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Strategic R&D Priorities

TSE Inactivation and
Management of
Bovine Specified Risk Material



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Thanks...

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Report Orientation

This report is targeted at investors in Alberta's public and private R&D sector. Recommendations are given to address the destruction and disposal of specified risk material (SRM) generated from livestock (primarily cattle) carcasses.

Additional information is provided in a more detailed *Background* section and *Detailed Analysis*. Three appendices supplement this information with a relevant and up-to-date bibliography of peer-reviewed papers, patent filings that address the SRM issue and a comparison of CFIA and AAFRD cost estimates of the proposed regulation of an enhanced feed ban.

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Executive Summary

Standard North American rendering methods do not effectively destroy transmissible spongiform encephalopathy (TSE) infectivity in components of livestock carcasses referred to as specified risk material (SRM). The rendering process itself converts an estimated 75,000 MT of raw bovine SRM produced in Alberta annually into approximately 19,000 MT of meat and bone meal and 16,000 MT of tallow. Protein-free SRM tallow will most likely continue to flow into existing markets, however, protein-rich SRM meat and bone meal will probably be regulated for strict containment or destruction once new CFIA regulations take effect in Spring or Summer 2005. Alberta Agriculture, Food and Rural Development (AAFRD) estimates a resulting \$3 million loss in terms of unrealized sales of SRM meat and bone meal as well as containment and destruction costs.

A \$3 million loss is small relative to the size of the industry, however, the presence of raw and rendered SRM creates a number of related public, industry and scientific concerns. While landfilling SRM would account for only 1% of total capacity in approved facilities, public acceptance and contamination concerns emerge under this scenario. Meat processing and rendering companies are likely to be interested in in-house or integrated SRM management solutions.

Fortunately, intensive patenting activity (Appendix II) indicates a drive towards commercial solutions addressing TSE containment, detection, and destruction or inactivation. These developments remain constrained by a lack of critical understanding of the underlying mechanisms involved in the protein-folding phenomenon.

Destruction or inactivation of prions is used as the first indicator that TSE infectivity has been destroyed. Scientific proof of inactivation is achieved through infectivity testing where lab rodents are exposed intercerebrally to test samples followed by a 180- to 250-day incubation period where potential symptoms of the disease and overall health status of the animals are monitored.

In the short to medium term, expanded capacity for rodent bioassay experimentation (i.e. infectivity analysis) is required to handle a backlog of work in assessing TSE infectivity and inactivation applied to various scenarios and inactivating technologies. A partnership approach with existing large capacity facilities (primarily located in the United States or UK) could be applied in infectivity analysis where Alberta possesses expertise, namely, in surrogate and mathematical infectivity modeling.

Limited capacity in TSE infectivity analysis constrains progress in SRM and broader TSE and prion-related R&D. Surrogate approaches to studying prions use proteins with similar properties to normal and misfolded prion proteins for research purposes and can dramatically reduce costs and provide more rapid and pervasive testing and analysis,

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overcoming a lack of BSE infected material available for R&D. Results from surrogate analysis will require confirmation with conventional rodent experimentation.

Enhanced capacity to detect and evaluate infectivity is necessary in analyzing the presence of TSE in various environments such as in landfills, wastewater, soil and industrial facilities. Funding and research partnerships with groups that have already conducted infectivity and transmission studies (e.g., the Rocky Mountain Laboratory in Montana) should lead to more effective R&D outcomes in this area.

Currently, there are two SRM disposal technologies that have been scientifically validated for their capacity to inactivate TSE-infected material: incineration and alkaline hydrolysis. Standard incineration processes applied in power plants, waste incineration facilities and in cement kilns take advantage of the fact that SRM has 60% to 75% of the energy efficiency (BTU capacity) of coal. Under proposed CFIA regulations, the residual ash of incinerated SRM will probably require special handling. However, when SRM is incinerated in a cement kiln, the residual ash is safely incorporated into the final product.

Other incineration approaches to TSE inactivation involve conversion of SRM waste to energy rich fuels in a high-temperature chamber with limited oxygen (gasification) or no oxygen (pyrolysis). These approaches are deemed acceptable as they subject waste materials to temperature in excess of the European Union requirement of 850° C for SRM decontamination. At present, standard incineration is a more proven technology than gasification and pyrolysis. As with many emerging technologies, early industrial models suffer from limited volume capacity which in turn leads to higher unit costs of operation.

Alkaline hydrolysis is a process where temperature, pressure and alkali (pH 14) are combined to destroy TSE-infectivity. The six-hour process is effective at eliminating infectivity, but requires considerable energy input, involves highly caustic materials, and has a limited capacity to handle large volumes of material. The end product is suitable for use in biogas production; the possibility exists for bio-fertilizer production, however, future regulations may preclude this option.

Other TSE inactivating technologies requiring scientific verification are at various stages of development. Thermal hydrolysis involves an application of heat, pressure and time and is currently being tested with results due in possibly five to eight months. An Alberta company¹ has developed a prototype thermal hydrolysis model and hopes to scale up to a pilot plant version in the near future. Other promising TSE inactivating technologies include composting, a UHT sterilization process, and enzymatic degradation. A favourable aspect of these technologies is their scale-up capacity relevant to larger volume (i.e., real world) scenarios. It is worth noting that enzymatic degradation expertise exists in the Alberta context.

¹Biosphere/Biorefinex Technologies Inc., www.biorefinex.com

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In managing the SRM issue, different regions of the province may require different technology solutions given variances in industry concentration, distance factors, etc. Furthermore, the nature of the feedstock requirements for any inactivation technology will have economic implications. If, for example, the feedstock for a particular TSE inactivation technology is raw SRM, then capturing the value of tallow extracted in the rendering process is precluded. Economic implications arise on account of variation in weight, moisture content, spoilage and ease of handling of raw versus rendered feedstock materials along with the traditional role renderers have served as collectors and processors of the raw byproducts.

A spatial economic model with input from key industry players could address the socio-economic and logistical implications of the various SRM management options. A flexible model would incorporate feedstock, regulatory constraints and technology frontier variables, focusing on proven or promising technology solutions. (Some of the necessary cost data has already been estimated in a U.S. report on carcass disposal².)

In brief, R&D is essential in moving towards a solution to the SRM problem. Basic science has not been exploited to the point where applied research and technology solutions are vastly accelerated. In the mean time, cement kilns in Europe are the most widely applied technology solution and may provide a benchmark for alternate technologies. When a rendering process is applied prior to incineration, the value of SRM tallow is captured. Narrow profit margins in the agriculture and food sector call for low cost or net value-creating R&D solutions.

² Carcass Disposal: A Comprehensive Review. August 2004. National Agricultural Biosecurity Center Consortium, Carcass Disposal Working Group.

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1. Report Objectives

Specified risk material (SRM) for cattle is tissue that potentially harbours BSE-infectivity. This report examines R&D challenges and opportunities of inactivating and potentially deriving commercial value from SRMs in Alberta. The issue is reviewed from an economic perspective prior to examining implications for technology commercialization and basic and applied R&D. The objective of this report is to provide informed input to the funding of SRM-related research. A secondary objective to generate debate and supplementary information regarding important future R&D work has been adopted in order to revise and improve upon material presented in this report.

2. Briefing

Bovine SRM describes the parts of slaughtered cattle associated with Bovine Spongiform Encephalopathy (BSE) infectivity. The historical practice of feeding cattle with meat and bone meal (MBM) from rendered ruminant SRMs has been widely regarded as the key route of infectivity underpinning Britain's BSE crisis where an estimated one to two million cows were infected with the disease. For industry and consumers alike, the goal becomes one of reducing risks by containing and destroying infectivity at the top of the food chain.

Since the early 1980s, basic research has contributed to our current understanding of the role of mis-folded or pathogenic prion protein in transmissible spongiform encephalopathies (TSEs) such as BSE, scrapie, CWD (chronic wasting disease) and human spongiform encephalopathy strains (e.g., fatal familial insomnia, CJD and vCJD). While basic research on prions and TSE infectivity has progressed in many ways, many desired R&D outcomes remain outstanding. The most obvious example, in spite of massive public and private funding, is the failure of numerous attempts to develop a live animal test. Clearly, progress on the applied research front is constrained by gaps in our basic understanding of prion biology and TSE infectivity. These gaps are perpetuated in part because of the lengthy incubation period for TSEs, the relative newness of the protein folding concept itself and implicated factors, technical difficulties of experimentation, and the resultant high cost of prion and TSE-related research.

Recent R&D work has culminated in the development of several TSE inactivation technologies that are promising or, in some cases, have been validated for their TSE inactivation efficacy. From age-old incineration to more recent methods such as alkaline hydrolysis, the technology to inactivate prions exists and is in a state of refinement. In the European context, SRMs are generally rendered and then incinerated, often in cement plants where they offer a fuel source that is 60 to 75% as efficient as coal with the ash generated in the process safely incorporated into the end product. Other technologies convert SRMs into biodigester input material, bio-diesel fuel, fertilizer, etc.

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Thin profit margins associated with animal byproducts suggests that economics will play an important role in defining future approaches to managing the SRM issue. Regulations and government policies will also impact the fate of SRMs. Efficiently and effectively addressing the SRM issue in this context gives rise to a number of R&D challenges.

3. Implications/Recommendations

1. Economic analyses should be conducted on validated or near-validated inactivation technologies. Costs have been estimated, notably in a U.S. report on carcass disposal³. A detailed economic analysis specific to the Alberta context could be an initial step in working towards an efficient solution to SRM disposal and destruction. Such a study would need to account for variables such as existing and projected costs and revenues, regulatory constraints, regional SRM volumes and the spatial location of rendering facilities, packing plants, feedlots, landfills, incinerators, etc.
2. In the short term, expanded capacity for rodent bioassay experimentation (i.e. mouse infectivity) is required to handle the backlog of work in assessing lower and upper limits of TSE infectivity and inactivation applying various scenarios and technologies. Funds directed to strategic partners operating well-established rodent experimental facilities could enhance validation of unproven TSE destruction technologies and provide opportunities to further develop surrogate and mathematical models with parallel rodent infectivity experimentation (an area of expertise for Alberta).
3. The limited understanding of TSE infectivity in the various environments, such as in landfills and wastewater, calls for directed detection and inactivation work in select media. Funding and research partnerships with groups that have already conducted infectivity and transmission studies (e.g., the Rocky Mountain Laboratory in Montana) could lead to more effective R&D outcomes.
4. Through Alberta-based efforts, pre-commercial TSE inactivation technologies have been developed. Given the benefits of maintaining local expertise (and localizing economic development with a rural development focus), consideration could be given to developing creative support mechanisms for targeted early stage commercial enterprise.
5. Novel areas of TSE inactivation should be monitored, including enzymatic degradation processes, composting and applied work involving UHT sterilization.
6. For the SRM issue, regulations will greatly impact the value of various types of R&D work. For example, SRM tallow will not likely be banned from existing marketable uses, limiting the value of R&D work in that area. The regulatory environment is unlikely to allow SRM to enter the animal feed chain in the foreseeable future. Even fertilizers developed from SRM disposal and destruction technologies appear to be disallowed if proposed regulations are enacted in Spring

³ Carcass Disposal: A Comprehensive Review. August 2004. National Agricultural Biosecurity Center Consortium, Carcass Disposal Working Group.

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2005. Research involving TSE inactivation for food/feed purposes will likely be redundant until the regulatory environment changes.

4. Summary Analyses

4.1 Economics⁴

Volume

Alberta is estimated to produce 74,000 tonnes per year of raw SRM including dead stock. This generates 19,000 tonnes of meat and bone meal (MBM) and 16,000 tonnes of tallow. Only the MBM will likely legislatively require destruction or containment. On average, MBM from SRMs accounts for 12% of the total bovine MBM generated from the rendering process. Following the rendering of bovine SRM in Alberta, the resulting MBM could be incinerated, treated with various TSE inactivating technologies, or shipped to designated landfills where the total volume would amount to approximately 1% of the 2.2 million tonnes of solid waste that went to Alberta municipal landfills in 2002.

Costs

The banning of MBM from SRMs and dead stock will incur costs and benefits. This analysis considers only the costs due to the lost sale value of the MBM and cost to destroy or contain it. The annual lost market value of the MBM is estimated at \$2 M. If destruction or containment of the MBM cost \$50/tonne, this would result in an annual cost of \$0.9 M. This estimate is consistent with the cost of landfilling the material (including transport). The actual cost of destruction or containment will depend on the method of disposal. The lost sales value and destruction or containment cost can also be calculated on a per head basis, which varies on the class of bovine. For example, the cost varies from \$0.56 per animal under 30 months slaughtered in a federal plant, to a maximum of \$25 for a dead mature bovine.

Alternate technologies employ applications of heat, moisture, alkaline, pressure and time (see *Technology Commercialization* below) to reduce or eliminate prion infectivity. The value of output materials will depend on the technology employed. The most economical approach to managing the SRM problem may involve single or multiple technologies depending on regional variations in SRM volumes, cost and price factors, distance to treatment/containment facilities, technology developments and regulatory parameters.

CFIA has estimated that recent amendments to animal feeding regulations, essentially amounting to a full ban on all bovine SRM-derived MBM, would cost Canadian industry between \$20 to \$27 million annually. An estimated one-third of this amount would be lost in Alberta (see *Appendix III* for more details).

4. Includes summary of material provided by Dr. Brian Radke, Economics Unit, AAFRD.

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4.2 Technology Commercialization⁵

In Europe, the bulk of bovine SRM is first rendered and then incinerated. The EU approved rendering process for potentially TSE-infective material involves an application of 133°C and 3 atmospheres (43.5 psi) for 20 minutes. The procedure reduces TSE-infectivity 1000-fold. Lower temperatures and continuous rendering processes generally applied in North America may serve to enhance the protein quality and reduce odors, however, they appear to be unsuccessful at effectively reducing TSE infectivity. Researching the efficacy of combining North American-style rendering with alternate TSE-inactivation technologies is cited as a research priority in a recent Kansas State publication on carcass disposal.⁶

In Ireland in late 2003, an agency looking at disposal options for MBM⁷ concluded that co-incineration of MBM by the cement manufacturing industry was the most practical recovery outlet. EU regulations have established minimum temperatures for incineration of SRMs at 850°C. Cement kilns operate in excess of 2000°C. The rendered meal provides a substitute fuel for cement kilns, with the resultant ash incorporated into the final product. Two waste management facilities, various power plants, or two cement kilns located in Alberta could be adapted to incinerate the volume of SRM produced in Alberta. A mobile incineration unit known as an air curtain burner could be employed in select or remote sites, providing that the incineration temperature within the burner is maintained at or above 850 C when burning SRMs.

Alternate TSE inactivation technologies include alkaline hydrolysis, thermal depolymerization and pyrolysis/gasification. Alkaline hydrolysis involving a combination of temperature, pressure and alkali to inactivate TSE infectivity has been demonstrated to be effective, however cost and handling concerns may limit the application of this technology. Thermal depolymerization is an extreme heat and pressure technology that converts fats, bones, cartilage and other wastes into diesel oils, gases, fertilizers and specialty chemicals. Pyrolysis and gasification technologies are both capable of producing valuable end products including combustible materials and high calorific value oil. Combustible products are generally derived from materials that can otherwise be converted into tallow in the rendering phase. Although these technologies provide a variety of end-products, the value of these will be dependent upon the proposed regulations regarding the use of SRM.

An additional inactivation technology at a pre-commercial state in Alberta is thermal hydrolysis. Alberta-based Biosphere/Biorefinex Technologies Inc., in conjunction with

5. Includes summary of input provided by Nancy Facklam, M.Sc.

6. Carcass Disposal: A Comprehensive Review. August 2004. National Agricultural Biosecurity Center Consortium, Carcass Disposal Working Group.

7. Report of Inter-Departmental/Agency Committee on Disposal Options for Meat and Bone Meal

(<http://www.agriculture.gov.ie/publicat/mbm/Toc55725200>)

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Kinetic Process Systems Ltd., have developed a high pressure, high temperature saturated steam reactor vessel that appears capable of reducing TSE infectivity beyond measures currently required by EU regulations. Valued outputs derived from this technology include a methane feedstock for anaerobic bio-digesters (for generation of electricity or heat).

Other technologies such as enzymatic degradation and composting are still generally confined to early stage exploration and are discussed in the following section on Basic Science.

4.3 Basic Science⁸

Basic science of prions and TSE infectivity has advanced fairly dramatically since the concept of prion folding emerged in the early 1980s. Ongoing gaps in our basic understanding of the disease limit advancement of successful applied research in areas such as live animal diagnosis, therapeutics, pathogenesis, etiology, etc. Fortunately many countries are collaborating to advance R&D capacity. The opportunity exists for Alberta to join an increasing global research community in a results or outcome driven manner.

Basic research has allowed a number of inactivation technologies to progress to the point of pre-commercial or commercial status by validation using a rodent bioassay system (monitoring animals for 180 – 250 days). At present, the rodent (normally hamster or mouse) model is the only proven quantitative testing methodology, however new methods such as surrogate analysis and tissue culture are emerging and may someday allow for less expensive and more rapid testing. Initially, these methods will need to be tested and validated in conjunction with the existing or transgenic (e.g., bovinized mouse) animal models. The importance of the rodent model, as a final validation method, will likely remain intact for years to come on account of its high degree of sensitivity and selectivity.

Currently, very limited experimentation is undertaken in validating inactivation technologies because of the time, financial requirements of rodent assay validation experiments, and the impracticality of testing large-scale industrial systems with infectious TSE material. In most cases, TSE inactivation research related to the SRM issue has focused on re-engineering industrial-scale systems down to bench-scale replicas. As bench-top or scaled down models of larger industrial systems are taken through the testing phase, engineering flaws may emerge as a result of variables that are difficult to predict. Assessing TSE inactivation technologies relevant to the SRM issue could be better evaluated through multiple testing approaches.

Basic R&D has recently examined opportunities of new inactivation methodologies involving enzymatic degradation. Whether through simple composting research currently

8. Includes summary of input provided by Dr. Norm Neuman (University of Calgary), Dr. Bob Rohwer (University of Maryland) and Dr. David Taylor (Sedecon 2000).

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conducted in Canada or through advanced work on prion degrading enzymes, new opportunities may emerge to commercialize increasing economical and effective inactivation technologies.

5. Additional Background

The internal components of slaughtered cattle that do not end up on grocery shelves or in restaurants are typically sent for rendering. Renderers turn this material primarily into tallow and meat and bone meal (MBM). Tallow is primarily used in manufacturing soap, candles and lubricants, while MBM is used primarily for animal feed. In general, the rendering industry has evolved into a low margin industry dominated by a few very large-scale companies that effectively create value out of animal waste that would otherwise be destroyed or shipped to landfills.

Rendered material includes protein-rich MBM and protein-free tallow that presents negligible BSE-related risk. Research informs us that conventional rendering processes do not effectively destroy or inactivate prions, believed to be the infective agent of BSE and other transmissible spongiform encephalopathies (TSEs).

Since 1997, the Canadian Food Inspection Agency (CFIA) has banned the feeding of cattle and other ruminants with protein products derived from mammals other than pigs and horses (excepting those derived from milk or blood). Current CFIA regulations permit rendered bovine SRM to be used as feed for non-bovine animals (e.g., pets, chicken, pigs). In December 2004, CFIA proposed amendments calling for an extension of the ban to include all animal feed, pet food and fertilizer. Also under the proposed regulations, fallen or dead stock (i.e., cattle that die in the field, feedlot or in transit) and downers (i.e., cattle that are unable to walk) are classified as SRM. Under the proposed draft, no permits will be required for SRM or dead stock as long as they remain on the farm of origin. Off-farm dead stock could be issued a permit “for disposal of SRM if it were through incineration or another method that would ensure the SRM or carcass would not be used as food for humans or animals and would not enter the environment in such a way that it could contaminate any water or food supply”⁹. A 75-day comment period, ending February 24, 2005, has been issued by the CFIA.

The skull, brain, trigeminal ganglia (nerve cells connected to the brain), eyes, tonsils, spinal cord, dorsal root ganglia (nerve cells connected to the spinal cord) and the distal ileum (part of small intestine) from cattle over 30 months of age are regarded as SRM. For cattle under 30 months, only the distal ileum is labeled SRM. In the future, cattle over 30 months of age—i.e., dead stock and downers—may fall under the SRM banner as well. Dead stock and downer SRM refers to the whole animal carcass. At present, the EU regards all materials that were previously sent for rendering as SRM.

⁹ CFIA: <http://www.inspection.gc.ca/english/corpaffr/newcom/2004/20041210bge.shtml>

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The anticipated volume expansion of bovine SRM that must be diverted from the animal feed and agri-industrial product channels in Alberta creates economic and managerial concerns. Producers, packers, renderers and consumers could be adversely impacted based on increased segregation, handling and destruction costs as well as the loss of protein-based value from the supply chain. As SRMs have been linked to TSE infectivity, at issue is the economically viable and socially acceptable inactivation of TSEs through advances in basic and applied research and technology commercialization.

Basic R&D involves the observation, measurement and prediction of TSE infectivity and inactivation. Applied R&D employs these factors in developing and evaluating various inactivation methodologies. Technology commercialization is the next step in the development continuum involving scaled-down prototypes to industry-ready inactivation technologies. An exhaustive array of regulatory and procedural challenges and the need to entice investors to be involved in a potentially risky enterprise confounds the commercialization process.

6. Detailed Assessments

6.1 Economic Cost of Banning Specified Risk Materials in Alberta

Brian Radke, DVM, Ph.D., Economics Unit, AAFRD

The following table estimates the economic cost of banning the sale of byproducts, produced from specified risk materials (SRMs) and dead stock, as ingredients for animal feed (Table 6.1). In calculating the cost, the lost sales value of the banned byproducts and the cost of disposing of the banned material are considered. For a detailed explanation regarding the discrepancies between the federal and provincial cost estimates, see Appendix III.

The left side of the spreadsheet estimates the weight of raw SRM and byproducts, and the cost of banning those products on a per head basis for animals of different ages (less than or greater than 30 months), slaughtered in plants with different accreditation (provincial or federal). It also includes the weights and costs associated with dead stock. The weights and costs for banning meat and bone meal (MBM) and tallow are presented separately and then totaled. A generic disposal cost of \$50/tonne (including transportation cost) is used in the analysis. The actual cost of disposal will depend on the method of disposal. For example, Alberta landfills are estimated to charge between \$10 and \$35/tonne of MBM, and transportation costs are estimated to range between \$18 and \$30 to haul a tonne of MBM 100 km.

The Total Cost line on the lower left estimates the cost per head the renderer would extract from the slaughter house or dead stock owner to compensate for the lost sales value of tallow and/or MBM and associated disposal costs. For example, if MBM from SRMs was banned and required disposal, the renderers would charge federally accredited slaughter houses \$0.56/head. Dead stock owners would pay an extra \$22.88/head to have their animals rendered. Below this line, this cost is presented as the amount the renderer

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would charge per kg of raw material. If MBM from SRMs was banned, this analysis suggests the renderers would charge an extra \$0.04 for every kilogram of raw SRM it processed. Although the renderer would extract these costs for slaughter cattle from the respective plant, it is expected that these costs would be passed back to the cow-calf producer in the form of lower bid prices for the slaughter animals.

The right side of the spreadsheet presents the same information but on an annual population basis which is derived by multiplying the weight or cost per head by the number of head in each category. The number of dead stock that are rendered is difficult to ascertain or predict for the future. This number declines as the charge to the farmer increases. However, if policies for on farm disposal of cattle carcasses were to become more onerous the number of animals rendered would increase. The annual volume of MBM generated from SRM and dead stock is estimated at approximately 19,000 tonnes. This represents less than 1% of the 2.2 million tonnes of solid waste that went to Alberta municipal landfills in 2002. This weight of MBM from SRMs represents 12% of the total bovine MBM generated from Alberta cattle.

This analysis suggests if the MBM produced from SRMs and dead stock was banned and required disposal it would cost renderers approximately \$3 million a year which could be passed back to the animal owners by charging \$0.04 for every kilogram of raw SRM rendered. The \$50/tonne disposal cost equates to a total disposal cost of approximately one-third of the total cost (i.e., \$1 million). A disposal cost of \$100/tonne would add an additional \$1 million to the provincial cost of banning MBM produced from SRMs. Including tallow in the ban would increase the annual cost by \$6 million.

This analysis does not consider various other benefits and costs of banning byproducts from SRMs and dead stock. For example, the benefit of maintained or increased consumer support for the cattle industry as a result of any ban has not been factored into this analysis. This analysis does not extend beyond renderers in the supply chain. For example, the industries that purchased byproducts produced from SRMs and dead stock will need to substitute this material with alternatives which will likely be more expensive. Potential alternative substitutes include byproducts (i.e., MBM) not produced from SRMs or dead stock. As the demand for this MBM or tallow not produced from SRMs and or dead stock increases, these byproduct prices will likely increase. Neither the increase cost to the purchaser, nor the increase benefit to the renderer is included in this analysis. This analysis assumes that all the estimated weights of raw SRM and dead stock are currently being rendered and the byproducts sold. If raw product is being directly disposed of, this analysis overestimates the costs. The cost estimated in this analysis due to banning byproducts from SRMs and dead stock are expected to be largely borne by cow-calf producers. Then these cost estimates are overestimated to the degree that the livestock slaughtered in Alberta were originally sourced from outside of Alberta.

Alberta producers are paid up to \$225 to have eligible animals sampled under the government BSE surveillance programs. Carcasses can be disposed, including rendered,

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after testing negative. This revenue to producers that offsets the costs of carcass disposal is not included in this analysis

Table 5.1

Cost of SRM & Deadstock Feed Ban

PER HEAD

Plant type	Age of animal (months)			Dead	
	<30	Prov.	Fed		>30
Raw SRM Weight (kg/hd)	14	110	40	140	550
Rendered Weight (kg/hd)	7.0	55.0	20.0	70.0	302.5
Water	3.5	27.5	10.0	35.0	99.0
Tallow	3.5	27.5	10.0	35.0	143.0
Meals	7.0	55.0	20.0	70.0	242.0
T + M					

Sales Value (\$/tonne)					
Tallow	\$ 1.12	\$ 8.80	\$ 3.20	\$ 11.20	\$ 31.68
Meals	\$ 0.39	\$ 3.03	\$ 1.10	\$ 3.85	\$ 15.73
Lost Rendered Sales	\$ 1.51	\$ 11.83	\$ 4.30	\$ 15.05	\$ 47.41
Disposal (\$/tonne)					
Tallow	\$ 0.18	\$ 1.38	\$ 0.50	\$ 1.75	\$ 4.95
Meals	\$ 0.18	\$ 1.38	\$ 0.50	\$ 1.75	\$ 7.15
Total Disposal Cost	\$ 0.35	\$ 2.75	\$ 1.00	\$ 3.50	\$ 12.10
Total Cost (\$/tonne)	\$ 1.30	\$ 10.18	\$ 3.70	\$ 12.95	\$ 36.63
Tallow	\$ 0.56	\$ 4.40	\$ 1.60	\$ 5.60	\$ 22.88
Meals	\$ 1.86	\$ 14.58	\$ 5.30	\$ 18.55	\$ 59.51
TOTAL COST					

Total cost/kg raw material					
MBM	\$ 0.04	\$ 0.04	\$ 0.04	\$ 0.04	\$ 0.04
Total	\$ 0.13	\$ 0.13	\$ 0.13	\$ 0.13	\$ 0.11

POPULATION

Plant type	Age of animal (months)			Dead	
	<30	Prov.	Fed		>30
Number (hd)	2,100,000	30,000	230,000	6,000	56,000
(tonnes)	29,400	3,300	9,200	840	30,800
Rendered Weight (tonnes)					
Tallow	7,350	825	2,300	210	5,544
Meals	7,350	825	2,300	210	8,008
T + M	14,700.0	1,650.0	4,600.0	420.0	13,552
Totals					
	2,422,000				73,540

Sales Value					
Tallow	\$ 2,352,000	\$ 264,000	\$ 736,000	\$ 67,200	\$ 1,774,080
Meals	\$ 808,500	\$ 90,750	\$ 253,000	\$ 23,100	\$ 880,880
	\$ 3,160,500	\$ 354,750	\$ 989,000	\$ 90,300	\$ 2,654,960
Disposal					
Tallow	\$ 367,500	\$ 41,250	\$ 115,000	\$ 10,500	\$ 277,200
Meals	\$ 367,500	\$ 41,250	\$ 115,000	\$ 10,500	\$ 400,400
	\$ 735,000	\$ 82,500	\$ 230,000	\$ 21,000	\$ 677,600
Total Cost					
Tallow	\$ 2,719,500	\$ 305,250	\$ 851,000	\$ 77,700	\$ 2,051,280
Meals	\$ 1,176,000	\$ 132,000	\$ 368,000	\$ 33,600	\$ 1,281,280
	\$ 3,895,500	\$ 437,250	\$ 1,219,000	\$ 111,300	\$ 3,332,560
TOTAL COST					
	\$ 6,004,730				\$ 2,990,880
					\$ 8,995,610

Proportion of mass					
Water	SRM	Dead			
Tallow	50%	55%			
Meals	25%	18%			
	25%	26%			
	100%	100%			

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6.2 Potential Commercial Solutions to the SRM Problem

Nancy Facklam, M.Sc., Food Safety Division, AAFRD

Existing and anticipated CFIA regulations will allow for innovative use of the SRMs, provided the process incorporates a prion inactivation step or ensures that the material is effectively controlled throughout. AAFRD is investigating the feasibility of a number of alternative technologies that destroy BSE infectivity in SRM and dead stock, as well as technologies that can safely create new revenue streams from this material.

6.2.1 Existing Technologies

Rendering

Rendering is a cooking and separation process that produces tallow and MBM from slaughterhouse waste and deadstock. There are several types of rendering processes, using different temperatures and pressures and with varying ability to inactivate prion infectivity. Experiments¹⁰ involving BSE- and scrapie-spiked abattoir waste demonstrate that the low-temperature rendering systems favored in North America, which operate under vacuum or at atmospheric pressure, do little to inactivate prions. Infectivity was detected after exposure to all rendering procedures apart from one that involved autoclaving at 133°C under a pressure of 3 bar for 20 minutes. This process appeared to be effective with both BSE and scrapie agents and produced up to a 1,000-fold reduction in infectivity levels. The European Commission adopted this procedure (Method 1) as the preferred method for rendering Category I (TSE containing) material.

Incineration

When prions were found to be resistant to a wide variety of inactivation procedures, incineration was investigated as a destruction procedure. A study¹¹ by Dr. Paul Brown¹² demonstrated that transmission was still possible even when tissue had been ashed at 600°C. No infectivity remained after incineration at 1000°C. The EU Animal By-Products Regulation stipulates incineration must be done at 850°C. Mass burn municipal waste incinerators that operate at 1000°C should inactivate TSE pathogens.

In Alberta, the Wainwright Regional Waste to Energy Facility incinerates biomedical waste, solid municipal waste and non-hazardous waste. Operated by G.M. Pearson, Biomedical Waste Specialist Ltd for the Wainwright Regional Authority, the plant operates 24 hours a day, 7 days a week. Plant capacity is 13 tons per day; in case of an emergency, the facility can handle up to 20 tons per day. Biomedical waste is burned at 1000 °C plus.

10 Inactivation of the bovine spongiform encephalopathy agent by rendering procedures, *Vet Rec.* 1995 Dec 9;137(24):605-10 and Effect of rendering procedures on the scrapie agent, *Vet Rec.* 1997 Dec 20-27;141(25):643-9.

11 "New studies on the heat resistance of hamster adapted scrapie agent: Threshold survival after ashing at 600°C suggests an inorganic template of replication" (<http://www.pnas.org/cgi/reprint/97/7/3418>)

12 Senior Investigator, National Institutes of Health, Bethesda, Maryland, USA, retired.

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The Swan Hills Treatment Centre, used to dispose of Alberta's case of BSE, has a high-temperature (1200° C) rotary kiln incinerator that can destroy up to 35,000 tonnes of hazardous organic material per year.¹³ Gases and particulate matter are scrubbed from the resulting flue gases in a multi-stage process; bottom ash and flyash are stabilized and placed in secure on-site landfill cells. The facility has the capacity to store approximately 17,500 drums of waste on-site.¹⁴

MBM contains 60% to 75% of the energy content of coal¹⁵ and can be burned as fuel in power plants. In the UK, power stations and waste-to-energy incinerators have destroyed 93% of the 700,000-ton backlog of MBM.¹⁶

Cement kilns can achieve temperatures of greater than 2000°C. Meat and bone meal is fed directly into the high temperature part of the kiln and can comprise up to 10% of the fuel source. The residues or ash from the combustion process combine with the limestone being processed in the kiln and become cement. MBM is incinerated in cement kilns in Germany, France, Belgium, Holland, Denmark, Switzerland, Sweden, Norway and Slovakia. In France the cement industry consumes over 400,000 tonnes of MBM on an annual basis.¹⁷ Lafarge is also now burning MBM in its cement kilns in Japan. There are two cement kilns in Alberta: Inland Concrete in Edmonton and Lafarge in Canmore.

Air curtain burners are skid-mounted, refractory-walled fireboxes that range in size from 6 feet wide by 6 feet high to 12 feet wide by 12 feet high. Originally designed for disposal of wood waste, they have recently been used to dispose of livestock carcasses. In January 2002, Building Research Establishment Ltd (BRE) in the UK performed a temperature verification study¹⁸ of an S-321 air curtain burner¹⁹ as part of DEFRA's²⁰ assessment of their use to dispose of cattle as part of a Foot and Mouth disease contingency plan. Results showed the air curtain burner capable of maintaining a steady temperature of 1,000° C ± 50° C over a period of many hours. During the 2002 UK foot and mouth outbreak 400,000 animals were incinerated in 11 fireboxes.

Alkaline Hydrolysis

Prions are known to be relatively resistant to a wide variety of inactivation procedures that are effective with conventional microorganisms. However, a number of studies have

13 <http://www.shtc.ca/Processes.htm>

14 <http://www.shtc.ca/shtc.htm>

15 [http://www.ghd.com.au/aptrixpublishing.nsf/AttachmentsByTitle/PP+CowsKilowatts+PDF/\\$FILE/Cows+to+Kilowatts.pdf](http://www.ghd.com.au/aptrixpublishing.nsf/AttachmentsByTitle/PP+CowsKilowatts+PDF/$FILE/Cows+to+Kilowatts.pdf)

16 BSE: Measures Taken by the UK. DEFRA Report for the Month to the end of August, 2004.

(<http://www.defra.gov.uk/animalh/bse/publications/monrep/monrep77.pdf>)

17

<http://www.castlecement.co.uk/documents/AWDF%20PPC%20variation%20Oct%202003%20Submitted%20to%20EA.pdf>

18 I received a hard copy of the study from my Air Curtain Burner sales rep. contact.

19 Cando Construction in Brandon, MB has this model.

20 Department for Environment Food and Rural Affairs - UK

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shown that complete inactivation can be achieved if procedures are combined consecutively or simultaneously (Taylor, 2000).²¹ The company Waste Reduction by Waste Reduction (WR²) used this principle to develop a procedure that combines temperature, pressure and alkali (pH 14) to inactivate prions. A validation study conducted at the Institute of Animal Health at the University of Edinburgh found that the six hour long alkaline hydrolysis process eliminated all prion infectivity in the brains of mice injected with the hydrolysate. Based on these experiments, the European Commission Scientific Steering Committee has approved alkaline hydrolysis for Category I (TSE-infected) material. WR² manufactures hydrolysis vessels ranging from 30 pound (US\$106,000) to 8000 pound (US\$1,360,000) and has a 4,000 pound mobile unit available (US\$900,000). A 40,000 pound rendering model is currently in the process.

6.2.2 Upcoming Technologies

Thermal hydrolysis

BioRefinex is an advanced technology and development company headquartered in Calgary, Alberta. Their thermal hydrolysis process²² uses high temperature (180°C) and pressure (12 atmospheres) to denature the long-chain molecules of SRM and deadstock (or MBM) into smaller and simpler molecules.²³ Mouse bioassay validation trials are currently underway at the Institute for Animal Health in Edinburgh, Scotland to confirm that this process destroys TSE infectivity. Results of these validation tests will be presented to the European Commission's Scientific Steering Committee.²⁴ Dr. David Taylor, a world-renowned expert in prion inactivation who was responsible for obtaining funding for the validation study has remarked on the capability of this process to inactivate prions: *"Given that, even at 138°C, complete inactivation (of prion infectivity) was almost achieved, it seems likely that the 180°C "BioRefinex" process can achieve complete inactivation, especially since it has been shown to effectively break proteins down into amino acids and peptides. ... this will be completely effective under extremely high challenge conditions."*

The output of the thermal hydrolysis process can be used to enhance production of biogas generated by anaerobic digestion. Thermal hydrolysis of anaerobic digester feedstock increases methane production by 50% or more. Because the process splits organic matter into short-chain fragments, the feedstock becomes biologically more available for microorganisms allowing fermentation to run more quickly and completely than in conventional digestion processes.²⁵

21 Taylor, D. M. and S. L. Woodgate, *Rendering practices and inactivation of transmissible spongiform encephalopathy agents*, Rev. sci. tech. Off. int. Epiz., 2003, **22** (1), p. 302.

22 United States Patent No. 6,197,081

23 <http://www.biorefinex.com/technology.htm>

24 <http://www.biorefinex.com/research.htm>

25 Thermal hydrolysis as a pretreatment method for the digestion of organic waste, D. Schieder, R. Schneider and F. Bischof (<http://www.iwaponline.com/wst/04103/wst041030181.htm>) *ATZ-EVUS, Application and Technology Center, Department of Environmental Engineering, Kropfersrichter Str. 6-8, D-92237 Sulzbach-Rosenberg, Germany
Water Science and Technology Vol 41 No 3 pp 181–187 © IWA Publishing 2000

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Thermal Depolymerization

Thermal depolymerization (TDP) is a process that uses intense heat and pressure to break down organic polymers into their smallest units and reforms them into new combinations to produce fuels.²⁶ When applied to animal by-products, TCP converts fats, bones, cartilage, feathers and other wastes into diesel oil, gases, high-quality fertilizers and valuable specialty chemicals.

Renewable Environmental Solutions, LLC (RES), a joint venture between Changing World Technologies, Inc. (CWT) and ConAgra Foods, Inc., operates a commercial-scale TCP plant in Carthage, Missouri adjacent to a ConAgra Butterball turkey plant. At full capacity, 200 tons of low-value turkey slaughterhouse by-products per day will be converted into 400 - 500 barrels (21,000 gallons or 80,000 liters) of oil as well as gas, minerals and fertilizer. The gas is used on-site to operate the plant. Eleven similar plants are planned.

Pyrolysis / Gasification

Pyrolysis and gasification technologies have been available for many centuries. Pyrolysis is the decomposition of complex organic molecules in the absence of oxygen to produce Syngas, oil and char. Gasification is the decomposition of solid and liquid organic material into a gas by controlling the amount of oxygen available. These processes are usually achieved by placing the organic material inside a sealed vessel with either an inert or vacuum atmosphere and externally applying heat. The products of decomposition depend upon the heat, pressure and time the material is held within the vessel. As the organic molecules complexity increases, more energy is required to perform the decomposition. Complex molecules require either; higher temperature, lower pressure or longer processing times to achieve complete decomposition. If these conditions are not met, only partial decomposition of the molecule may occur.²⁷

Recently a Quebec researcher performed vacuum pyrolysis of MBM in a laboratory reactor.²⁸ *“The results revealed that vacuum pyrolysis could be an attractive alternative to incineration and cement kilns. The process generated a combustible gas, high calorific value oil, a solid residue rich in minerals and an aqueous phase rich in organics. The gas and the aqueous phase can be used to provide heat to the vacuum pyrolysis reactor and the MBM drying unit. The oil can be used alone or mixed with petroleum products as a fuel in boilers or gas turbines. Conversion of animal waste by pyrolysis into fuels can contribute to the reduction of greenhouse gases. It is suggested to use the solid residue for agricultural soil enrichment in minerals and as a soil moisturizer.”*

²⁶ <http://www.res-energy.com/technology/index.asp>

²⁷ Direct quote from: http://www.hatch.ca/Sustainable_Development/Articles/organics_processing_2001.pdf

²⁸ Chaala, A. and C. Roy (2003). "Recycling of meat and bone meal animal feed by vacuum pyrolysis." Environ Sci Technol 37(19): 4517-22.

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6.3 TSE Inactivation: Basic and Applied Research²⁹

Basic research continues to contribute to our understanding of TSE-infectivity and inactivation. For our purposes in addressing SRMs, the term *basic research* is used to describe methods of scientific observation, measurement and prediction regarding TSE inactivation. In this context, applied research draws on basic work to properly test existing technologies and/or in the development of novel approaches to TSE inactivation.

Basic research conducted on TSEs has revealed that only a relatively small proportion of infectious material is ‘resistant’ to most inactivating processes. The resistant population that remains requires considerably more heat, pressure, application of acids, etc., to achieve inactivation. This ‘tailing effect’ has been well described in studies involving both infectious microbes and misfolded proteins associated with TSE.

The degree that BSE and other TSEs are transmissible depends upon the route of transmission and the dosage. While high levels of TSE infectivity are associated with SRM, low levels of TSE infectivity have been demonstrated to be present in the blood of experimentally infected rodents showing symptoms of the TSE.³⁰ While TSE infected blood appears unlikely to transmit the disease via natural transmission, concerns arise where dosage levels are relatively high. Another concern arises given our limited understanding of TSE infectivity in the environment and the potential deposition of SRM in landfills. Research on scrapie and CWD has emphasized the importance of considering the environment as a possible reservoir for transmission of TSEs.

The phenomenon of the “tailing effect” (i.e. incomplete inactivation) coupled with the fact that disease transmission is intricately dependent on the dose and route of transmission, necessitates that a baseline consensus of acceptable risk be developed. This level of acceptable risk will help define the “target” that inactivation technologies should achieve in order to be considered validated as a technology useful for inactivating TSEs.

The results of ELISA-based or Western Blot methods indicate, with considerable confidence, whether an animal has succumbed to TSE. However, the only way to quantitatively test for TSE infectivity at present is to conduct bioassay experimentation where rodents are exposed to TSE infective material and monitored for 180 – 250 days. The requirements for Level III animal housing facilities (required for handling TSE infective material), the extended duration of the rodent monitoring period, and the delicate nature of working with highly infective material while running low dosage experiments means that the cost of each validation experiment is substantial. Given these

29 Based on input from Dr. Norm Neumann, Dr. Bob Rohwer, Dr. David Taylor and Dr. Lloyd Spencer. Research of existing literature was also used in developing this section of the report.

30. Brown, P., L. Cervenakova, L. M. McShane, P. Barber, R. Rubenstein, and W. N. Drohan. 1999. Further studies of blood infectivity in an experimental model of transmissible spongiform encephalopathy, with an explanation of why blood components do not transmit Creutzfeldt-Jakob disease in humans. *Transfusion* 39:1169-1178

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testing requirements, policies have reportedly been guided by data derived from very limited experimentation.

Accordingly, experts in the field note that an insufficient number of infectivity studies have taken place. While a leading lab might operate with 5,000 or more rodents, it is suggested that a lab with 30,000 to 40,000 rodents and annual operational costs in the order of C\$4 and C\$6 million is required. Among the work that remains outstanding is testing for minimum requirements for inactivating TSEs under a variety of scenarios. The priority of assessing upper and lower infectivity thresholds has risen with the discovery of low levels of infectivity in the blood of lab animals.

While the conventional mouse or hamster model remains the standard for infectivity testing, new methodologies are in development. Transgenic mice expressing a bovine prion protein stand to accelerate procedures. Tissue culture models could greatly accelerate the screening for infectivity and may some day replace the rodent model. In this case infective material is administered to animal cells growing in culture. While tissue culture models may be used in quantitatively testing TSE-infected material in the future, currently only one strain of TSE (mouse scrapie) has been grown in a tissue culture system.

An additional infectivity testing methodology lies in the use of surrogates (i.e., non-infectious proteins that react in a similar physical and chemical manner as prions), which could accelerate the data assessment process considerably while reducing cost and time requirements. Such approaches could be validated alongside a parallel application of proven rodent models. Applying a combination of testing approaches to validate inactivation technologies serves to enhance confidence in the test results. As experiment methodologies evolve, the concerns that fixed cost investments in laboratories are rapidly depreciated through obsolescence is reportedly invalid in the new era of bio-terrorism related research.

Applied research involved in the validation of industrial TSE inactivation technologies are based on re-engineered 'scale-down' models. Essentially, bench-scale replicas of industrial scale models are used in the validation process. Scaled-down bench models are seeded with infectious TSE material in a laboratory setting and tested quantitatively using rodent infectivity assays. Although considerable effort is invested in engineering scaled-down versions of industrial inactivation systems, inherent and unpredictable variables can contribute to design irregularities that may invalidate test results. Furthermore, the limited number of experiments typically carried out to validate these technologies does not allow for a composite assessment of all of the variables that could possibly affect the inactivation technology. This is particularly relevant when scaled down experiments are carried out in the idealistic setting of the laboratory, where it is easier to control confounding variables. The scaling-down approach is necessary given the financial implications of building industrial scale models before proof of concept has been achieved in addition to the difficulty of obtaining enough TSE-infected material to test industrial scale systems for inactivation effectiveness. Engineering irregularities and

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challenges with scaled-down systems are well described in the scientific literature involving, for example, wastewater and drinking water treatment systems.

The concept of composting SRM material is particularly appealing because of its low energy input compared to other disposal methods. The Animal Diseases Research Institute has undertaken preliminary work regarding the composting and destruction of TSE infected material. Infected material was surrounded by sawdust and put in a contained, static compost pile with passive aeration. At present, they have shown that prions are destroyed during the composting process. Infectivity measurements are still needed, but the nature of the composting method makes it difficult to isolate the effects of TSE infected material from that of other microorganisms in the compost on the rodent. Any advances in tissue culture infectivity assays would especially help to verify the composting method.

Advances in the study of prions have identified enzymes which are capable of hydrolyzing prions. Bacterial produced enzymes proteinase K³¹, subtilisin DY and keratinase³² are all capable of degrading prions after a heat and detergent pre-treatment. Recently, a new bacterial proteinase, termed “prionase” was shown to be superior in its ability to degrade prions, especially in the presence of non-polar solvents³³. This finding and new enzyme degradation research could result in new techniques for treatment of SRM materials and for sterilizing equipment.

31 Yakovleva, O.; Janiak, A.; McKenzie, C.; McShane, L.; Brown, P., and Cervenakova, L. Effect of protease treatment on plasma infectivity in variant Creutzfeldt-Jakob disease mice. *Transfusion*. 2004 Dec; 44(12):1700-5

32 Langeveld, J. P.; Wang, J. J.; Van de Wiel, D. F.; Shih, G. C.; Garssen, G. J.; Bossers, A., and Shih, J. C. Enzymatic degradation of prion protein in brain stem from infected cattle and sheep. *J Infect Dis*. 2003 Dec 1; 188(11):1782-9

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Compiled January 2005

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Appendix II: Patent Search

Prion inactivation patent search – Nov. 26, 2004

Recently filed patents provide evidence of the direction of scientific discovery and the future direction of commercial solutions. In developing this report, a cursory analysis of patenting activity was undertaken regarding TSE-inactivity and containment.

Detection-related patents address the risk of SRM contamination. Patents recently filed in this area are directed at identifying SRMs during processing to prevent unsafe disposal or accidental mixing with non-SRM material. One patent in particular outlines a method of detecting animal product contamination of feed, specifically SRM material.

Overall, TSE-inactivation is the major theme for SRM-destruction and disposal-related patents. Some use chromatographic techniques to separate prions from solution. Many of these solution-related patents focus on maintaining the physiological activity of the non-TSE-related components in the solution. Other patent methods use incineration of SRM as the main destruction method. With incineration, safe and efficient disposal of SRMs are the primary concern. Some incineration-related patents also address greenhouse gas emissions inherent in the process. Digestion-related patents use enzymes to destroy TSE-infectivity, either generally with a biodigester, or specifically with a prion-destructive protease.

Slaughter-related patents are included in this summary because they may be of interest to some stakeholders. Basically, their content focuses on the efficient removal of SRM from the animal carcass while minimizing the risk of contamination to the rest of the carcass or people handling the meat.

The following tables summarize some recent patents relevant to SRM inactivation and containment.

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Detection-related patents

Patent Number	Brief Description
EP0803194A2	Blood and innards of animals infected with BSE are specially treated to identify their possible infectivity. The innards are reduced in a dissolver. Both are treated with a denaturant and colourant then stored in a collection vessel.
WO03075000A1	Quality of animal feed is evaluated by detecting the presence of animal protein in the food. Especially useful to prevent ruminant-derived MBM in ruminant feed. Detection of animal proteins is by MALDI-TOF mass spectrometry or by chromatography and sequencing of peptide fragments.

TSE Decontamination/ Destruction-related patents

Solution-related patents

Patent Number	Brief Description
NZ0526502A	Reduction of prion contamination in animal feed by adding alkali (pH 8.5) and heating (60 – 99 C) the material, then dehydrating it.
EP0954528B1	Removal of prions from solution by anion-exchange chromatography.
US6221614	Separation of prions from liquids using beads covered with a prion complexing agent. As the liquid passes through the column, the prions form a complex with the salt on the bead and are removed from the liquid.
JP2000212097A2	Removal of TSE infectivity by adding a water-soluble organic substance (ethanol, polyethylene glycol) or a salt (NaCl) to the material and filtering it through a membrane.
US6720355	Treatment of TSE infectious material with an antiseptic that contains sodium dodecyl sulfate (SDS). The composition may be added to livestock feed to denature any prions in the feed.
US20040062832A1	Decontamination of animal feed containing prions by alkali (pH 8.5) treatment followed by heating to below 100C at atmospheric pressure. Achievable in standard animal carcass rendering facilities.
US5756678	Inactivation of prions in connective tissue material (collagen) by exposure to NaOH at a temperature of 25C, or less. Collagen's ability to form stable fibres

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	after treatment is maintained.
WO0249449A1	Hydrolyzing all proteins associated with TSE-infectivity to amino acids and using them again to replace the traditional uses for MBM.

Incineration-related patents

Patent Number	Brief Description
JP2004195361A2	Utilization of MBM as fuel for an ash melting furnace. The MBM is fed to the furnace in combination with ash. The ash is melted by the furnace (1000C) by using the MBM as a fuel.
JP2004155915A2	SRMs are melted at 1200 – 2600 C in a melting furnace where oxygen is not available. A high-temperature melt reduction gas is recovered as an energy resource.
US6694928	Tallow is combusted in an enriched oxygen atmosphere combustion engine
JP2004181294A2	SRM is destroyed by disintegration of the material into tiny pieces, then treating it for between 20 to 240 minutes under the conditions of 3 to 10 atm at 133 to 180C. After the process, the material goes to an incineration furnace.
EP1241406A3	Pre-treatment of SRM by crushing and forming atomized particles before combustion at 850C.
JP2004169994A2	SRM combustion using an external circulation fluidized bed combustor. Exhaust gases are collected and separated from each other.
JP2004108688A2	SRM combustion in an external circulation-type fluidized bed incinerator where a calcium agent is added to prevent sintering.
GB2399343A1	Animal waste is incinerated and forms an ash. The ash is then treated with acid to form products that may undergo further processing. These products could include fertilizers, water treatment chemicals, plasterboard, gypsum blocks, or white paper fill.

Digestion-related patents

Patent Number	Brief Description
US20040025715A1	Anaerobic digestion of SRM to produce biogas and an end-product that can be used for fertilizer
US6613505	Destruction of prions by thermal/enzymatic treatment of tissue with a prion-destructive protease.

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Slaughter-related patents

Patent Number	Brief Description
JP2003144042A2	Removal of the spinal cord using compressed air
WO0237971A3	Removal of the spinal cord by suction
WO9739633A1	Removal of the spinal cord with a specially designed saw which cuts the carcass on either side of the cord.

Other

Patent Number	Brief Description
US6635222	Sterilization of TSE-infected material by low dose irradiation.
US6517855	Denaturing prions by exposure to a solution of polycationic dendrimers.
GB2390291A1	Growing edible mushrooms in bio-feed made from MBM.

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Appendix III: Reconciling AAFRD and CFIA Cost Estimates of the Proposed Regulation of an Enhanced Feed Ban

Brian Radke, DVM, Ph.D., Economics Unit, AAFRD

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Using the CFIA cost methodology, the annual cost estimate of the proposed regulation of an enhanced feed ban for the province of Alberta is \$8.7 million. An AAFRD analysis estimated the cost to be \$3.0 million. The CFIA’s national cost analysis was adapted to an Alberta analysis by changing the slaughter and deadstock statistics to be representative of Alberta. (Specifically, annual slaughter of 2.13 million cattle <30 months, annual slaughter of 236,000 cattle >30 months, and collection of 30,800 tonnes of bovine deadstock is used.) The purpose of this document is to briefly identify the methodological differences that result in the respective total annual cost estimates.

In overview, the CFIA analysis estimates a lower total volume of MBM production but a higher cost per unit to result in a higher total cost than the AAFRD analysis. Each effect will be considered in turn.

The CFIA analysis estimates a total MBM production from SRMs of 12,300 tonnes versus AAFRD’s estimate of 18,700 tonnes. The difference in estimated MBM production is due to varying assumptions about the MBM yield from the small intestine. The CFIA uses a yield of 5% versus AAFRD’s yield of 25%.

The per unit costs used in each analysis are summarized in the following table:

Description of Cost	Cost units	ANALYSIS	
		CFIA	AAFRD
Removal and segregation of SRM	\$/kg of raw SRM	0.0176 (4.3%) ¹	0
Transportation of SRM	\$/kg of raw SRM	0.0374 (27.9%)	0
Processing of SRM	\$/kg of raw SRM	0.055 (42.3%)	0
Lost revenue of MBM from SRM	\$/kg of MBM	0.099 ² (13.9%)	0.110
Disposal of SRM	\$/kg of MBM	0.0825 (11.6%)	0.05

1. The respective cost’s percentage share of the \$8.7 million estimated total cost.
2. Lost revenue of MBM from SRM, net of production costs, calculated as 50% of a market value of \$198/tonne.

SRMs are currently removed from slaughter carcasses so AAFRD’s analysis does not include this cost in calculating the cost of the proposed regulation. AAFRD’s understanding is the Alberta industry currently produces a MBM product made from SRM and deadstock, (in addition to MBM products not made from SRM or deadstock). This requires the industry segregate, transport and process the SRMs. In this case, these activities are currently occurring and are not the result of the proposed regulation; therefore, these costs are excluded from the AAFRD analysis. The CFIA analysis already includes the cost of processing, so the \$99/tonne lost revenue of MBM from SRM represents the margin (i.e., lost revenue of MBM from SRM less the production costs). The AAFRD analysis uses a \$110/tonne market value of MBM made of SRM to represent the lost market value. In terms of MBM disposal costs, AAFRD uses a cost \$50/tonne versus the CFIA estimate of \$82.50/tonne.