (300 cm^2). This area is frequently trimmed and sent to the grinders for the production of ground beef, but differs from the USDA-APHIS (United States Department of Agriculture-Animal and Plant Health Inspection Service) carcass inspection area. Therefore, *C. jejuni* may be introduced into ground beef from trimmings, and *C. jejuni*-contaminated trimmings pose a risk factor for consumers. Calf fecal samples were collected from the range, feedlot, and at slaughter to determine the presence of *C. jejuni* in beef cattle and meat. Carcass swipes were also collected during slaughter, aging, and from samples of beef ground from these areas. Environmental samples were obtained to determine the prevalence and sources of *C. jejuni* in cattle at the feedlot.

A cohort of thirty-six randomly selected cattle was followed from the range to feedlot, and slaughter to quantify *C. jejuni* colonization. Feedlot environmental samples (including drag swabs, feed bunk swipes, water units, flies, and wild birds) were collected to describe *C. jejuni* feedlot contamination and potential infection sources.. For carcass sampling, two sites were selected; the USDA-APHIS sampling area, and the ventral midline area.

At slaughter, all calf fecal samples were positive for *C. jejuni*, compared to one calf (3%) at the range and feedlot arrival. There was no significant difference in colonization between calves on traditional feed containing tylosin and the un-medicated group. Bird fecal samples collected at pre-arrival, months 3 and 6 showed that birds were consistently infected – 32%, 28% and 30%, respectively. A fly sample at pre-arrival also tested positive for *C. jejuni.* There was significant disagreement between isolation of *C. jejuni* from carcass swipes at USDA-APHIS versus ventral-midline sites at evisceration: *C. jejuni* was isolated from the ventral midline area from 12 (33%) carcasses, but not from the USDA-APHIS area. However, MPN values at evisceration were significantly and positively correlated. Environmental sampling results indicate that wild birds and flies may be a source of contamination in beef cattle.

Further characterization of the environmental and bovine isolates might identify which specific strains of *C. jejuni* are responsible for the subsequent infection of cattle. The ventral midline sampling area may be a useful addition to standard sampling areas. Although cattle can become rapidly colonized with *C. jejuni*, contamination of the meat, following aging, remains low.

6. Managing risk: Studies of the biology and epidemiology of bluetongue viruses and their vectors in NSW

Funding agency: NSW Centre for Animal and Plant Biosecurity
Period: 2011–2014

Bluetongue infections of livestock are important for both animal health and trade. Bluetongue viruses (BTVs) have in recent years assumed a high profile because of unprecedented disease outbreaks in Western Europe, the Scandinavian countries and England. Higher than average temperatures are believed to have aided the infection of local midge species – that are widespread in Europe but not previously known to be competent vector species – by introduced serotypes. This situation could be repeated in NSW, where there is an interface between the distribution of BTVs and susceptible sheep and cattle populations, with further impacts on trade and the risk of disease outbreaks. It is important that the distribution of both viruses and insects in NSW are closely monitored using the most sensitive and efficient tools that are available, so that risks can be appropriately managed, the livestock industries alerted and control measures implemented.

Meat & Livestock Australia, in conjunction with Industry & Investment NSW, recently funded a major project at Elizabeth MacArthur Agricultural Institute to develop new diagnostic tools for the rapid identification of insect vectors and for the detection of bluetongue viruses. This project is being augmented by the addition of a PhD student, funded by the NSW Centre for Animal and Plant Biosecurity – an alliance between Industry & Investment NSW and the University of Sydney to develop and apply cutting-edge science to address biosecurity issues.

The first stage of the existing MLA project will develop rapid assays for the identification of midges. Prototype real time PCR (qPCR) assays, already available, will be validated by early 2011. Future studies could include:

- Estimation of the number of midges in a light trap collection based on qPCR reactivity;
- Discovery of the overwintering mechanism of BTVs;
- Create models to predict the early expansion and spread of midge populations;
- Develop and evaluate systems to experimentally feed insects on BTV infected blood;
- Determine capacity of local NSW midges to transmit virulent, Northern Australian strains of BTV.

7. What role does wildlife play in emergency disease? The case of the feral pig

Funding agencies: Australian Research Council
Commonwealth Dept. of Agriculture, Fisheries & Forestry
Cattle Council
Dept. of Agriculture and Food, Western Australia
Meat & Livestock Australia
Australian Pork Limited
Period: 2010–2013

Wildlife populations have been responsible for many recent disease emergencies including SARS, Nipah, Hendra and Menangle viruses, avian influenza, classical swine fever and foot-and-mouth disease. Yet our understanding of how such diseases move through and emerge from wildlife is poor and inadequate for developing and applying successful response, control and prevention programs.

This project will use feral pigs in northern Australia as a case study for characterising wildlife disease dynamics (using Salmonellosis) with a novel integration of population and epidemiological genetic approaches, demographics and simulation modelling. A problem of great importance to agriculture in Australia – the role of feral pigs in trans-boundary infectious disease transmission – and to our partners (DAFF, Cattle Council, DAFWA and I&I NSW) will then addressed. A framework (tools and methods) to assist understanding and management of wildlife disease that is applicable to feral pigs and other wildlife diseases in Australia and globally will be created. Specifically, project aims are to:

1. Quantify and describe endemic disease transmission in feral pigs and cattle in northern Australia;
2. Forecast the potential role that feral pigs might play in exotic trans-boundary animal disease (for example, Foot-and-Mouth disease and Classical Swine Fever) incursions; and
3. Define appropriate surveillance and mitigation strategies for managing trans-boundary disease incursions involving feral pigs and other wildlife populations.

By achieving these aims, a core biosecurity objective of the partners will be addressed: preparedness for emergency disease events. Importantly this will be achieved in hitherto poorly understood and complex wildlife-livestock systems. Achievement of these aims will also result in a conceptual leap forward in our understanding of wildlife disease epidemiology, thus improving the management of many endemic wildlife diseases of importance for the partners.

8. Managing risk: Studies of the biology and epidemiology of bluetongue viruses and their vectors in NSW

Funding agency: University of Sydney Biosecurity Program
Period: 2010–2011

Vector-borne diseases can have a major impact on human and animal health. West Nile virus (WNV) is of particular international importance due to its recent emergence and impact in the Western Hemisphere.

Despite the presence of a sub-type of WNV – Kunjin virus (KUN) – in Australia, a potential ecological niche could exist for an exotic strain of WNV. The current study assessed the probability of a virulent strain of WNV entering Australia at Sydney airport via an infected mosquito on an aircraft from United States, the probability of spread to susceptible species and the impact of the resulting outbreak on human and animal health. Release, exposure and consequence assessments were conducted (OIE, 2009). The release assessment estimated the probability a WNV-infected mosquito is present in an aircraft arriving at Sydney airport from the U.S., and the number of WNV-infected mosquitoes that could be introduced over a 12 month period. The exposure assessment evaluated the potential pathways required for local mosquitoes and avian species to become infected, and the consequence assessment described the pathways for WNV to spread and establish in wild birds, mosquitoes, horses and humans.

Given the paucity of data available to parameterise the inputs for this model, expert opinion was elicited and scientific literature reviewed. Following establishment of WNV, the spatio-temporal spread of WNV was predicted based on the Australian population at risk, the known distribution of other mosquito-borne flaviviruses in Australia, climatic factors and the spread of WNV in the U.S. following it's incursion in New York City in 1999. The impact of this spread was measured as a

multiplier of human and equine demographics over a six year period, using the U.S. incidence and case fatality rates as a reference.

For a 12 month period and considering WNV was endemic in the U.S., the median probability WNV-infected mosquito was introduced at Sydney airport from the U.S via aircraft was estimated to be 0.13, and the number (median, 5–95%) of infected mosquitoes 0 (0–1). After the introduction of a WNV-infected mosquito, the median probability of a WNV outbreak is estimated to be 5.6×10^{-6} in humans and 3.0×10^{-6} in horses. The presence of mosquitoes in aircraft and the probability of the WNV-infected mosquito contacting wild birds were the input variables with most influence on the outcomes of the model.

Results of this study suggest there is a non negligible risk of introduction and spread of an exotic strain of WNV from the U.S via aircraft, and provide an insight into the magnitude and impact of the spread among human and horse populations.

9. A risk assessment and simulation modeling framework for exotic disease prioritisation in the Australian pig industry

Funding agency: Australian Pork Limited
Period: 2011–2014

Emerging and transboundary diseases have been responsible for dramatic impacts on human health, the economy, trade, animal health and biodiversity in Australia and around the world. For example, Nipah virus emerged from wildlife, killed hundreds of people in Malaysia and lead to the mass culling of >1 million pigs and in the late 1990's (Epstein et al. 2006). An outbreak of Foot-and-Mouth Disease has been estimated to cost Australia $6-13 billion (Productivity Commission 2002).
The benefit that Australian producers gain from the freedom from devastating epidemic diseases in other parts of the world is enormous. The main emergency animal diseases that could affect the pig industry are Foot and Mouth Disease (FMD); Classical swine fever; African swine fever; Aujeszky's disease; Porcine reproductive and respiratory syndrome (PRRS); and Postweaning multisystemic wasting syndrome (PMWS).

The Australian pig industry's health status provides it with a competitive advantage. Freedom from major transboundary diseases – such as foot-and-mouth disease and classical swine fever – secures access to international markets and enables producers to invest in their businesses free from the complication of major incursions, ensures the industry's future sustainability and allows it to meet community standards for food production.

The potential exotic disease hazards that threaten the industry, and measures of potential impact, have not been quantitatively described. To plan and develop appropriate response strategies, a risk assessment of hazards and development of modelling methodology is needed.

This project specifically addresses the industry outcomes of enhanced biosecurity and animal health preparedness; industry preparedness, rapid response and effective recovery; and minimal disruption to trade.
This disease modelling project – including disease spread scenarios and the impact of control measures on the spread of disease, the costs of containment and the costs to producers of disease control options – will ensure that APL is well informed about likely scenarios and potential costs of an exotic disease incursion.

An innovative approach integrating risk assessment and disease spread modelling is being undertaken to fully examine, for the first time, the risks and consequences to the Australian pig industry of exotic diseases. We will apply this information to meet industry objectives (prepare, rapidly respond and recover from crises and emergencies with minimal disruption) and to enhance contingency plans for emergency animal diseases.

Objectives are:

- Undertake a risk assessment to prioritise the potential exotic disease hazards for the Australian pig industry.
- Develop a simulation model specifically tailored to exotic disease spread in the Australian pig industry.
- Parameterize the disease spread model via literature review, expert opinion and questionnaire surveys.
- Targeting the 3 highest exotic disease hazards, prioritize future surveillance based on estimated epidemic size, duration and financial impact.

This risk assessment will follow the OIE guidelines for Risk assessment, including a hazard, release, and exposure assessment (disease spread modelling will form part of the consequence assessment). For this assessment the following will be conducted:

- Hazard assessment: A review of pathogens of pigs that are absent from Australia will be undertaken via examination of the literature and OIE documentation. All pathogens that cause clinical disease or production losses will be included.
- Release assessment: This assessment will evaluate the potential pathways of introduction of hazards into Australia and the likelihood of each hazard being introduced. All the potential introduction pathways will be evaluated; however, it is expected that the import of pig meat will be the most likely pathway for most hazards identified.
- Exposure assessment: Focusing on the most likely pathways of introduction, conduct an exposure assessment. This assessment will include an evaluation of potential exposure groups (segments of the industry), and an estimation of the likelihood of exposure in each of these groups.

The simulation model will be specifically tailored to exotic disease spread in the Australian pig industry. As a contemporary technology, disease simulation provides us with an opportunity to improve our response to outbreaks of emergency transboundary diseases in Australia. Simulation modelling approaches have undergone a revolution in recent decades and can now be used to create new generation, spatially explicit epidemiological models that truly represent the complexity of exotic disease incursions. These models can capture the key ecological, behavioural, spatial and temporal features of the industry, and can be used to inform policy- and decision-makers on disease preparedness policy. Empirical data and inferences about disease dynamics will be incorporated into a simulation modelling framework.

We will use a disease simulation model that has been developed and refined within the DAFF over a period of >15 years, and applied successfully to simulate the spread of FMD in the livestock industries of Australia and Texas, and to examine the recent epidemic of equine influenza in Australia. It is a state-transition model that has been developed from a Markov chain and modified to include stochastic elements (represented as probability distributions, which incorporate the uncertainty or natural variation inherent in particular model parameters). Monte Carlo methods are

used to select values from these probability distributions each time that the model is 'run'. The process leads to output distributions from which statistics such as minimums, maximums, means and medians can be obtained. The model allows for interactions between herds and production type. The user can evaluate the impact of constraints on the availability of resources for mitigations or eradication measures. Outputs include a range of maps and tabulated outbreak statistics describing the geographic extent of the outbreak and its duration, the numbers of affected, slaughtered, and, as relevant, vaccinated herds, and the cost of control and eradication. These outputs are a valuable resource to assist with policy development and disease management.

The model will be adapted to the likely behaviour of key exotic diseases to describe potential emergency disease ecology using a combination of published literature, expert opinion and surveys. In consultation with industry, experts will be identified and their opinions on the likely entry and spread of disease hazards will be sought via a combination of paper- or online-based surveys, face-to-face interviews, small group meetings and Delphi techniques. If necessary, opinion from overseas experts will also be sought.

Targeting the 3 highest exotic disease hazards as determined by the risk assessment, simulate disease spread and measure its impact. For each of the disease risks, disease spread using a likely incursion scenario (suggested by experts) will be simulated. Average as well as best case and worse scenarios will be calculated for number of herds infected, duration of the simulated epidemic, and the likely financial costs. Disease control will be included in these studies based on the stated 'default' strategy in the relevant AUSVETPLAN. Finally, the risk of introduction (risk assessment) and the impact (disease spread modelling) will be combined to provide the industry will information for prioritization and planning response strategies.

10. *E. coli* O157 colonisation and shedding in cattle

Funding agency: Meat & Livestock Australia
Period: 2011–2015

Outbreaks of *Escherichia coli* O157:H7 (*E. coli* O157:H7) infection associated with consumption of hamburger meat have occurred in the USA over the past few years. Although *E. coli* O157:H7 is not a major public health concern in Australia, it is in North America which is a major market for Australian beef, particularly manufacturing beef sourced largely from cull beef and dairy cows.

Previous studies conducted with MLA support have indicated that only few animals shed high levels of E. coli O157 and Australian processing systems appear to cope well with the majority of animals coming to slaughter, but may be less successful when animals shedding very high numbers of *E. coli* O157 are presented. Some researchers have estimated that supershedding animals may represent less than 10% of cattle in a herd but can account for more than 96% of all *E. coli* O157 shed.

Attention in the USA is increasingly turning towards pre-harvest (that is, live animal) interventions. Supershedding has become an active area for pre-harvest research. Aspects concerning the microbe, the host and the environment are being considered as the information about supershedding in Australia and internationally is quite limited.

This project seeks to conduct a microbiologically and epidemiologically robust investigation of the occurrence and behaviour of *E. coli* O157 in supershedders. It will:

- Provide a review of the microbiological techniques available to detect the *E. coli* O157 supershedding state;
- Identify effective and efficient methodology for use within the Australian red meat industry;
- Estimate the frequency of occurrence of the supershedding state and predictors of this phenomenon;
- Describe future disease modelling studies that could be undertaken to transform empirical field data to information that can be used by industry to develop a control program.

The project is a collaboration between University of Sydney (focused on dairy cattle) and Charles Sturt University (focused on grass-fed beef cattle). The project is being conducted in several parts, as follows:

- **literature review**, focused on methods of sampling, detection and enumeration of *E. coli* O157 and definition of the supershedder state;
- **technical training** in *E. coli* O157 isolation and enumeration techniques, and a **pilot study** in both USyd and CSU herds to identify the presence of *E. coli* O157 carriers and supershedders within the herds, and assess sampling procedures and compare the most common procedures (faecal grab and recto-anal junction swabbing);
- **laboratory skills validation** using samples from the pilot study;
- **longitudinal study** of herds to estimate incidence density rates and identification of risk factors for colonisation and supershedding of *E. coli* O157;
- **expert opinion exercise**, to obtain additional information on supershedding through conducting a face to face meeting with national experts and a survey of an international group of experts;
- **simulation modelling**, using a pre-specified model parameterised with data collected in the other parts of this project to identify and report on critical control points for mitigation of supershedding of E. coli O157 organisms; and
- a **national forum**, to present the results of this project and conduct open discussion with forum participants.

Between 2008 and 2011, Professor Ward has published 45 papers in the peer-reviewed literature, with a further 9 papers in press and 9 papers currently submitted. Of relevance to Veterinary Public Health and MLA, topics include foot-and-mouth disease, West Nile virus disease risk, rabies, epizootic hemorrhagic disease virus, Johne's disease, risk assessment, disease spread modelling and surveillance methods. During this same period, Professor Ward supervised the following postgraduate students:

1. Lisa Benjamin PhD, *An environmental perspective to decision-making for the control of Johne's disease on beef ranches*, Texas A&M University

2. Stacey Brady BVSc (Hons) *Canine parvovirus in Australia: the role of socio-economic factors in disease clusters*, The University of Sydney

3. Dipa Brahmbhatt PhD, *Contacts between domestic livestock and wildlife at the Kruger National Park Interface of the Republic of South Africa*, Texas A&M University

4. Viki Brookes PhD (Supervisor) *A risk assessment and simulation modeling framework for exotic disease prioritisation in the Australian pig industry*, The University of Sydney

5. Simon Firestone PhD (Associate Supervisor) *Epidemiology of Equine Influenza during the 2007 Australian outbreak*, The University of Sydney

6. Linda Highfield PhD (Committee Chair) *The potential role of wildlife in the spread and control of Foot and Mouth disease in an extensive livestock management system*, Texas A&M University

7. Edwina Leslie PhD (Associate Supervisor) *Classical swine fever in the eastern islands of Indonesia*, The University of Sydney

8. Monika Ling BVSc (Hons) *Risk factors for mortality from canine parvoviral-related disease in Australia*, The University of Sydney

9. Ana Mustiana MSc (Associate Supervisor) *Risk assessment of rabies incursion in Lombok, Indonesia*, The University of Sydney

10. Katherine Negus PhD (Supervisor) *What role does wildlife play in emergency disease? The case of the feral pig*, The University of Sydney

11. Elizabeth Parker MVPHMgt (Supervisor) *Risk Assessment: animal diseases as they relate to food safety*, The University of Sydney

12. Kathrin Schemann PhD (Associate Supervisor) *Management, perceptions and experiences during the 2007 equine influenza outbreak in Australia*, The University of Sydney

13. Sang-Cheol Shin PhD (Committee Member) *Three Essays on Applied Economics*, Texas A&M University

14. Tenzin PhD (Supervisor) *Studies on the epidemiology of rabies in Bhutan*, The University of Sydney

15. Matthew van der Saag PhD (Supervisor) *Managing risk: Studies of the biology and epidemiology of bluetongue viruses and their vectors in NSW*, The University of Sydney

16. Stephanie White MVPH (Committee Chair) *A Comparison Study of Gravid and Under House CO_2 Mosquito Traps in Harris County, Texas*, Texas A&M University

17. Karen Williams PhD (Supervisor) *E. coli O157 colonisation and shedding in cattle*, The University of Sydney

18. Sarah-Jane Wilson PhD (Supervisor) *A framework for evaluating the economics of the control and prevention of animal health emergencies*, The University of Sydney

The University of Sydney Biosecurity Programme (USBP)

The USBP was initiated during 2006−2007, with a series of cross-disciplinary meetings of interested academics. It was funded for the period 2008−2010. The concept of *biosecurity* includes infectious disease threats that might have potentially severe political, economic and strategic impacts. One of the stated USBP objectives is to promote biosecurity-relevant research. Biosecurity research demands collaboration between researchers from a wide range of disciplines. Thus, the challenge is

to create teams of researchers from often widely disparate disciplines. Without a cross-disciplinary approach, it is unlikely that solutions to current biosecurity issues can be found.

Professor Ward led a Collaborative Forum, sponsored by the University of Sydney Biosecurity Programme (USBP), held on 27 November 2008. A total of 23 participants attended this Forum, with expertise in veterinary public health, international politics, microbiology, psychology, law, political science, ethics, international science, and wildlife health.

The aims of this Forum were: 1. to develop a cross-disciplinary network of faculty to address current issues in biosecurity research; and 2. to foster team-building that might lead to cross-disciplinary proposals for externally-funded research in biosecurity.

A theme that emerged during discussions was compliance (by individuals, communities, and states in areas of disease response and control policies, laboratory safety and security protocols, and ethical norms) and its impact on biosecurity.

The Sydney Institute for Emerging Infections and Biosecurity (SEIB)

Epidemic and emerging infectious diseases are common causes of severe illness and mortality worldwide. They are a major cause of social disruption and economic hardship, especially in developing countries and cost many billions of dollars to the world economy.

Why do infectious diseases emerge? Though not fully understood, known drivers include increased global travel; commerce, agriculture; population displacement due to natural catastrophes and wars; climate change; incursions of humans into animal habitats and vice versa; genetic mutations in micro-organisms and the use of pharmaceuticals and other chemicals.

Anticipating and controlling epidemics and emerging infectious diseases is a multidisciplinary problem that crosses geographic and social boundaries. Australia's position as one of the few developed nations in the Asia-Pacific region provides us with a unique opportunity to establish and lead interdisciplinary research and capacity building, and to provide leadership in prevention, containment and eradication of emerging infectious diseases at home and abroad.

The University of Sydney is well-placed to establish a Centre of Excellence in Emerging Infectious Diseases because of:

- its strengths in research and education in key disciplines, including human, animal and plant health (especially Public Health Microbiology, Infectious Diseases, Epidemiology, Immunology), Social Sciences (especially Behavioural Sciences, Health Ethics, Media Studies), Science, Health and International Law, Political Science, Information Technology, Engineering and Architecture ("green, healthy buildings", airflows in hospitals and laboratories), Economics, Biosecurity and Political Science.
- state and national profiles of the existing National Centre for Biosecurity (main campus) and the Centre for Infectious Diseases and Microbiology – Public Health (Western Campus).
- established track records of individuals within the University in capacity building in the Asia-Pacific region and other developing countries.
- involvement of University staff in government policy development and implementation through membership of State and National Advisory committees and international forums such as WHO and the Food and Agriculture Organization.

Furthermore a niche presently exists for the development of a regional, interdisciplinary approach to emerging infections which integrates basic and clinical research with training and translation into policy and practice.

In 2009, the *Sydney Institute for Emerging Infections and Biosecurity (SEIB)* was established. SIEB's *vision is to reduce global impacts of (re)emerging infectious diseases on humans and animals through leadership and excellence in research and education, especially in the Asia-Pacific region. G*oals include:

- Build knowledge and understanding of the factors which influence emerging and re-emerging infectious diseases affecting humans and animals
- Develop and facilitate the implementation of strategies which minimise adverse effects of these diseases on human and animal health, communities and national economies.

A governance model designed to ensure growth and sustainability for the Institute was implemented, with the Board of Management and Director of the Institute being supported by an expert Scientific, Education and Policy Implementation Advisory Committee. Professor Ward has been an integral part of SEIB, being an elected Board of Management member. HE has coordinated networking workshops and conferences.

NSW Centre for Animal and Plant Health Symposium

The NSW Centre for Animal and Plant Biosecurity is an alliance between Industry & Investment NSW at Elizabeth MacArthur Agricultural Institute, the Faculty of Agriculture, Food and Natural Resources and the Faculty of Veterinary Science of the University of Sydney at Camden.

On 18 November 2009, the New South Wales Centre for Animal and Plant Health Symposium host an animal biosecurity symposium, Protecting Our Future: Delivering Biosecurity Research Solutions. The Symposium was opened by the Hon. Michael Veitch MLC (Parliamentary Secretary Assisting the Minister for Primary Industries), Dr Andrew Black (Director Research Development, University of Sydney) and Renata Brooks (Executive Director, Agriculture and Primary Industries, Science and Research, I&I NSW). Keynote addresses were provided by Dr. Mike Bond (Chief Executive Officer, Animal Health Australia), Dr. Mike Nunn (Principal Scientist, Biosecurity Australia), Prof Lyn Gilbert (Centre for Infectious Diseases, Westmead Hospital & University of Sydney) and Mr Nick Keatinge, a livestock producer. Sessions were then held covering *On-farm Biosecurity Research*, *New Disease Investigations* and *Delivering Biosecurity Solutions*.

Professor Ward was a member of the Symposium organizing committee, chaired one of the Symposium sessions, and presented a paper at the Symposium, *What role does wildlife play in emergency diseases? The case of the feral pig*.

The Symposium brought together many industry representatives, including:

- Animal Health Australia
- Commonwealth Department of Agriculture, Fisheries and Forestry
- Biosecurity Australia
- Industry & Investment NSW
- Meat and Livestock Australia
- Australian Centre for International Agricultural Research
- NSW Farmer's Federation

Issues relevant to veterinary public health were discussed, including training and capacity in emerging disease detection and diagnosis.

In conjunction with this Symposium, a PhD Scholarship Opportunity in Biosecurity Research was initiated. Some of the aims of this Scholarship were to foster collaboration between I&I NSW (EMAI) and The University of Sydney at Camden, and to promote capacity building in biosecurity research in NSW. The Scholarship is funded equally by I&I NSW and the Faculty of Veterinary Science, with operating funding to be provided by an existing project. An application by Dr. Peter Kirkland (Head of Virology, EMAI) and Prof. Ward was successful. This application, *Managing risk: Studies of the biology and epidemiology of bluetongue viruses and their vectors in NSW*, was based on a major project at EMAI to develop new diagnostic tools for the rapid identification of insect vectors and for the detection of bluetongue viruses, funded by Meat and Livestock Australia. In December following a search and interviews, a candidate was identified. Mr Matthew van der Saag (a USyd AVBS(Hons) graduate). This candidate enrolled in a PhD in Semester 1, 2011, and is being supervised by Prof Ward and Dr. Kirkland.

5 Success in Achieving Objectives

5.1 Established a new unit in Veterinary Public Health and Food Safety in the Faculty of Veterinary Science

With co-funding from Meat & Livestock Australia, a new unit in Veterinary Public Health and Food Safety in the Faculty of Veterinary Science was established in 2006.

5.2 Appointed a new Chair to lead the unit

Interviews for Chair, Veterinary Public Health and Food Safety were conducted in February 2007. Dr. Michael Ward, then Professor of Epidemiology within the College of Veterinary Medicine, Texas A&M University, was offered the position. Dr. Ward subsequently commenced employment in January 2008 and has led this new unit since that time.

5.3 Delivered broad outcomes for the red meat industry through research and training

Following appointment, Professor Ward has led, co-ordinated and managed the new unit in Veterinary Public Health and Food Safety, taking responsibility for research, training and advisory services. The major outcomes produced include:

- *Decreasing production costs*

  This project has decreased production costs by promotion of a risk-based approach to animal health. This ranges from research on animal diseases that allow the concept of zoning to be implemented (for example, in the case of an exotic disease outbreak such as foot-and-mouth disease or bluetongue disease) to research on foodborne animal pathogens (e.g. *Campylobacter* and *E.coli* O157) to modern meat inspection. Development of frameworks for emerging foodborne zoonoses and emergency animal disease prioritisation allows more efficient use of the limited national animal health budget.

- *Maintaining market access*

  A research program to address diseases and infections that specifically restrict market access for the red meat industry – or that have the potential to restrict access should they occur, in the case of exotic diseases – has been initiated. The program includes research on foot-and-mouth disease, bluetongue disease and *E.coli* O157. Funding for this program (> $2.7M) has been provided by MLA, the Australian Research Council, NSW Centre for Animal and Plant Biosecurity, Australian Pork Limited, Cattle Council and the Commonwealth Department of Agriculture, Fisheries and Forestry. Technical skills and capacity (e.g. disease spread modelling; spatial and geostatistical analysis; molecular epidemiology; diagnostic tests) has been enhanced. To date, this program has produced 54 papers in peer-reviewed journals and 12 conference presentations. In addition, a broader research program addressing other issues – such as equine influenza, rabies, economic framework for emergency disease and exotic disease prioiritisation – has also contributed to maintaining market access for the red meat industry by increasing the technical capacity of animal health

personnel in Australia. Overall, the program has been responsible for the training of 18 postgraduate students who collectively address a wide range of issues that affect market access.

- *Reducing risks of loss of export market access*

Studies on exotic diseases directly reduce the risks of loss of export market access by generating knowledge that will help the industry get 'back-to-business' should an exotic disease be introduced, or that provide confidence in our market integrity systems. Specifically, research of potential foot-and-mouth disease incursions has generated results that allows more effective surveillance for an FMD incursion, and provides guidance on the scope of sampling that would be needed should such an incursion occur. Research on methods to assess the economic impact of exotic disease permits industry and government to focus on those diseases posing the greatest risk to the industry. Endemic disease research (*E.coli* O157) is focused on producing information to improve disease control, one part of the strategy to maintain market access should our customers introduce more stringent import conditions for the importation of red meat products.

- *Increasing microbiological safety of product*

A generic framework for assessing an emerging animal disease as a food safety risk has been developed. This framework – when used in conjunction with other quality control procedures – aims to increase microbiological safety. Research on *E.coli* O157 is providing insights into why, when and how some cattle become supershedders; this has direct implications for food safety − if such animals can be removed from the food chain.

- *Advancing technology to maintain competitiveness*

Training has focused on exploring existing and new analytical techniques that can be applied to solve animal health issues. To this end, a range of workshops and continuing education opportunities have been presented in this project. These included logistic regression modelling, GIS/GPS and disease mapping, Bayesian approaches to diagnostic test evaluation, import risk assessment, and network analysis. These training initiatives place Australia at the global forefront in epidemiology and public health. They have resulted in a large body of published work (54 peer-reviewed papers) and requests to present at 19 national and international meetings (South Africa, United States, Indonesia). Continuing education initiatives are supported by an established coursework training program, the Masters of Veterinary Public Health Management program. Within this program (50 graduates to date), advanced topics directly relevant to the competitiveness of the Australian red meat industry – for example risk assessement, food safety, epidemiology, policy, hazards, and animal health economics – have been integrated. Finally, the third tier of education initiatives to maintain competitiveness is focused on undergraduate training. The concepts of emerging diseases, outbreak investigation, disease control and surveillance and monitoring have been integrated within veterinary and bioscience curricula. Within this project, undergraduate teaching (veterinary and bioscience degrees) has been revitalised to produce graduates with the skills, knowledge and confidence to address current and future industry needs in veterinary public health.

- *Promoting research activity*

P.PSH.0194 has directly promoted research to the value of >$2.7M (a return on investment of >2.5-fold). It has resulted in the creating and recruitment of a new permanent faculty position in Food Security and postdoctoral positions (food safety, biosecurity, exotic disease preparedness). Research activities have generated 54 peer-reviewed published papers, 12 conference proceedings, 33 scientific abstracts and 19 invited presentations. Research network meetings have been held within the University of Sydney Biosecurity Program and the Sydney Emerging Infections and Biosecurity Institute to explore new research based on a One Health approach.

- *Educating to increase human resource capacity*

Capacity has been increased in both the fields of veterinary science and animal bioscience at the undergraduate and postgraduate level. This has been achieved by incorporating material into the curricula of the BVSc and AnVetBioSc degree programs (epidemiology, emerging diseases, outbreak investigation, disease control, surveillance), and the MVPHMgt program, and by training postgraduate students. The MVPHMgt program has been consolidated as a world class online program for advanced training in veterinary public health. During this project, 18 research postgraduate students have been recruited and trained in epidemiology and veterinary public health. They have investigated a range of topics of direct relevance to the red meat industry, such as emerging zoonoses, exotic disease prioritisation and preparedness, economic evaluation and surveillance. This cohort of students would not exist without the successful completion of this project.

- *Advocacy*

A series of public presentations (both national and international) has been given during this project. Advocacy has been achieved via the Australian Veterinary Association and the Australian College of Veterinary Science, and via the Sydney Emerging Infections and Biosecurity Institute conferences and workshops and the group's Board of Management. Another forum has been the Public Health University Network (PHUN). These have maintained a high profile for the red meat industry. Meetings and discussions on current issues – for example, antimicrobial resistance and food security – have been organised and presented. This project has enhanced the ability and reputation of the Australian red meat sector to develop and implement an animal health program via membership of scientific review panels in Australia, the United States and the European Union, promotion panels, external reviewer of PhD students and Faculty promotion roles, conference and short course facilitation, editorship of *Preventive Veterinary Medicine* and other scientific journal editorial board memberships.

- *Change management and planning for future change*

A one-day forum of more than 50 industry, government, academic and interest-group representatives was held in 2011. This workshop produced a roadmap for the future direction of Veterinary Public Health in Australia. It will have a lasting impact on the meat and livestock industry by facilitating change from primarily a government-driven veterinary public health program that has been in place from the 1950s to a modern industry-government-academic partnership.

6 Impact on Meat and Livestock Industry

This MLA project has immediately benefited the industry via improved training of undergraduate veterinary and bioscience students to recognise and address industry issues, the training and mentoring of a large group of postgraduate students who will continue to work in animal health in this country, and the creation of local and international networks to benefit the industry and its attempts to maintain market competitiveness. The beneficiaries of this MLA project are livestock producers, processors and associated interests throughout Australia.

A key strategy for creating an impact in this project was to *convene a workshop of stakeholders to identify what attributes graduating veterinarians should possess to meet the challenges posed by Veterinary Public Health in the 21st Century.*

A range of industry (e.g. MLA, AHA), government (including state DPIs, DAFF, ACIAR) and private (e.g. conservation societies) organisations seek graduates with excellent problem-solving and leadership skills. Providing a forum for such organisations to help us determine the type of attributes our future veterinarians should possess will help ensure that those graduates are successful. An added benefit is that these organisations would begin to identify with the B.V.Sc. curriculum and feel some responsibility for its success.

The workshop took a strategic perspective and asked three critical questions:

- where are we now?
- where do we want to be in 5-10 years time?
- how do we fill in the gaps?

Desired outcomes from this forum included:

- maintenance of the international accreditation status of the University of Sydney B.V.Sc. qualification
- improved career opportunities both in Australia and overseas for our graduates
- increase the reputation of the Faculty as the premiere location for training in Veterinary Public Health and related disciplines.

The Veterinary Public Forum was held at Camden on 8 March, 2011. Participants (51 in total) represented government (Commonwealth Dept. of Agriculture, Fisheries and Forestry, Australian Quarantine & Inspection Service, Australian Pesticides and Veterinary Medicines Authority, DPI Victoria, NSW Industry & Investment, NSW Health–Communicable Diseases, Primary Industries South Australia), industry (Australian Health Australia, Australian Veterinary Association, Meat & Livestock Australia, NSW Livestock Health and Pest Authority) and Schools of Veterinary Science (Sydney, James Cook, Adelaide, Melbourne and Queensland). Several private consultants also participated in the Forum. The Forum was facilitated by Dr. Lisa Adams.

The Forum was opened by Rosanne Taylor, Dean of Veterinary Science. Session 1 consisted of Scene Setting - short presentations with questions and answers. Topics included what is the scope of veterinary public health, how is it changing, and what do we need to consider for determining actions for shaping Veterinary Public Health (capacity and outcomes) over the coming decade. Mike Nunn (Dept. of Agriculture, Fisheries and Forestry) gave the government's perspective, Ian Jenson (Meat & Livestock Australia) the industry's perspective, and Michael Ward a global perspective. Richard Whittington and Jenny-Ann Toribio gave the academic perspective, providing background to initiatives in both postgraduate (VPHMgt) and undergraduate education.

Session 2 focused on Future Needs. Groups of 6-8 people were created to represent the interests and perspectives of government, industry, universities and communities. The groups were posed the following questions,

1. How does the world look now? What issues do we confront?
2. What is behind the changes we are seeing? What trends and drivers can we identify?
3. What are the unknowns? What questions need answering to enable good decisions about the future?

The final session, Where to from here – Identifying future scenarios and strategies, consisted of a variety of approaches to identifying capacity building needs in Veterinary Public Health and potential solutions. The Forum concluded with a panel discussion.

Some of the immediate challenges identified include:

- a need to define Veterinary Public Health and its scope;
- promotion and advocacy of what has been achieved for the public good and veterinary public health as an insurance policy for government and society;
- the need to demonstrate the value of veterinary public health, in real terms;
- a need to make Veterinary Public Health open and accessible (not just a vet's club); and
- and identifying who should lead further discussions.

The following recommendations were made:

1. That veterinary public health is defined – from an operational perspective – as animal health activities undertaken with the aim of improving the health of human communities.

2. That one or more national organisations or agencies take leadership of strategic planning and capacity in Veterinary Public Health.

3. That the benefits of veterinary public health be clearly defined, in economic, social and scientific terms.

4. That veterinary public health is promoted as a public good at all levels of government, industry and academia.

5. That Australia's capacity in veterinary public health is strengthened primarily through the development and maintenance of postgraduate education opportunities funded through a joint mechanism of government, industry, academia and user-pays.

This forum provided a roadmap for veterinary public health development within Australia to benefit industry and society. It will have a lasting impact on the meat and livestock industry.

Another tangible impact of this project is Professor Ward's participation in the MLA Scientific Risk Management Panel. This group of food safety experts has provided advice to MLA on a range of issues that can adversely affect market access, including including pathogenic *E. coli* detection and control, *Listeria*, Codex developments, antimicrobial resistance, emerging pathogens [*Toxoplasma*, *M.paratuberculosis*, *C.difficile*, MRSA], and risk profiling. The Scientific Risk Management Panel was also used as a group of experts to modify and validate the risk assessment model developed as part

of the MLA funded project, *Risk Assessment: animal diseases as they relate to food safety* was presented and the project was further developed.

Professor Ward has participated in MLA-led initiatives such as those to address potential food safety risks from Ovine Johne's Disease, and modern meat inspection standards. He was an invited member of a group of 28 experts (microbiology, epidemiology, biostatistics, diagnosticians, pharmacologists, and production animal medicine) that developed the CONSORT (Consolidated Standards of Reporting Trials) Statement, to improve the quality of reporting for therapeutic, preventive & food safety intervention studies in livestock. This document was subsequently published concurrently in 5 international journals.

7 Conclusions and Recommendations

7.1 Conclusions

A new unit in Veterinary Public Health has been established within the Faculty of Veterinary Science at The University of Sydney for the benefit of the red meat sector. Within a short 4 year period this unit has produce substantial outcomes and achieved some important milestones. A core group of expertise now exists and a growing number of graduates have received training in veterinary public health, to the immediate benefit of the red meat sector. Many challenges remain, such as the abattoir experience for undergraduates, and support for postgraduate research projects. However, human capacity now exists to achieve further progress to the benefit of the sector.

7.2 Recommendations

7.2.1 Support for Research and Experimental Projects

It is recommended that MLA – in partnership with the Faculty of Veterinary Science − seek industry support for continued investment in training and research in veterinary public health and food safety via specific research and experiential projects that deliver immediate outcomes to the industry and support the development of human capital – graduates and postgraduates with highly developed skills in veterinary public health.

7.2.2 Promotion of Veterinary Public Health as a Public Good

The World Animal Health Organization (OIE) during the past 4 years has promoted the concept of veterinary public health as a public good. It is recommended that MLA – together with other agencies and organisations – develop a strategy to promote the public good of veterinary public health.

7.2.3 Prioritisation of Animal Health Issues

A range of issues constantly emerge that have the potential to threaten the competitiveness of the red meat industry. Industry can respond to each of these issues, but this is not an efficient approach. Rather, prioritisation of emerging issues in terms of their likelihood of causing disruption and their impact offer a method of keeping ahead of these issues. It is recommended that MLA invest more in developing and assessing methods to anticipate the risk to the red meat sector posed by emerging disease issues.