Final
Technical Work Paper For Human Health Issues

Animal Agriculture GEIS

Prepared for:
Minnesota Planning
658 Cedar Street, Room 300
St. Paul, MN 55155

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1.0 EXECUTIVE SUMMARY

The State of Minnesota has identified a need for a Generic Environmental Impact Statement (GEIS) on Animal Agriculture in Minnesota. The Legislature directed the Environmental Quality Board (EQB) to "examine the long-term effects of the livestock industry, as it exists and as it is changing, on the economy, environment and way of life of Minnesota and its citizens." This task will be partially accomplished through the generation of Technical Work Papers (TWPs) on twelve topical issues. This TWP addresses Topic K, Human Health Issues.

Earth Tech, Inc., (Earth Tech) examined the GEIS Literature Summary and other sources addressing outputs and human health. Information was screened for data reliability, documentation, and applicability to the overall GEIS effort. As indicated in Figure 2.1 - Human Health Risk Model, some outputs are adequately documented in the literature as being of high priority, some require further study, and others appear to be of low priority and are not addressed further at this time. The filtering mechanism is partly quantitative, but is largely based on the available information and the experience of the reviewers. Earth Tech's project team has also addressed some low priority outputs in greater detail where appropriate to meet EQB needs, such as those emerging issues where there was a need to summarize a rapidly increasing body of information.

The public's sensitivity to the increasing industrialization of animal agriculture in Minnesota has put enormous pressure on policymakers, regulators, and the animal agriculture industry to answer some very complicated questions regarding the environmental health impacts of larger animal feeding operations (AFOs). It is very challenging to address these questions about health and the environment because they are tightly entangled in a web of important social and economic issues.

We found that the same questions have been raised elsewhere around the world and, like the United States (U.S.), the affected countries are struggling to find the right combination of laws, policies, and education to protect their citizens as well as to provide support for their agricultural sectors. In Europe, the European Union has taken a leadership role in the management of water pollution from animal agriculture and has set a timetable to meet certain pollution reduction goals.

In our review, the cornerstones of all of the regulatory programs selected for review have been the protection of water resources and the safety of the food products from the animal agriculture industry. Protection of water resources has generally been limited to managing nutrients (phosphorus and nitrogen) and minimizing the spread of pathogens.

There are a variety of outputs from animal agriculture that could raise serious environmental concerns. The project team identified the following outputs as being of high priority because of their ability to be transmitted through air to off-site residents at levels sufficient to adversely affect human health or well-being: ammonia (NH_3), hydrogen sulfide (H_2S), odor, respirable dust (PM_{10}), and dust containing allergens, fungi, and endotoxins. Our review of occupational data on the effects of H_2S exposure during manure handling or manure pit entry revealed that H_2S (or toxic gas) exposure was involved in nine of the 15 fatalities in Minnesota from 1984-2000. Three toddlers died during accidental manure pit entries. Although it was not possible to ascertain the role of asphyxiation versus drowning, this risk should be addressed immediately, although it does not affect off-site residents. This output is considered to be unrelated to facility size. Odor is a high priority based on studies documenting an association between the exposure to odorants and respiratory and psychological effects.

Nitrate, allergens, PM_{10}, endotoxins, odors, and pathogens were classified as high-priority outputs transmitted through soil and water. Excess nitrate in groundwater can cause "blue baby syndrome" in infants. Manure-amended soil is a significant source of allergens, PM_{10}, endotoxins, and odors, which are classified as high-priority outputs transmitted through air. Many food-borne pathogens are also transmitted through soil and water, and incidences of disease in humans have resulted from these outputs.

Fortunately, the rapid development of control strategies at the federal level coupled with the new feedlot rules promulgated by the Minnesota Pollution Control Agency (MPCA) in October 2000, set a strong regulatory foundation in place to ensure that facilities of all sizes and types do not harm human health. This permitting program should provide adequate human health protection as long as sufficient resources are made available for permitting and enforcement by the MPCA and delegated counties (Minnesota Legislative Auditor, 1999).

At the same time, many questions remain unresolved regarding air emissions from animal agriculture. Research emphasis has historically focused on odors, both in Minnesota and elsewhere. There has been much less emphasis on detailing the specific chemical constituents that cause these odors. In addition, not all chemicals that may be of concern contribute to odors.

The project team reviewed current information on emerging issues and determined that bovine spongiform encephalopathy (BSE) is adequately addressed by current U.S. regulations and practice. Antimicrobial resistance is a significant issue and requires additional research on the impact of traces of antimicrobials in soil and water. Endocrine disruptors also require additional research in order to prioritize them appropriately. Transgenic animals were not specifically addressed in this TWP, but warrant additional study.

Earth Tech recommends that the State of Minnesota proceed to gather more information about several air contaminants known to be released from AFOs. We believe the following pollutants merit further attention:

- Quantification and standardization of odor parameters and the relative role of H_2S and reduced sulfur compounds.
- Volatile organic compounds (VOCs) (refine rural VOC data as to their contribution to odors and health impacts).
- Respirable dust (PM_{10}, including endotoxins and odorants absorbed on particles).
- Ammonia (evaluation of environmental fate and work to understand background conditions in agricultural areas).
- Transmission of pathogens off-site through air, soil, and water.
- Pathogens in soil or water, with an emphasis on anthrax.

We emphasize our recommendation for further monitoring and quantification of sources only in part due to the potential for significant health impacts. We also believe that quantifying these emissions will make it possible to compare emissions from AFOs to other sources to help regulators prioritize efforts and to provide some perspective for the public. We want to emphasize that we *do not* have evidence that AFOs are major sources of these pollutants compared to mobile sources, other industrial sources, or other human activity. However, current unknowns are a major hindrance to all concerned parties during project review and permitting. These gaps are negatively affecting project timing and cost, and are reducing public confidence in the review process.

We do not wish to dismiss the human health importance of these outputs in any manner. We believe the topics discussed above are very important in terms of human health risk, but we are attempting to lend some perspective. For example, we don't believe these concerns rise to the level that calls for a moratorium action while data is gathered even though more information may very well point to the need for additional regulatory action by state or local government in the future. At the same time, it is certainly possible that some of these outputs may fall away as health concerns, in the context of AFOs, once we have greater knowledge of source strength and environmental fate.

Also, while it could be expedient for government, we do not recommend that these data be gathered on a source-by-source basis through individual permit requirements. Gathering research data in that fashion is highly inefficient and will lead to inappropriate inequities among permittees. It also often leads to accusations of bias which diminish the value of the work. Therefore, we suggest that the research be done by an independent party in a manner that addresses these outputs on an industry-wide basis.

1.1 POLICY RECOMMENDATIONS

- The new feedlot rule recently promulgated by the MPCA provides a sound regulatory foundation for addressing AFOs in Minnesota. Both state and county regulators are responsible for implementation and, with the new rule, each should have adequate tools to safeguard the public's health as more detailed information is gathered about some of the outputs previously discussed. Timely implementation of the permitting provisions of the rule along with follow-up inspections and enforcement are critical to the program's success. Full implementation will require the application of more resources to this program at the MPCA and delegated counties.

- Best management practices (BMPs) are a very important component of the overall management and control strategies for AFOs. To be effective, BMPs must be carefully selected and fitted to local conditions. BMPs must be designed to meet a set of performance standards in order to ensure their efficacy. The performance standards can be such things as nitrate standards in water or ambient air standards.

- The regulatory structure should be augmented by an aggressive implementation of flexible incentives and additional operator education. Employing a "best management practices" approach to all aspects of animal agriculture is the best way to ensure that health and environmental impacts are kept below thresholds of concern. As a practical matter, this goal will be most effectively achieved by employing reasonable regulatory tools along with customized flexible incentives and strong training initiatives.

- In order to ensure that regulatory practices are strategically aligned with voluntary programs and flexible incentives, state government, the industry and other key stakeholders should strive to agree on one strategic vision for the animal agriculture industry in Minnesota. We believe that this unifying vision does not currently exist and its absence is creating confusion among the stakeholders and the general public.

- Additional research to characterize health effects, quantify source strength and determine the environmental fate of several outputs of animal agriculture is warranted as noted in Section 2.4 of this report. Unless an issue is unique to a specific AFO, we do not recommend that individual operators be held responsible for sponsoring the research activities discussed here. Publicly funded research or public-private partnerships are recommended to spread out the costs of basic and applied research.

- Due to the significant and growing concern regarding antimicrobial resistant organisms, we recommend that the State of Minnesota should:

  – Continue surveillance on the occurrence and causes of infections by bacteria exhibiting antimicrobial resistance. Extend research to establish the environmental fate and drug-resistant properties of pathogens in feedlot runoff.
  – Monitor the use of antimicrobial drugs in food animals that are used in treating infectious diseases in humans.
  – Provide agricultural extension services to reduce stress factors associated with pathogen-shedding and disease transmission among food animals.
  – Promote research on the biochemical mechanisms of antimicrobial drug and biocide action and bacterial resistance to antimicrobials. This may aid the effort to develop new therapeutic drugs to treat multidrug-resistant pathogens.
  – Promote research on alternatives to antimicrobials in promoting growth and preventing disease.
  – Support federal initiatives to protect drugs used therapeutically in humans from the development of antibiotic resistance.

- No cases of bovine spongiform encephalopathy (BSE) have been diagnosed in the U.S.; however, because even one case of BSE would be devastating to the beef and dairy industry, Minnesota must assure that it does not occur here. The State of Minnesota should support every reasonable effort to prevent the importation or use of BSE-contaminated feed. Although the FDA banned the use of mammalian animal carcasses in the production of feed for ruminants in 1997, some pure non-ruminant animal protein is allowed. Minnesota should promote research and outreach education to:

  – Determine if this policy is protective enough.
  – Develop a way of diagnosing asymptomatic BSE in living animals.
  – Determine the prevalence of transmissible spongiform encephalopathies (TSEs) in other animals native to Minnesota.
  – Reinforce the importance of medical surveillance and maintaining the required records and label information to show where animal feeds came from, in case an outbreak is suspected.
  – Assure that workers exposed to animals or humans infected with TSEs should be trained on the potential hazards of these diseases.
  – Prevent the accidental exposure of students to BSE during cow, sheep, or goat eye dissection in the classroom.

2.0 HUMAN HEALTH IMPACTS

2.1 REVIEW OF THE HUMAN HEALTH LITERATURE SUMMARY

In the course of preparing this Human Health Issues TWP as part of the GEIS for Animal Agriculture, Earth Tech staff reviewed in detail Section K of the Draft GEIS Literature Summary prepared by the University of Minnesota (U of M), subtitled "A Summary of the Literature Related to the Effects of Animal Agriculture on Human Health" (Addis, *et al.*, 1999). The breadth of the document was sufficient to form a basis for most of the sections in this TWP. Due to the broad treatment of some issues, the changing nature of the animal agriculture industry, and the issues confronting public health policymakers, this TWP is an extension of that work.

Since the body of information related to emerging issues of concern is constantly growing, and the issues of concern to Minnesotans often change, it is unlikely that a definitive "endpoint" in the search for information can be achieved. Nonetheless, this TWP attempts to summarize and prioritize the human health significance of the existing information and supplements it with up-to-date information, data, and trends related to emerging issues. For example, additional information is provided regarding the issues of antimicrobial resistance, bovine spongiform encephalopathy (BSE), endocrine disruptors, and pathogens such as the agent that causes anthrax. The regulatory framework addressing AFOs had changed significantly in Minnesota and nationwide in the short period since the U of M completed the original literature summary. Some of the information obtained and reviewed has not been included in this TWP, and is addressed in Section 2.4.

2.2 DEVELOPMENT OF THE LIST OF OUTPUTS FROM ANIMAL AGRICULTURE

In general, the literature summary provided the basis for developing a list of outputs from animal agriculture that could negatively impact human health. The list was supplemented based on the experience of the project's environmental health and risk assessment staff and comments from the GEIS Citizens' Advisory Committee (CAC). The outline in Appendix A presents and summarizes the outputs considered in the development of this TWP. This list is organized in terms of the mode of transmission of the output. Thus, the list is organized into three sections: 1) Outputs transmitted by air, 2) Outputs transmitted by soil, and 3) Outputs transmitted by water. Within these categories, the outputs are organized into the following groupings suggested by the scoping questions developed by the CAC:

1. Gases
2. Dust
3. Odors
4. Pathogens

The list in Appendix A refers to two major topics that the CAC has agreed are not within the scope of this Human Health TWP. As indicated in the summary list of outputs from animal agriculture, the following topics that were discussed in the GEIS literature summary are not included in the body of this TWP:

1. Occupational injury.
2. Occupational exposure to noise.
3. Musculoskeletal disorders.
4. Pathogens transmitted through ingestion of consumer commodities.
5. Environmental toxicants transmitted through consumption of food products of animal origin.

Transmission of airborne outputs in the workplace is included because these outputs could be transmitted to receptors outside of the AFO. Also, occupational transmission of outputs of environmental health concern is well documented and may serve as a basis for establishing occupational and non-occupational exposure limits for airborne contaminants. Since the development of antimicrobial resistance may affect more than just consumers of food animals or animal products, the project team has addressed this topic in detail, but in a separate section (see Section 2.3.3 - Special Topics and Emerging Issues). We also discuss BSE and endocrine disruptors in this section, because of the significant level of public concern regarding these topics.

2.3 EVALUATION AND TABULATION OF INFORMATION ON HUMAN HEALTH

In general, the project team used the model summarized in Figure 2.1 to filter the high priority outputs from less important outputs. This effort was systematic and rigorous, but the degree of certainty of any of the preliminary findings varies, depending on the amount and strength of the scientific evidence underpinning the published conclusions. The findings and degree of emphasis any one area of study presented in this TWP are subject to change based on future events, industry developments, or scientific knowledge. The emphasis in this process was to screen information for data reliability, documentation, and applicability to the overall GEIS effort. The designation of "high priority" outputs was assigned if two or more of the following conditions were met:

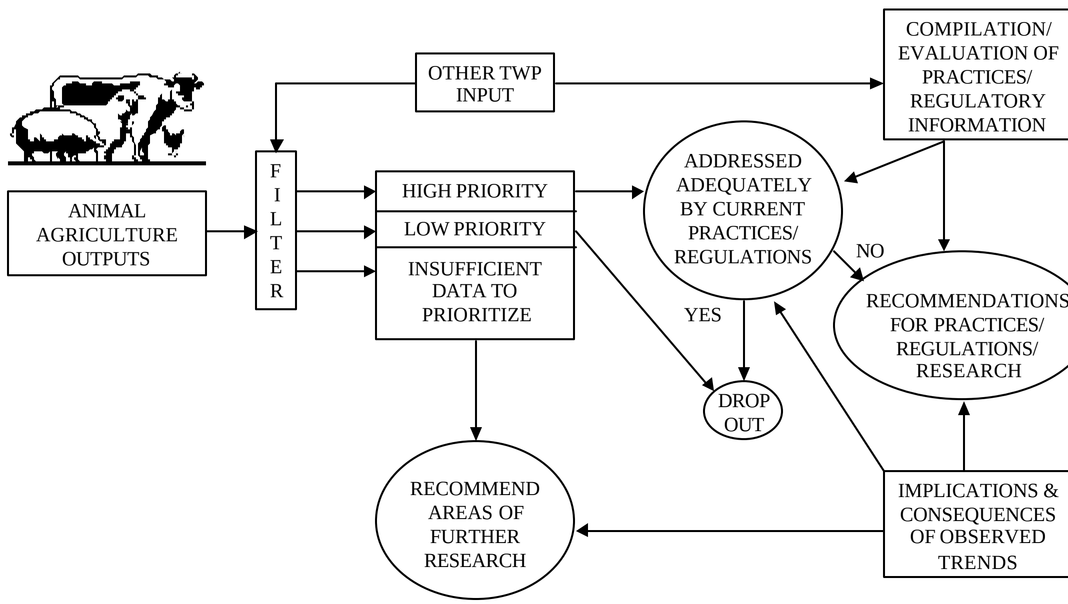
1. The output has documented serious adverse health effects in humans or strong evidence of serious adverse effects in test animals can be extrapolated to humans.
2. Sufficient off-site transmission to cause adverse health effects has been demonstrated or can be reasonably expected.
3. The well-being of a significant number of persons off-site is likely to be negatively impacted.

As indicated in Figure 2.1, some outputs are adequately documented in the literature as being of high priority, some require further study, and others appear to be of low priority and are not addressed further at this time. The filtering mechanism is partly quantitative, but is largely based on the experience of the reviewers. In cases where the potential human health outcome of transmission of these outputs could be life threatening the project team has also addressed some outputs in more detail.

Because of the apparent interaction of some of the exposures, the literature that this TWP summarizes and evaluates may cover many subtopics and presents data on outputs, practices, and policy. Thus, while some practices are discussed in this section, the reader should consult Sections 3 - Federal, State, and Local Control Strategies, and Section 4 - Interaction Practices and Policy to review most of the information we collected regarding practices and regulations that prevent, or reduce the severity of these outputs.

FIGURE 2.1

HUMAN HEALTH RISK PROCESS MODEL



2.3.1 Outputs Transmitted through Air

AFOs contribute to the airborne contaminants in the rural environment. These airborne contaminants may include gases, dust, odors, and disease-causing organisms (pathogens). The distinction between these different groups is not always clear. For example, odors are a physiological response to odorants (chemicals which the human nose can detect). Thus, some odorants are discussed under the gases section, and some pollutant gases and vapors are also odorants. Much of the literature refers to "odors" without specifying the constituent odorant compounds that give the air its odor. The North Carolina State University Odor Task Force Report (Williams, *et al.*, 1998) points out that odorants may adsorb onto small dust particles and accumulate and release odorants in ways that would not be predicted if the odor behaved only as a gas or vapor. Dusts produced by animal agriculture include feed dust, dusts of animal origin (such as hair, feathers, skin flakes, dried urinary and fecal proteins), microbial cell wall remnants (such as endotoxin and (1→3)-ß-*D*-glucan), and also soil particles generated during open pasture feeding (Feddes and Barber, 1995). Please note that these categories overlap; for example, airborne dust may contain fungal or bacterial pathogens, as well.

Table 2.1 summarizes the agents of concern, prioritizes them, summarizes the major health effects, and discusses briefly the types of control methods used [regulatory and best management practices (BMPs)]. The contribution of many of these outputs to the environment is difficult to assess. Although some parameters, such as carbon monoxide (CO), have been monitored in air for many years, and its background levels are known, this is not the case for most of airborne agents. More information

TABLE 2.1

ADVERSE EFFECTS OF ANIMAL AGRICULTURE OUTPUTS ON HUMAN HEALTH
OUTPUTS TRANSMITTED THROUGH AIR

Output	Priority	Mode of Transmission from AFO	Adverse Health Effects	Methods of Control	Comments
GASES					
Ammonia (NH_3)	High	Off-gassing from livestock and poultry confinement, manure storage pits, lagoons, or open grazing; also released during land application of manure	• Respiratory irritant • Temporarily paralyzes dust-clearing mechanisms • Odorant	Regulatory: • Comprehensive Nutrient Management Plans • Odor air emissions and odor reduction plan • See Table 2.2 for exposure guidelines Other controls: • Absorbent litter with high pH • Dietary modification • Covering manure storage • Ventilation and biofilters • Setbacks	See Table 2.2 for health effects at various concentrations of ammonia.
Hydrogen sulfide (H_2S)	High	Off-gassing from livestock confinement, manure storage pits, lagoons, or open grazing; also released during land application of manure	• Odorant • Eye irritant • Respiratory irritant • Nausea, cramps, vomiting • Decreased hemoglobin synthesis • Serious eye injury • Olfactory fatigue/paralysis • Possible risk of fatality during manure pit entry	Regulatory: • Ambient air standard and monitoring requirement • Air emissions and odor reduction plan • See Table 2. for exposure guidelines Other controls: • Dietary modification • Covering manure storage • Ventilation and biofilters • Setbacks	See Section 3 for H_2S monitoring requirements and Table 2.3 for health effects at various concentrations of H_2S. H_2S concentrations are not necessarily proportional to the odor intensity; some other reduced sulfur compounds, such as methyl and ethyl mercaptan may contribute to measured H_2S concentrations.

TABLE 2.1

ADVERSE EFFECTS OF ANIMAL AGRICULTURE OUTPUTS ON HUMAN HEALTH
OUTPUTS TRANSMITTED THROUGH AIR

Output	Priority	Mode of Transmission from AFO	Adverse Health Effects	Methods of Control	Comments
Volatile organic compounds (VOCs) with documented inhalation toxicity values	Insufficient Data to Prioritize	Off-gassing from livestock confinement, manure storage pits, lagoons, or open grazing; also released during land application of manure	• Mucous membrane irritation • See Table 2.4 for health effects for specific compounds	Regulatory: • Not addressed as individual compounds, although some have MN Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs) • See Odorants	
Hydrazine	Low	See above	• Severe skin and mucous membrane irritation • Carcinogen	• Not specifically addressed • See ammonia control methods	Only one study involving only one species reported the presence of this output in or near manure storage. No evidence of worker exposure on site.
Sulfur dioxide	Low	Oxidation of sulfur compounds	• Respiratory irritant	• Not specifically addressed	
Carbon dioxide	Low	Product of aerobic microbial respiration	• Toxic in confined spaces	Regulatory: • MN OSHA PEL • Not specifically addressed in ambient air	Greenhouse gas.
Methane	Low	Product of anaerobic microbial metabolism	• Asphyxiant	Regulatory: • Not specifically addressed Other controls: • Aeration • Biogas collection as alternative fuel	Potent greenhouse gas.
Carbon monoxide	Low	Product of anaerobic microbial metabolism; agricultural vehicles	• Systemic toxicant • Binds with hemoglobin to prevent proper oxygen utilization asphyxiation	Regulatory: • MN OSHA PEL	Priority air pollutant.

TABLE 2.1

ADVERSE EFFECTS OF ANIMAL AGRICULTURE OUTPUTS ON HUMAN HEALTH
OUTPUTS TRANSMITTED THROUGH AIR

Output	Priority	Mode of Transmission from AFO	Adverse Health Effects	Methods of Control	Comments
VOCs produced by microbes (MVOCs)	Low	Product of microbial metabolism	• Similar to VOCs and alcohols • Odorant effect	Addressed by same practices as odor	Note: Many of the VOCs produced by bacteria are included under VOCs. Very little information is available regarding health effects of the ketone and alcohol products produced by fungi.
DUSTS					
Fungi and other allergens	High	Fugitive dust, dried litter, dried manure, fur, feathers made airborne by wind, vibration, natural or mechanical ventilation, fungi	• Asthma • Rhinitis • Bronchitis • Hypersensitivity pneumonitis	• Use pelletized feed • Maintain humidity to reduce dust generation from litter • Reduce excessive air velocities • Use non-toxic dust suppressants	See also pathogens.
PM_{10}	High	Fugitive dust	• Asthma • Irritation		Ultrafine particles are included in this category. However, there were insufficient data from agricultural settings.
Endotoxins	High	Lipopolysaccharide (LPS) from gram-negative bacteria cell walls	• Fever • Malaise • Changes in white blood cell counts • Respiratory distress		Endotoxin levels can be high even when air-borne gram-negative bacteria concentrations are low.
Mycotoxins	Low	Toxic metabolites of fungi	• Carcinogenicity • Neurotoxicity • Nausea		Mostly due to ingestion of contaminated food or work in contaminated silos.
(1→3)-ß-*D*-Glucan	Low	Glucose polymers from cell walls of fungi	• Respiratory irritant • Stimulate immune system • Inflammatory response • Allergen • Possible role in organic dust toxic syndrome (ODTS)		

TABLE 2.1

ADVERSE EFFECTS OF ANIMAL AGRICULTURE OUTPUTS ON HUMAN HEALTH
OUTPUTS TRANSMITTED THROUGH AIR

Output	Priority	Mode of Transmission from AFO	Adverse Health Effects	Methods of Control	Comments
ODORANTS					
Volatile fatty acids, adehydes, ketones, phenolics, N-heterocyclics and various other classes of odorous compounds	High	Off-gassing from livestock and poultry confinement, manure storage pits, lagoons, or open grazing; also released during land application of manure	• Tension • Depression • Anger • Fatigue • Confusion • Decreased vigor • Respiratory irritation	• Diet manipulation with feed additives • Improvement of dietary nutrient utilization • Dust reduction • Air treatment • Covers • Manure treatment • Product additives	In a larger context, land use restrictions such as setbacks can reduce the impact of this output.
PATHOGENS					
Bacteria					
Bacillus anthracis (anthrax)	Insufficient data to prioritize	Spores released into the air from infected animals or contaminated soil	Pulmonary form • Mild fever • Malaise • Nonproductive cough	• Burn infected animal carcass and bury ashes • Disinfect contaminated area • Vaccinate remainder of herd if appropriate	Anthrax bacilli form spores that can survive in the environment for decades.
Coxiella burnetii (Q fever)		Airborne dust contaminated with birth fluids and excreta of infected animals	• High fever • Severe headache • General malaise • Sore throat • Nonproductive cough • Nausea • Abdominal pain	• Strict hygiene to manage tissues and excreta of infected animals • Institute measures to reduce dust generation	Coxiella is a highly infectious agent that is rather resistant to heat and drying. Cattle, sheep, and goats are the primary reservoirs.

TABLE 2.1

ADVERSE EFFECTS OF ANIMAL AGRICULTURE OUTPUTS ON HUMAN HEALTH
OUTPUTS TRANSMITTED THROUGH AIR

Output	Priority	Mode of Transmission from AFO	Adverse Health Effects	Methods of Control	Comments
Viruses					
Influenza A (influenza)	Insufficient data to prioritize	Respiratory droplets from infected animal	• Malaise • Fever • Nasal symptoms • Nonproductive cough • Muscle pain • Headache • Pneumonia	• Vaccination	Swine-specific virus causes mild disease in humans. Swine may act as mixing vessels for reassortment of avian and human strains, resulting in new strains highly infective for humans.
Fungi					
Histoplasma capsulatum (histoplasmosis)	Insufficient data to prioritize	Spores released to air from soil or other material contaminated with bird droppings	• Fever • Chest pains • Dry, nonproductive cough	• Manure management • Institute measures to reduce dust generation	

Notes:

1. Odor is treated as a single entity in many of the regulations and in the most of the community health effects literature. However, odor is the result of various odorants interacting with the olfactory system to produce a detectable or recognizable odor in the observer.
2. Odor control practices are discussed at length in the GEIS: A Summary of the Literature Related to Air Quality and Odor (Topic H).
3. The Minnesota Employee Right-to-Know Act of 1983 requires that employees be trained on hazards of hazardous chemicals and infectious agents (see specific chemicals and infectious agents listed in MR §5206.0400).

associated with animal agriculture on the regulatory practices is presented in Section 3 - Federal, State, and Local Control Strategies. Please note that some of the methods of control have not been proven to work in all types of animal agriculture facilities. Also, some practices to control one output may result in increased transmission of another output.

2.3.1.1 Gases

Although there are technical differences between gases and vapors, this document will refer to both as "gases." Animals produce gases directly through their metabolism and indirectly through decomposition of their waste products by microorganisms (bacteria and fungi). If the waste storage facility is not aerated, the types of microorganisms that can grow in the waste are adapted to survive with little oxygen, and are called anaerobic. The products produced by anaerobic decomposition are often very odorous and irritating. Decomposition of manure in storage structures yields the following percentages of gases (Addis, *et al.*, 1999):

1. Methane (60 percent)
2. Carbon dioxide (40 percent)
3. Ammonia
4. Hydrogen sulfide
5. Various other gases, including odorants

Methane (CH_4) and carbon dioxide (CO_2) are greenhouse gases. Methane is flammable and a simple asphyxiant gas (displacing oxygen), and CO_2 is relatively non-toxic. Both NH_3 and H_2S are associated with the odor of livestock waste.

As indicated in Table 2.1, the two primary gases of concern are NH_3 and H_2S. It is appropriate to emphasize these two gases because they are well documented as resulting from animal waste and there are wide-ranging reports of significant environmental and human health impacts from the transmission of these gases in air and other routes.

2.3.1.1.1 Ammonia

Human Health Effects

Ammonia is a strong respiratory irritant produced by animals used in agriculture. Protein consumed by animals is the primary source of NH_3 in animal waste. Protein contains amino acids, which are broken down to urea and uric acid, and excreted from the bodies of mammals and poultry. The use of quaternary ammonium compounds for sanitation may produce a very small portion of the NH_3 detected in livestock buildings and waste structures.

Ammonia is very stable in liquid solutions and often is not released until the waste dries. For this reason, NH_3 is unlikely to reach an immediately dangerous or life-threatening concentration during agitation of waste in manure storage structures (Donham, 1995). Due to the strong odor and irritant properties of NH_3, persons exposed to concentrated sources of NH_3 typically remove themselves from exposure. Levels of 2,500-6,000 parts per million (ppm) are fatal, due to pulmonary edema. Most of the cases of fatal exposures to NH_3 are due to exposure to anhydrous ammonia released from compressed gas cylinders or from NH_3 refrigerant systems.

Most of the inhaled NH_3 (83 percent) is retained in the nasal passages, since it goes into solution in the moist surfaces in the mucous membranes (ACGIH, 1991). Ammonia damages or impedes the performance of the cilia (hair-like structures) in the upper respiratory tract of mammals (ACGIH, 1991, USEPA:IRIS, 1991). Since ciliary action is required for normal clearance of dust particles, studies have shown that the effects of NH_3 and dust are worse than the additive effects of the dust and the exposure to NH_3 (ACGIH, 1991). Based on human case studies the U.S. Navy established an exposure limit of 25 ppm for submarines in 1962.

Please note that the inhalation health risk values (IHRVs) shown in Table 2.2 are set to protect all susceptible populations during continuous exposure, whereas the occupational exposure limits (ACGIH TLV and MN OSHA PEL) are based on short-term exposures and periods of no more than eight hours and assume that workers who are exposed are relatively healthy and acclimatized to working in environments with NH_3 vapors in air.

TABLE 2.2

AMMONIA
HEALTH EFFECTS AND EXPOSURE GUIDELINES

Ammonia (NH_3) Concentration (ppm)	Adverse Health Effect	Comment
Range: 0.043-53 AIHA Accepted value: 16.7 ACGIH citation: Less than 5	Odor threshold	(AIHA, 1989; ACGIH, 1991)
0.12	To prevent upper and lower respiratory irritation	Proposed Chronic Inhalation Health Risk Value (Minnesota Department of Health, 2000)
4.6	Eye and respiratory irritation	Proposed Acute Inhalation Health Risk Value (MDH, 2000)
25	Irritation	Occupational Threshold Limit Value (ACGIH, 2000); Poultry industry recommendation for bird health and performance (Wheeler, 2000)
35	Irritation	ACGIH TLV-Short-Term Limit Value (2000) and MN OSHA Short-Term Exposure Limit (Minnesota Rules, §5205.0010, 1989)
300	Maximum short-term irritation tolerance (occupational)	Immediately Dangerous to Life or Health (IDLH) level (NIOSH, 1999)
2,500-5,000	Lethal concentration (pulmonary edema and systemic effects)	(Hurst, 1995)

Notes:
ppm = parts per million
$\mu g/m^3$ = micrograms per cubic meter of air
1 ppm = 696 $\mu g/m^3$

Monitoring

Monitoring of NH_3 has been conducted extensively in animal confinement feeding operations. Wheeler and her associates studied NH_3 levels indoors during nine successive flocks of broilers in central Pennsylvania during the winter months. They found that NH_3 levels greater than 25 ppm were common, especially when litter was reused for successive flocks (Wheeler, *et al.*, 2000). They reported a range of NH_3 values from 27 to 121 ppm. Poultry confinement employees may have been exposed above the occupational exposure limits; however, workers who are exposed to NH_3 routinely get acclimatized to elevated levels in this range, and weren't likely to recognize when the NH_3 levels were of concern to themselves or the poultry.

Donham and associates studied NH_3 levels and other parameters in swine confinement feeding operations and reported an average worker exposure to NH_3 of 5.6 ppm, which is much lower than the levels reported in poultry houses (Donham, *et al.*, 1995). Based on this research and other swine feeding operations the researchers proposed an exposure guideline of seven ppm NH_3. The effects of NH_3 were reported to be synergistic with respirable dust, total dust, and endotoxin exposures, so this exposure guideline should not be viewed in isolation, nor is it relevant for poultry operations, as described below.

British research indicates levels between 1.5 and 13.2 ppm NH_3 in swine confinement (Crook, 1991). Researchers in the Netherlands reported a range of 0.6 to 6.0 ppm NH_3 in Dutch swine confinement workers (Preller, *et al.*, 1995). The Dutch researchers also reported an association between NH_3 exposure and lung function. Ammonia was not expected to affect lung function, because in a gaseous state it affects only the upper airways. They explain this phenomenon by noting that NH_3 can adsorb to dust particles small enough to enter the deep lung (Preller, *et al.*, 1995).

Based on extensive study of declines of lung function in poultry workers and environmental parameters, Donham and colleagues demonstrated a dose-response relationship between occupational exposures to dust and NH_3 (Donham, *et al.*, 2000). They proposed an industry-specific standard of 12 ppm NH_3 for poultry confinement work.

Much less ambient data were available for areas downwind of these facilities. Preliminary data from a study conducted jointly by the Agency for Toxic Substances and Disease Registry (ATSDR) and the Missouri Department of Health indicates that NH_3 levels correlated to discomfort and acute asthma attacks better than hydrogen sulfide levels (Joran-Izaguirre, 2000). These data have not been analyzed and were not available to review or summarize. One of the problems with ambient monitoring is the fact that anhydrous ammonia is used in agriculture as a fertilizer precursor. Also, some refrigeration systems in dairies and food processing facilities use ammonia as a refrigerant, and minor leaks may occur in outdoor piping and during recharging of the NH_3 refrigerant.

The MPCA, the MDA, the U of M Department of Biosystems and Agricultural Engineering, the Minnesota Pork Producers Association, and Land O' Lakes entered into a cooperative agreement to study odor, ammonia, and hydrogen sulfide emissions. Emission rates for NH_3 from various facilities were measured (MPCA, 1999). The ambient NH_3 concentrations were not determined, but could be modeled mathematically from these emission factors. Refer to the "Technical Work Paper for Air Quality and Odor" for an in depth discussion (Earth Tech, 2000).

Control

Much of the research related to NH_3 emission reduction from animal agriculture is related to manipulation of the animals' diet. The following are strategies that have been researched, but most are still being tested (Jacobson, Moon, *et al.*, 1999):

- Feed additives:

  - Binding agents, such as zeolite or activated charcoal (may increase fecal nitrogen excreted).
  - Urease inhibitors, such as *Yucca schidegera* or sarsaponin (reduces NH_3 excreted).
  - Masking agents (doesn't reduce total emissions; results not consistent).
  - Fat or oil additives (reduces dust and may reduce odor; possible addition to volatile fatty acids).

- Improving dietary nutrient utilization:

  - Synthetic amino acids (lowers nitrogen in manure, may add other odorous compounds).
  - Ingredient selection and feed processing (reduced NH_3, H_2S and overall odor).
  - Modifying microflora in the animal's gut using polysaccharides (reduces odor, but does not reduce NH_3 emissions).
  - Antibiotics (mixed results; some reduce NH_3 and some increase it).
  - Probiotics (cultures of beneficial microbes) to improve feed utilization and reduce dependence on antibiotics (reduces NH_3 and odor, but much more research is needed).

The NH_3 in cattle barns increased with additional ventilation in a Finnish study (Linnainmaa, 1993). The researchers reported ranges of 4.2 to 12.8 ppm NH_3 in the autumn and 5.7 to 15.4 ppm NH_3 during the winter months. The NH_3 evolution rate was reduced 62 percent in cattle facilities using litter. This is apparently due to the fact that the airflow across the particles on which the NH_3 is adsorbed affects the rate of transfer from the liquid to gaseous state. Thus, although ventilation is required to improve air quality in feeding operations, it may result in higher NH_3 emissions that may increase off-site concentrations. The authors of the Finnish study noted that NH_3 concentrations were reduced 62 percent when peat was used in poultry houses (Linnainmaa, 1993). In general, using litter with a relatively low pH reduced emissions.

Various methods to reduce NH_3 emissions during land application of manure are used in Europe. In Denmark, the practice is to apply manure to actively growing crops. This reportedly results in little or no off-site odor (Just, 2000). It also assures that the NH_3 will not be lost to air or contribute to nitrates in water.

The conventional method of spreading manure on fields is by using a splash-plate spreader. Low trajectory spreaders and shallow injection both reduce NH_3 volatilization significantly. Chadwick and associates report NH_3 reductions ranging from 39 percent to 75 percent with band-spreaders and trailing shoe spreaders, respectively, to 85 percent with shallow injection (Chadwick, 2000). They also report, however, that nitrous oxide (N_2O) emissions are significantly increased with shallow injection. This effect is not believed to have direct human health implications; however, N_2O is a major contributor to global warming.

Please refer to Section 2.3.1.3 - Odors for additional information regarding odor control, since most of the research practices to reduce odor emissions are also effective for controlling the contribution of NH_3 to off-site concentrations.

2.3.1.1.2 Hydrogen Sulfide

Human Health Effects

Hydrogen sulfide overexposure can be more serious than exposure to NH_3, since it affects the body's uptake of oxygen (O_2) by poisoning the blood-forming tissue and acts as a chemical asphyxiant, preventing the proper transport and use of O_2 in the body's metabolism. Sulfur compounds in animal feed that end up in livestock waste include H_2S and other reduced sulfur gases. University of Iowa researchers report that during agitation of liquid manure, the concentration of H_2S in the breathing zone of workers can climb from five ppm to lethal levels over 500 ppm within seconds (Donham, 1995). The odor of H_2S does not give adequate warning of hazardous concentrations because olfactory fatigue (the inability to smell H_2S) occurs after exposure to concentrations in the range of 100 to 150 ppm.

Inhaled H_2S affects synthesis of blood-forming heme, the iron-containing molecule in hemoglobin (Jäppinen, 1990). Reiffenstein, Hulbert and Roth report that the effect of H_2S on oxidative enzymes is similar to that of hydrogen cyanide (Reiffenstein, 1992).

At lower levels of exposure, H_2S exerts a reversible effect on the respiratory system, increasing airway resistance and decreasing airway conductance (Jäppinen, 2000). Based on this information, the Minnesota Department of Health has proposed an inhalation Health Risk Value (IHRV) for H_2S of 0.06 ppm (60 parts per billion), to prevent acute effects and 0.007 ppm (seven parts per billion) to prevent chronic effects. A study of sewer workers exposed to H_2S in the 0.5 to 10 ppm range exhibited a long-term reduction in pulmonary function (Richardson, 1995). The potential exposures to workers entering manure pits or pumping liquid animal waste could have short-term exposures well above this range.

Many of the confined space fatalities in manure pits have been attributed in part to exposure to high concentrations of H_2S (CDC, 1993; National Research Council, 1979; Donham, 1995). Although H_2S-related fatalities are an occupational hazard, not all of those killed in manure pit accidents were workers. A 1996 issue of Farm Safety & Health Digest reported that of the twelve Minnesotans that died during entry into manure pits from 1984 to 1996, three (25 percent) were children under six years of age (Farm Safety and Health Program, 1996). In the ten-year period from 1990-1999, the overall percentage of persons under the age of 16 who died in farming accidents in Minnesota was approximately 18 percent, so a disproportionate number of preventable non-occupational fatalities occurred due to manure pits lacking proper security fences or covers on openings to keep children out and prevent falling hazards. Appendix B provides narratives on the manure pit fatalities from 1984 through October 2000 (Farm Safety and Health Program, 2000) in Minnesota. Please note that many of these fatalities occurred on relatively small facilities. Thus, the hazard does not necessarily increase with facility size.

When referring to the IHRVs for H_2S, it should be noted that these are ambient outdoor air standards designed to protect even susceptible populations, such as infants, the elderly, and persons with existing respiratory impairments. Also, the occupational exposure limits (MN OSHA PELs) apply to healthy works who are exposed no more than 8 to 10 hours per day or 40 hours per week.

TABLE 2.3

**HYDROGEN SULFIDE
HEALTH EFFECTS AND EXPOSURE GUIDELINES**

H_2S Concentration (ppm)[1]	Adverse Health Effect	Comment
0.0007 (1 µg/m^3)[2,3]	One thousandth of the no observable effect level for inflammation of nasal mucosa	Reference Concentration (USEPA:IRIS, 1995)
0.001-0.13	None known	Threshold for odor detection
0.007	Based on prevention of chronic effects (mucous membrane irritation in rats)	Proposed Subchronic Inhalation Health Risk Value, Minnesota Department of Health (MDH, 2000)
0.060	Based on prevention of reversible respiratory effects	Proposed Acute Inhalation Health Risk Value (MDH, 2000)
0.15-5	Offensive odor	May be associated with nausea, discomfort, loss of appetite
5		Proposed TLV (ACGIH, 2000)
10	Irritation	TLV (ACGIH, 2000) and MN OSHA Permissible Exposure Limit; Time-weighted average (Minnesota Rules, §5205.0010)
15	Irritation, central nervous system effects above this level	Short-Term Exposure Limit (ACGIH, 2000) and MN OSHA Short-Term Exposure Limit (Minnesota Rules, §5205.0010)
50-100	Serious eye injury (gas eye)	
100	Olfactory fatigue	Immediately Dangerous to Life or Health (NIOSH, 1995)
150-250	Olfactory paralysis	Possible edema with prolonged exposure at 250 ppm
300-500	Pulmonary edema	
600	Lowest lethal concentration in humans (30-minute exposure)	(NIOSH, 1995)
500-1,000	Strong nervous system stimulation, apnea	
1,000-2,000	Immediate collapse with respiratory paralysis; possible nervous system paralysis	
5000	Imminent death	(Hurst, 1995)

Notes:
1 ppm = parts per million
2 µg/m^3 = micrograms per cubic meter of air
3 1 ppm H_2S = 1,394 µg/m^3
4 Additional sources:
a. National Research Council, 1979
b. Beauchamp, *et al*., 1984

Monitoring

Significantly more ambient H_2S monitoring has been done than for NH_3. However, very little information was available on typical indoor H_2S concentrations in AFOs. Since H_2S is heavier than air, exposures usually occur only during agitation of manure. The MPCA can require H_2S monitoring, as described in Section 3. There are also acceptable levels established for areas off-site, including the proposed inhalation health risk values (IHRVs) shown in Table 2.3.

Due to instrumentation limitations, total reduced sulfur is usually reported as H_2S. U of M researchers have demonstrated that total reduced sulfur (TRS) measurements and H_2S concentrations (verified by gas chromatography) correlated to odor units in the range of 0.86 to 0.91 (1.0 being the highest possible correlation), which is a very high statistical correlation (Clanton, 2000). Odor is discussed later in Section 2.3.1.3 - Odors and in the *Technical Work Paper on Air Quality and Odor Impacts* (Earth Tech, 2000).

The MPCA Air Quality Work Group has conducted screening level H_2S monitoring near feedlots to document typical concentrations for various types of facilities. Earth Tech analyzed the data sets from 1998 for statistical trends and noted that the highest concentrations were near swine facilities (Earth Tech, 2000). This may have been an artifact of the non-random nature of facility selection, since many of the monitoring locations were determined following odor complaints.

Additional trends evident in the 1998 MPCA data include the following:

- The overall 30-minute average for all monitoring events was 0.012 ppm H_2S.
- The average distance monitoring was conducted from the source was 757 feet.
- 97.7 percent of the 30-minute average values were below the proposed MDH IHRV (Acute) for H_2S.
- 59.3 percent of the values were below the proposed MDH IHRV (Subchronic).
- Only 4.4 percent of the 30-minute averages were below the USEPA Reference Concentration (RfC) of 0.0007 ppm. (Note: The detection limit for the instrument used was 0.001 ppm.)
- 5.3 percent of the monitoring events were done during manure system pump-out.
- The average distance from the manure pump-out location was 885 feet.
- The average 30-minute average near a manure pump-out event was 0.031 ppm H_2S.

Control

Many of the same methods of diet manipulation are applicable to H_2S reduction as were discussed in the previous section for NH_3. Some methods, such as maintaining low pH in manure storage or in litter, while effective for reducing NH_3 emissions, low pH increases H_2S emissions. Refer also to Section 2.3.1.3 - Odors for additional control strategies aimed at overall odor reduction.

Controlling the potential fatal effects of H_2S and confined spaces in which manure is stored should be a priority in future regulation in Minnesota. This could be modeled on the Canadian Farm Building Code, which was adopted in 1990 to prevent manure pit fatalities and toxic gas overexposure. These Canadian building codes require the following safeguards (Feddes and Barber, 1995):

1. Locking devices on covers weighing less than 20 kilograms (45 pounds), so that they cannot be opened without authorization.
2. Proper guarding of the pump-out access to prevent persons from falling in.
3. Permanent fencing (at least 1.5 meters high) and locking gates (if fixed covers are not provided).
4. Warning signs regarding toxic manure gases.

2.3.1.1.3 Other Volatile Compounds

Although much attention has been focused on NH_3 and H_2S, many other VOCs have been detected in and around livestock facilities or livestock wastes. A literature review by O'Neill and Phillips (1992) identified 168 VOCs. Their review was concerned mostly with odor nuisance, but some of the volatile compounds have been shown to have adverse health affects apart from those associated with odor. The complete list of these compounds is found in *GEIS on Animal Agriculture: A Summary of the Literature Related to Air Quality and Odor* (Jacobson, Moon, *et al*, 1999).

Eighteen (in addition to NH_3 and H_2S) of the 168 AFO-associated VOCs have documented USEPA or state agency inhalation toxicity values. These compounds and their toxic endpoint(s) - the tissue, organ, or system that is the most sensitive target of the chemical's toxicity-are listed in Table 2.4. Some of the listed chemicals have more than one source for an inhalation toxicity value, but the value from only one source is given, using the following hierarchy: 1) the Minnesota Department of Health (MDH) proposed Inhalation Health Risk Values (IHRV; MDH, 2000), 2) the USEPA's Integrated Risk Information System (IRIS; USEPA, 2000) and Health Effects Assessment Summary Tables (HEAST; USEPA, 1997), and 3) the California USEPA's Office of Health Hazard Assessment (Cal-OEHHA) Reference Exposure Levels (RELs; Cal-OEHHA, 2000).

TABLE 2.4

VOLATILE COMPOUNDS IDENTIFIED IN LIVESTOCK WASTES WITH DOCUMENTED ACUTE OR CHRONIC INHALATION TOXICITY VALUES

Compound	Acute Toxicity Values			Chronic Toxicity Values				
				Cancer		Non-cancer		
	Toxicity Value ($\mu g/m^3$)	Toxic Endpoint	Source	Toxicity Value ($\mu g/m^3$)	Source	Toxicity Value ($\mu g/m^3$)	Toxic Endpoint	Source
Acetaldehyde	---	---	---	5	MPCA IHRV [1]	9	Upper respiratory system	USEPA RfC
Acrolein	0.19	Irritant - eye	Cal-OEHHA REL [2]	---	---	0.02	Upper respiratory system	USEPA RfC
Benzene	1,000	Developmental	MPCA IHRV	1.3	MPCA IHRV	60	Nervous system; blood; developmental	Cal-OEHHA REL
2-Butanone (methyl ethyl ketone)	10,000	Irritant - eye and respiratory system	MPCA IHRV	---	---	1,000	Developmental	USEPA RfC
Carbon disulfide	6,000	Developmental	MPCA IHRV	---	---	700	Nervous system	MPCA IHRV
Chloroform	100	Developmental	MPCA IHRV	0.4	USEPA	300	Liver; kidney; developmental	Cal-OEHHA REL
Formaldehyde	94	Irritant - eye and respiratory system	MPCA IHRV	0.8	MPCA IHRV	3	Respiratory system; eyes	Cal-OEHHA REL
Hexane	---	---	---	---	---	2,000	Nervous system; upper respiratory system	MPCA IHRV
Methanol	25,000	Central nervous system	MPCA IHRV	---	---	4,000	Developmental	Cal-OEHHA REL
2-Methoxyethanol (ethylene glycol methyl ether)	90	Developmental	MPCA IHRV	---	---	20	Reproductive	USEPA RfC
Naphthalene	---	---	---	---	---	3	Upper respiratory system	MPCA IHRV
Phenol	5,800	Irritant - eye and respiratory system	MPCA IHRV	---	---	200	Liver; cardiovascular; kidney; nervous system	Cal-OEHHA REL

TABLE 2.4

VOLATILE COMPOUNDS IDENTIFIED IN LIVESTOCK WASTES WITH DOCUMENTED ACUTE OR CHRONIC INHALATION TOXICITY VALUES

Compound	Acute Toxicity Values			Chronic Toxicity Values				
				Cancer		Non-cancer		
	Toxicity Value (μg/m³)	Toxic Endpoint	Source	Toxicity Value (μg/m³)	Source	Toxicity Value (μg/m³)	Toxic Endpoint	Source
Tetrachloroethylene (perchloroethylene)	20,000	Irritant - eye and respiratory system; central nervous system	MPCA IHRV	17	USEPA	35	Liver and kidney	Cal-OEHHA REL
Toluene	37,000	Irritant - eye and respiratory system; central nervous system	MPCA IHRV	---	---	400	Nervous/upper respiratory system	MPCA IHRV
Triethylamine	2,800	Irritant - eye; transient corneal edema	MPCA IHRV	---	---	7	Upper respiratory system	USEPA RfC
Xylenes	22,000	Irritant - eye and respiratory system; central nervous system	MPCA IHRV	---	---	700	Nervous/upper respiratory systems	Cal-OEHHA REL

Notes:
[1] The Inhalation Health Risk Values (IHRVs) shown are from a draft document (MPCA-MDH, 2000), subject to final review and approval.
[2] The California Office of Environmental Health Hazard Assessment (OEHHA), the group tasked with reviewing and updating the list of “Proposition 65” chemicals, developed the Reference Exposure Levels (RELs) shown above.

For acute and chronic noncarcinogenic effects (for example, skin and eye irritation or developmental effects), the inhalation toxicity value is an estimate of the air concentration at or below which no adverse noncancer effects are expected to occur, even in sensitive individuals. For carcinogenic effects, the toxicity value is the air concentration to which lifetime exposure is associated with an individual excess lifetime cancer risk (ELCR) of 1 in 100,000.

According to MDH policy, simultaneous exposure to multiple chemicals may result in additive effects. All cancer risks are considered to be additive (that is, the total ELCR is the sum of the chemical-specific ELCRs). Noncancer effects are additive for chemicals with similar toxicological effects. Some of the compounds listed in Table 2.4 have effects such as irritancy to the eye and respiratory tract on a chronic or acute basis, and therefore their effects would be considered additive with those of ammonia and hydrogen sulfide.

Although many VOCs have been identified in and around livestock waste, there is little quantitative information on the air concentrations of these chemicals inside AFOs or in the ambient air outside of these facilities. This is particularly true for those compounds with documented inhalation toxicity values.

There is evidence that the ambient air concentrations of some of the volatile chemicals listed in Table 2.5 are higher in areas of that have high feedlot density. The MPCA monitors 75 air toxics at a number of locations in Minnesota. Three of the monitoring sites that report VOC concentrations are located in southern Minnesota rural areas with high feedlot density: Pipestone, Granite Falls, and Zumbrota. The mean concentrations of selected air toxics are lower at these sites than at sites located in urban areas. However, they are higher than the mean concentrations reported at the monitoring site located in Warroad, a rural northern Minnesota community with little agricultural activity (background). Table 2.5 shows air toxics monitoring data for the VOCs with toxicity values at the selected sites and the cancer and noncancer toxicity values.

TABLE 2.5

MEAN CONCENTRATIONS OF SELECTED VOCs IDENTIFIED IN AREAS WITH AFOs AND OTHER LOCATIONS AND THEIR INHALATION TOXICITY VALUES (mg/m^3)

VOC	High Feedlot Density Agricultural Area			Urban		Background	Inhalation Toxicity Value	
	Pipestone	Granite Falls	Zumbrota	Holman Field	Minneapolis Library	Warroad	Cancer	Noncancer
Acetaldehyde	0.75	1.0	0.63	1.3	1.7	0.57	5	9
Benzene	0.82	0.93	0.65	1.7	2.5	0.64	1.3	60
Chloroform	0.13	0.08	0.11	0.14	0.14	0.10	0.4	300
Formaldehyde	1.3	2.0	1.2	1.5	2.2	1.2	0.8	3
Perchloroethylene	0.28	0.21	0.28	0.54	1.2	0.18	17	35
Xylene	0.97	0.64	0.56	2.4	4.3	0.60	---	700

According to the MPCA (1999), mobile sources are the highest emission sources for benzene and formaldehyde, and area sources (the source category that includes agricultural operations) are the next major sources. It is not possible, however, to determine the relative contribution of high-density feedlots to the monitored ambient air concentrations.

Because there is a great deal of uncertainty in the emission rates of volatile compounds from animal facilities, it is not possible to reliably estimate the concentrations of these chemicals in the surrounding communities through air dispersion modeling. This uncertainty is especially high for estimating short-term, worst-case emission rates, which are used to evaluate acute effects.

In addition to the VOCs listed in Table 2.4, other trace VOCs may be produced by microbial metabolism in feed or waste. These VOCs of microbial origin, known as MVOCs, are reported to include some of the VOCs listed in Table 2.4, such as acetone, toluene, and xylene. Other VOCs may include the following alcohols and ketones, most of which are odorous compounds (Macher, 1999):

- 1-Octen-3-ol
- Geosmin
- 3-Methylfuran
- 3-Methyl-1-butanol
- 3-Methyl-2-butanol
- 2-Pentanol
- 2-Hexanone
- 2-Heptanone
- 3-Octanol
- 3-Octanone
- 3-Octan-1-ol
- 2-Methylisoborneol
- 2-isopropyl-3-methoxypyrazine

The health significance of MVOCs is unclear at this time. Many of these compounds have fairly low odor thresholds. The predominant type of odor is often described as “moldy” or “musty,” but other odors, both pleasant and unpleasant, have been described in the literature. Most of the research related to MVOCs pertains to indoor air quality in buildings impacted by moisture problems. There is very little information available related to specific health effects and even less information directly related to animal agriculture.

VOCs are classified as an AFO output that requires more research to determine the magnitude of their impact on human health. More data are needed on the concentrations of these chemicals in and near animal facilities. In addition, quantitative toxicity data are not available for most of the volatile chemicals potentially associated with AFOs.

2.3.1.1.4 Other Gases

In addition to NH_3, H_2S, and VOCs, additional gases of potential concern include hydrazine, sulfur dioxide (SO_2), CO_2, CO, and CH_4. The review by O’Neill and Phillips of odorant compounds associated with livestock and animal waste (O’Neill and Phillips, 1992) indicates that hydrazine and SO_2 were only reported in one study each and with one species (hogs). Hydrazine was detected in a livestock building, but not in waste. Sulfur dioxide was reported in livestock waste, but not in livestock buildings. Data in turkey houses were consistently below 0.4 ppm SO_2, indicating that off-site effects are improbable (Reynolds, *et al.*, 1994). Thus, these substances are not considered significant, despite their acute toxicity levels at high concentrations. Most of the odor associated with livestock and poultry is related to NH_3 and reduced sulfur compounds. Therefore, both hydrazine and SO_2 are of low priority. The proposed IHRV for hydrazine is 0.002 $\mu g/m^3$. The California Reference Exposure Limit (REL) for SO_2 is 660 $\mu g/m^3$ to prevent respiratory irritation.

Carbon monoxide is hazardous, but levels are only expected to be high in manure storage pits. Carbon dioxide can also be present in hazardous concentrations in manure storage, but off-site concentrations are probably indistinguishable from the background levels. Internal combustion engines are the most likely source of off-site CO_2 and CO concentrations. The ambient background concentration of CO_2 is 325-360 ppm. Carbon dioxide is non-toxic up to 3 percent in air (30,000 ppm), based on short-term exposure and 10,000 based on long-term (8-10 hour) exposure.

Methane is also emitted from manure storage and farm animals. It is an asphyxiant gas with a flammable concentration in the 5-15 percent (50,000 to 150,000 ppm) range. This gas dissipates rapidly and is odorless. However, some manure pit fatality reports indicated that CH_4 asphyxiation was responsible for the fatality (Farm Safety and Health Program, 2000). The off-site concentrations and human health effects of CH_4 are presumed to be negligible. Due to the potential fuel value of this effluent, more large facilities are investing in equipment to recover and use this "biogas" for on-site heating. Due to the presence of H_2S in the gas; however, it is considered unsuitable for powering vehicles, due to the adverse effect on metal engine parts (Jacobson, *et al.*, 1999).

No direct off-site consequences for any of theses trace gases were described in the literature. The main indirect off-site consequence of both CO_2 and CH_4 emissions is their role in global warming due to the "greenhouse effect." Recycling CH_4 is a good example of a way to reduce environmental impacts and improve the sustainability of animal agriculture (and reduce the negative health impacts of fossil fuel reduction and power generation).

2.3.1.2 Dust

Various researchers have tried to characterize the dust associated with agriculture, including crop farming, livestock, and poultry feeding operations. In general, the types of dusts include inorganic and organic dusts. Table 2.6 summarizes the types of dust in greater detail.

2.3.1.2.1 Inorganic Dust

The dust present in agricultural environments is largely organic in nature, although a significant portion is inorganic (mineral). The effects of mineral dust exposure include acute and chronic bronchitis, chronic obstructive airways disease, and interstitial lung disease (Kirkhorn and Garry, 2000). Soils contain silicates, calcium carbonate and free (crystalline) silica. Crystalline silica (quartz) is capable of producing pulmonary fibrosis silicosis based on long-term overexposure. A study of dust from twelve farms in Alberta, Canada (mostly soil), indicated quartz levels between 0.8 percent and 17.5 percent (Schenker, 2000). The mineral dusts in rural environments apply to any agricultural activity that disturbs the soil. Thus, although animal agriculture contributes to the overall load of inorganic dust, the greatest contribution is crop farming, due to the large amount of soil that is disturbed. Adverse effects of mineral dust exposure (pneumoconiosis) were documented in half of the autopsies of Hispanic males in Fresno County, and lung tissue evidence of dust-related disease was strongly associated with an agricultural work history (Schenker, 2000). Silicosis has been documented in horses and 20 out of 100 autopsies performed on animals at the San Diego Zoo revealed interstitial fibrosis associated with mineral deposits in the lung (Schenker, 2000). This effect should be less pronounced in confinement feeding operations where there is less exposure to soils.

The highest concentrations are found during harvest times, and some agricultural regions, such as the San Joaquin Valley, are out of compliance with the federal USEPA ambient air standard for particulate matter with an aerodynamic diameter of less than 10 microns (PM_{10}, James, 2000). PM_{10} is roughly analogous to what is referred to as "respirable" in occupational exposures.

The potential chronic effects of off-site exposure to inorganic dusts related to animal agriculture needs to be studied further. In the absence of hard data, it is believed that continued exposure to relatively high concentrations of silica-containing dust is necessary to develop interstitial fibrosis (silicosis). Another area needing more research is the role of $PM_{2.5}$ particles. Reportedly, a significant amount of the ammonia from AFOs reacts with sulfur oxides to produce ammonium sulfate, which is in the $PM_{2.5}$ size range (Pratt, 2000).

2.3.1.2.2 Organic Dust

Organic dusts are of greater concern in the short-term, because of the ability to develop an immunological reaction to these agents in ways that inorganic dusts do not. Asthma is associated with organic dusts, although exposure to any type of airborne particles can worsen pre-existing lung conditions (Kirkhorn and Garry, 2000). Exposure to organic dusts is associated with asthma, rhinitis, bronchitis, hypersensitivity pneumonitis (HP), and organic dust toxic syndrome (ODTS). Symptoms of ODTS with flu-like aspects, including fever, chills, headache, cough, chest discomfort, breathing difficulty, muscle aches, and possible nausea (McDuffie, 1995). ODTS is associated with short-term overexposure to organic dusts which may contain various bacteria or molds, including *Thermophilic actinomycetes, Aspergillus* species, and even algae, although the causative agents are in dispute. Exposure to fungi that thrive in moist environments with elevated temperatures, such as moldy hay or silage or certain composting conditions (Addis, *et al.,* 1999; McDuffie, 1995) appears to be a risk factor for ODTS. ODTS attack rates are usually very high, regardless of previous exposures. Although some symptoms are similar to endotoxin exposure, no dose-response for the endotoxin content of the dust has been demonstrated. Organic Dust Toxic Syndrome is distinct from HP, which is an allergic reaction to bacterial and fungal antigens and bacterial proteases (protein enzymes) that requires susceptibility and follows an immune system sensitization experience (Macher, 1999). Identification and description of the actual agent(s) responsible for ODTS is elusive (Donham and Thorne, 1994).

Sprince and colleagues reported that Iowa farmers who applied pesticides to livestock were significantly more likely to report respiratory symptoms (Sprince, *et al.*, 2000). The finding of flu-like symptoms associated with this activity can be explained by close contact with animals and the possible exposure to elevated concentrations of dust associated with ODTS.

The main categories of organic dusts are discussed further in the following sections:

<u>Bacteria</u>: Airborne bacterial pathogens are discussed in Section 2.3.1.4.1 - Anthrax. With the exception of soil-borne bacteria, such as *Bacillus anthracis,* most bacteria are not viable unless suspended in a mist form from a liquid reservoir. Consistently low concentrations have been detected at distances up to 300 meters from a 500 sow operation (Homes, *et al.*, 1996).

<u>Endotoxin</u>: Gram-negative bacteria (so-named due to their ability to be stained with saffranin dye for microscopic examination) have unique lipopolysaccharide (LPS) macromolecules in their outer cell walls, which are known as endotoxin (ACGIH, 1999). Endotoxin can remain biologically active long after the bacteria have died and fragments of LPS of various sizes are biologically active, affecting the upper and lower respiratory systems. Endotoxin is toxic in low concentrations and can cause fever and malaise, changes in white blood cell counts, respiratory distress, and shock (Macher, 1999). Endotoxin is quantified using the *Limulus* amebocyte lysate (LAL) assay, by GC- mass spectrometry, or by the more recent EndoFluor™ test. ACGIH notes that due to the presence of interferences from fungal cell wall components (see (1→3)ß-D-glucan, below) and lack of standardized methods of sample collection and analysis, that it is premature to establish a TLV for endotoxin (Macher, 1999). Endotoxin retains much of its biological activity for a long time and can be present in total inhalable and respirable (PM_{10} or smaller)

particles. Thus, it is considered a high priority for research to quantify concentrations, determine its environmental fate and determine the best methods of control.

Typical background concentrations in air are three endotoxin units per cubic meter of air (EU/m^3) during the growing season. Low-level endotoxin exposures, only slightly in excess of normal backgrounds levels, have been associated with increased severity of asthma (Macher, 1999).

Fungi: Fungi in general can elicit allergic reactions in susceptible people. Fungal levels in agricultural areas are generally high. Individual susceptibility, temporal variability, and the lack of standardized methods for sampling and analysis make it difficult to establish occupational exposure guidelines. Studies in Minnesota by Mulhausen and colleagues in turkey confinement houses reported indoor concentrations of *Aspergillus* species were very low with respect to outdoor concentrations, while Reynolds and others reported bacteria levels ranged from 300,000 to 38.7 million colony-forming units per cubic meter of air (CFU/m^3) (Addis, *et al.*, 1999). Indoor fungi levels were reportedly up to five times higher in the winter months versus summer.

Mycotoxins: The presence of toxic secondary metabolites makes the presence of some types of fungi more serious. Some mycotoxins have neurotoxic effects, some are carcinogenic (aflatoxin), and some cause nausea. The most common mycotoxin contaminant in feed is fumonisin B_1, which was found at levels above the 2 ppm tolerance in over 5 percent of the feed supplied to horses in the U.S. (USDA:APHIS, 2000b). NIOSH-funded research indicated that farmers can be exposed to potentially hazardous levels of aflatoxin B_1 during harvest, grain loading, and animal feeding in confinement buildings (Selim, *et al.*, 1998). Although this can be a serious problem for farmers handling contaminated grain, or entering silos with contaminated grain, there is no evidence of a detectable mycotoxin problem off-site. For example, during the NIOSH study, no aflatoxin was detected outside of the cab of the harvester. Also, airborne dust containing mycotoxins are usually associated with grain crops and would thus not be limited to animal agriculture.

(1→3)-ß-D-glucan: This agent is a glucose polymer derived from the cell walls of most fungi. These glucans stimulate T-cell function and have anti-tumor properties. They have an effect on lung cells similar to endotoxin (Macher, 1999). This molecule is ubiquitous in outdoor air. Workers handling dry (1→3)-ß-*D*-glucan dust as a food additive exhibited no irritant effects (Macher, 1999). This agent cross-reacts with endotoxin in the LAL test. More specific immunoassays are available. This is believed to be a low priority output, pending further research.

Allergens: Various allergens are present, in addition to fungi. These may include fecal proteins, animal dander, skin flakes, mite antigens, urine or saliva antigens, pollen, and a host of other airborne allergenic particles (Donham, 1986; Iversen and Dahl, 1994).

Monitoring

Table 2.6 summarizes the literature on the types dusts found in or near agricultural facilities and specifically in livestock confinement feeding operations. Although this table provides typical airborne concentrations (Kirkhorn and Garry, 2000; Donham, 1986; Donham and Thorne, 1994; Kullman, *et al.*, 1998), it is not an exhaustive summary of all the on-site data. Very little data were available off-site for most of the parameters shown.

TABLE 2.6

DUSTS AND DUST LEVELS FOUND IN ANIMAL AGRICULTURE

Dust Type	Description	Concentration (mg/m^3)[(1)]	Comment
Inorganic	• Diatomaceous earth • Amorphous silica (diatomite) • Crystalline silica	Respirable dust: 2-20 (open cab) 0.1-1 (closed cab)	MN OSHA PEL for respirable dust: 5 mg/m^3, or 0.1 mg/m^3 for silica to prevent silicosis
Organic	Grain dust	Total dust: 72.5 (grain cleaning)	Threshold Limit Value: 4 mg/m^3 (ACGIH, 2000)
	Livestock confinement dust	Total particulate: 4.53 (swine) 6.5 (average in poultry) 1.78 (dairy) Respirable: 0.23 (average in swine) 0.63 (poultry) 0.07 (dairy)	Particle size (diameter) range: <0.1 µM to 100 µM; [(2)] MN OSHA PEL for total dust: 15 mg/m^3 resp. dust: 5 mg/m^3
	Animal feces (fecal proteins, undigested feed, gut epithelium)	See total dust data	
	Animal feed	See total dust data	Starch, grain meal, plant matter
	Animal dander, dust mites, other antigens	See total dust data	(Kullman, *et al*., 1998)
	Endotoxin	Total dust: 202.3 EU/m^3 (swine) [(3)] 1,589 EU/m^3 (poultry) 647 EU/m^3 (dairy) Respirable dust: 16.6 EU/m^3 (swine) 58.9 EU/m^3 (poultry) 16.8 EU/m^3 (dairy)	See text regarding exposure guidelines
	Bacteria	Highly variable results Methods not comparable	1,300 CFU/g gram positive; [(4)] 100 CFU/g gram negative (swine)
	Pollen	Insufficient data available	Allergen
	(1→3)-ß-D-glucan	Insufficient data available	
	Fungi and mycotoxins	Highly variable results Methods not comparable	394 CFU/g (swine)
	Insect parts	Insufficient data available	

Notes:

[1] mg/m^3 = milligrams per cubic meter of air; most of the values shown are geometric mean (GM) values from worker breathing zone sampling

[2] µM = one millionth of a meter in length

[3] EU/m^3 = endotoxin units per cubic meter of air

[4] CFU/g = colony-forming units of bacteria or fungi per gram of dust

Control

Control of the these dusts is related to the sources from which it arises. The following are general suggestions for control (BMPs):

- Dust from feed may be controlled by using pelletized feed or enclosing the feeding apparatus.
- Dust in confinement houses may be reduced by maintaining a modest amount of humidity to reduce dust generation from litter.
- Reduce excessive air velocities while maintaining adequate air exchange year-round.
- Dust suppressants may be used, as long as they are non-toxic.

2.3.1.3 Odors

Background

Many of the gases and vapors emitted from animal feeding operations are odorants. In other words, they are chemicals that the human olfactory system (nose) can detect. The receptors for the sense of smell are located in the mucous-covered olfactory epithelium in the nasal passages. These receptors are specialized bipolar neurons with cilia that protrude into the mucous layer (Schiffman and Gatlin, 1993). These nerves connect to the olfactory bulb, which projects into the primitive cortex. The areas of the primitive cortex that process odors also process emotional information (Schiffman and Gatlin, 1993). Strong odors are reported to stimulate electrical activity in the amygdala and hippocampus portions of the limbic system. The most important role of the limbic system is the regulation of temperature and blood circulation through the hypothalamus. Stimulation of these limbic networks is believed to be involved in triggering of the primitive "fight or flight" response associated with panic disorder (Ashford and Mller, 1991). Fulbright and colleagues have shown using NMR brain scans that response to pleasant and unpleasant odors (valeric acid being the chosen unpleasant odor; see Table 2.6), different parts of the human brain are activated (Fulbright, *et al.*, 1998). The frontal region of the cerebral cortex was the most active and additional regions were involved with pleasant odors.

In comparison to rats and dogs, primates have long been considered "microsmatic," or relatively incapable of detecting very low levels of odorants (Laska, *et al.*, 2000). Recent German research published by Laska and others reported that squirrel monkeys demonstrated an ability to detect volatile fatty acids and aldehydes at levels far below what they were believed to be detectable at previously. They proposed that odors may play a greater role in primate behavior than was previously believed (Laska, *et al.*, 2000). The relevance of this finding to humans is yet to be determined.

Most of the odorant substances associated with animal feeding operations are volatile organic compounds, although ammonia and hydrogen sulfide are notable exceptions. The O'Neill and Phillips conducted a comprehensive literature review on odorous substances associated with livestock wastes or the air in animal feeding operations (O'Neill and Phillips, 1992). Although they found 168 individual chemicals associated with waste, their review identified only 26 compounds in air exhausted from these facilities. Table 2.4 presented the subset of VOCs identified that have inhalation toxicity values. Table 2.7 presents those 26 compounds identified in livestock air. The locations of ambient indoor air sample collection were not specified in the review article.

The full list of 168 chemicals can be found in the "Generic Environmental Impact Statement on Animal Agriculture: A Summary of the Literature Related to Air Quality (Topic H)"

(Jacobson, *et al.*, 1999). It is possible that some compounds in waste that were not detected in the buildings may be detected downwind of manure pits or manure freshly applied to land.

TABLE 2.7

CONCENTRATIONS OF ODORANTS IDENTIFIED IN LIVESTOCK AIR [(1)]

Substance	Chemical Class	Concentrations (mg/m^3) [(2)]			
		Odor Threshold	Range of Reported Values	By Species	
				Pigs	Poultry
Formic acid	VFA[(3)]	2 - 640	0.08 - 1.2 [(4)]	-	
Acetic acid	VFA	0.025 - 10	0.015 - 6.7	0.005 - 0.326	0.005 - 0.320
Propionic acid	VFA	0.003 - 0.89	0.002 - 1.1	0.004 - 0.290	0.003 - 0.049
n-Butyric acid	VFA	0.0004 - 42	0.001 - 0.7	0.002 - 0.617	0.002 - 0.027
Isobutyric acid	VFA	0.005 - 0.33	0.001 - 0.16	0.001 - 0.078	0.001 - 0.025
n-Valeric acid	VFA	0.008 - 0.12	0.012 - 0.08	0.002 - 0.063	0.002 - 0.012
Isovaleric acid	VFA	0.0002 - 0.0069	0.012 - 0.211	0.002 - 0.092	0.001 - 0.009
n-Caproic acid	VFA	0.02 - 0.52	0.01	-	-
Isocaproic acid	VFA	0.037	0.004	-	-
Heptanoic acid	VFA	0.022 - 0.033	0.003	-	-
Octanoic acid	VFA	0.003 - 0.6	0.005	-	-
Nonanoic acid	VFA	0.0016 - 0.12	0.004	-	-
Acetaldehyde	Aldehyde	0.0027 - 1	0.124	-	-
Propionaldehyde	Aldehyde	0.0036 - 0.69	0.024	-	-
Acetone	Ketone	0.95 - 1,550	0.043	-	-
Phenol [(5)]	Phenolic	0.022 - 4	0.002 - 0.065	0.001 - 0.043	0.001 - 0.173
p-Cresol	Phenolic	0.00005 - 0.024	0.002 - 0.004	0.002 - 0.075	0.001 - 0.06
m-Cresol	Phenolic	0.00022 - 0.035	See Note 5	-	-
Indole	N-Heterocyclic	0.0006 - 0.0071	0.003	-	-
Skatole (3-methyl indole)	N-Heterocyclic	0.00035 - 0.00078	0.003	-	-
Dimethyl sulfide	Sulfide	0.0003 - 0.16	0.0022	-	-
Xylene	VOC	0.35 - 86	0.0045	-	-
Ammonia	Gas	0.03 - 37.8	0.01 - 18	1 - 24	0.5 - 7.5
Hydrogen sulfide	Gas	0.0001 - 0.27	0.004	-	-
Trimethylpyrazine	N-Heterocyclic	-	0.00045	-	-
Tetramethylpyrazine	N-Heterocyclic	-	0.000090	-	-

Notes:
1 Adapted from O'Neill and Phillips, 1992.
2 mg/m^3 = means milligrams per cubic meter of air.
3 VFA = means volatile fatty acid.
4 One reference reported the concentration as all of the VFAs through valeric as 0.08 to 1.2 $\mu g/m^3$.
5 One reference combined all of the phenols together and reported 0.04 mg/m^3 for pig operations and 0.005 mg/m^3 for poultry.

Health Effects

Odorant molecules in a gaseous state or adsorbed to dust particles can cause nasal and respiratory irritation (Addis, *et al.*, 1999). Research by Allison and Powis showed that nasal irritation can elevate adrenaline, which can convert mild annoyance to irritability, tension, and anger (Addis, *et al.*, 1999). The fact that some odorant compounds are in themselves irritants or VOCs can complicate the assessment of potential health effects, especially in susceptible populations. Baldwin, Bell, and O'Rourke report that people reporting chemical odor intolerance are more likely than the general population to report a history of hay fever. They are also were most likely to report upper and lower respiratory discomfort when exposed to smoke and exhaust particulates and VOCs (Baldwin, *et al.*, 1999). People with a history of childhood asthma were more likely to report feeling ill from VOCs (solvents), perfumes, and disinfectants. Some odorants may stimulate the trigeminal nerve, which can result in respiratory irritation, while other odorants appear to stimulate other receptors (Baldwin, *et al.*, 1999). Odorants can exacerbate the effects of asthma, but it is not known whether they can induce new cases of asthma. Clearly, more research is needed on chemical intolerance and on understanding the mechanisms of odorant activity on the respiratory system.

Odorant chemicals such as H_2S or toluene produce peripheral vasoconstriction as well as pupil dilation (Winneke, 1992). Exposure to environmental tobacco smoke and noise also had the same effect and was statistically significant for the test subjects, but responses to the exposure to a 50 ppb H_2S odorant stimulus was not statistically significant (Winneke, 1992). This suggests that there is a subjective component to odor response and that adaptation occurs.

Social psychological factors and low population density affect the ability of researchers to do highly controlled and statistically significant work to assess the true human health impact of exposure to odorants from animal feeding operations. Exposure, in itself, does not result in the reporting of general health complaints. The likelihood of persons exposed to chemical odorants to report symptoms is positively associated with their perception that the odor is physically threatening (Addis, *et al.*, 1999). Unpleasant odors can affect cognitive performance skills; however, it may be difficult to separate out conditioned behaviors from neurophysiological changes caused by odorant molecules (Addis, *et al.*, 1999). Van den Bergh and associates demonstrated that subjects exposed to odorants in association with a stimulus challenging the respiratory system can demonstrate the adverse physiological response in the presence of the odor without the respiratory challenge (Van den Bergh, *et al.* 1999). Thus, somatic symptoms, such as chemical intolerance may have a component that involves behavioral conditioning. It should be noted that the subjects in the Belgian study were healthy volunteers and do not necessarily represent the full spectrum of persons exposed to environmental odorants in agricultural areas.

Schiffman and colleagues (Schiffman, *et al.*, 1995) reported that 44 persons living near a large swine feeding operation in North Carolina had statistically lower scores for Profile of Mood States (POMS) parameters than 44 matched controls. Persons who experienced odorous emissions from the facility reported significantly more of the following psychological effects:

- Tension
- Depression
- Anger
- Decreased vigor
- Fatigue
- Confusion

Thu and colleagues conducted a community study of physical and mental health was near a large (4000 sow) swine confinement facility in Iowa. The "exposed" population of 18 persons was matched with a group of non-exposed rural residents in the same general area. Despite the small sample size, they reported statistically significant differences in three clusters of physical health effects between exposed and relatively unexposed populations (Thu, *et al.*, 1997). These symptom clusters included 1) respiratory inflammation or hyperreactive symptoms, 2) nausea, dizziness, weakness and fainting, and 3) headaches and plugged ears. There was no evidence of a significant difference in psychological symptoms, with an emphasis on indicators of depression.

Monitoring

Odors can be monitored using trained human odor panels using dynamic dilution devices (olfactometers) to determine odor intensity. Also, surrogate odorants, such as reduced sulfur compounds, or H_2S, can be used in the field. Please note that there is no widely accepted threshold for discomfort or health effects based on odor concentrations.

The "Feedlot Air Quality Stakeholders Report" reported odor emissions and ambient odor concentrations in odor units (OU) at distances downwind and on-site at wean-to-finish and finishing barns. Odor plume odor concentrations ranged from 80 OU on-site to 20 OU at 150 meters at the finishing site and 200 OU on-site to 20 OU at 100 meters at the wean-to-finish site (MPCA, 1999).

Control

Regardless of the actual human health effects of exposure to odorants, various methods of control of odors are available and are discussed in detail in the "Generic Environmental Impact Statement on Animal Agriculture: A Summary of the Literature Related to Air Quality and Odor (Topic H)" (Jacobson, *et al.*, 1999):

- Feed additives:
  - Binding agents, such as zeolite or activated charcoal (may increase fecal nitrogen excreted).
  - Urease inhibitors, such as *Yucca schidegera* or sarsaponin (reduces NH_3 excreted).
  - Masking agents (doesn't reduce total emissions; results not consistent).
  - Fat or oil additives (reduces dust and may reduce odor; possible addition to volatile fatty acids).
- Improved utilization of dietary nutrients:
  - Synthetic amino acids (lowers nitrogen in manure, may add other odorous compounds).
  - Ingredient selection and feed processing (reduced NH_3, H_2S and overall odor).
  - Modifying microflora in the animal's gut using polysaccharides (reduces odor, but does <u>not</u> reduce NH_3 emissions).
  - Antibiotics (mixed results; some reduce NH_3 and some increase it).
  - Probiotics (cultures of beneficial microbes) to improve feed utilization and reduce dependence on antibiotics (reduces NH_3 and odor but much more research is needed).

- Dust reduction (since many odorants are readily adsorbed onto dust particles):

  - Dust suppression using vegetable oil (oil reduces airborne dust, but may create a greasy environment; may create slipping hazard).
  - Air filtration (energy intensive and high maintenance cost).
  - Biomass filters (initial capital cost; lower efficiency during higher airflow rates in the summer).
  - Wind-break walls to reduce off-site dispersion of odorant dust.
  - Shelterbelts (rows of trees and other vegetation) act like wind-break walls but may not be effective until the trees are established.
  - Air scrubbers (very effective for point sources, but high capital and O&M costs).
  - Wetted dust impaction walls (residence time is short, so may be low efficiency).

- Air treatment:

  - Ozonation to deactivate odorants (ozone is a deep lung irritant to humans and animals and can create aldehydes and ketones when VOCs are treated).
  - Non-thermal plasma (more research needed; studies are on-going at the University of Minnesota).

- Covers:

  - Rigid covers are effective to reduce odor emissions (but require venting and are a very high capital investment); may help prevent some types of manure pit fatalities, but may concentrate the toxic gases and may make rescue retrieval more difficult during planning entries).
  - Flexible covers and organic mat covers are also effective, as long as they can seal in the products of anaerobic activity until the manure is land applied.
  - Straw covers reduced odor at a swine manure basin from 79.0 to 16.6 OU (MPCA, 1999).

- Manure treatment:

  - Solids separation (capital and operating costs; may not be feasible for smaller facilities).
  - Chemical binder addition to precipitate phosphorus and reduce H_2S and NH_3 emissions during agitation (chemicals may be expensive and hazardous).
  - Solid and liquid composting (capital and operating costs and investment in business development to sell the final product).
  - Aerobic finishing (requires capital investment and pre-separation to be effective).
  - Anaerobic digesters (huge initial capital investment, but can be recovered in energy savings over the long run in larger facilities).
  - Electrolytic treatment (more research needed; energy cost may be high).

- Product additives:

  - Microbes or microbial enzymes to reduce odorous compounds (not predictable; subject effects of uncontrollable variables).

- Masking agents (low cost but not always effective; may not reduce overall emissions.
- Acidification of the manure reduces NH_3, but increases H_2S

- Land application of manure:

  - Low trajectory methods of spreading are the least odorous.
  - Shallow injection requires a high investment in equipment and may increase nitrous oxide emissions (Chadwick, *et al.*, 2000). Various technologies for odor reduction during land application of manure are discussed in Section 2.3.1.1.1 - Ammonia.

2.3.1.4 Pathogens

Although airborne zoonoses are certainly a potential risk for farmers and other individuals with occupational exposure to animals, there is no direct evidence that individuals living near AFOs are at increased risk for developing diseases associated with pathogens transmitted via the air from these facilities. Little research has been conducted on the emission rates of microorganisms from AFOs, and there is a wide variation in the reported ranges of microorganism concentrations in air and emission rates from AFOs. Even less is known about the impact of these organisms on people living nearby.

Microorganisms have been shown to be transmitted considerable distances through dispersion. However, their ability to initiate and spread disease depends on their ability to survive and their ability to cause infection. Survival is a prerequisite for infectivity, but the attributes that allow for infectivity are more easily lost through environmental stress. Potential stresses to microorganisms that may affect their ability to survive or remain infective include humidity, temperature, radiation, oxygen, and pollutants (Cox, 1995). Even though many of the microorganisms emitted from AFOs may lose their infectivity, there are groups of individuals who are hyper-susceptible to infections and in whom a comparatively low number of organisms may cause disease. Patients afflicted with AIDS are particularly vulnerable to devastating infections caused by organisms that produce only mild or asymptomatic disease in most people.

Examples of diseases that could potentially be transmitted from an AFO to humans through inhalation include anthrax, Q fever, brucellosis, Influenza A, and histoplasmosis. The pathogens that cause these diseases, the associated signs and symptoms, and means of control are tabulated in Table 2.1. Diseases for which domestic animals are the primary host (anthrax, for example) are primarily an occupational hazard for those working with animals or animal products. In a recent, well-publicized incident in Roseau County, members of a farm family were exposed to anthrax. Because of the interest in anthrax, a brief overview of this disease is provided in Section 2.3.1.4.1 - Anthrax. Theoretically pathogens could be transmitted through air and cause disease in individuals living near animal production facilities if the causative organisms remain infective and are present in high enough concentrations.

Organisms that cause food-borne illness could potentially be transmitted via flies from animal production facilities to human food and cause disease. Examples of bacteria that cause food-borne zoonoses include *Salmonella*, *E. coli* O157:H7, and *Campylobacter*. The clinical features associated with these diseases in humans are presented in Table 2.8. There have been several studies that have attempted to incriminate flies as vectors of food-borne disease from animal confinement facilities. However, flies have yet to be demonstrated as important contributors to incidence of diarrheal disease in communities around such facilities (Addis, *et al.*, 1999). While air emissions of these enteric bacteria from animal confinement facilities increase the population of these microorganisms in the environment, there are insufficient data to determine if this results in an increased risk to human health (Jacobson, *et al.*, 1999).

TABLE 2.8

ADVERSE EFFECTS OF ANIMAL AGRICULTURE OUTPUTS ON HUMAN HEALTH
OUTPUTS TRANSMITTED THROUGH SOIL AND WATER

Output	Priority	Mode of Transmission from AFO	Adverse Health Effects	Methods of Control	Comments
GASES/DISSOLVED GASES AND IONS					
Hydrogen sulfide	Insufficient data to prioritize	• Releases to air from open grazing, manure spills, or land application of manure	• Respiratory irritation • Odorant • Nausea, cramps, vomiting • Decreased heme synthesis	Regulatory: • Ambient air standard and monitoring requirement Other controls: • Dietary modification • Manure management	
Ammonia	Insufficient data to prioritize	• Releases from open grazing, manure spills, or land application of manure	• Eye and respiratory irritation • Paralyzes dust-clearing mechanisms	Regulatory: • Comprehensive nutrient management plan • Air emissions and odor reduction plan Other controls: • Dietary modification • Manure management	
Nitrate	High	• Run-off from manure-fertilized fields, direct spill, or animals defecating in water	• Methemoglobinemia	• Manure management • Dietary modification • Monitoring of drinking water	
Other volatile compounds	Insufficient data to prioritize	• Releases to air from open grazing, manure spills, or land application of manure • Run-off from manure-fertilized fields, direct spill, or animals defecating in water	• See Table 2.4	• See odorants	

TABLE 2.8

ADVERSE EFFECTS OF ANIMAL AGRICULTURE OUTPUTS ON HUMAN HEALTH
OUTPUTS TRANSMITTED THROUGH SOIL AND WATER

Output	Priority	Mode of Transmission from AFO	Adverse Health Effects	Methods of Control	Comments
DUSTS					
Allergens, PM_{10}, endotoxins	High	Fugitive dusts from soil amended with manure	• Asthma • Rhinitis • Bronchitis • Fever • Malaise	• Manure management • Setbacks • Windbreak vegetation	
Mycotoxins	Low	Toxic metabolites of fungi - found in fugitive dusts	• Carcinogenicity • Neurotoxicity • Nausea	Regulatory: • Residue testing of foodstuffs	Exposure unlikely without nearby reservoir of toxigenic fungi.
(1→3)-ß-*D*-Glucan	Low	Glucose polymers walls from cell walls of fungi - found in fugitive dusts	• Respiratory irritant • Allergen • Immune system stimulant		
ODORANTS					
Volatile fatty acids, adehydes, ketones, phenolics, N-heterocyclics	High	• Releases to air from open grazing, manure spills, or land application of manure • Run-off from manure-fertilized fields, direct spill, or animals defecating in water	• Tension • Depression • Anger • Fatigue • Confusion • Decreased vigor • Respiratory irritation	• Diet manipulation with feed additives • Improvement of dietary nutrient utilization • Manure treatment • Product additives	

TABLE 2.8

ADVERSE EFFECTS OF ANIMAL AGRICULTURE OUTPUTS ON HUMAN HEALTH
OUTPUTS TRANSMITTED THROUGH SOIL AND WATER

Output	Priority	Mode of Transmission from AFO	Adverse Health Effects	Methods of Control	Comments
HEAVY METALS					
Arsenic	Insufficient data to prioritize	• Ingestion of water contaminated with run-off from manure-fertilized fields, direct spill, or animals defecating in water • Ingestion of crops grown in soil contaminated with heavy metals from manure	• Arsenic is a carcinogen by the oral route of exposure (skin, lung, liver kidney, and bladder cancer) • Hyperpigmentation of skin • Skin lesions • Possible vascular complications • Possible abnormalities in nerve conduction	• Improvement of dietary nutrient utilization	Adverse health effects related to exposure to metals generated from animal agriculture have not been documented. Concentrations of these metals in manure are not likely to exceed ceiling limits for sewage sludge set by EPA 503 sludge rules. Loading limits set by the rules could be exceeded after very long-term application.
Copper	Insufficient data to prioritize		• Gastrointestinal distress		
Zinc	Insufficient data to prioritize		• Affects metabolism of copper, which could lead to copper-deficiency anemia		

Pathogens transmitted through the air to surrounding communities, either directly or through mechanical vectors such as flies, are classified as animal agriculture outputs that need further research to classify them with regard to their potential to cause adverse effects to human health.

On-farm measures to control air- and vector-borne zoonotic diseases include:

- Practice good farm hygiene to prevent or reduce infection in livestock.
- Control vermin and insects.
- Institute measures to reduce the emission of dusts.

2.3.1.4.1 Anthrax

Anthrax is a zoonosis caused by the bacterium *Bacillus anthracis*. It is primarily a disease of herbivores (cattle, sheep, and goats), but few mammals are totally resistant. The bacteria multiply in the body of the infected animal, but form spores when exposed to air. The spores are resistant to environmental destruction and therefore can persist in soil for decades (Hunter, Corbett, and Grindem, 1995). Anthrax is most commonly found in areas with neutral to mildly alkaline soil and periods of flooding and drought. Most infections in animals occur after they have grazed in areas that have previously experienced anthrax. Flooding allows low-lying areas to accumulate high concentrations of anthrax spores; a drought then makes the spores accessible. The disease is transmitted in animals through the consumption of contaminated forage or water (Hugh-Jones, Hubbirt, and Hagstad, 1995).

In the U.S., anthrax is most commonly reported in the southern Mississippi River valley, but it has been reported in nearly every state. According to the Minnesota Animal Board of Health (ABH), as of September 8, 2000, anthrax had been diagnosed in seven beef herds, one each in Clay, Becker, Pennington, and Marshall counties, and three in Roseau County. Before 2000, no animal anthrax cases had been reported in Minnesota since 1909 (CDC, 2000). Veterinarians are required to immediately report cases of anthrax to the ABH by telephone or fax. Human cases of the disease are also immediately reportable by health professionals to the MDH. In North Dakota, 120-150 cattle died of anthrax in 2000. In Manitoba, 11 farms have reported anthrax deaths in cattle (CDC, 2000).

The form of disease that occurs in humans is dependent upon the pathway by which the spores enter the body. The cutaneous form usually develops after a traumatic injury causes the spores to be deposited underneath the skin (Hugh-Jones, Hubbirt, and Hagstad, 1995). It begins as a small pimple that eventually ulcerates and becomes a dry, black scab. The lesion is always accompanied by massive swelling. The infection may spread to the bloodstream if left untreated (Turnbull, 1998).

The disease can also be acquired through the inhalation of spores from contaminated dust, wool, or hair, especially in confined spaces. The intestinal form of anthrax occurs following the ingestion of contaminated, inadequately cooked meat (Hugh-Jones, Hubbirt, and Hagstad, 1995). In the recent incident in Roseau County, two of six farm family members who consumed meat from a cow that died of anthrax developed abdominal symptoms. They were advised to seek treatment for possible gastrointestinal anthrax. The cow was processed by local butchers, but neither they nor their families reported subsequent illnesses.

Both pulmonary and intestinal anthrax typically begin as a mild, flu-like illness that can end abruptly with the onset of severe illness with fever, chills, shock, collapse, and death. Humans are somewhat resistant to anthrax, and limited data suggests that mild infections are not uncommon (Turnbull, 1998).

The death rate for untreated cutaneous cases is estimated to be 10-20 percent. For pulmonary and intestinal forms of anthrax, the failure to recognize the disease early enough can result in fairly high fatality rates. Diagnosis often depends upon the knowledge that a person has been exposed to the spores. Antibiotics need to be administered in time to kill the bacteria before they liberate enough toxin to cause death. All forms of anthrax are treatable if the disease is not advanced (Turnbull, 1998).

Anthrax usually infects people who work closely with animals or animal carcasses, such as farmers, butchers, and veterinarians. Individuals exposed through the handling and processing of hides, bones, and other animal products have a higher chances of being exposed through inhalation (Turnbull, 1998).

Carcasses of animals that have died of anthrax must be burned and the ashes buried on site, followed by disinfection of the premises. To prevent formation of spores, the carcass should not be cut open. Vaccination of the remaining herd may be recommended by a veterinarian.

Additional research on the prevalence of anthrax is needed and should be coordinated with North Dakota and Manitoba, since they have reported a significant number of cases.

2.3.2 Outputs Transmitted Through Soil and Water

The "List of Outputs from Animal Agriculture that Could Negatively Impact Human Health" (see Appendix A) distinguishes outputs transmitted through soil and from those transmitted through water. However, we have combined them for this Human Health TWP because surface water and groundwater contamination with agricultural outputs often occurs secondary to soil contamination. Irrigation with contaminated water recycles the manure components to the soil. Soil and water serve as vehicles for transmission of agricultural outputs to other environmental media as well, such as ambient air and crops consumed by humans and animals. The agricultural outputs to soil and water are generally associated with animal manure and dead animal carcasses.

Intensive, large-scale animal production facilities produce large amounts of waste. Farm animals produce about ten times as much waste as humans (Haapapura, *et al.*, 1997). Feedlots, animal housing units, and manure storage areas (such as lagoons) can serve as point sources of manure contamination of soil and water. Application of animal manure to soils as a crop fertilizer is an important means for recycling the nitrogen and phosphorus that the manure contains. Grazing animals are also a source of manure to fields. Manure in the soil can contaminate surface water through runoff and groundwater through leaching. Contaminated groundwater and surface water used for crop irrigation or drinking water can cause disease in humans and recycle manure components such as pathogens in livestock. Wind erosion of contaminated soil and spray application of slurry can release the components of manure into the air. Improper disposal of dead animal carcasses can also lead to contamination of soil and water.

This section discusses the various outputs of animal agriculture that can adversely affect human health through releases of manure into soil and water. The output categories are: gases/dissolved gases, dusts, odors, heavy metals, and pathogens. Table 2.8 summarized the effects on human health of animal agriculture outputs transmitted through soil and water.

2.3.2.1 Gases/Dissolved Gases

Manure applied to land can release volatile constituents to the ambient air. The VOCs associated with animal wastes are discussed in Section 2.3.1.1 - Gases. With the exception of hydrogen sulfide and ammonia, it is unlikely that volatile compounds would be released in concentrations toxic to individuals living nearby. However, there have been no studies that quantified concentrations of other volatile compounds emitted from manure-amended soil. The known health effects of inhaled hydrogen sulfide, ammonia, and other volatile chemicals are tabulated in Tables 2.2, 2.3, and 2.4.

Spills or leaks from manure storage areas or runoff from manure-amended soils may directly release volatile chemicals into surface waters. In addition, volatile chemicals in spills or manure-amended soils can leach into groundwater. It is well known that nitrate in groundwater is a special risk for infants. An overview of nitrate is presented in Section 2.3.2.1.1 - Nitrate. There is no information on the contribution of agricultural facilities or agricultural runoff to the concentrations of volatile chemicals in surface waters or groundwater.

In addition to various manure treatment methods, there are several techniques for land application of manure, such as manure injection, that can reduce the emissions of ammonia, and presumably other volatile compounds. These methods are summarized in Section 2.3.1 - Outputs Transmitted through Air.

Hydrogen sulfide, NH_3, and nitrate are classified as high priority animal agricultural outputs. More research is required to determine the potential for adverse impact to human health from other volatile chemicals associated with animal facilities and land application of manure.

2.3.2.1.1 Nitrate

Nitrate occurs in animal agricultural operations primarily as a result of animal waste products. Ammonium nitrogen in animal urine and organic nitrogen in solid wastes are converted to nitrate by soil microbes. Nitrate is not readily held by soil, particularly coarse soils, and can leach to groundwater. In addition, nitrates can be added directly to soil as inorganic fertilizers in agricultural operations.

Human health effects from exposure to nitrates of agricultural origin are well documented in the literature. The principle effect, methemoglobinemia (blue baby syndrome) was first documented in 1941. This syndrome results from overexposure to nitrates, resulting in the displacement of oxygen in the bloodstream. Infants are most susceptible to the disease, hence its name. Since its initial identification, numerous cases of exposure have been documented, as recently as the 1990s. Virtually all of the cases resulted from ingestion of drinking water contaminated with nitrates.

Other toxic effects of nitrate exposure have also been studied and documented in the literature. In a review of developmental effects of nitrate exposure, Fan and Steinberg discuss a possible link between high nitrate exposure and increased deaths during infancy (Fan and Steinberg, 1996). Fan and Steinberg also describe several studies that were inconclusive, but suggested a correlation between nitrate consumption in drinking water and congenital malformations. Van Maanen, and colleagues studied a possible link between nitrate exposure and childhood diabetes mellitus in the Netherlands and concluded that the current World Health Organization and European Union standards of 50 mg/liter (as nitrate) may not be low enough to prevent risk of the disease (van Maanen, *et al*., 2000).

The link between nitrate consumption and cancer has received considerable attention. Several laboratory studies have suggested possible links between nitrate exposure and gastric, esophageal and nasopharynx cancers as well as non-Hodgkins lymphoma (van Maanen, *et al*., 2000). Epidemiological evidence for a link between cancer and nitrates, however, remains inconclusive. Although nitrate itself is not believed to be carcinogenic, it can be converted in the body to nitrite as well as N-nitroso compounds, the latter of which are well known for their carcinogenic potential. The uncertainty that exists in the literature on this topic stems from inadequate data on the rates and factors affecting conversion of nitrate to nitrite and N-nitroso compounds. Packer and colleagues suggested that a total reassessment of the role of nitrate in cancer is needed (Packer, *et al*., 1991).

Currently, drinking water standards established in the U.S. and elsewhere continue to be based on prevention of methemoglobinemia. The current Maximum Contaminant Level (MCL) for nitrates in drinking water is 45 mg/liter (as nitrate ion) or 10 mg/liter (as nitrogen). The USEPA initially established this standard under the Safe Drinking Water Act in the mid-1970s. The standard was re-evaluated in 1987 and determined to be protective of public health.

The scenarios resulting in human exposure to nitrates from animal agricultural operations are well documented and discussed in "Generic Environmental Impact Statement on Animal Agriculture: A Summary of the Literature Related to the Effects of Animal Agriculture on Water Resources" (Mulla, *et al.*, 1999). This document indicates that nitrates are generally not a significant component in runoff from these operations but that they can be found in significant levels in subsurface tile drain effluents when manure is applied to fields as fertilizer (Mulla, *et al.*, 1999). Seepage from manure holding basins and lagoons as well as spills of liquid manure and fertilizer can result in significant impacts of nitrate to groundwater, especially in areas of karst geology and coarse soils.

Proper management and prevention of excessive nutrient inputs to soil is critical to the reduction of nitrate contamination in groundwater. The technical work paper covering manure and crop nutrients describes methods for determining a nitrogen balance for farmland. These methods can provide useful information in establishing a comprehensive nutrient management plan, which is particularly important in sensitive geologic areas.

2.3.2.2 Dust

Fugitive dusts from wind erosion of manure-amended soils contain the same outputs as those emitted directly from the AFOs. These dusts can be inhaled by neighboring residents, and the dusts can settle on crops, posing a potential risk to humans through ingestion of pathogen-contaminated food. Also, the dusts may recycle pathogens to animals through inhalation or ingestion of dust-laden crops. The potential human health effects related to inhalation of dusts are discussed in Section 2.3.1.2. The potential effects from ingestion of heavy metals or pathogens in crops are discussed in Sections 2.3.2.4 and 2.3.2.5, respectively.

2.3.2.3 Odors

It is well documented that manure applied to land is a source of offensive odors. The effect of odors related to animal production on surrounding communities are discussed in Section 2.3.1.3.

2.3.2.4 Heavy Metals

Many metal-containing compounds are added to animal feed, often in the form of antimicrobials to improve animal health. Most of these metals are essential nutrients that can be toxic at high concentrations. A non-nutrient metal, arsenic, is common in poultry diets. These metals are excreted in manure and could potentially pose a risk to human health if they are transported in excessive amounts to surface water or groundwater from manure-amended soils. In addition, some metals are known to bioaccumulate in plants. Although there is a potential risk to human health, there is no documentation that adverse health effects have occurred secondary to exposure to heavy metals in the environment as a result of animal production. According to Mulla, *et al.*, (1999), nitrate and pathogens are the outputs of animal agriculture most associated with risk to human health from drinking water.

Besides nitrogen, phosphorus, copper, arsenic, and zinc were singled out by Moncrief, *et al.* (1999) as the elements in animal manure of greatest environmental concern. The toxic effects of chronic exposure to excess arsenic, copper, and zinc are well documented and are presented in Table 2.8. The 1993 USEPA 503 sludge rules set limits on the concentrations of these metals in sludge and on the quantity that can be applied over the lifetime of a site. It is unlikely that any manure would violate the ceiling concentration limits, but with long-term application the loading limits could be exceeded. Assuming average metal contents in manure with 30 percent moisture, at an application rate of 10-12 tons/acre the limits would not be exceeded for zinc in 388 years and for copper in 660 years. For poultry manure, which is higher in arsenic, the limit for arsenic would be exceeded in about 100 years (Moncrief, *et al.*, 1999).

Heavy metals such as arsenic, copper, and zinc in manure are classified as outputs of animal agriculture that require further research to determine their potential to cause adverse health effects to the general public.

2.3.2.5 Pathogens

Animal manure potentially contains bacteria, viruses, and protozoa that cause disease in humans. The type and number of pathogens depends on the source animal, the animal's state of health, and how the manure was stored or treated prior to use (Gagliardi and Karns, 2000). Exposure to the environment inactivates many manure organisms. The survival time of fecal coliforms and *Salmonella* spp. is reportedly less than 70 days, but usually less than 20 days (Mulla, *et al.*, 1999)

Any zoonotic disease spread through contact with feces could theoretically be soil- or waterborne. Soil pathogens spread to groundwater through leaching or to surface water through runoff after rainfall or floods. Groundwater contamination is most likely to occur when intensive animal agriculture occurs in areas with coarse-textured soils, shallow groundwater, and heavy precipitation (Mulla, *et al.*, 1999). The very young, the elderly, pregnant women, and persons with compromised immune system (such as persons receiving chemotherapy and those with AIDS) are especially susceptible. Fewer organisms are required to cause disease in these individuals, and their infections tend to be more severe.

Table 2.8 tabulates the health effects of some of the pathogens that could potentially be spread to humans through manure-contaminated soil and water. Zoonotic bacteria linked to waterborne disease include *Campylobacter, Salmonella, E. Coli, Leptospira, Yersinia, and Mycobacteria* (Ford, 1999; Mulla, *et al.*, 1999). There is a report of transmission of *E. coli* O157 through direct contact with soil. This organism was the apparent cause of an outbreak of gastroenteritis in people attending a music festival held in fields previously used to graze cattle (Maule, 2000). Zoonotic bacteria with a low risk of being transmitted through water include those that cause tetanus (*Clostridium tetani)*, brucellosis (*Brucella abortus (melitensis*)), anthrax (*Bacillus anthracis*), and erysipelosis (*Erysipleas rhusiopathie*) (Mulla, *et al.*, 1999).

Significant proportions of *Giardia* and *Cryptosporidia* infections are waterborne. These protozoa form cysts or oocysts that are resistant to disinfection, and filtration systems are required to remove them from drinking water (Ford, 1999). Four cryptosporidium disease outbreaks in the U.S. have been linked to agricultural runoff (Mulla, *et al.*, 1999).

Nearly all the viruses that cause gastroenteritis in humans have related strains that can cause diarrhea in livestock. Rotaviruses are the most common cause of severe diarrhea in humans worldwide; they are also a major cause of mortality in calves and piglets. Large numbers of viruses are excreted in an infected animal's feces and these viruses can enter waterbodies through land application of animal wastes or by direct contamination from pastures and feedlots (Addis, *et al.*, 1999). However, these strains appear to be highly host specific (LeBaron, *et al.*, 1990). Although these animal viruses have been found in humans (Addis, *et al.*, 1999), they have not been documented as having an important role in human disease, either endemically or in outbreaks (LeBaron, *et al.*, 1990).

There are no regulations concerning the pathogen content of soil. Fecal coliforms, which generally do not cause disease in humans, are used as indicators of the presence of other pathogens in surface water and groundwater. The limit for fecal coliforms in surface water is 200 Colony Forming Units per milliliter (CFU/ml). Studies have shown that concentrations of fecal bacteria in surface waters from manured lands are often not significantly different from levels in surface waters from unmanured lands if the manure has been stored and aged before land application. However, fecal bacteria in surface waters from lands receiving fresh manure can be a significant proportion of the fecal bacteria carried in surface waters (Mulla, *et al.*, 1999).

Sewage sludge must be treated before it is applied to fields, but there is no such requirement for livestock manure. The Clean Water Act (40 CFR 122) regulates pollution from point sources, including feedlots, under the National Pollutant Discharge Elimination System (NPDES) permit program. This regulation covers stored manure, but not manure spread on fields. State feedlot permitting regulations generally require management plans and incorporate BMPs that limit nitrogen to amounts crops can readily utilize in a growing season. Some research has shown that *E. coli* levels correlate with nitrogen levels. Therefore, nutrient management through permitting may help control some pathogens (Gagliardi and Karns, 2000).

Many zoonotic pathogens have a wide range of hosts, including wildlife, and therefore their elimination from the watershed is impossible. However, on-farm control measures help to reduce the risk of soilborne and waterborne disease. As described by Addis *et al.* (1999), the Hazard Analysis Critical Control Point (HACCP) is a systems approach to food safety management and decision-making about a product and its manufacturing process, the identification of hazards, and the selection of points and measures for control. The HACCP approach has successfully been applied to the food processing industry, resulting in reduced risk to the consumer. This approach is applicable to the farm, as well, where it would affect not only food-borne disease, but other pathways of transmission, as well (Hugh-Jones, Hubbirt, and Hagstad, 1995).

The Minnesota Department of Agriculture and the University of Minnesota have developed a cooperative program for certifying agricultural quality production procedures. This program is referred to as "Minnesota Certified" (MnCERT). Through this program, quality and safety standards would be implemented by a for-profit quality management consulting group (QM-Ag9000). MnCERT would evaluate and approve the standards and certify the defined production procedures. The standards to be evaluated include quality production standards to reduce food-borne pathogens and protect the environment. The official pilot project for MnCERT is MNCEP (Minnesota Certified Pork), a cooperative for pork producers developed to minimize the risk of food-borne disease through standardized, audited and certified production procedures. The quality standards of MNCEP are outlines in a handbook that includes information on such topics as best production procedures and pre-harvest food safety.

On-farm measures to control soil- and waterborne zoonotic diseases include:

- Practice good farm hygiene to prevent or reduce infection in livestock.
- Manage manure to prevent spills and leaks.
- Store or treat manure before application to land to reduce the population of pathogenic bacteria.
- Pasture animals at low densities, away from surface water bodies used by humans.
- Control vermin and insects.
- Restrain animals from defecating and urinating directly into surface water used by humans.

Zoonotic pathogens spread through manure-contaminated soil and water are classified as high priority outputs of animal agriculture. Transmission of disease from animals to humans through contaminated water has been documented. Bacteria and protozoa are the primary zoonotic waterborne pathogens. More research is required to document the importance of animal enteric viruses in soil- and waterborne disease transmission to humans.

2.3.3 Special Topics and Emerging Issues

2.3.3.1 Antimicrobial Resistance

Background

Subtherapeutic doses of antibiotics and other antimicrobial agents have been used in food animals in increasing amounts in the U.S. for the latter half of the twentieth century. The U.S. Food and Drug Administration (FDA) has approved the routine use of many antimicrobial agents for use in animal agriculture to reduce the likelihood of infection and to promote growth.

The most common route of administration is in the feed. Incidental use of antimicrobials includes growth promotant implants used in cattle to reduce the incidence of infection at the site of implant (APHIS: USDA, 2000). Since such dosages are subtherapeutic, administration in feed has typically been done without direct intervention of a veterinarian.

Other antimicrobial substances are used for sanitation and disinfection of equipment. Some agents are used to prevent mastitis in dairy cows, and others may be used to reduce pathogens in carcasses at meatpacking houses. Antimicrobials are used extensively for infection control in hospitals and other health care institutions. These agents are usually broad-spectrum chemicals that are fatal to virtually all microorganisms. Some groups, including the American Medical Association have voiced concerns that the mode of action of these agents may be more selective than was previously believed. For example, a strain of *E. coli* was found to have a gene that blocks the ability of triclosan (commonly found in antimicrobial hand soaps) to inhibit bacterial cell wall synthesis (Crabb, 2000).

Outputs

Potential outputs as a result of antimicrobial use potentially include on direct output and one indirect output:

- Chemical residues in food.
- Bacteria (or fungi) that have developed resistance to antimicrobials.

The former output has long been a concern, but has been addressed by the FDA and other agencies. The initial emphasis of regulation was to prevent the introduction of toxicants or carcinogens into animals that might persist in food products ingested by humans. The FDA withdrew approval of several animal drugs (including nitroimidazoles and diethylstibestrol, also known as DES) from the market because they were defined as carcinogens under the Delaney Clause (National Research Council, 1999). There has also been concern that the traces of these chemicals might be converted through normal metabolism into toxic constituents. The residue-testing program includes some metabolites in the chemical screening. Outputs transmitted through food consumption are outside of the scope of this document. There is also no evidence that the minute traces of these antimicrobials left in meat products are sufficient to affect the bacteria present in the human body. To further reduce the impact of drug residues, the United States Department of Agriculture (USDA) recently issued a rule forbidding the sale of any part of an animal carcass that was condemned due to the presence of drug residues exceeding the FDA tolerances for livers and kidneys (Aird, 2000).

Antibiotic resistance results from the development of or transference of genes that allow bacteria to circumvent the antibiotic action of a given drug. Such changes may occur spontaneously, by mutations in the bacterial genetic material (DNA). Another way resistance is spread is through a form of microbial sex called transformation. Bacteria share parts of their genetic material through conjugation (attachment of one cell to another). Another method is by transference of a small circle of DNA (called a plasmid) from one cell to another. In this way, resistance can be spread from one bacterial species to another (Lewis, 1995).

Ricki Lewis, Ph.D. wrote in *The FDA Consumer* magazine about a tragic outbreak of Shigellosis diarrhea in Guatemala in 1968. The illness was caused by a strain of *Shigella* that had acquired a plasmid that gave the organism resistance to *four* common antibiotics. As a result of aggressiveness and of the illness and its rapid spread under unhygienic conditions, this outbreak claimed an estimated 12,500 lives (Lewis, 1995).

Transfer of antimicrobial-resistant *Salmonella* species from animals to humans has been demonstrated by the Centers for Disease Control and Prevention (CDC) and at least five other peer-reviewed studies (Addis, *et al.*, 1999). Other species that may potentially develop resistance include *Escherichia coli* O157:H7, *Yersinia enterocolitica* and *Listeria monocytogenes*. Of recent importance is the documented resistance to antimicrobials that has been documented in fluoroquinolone-type drugs.

Case Study: Fluoroquinolone-Resistant Campylobacter jejuni

Campylobacter jejuni (a reportable illness in Minnesota since 1979) is the most commonly recognized cause of bacterial gastroenteritis in the U.S. (Smith, 1999). This infection has usually been treated with erythromycin or a fluoroquinolone, such as Ciprofloxacin™. Bacterial resistance to fluoroquinolones has been increasing since the 1980s, with high rates of resistance developing in Europe. Enrofloxacin had been approved for use in poultry in the Netherlands in 1987 and in Spain in 1990. During the period from 1985 through 1989, the rate of Ciprofloxacin-resistance in *Campylobacter* specimens from infected people in the Netherlands rose from 0 percent to 11 percent. A more dramatic increase in Spain was noted: from 0 percent to 3 percent in 1989 to 30 percent to 50 percent in 1991 (Smith, 1999).

Despite the evidence of a potential resistance problem in Europe, in 1995, the FDA approved two fluoroquinolones for use in poultry. These drugs include enrofloxacin and sarafloxacin. FDA also approved enrofloxacin (Baytril™ 100) in 1998 for use in beef cattle, but only to treat bovine respiratory disease associated with *Pasteurella* spp. and *Haemophilus somnus* (Grassie, 2000).

Prompted by an apparent increase in fluoroquinolone-resistant *Campylobacter jejuni* infections, the Minnesota Department of Health (MDH) carried out a case-control epidemiology study to understand the underlying factors for the increase in resistance. The MDH investigators reported that only 15 percent of the resistance could be traced to previous therapeutic use of fluoroquinolones in the infected persons (Smith, 1999). The team also tested poultry products in retail outlets, and found high rates of infection with fluoroquinolone-resistant *Campylobacter jejuni*.

Similar studies in Denmark detected the development of widespread resistance of *Enterococcus faecium* in beef cattle to vancomycin (Wegener, *et al.*, 1999). Wegener and associates attributed this to the use of avoparcin as an animal growth promoter. This finding is significant, because *E. faecium* is a common hospital-acquired infection, and vancomycin is believed to be the last line of defense available at this time (Wegener, *et al.*, 1999). Streptogramin-resistant *E. faecium* in the U.S. was recently reported in retail meats by the United States Food and Drug Administration (FDA) Center for Veterinary Medicine, and is believed to be due to the use of virginiamycin in food-producing animals (Aird, 2000).

Practices to Reduce the Increase in Antimicrobial Resistant Organisms

Whereas residues of chemicals in food are routinely tested and acceptable levels enforced, regulation to prevent microbial resistance crosses several jurisdictions, such as state health departments, FDA, USEPA, USDA, and possibly even international trade organizations. In response to the recommendations of several groups, including a 1995 task force representing the American Society of Microbiologists, the National Antimicrobial Resistance Monitoring System (NARMS) was established as a collaborative effort of representatives from FDA, CDC, and USDA. This monitoring system has focused on a list of 17 antimicrobial drugs and certain pathogens in cooperating states. Minnesota is one of those states.

The FDA issued a notice to withdraw approval of two fluoroquinolone antibiotics used in poultry. This action is related to the development and proliferation of antibiotic resistant pathogenic organisms that can be transmitted to humans (Sundlof, 2000) and is also a result of a risk assessment that was developed by the FDA Center for Veterinary Medicine (FDA, 2000). The FDA and other agencies have also published a draft document to combat antimicrobial resistance (Interagency Task Force on Antimicrobial Resistance, 2000). The key proposals from the draft document included the following priorities and action goals relevant to animal agriculture:

1. Develop and implement a coordinated national plan for antimicrobial resistance surveillance; monitor patterns of antimicrobial drug use. [As of April 2000, the FDA Center for Veterinary Medicine announced its plan to propose regulations to require pharmaceutical companies to submit data on the volume of sales of antimicrobial drugs for use in food-producing animals (FDA, 2000).]
2. Monitor antimicrobial resistance in the agricultural setting to protect the public's health by ensuring a safe food supply (as well as animal and plant health).
3. Prevent and control emerging antimicrobial resistance problems in agriculture by:

    a. Improving understanding of the risks and benefits of antimicrobial drug use.
    b. Developing principles for prudent antimicrobial use in food production animals.
    c. Improving animal husbandry and food-production practices to reduce the spread of pathogens.
    d. Establishing a regulatory framework to address the need for antimicrobial drugs in agriculture while ensuring that such use does not pose a risk to human health.

4. Improve the infrastructure for basic and applied research to uncover the mechanisms of antimicrobial resistance and develop ways to prevent it.
5. Develop an Antimicrobial Resistance Product Development Working Group to identify and prioritize public health needs and identify ways to promote development of products to address gaps in the ability to fight infections where market incentives are to develop such drugs are insufficient.

International Practices to Control Antimicrobial Resistance

Use of antimicrobials in Europe has been sharply curtailed. Denmark and many other European Union nations now require human antibiotics to be administered in food animals only when prescribed by a veterinarian (Just, 2000). Nutritional use of antibiotics is increasingly rare in Europe. The United Kingdom (UK) banned nutritional use of antibiotics in animal feed in 1969 (National Research Council, 1999). The World Health Organization stated in its report on an international meeting in Berlin on "*The Medical Impact of the Use of Antimicrobials in Food Animals*" that "The use of any antimicrobial agent for growth promotion in animals should be terminated if it is used in human therapeutics or known to select for cross-resistance to antimicrobials used in human medicine" (World Health Organization, 1997). The use of avoparcin in animals was prohibited in Denmark in 1996, in response to the development of vancomycin resistant *E. faecium.*

In December 1998, the European Union adopted a ban (effective July 1, 1999) on four antibiotics used at subtherapeutic levels to promote animal growth. The directive prohibits the nutritional use of bacitracin zinc, spiramycin, tylosin, and virginiamycin. The FDA is in the process of modeling the human health risk of continued use of virginiamycin in food animals in the U.S. (FDA, 2000).

The European Union recently adopted the Biocidal Products Directive (BPD), which requires the testing of all biocidal products for effectiveness and their impact on human health. An industry estimate predicts that the BPD may effectively eliminate the number of biocides available in Europe by 75 percent.

Policy and Program Recommendations for Minnesota

Food-borne outbreaks involving bacteria that are resistant to antimicrobials occur across state lines. Also, drugs used in animal agriculture are regulated nationally. Thus, if Minnesota were to enact broad regulations to combat antimicrobial resistance, it 1) may violate federal protections to prevent restraint of interstate trade and 2) may not be effective to prevent resistance that develops in other states. Within this context, the state of Minnesota should:

1. Continue surveillance on the occurrence and causes of infections by bacteria exhibiting antimicrobial resistance.
2. Monitor the use of antimicrobial drugs in food animals that are used in treating infectious diseases in humans, if the FDA fails to propose or enact such regulations.
3. Provide agricultural extension services to reduce stress factors associated with pathogen-shedding and disease transmission among food animals.
4. Promote research on the biochemical mechanisms of antimicrobial drug and biocide action and bacterial resistance to antimicrobials. This may aid the effort to develop new therapeutic drugs to treat multidrug-resistant pathogens.

5. Promote research on alternatives to antimicrobials in promoting growth and preventing disease.
6. Support federal initiatives to protect drugs used therapeutically in humans from the development of antibiotic resistance.

Although it may be difficult to develop policies that overlap the jurisdiction of the FDA, the state MDH and MDA should consider requiring additional labeling on certain antimicrobial drugs or supplemental documents or signage to warn veterinarians and food animal producers that some drugs have been determined to constitute a higher risk for increasing the prevalence of drug-resistant bacterial infections in humans.

Long-Range Consequences of Observed Trends

The future scope of the problem of antibiotic resistance is subject to conjecture, since the modes of resistance by bacteria and other pathogens cannot always be anticipated. Thus, a wide spectrum of opinions have been circulating, ranging from outright skepticism that any problem exists to doomsaying of global proportions. On the other hand, antimicrobial resistance has not been widely reported in the media in the U.S.. Minnesota's media coverage of these issues is probably better than in most states; a fact that may have more to do with the world-class infectious disease epidemiology program at the MDH than the fact that the problem is any worse than in other states.

Three of the factors will shape the regulatory arena in the area of the use of antibiotics and antimicrobials in feed animals that are:

- Public and Industry Awareness.
- Market Forces.
- Development of Alternatives.

One factor is the number of media reports and the seriousness of the issues presented. A major incident involving transmission of pathogens from food animals to humans could have irrevocable effects on the approval process for the use of human antibiotics in animals. Such an incident as the 1968 Guatemalan shigellosis outbreak in the U.S. or Canada, even if it were contained to a fraction of the magnitude of the outbreak in Guatemala, would have lasting impacts on the new drug review process and other aspects of animal agriculture. The second factor is in the economics of the development of new drugs. According to data complied by the Animal Health Institute in 1994, the overall market value of FDA-regulated prescription drugs used in humans in was $51.3 billion, compared to $3.2 billion for all drugs used in animal agriculture by prescription, over-the-counter and feed drugs (National Research Council, 1999). The pharmaceutical industry may willingly comply with increasing restriction of subtherapeutic use of antimicrobials in animals if it can extend the life cycle of its drugs used in human medicine. Also in the realm of market forces is consumer awareness. Although there is little evidence that most consumers would pay more for meat produced without routine use of antimicrobial additives, this could change, based on public awareness or effective marketing by "green" producers.

The most promising area for reducing the rate of development of microbial resistance to antimicrobials is in the use of competitive bacteria added to feed to promote the growth of normal bacteria and exclude pathogenic bacteria in food animals. These agents, called probiotics, will most likely see a significant increase in use over the next ten years, and may replace some of the nutritional uses of antimicrobial agents. The new presidential administration has made it a priority to see that Medicare pays for part of the costs of outpatient prescription drugs. Thus, market forces will inevitably affect public policy on the use of antimicrobials in animal agriculture because Medicare, Medicaid, and the Veterans Administration will bear the brunt of the increased costs of developing new drugs to replace antimicrobials to which microbes have developed a resistance.

2.3.3.2 Endocrine Disruptors

Endocrine disruptors, also referred to as hormonally active agents or endocrine modulators, refers to a broad category of agents having impacts on the normal functioning of hormone systems. This action by itself does not necessarily produce a "toxic" effect, but can lead to such effects in subsequent generations or later in the life of the organism. Naturally occurring endocrine disruptors are prevalent throughout the environment and are commonly found in plants, either through production by the plant itself, or through fungal infection of plants. Non-natural forms of these agents can occur from use of pesticides and other synthetic organic chemicals, including hormones, which are important tools in plant and animal production systems. Synthetic chemicals are often referred to as xenobiotics, or xenoestrogens, if they mimic the action of estrogen.

Several classes of endocrine disruptors have been described by in the literature (Nilsson, 2000). These include:

- Xenobiotic compounds that mimic or antagonize the effect of sex hormones.
- Natural compounds that mimic or antagonize the effect of sex hormones.
- Substances affecting thyroid function.
- Substances that cause mineral corticosteroid imbalance.

The first of these classes is probably the most studied and includes chlorinated compounds such as PCBs, dioxins and DDT. The second class of compounds, however, is most likely to represent a potential risk from animal agricultural facilities, since these are the types of compounds typically administered to animals as growth hormones. An example of a hormone used in animal agriculture is bovine somatotropin (BST). According to an FDA spokesperson, BST was used therapeutically in the U.S. during the 1950s to counteract growth deficiencies in children and had no observable positive or negative effects. Trace levels of this hormone have no hormonal effect and are easily metabolized as dietary protein. Based on this information, and historical human exposure data, FDA approved the use of BST in dairy cows to increase milk production (Aird, 2000).

One of the most well known examples of exposure to endocrine disruptors stemmed from the effects of diethylstilbestrol (DES), a synthetic estrogen, in the offspring of mothers who had taken DES during pregnancy. Examples of exposures to endocrine disruptors through environmental exposures include adverse effects on Great Lakes fish and other wildlife exposed to polychlorinated biphenyls and lower birth weight and shorter gestation times in humans exposed to PCBs from consumption of contaminated fish. A case of possible exposure through an animal agricultural pathway occurred in the 1980s in Puerto Rico, where an outbreak of precocious pubertal changes in thousands of children was believed to be linked either to the use of a steroid in cattle and poultry or a mycotoxin present in animal feed. Other, more wide ranging effects, including a global reduction in male sperm count resulting from exposure to environmental contaminants have been suspected but are not yet conclusive. The USEPA has recognized the need for additional research in this area and in 1998, established a comprehensive research plan to evaluate effects, exposure scenarios and possible risk management approaches.

In animal agriculture, the most likely exposure pathway for endocrine disruptors is from runoff through contaminated manure to drinking water sources. For example, 17-β-estradiol, used to promote growth in poultry, has been documented in runoff from fields where the used poultry litter has been applied as a fertilizer (Addis, *et al.*, 1999). The lack of research designed to evaluate linkages between exposures and documented health effects makes it difficult at this time to establish this output as either high or low priority. However, it is clear that proper manure management is the key to reducing potential for human health impacts from this exposure scenario. Such practices are prudent for many other reasons, as well.

2.3.3.3 Bovine Spongiform Encephalopathy

Background

The first confirmed case of Bovine Spongiform Encephalopathy (BSE), also known as "mad cow" disease, was reported in April 1985 in the UK, although a conclusive diagnosis was not reached and published until the end of 1987. The conclusive autopsy and diagnosis were performed by the Pathology Department of the Central Veterinary Laboratory (CVL) of the State Veterinary Service (SVS) after an inconclusive autopsy form the 1985 case (Phillips and Ferguson-Smith, 2000). A similar transmissible encephalopathy (TSE), now called scrapie, was first described in sheep in the UK in 1732 (Phillips and Ferguson-Smith, 2000). In retrospect, the first probable case of BSE in beef cattle was published in 1883 by French veterinarian M. Sarraet, who described it as "Un cas tremblante sur un boeuf," which roughly translates as "a case of scrapie in a cow" (Phillips and Ferguson-Smith, 2000).

Two later cases at the end of 1986 were studied and the Pathology Department concluded that these were likely to be transmissible spongiform encephalopathies (TSEs). By the end of 1987, the CVL Epidemiology Department concluded that the reported cases of BSE in cattle were caused by consumption of meat and bone meal (MBM) that was produced from animal carcasses and incorporated in the animal feed. The report also incorrectly stated that the disease was caused by the use of rendered sheep carcasses, and that the causative agent was not inactivated, because of a change in the rendering process. These assumptions prolonged the course of the disease, because it was assumed that MBM from beef carcasses was not infectious and that the rendering process could inactivate the agent for BSE.

Prior to mid-1996, the UK Ministry of Agriculture, Fisheries, and Food (MAFF) published statements reassuring the public that BSE could not be transmitted to humans (Phillips and Ferguson-Smith, 2000). The government reversed this stance on March 20, 1996, with a statement that acknowledged a probable link between BSE and new variant Creutzfeldt-Jakob Disease (vCJD) in humans. The public was outraged that they had been misinformed and the BSE Inquiry was launched to investigate the government's response to the BSE crisis.

Health Effects

Bovine Spongiform Encephalopathy is a chronic, transmissible, and fatal disease of the nervous system of adult cattle (Crooker, *et al.*, 1999). It is currently only a *potential* output from domestic animal agriculture, since it has not been diagnosed in any animals raised in the U.S. BSE is characterized by the perforations it leaves in the brain tissue of its victims, hence the name "spongiform." The initial symptoms in cattle are (Crooker, *et al.*, 1999; Phillips and Ferguson-Smith, 2000):

- Changes in temperament.
- Nervousness or aggression.
- Abnormal posture.
- Incoordination and difficulty standing up.

- Decreased milk production.
- Loss of body weight despite continued appetite.

The latency period from exposure to development of observable symptoms is two to eight years. Once clinical symptoms are evidenced, the animal is usually destroyed within two weeks to six months.

In addition to BSE and scrapie (in sheep and goats), TSEs have been seen in mink, cats, mule deer, and rare diseases in humans: Kuru (only know to be spread through ritual cannibalism), Creutzfeldt-Jakob Disease (CJD), and Gertsmann-Straussler Syndrome (Crooker, *et al*., 1999). Thorough investigation of new CJD cases in the UK identified the first case of new variant CJD (vCJD) in May 1995. CJD was associated with BSE through epidemiological evaluation CJD cases in dairy farmers whose herds had a history of BSE (Phillips and Ferguson-Smith, 2000). Molecular evidence for the association was found when abnormal prion (pronounced PREE-on) proteins (PrP) were found in brain tissue of CJD victims that were similar in structure to prions isolated from cattle with BSE. Aside from PrP molecules, there has been no pathogen identified. In scrapie, PrPs are associated with the fibrils that can be seen in infected brain tissue under an electron microscope. The minimum infective dose of BSE-tainted animal feed of MBM origin in ruminants is reportedly "the size of a peppercorn" (Phillips and Ferguson-Smith, 2000).

As of late 2000, the total number of confirmed cases of BSE in animals in Europe were distributed as follows (Brugère-Picoux and Brugère, 1999; MAFF, 2000; Office International des Epizooties, 2000):

- United Kingdom: 177,531 (as of December 1, 2000)
- Switzerland: 364
- Ireland 499 (including 12 imported cases)
- Portugal 481 (including 6 imported cases)
- France 191 (including 1 imported case)
- Netherlands 6
- Belgium 19
- Liechtenstein 2
- Luxembourg 1
- Germany 11 (including 6 imported from Great Britain)
- Italy 2 (imported from Great Britain)
- Denmark 2 (including 1 imported from Great Britain)
- Spain 2

Spain recorded its first cases of BSE in 2000 and a BSE-infected cow was diagnosed in the Portugal's Azores Islands for the first time. The cases diagnosed in Germany also occurred in native cattle for the first time in 2000 (Associated Press, 2000a; 2000b).

As of June 2000, 80 cases of vCJD had been diagnosed in the UK. This represents a 42 percent increase in cases from 1995-2000 (Andrews, *et al*., 2000), which is cause for concern.

Control

The UK has taken strict precautions to dispose of all BSE-affected animals and instituted strict labeling requirements for animal feed and animal tissues. They banned the use of ruminant carcasses in animal feed production, banned the use of bovine offal (requiring that it be dyed blue to prevent its use in meat products), and have a compensation scheme as incentive to report new cases and assure proper disposal. Carcass disposal by incineration is required. Landfilling of BSE carcasses was outlawed in 1991 (MAFF, 2000).

As a result of these measures, the rate of increase in the total number of BSE cases in UK cattle is reduced 97 percent from the number confirmed in 1992 (MAFF, 2000). Although 1168 new cases were confirmed in 2000 (through December 1, 2000), UK authorities report that they have contained the epidemic and have projected that there will be no new cases of BSE in the UK after 2001. Other European countries remain skeptical due to the fact that the removal of trade barriers between European countries have resulted in virtually open borders. Other countries have instituted restrictions on the importation of beef and beef cattle from the UK.

One of the measures taken was to identify occupations at risk of exposure to BSE, CJD, and other TSEs in animals, patients or tissues and develop guidelines to minimize exposure. These include (Phillips and Ferguson-Smith, 2000):

- Slaughterhouse workers
- Agriculture workers
- Anatomy and pathology teachers
- Coroners
- Doctors
- Ear, nose and throat doctors
- Educational establishments
- Emergency service workers
- Farmers
- Field workers
- Handlers and transporters of suspected BSE cases
- Handlers of animals, carcasses, and tissues
- General
- Knackers (including hunt kennels and maggot farms)
- Laboratory workers
- Livestock workers
- Neuropathologists
- Neurosurgeons and ophthalmic surgeons
- Orthopaedic workers
- Pathologists
- Renderers
- Surgeons
- Undertakers
- Veterinary lab workers
- Veterinary surgeons

Educational establishments were informed of the possibility that the BSE agent might be present in the cow or bull eyes used in school eye dissection experiments. The conclusion was, that, based on evidence in rodents that the encephalopathy indeed affects the retinal tissue, and that it was not worth the remote risk that eyes from non-symptomatic but BSE-infected cattle could expose children to the agent during a reasonably foreseeable scalpel mishap. Cow eye dissection was discontinued in Scottish schools in 1990 (Phillips and Ferguson-Smith, 2000).

The USDA's Animal and Plant Health Inspection Service (APHIS) maintains vigilant surveillance of the health of American herds and any imported herds. Of all the cattle imported from the UK, all but 32 have been traced by APHIS. Since all of these cattle would be over ten years old, it is unlikely that they were infected with BSE, or the symptoms would have developed by now (USDA, 2000h). Only four of the traced cattle were still living as of February 1999, and are under quarantine (USDA, 2000g). USDA reported that two cattle imported into Minnesota from Belgium in 1996 are also under quarantine (USDA, 2000h). Belgium reported its first case of BSE in cattle in 1997 (Office International des Epizooties, 2000). Although no BSE cases in native cattle have been diagnosed in North America, Canada had an imported case of BSE traced to the UK. The affected cow and all cattle that were at risk of exposure to this animal were destroyed (USDA, 2000g). Animal feed production and use is closely regulated. Livestock feeding operations are required to maintain records and lot numbers for all of the types of feed used (Aird, 2000).

Efforts in the U.S. include FDAs comprehensive ban on any product containing bovine tissues from any BSE-endemic countries (FDA, 2000). The directive, issued February 17, 2000, lists Great Britain (including Northern Ireland and the Falkland Islands), Switzerland, France, Ireland, Oman, and Portugal as countries where BSE exists. This list needs to be updated, and it is remotely conceivable that products may have been exported from Spain, Germany, or the Netherlands.

The FDA also has banned the donation or transfusion of blood by persons who have lived in the UK (Gottleib, 1999). Recently published research supports the theory that the BSE agent is a blood-borne pathogen (Houston *et al*., 2000).

The MDH is part of a network that is monitoring every new CJD case to verify that it is the classic CJD and not vCJD. No BSE or vCJD cases have been identified in the U.S. (Danila, 2000; CDC, 1996b).

In conclusion, although more research and continued vigilance are necessary, especially in light of the new BSE cases in countries such as Spain, Portugal, and Germany, BSE is provisionally identified as low priority output from animal agriculture in Minnesota. Nonetheless, we offer recommendations in the next section.

Policy and Program Recommendations for Minnesota

No cases of bovine spongiform encephalopathy (BSE) have been diagnosed in the U.S.; however, because even one case of BSE would be devastating to the beef and dairy industry, Minnesota must assure that if there is a case in the U.S., that it does not occur in Minnesota. Thus, the state of Minnesota should support every reasonable effort to prevent the importation or use of BSE-contaminated feed. Although the FDA banned the use of mammalian animal carcasses in the production of feed for ruminants in 1997, some pure non-ruminant animal protein is allowed. Minnesota should:

1. Promote research to determine if the mammalian feed restrictions for ruminants are conservative enough.
2. Participate in research to develop methods of diagnosing asymptomatic BSE in living animals.
3. Determine the rate of transmissible spongiform encephalopathies (TSEs) in other animals native to Minnesota and possible risks to humans or food-producing animals.
4. Minnesota should continue to provide outreach to reinforce the importance of medical surveillance and maintaining the required records and label information to show where animal feeds came from, in case an outbreak is suspected.
5. Assure that workers exposed to animals or humans infected with TSEs should be trained on the potential hazards of these diseases. The Creutzfeldt-Jakob Disease "virus" is currently included in the list of hazardous biological agents under the Minnesota Employee Right-to-Know Standard.
6. Educate Minnesota schools on the potential hazards of using cow, sheep, or goat eyes for classroom dissection.

2.4 RECOMMENDATIONS FOR FURTHER HUMAN HEALTH RESEARCH

In the course of preparing to draft this Human Health Issues Technical Work Paper, Earth Tech staff used Section K of the Draft GEIS document prepared by the University of Minnesota (U of M), subtitled "A Summary of the Literature Related to the Effects of Animal Agriculture on Human Health" as a primary resource, but supplemented this with a significant amount of new material and information connected to the outputs identified in Appendix A. Throughout this effort, we identified numerous areas where the existing body of data was insufficient to characterize the priority of the output in terms of its potential impact on human health. These limitations are discussed under the various individual topics in Section 2.3, and are summarized in Table 2.9.

2.4.1 On-going Research

Ammonia: The "Feedlot Air Quality Stakeholders Report" details research on ammonia, hydrogen sulfide, and odor emissions from swine and dairy operations (MCPA, 2000). The Centers for Disease Prevention and Control (CDC) Agency for Toxic Substances and Disease Registry (ATSDR) has done ambient dust, ammonia, and H_2S monitoring near animal agriculture facilities in Northeast Missouri in conjunction with the Missouri Department of Health. According to an ATSDR representative involved with the research, the preliminary data indicate a better correlation between health status and ammonia exposure than with H_2S (Joran-Izaguirre, 2000). This study is still in progress, so no data were available to review.

Hydrogen Sulfide: The ATSDR has done evaluations of H_2S near a beef processing facility in the South Sioux City, Iowa area (Joran-Izaguirre, 2000). Health status was correlated with the H_2S readings at various distances from the apparent source. Apparently, the results were higher than typical H_2S results near livestock facilities, but these data, when published, may serve to support or refine the basis for the IHRVs for ambient air or the MPCA air monitoring requirements for H_2S.

Odor: David Schmidt and Larry Jacobson at the U of M, and various research groups at Iowa State University, North Carolina State University and Purdue University are carrying out significant studies related to odor control engineering. Some of these projects are summarized in the GEIS on Animal Agriculture Summary of the Literature Related to Odor and Air Quality (Jacobson, *et al.*, 1999) and at the respective internet web sites for these universities. Please note that these web links are subject to change:

- U of M: http://www.bae.umn.edu/
- Iowa State: http://www.ae.iastate.edu/research.htm
- NCSU: http://cals.ncsu.edu/waste_mgt/control.htm
- Purdue: http://danpatch.ecn.purdue.edu/~odor/

Pathogens: Research regarding fly-borne disease transmission is being done by the Ohio Department of Health (Richard L. Berry, Vector-borne Disease Program, Ohio Department of Health, e-mail: DBERRY@gw.odh.state.oh.us). Also, Dr. Roger Moon at the U of M has conducted field studies relating fly populations to annoyance in humans in Renville, Clay and Jackson Counties. The USDA Research Center in Clay Center, Nebraska is also sponsoring research on the effect of forage feeding on fecal shedding of *E. coli* O157:H7 in cattle (Dr. Robert Elder and others).

2.4.2 Recommendations for Further Research

Earth Tech recommends additional research to address gaps in the current knowledge of potential impacts of animal agriculture on human health in Minnesota. This is summarized in Table 2.9. In addition to the issues listed, it is important to document the source strength and environmental fate of these outputs to the extent possible or appropriate.

TABLE 2.9

PROPOSED ADDITIONAL RESEARCH

Output	Issues to be Studied	Factors to Consider	Comments
Ammonia (NH_3)	Irritation Asthma Odor detection	Difficulty of isolating sources of ammonia in background air	Preliminary research has been done by the ATSDR in conjunction with the Missouri Department of Health
H_2S and Odor	Role of H_2S and reduced sulfur on odor detection	Need to standardize approaches between states	See also VOCs
Volatile organic compounds (VOCs)	Odor detection and other health impacts	More focused study of animal agriculture and documentation of background sources	Possible need to monitor other VOCs (such as volatile fatty acid compounds) in addition to air toxics
Dust, respirable (PM_{10})	Asthma Respiratory irritation Pulmonary function • Silica • Endotoxins • Odorants absorbed to particles	Need to quantify the role of ultrafine particles	Difficulty of separating out contribution of crop farming
Pathogens in air, soil and water	Various diseases. A special emphasis on soil-borne anthrax reservoirs is justified.	Study effects of diet, stress, and antimicrobial use on fecal shedding; viability of organisms	The anthrax study should be a joint effort by Minnesota, North Dakota, and Manitoba
Antimicrobial resistant organisms	Transmission of resistant organisms to humans	Collect data on use of antimicrobials in Minnesota and other states, the spread of resistance; and methods to reduce unnecessary use of antimicrobials	See the Interagency Task Force on Antimicrobial Resistance Draft Action Plan (2000)
Endocrine disruptors	Reproductive, developmental, or cancer risk	Need to develop in vitro assays to detect these effects	
Transgenic organisms	Risk of increased susceptibility of animals to human disease and transmission between humans and animals	Potential uses of these technologies need to be catalogued, but many future uses cannot be anticipated	Emphasis on the risk of human disease susceptibility and transmission due to xenotransplantation

In addition, studies of the role of best management practices in reducing risks of human health impacts needs to be quantified to improve acceptance by producers. For example, Hazard Analysis Critical Control Points (HACCP) may be applied on the farm, but further research is needed to demonstrate its effectiveness and develop effective ways to transfer this technology from food processing to food animal production.

3.0 FEDERAL, STATE, AND LOCAL CONTROL STRATEGIES

This section presents the results of our inventory and compilation of information on local, state and federal regulatory strategies and their effectiveness in addressing outputs related to animal agriculture. States and local entities were selected based on overall diverse types of animal agriculture, leadership, and geography.

In essence, our analysis consisted of:

- Inventorying and compiling federal, state, and local regulatory programs.
- Conducting an inventory and compiling information on AFO operational practices in Minnesota.
- Evaluating existing regulatory programs and identifying potential gaps.

3.1 FEDERAL LEVEL REGULATORY FRAMEWORK

3.1.1 Methods Used to Compile Federal Regulatory Information

The USDA and the USEPA are key federal agencies addressing animal feeding operations. We examined documentation available on the Internet to clarify the nature and scope of their involvement in addressing issues related to AFOs. The National Resources Conservation Service (NRCS) and the USEPA Office of Water Management are the specific offices primarily responsible for developing regulation and federal strategies for dealing AFOs.

3.1.2 Federal Regulatory Programs

The Clean Water Act and Related Activities

Regulation of AFOs at the federal level was addressed as early as the 1970s when the Clean Water Act (CWA) was passed identifying certain AFOs as point source polluters requiring National Pollution Discharge Elimination System (NPDES) permitting. Despite continued improvements in overall water quality, the federal government recognized that traditional point source control alone would not achieve water quality goals. Consequently, in February 1998 President Clinton released the Clean Water Action Plan (CWAP). The CWAP called for the establishment of a joint national strategy to be developed by both the USDA and the USEPA to minimize the water quality and public health impacts of AFOs.

The USDA and the USEPA developed and then published a Unified National Strategy (UNS) on March 9, 1999. The strategy's guiding principle include:

1. Minimizing water quality and public health impacts from AFOs.
2. Focusing on AFOs that represent the greatest risks to the environment and public health.
3. Ensuring that measures to protect the environment and public health complement the long-term sustainability of livestock production in the U.S.
4. Establishing a national goal and environmental performance expectation for all AFOs.
5. Promoting, supporting, and providing incentives for the use of sustainable agricultural practices and systems.
6. Building on the strengths of USDA, USEPA, state and tribal agencies, and other partners and make use of diverse tools including voluntary, regulatory and incentive-based approaches.
7. Fostering public confidence that AFOs are meeting performance expectations and that the parameters referenced above ensure the protection of water quality and public health.

8. Coordinating activities among the partners, and other organizations that influence the management and operation of AFOs.
9. Focusing technical and financial assistance to support AFOs in meeting the national goal and performance expectation established in the Unified National Strategy.

The UNS outlines a program intended to regulate large AFOs which amount to about 15 percent of AFOs in the U.S. with the remaining 85 percent to be encouraged to voluntarily comply with UNS performance. The focus of the UNS is protecting water quality, although impacts such as ground water depletion, habitat loss, and dust are expected to receive indirect benefit from the UNS.

One very important requirement of AFOs is to develop a site-specific Comprehensive Nutrient Management Plan (CNMP) which addresses the following:

- Feed management.
- Manure handling and storage.
- Land application of manure.
- Land management.
- Record keeping.
- Other utilization options.

Animal Feeding Operations will be provided technical assistance in the development of CNMPs from the NRCS, state and tribal agricultural and conservation staff, Extension Service agents, Soil and Water Conservation Districts (SWCDs), and Land Grant Colleges and Universities.

The AFOs that are defined as concentrated animal feeding operations (CAFOs) by 40 CFR, Part 122, Appendix B, require NPDES permits and will be required to develop CNMPs as a condition of permitting. AFOs larger than 300 animal units (AU) but smaller than 1,000 AUs may be designated CAFOs and subject to NPDES requirements if pollutants are discharged to navigable waters by man-made systems; or if pollutants are discharged directly into waters that originate outside of, and pass over, across, or through the facility or come into direct contact with confined animals. AFOs with less than 1,000 AUs and do not discharge pollutants except in the event of a 25-year, 24-hour or longer storm event are not required to have a NPDES permit.

On December 15, 2000, EPA finally proposed revisions to the NPDES regulations and effluent guidelines for CAFOs. These new regulations are expected to address as many as 39,000 of the largest AFOs in the U.S. Details regarding the proposed NPDES program can be found in the draft *Guidance Manual and Sample NPDES Permit for Concentrated Animal Feeding Operations* published on September 21, 2000.

On October 17, 2000 EPA published another related draft technical guidance and reference document entitled, "National Management Measures to Control Nonpoint Source Pollution from Agriculture". This guidance document is for use by state, local, and tribal managers in the implementation of nonpoint source pollution management programs. It contains a wealth of information on the best available, economically achievable means of reducing pollution of surface and ground water from agriculture. EPA will be soliciting comments on this draft guidance until January 16, 2001.

In addition, more information can be found on BMPs in the National Resources Conservation Service (NRCS) document entitled, "Comprehensive Nutrient Management Planning Technical Guidance" dated December 1, 2000. This technical guidance from the NRCS is supported at the state level by the Minnesota Board of Water and Soil Resources.

The Coastal Non-point Pollution Control Program implemented under the Coastal Zone Act Reauthorization Amendments (CZARA) of 1990. An element of this program requires that CAFOs in areas regulated under the CZARA are required to have a NPDES permit. In addition those CAFOs are to be implemented by CZARA management measures.

3.2 STATE LEVEL REGULATORY FRAMEWORK

3.2.1 Methods Used to Compile State Regulatory Information

Earth Tech collected regulatory information from the following selected states:

- California
- Illinois
- Indiana
- Iowa
- Michigan
- Minnesota
- Nebraska
- North Carolina
- Ohio
- Texas
- Wisconsin

These states were selected because of their fairly diverse types of animal agriculture and generally similar geographic nature and proximity to Minnesota. We also presume they would have a relatively proactive approach to larger scale animal agriculture. For the most part, information for these states was obtained by accessing regulatory and other appropriate information found on Internet pages maintained by legislative, environmental, and/or agricultural regulatory agencies in those states. In some case, regulatory personnel were also contacted by telephone. Table 3.1 summarizes the information collected from the selected states.

Information obtained pertained to a wide range of regulatory practices on the state level related to animal agriculture issues, especially those related to AFOs. Such issues include land use restrictions regulating placement of AFOs, requirements for manure management plans (MMPs), monitoring requirements for odors, air toxics, groundwater, and the nature of permits that may be required for operating AFOs.

3.2.2 State Regulatory Programs

3.2.2.1 Summary of Common Regulations

A number of common regulatory practices were found across the states surveyed. Table 3.1 includes a summary of information collected for each of the states. The regulations and practices found are summarized below:

<u>Land Use Restrictions</u>: One very important measure governing the placement of AFOs is setback requirements, a form of land use restriction, that dictate how far an AFO must be from residences, surface waters, floodplains, and other sensitive areas. Most states dictate specific distances; however, this is a restriction that is often delegated to the county level.

<u>Odor Emission Regulations</u>: In general, regulations addressing the control of odor emissions were found in half of the states' surveyed. Those states include Illinois, Minnesota, North Carolina, Ohio, and Texas. Odor control is addressed in several ways including: 1) delegating odor control to the county level in Wisconsin and North Carolina; 2) controlling odor only during manure removal and application in

TABLE 3.1

STATE BY STATE COMPARISON OF REGULATORY MEASURES
Human Health Technical Work Paper
Animal Agriculture Generic EIS

Question No.	Regulatory Measures Surveyed	Illinois	Indiana	Iowa	Michigan	Minnesota	Nebraska	North Carolina	Ohio	Texas	Wisconsin
1	Regulate, advise, maintain data on animal feeding operations (AFOs)?	Yes.	Yes.	Yes.	MI encourages use of accepted/published ag. management practices. If used, farms are exempt from certain lawsuits and are assumed to be acting in good faith regarding environ. Controls.	Minnesota Rules, Chapter 7020 Permanent Rules Relating to Animal Feedlots and Storage, Transportation, and Utilization of Animal Manure and Minnesota Rules Chapter 4605, subpart 5.	Yes.	Yes, NC General Statute 143-215.10A Animal Waste Management Systems, Senate Bill 1217 Waste Management Systems for Animal Operations.	Yes, permits required for discharge of waste to state waters; animal pollution ergs enforced by Ohio DNR encourages voluntary OH compliance with MBPS; Ohio Rev. Code (3667)-excessive odor from feeding of animals is public nuisance; OH Admin. Code-abatement of animal ag. Pollution.	Yes, CAFOs are regulated thru TX Ad. Code. AFOs larger than 1,000 animal units require permitting. AFOs with 300 to 1,000 units & discharge pollutants into state waters require state authorization.	WDNR and DATCP regulate Afro's, Chapter 92.16 allows county, city, village, or towns to enact ordinances requiring manure storage facilities built after July 2, 1983, to meet the technical st'ds of the county, city, village, or town or rules of the WDNR.
3	Keep data on the size and number of livestock feedlots (or other AFOs).	None found.	None found.	None found.	None found.	MN Rules 7020 requires facility reporting and extensive information in MN Planning database.	None found.	Yes.	None found.	None found.	None found.
4	Does state have land use restrictions (zoning or set back distances) to control the impact of animal feeding operations (AFOs)?	Yes, set backs, location conditions placed on applications. There are requirements for minimum distances for animal waste application within certain distances of residences, surface waters and floodplains.	Yes, The state has a permitting process in place that requires the submission of a MMP outlining the application of manure.	Yes, land use restrictions, in the form of set back distances are in place. Zoning is a function of local county/city/township government.	Set backs and other site conditions that should be met based on the animal units size (50-999) and (≥1000) are in place and are described in stipulated generally accepted ag. management practices.	Yes, restrictions are identified in MN Rules 7020.200 "LOCATION RESTRICTIONS AND EXPANSION LIMITATIONS".	Yes, there are stipulated set back requirements and restrictions for domestic and public supply wells, sensitive areas, and areas where protection of ground water and cold water streams is judged warranted.	Yes, swine siting requirements (Senate Bill 1217) has the following distances: 1,500' for occupied residences, 2,500' for schools/hospitals/churches, and 500' for property boundaries.	None found.	No set back distances for non-odor issues. The PPP, required for each AFO, requires site plans that indicate animal operations and border locations which are reviewed and subject to approval. Set-backs are given in air st'd for odor emissions.	Not included in WI statutes. Local governments may enact such rules. Apparently very few have. Draft rules have been prepared/will be going thru a public hearing process with final expected Fall 2001.
5	Does state have odor emissions regulations pertaining to AFOs?	Odor control methods shall be practiced during manure removal and application. Odor control measures are stipulated in adopted rules.	None found.	None found.	None found. However, notices of farming practices that may emit odors are given for property transfer within one mile of a farm operation.	Yes, feedlots larger than 1,000 animal units or manure storage areas capable of holding manure produced by 1,000 animal units must submit an air emissions plan.	None found.	Yes, the State Environ. Mangm't Comm. adopted temp. odor rules in 2/99, under mandate from the NC Gen'l Assembly, to require "economically feasible" odor controls for animal operations. County authority to regulate odor emissions is thru NC House Bill 515.	OH Rev. Code -excessive odor from AFOs is public nuisance; OH Rev. Code provides for ag. exemption for AFOs operating outside of municipalities and conform to generally accepted ag. practices which considerably reduce adverse effects on public health, safety, or welfare.	Yes, the Air St'd Permit requires operators to locate odor sources more than 0.50 miles of residence or business, school, church, or public park and more than 0.25 miles when an odor control plan is implemented as part of the PPP.	Not included in WI statutes. Local governments may enact such rules. Apparently very few have. Draft rules have been prepared/will be going thru a public hearing process with final expected Fall 2001.
6	Does state have specific air emission or toxic air contaminant regulations pertaining to AFOs?	None found.	None found.	None found.	None found.	Yes, monitoring for violations of state ambient air quality standards are in place for response to citizen complaints. MN rules exempt AFO owners from ambient air quality standards during removal of manure.	None found.	Information Not Clear.	None found.	Yes, air quality requirements are referenced in the pollution prevention plan section 321.39 and the TX Clean Air Act. TAC 112.31 sets hydrogen sulfide exposure at 0.08 ppm average over any 30 minute period if downwind properties are inhabited.	Not included in WI statutes. Local governments may enact such rules. Apparently very few have. Draft rules have been prepared/will be going thru a public hearing process with final expected Fall 2001.
7	Does state have specific air monitoring requirements pertaining to AFOs?	None found.	None found.	None found.	None found.	Yes, see responses to Questions 5 & 6.	None found. The state may require monitoring on a case-by-case basis.	Monitoring of ammonia, total volatile organics, hydrogen sulfide or other sulfur compounds to determine odor emissions and the existence of objectionable odors (2D.1802 Odor Emission Standard).	None found.	None found.	Not included in WI statutes. Local governments may enact such rules. Apparently very few have. Draft rules have been prepared/will be going thru a public hearing process with final expected Fall 2001.

TABLE 3.1

STATE BY STATE COMPARISON OF REGULATORY MEASURES
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Animal Agriculture Generic EIS

Question No.	Regulatory Measures Surveyed	Illinois	Indiana	Iowa	Michigan	Minnesota	Nebraska	North Carolina	Ohio	Texas	Wisconsin
8	Are Manure Management Plans (MMPs) required?	Yes, requirements of the Plan include an estimate of annual volume of waste, types of waste storage, application rates, land area required, waste nutrient content, and inspection.	Yes, They are required to include the following: (1) operational status of farm, (2) number and types of animals, (3) soil testing, and (4) manure testing.	Yes, IA law requires that MMPs for confinement feeding operations be submitted to the DNR. Open feedlots do not require MMPs.	Plans are to focus on the management of manure, nutrients, and odor. Plan components include production of manure and byproducts, collection of manure, storage, transfer, treatment, utilization, and recordkeeping.	Yes, MN Rules 7020.2225 "LAND APPLICATION OF MANURE" Subpart 4 "MMPs" requires owners of feedlots to prepare and retain a MMP.	Plans having equivalent effect are used including: (1) nutrient mangm't plan, (2) sludge mangm't plan, (3) operational and maintenance plan, (4) emergency response plan for spill or release, and (5) a closure plan for the facility to include the disposition of waste.	Yes, animal waste management plans are part of the application and permitting process. General Statute. 143-215.10C and Senate Bill 1217.	Yes, for operations over certain size l limits.	No, the required PPP contains some aspects which pertain to manure management. AFOs are also required to utilize BMPs listed in TAC 321.40 and are required to document all BMPs used to comply with the regulation.	An animal waste management plan is required for large AFO's (see response to Question 15 for definition of large AFO), which are required to obtain a WPDES permit which complies with the specifications for waste utilization in st'd no. 633 of the tech. guide.
9	Does state have AFO regulations pertaining to land application of manure?	Yes, outlined in Waste Mangmt Plan. Requirements include waste application calculations, amount of Nitrogen (N) available, N loss, Amount of N required by crop type and credits from previous crop.	Yes, construction of a AFO requires a map of manure application areas and info re: topo. features, soil types, drainage courses, nearest streams, ditches, and lakes, location of drainage field tiles, land application areas, and wells on site.	Yes, the IA has both requirements and recommended practices concerning land application of manure.	Manure application guidelines include soil fertility testing, manure analysis, manure nutrient loading on pasture land, method and timing of application, management of manure applications to land.	Yes, requirements are in place for applying manure, including nutrient testing, application rates, manure mangm't plans, recordkeeping, and manure and process wastewater application requirements in special areas.	Yes, there is a requirement for a nutrient management plan that describes the waste application areas and waste and soil analysis procedures. Recordkeeping is also addressed in the plan.	Yes, part of the waste mangm't plan, waste utilization plan that assures a balance between N application and crop requirements. General Statute 143-215.10C also requires the periodic testing of waste products used as nutrient sources.	Yes, standards are in place for use of manure to meet agronomic needs of the crop, prescribe application rates to avoid excess nutrient application, improve or maintain soil structure, and to safeguard water resources.	Land application issues are generally covered in the pollution prevention plan, best management practices, and air standard permit sections of the CAFO regulation.	Not included in WI statutes. Local governments may enact such rules. Apparently very few have. Draft rules have been prepared/will be going thru a public hearing process with final expected Fall 2001.
10	Does state have AFO regulations requiring water (or other environmental) monitoring to detect runoff?	Yes, parameters to be monitored include nitrate-nitrogen, ammonia-nitrogen, phosphate, chloride, sulfate, E-coli, fecal coliform. No apparent monitoring requirement for surface waters.	AFOs may fall under NPDES permit requirements. IN Code 13-18-10 states that DEQ review applications to determine they meet water pollution control laws and rules. This implies that monitoring may be decided on a case-by-case basis.	Yes, manure structure storage designs require temporary monitoring. wells to determine ground water table. Rule has been proposed requiring periodic ground water monitoring	None found.	Yes, MN Rules 7020.2002 and 7020.2003, these rules reference MN Statute 116.0713, and Code of Federal Regulations 40 CFR , part 412.	Ground water monitoring may be required for livestock waste control facilities at the discretion of the state DEQ.	None found.	This does not appear to be required. However, normally NPDES require sampling and analysis of discharged wastewater on a periodic basis.	Ground water monitoring wells may be required at AFOs with site specific conditions, as determined by a NRCS engineer, licensed PE, or qualified ground water scientist, which require hydraulic monitoring.	NR 243.14c allows the WDNR to require ground water monitoring in the vicinity of earthen storage facilities in where critical ground water, geologic or construction conditions warrant.
11	Does state have AFO regulations pertaining to carcass disposal?	None found.	Yes, State Board of Animal Health requires disposal of animal carcasses within 24 hours of knowing of the animals death using either burial, incineration, composting, or rendering.	Yes, 24-hour disposal is required. Incineration, burial, composting, and sanitary landfill disposal are allowed with qualifications.	Yes, disposal of carcasses required within 24 hours after death by burial, burning, composting, rendering, or via a licensed animal food manufacturing plant	Yes, Animal Health Board Rules, MN Rules Chapter 1719.	Title 130, chapter 11 requires that animal carcasses not be placed in facilities or land applied with livestock waste.	Yes, within 24 hours per 2D.1802 Odor Emission Standard. Disposal methods are in the veterinary standard General Statute 106-403.	None found.	Yes, the BMP requires carcasses to be properly disposed of within 3 days. Animals are to be disposed of so as to prevent contamination of state waters or creation of a nuisance or public health hazard.	Not included in WI statutes. Local governments may enact such rules. Apparently very few have. Draft rules have been prepared/will be going thru a public hearing process with final expected Fall 2001.
12	Require operators to be trained in animal waste management?	Yes. A livestock waste handling facility serving 300 or greater animal units shall be operated only under the supervision of a certified livestock manager.	None found.	Yes, the DNR has proposed a rule change that would require commercial and confinement site manure applicators to complete a training course or take an exam that fulfills the training requirement.	None found.	Yes, commercial manure haulers must be tested as a MPCA requirement, see fact sheet "Manure Application Requirements".	No apparent regulations requiring the training of operators in animal waste mangm't; however, a waste control facility permit applicant must attend a land application training program every 5 years.	Yes, Senate Bill 1217, requires certification program for animal waste management system operators - includes: applications, training and examination of applicants, and investigation of applicants.	None found.	Yes, AFO operators in TNRCC's Dairy Outreach Program Areas have training requirements. AFO operators need an 8-hour course on animal waste mangm't and at least 8 hours of continuing waste mangm't ed. for each two-year period after the first 12 months.	Not a requirement. However, DATCP Subchapter VII, s. 50.95 creates a certification program for county land conservation committee staff and others who review or engage in agricultural engineering practices.
13	Does state have AFO Regulations for Companies that Pump and Transport Waste (including vehicle requirements)?	None found.	None found.	No Info yet.	None found.	Yes, MN Rules 7020.2010 "TRANSPORTATION OF MANURE" requires that manure be hauled so as to prevent leaking or spillage on a public road.	There are no apparent regulations requiring the licensing of animal waste transporters.	None found.	None found.	The pollution prevention plan section states that the required pollution prevention plan shall provide a description of potential pollution sources found at CAFO facilities including manure stockpiling , pond cleaning , and vehicle traffic.	Not included in WI statutes.

TABLE 3.1

STATE BY STATE COMPARISON OF REGULATORY MEASURES
Human Health Technical Work Paper
Animal Agriculture Generic EIS

Question No.	Regulatory Measures Surveyed	Illinois	Indiana	Iowa	Michigan	Minnesota	Nebraska	North Carolina	Ohio	Texas	Wisconsin
14	Does state require an AFO to prepare a PPP?	None found.	None found.	No Info yet.	Yes - Pollution Prevention Strategy Document and Ag. Pollution Prevention Implem. Plan. There is also a requirement for an emergency action plan that identifies action in the event of a spill or discharge.	Yes, see response to Question 16.	Components of such a plan are required.	Discharge permits are required for intensive animal operations that discharge animal wastes to state waters. Animal waste mangm't plan requires provisions for an emergency mangm't plan with emergency spillways for animals wastes.	None found.	Yes, PPs are a requirement of CAFOs covered by the rule. TAC 321.39 lists the requirements of the pollution prevention plan.	Not included in WI statutes. Local governments may enact such rules. Apparently very few have. Draft rules have been prepared/will be going thru a public hearing process with final expected Fall 2001.
15	Does state issue Permits or Certificates of Compliance to AFOs?	Certification that waste lagoon, liner facilities comply with enacted standards required from AFO owners.	Approvals to operate are required.	Yes, the IA issues Operation permits and Construction permits through the County.	No apparent requirement to have an operating permit from the state to operate a feedlot. However, a siting request package must be submitted to MI Dept of Ag. as part of a "Site Review and Verification Process".	Yes, MN Rules 7020.0405 identify four types of permits: interim, construction short-form, SDS, and NPDES permits.	Yes, for AFOs >300 animal units when wastes may violate surface or ground water rules, discharge into state waters, or violate the NE Environ. Prot. Act. AFO operators must have a permit. AFOs <300 units w/ high potential to discharge into state waters are not exempt from permitting. Construction permits required for new construction/ expansion.	Yes, permits are required for operations that have ≥ 250 swine, 100 cattle, 75 horses, 1,000 sheep, and 30,000 chickens (liquid system) according to the Department of Water Quality.	Yes, for certain size operations.	CAFOs larger than 1,000 animal units require a permit. CAFOs with 300 to 1,000 animal units require registration/state authorization.	Large AFO's are required to have a permit. For other AFO's, only those which improperly manage waste and cause ground or surface water pollution, or those subject to the requirements for large AFOs are regulated under Chapter 243. It is not the intent of the WDNR to require that all AFO's obtain a permit.
16	What is required as documentation from AFOs seeking Permits or Certificates of Compliance?	Certification & supporting documentation that facility complies with enacted standards required from AFO owners.	Plots maps, manure storage structure plans, and manure management plans.	Outlined in operation permit and construction permit.	A completed site plan and manure management plan must be submitted as part of the Site Review and Verification Process.	Yes, An environ. assessment worksheet is required if AFO is > 1,000 animal units or more or if the feedlot is expanding by > 1,000 units. An EAW is required if it has a capacity > 500 units or is expanding > 500 animal units and is located in an environmentally sensitive area.	Type of livestock, animal capacity drawings showing land application areas, source of water supply, surface water flow direction, conveyance structures, construction procedures.	Potential odor sources, insect sources, disposal method for carcasses, BMPs for riparian buffers, use of emergency spillways.	Yes, for certain size operations.	Date of construction, type of animals, max. number of animals, county.	Designs for permanent runoff control structures, Large AFOs need an animal waste management plan.
17	Who is allowed to design or approve manure storage structures for large AFOs? What is the size threshold for this requirement (gallons of capacity)?	PE or PG.	None found, although state must approve construction plans.	No Info yet.	None found, however guidelines found in Natural resources Conservation Service-Field Office Tech. Guide should be met.	Design plans and specifications, except for concrete-lined manure storage areas having a capacity of 20,000 gallons or less must be prepared and signed by a design engineer.	The Nebraska Department of Environmental Quality may require an assessment of a facility by a licensed professional engineer under some circumstances.	Animal waste management plans must be certified by a technical specialist as designated by the Soil and Water Conservation Commission.	None found.	The AFO application process requires a certification by a NRCS engineer, licensed prof. engineer or qualified ground water scientist documenting the absence or presence of any recharge features identified on any tracts of land associated with the AFO.	Not included in WI statutes. Local governments may enact such rules. Apparently very few have. Draft rules have been prepared/will be going thru a public hearing process with final expected Fall 2001.
18	What geological or hydrogeological features in state could make feedlot runoff a threat to surface and ground water?	Aquifers less than 50 feet from bottom of waste lagoons, nearby surface waters, flood-plains & karst.	No Info.	Requirements not specified in spreadsheet, need to review code.	No Info.	Shoreland, flood plain, Mississippi River headwaters, wellhead protection areas, Karst areas, resurgent springs.	No info.	Storms particularly in the coastal, eastern counties.	The Ohio Livestock Manure and Wastewater Management Guide, provides differing recommendations based on site conditions and application rates. Special consideration is given to sites with erosion protection measures in place.	In addition to recharge features, the maximum required storage value calculated by the hydrologic analysis requirements shall not encroach on the storage volume required for the 25-year, 24-hour rainfall event.	None found.
19	Does the state account for environmentally sensitive areas when considering permits to AFOs?	Apparently only karst features.	Yes, lakes, ponds, streams, rivers, wells, etc.	A rule change has been proposed to address this issue.	No Info.	Yes, shoreland, flood plain, Mississippi River headwaters, wellhead protection areas, Karst areas, resurgent springs.	No info.	As part of the animal waste management plan, each animal operation has an operation review conducted yearly by a technical specialist employed by DSWC.	None found.	Yes, TX TNRCC has designated a Dairy Outreach Program Areas (DOPAs) for several counties, which requires AFO owners/operators to be trained in animal waste management.	Ground water monitoring may be required in vicinity of earthen storage facilities where critical ground water, geologic, or construction conditions warrant.

TABLE 3.1

STATE BY STATE COMPARISON OF REGULATORY MEASURES
Human Health Technical Work Paper
Animal Agriculture Generic EIS

Question No.	Regulatory Measures Surveyed	Illinois	Indiana	Iowa	Michigan	Minnesota	Nebraska	North Carolina	Ohio	Texas	Wisconsin
20	Require site inspection of AFOs to assure appropriate design and construction of animal waste management facilities?	Yes, State will inspect earthen livestock waste lagoons at least once during the pre-construction, construction, or post-construction phase and shall require modifications as warranted.	None found.	Yes.	Yes, the state is to investigate complaints of odors, manure use, ag. wastes, dust, noise, fumes, air pollution, surface or ground water pollution. MI Dept. of Ag. inspects new and expanded livestock production facilities.	Yes, MN Rules 7020.0250"SUBMITTALS AND RECORDS", subpart 2 "Record retention, access to records, and inspections requires access to facilities and records.	Yes, an inspection by the department of environmental quality must be requested prior to a permitted facility beginning operations.	Yes, AFOs are required to have yearly inspections to determine if any violation of water quality st'ds and if system is in compliance with its animal waste mangm't plan or any other condition of its permit.	None found.	The AFO PPP requires that structural controls be inspected at least four times per year for structural integrity and maintenance.	None found.
21	Regulate non-permitted AFOs?	Yes since actual permits are not issued.	Shoreland, flood plain, Mississippi River headwaters, wellhead protection areas, karst areas, resurgent springs.	No info.	Operators are required to comply with MI Natural Resources and Environ. Protection Code PA 451 of 1994 no distinction is made for permitted/unpermitted operations.	Yes.	No, unless there has been a discharge into state waters or if there is a high potential for discharge.	AFO < 250 swine, 100 cattle, 75 horses, 1,000 sheep, or 30,000 confined poultry (liquid waste) are not subject to the rules/regs set forth in the NC animal waste and operation Gen'l Statutes.	Smaller operation of less than 1,000 are encouraged to follow BMPs.	Operators of AFO not required to obtain authorization must locate, construct, and manage waste control facilities and air control facilities to protect the air, surface water, and ground water in accordance with the requirements.	Yes.
22	Require reporting of diseases in humans that can be acquired from livestock (zoonoses)? If so, what diseases are reportable?	None found.	Yes, IN Code requires a duty to report any diseases that could be transmitted to humans.	No info.	Yes, for any communicable diseases including those from animals.	Yes, MN Rules 4605.7300, under some circumstances, requires veterinarians to report diseases that can be transmitted to humans.	Yes for any communicable diseases including those from animals.	All persons practicing veterinary medicine in NC shall report promptly to the State Veterinarian the existence of any contagious or infectious disease in livestock and poultry.	None found.	Yes, by statute, TX veterinarians are required to report reportable diseases. See the zoonosis file for more information.	None found.
23	Does state have regulations pertaining to feed supplements (such as amino acids, antibiotics, and hormones)?	None found.	None found.	No info.	None found.	Yes, MN Rules, chapter 1510 address labeling of feed and reference USC, Title 21, and Minnesota Statutes, section 25.33.	State regulates commercial feed; labeling is required for drugs added to feed.	Information not clear.	None found.	None found.	None found.

Notes:
AFO = Animal Feeding Operation
BMP = Best Management Practices
CAFO= Concentrated Animal Feeding Operation
CFR = Code of Federal Regulations
DATCP = Wisconsin Department of Agriculture, Trade, and Consumer Protection
DEQ = Department of Environmental Quality
DNR = Department of Natural Resources
DOPA = Dairy Outreach Program Area
DSWC = Division of Soil and Water Conservation
EAW = Environmental Assessment Worksheet
MMP = Manure Management Plan
MPCA = Minnesota Pollution Control Agency
N = Nitrogen
NPDES = National Pollution Discharge Elimination System
NRCS= Natural Resource Conservation Service
PE = Professional Engineer
PG = Professional Geologist
SDS = State Disposal System
TAC = Texas Administrative Code
TNRCC = Texas Natural Resource Conservation Commission
USC = United States Code
WPDES = Wisconsin Pollution Discharge Elimination System
The definition of an "animal unit" may vary by state.

Illinois; 3) providing notices of farming practices that may emit odor for property undergoing an ownership transfer in Michigan; and 4) preparing and implementing an air emissions plan or odor control plan in Minnesota and Texas.

General Air Emission or Toxic Air Contaminant Regulations: Two states, Texas and Minnesota, address air emission/toxic contaminants in directly. Texas applies air quality requirements which are referenced in pollution prevention plans (PPPs) and Minnesota has required air monitoring in response to citizen complaints. Minnesota law exempts AFO operators from ambient air quality standards during removal of manure.

Specific Air Monitoring Requirements: North Carolina regulations address air monitoring of NH_3, total volatile organics, and H_2S for determining odor emissions and the existence of objectionable odors.

Manure Management Plans: Manure management plans or similarly stipulated plans that address the appropriate management, storage, and disposal of manure is commonly required for AFOs, although there are usually some exemptions for small AFOs. These plans are central to protecting health in the vicinity of AFOs.

Regulations Pertaining to Land Application of Manure: Nearly all the states surveyed include generally similar regulations addressing the proper application of manure. In many cases, these requirements are part of a MMP. These typically include soil fertility testing, manure testing and analysis, determining proper waste application rates, determining amounts of nitrogen available and required by disposal field crops, and record-keeping.

Regulations Requiring Water or Other Environmental Monitoring: The surveyed states exhibited a range of requirements regarding water or other environmental monitoring. No requirements were found for Michigan, North Carolina, or Ohio. Certain regulatory agencies at the state level including those in Indiana, Nebraska, Texas, and Wisconsin can require discretionary groundwater monitoring. Illinois requires groundwater monitoring for nitrate-nitrogen, ammonia-nitrogen, phosphate, *E. Coli*, and fecal coliform. Minnesota also requires monitoring.

Regulations Related to Carcass Disposal: Carcass disposal is addressed by most of the states surveyed requirements generally state that carcasses are to disposed of in ways that would not create health problems. Such prescribed methods include burial, composting, rendering, or incineration. However, regulations regarding carcass disposal were not found for Ohio and Illinois. Wisconsin appears to delegate carcass disposal regulations to counties, although state draft rules that may address this issue have been prepared and will be shortly undergoing a public review process.

Training Requirements for Animal Waste Management: Approximately half of the surveyed states address this issue in a variety of ways. Illinois, Iowa, and Minnesota require that AFO operators or manure applicators be certified or tested in order to perform their duties. North Carolina is pursuing a certification program for animal waste management system operators which includes training, examination, and inspection of applicant sites. No requirements were found in Ohio, Indiana, or Michigan.

Regulations for Companies that Pump and Transport Waste: Of the surveyed states only Minnesota addressed this issue. Minnesota rules require that manure be hauled so as to prevent leaking or spillage on public roads.

Pollution Prevention Plan Requirement: Michigan, Minnesota, and Texas specifically require such PPPs. Components of a PPP are required in Nebraska and North Carolina. No requirements were found for PPPs in Illinois, Indiana, and Ohio. Wisconsin has no provisions for PPPs although the state allows counties to enact such measures.

Permit or Certificate of Compliance Requirements for AFOs: Permitting for large AFOs is required in various forms for all the states surveyed, while smaller operations typically have fewer permitting requirements with more flexibility. Indiana and Iowa require permits to operate. Michigan does not require an operating permit; however a siting request package must be submitted to the state as part of a "Site Review and Verification Process."

Documentation Requirements from AFOs Seeking Permits or Certificates of Compliance's: Documentation requirements vary considerably for the surveyed states. Requirements usually include MMPs, site plans, volumes of waste to be disposed, size and location of disposal fields, designs of permanent runoff control structures, and types and numbers of animals. Minnesota may require an Environmental Assessment Worksheet (EAW) and/or Environmental Impact Statement (EIS) in accordance with the number of AUs involved and level of public interest.

Regulations Regarding Who Can Design or Approve Manure Storage Structures for Large AFOs: Most of the states have provisions indicating who can design or approve manure storage structures. Illinois has a requirement for a professional engineer (P.E.) or professional geologist (P.G.). Nebraska may require assessments by a P.E. under certain circumstances, Minnesota requires that a P.E. approve plans and specifications except for concrete-lined manure storage structures of less than 20,000 gallons. Wisconsin delegates this activity to local governments.

Regulations that Address Geologic or Hydrogeologic Features that Make Feedlot Runoff a Threat to Surface or Groundwater: The states address several circumstances that pose threats to surface and groundwater. These include the following: 1) aquifers less than 50 feet from the bottom of waste lagoons, in Illinois; 2) shoreland, flood plain, Mississippi headwaters, wellhead protection areas, karst areas, and resurgent springs in Minnesota; and, 3) and protection under major storm events in most of the states.

Requirements for Addressing Environmentally Sensitive Areas: Most states account for sensitive areas in their AFO regulations. These include the following: 1) five specific water bodies, 22 specific groundwater basins, and coastal zones in California; 2) karst features in Illinois and Minnesota; 3) shoreland, flood plain, Mississippi headwaters, wellhead protection areas, karst areas, and resurgent springs in Minnesota. No information addressing sensitive areas was found for Michigan, Nebraska, and Ohio.

Requirements for Site Inspection of AFOs to Assure Appropriate Design and Construction of Waste Management Facilities: Inspections are an important part of any regulatory program. No requirements for inspection were found for Indiana, Ohio, and Wisconsin. Illinois inspects earthen livestock lagoons, North Carolina requires yearly inspections to determine compliance, and Texas requires that AFO PPPs include inspections for structural controls. In all cases, proper inspections require appropriate allocations of resources. Without resources for implementation, regulation will be impaired to some degree.

Regulation of Non-Permitted AFOs: State regulation of non-permitted AFOs varies considerably. Michigan requires compliance with environmental protection codes irregardless of facility size. Nebraska and Indiana do not regulate non-permitted AFOs unless there has been a discharge of wastes into state waters or a high potential exists. Smaller operations in North Carolina and Ohio are not regulated although they are encouraged to follow best management practices in Ohio. Minnesota, Illinois, and Texas regulate non-permitted AFOs, by various means.

Requirements for Reporting of Diseases in Humans that can be Acquired from Livestock: No information regarding this requirement was found for Illinois, Iowa, Ohio, and Wisconsin. However there are requirements to report such diseases in the other states. Indiana, Nebraska, and Michigan require reporting any disease that can be transmitted to humans from animals. Minnesota, North Carolina, and Texas require veterinarians to report such diseases.

Regulation of Feed Supplements: Information regarding feed supplement regulations was not found in most of the states surveyed. Minnesota statutes address labeling of feed and reference U.S. Code (USC), Title 21. Nebraska regulates commercial feed and labeling is required for drugs added to feed.

California: Information related to California was difficult to evaluate and compare to that of the other states (Table 3.1) due to USEPA Region 9's leading role in addressing AFO issues. Therefore, findings for California are presented separately below.

The USEPA Region 9 is currently working with its states to develop and implement state-specific strategies for animal feedlots. Although Arizona, Nevada, and Hawaii have a number of animal feedlots, the overwhelming number of facilities are in California (over 2400 dairy operations, 200 swine operations, and 700 poultry operations). California agricultural animal production nationally ranks first in eggs, first in dairy, second in sheep and lambs, seventh in beef and eighth in poultry operations. There are an estimated 2.5 million cows in California, and approximately 1.3 million head are being raised on 38 feedlots. For this reason USEPA Region 9 has focused its efforts in California, primarily the dairy sector.

The lead animal feedlot regulatory agencies in California are the State Water Resources Control Board (SWRCB) and the Regional Water Quality Control Boards. They regulate the discharge of animal wastes into state waters through the NPDES permitting process. In 1998, the SWRCB listed the water quality of nine rivers and 49 ground water basins to be impaired by animal operations. The USEPA uses its regulatory authority under the CWA and the Safe Drinking Water Act to prevent animal waste pollution. In California, the USEPA and state regulatory agencies send inspectors to dairies to determine if they are in compliance with NPDES requirements and, if applicable, the conditions imposed under their NPDES permit.

On September 9, 1999, the State of California, various federal agencies, the University of California, and the California dairy industry signed a partnership agreement titled "Dairy Waste Management: An Integrated Approach to Education and Compliance." The Dairy Quality Assurance Partnership is a collaborative effort designed to prevent water pollution. The Partnership plays an important role in helping California dairy producers understand environmental regulations and learn management practices to prevent surface water and ground water pollution. The Partnership also oversees a training and certification (Environmental Stewardship) program that includes the development of farm management plans.

3.3 COUNTY REGULATORY FRAMEWORK

3.3.1 Methods Used to Compile County Regulatory Information

We contacted eleven Minnesota counties, to obtain a representative inventory and compilation of the local regulatory framework. Figure 3.1 presents the location of these counties and Table 3.2 summarizes the information collected by county. The following counties were contacted:

- Becker
- Blue Earth
- Fillmore
- Houston
- Morrison
- Martin
- Olmsted
- Ottertail
- Renville
- Stearns
- Winona

FIGURE 3.1

COUNTIES CONTACTED REGARDING REGULATIONS

These counties were selected due to their broad range of approaches to large-scale animal agriculture. In general, information for these counties was obtained by contacting the county representative responsible for animal agriculture regulation. Of the eleven counties contacted, one county declined to participate.

Information obtained pertained to a wide range of regulatory practices on the county level related to animal agriculture issues, especially those related to AFOs. Such issues include land use restrictions regulating placement of AFOs, requirements for MMPs, monitoring requirements for odors, air toxics, groundwater, and the nature of permits that may be required for operating AFOs.

In addition to the work presented here, it should also be noted that the Minnesota Department of Agriculture (MDA) recently published a report on this topic entitled, "Summary of Animal-Related Ordinances in Minnesota Counties"(MDA, 2000). This report includes detailed information on the most common areas of county regulation including setback restrictions, separation distances, conditional use permits, feedlot size limitations, minimum acreage, land application of manure, manure incorporation and certificate of compliance requirements.

3.3.2 County Regulatory Programs

Table 3.2 summarizes the results of telephone interviews. In Minnesota, any county board may assume responsibility for processing feedlot permit applications as indicated in Minnesota Statute 116.07, Subdivision A. This responsibility may in turn be delegated to a specific county official, usually a county

TABLE 3.2

COUNTY BY COUNTY COMPARISON OF REGULATORY MEASURES
Human Health Technical Work Plan
Animal Agriculture GEIS

Question No.	Agricultural Regulations	States Human Health TWP								
		Blue Earth	**Becker**	**Houston**	**Fillmore**	**Martin**	**Morrison**	**Renville**	**Stearns**	**Winona**
1	Regulate, advise, maintain data on animal feeding operations (AFOs).	Yes.	Undelegated county; there is a zoning ordinance that does impact feedlot operations.	Yes.	The county issues permits, and Certificates of Compliance (COCs), works to correct runoff problems, responds to complaints, and conducts inspections.	Yes.	Undelegated county; zoning ordinance does impact feedlot operations.	Undelegated, county zoning ordinance only.	Yes.	Yes.
2	Contact	Veryl Morrell or George Leary (507) 389-8381.	Daniel Holm (218) 846-7310 Planning & Zoning, non-delegated county, no CFO.	Robert Scanlan, CFO (507) 725-5800.	Michal Farauenkron, CFO (507) 765-4571 (information provided by Mr. Norman Craig, former CFO).	Pam Flitter, CFO and Zoning Administrator (507) 238-3242.	Michelle Warnberg, Planning and Zoning (320) 632-2941 Non-delegated County, no CFO.	Eric Van Dyen (320) 523-3768 Non-delegated County, no CFO.	Leonard Hurlburt (3 other CFOs and 1 supervisor) (320) 656-3613.	Mark Gernes, Environmental Services Dept. (507) 457-6335.
3	Does the county keep data on size and number of feedlots or other AFOs?	Yes, based on animal type and number of units. Total 181: 143 with 300-999 AUs, 38 with 1000 or more AUs.	Yes. Total 48: estimate 45 <300 Animal Units (AUs), 2 with 300-999 AUs, 2 >500 AUs, 1> 1000 AUs.	Estimate 80-90% of feedlots are less than 300 AUs.	The data was not available from this source.	The data was not available from this source.	The number of feedlots is unknown. Efforts are underway to inventory all feedlots in county at direction of planing board.	There are an estimated 700 feedlots, no size breakdown.	Yes. Total 2979: 2721 < 300 AUs, 46 with 300-999 AUs, 6 >1000 AUs.	Yes. Total 740: 618 <300 AUs, 77 with 300-999 AUs, 30>500 AUs, 4> 1000 AUs.
4	Does the county have land use restrictions (zoning or setback distances) to control the impact of animal feeding operations (AFOs)?	Yes, there are setback distances between feedlots and dwellings, and there is minimum acreage required based on the number of animals. Feedlot and land use ordinances are coordinated. Siting of feedlots in floodplains is prohibited. There are setback distances for surface water bodies, tile inlets, sinkholes, wells, drainage ditches, steep slopes, and riparian zones.	Yes, zoning ordinances require feedlots to be setback 300 feet from watercourses. There are no requirements for residential setbacks.	Yes, no new feedlot or residence is permitted within ¼ mile of any exiting feedlot or residence.	Yes, county ordinances, feedlots may not be constructed within 100 feet of any non-farm home and vice-versa. No feedlots larger than 2000 AUs are permitted, feedlots must be setback 200 feet from sinkhole, 300 feet from shoreland, and no feedlots are permitted on bluffs or in wetlands.	Yes, zoning ordinances, setbacks: feedlots must be ½ mile from any municipally, 1320 feet from any dwelling not operator-occupied, ½ mile from any subdivisions, 1000 feet from lake or pond, and 300 feet from any stream of ditch.	Yes. Feedlots are classified in tiers according to size, for setback requirements. Tier 1=50-300 AUs, Tier II=300-650 AUs, Tier III=650 to 1000 AUs, Tier 4>1000 AUs.	Yes, the county has a zoning ordinance that has established specific setback distances between feedlot operations and types of land uses (e.g., residential, commercial, etc.)	Yes, the county has a zoning ordinance that has established specific setback distances between feedlot operations and types of land uses (e.g., residential, commercial, etc.)	Yes a setback of 1000 feet from a feedlot to the nearest residence is required, other setbacks are whatever the MPCA requires.
5	Does the county have odor emissions regulations pertaining to AFOs?	No, the state regulates odors in accordance with MN statutes chap. 116.	No.	The county requires a Good Neighbor Plan that has questions regarding activities associated with odor control, but no specific regulations regarding control.	No.	No, odor complaints are handled by MPCA.	No.	No.	An odor control plan is required as part of permitting process.	No.
6	Does the county have specific air emission or toxic air contaminant regulations pertaining to AFOs?	No, the state regulates air emissions in accordance with MN statutes chap. 116.	No.	No.	No.	No.	No.	No.	No.	No.
7	Have specific Air Monitoring Requirements pertaining to AFOs?	No, the county did some monitoring on behalf of state. The county responds to odor complaints but does not do any regular monitoring.	No.	No.	No.	No.	No.	No.	No.	No.
8	Are Manure Management Plans required?	No, the county does issue conditional use permits that require agronomic application, an estimated 85% of feedlot operators conduct voluntary soil testing.	Operators do work with SWCPs to develop MMPs, but the county does not have specific requirements for manure management plans.	Yes, feedlots greater than 50 AUs must be permitted and MMP submission is a part of the permit process.	Yes.	Yes, Extension Service works with producers to develop plans.	Operators choose whether to write a plan or not.	Yes, county zoning ordinance includes setbacks for manure application.	Yes, county recommends using U of M extension “Developing a MMP” or consultant be used. If eligible cost share through Natural Resource Conservation Service.	Yes, estimate of production, analysis, handling procedures, coverage rate, months of applications, and soil test results. Normal application rates based on nitrogen, but may be based on other parameters.
9	Does the county have AFO regulations pertaining to land application of manure?	Yes, ordinance essentially MPCA Chap.7020 rules.	Operators work with SWCPs for land application practices, but the county does not regulate land application.	Compliance with MMP. Soil and manure testing or use of charts from extension service for N in soil for agronomic application.	Yes, county ordinances, manure testing, aggregate application rates, liguid-1 pass application only, soil tests for agronomic rate, maps identifying application areas. If spread on property not owned by feedlots, require agreement.	Yes, setbacks: 300 feet from lakes, rivers, streams; one rod from public ditches, road rights-of-way 60 feet (frozen/snow covered) 1 rod (unfrozen); surface water intakes 300 feet (unfrozen) 150 feet(frozen or snow covered).	Setback guidelines, not requirements. Manure or soil testing not required. Agronomic application required.	No.	Yes. Setbacks for application of manure from houses, wells, tile inlets, road, lakes, waterways, or conduits to waterways.	No, but application may be regulated as part of conditional use permit issued by the county.

TABLE 3.2

COUNTY BY COUNTY COMPARISON OF REGULATORY MEASURES
Human Health Technical Work Plan
Animal Agriculture GEIS

Question No.	Agricultural Regulations	States Human Health TWP								
		Blue Earth	Becker	Houston	Fillmore	Martin	Morrison	Renville	Stearns	Winona
10	Does the county have AFO regulations requiring water (or other environmental) monitoring to detect runoff?	The county requires earthen basins and pits to have tile with sampling inlets, but no monitoring is required unless there is complaint or spill.	No.	No.	No.	No.	No.	No.	Yes. County Planning Commission may require perimeter tile water monitoring by larger feedlots, case-by-case basis.	No, but may be regulated as part of conditional use permit issued by the county.
11	Does the county have AFO regulations pertaining to carcass disposal?	The county requires enclosed storage location, encourages composting. Pigs, possibly turkeys are being composted in the county.	No.	As Board of Animal Health directs, rendering or composting.	Dispose according to Minnesota Dept. of Health - Animal Health Rules. Some composting of animal carcasses.	Yes, State Animal Dept. of Health regulations implemented.	No.	No.	Yes, county follows Dept. of Animal Health rules.	No. Dept. of Agriculture rules apply, some composting done in county.
12	Does the county require operators to be trained in animal waste management?	Not currently. County trying to become a testing station for certification testing under new 7020 rules.	No.	State requirement.	No, must pass state test (requires workshop attendance).	No.	No.	No.	No.	No. Expected to comply with manure management plans. CFO indicated county complies with Dept of Ag regulations.
13	Does the county have AFO regulations for companies that pump and transport waste (including vehicle requirements)?	Transporter (public or private) must have MMP.	No.	State requirement.	No, state rules require leakproof transport.	No.	No, state requirements.	No.	Yes, county zoning ordinance requires that manure moving devices be leak-proof and spill-proof.	No.
14	Does the county require an AFO to prepare a Pollution Prevention Plan?	No, other than normal spill reporting requirements.	No.	No.	No.	No.	No.	County issues conditional use permits for land use, may require plans if appropriate on case-by-case basis.	No.	No, just requirements of normal application process.
15	Does county issue permits or certifications of compliance to AFOs?	Yes, county issues 3-year permit. Inspection is part of permit renewal.	No.	Yes, anticipating change on 10/23/00 when new state rules go into effect.	Yes, both. See Question 4 regarding interim permits. Permits are required for construction or expansion >500 AUs. CUPs are issued until construction is done, then final inspection for COC or permit. Interim permits required for mitigation of pollution problems.	Yes, delegated according to state rules-issue permits, interim permits, and COCs.	Yes. Permits, interim permits, and COC.	County issues conditional use permits for land use, not delegated so no permits or COCs issued.	Yes, county issues interim permits and COCs, permits for construction, or modification, no lower limit on size threshold.	County issues CUPs, feedlot permits, and COCs.
16	What is required as documentation from AFOs seeking permits or COCs?	Documentation required based on state application requirements.	Nothing.	Yes, MMP, aerial photographs of spread areas, Good Neighbor Plan, state application for permit form. Good Neighbor Plan addressees odor, manure application, spring weight restrictions on local roads,	Yes, see Item 4 regarding permits, soil testing, manure testing, required maps.	Registered P.E. (also required for inspection), state rules apply.	MPCA application form.	Copy of MPCA information is required for conditional use permit.	Odor Control Plan, MMP, Carcass Disposal Plan, Township approval, Good Neighbor Plan, and application. Odor control plan is essentially requirement to maintain crust or cover on liquid manure pit. Good Neighbor Plan requires a list of all neighbors within ¼ mile for notification purposes.	MMPs, track land parcels using GIS, track manure application locations to ensure agronomic application rates.
17	Who is allowed to design or approve manure storage structures for large AFOs? What is the size threshold for this requirement (gallons of capacity)?	P.E. is required for construction of concrete structures and pits. Must furnish county with "as built" statement for completed structures.	Soil and Water Conservation District personnel.	No county requirements, state requirements apply.	County will start reviewing designs, previously were sent to MPCA for review. No P.E. at county. P.E. required to design liquid manure storage facility unless facility is cement lined and has less than 20,000 gallon capacity.		State rules are used.	No, state requirements.	County gets plans as part of construction permit, forward the plans to MPCA for review. P.E. required to design liquid manure storage facility unless facility is cement lined and has less than 20,000 gallon capacity.	P.E. is required for all liquid manure storage facilities.
18	What geological or hydrogeological features in state could make feedlot runoff a threat to surface and ground water?	257 miles of rivers, 7 major riverways, bluffs, some shallow bedrock, normal soils 150-250 feet of clay over bedrock.	None.	Some sinkholes.	Many sinkholes.	None.	None.	None.	A lot of lakes.	Sinkholes, rolling topography, a number of feedlots are on ridges-runoff goes towards waterways.
19	Does the county account for environmentally sensitive areas when considering permits to AFOs?	Wellhead protection buffers, Dept. of Health map/assistance. See Item 4.	No.	No.	Yes, see Item 4. Also depth to bedrock, perched water table are limiting factors.	Many lakes and flat areas.	None.	Minnesota River.	Yes, there is a review of the Minnesota County Biological Survey Map for botanical features.	Wetlands, none are very big.

TABLE 3.2

COUNTY BY COUNTY COMPARISON OF REGULATORY MEASURES
Human Health Technical Work Plan
Animal Agriculture GEIS

Question No.	Agricultural Regulations	States Human Health TWP								
		Blue Earth	**Becker**	**Houston**	**Fillmore**	**Martin**	**Morrison**	**Renville**	**Stearns**	**Winona**
20	Does the county require site inspection of AFOs to assure appropriate design and construction of animal waste management facilities?	Yes, required every 3 years as part of permit renewal or when any expansion or new construction occurs.	No.	Yes, inspections are made when new construction or expansion is done, when registration/permitting is done, when complaints are received.	Yes, CFOs inspect when permits are issued. After construction in response to complaints or spills.	Feedlots inspected on five-year rotation, when new construction permits issued. Building permits establish setbacks for county.	Yes, 10% of feedlots per year are targeted (state requirement), building permits for expansion generate inspection.	County will inspect, but is collecting data to prepare a Tier II inventory of feedlots. Inspections will be conducted based on inventory data.	Yes. Inspections are conducted for each permitted facility.	Yes, feedlot control officers inspect when permits are issued. After construction in response to complaints or spills.
21	Does the county regulate non-permitted AFOs?	County will not issue COCs to about 12 AFOs until sites upgraded. Otherwise leave to state.	No.	Yes, there are 550 to 600 feedlots, there are 250 permitted feedlots.	Yes, estimate 990 feedlots, 150-200 are permitted. Trying to get others registered/permitted/COC, but economic hardship for many which is a big problem.	No, 768 permitted feedlots-no unpermitted feedlots.	614 permitted feedlots in county. Currently, inventorying county.	Not applicable.	About half of the feedlots are un-permitted.	Yes, of 800 feedlots about half are not permitted. Lack of public awareness may be primary reason for lack of permitting.
22	Does the county require reporting of diseases in humans that can be acquired from livestock (zoonoses)? If so, what diseases are reportable?	No.	No.	No.	No.	No.	No.	No.	No.	No.
23	Does the county have regulations pertaining to Feed Supplements (such as amino acids, antibiotics, and hormones)?	No, has been requested by some townships, but county not trained or equipped for this type of regulation.	No.	No.	No.	No.	No.	No.	No.	No.
24	Other comments?	One of first to pass feedlot ordinances in 1995. MPCA presented county with environmental award. Estimated county has cleaned up 40-50 feedlots. In 1993-4 DNR and MPCA prosecuted feedlot violations, some operators jailed. New MPCA rules effective 10/16/00 and official 10/31/00. County is one of few that has a level III inventory per new rules. 1.5 people assigned to feedlot office.	Generally, county will enforce zoning ordinances (setbacks). Feedlot operators work with SWCD and MPCA directly.	None.	Economic problems make it difficult for some farmers to meet requirements of permits or certificates of compliance.	None.	None.	A county ordinance is being revised. There is a proposed draft revision on file. It is likely that Renville will apply to become delegated county in future, ordinance will then be revised again.	None.	None.

Notes:
AV = Animal Unit
SWCD = Soil and Water Conservation District
MPCA = Minnesota Pollution Control Agency
DNR = Department of Natural Resources
COC = Certificate of Compliance
CFO = County Feedlot Officer
AFO = Animal Feeding Operation
CAFO= Concentrated Animal Feeding Operation
CUP = Conditional Use Permit
P.E. = Professional Engineer

feedlot control officer (CFO). Permits for feedlots requiring NPDES permits must be processed by the MPCA. The MPCA has an oversight role with respect to delegated counties. The MPCA can withdraw the delegated authority from a county if the MPCA believes the county is not effectively implementing the program. Counties participating in the program receive some funding from the state for program implementation although some counties feel the funding is insufficient to support delegation. Counties may pass ordinances more stringent than state rules regulating feedlots if they choose to. This is usually done in the form of zoning regulations. At present, 54 of 87 counties in Minnesota have been delegated by the MPCA to issue and administer feedlot permits.

Four of the eleven counties contacted, Becker, Morrison, Olmsted, and Renville, are undelegated counties. These counties currently regulate animal agriculture at the local level through zoning ordinance requirements only. The MPCA maintains the responsibility for processing feedlot permit applications. The remaining seven counties have assumed responsibility for processing feedlot permit applications.

A number of common regulatory practices were found across the range of counties surveyed. These practices include the following:

<u>Land Use Restrictions</u>: One basic requirement governing the placement of AFOs is a setback requirement. All of the counties interviewed had requirements that dictate the minimum distance at which an AFO can be operated near non-farm home residences. Other counties have expanded setback requirements to address other environmental features such as surface waterbodies, floodplains, sinkholes, steep slopes, road rights-of-way, tile intakes, and other sensitive areas.

<u>Odor Emission Regulations</u>: In general, odor emissions are left to be addressed at the state level. Some counties include odor control in their Good Neighbor Plans, but do not have specific requirements. Others simply respond to odor complaints. Stearns County requires an odor control plan as part of its local permitting process.

<u>Air Emission or Toxic Air Contaminant Regulations</u>: In general, air emissions are regulated at the state level (Minnesota Statutes Chapter 116).

<u>Specific Air Monitoring Requirements</u>: None of the counties surveyed have specific air monitoring requirements. Blue Earth County participates in some monitoring on behalf of the state and responds to complaints.

<u>Manure Management Plans</u>: Approximately half of the counties contacted require MMPs. Some recommend that owners/operators use the U of M Extension Service, SWCD, or the NRCS for assistance in developing a plan. Stearns County indicated that there is a cost-sharing program available through the NRCS if the operator is eligible. Some delegated counties still include setbacks for manure application in their zoning ordinance.

<u>Regulations Pertaining to Land Application of Manure</u>: Most counties have some level of regulation ranging from setback requirements to MMPs. Undelegated counties refer to MPCA rules. Some counties require soil and manure testing or the use of Extension Service charts for nitrogen levels in soil for agronomic application. Fillmore County requires agreements to be in place for manure spread on property not owned by AFO owners/operators.

<u>Regulations Requiring Water or Other Environmental Monitoring</u>: Most counties do not require water or other environmental monitoring. Stearns County requires perimeter tile water monitoring by larger

feedlots on a case-by-case basis. Blue Earth County requires earthen basins and pits to have tile with sampling inlets, but typically does not require monitoring unless there is a complaint or spill.

Regulations Related to Carcass Disposal: Counties rely on Minnesota Animal Health Board Rules. Blue Earth County requires an enclosed location and encourages composting. Some composting of animal carcasses is being done. Rendering is also conducted.

Training Requirements for Animal Waste Management: Most counties refer to state requirements and testing, which requires workshop attendance. Blue Earth County is in the process attaining certification under new Chapter 7020 rules, MMP requirements, or Department of Agriculture requirements.

Regulations for Companies that Pump and Transport Waste: Most of the surveyed counties rely on state regulations for the dumping and transport of waste. Stearns County zoning ordinance requires manure-moving devices to be leak and spill proof. Blue Earth County requires public and private transporters to have a MMP.

Pollution Prevention Plan Requirements: Stearns County issues conditional use permits for land use that may require PPPs on a case-by-case basis. None of the other counties surveyed require a PPPs. Some require that normal spill reporting requirements be met.

Permit or Certificate of Compliance Requirements (COCs) for AFOs: Most delegated counties interviewed issue permits, interim permits, and COCs. Inspection is a component of permit renewal. Some undelegated counties issue conditional use permits under their zoning ordinances.

Documentation Requirements for AFOs Seeking Permits or Certificates of Insurance: Requirements range from none in undelegated counties to requiring a copy of the MPCA permit application. Delegated counties may require several forms of documentation. Some forms of documentation identified include Odor Control Plans, MMPs, Carcass Disposal Plans, township approval, Good Neighbor Plans (may include odor control methods, manure application, list of all neighbors within specified distance for notification purposes, plan to handle weight restrictions on roads, manure testing, aerial photographs of spread areas, or various maps). Winona County tracks land parcels using GIS and tracks manure application locations to ensure agronomic application rates.

Regulations Regarding Who Can Design or Approve Manure Storage Structures for Large AFOs: Some counties require a P.E. for the construction of concrete structures and pits or for all liquid manure storage facilities. Some forward plans to MPCA or SWCD personnel for review. Other counties defer to state requirements.

Regulations that Address Geologic or Hydrogeologic Features that Make Feedlot Runoff a Threat to Surface or Groundwater: Counties interviewed cited rivers, bluffs, shallow bedrock, sinkholes, and surface waterbodies as features that could be affected by runoff from feedlots.

Addressing Environmentally Sensitive Areas when Permitting AFOs: Counties account for wellhead protection buffers, shallow depth to bedrock and perched water tables, lakes, rivers, botanical features identified in the Minnesota County Biological Survey, wetlands and features that require setbacks (see Land Use Restrictions) as environmental sensitive areas that they consider when permitting AFOs.

Requirements for Site Inspection of AFOs to Assure Appropriate Design and Construction of Waste Management Facilities: Most counties require inspections related to permitting or in response to complaints or spills. Other counties target a percentage of feedlots each year for inspection.

Regulation Non-Permitted AFOs: Most counties have some unpermitted feedlots. Lack of AFO operator/owner awareness, AFOs not meeting requirements without upgrading, and economic hardship for operators/owners were cited as reasons for some facilities not having permits. In most cases, the counties are trying to complete registration or are in the process of inventorying facilities to determine how many unpermitted facilities exist.

Requirements for Reporting of Disease in Humans that can be Acquired from Livestock: None of the counties interviewed require this reporting.

Regulation of Feed Supplements: None of the counties have regulate feed supplements. However, Blue Earth County has received requests for this type of regulation; but indicated it is not authorized, trained, or equipped to handle such a program.

Other Comments: It is an economic problem for some AFO operators/owners to meet requirements for permitting or obtaining a COC. Renville County indicated that its county ordinance is being revised. It will likely apply to become a delegated county in the future and will revise its ordinance again at that time. Blue Earth County is one of few counties that have completed Level III inventory per new rules.

3.4 OPERATOR PRACTICES

3.4.1 Methods Used to Compile Information Regarding Operator Practices

This section presents the results of an inquiry into AFO operational practices in the State of Minnesota. This inventory was compiled from phone interviews with University of Minnesota County Extension Office Educators from across the state. A total of eleven counties were included in this inventory and were selected based on geographic location, the density of AFOs, and the variety animal species housed in AFOs within the county. The counties selected provided a representative set of information with geographic distribution, information from counties with higher densities animal feedlots, and a variety of AFO species. Information operator practices was also collected by Earth Tech during a tour of a variety of animal agriculture confinement facilities provided by the Waseca County Agricultural Extension Educator.

A summary of the inventory is contained in Table 3.3, which includes:

- The function of the county extension office and its role in regulating, advising, and maintaining data on AFOs.
- The types educational programs provided and the BMPs recommended by the county extension educator (i.e., proper land use, MMPs, protection of environmentally sensitive areas, etc).
- Variations between common practices, rules, and recommended practices.
- The types of clients served by the extension office, and the driving factor behind the work of the extension office.

Given the limited scope of our survey, good information was collected from the interviews on the role of the extension office and the types of education programs and information available throughout Minnesota. It should be noted that summarizing common practices and the variation in practices is a very broad topic

TABLE 3.3

UNIVERSITY OF MINNESOTA COUNTY EXTENSION EDUCATOR INTERVIEWS
Human Health Technical Work Plan
Animal Agriculture GEIS

Question No.	Agricultural Practices	Becker	Blue Earth	Fillmore	Houston	Kandiyohi	Martin	Morrison	Olmsted	Ottertail	Stearns	Winona
1	Regulate, advise, maintain data on animal feeding operations (AFOs)?	No regulatory role, but work with farmers to help them interpret and understand new feedlot rules.	No involvement.	No involvement, tasks handled by the county feedlot officer.	No involvement, but provide support to farmers in non-compliance situations.	No role in regulating or maintaining data.	No role in regulating, but work extensively with clients to help them comply with new feedlot regulations.	No role in regulating or maintaining data.	No role in regulating, but work extensively with clients to help them comply with new feedlot regulations.	Not a regulator, but serve as a neutral party to help clients understand and comply with feedlot regulations.	No role in regulating or maintaining data.	No active role, this is handled by the county feedlot officer.
2	Keep data on size and number of Feedlots or other AFOs?	This is handled by other county agencies.	This is handled by the division of environmental services.	CFO is currently compiling a county animal inventory.	This is handled by the CFP and the Planning and Zoning Department.	No, an animal inventory for Kandiyohi county has not been prepared to date.	This is handled by the Environmental Services Department.	This is handled by various other agencies within the county.	This is handled by the feedlot officer and the Planning and Zoning Department.	An animal inventory has not been compiled for Ottertail county as of yet.	This is handled by the CFO.	This is handled by the CFO and the planning officers.
3	How is the county extension office setup to work with AFOs?	The county has one individual dedicated to animal feedlot issues, and works extensively with other county extension offices on educational programs.	The county has three full time educators to deal with animal related issues. Also part of six county area that conducts a lot of joint educational programs.	The county has one individual dedicated to all animal feedlot issues.	The county has two extension educators who work with all agricultural issues.	Kandiyohi county has one livestock educator to cover a cluster of counties including: Kandyohi, Meeker, Renville, and dairy education for 4 to 5 counties to the west.	The county has one two-time extension educator dedicated to livestock.	The county employs one educator to work with both animal agriculture and horticulture educational programs.	The county extension office has two full-time educators, and one part-time feedlot technician who work with all agricultural education/advisement issues.	The county has two agricultural educators, one in the north and one in the south of Ottertail county.	Two county has two full-time agriculture extension educators who are specialized in different areas .	The county has one full-time educator who works extensively with a number of other agricultural groups and committees.
4	Who are the county extension offices main clients?	Dairy , beef, and turkey farmers.	Producers, crop consultants, and suppliers.	Farmers, agricultural businesses, and other agricultural agencies.	Operators, landowners, and homeowners.	A wide variety of livestock producers.	Producers, residents, operators, and absentee landowners.	Primarily livestock producers.	Mainly the livestock owners and operators.	Mainly small to mid-sized dairy farmers.	Producers, agricultural business, the public, and other agencies.	A wide variety of livestock producers.
5	Involvement with programs and practices on land use restrictions (zoning or set-back distances)?	No involvement.	The extension office puts out a lot of information and promotes awareness of land use regulations.	Has worked to develop a series of land plots for determining proper use and manure application.	Encourages proper buffer strips for permits near environmentally or hydrogeologically sensitive areas.	The extension educator is on the planning and zoning committee and provides information and makes decisions on zoning and setback distances.	No involvement.	Not a lot of involvement in land use decisions or education. Usually handled by the planning and zoning department.	The county planning and zoning commission handles a majority of the land use related tissues. The extension office provides support when needed.	Lots work promoting proper set back distances and buffer strips to protect the water quality of 1,000 lakes.	An extension official works directly with clients on all political agricultural zoning issues.	Provide population trends and statistics for presentations, and make decisions on land use.
6	Provide education practices involving monitoring of odors and air toxics from AFOs?	No involvement.	No involvement.	Have worked with the University of Minnesota in research studies of odors and air toxics.	No involvement.	No involvement.	Have been involved in University of Minnesota indoor air quality studies.	No involvement.	No involvement.	No involvement.	Have been involved in University of Minnesota feedlot air emissions studies, and have offered tours pertaining to odor management.	Have been involved in University of Minnesota feedlot air emissions studies.
7	Provide education practices involving proper manure management at AFOs?	Involvement with operators to develop manure and nutrient management plans.	Lots of one on one work with clients to develop manure and nutrient management plans.	Develops MMPs for feedlots, and conducts manure spreader calibrations when requested.	Works with operators on proper selection of sites for spreading of manure and proper nutrient applications rates.	Work one on one with clients to develop manure and nutrient management plans.	Work directly with clients to develop MMPs.	No involvement with manure management plans, they are handled by the extension educator in staples.	The extension office works very actively with the clients in development of proper MMPs.	The county extension office places a lot of time and importance in education on proper manure handling and spreading of manure.	All of the manure management is handled by the Benton county extension office.	Tours are given frequently to observe facilities utilizing certain manure management practices.
8	Provide education practices involving environmental monitoring?	No involvement.	No involvement.	Has been involved with the IA's watershed water quality monitoring project.	No involvement.	No involvement.	No involvement.	Has done some work with the water quality coordinator to monitor water quality of nearby feedlot operations.	No involvement, the water quality is handled by the County Water Quality Coordinator.	No involvement.	Work with the Soil and Water Conservation Department to monitor and protect water quality.	No involvement.
9	Provide education practices pertaining to environmental sensitive areas (geological/ hydrogeological)?	Work heavily with farmers to develop practices to prevent soil erosion.	Was one of the initiators of the river family farmer program, and works hard to protect water quality.	Work with other agencies to put on seminars on proper tillage to prevent soil erosion.	Encourage proper buffer strips for permits near environmentally or hydrogeologically sensitive areas.	Provide information to clients to protect the water quality of nearby lakes and streams.	Work to educate clients to protect nearby bodies of water.	The county is part of the Mississippi Headwaters program, and works with other agencies to protect shorelines and native vegetation.	The extension office works with the county Water Quality Coordinator to protect environmentally sensitive areas.	Work extensively to help protect the water quality of the large number of lakes within the county.	Involved in monitoring and educational programs to protect water quality.	Work with other agencies to put on seminars on proper tillage to contamination of nearby water.
10	Provide education practices involving carcass management?	No involvement.	Works with other county educators to provide carcass management programs.	No involvement.	Lot of effort is place on emphasizing proper carcass composting and biosecurity.	With 35-40 facilities in the nearby area composting animals, lots of emphasis has been placed on carcass composting programs.	No involvement.	No current involvement in carcass composting programs, but see a need for establishing one in the future for larger animals.	Information is provided upon request.	Information is provided upon request.	No involvement.	Information is provided upon request.
11	Provide education practices pertaining to pollution prevention?	Work directly with farmers prevent runoff and contamination of nearby watersheds.	Heavily promote the per quality assistance training information.	Have been involved in programs pertaining to well sealing and septic tank management.	Proper manure management programs to protect the environment surrounding the AFOs.	Active involvement with the clients to develop BMPs that will protect surrounding bodies of water.	Work with clients on proper manure management to protect nearby waters and prevent disease.	Work with the SWCP to protect water quality and shoreline.	Work actively through newsletters, radio programs, and public meetings to promote proper manure management.	A lot of time and resources go into education on proper manure handling and spreading of manure to prevent disease and protect water quality.	Promote proper nutrition management practices, protecting water quality, and proper biosecurity practices.	Present a large amount of pollution prevention material in weekly radio programs and agricultural newsletters.

TABLE 3.3

UNIVERSITY OF MINNESOTA COUNTY EXTENSION EDUCATOR INTERVIEWS
Human Health Technical Work Plan
Animal Agriculture GEIS

Question No.	Agricultural Practices	Becker	Blue Earth	Fillmore	Houston	Kandiyohi	Martin	Morrison	Olmsted	Ottertail	Stearns	Winona
12	Provide education practices pertaining to animal disease reporting/practices related to disease?	Periodically put on seminars on animal disease reporting.	No involvement.	None.	No, this is handled by the Board of Animal Health.	No, this is handled by the State Veterinarian.	No involvement.	Ongoing maintenance type work with disease reporting.	No involvement.	No involvement.	The extension office puts on education programs related to proper biosecurity practices.	No involvement.
13	Provide education practices regarding feed supplements (amino acids/antibiotics, hormones)?	Periodically put on seminars on feed supplements.	No involvement.	Has conduced environmental quality assurance programs, which addresses proper antibiotic and hormone usage.	No involvement.	No involvement.	No involvement.	Ongoing maintenance type work with feed supplements.	No involvement.	No involvement.	The extension office puts on education programs related nutrition, with and emphasis on not to overfeed animals or over fertilize crops.	Occasionally an expert will be brought in to provided information and material.
14	What drives the extension offices programs and practices?	Local need.	Client demand, and other individuals aware of the environmental issues.	Client need, which is determined mainly by the county advisory committee.	The ongoing needs of the county.	Consumer need and request.	The regulations that require clients to obtain manure management plans.	Primarily client needs.	Client need, or response to bad press on an environmental issue related to animal feedlots.	Identifying a need for information.	What the people want and need.	Mainly on a feel for the demand.
15	What are common deviations and difficulties associated with implementing recommended best management practices?	Manure management is a new thing and can be hard to handle. There are lots of difficulties including; poor nutrient management, soil erosion, and runoff.	Producers tend to want to follow best management practices, but many can be tough to coordinate due to the weather, or other unexpected problems.	Physical barriers, soils with high phosphorus concentrations, and weather place limitations on proper manure spreading.	Current farm prices make it difficult for farms to have an interest in carrying out some the prescribed best management practices.	The largest difficulty is just getting the consumers to assemble a manure and nutrient management plan.	The most difficulty involves the indecisiveness of clients in facility design when developing MMPs for new or expanding feedlots.	No real major variations or difficulties. The soil within the county is naturally non-fertile, therefore farmers have always been required to used manure and a tool.	The biggest difficulty is the lack of resources. Better programs need to be developed to get the information in a useable format to the operators.	The biggest difficulty is just getting everyone to realize the importance of these programs and participate.	Farmers are pushed to by and apply to much fertilizer to fields, and trend to over feed animals.	Large expansion in number and size of feedlots have made odor setback distances an maintaining water quality a more difficult task.

Notes:
AFO = Animal Feeding Operation
CAFO= Concentrated Animal Feeding Operation
CFO = County Feedlot Officer
SWCD = Soil and Water Conservation District

within a large industry. Therefore only a limited amount of subjective information was obtained from each of the interviews. A much larger, more focused study would be needed to gain more information and a better understanding of specific management practices.

3.4.2 Discussion of Practices

Common Practices

From the information provided by the extension educators, it appears that it is well-understood that feedlot regulations are requiring AFOs to follow better environmental management practices. Under the new MPCA feedlot rules, MMPs and soil testing are a requirement for feedlot operations greater than 300 AUs in size and manure testing is required for all storage areas holding manure from more than 100 au. As a result of these regulations, there has been increasing awareness of the benefits from good manure and nutrient management (Peters, 2000). Operators have begun to see better crop yields from the proper spreading of manure with desirable concentrations of nitrogen and phosphorus (Peters, 2000). The nutrient value of manure has created a market for animal manure, and has made the task of disposing manure profitable for a large number of operators (Peters, 2000; Carlson, 2000).

In many instances, it is still a difficult task to get operators to completely commit to the requirements of the MPCA animal feedlot rules. The lack of available resources such as: engineering support and programs to get regulations and BMPs in a more useable format for operators are a few of the difficulties associated with establishing best management practices (Stainard, 2000). A downward trend in agricultural prices also makes it difficult for feedlot operators invest in changes to comply environmental regulations (Haufman, 2000).

Range of Practices

The information collected from the county extension educators provides a general understanding of the range of practices seen across the state. The largest range or variation in practices was apparent in manure and nutrient management practices. A number of factors such as geographic location, physical barriers, soil characteristics, and weather have an impact of the range of feedlot manure and nutrient management practices carried out.

In some regions across Minnesota, the soil has always been nutrient deficient, and operators have relied on manure as a major source of nitrogen and phosphorus. In these instances, it has been less difficult for educators to have operators develop and maintain proper manure and soil nutrient management plans (Carlson, 2000).

In other regions, proper management of manure and nutrient management is a more difficult task. In some areas, the yearly spreading of manure has lead to an unwanted build-up of phosphorus in the soil, which makes it challenging to apply manure with appropriate concentrations of nitrogen and phosphorus (Tesmer, 2000). In a number of settings, operators are applying too much manure and artificial fertilizers to fields, and overfeeding livestock (Selfer, 2000). These practices result in an unwanted increase of nutrients in the soil and an increasing risk of adverse impacts to nearby land and water.

Weather can be difficult to predict during the spring and fall, which are the two common periods for manure spreading. Saturated fields can make it very difficult for operators to apply manure to the desired plots of land (Tesmer, 2000). Physical barriers such as hills and valley in some areas also make it economically infeasible to transport manure to the plots of land that best fit the manure nutrient content profile (Tesmer, 2000).

Best Management Practices

With the increasing growth in the number and size of AFOs, and with the environmental regulations placed on this industry, county educators serve as a neutral party to provide the producers, the public, agricultural businesses, and other agricultural agencies with the educational information and programs needed to meet these on-going changes within the industry. Of course, a major point of emphasis is manure management.

To help the producers meet AFO requirements, the county extension offices directly provide or make available one-on-one education instruction, a variety of seminars and publications, and local radio programs regarding manure management. These programs are designed to insure proper handling and storage of manure, proper selection of plots of land for spreading, support with nutrient measurements of soil and manure, and education information on other BMPs. Prescribed MMPs are also designed to prevent contamination of nearby waterbodies and other environmentally sensitive areas of geological or hydrogeological concern.

In conjunction with other state and local agricultural and environmental agencies, the extension educator plays a large role in providing information on programs designed to help engineer strategies to properly handle runoff water from animal operations and to protect water quality, protect shoreline of nearby lakes and streams, and providing educational information to promote proper tilling practices to prevent soil erosion (Peters, 2000).

A manure and wastewater management handling and storage system should include all of the management components needed for an AFO to prevent degradation of water quality and minimize other environmental impacts. The USDA (USDA 2000) suggests that complete manure and wastewater management system include, but is not limited to the following activities:

- Properly engineered collection, storage, and/or treatment systems that meet the NRCS Waste Management System Standard (Code 312) requirements.
- Testing of manure and organic sources.
- Proper disposal of dead animals.
- Prevention of spills and catastrophic events.
- Proper disposal of spoiled feed and other contaminants.
- Control of insects.
- Identification of needed water control devices around the production facility.
- Contain and dispose of silage leachate properly.
- Proper cleanup of milk houses.

Proper land application of manure is also a critical factor in protecting water quality and can have a positive impact on crop performance. The MPCA (MPCA 2000) plan for effective manure use and application includes:

- Determining the nitrogen, phosphorus, and potassium available in the AFO manure.
- Determining the nutrient content, pH, sodic condition, and organic condition of the soil and adjust application to account for variations.

- Set reasonable yield goals and calculate the amount of nutrients needed to reach these goals.
- Use manure as the primary source of nutrients, making up for shortfalls with commercial fertilizer.
- Calibrate the manure spreader properly.
- Identification of pathogens and odors.
- Identification of sensitive areas such as sinkholes, streams, springs, lakes, ponds, wells, gullies, and drinking water sources with setbacks, as necessary.

Aside from the BMPs previously mentioned, each of the county extension offices provides specialized educational programs and information based on specific needs of the clients they serve. The number and size of AFOs within the county as well as the types of animal species raised within the county tend to influence the types of programs that are emphasized within each county (Carne, 2000; Tesmer, 2000). For example, in areas with higher concentration of poultry, the extension office tends to place more focus on programs addressing biosecurity to protect the well-being of poultry, because poultry are more sensitive and susceptible to disease than a most of the other typical feedlot species (Tesmer, 2000). Carcass composting is becoming a more common method of animal disposal within the poultry and swine industry, and the extension educators in the areas of higher concentration of these species work more extensively to provide information and consultation to develop proper carcass composting practices (Carne, 2000). Feed supplements (i.e., hormones, amino acids, and antibiotics) are also areas of growing attention and concern within the industry. Extension educators and other local and state agencies have recognized the importance of sound practices to manage feed supplements, and have developed programs and information to meet the needs in this expanding area the agricultural industry (Broadwater, 2000; Tesmer, 2000).

3.4.3 Operational Practice Trends

To a great extent, the programs and information offered by the county extension offices, and the actual practices currently carried out at animal operations center around MPCA's animal feedlot regulations (Carne, 2000; Carlson, 2000; Crawford, 2000). To comply with these requirements, operators are establishing better MMPs. Feedlot operators have become more involved in monitoring manure and soil nutrient concentrations and proper manure application rates. Today, better and more advanced engineering practices are being utilized by AFO operators to store, handle, and spread manure to reduce potential environmental impacts (Peters, 2000).

The industry as a whole also appears to be more aware of the potential health and other environmental impacts of runoff from feedlots and the great potential to contaminate nearby bodies of water. In response, more emphasis has been placed on appropriate site selection (i.e., proper setback distances and adequate buffer strips) for new and expanding feedlot operations, proper fertilization of soils, and advanced engineering designs that prevent contamination of nearby waterbodies.

Odors and other potential air toxics emitted from AFOs have become a recent area of concern for the animal industry. With a lack of information on the potential impacts of air emissions from feedlots, and with a limited number of air emission regulation requirements placed on most AFOs, the industry as a whole is just beginning to address this issue. Currently the extension offices within Minnesota does not provide a great deal of assistance with air emissions, and only a limited number of AFOs have begun to take serious measures to control air emissions from AFOs (Peters, 2000).

3.5 EVALUATION OF OTHER LITERATURE SUMMARIES

Nearly all of the literature summaries prepared for this GEIS touch on human health impacts in some fashion. All of the summaries were reviewed and information from them has been incorporated into this TWP as appropriate. As TWPs are prepared on each of these topics, we will review them and incorporate new and constructive ideas. A few summary comments are provided below to highlight some of the most important associations between human health and the other topics.

3.5.1 Social/Community Impacts

The increased industrialization of the animal agriculture industry has had a significant impact on rural communities. The consolidation and increased vertical integration has affected employment patterns and neighborhood identities. In some cases, there have been significant changes in leadership and community values as a result of these dynamics.

Because of the increased size of these new facilities, BMPs are more important than ever to protect health and the environment. Food-borne illnesses have very high visibility in our society and will stimulate a very strong reaction in the marketplace. Also, a major spill from these large facilities holds the potential for much greater harm, at least in the view of concerned neighbors. These health concerns have become a source of leverage for groups who oppose the industry for a wide variety of reasons, some unrelated to human health.

Paradoxically, it is also true that consolidating industrial sources of pollution theoretically improves regulatory management because there are simply fewer sources to permit and inspect, thus making it easier for the regulators to “do more with less.”

3.5.2 Land Use Issues

Land use management and human health protection are very closely connected. Buffer zones are a very important tool to reduce impacts on neighbors, especially pertaining to odor. Land use management will continue to grow in importance as rural and urban areas continue to merge through urban sprawl. In many cases, these new residents have different expectations regarding lifestyle and tolerance of perceived nuisance conditions.

This literature summary provided a very valuable summary of zoning tools which was incorporated elsewhere in this TWP.

3.5.3 Role of Government

Government plays a major role in animal agriculture and the protection of human health. As the public controversy has grown, government has struggled to keep up. Historically, government has largely focused on food-borne disease and water quality/manure management issues in the context of human health. The response to air pollution has lagged behind, as work to regulate these pollutants has only recently moved beyond general odor/nuisance concerns.

Coordination among the levels of government has not been optimal. In some situations, government provides education and assistance. In others, it is responsible for control and enforcement. In order to improve the alignment of these roles, we suggest that more work be done by Minnesota to establish a unifying vision, incorporating both support and regulatory authority, to ensure that all parties understand the State's goals for this industry.

3.5.4 External Benefits and Costs

In standard economic terms, health and environmental impacts associated with animal agriculture are considered externalities. Quantifying the external benefits and costs is extremely beneficial to assessing the reasonableness of regulatory proposals. However, this is a very complex problem with few solid benchmarks. As expected, many of the costs and benefits are difficult to quantify although there are tools that can be used, and some work is underway, to improve our understanding of this topic.

A general conclusion that can be drawn is that these kinds of economic analyses favor using flexible tools which allow operators to choose, from a range of solutions, those actions which work best for them to attain the desired outcome.

3.5.5 Water Resources

As noted throughout this report, there is a very strong connection between human health and water resources. Historically, this has been the most well-understood avenue for the transmission of harmful substances to humans from AFOs. Specifically, water is an important transmitting agent for pollutants such as nitrates and phosphorus and a wide variety of pathogens such as bacteria and parasites. The findings of this literature summary are consistent with our findings incorporated elsewhere in the Human Health TWP.

3.5.6 Manure Management

Best management practices in manure management are the cornerstone to ensuring that AFOs do not negatively impact human health. Proper management will reduce air, water and land impacts. Moreover, it is critical to eliminating the spread of pathogens.

Although the literature summary does not address human health directly, we found detailed discussions of key variables and considerations critical to designing an appropriate MMP. Among other things, there was a good discussion of control options. Overall, this literature summary is very consistent with other sources of information we reviewed.

3.5.7 Animal Health

This topic and literature summary are very important to a discussion of human health because there is a definite correlation between animal health and human health in this context. While there are certainly technical justifications for this relationship, this issue is also entangled in social values and become a vanguard cause for opponents of AFOs. Although very important, we did not examine social values under this topic.

The environment of the confinement facility is important because indoor pollutants that are injurious to animals are generally also harmful to humans both within the facilities and potentially downwind or downstream. In addition, chemical additives in feed or on the animals are a significant public concern despite existing USEPA and FDA approval processes. We found the discussion in the literature summary as it pertained to health impacts to be generally consistent with our investigations.

At least in developing countries, we expect concern for animal well-being and associated human health considerations to continue to be a growing public policy driver which should lead to further needed research in this area.

4.0 INTERNATIONAL PRACTICES AND POLICIES

4.1 METHODS USED TO COMPILE INFORMATION REGARDING INTERNATIONAL PRACTICES AND POLICIES

The following information was obtained from the European Union's, European Commission on Environment and the Canadian Government's Agriculture and Agri-Food Internet sites.

4.2 INTERNATIONAL PRACTICES AND POLICIES

Earth Tech evaluated selected European and Canadian programs to gather information on each country's policy direction and to identify any new regulatory initiatives that might be helpful to the State of Minnesota. Our survey was not exhaustive, rather we were looking for trends and some general sense of the development of related programs outside of the U.S. In most cases, the cultural, political and geographic settings of these countries are very different from Minnesota's and one must use some caution and not attempt to broadly apply foreign policies and regulations to Minnesota's circumstances. These differences are important and we discuss just a few examples below.

Especially in Europe, where many areas are densely populated and land can be very scarce, there has been a more intense emphasis placed on policies and rules that directly mitigate impacts on neighbors and nearby communities. Land use has been a priority in some areas of Europe for centuries. This interest is enhanced by a strong sense of cultural history that often spans many hundreds of years. As a result, sustainable agriculture has been a major policy driver in Europe for some time. In fact, sustainability has been a major theme in the discussions surrounding the European Union's Common Agriculture Policy (CAP); (Stoltenberg, 1998)

Also, most European countries are much smaller than the U.S. Some are similar in to Minnesota in population and size. As a result, these countries tend to be very oriented to respond to foreign market conditions rather than attempting to dictate world markets and market policy on their own. Some have become very successful in capturing niche markets based upon special interests such as antibiotic-free meat products. Out of necessity, both government and industry must be very attuned to adapting to worldwide customers' needs rather than the other way around. This may be one of the factors that contributes to government and industry giving at least the appearance of working in better harmony in some European countries than in the U.S. If European countries have found better ways for industry and government to achieve an alignment of goals, we should certainly try to learn from their experiences and apply that knowledge here in the U.S.

Some countries have unique geography, e.g., Denmark, with very obvious environmental sensitivities such as very shallow aquifers. In these cases, the need to protect the water resource is urgent and policy consensus, although always a challenge, is much more easily developed.

In Europe, as in the U.S., the greatest regulatory and policy emphasis has been on protection of water supplies and the quality of the food derived from animal agriculture. Of course, odor control is also a serious concern, however, detailed knowledge regarding the chemistry of the air pollutants has lagged as it has in the U.S.

Like here in the U.S., allied industries are assisting with guidance and education to help AFOs. We found that the European Fertilizer Manufacturer's Association (EMFA), is contributing to the adoption of "BMPs" by publishing guidance regarding proper nitrogen management (EMFA, 1997). This initiative supports the European Union's actions regarding nitrogen reduction and is another example of the growing alignment of industry and government.

Europe

The European Community, through the European Commission and its member states, has been dealing with nitrogen pollution in waters for over twenty years. Initially the European Commission was mainly concerned with water for human consumption, in more recent directives the concern has expanded to environmental effects of excess nitrogen such as eutrophication from agricultural sources.

The European Nitrates Directive, adopted in 1991, is designed to prevent the pollution of waters by nitrates from agricultural sources by requiring Member States to place mandatory restrictions on agricultural practices to reduce water pollution caused or induced by nitrates from agricultural sources and to prevent further such pollution. One model suggests that the concentration of nitrate leaching from agricultural soils exceeds the guide level of 25 milligrams per liter (mg/l) for 87 percent of the agricultural area of Europe, and is above 50 mg/l for 22 percent of the areas. The Member States were required to identify waters that are currently affected by nitrate pollution or are vulnerable nitrate pollution and designate these areas as Vulnerable Zones.

In these Vulnerable Zones, or their entire territory if they so chose, the Member States are required to establish action programs that contain mandatory measures concerning the land application and storage of fertilizers. The most significant measures are:

- The requirement for each farm to have sufficient livestock manure storage capacity for the periods when they are not permitted to apply manure to land.
- The requirement for the land application of fertilizers to be based on a balance between the requirements of the crops and the supply to the crops from the soil and from fertilizers.
- The requirement for the land application of livestock manure to be limited to 170 kilograms (kg) of Nitrogen per hectare per year.

Denmark

Denmark is one of the Member States that has complied with the European Nitrates Directive and has been controlling nitrogen pollution through action plans since 1987. Denmark is a relatively small European country that is a significant producer of hogs. Over half of the land is devoted to agriculture with less than half being seeded to annual crops. Danish manure policy controls the input of nitrogen from both manure and commercial fertilizers and livestock production is generally limited to the land's capacity to produce feed. Danish legislation requires livestock producers to have a nine-month manure storage capacity and manure can only be applied to unfrozen cropland from February 1 to September 30, and to grassland from July 1 to September 30. Denmark also requires that 40-50 percent of the land must have winter crops to utilize the nitrogen in the soil. Animal densities are limited to 2.3 animal units per hectare on cattle farms and 1.7 animal units on pig farms with arable land, which equates to 30 pigs per hectare, 3 sows per hectare, or 1.7 cows per hectare. Each year Danish farms provide the government with a fertilization plan that includes a government-established quota for commercial fertilizer. The plans are subject to audit and a fine is levied for excess nitrogen use.

Canada

In Canada, there is no federal legislation regarding environmental pollution caused by livestock production. However, most of the Canadian provinces have their own guidelines or practice codes to govern the problems associated with animal pollution. We have summarized Manitoba's requirements as a strong example. Please note that 400 animal units by Manitoba's definition is roughly equivalent to 1,000 animal units in the U.S.

Manitoba

In Manitoba there are a number of provincial acts and regulations and local municipal by-laws that affect the establishment and management of livestock operations. The Livestock Manure and Mortalities Management Regulation under the Environmental Act is designed to protect the environment, enhance enforcement capabilities, and ensure long-term sustainable livestock production in Manitoba.

The following items are controlled by the Livestock Manure and Mortalities Management Regulation:

- The spreading of manure by large-scale livestock operations (greater than 400 animal units) is prohibited from November 10 until April 15. Livestock operations with fewer than 400 units, of any one type of livestock, are exempt unless their manure management practices are causing an environmental concern.
- The regulation sets enforceable limits on the amount of soil nitrates that can be present in the soil. The rate of manure application is determined on the basis of nitrogen content in the manure, residual nitrogen concentrations in the soil, soil texture, and annual nitrogen requirements.
- Large livestock operations are required to prepare and register an annual MMP. The MMP is designed to ensure optimal use of manure nutrients and that environmentally sensitive areas are identified and protected.
- Manure is required to be stored in appropriate designed structures that are permitted by Manitoba Environment prior to construction. In addition, prior to use or operation, the manure storage structures are required to be certified by an engineer as being constructed according to established engineering design standards.
- The regulation provides for proper disposal of mortalities by rendering, composting, incineration, or burial where environmental conditions are suitable. Mortalities are required to be kept refrigerated or frozen when retained for more than 48 hours after death.
- Persons transporting livestock manure are required to report immediately the occurrence of a manure spill or discharge when the location or quantity involved is believed to have an adverse effect on the environment.
- Manure storage facilities and composting sites are required to have a minimum setback distance of 100 meters from surface watercourses, sinkholes, wells, and springs.
- The regulation prohibits the direct contamination of surface and ground waters by livestock manure. It is imperative that livestock manure not be allowed to escape the property boundaries of land where it is stored or applied as a fertilizer.

4.3 INTERNATIONAL TRENDS

At a policy level, Europe and Canada are struggling with the same issues as the U.S. Policy implementation is closely connected to political and cultural norms of each country. Key observed trends are shown below:

- The efforts of the European Union to manage effluents from AFOs to unified goals and standards should be helpful to "leveling the playing field" for business in Europe.
- As in the U.S., other countries continue to emphasize protection of water resources by requiring best management practices for handling of manure and other wastes.
- Mitigation strategies are implemented with a combination of regulatory and voluntary programs with outreach and education playing key roles.
- Air pollution control has largely been viewed as an odor control issue and associated with nuisance management.
- There are strong efforts underway to protect sensitive resources through land use control and increased enforcement of limits on existing operations.

5.0 REGULATORY TRENDS AND THEIR IMPLICATIONS

The environmental regulatory landscape pertaining to animal agriculture has been rapidly changing in recent years. Increased public interest has translated into increased attention at all levels of government. As recently as 1990, the MPCA had only two full-time staff working on feedlot issues. Today the MPCA has at least 24 full-time staff committed to feedlot programs (Minnesota Legislative Auditor, 1999). Addressing the impacts of animal agriculture today is a very complex undertaking for both regulators and policymakers due to at least three dimensions of this issue (Copeland and Zinn, 1999).

One dimension involves the increasing industrialization of animal agriculture in the U.S. Agricultural industrialization is characterized by larger farms, increased vertical coordination in production and processing, and regional shifts in location. As in other industries, the economies of size and scale in production have been a major factor driving the movement toward larger farms (Norris and Thurow, 1999). These trends are illustrated in Figures 5.1 and 5.2

Vertical coordination in production and processing is also an important component of industrialization. Contracting offers opportunities for reduced transaction costs, increased responsiveness to consumer demand, improved quality control, risk shifting and risk reduction, and production efficiencies from specialization. In most cases, production contracts mean that contractors control feed and animals, but contract growers own the production facilities and are responsible for manure management (Norris and Thurow, 1999).

A second dimension is determining the roles of each level of government in responding to the environmental issues associated with animal agriculture. All levels of government have staked out certain territory, adding new interests to plates that are already full with a complicated mix of regulatory and incentive-based programs. Significant coordinating efforts are underway at the federal level, particularly between the USEPA and the Department of Agriculture, but these activities have not placed much emphasis on air quality and odor issues that are so troublesome at the local level.

A third dimension involves the role of technical information about many aspects of animal waste management. Research has increased in direct relationship with increased public interest, but many technical questions remain unanswered. These questions have become very effective tools for the interests that oppose agricultural concentration and industrialization for social, philosophical, or other reasons by providing another high-visibility avenue for raising their concerns. Today, it is easy to find detailed guidance on the internet for strategies to mount opposition to large AFOs (GRACE, 2000).

The dimensions of this issue have certainly provided the fuel to accelerate the policymaking process across this country to strike a viable balance between regulatory and incentive-based solutions to the challenges presented by this evolving industry. At the federal level, a key step was the development of the Unified National Strategy for Animal Feeding Operations by the USEPA and the Department of Agriculture. This Unified Strategy is not a new regulation, nor does it substitute for existing regulation, but it provides an overall approach and a timeline for addressing the pollution from agricultural operations.

FIGURE 5.1

CHANGE IN THE NUMBER OF OPERATIONS BY SIZE CATEGORY: HOGS AND PIGS, 1987 AND 1997

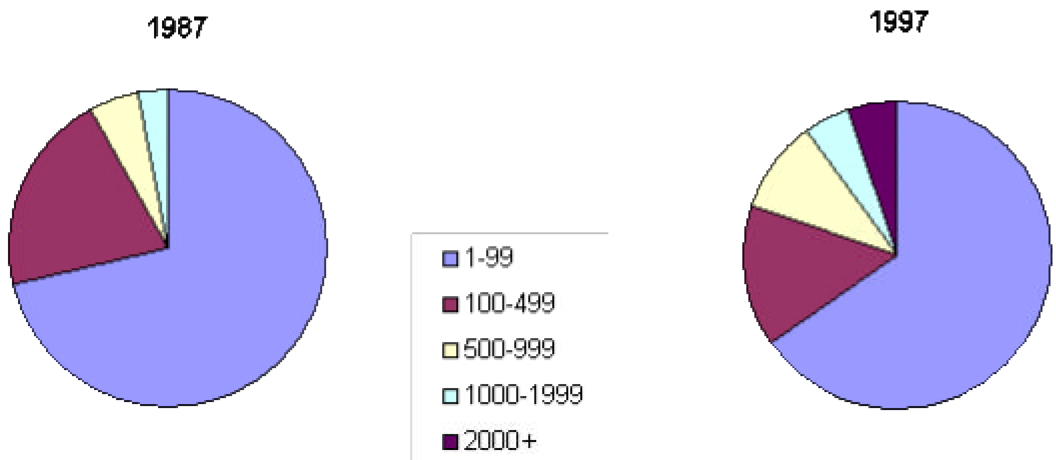
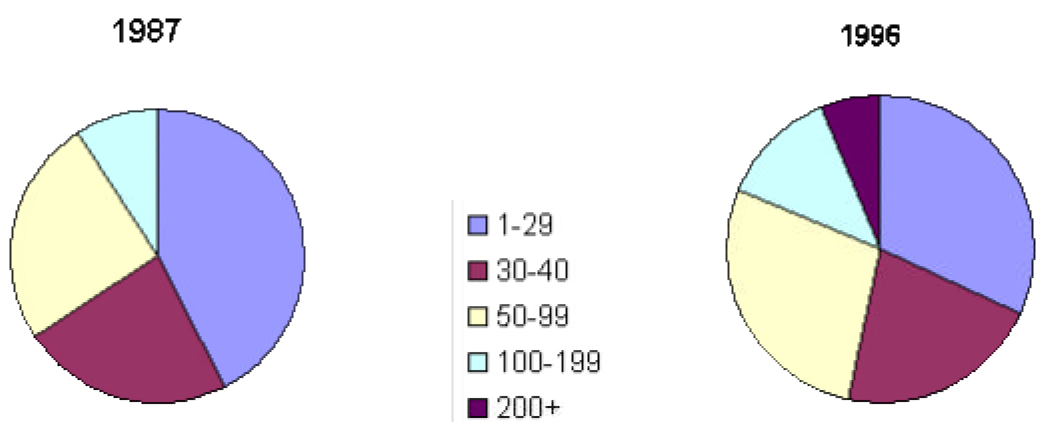


FIGURE 5.2

CHANGE IN THE NUMBER OF OPERATIONS BY SIZE CATEGORY: MILK COWS, 1987 AND 1996



From: Norris and Thurow, 1999.

Not surprisingly, response to the Unified Strategy has been mixed. Some operators fear further government intrusion into farming activities while others see it as an opportunity to harmonize conflicting federal, state, and local policy. Some states question the need for a national program and feel that the negatives outweigh the benefits of a "one size fits all" program arguing that variability from state-to-state is necessary. On the other hand, supporters say that the Unified Strategy sets forth the necessary minimum standards of performance and provides for a critical level of accountability at the state and local level. The response from environmentalists has been mixed as well. While the Unified Strategy defines important action steps, the implementation timeframe is relatively long (seven years) and the voluntary components of the program have been met with some skepticism (Copeland and Zinn, 1999).

Notwithstanding the new efforts at the federal level, states have been very active in developing new laws and regulatory programs to address concerns related to animal agriculture. These programs take significant time to develop and when government responses have lagged behind the speed of the industry, some state governments, including Minnesota, have imposed various types of partial or complete moratoriums on development of new CAFO projects until new regulatory programs are promulgated. Given the current advancements in understanding of the environmental issues coupled with the overall tightening of applicable regulations, there should be no need to impose such measures in Minnesota in the foreseeable future.

5.1 FEDERAL, STATE, AND LOCAL REGULATORY TRENDS

Earth Tech gathered information at all levels of government for this TWP to determine the depth and breadth existing regulatory programs. The survey work done by Earth Tech is consistent with other similar analyses presented elsewhere (Copeland and Zinn, 1999). The results of these surveys can be found in Section 3 - Federal, State, and Local Control Strategies of this report. Highlights of the trends are shown below.

5.1.1 Federal Trends

Earth Tech, Inc., identified the following federal trends:

- To date, the federal government has largely used the CWA as its regulatory platform for addressing AFOs.
- The present trend is to emphasize flexible policies differentiating between large operations designated and regulated as point sources by existing and smaller operations that are encouraged to voluntarily implement in water pollution prevention measures.
- Voluntary implementation will be encouraged through a combination of financial cost-sharing programs and regulatory incentives which might offer protection from nuisance lawsuits when in compliance with recommended practices.
- While the federal government might rely on voluntary programs to address smaller AFOs, in most cases states will be picking up the regulatory slack. Realistically, the federal thresholds are too high to satisfy citizens' concerns at the state and local level.
- Then new federal Total Maximum Daily Load (TMDL) program may lead to the use of area-wide NPDES permits for watershed protection. If so, coordination with existing feedlot programs will be important to ensure fairness and appropriate protection of public health.

5.1.2 State Regulatory Trends

Earth Tech, Inc., identified the following state regulatory trends:

- States occupy a central role in regulation of AFOs by implementing federal mandates and determining the regulatory framework for local government.
- AFO issues related to human health and environment are high priority problems for states with significant agricultural sectors.
- States are increasing the level of regulatory oversight of AFOs. Smaller operations, not subject to NPDES, are subject to an increasing level of regulation at the state and local level.
- The federal government is playing a role in coordinating state efforts through the NPDES program and TMDL program.
- Regulation of AFOs is becoming more explicit, potentially leaving less room for voluntary or incentive based programs.

5.1.3 County Regulatory Trends

Earth Tech identified the following county regulatory trends:

- Efforts are underway to make feedlot and zoning ordinances consistent.
- Some undelegated counties are regulating through zoning ordinances.
- Delegation effort routinely exceeds state funding support and the gap will likely continue to provide a rationale for not seeking delegation for some counties.
- There is an interest in some counties for cost-sharing or assistance in developing MMPs and other plans.

5.2 THE NEW MINNESOTA FEEDLOT RULE

Due primarily to the recent promulgation of a very comprehensive new feedlot rule in October 2000, Minnesota now has one of the most comprehensive state regulatory programs in the nation for AFOs. Some of the provisions are highlighted below:

5.2.1 1,000 or More Animal Units

- Mandatory EAW preparation.
- Individual or general NPDES permit.
- Location Restrictions.
- Expansion Limitations.
- Notification of neighbors.

All permit applications for feedlots with 1,000 or more animal units must include:

- Air Emissions Plan.
- Emergency Response Plan.
- Manure Management Plan.
- For construction or expansion activities involving liquid-manure storage areas, the permit application must also include engineering design plans and specifications prepared and signed by a P.E.

5.2.2 300 to 999 Animal Units

- Permit needed: Construction Short Form, Interim, NPDES, or SDS permit.
- Notifications of MPCA, County and neighbors prior to construction.
- EAW preparation for certain facilities in sensitive areas.
- Location restrictions.

5.2.3 Under 300 Animal Units

- Possible SDS permit required.
- Construction notifications.
- Meet manure storage structure requirements.
- Location restrictions.

See Minnesota Feedlot Rule (MN Rule Chapter 7020) for more details.

5.3 INTERNATIONAL STRATEGIES

Earth Tech examined a limited number of international programs addressing human health and animal agriculture. A detailed description of our review can be found in Section 4 - International Practices and Policies. More work could be done to better understand some advanced international programs, such as Denmark's program. In many ways, government and industry in Denmark seem to act in better harmony than in the U.S. However, we are unable to determine if that experience is transferable to the U.S. given the significant economic and cultural differences between the countries.

5.4 OTHER REGULATORY STRATEGIES

As an introductory statement, it should be said that it is almost always technically possible to bring regulation up to a higher level of stringency. In Minnesota, however, it is also necessary to apply a test of "need and reasonableness" as a requirement of law (Minnesota Statutes, Chapter 14). Therefore, increased regulation cannot be arbitrarily imposed. As a result, in our evaluation of outputs and regulatory strategies, we looked for gaps where regulatory programs either missed or fell short in addressing priority concerns. We have not focused attention on situations where, for example, 90 percent control is required and we know 95 percent could be technically achieved, but we can find no compelling justification to do so.

In Section 5.5, we examine specific outputs within each media to highlight some technical concerns. However, land use control will always be a critical management component. The following are some zoning strategies which might be considered in comprehensive planning at the county or township level (Durgan, B. and Drager, K., 1999).

- Multi-tier agricultural districts.
- Separation standards.
- Setbacks from roads.
- Minimum site area requirements.
- Limiting number of animals by area.

- Definitions for non-conforming or non-complying structures that bring pre-existing operations under current land use regulations.
- Requiring a Conditional Use Permit.
- Special exception review.
- Performance standards or BMP's.
- Clear definitions of what is regulated.
- Site suitability standards/performance standards.
- Exclusive agricultural zones.
- Large minimum lot sizes with small building lot sizes.
- Urban expansion zones/urban growth boundaries.
- Establishing an Agricultural Preserves area under the MN Agriculture Land Preservation Act.
- Purchase of Development Rights.
- Transfer of Development Rights.

5.5 REGULATORY GAPS

Regulatory gaps can be created when existing regulations are not implemented for some reason. This can occur if the regulations are poorly understood. It can also occur when there is inadequate funding for enforcement or the activity is deemed to be too low a priority for the allocation of scarce resources. These kinds of issues were addressed in detail by the Minnesota Legislative Auditor in his 1999 report where a number of problems were cited. The MPCA has used the Auditors report as a guide to make a number of improvements in its program over the last several months (Sabel, 2000).

Gaps can also occur where an issue has been overlooked, underestimated, or left behind. Sometimes there is a lack of technical information. In other cases, certain policy orientations can be the cause. For example, if water pollution and nutrient contamination have received all of the regulatory attention, air emission issues may be left behind to a certain extent. Also, if an issue is perceived as occupational in scope, it may be compartmentalized by other agencies as being only the concern of Minnesota OSHA.

We examined both kinds of issues, although the scope of this project has made it impossible to explore them in exhaustive detail. We interviewed CFOs, zoning and environmental staff, and extension agents to try to obtain a sense of what is happening on the "ground floor" of program implementation. We wanted to see if there was a gap in knowledge or action with respect to the existing regulations. It appears that most county staff, extension educators, and operators understand the importance of existing regulations and are geared to implementing them. Current education and outreach programs should be continued and potentially expanded because it does appear that stakeholders generally want to "do the right thing".

We also evaluated the existing technical information on the list of outputs from AFOs. By assigning a priority to each output as shown in Table 2.1, we have created a tool to examine high priority concerns to determine if they are being adequately addressed either by regulation or voluntary programs. These assessments are summarized in the following sections of this report. In Section 5.5.4, we examine human health risk as a function of feedlot size and animal species.

5.5.1 Air Emissions

Earth Tech recommends that the State of Minnesota proceed to gather more information about several air contaminants known to be released from AFOs. The following are the pollutants that we believe merit further attention:

- Hydrogen sulfide and reduced sulfur compounds (relative importance in odor and area-wide impacts).
- Volatile organic compounds.
- Dust (including endotoxins).
- Ammonia (evaluation of fate and work to understand background conditions in agricultural areas).

We recommend further monitoring and quantification of sources in part due to the potential for significant health impacts. We also believe that quantifying these emissions will make it possible to compare emissions from AFOs to other sources to help regulators prioritize efforts and to provide some perspective for the public. We want to emphasize that we *do not* have evidence that AFOs are major sources of these pollutants compared to mobile sources, other industrial sources, or other human activity. However, current unknowns are a major hindrance to all concerned parties during project review and permitting. These gaps are negatively affecting project timing and cost, and are reducing public confidence in the review process.

5.5.2 Non-Occupational Health and Safety Issues

Minnesota Rules §5205.1000-1040 cover *occupational* entry into confined spaces, such as manure pits. Earth Tech, Inc., reviewed the statistics regarding manure pit fatalities which revealed three non-occupational fatalities to children under six years of age over a 16-year period, with the latest incident in October 2000. The apparent regulatory gap in this case is that the confined space standard and pit guarding standards (MR §5205.0080) are not applied to non-occupational settings and workplaces with less than ten employees. Application of building codes to prevent accidental entry and outreach to promote voluntary application of proper confined space entry procedures could prevent every such fatality in the future.

5.5.3 Land and Water Emissions

Although not technically a regulatory gap, we want to emphasize again the importance of providing support and education to operators to ensure that pathogens and nitrates are properly controlled through the implementation of BMPs for manure management and animal management. Existing regulation in other areas needs to be integrated into the support program. For example, education is also essential to impress upon operators the importance of proper well abandonment procedures to protect groundwater resources from runoff even under catastrophic weather conditions. We believe that the current regulatory framework in Minnesota is sufficient to provide performance standards, but the delivery of information and support to the operators remains uneven. We would suggest enhancing education and training because we believe there is a desire and capacity among operators to perform better. We also agree with the Minnesota Legislative Auditor that meaningful enforcement by MPCA is important.

5.5.4 The Importance of Feedlot Size and Animal Species

Questions have been raised regarding the importance of feedlot size and animal species in connection with the potential for human health impacts. We found no studies specifically evaluating these issues; however, nearly every regulatory system we studied followed a consistent pattern which we believe strongly suggests that most regulators perceive human health risk to be directly related to size. Larger facilities are subject to more stringent requirements for environmental review, facility design and waste management. Most programs also adjust for facility size using animal units which is a method for accounting for the differences in volume and chemical characteristics of the animal waste and allows all species to be handled with one set of size thresholds. This suggests that regulators perceive the differences between animal species are small compared to other considerations. We agree with that assessment.

Some of the key factors which affect the potential for human health impacts are listed below.

- The potential for health impacts is related, in large part, to the character and volume of wastes produced at each facility.
- Depending on age distribution, the volume of waste from a given species will be proportional to the number of animals. Therefore, all other things being equal, a larger facility will produce a greater risk of health impacts.
- Wastes differ greatly in character from one animal species to another and these differences are very well documented.
- The moisture content of the waste is a key variable to determining the potential for water-related impacts. For example, a swine facility must include a larger and more complex wastewater management system on site than a poultry facility. Greater wastewater volume could lead to a greater health risk and odor problems.
- Management practices, applied at any size facility with any species of animal, will be the controlling variable which determines human health risk. Poor management practices will lead to problems regardless of the size of the facility or the animal species.

It can be argued that the need for BMPs is greater for larger facilities because the consequences of failure are greater. At the same time, it is also true that small facilities with poor management systems can be a serious problem individually and collectively due to their greater numbers and geographic distribution.

As a result, we recommend that all AFOs apply BMPs suitable to their individual circumstances. While a poorly run small AFO may have a limited impact area, it can be a significant problem for those directly or indirectly affected.

5.6 FLEXIBLE INCENTIVES

Flexible incentives are another tool to help the animal agriculture industry align more effectively with broad policy objectives. Flexible incentives are incentives that do not dictate how environmental objectives are to be achieved, but they can be extremely powerful tools when used in conjunction with a well-designed regulatory program. They are, however, a means to an end and not an end in themselves. Successful implementation of these incentives depends on clear, enforceable performance standards.

Furthermore, the best flexible incentive program will be one that involves a combination of instruments that fit local, social, economic, and environmental conditions. It is also important to keep in mind that there can be significant transaction costs associated with flexible incentives and these programs require a high level of management skill to implement (Batie and Ervin, 1999).

As evidence of the growing interest among all stakeholders in flexible incentives, USEPA recently announced an agreement with United Egg Producers (UEP) wherein UEP would assist member facilities in developing certain environmental management and audit programs and, in return, USEPA would allow the participating facilities to be regulated by a more flexible NPDES permit (USEPA, 2000).

Table 5.1 summarizes some of the flexible incentives which could be considered for the animal agriculture industry.

Flexible incentives can be very useful tools to promote desired behavior to accelerate the attainment of environmental standards. In order to determine which tools would be most appropriate, work must first be done to clearly identify broad strategic goals and objectives. Management of environmental concerns should be considered in conjunction with all other business factors impacting the industry as well as the social values of the community. This is difficult, slow work that must involve all stakeholders in some manner.

TABLE 5.1

TYPOLOGY OF FLEXIBLE INCENTIVES

Conceptual Approach	Potential Flexibility
Charges: Effluent Ambient Input	Charges levied on pollutants into air, water or soil, on the generation of noise or for exceeding standards of pollutant concentration, or on production inputs.
Subsidies	Financial assistance given to promote pollution prevention and/or pollution control.
Education and Technical Assistance	Assistance and/or education on pollution problems and solutions.
Compliance Rewards	Environmental performance requirements provided as a condition for continued eligibility for other government program participation.
Deposit Refunds	Incentives to recycle, reclaim or properly dispose of potential pollutants.
Marketable Permits	Provision of tradable permits for predetermined levels of pollution.
Ecolabeling	Market labels asserting environment protecting production processes or products.
Performance Bonds	Posting of a financial bond that is forfeited with unacceptable pollution behavior.
Other: Contract Assigned Liability	Other mechanisms to promote pollution prevention and/or pollution control.

Source: Batie and Ervin, 1999.

5.7 SUMMARY

As previously noted, there are a variety of outputs from AFOs that could raise serious environmental concerns. Fortunately, the rapid development of control strategies at the federal level coupled with the new feedlot rules promulgated by the MPCA in October 2000, set a strong regulatory foundation in place to ensure that AFOs of all sizes and types do not harm human health.

Historically, there has been greater emphasis on surface and groundwater protection in connection with AFOs, and the existing regulatory programs in Minnesota should provide adequate protection as long as adequate resources are made available for permitting and enforcement by the MPCA and delegated counties (Minnesota Legislative Auditor, 1999).

On the other hand, significant questions remain unresolved regarding air emissions from AFOs. Research emphasis has historically focused on odors in Minnesota and elsewhere. There has been less emphasis on detailing the specific chemical constituents that cause these odors. In addition, not all chemicals that may be of concern contribute to odors. We recommend that further research be conducted to inventory the VOCs and reduced sulfur compounds released from these facilities to better understand the chemistry of the associated odors and to ensure that all compounds of concern are accounted for in Minnesota's regulatory program. We also recommend that further work be done to qualify emissions of endotoxins and NH_3.

That said, there is no evidence that we found that there is an imminent or even long-term health danger associated with these outputs to the atmosphere from these facilities, so our work does not suggest a need for emergency action to address these concerns. Once again, the new feedlot rules in Minnesota have done a great deal to ensure human health protection from air impacts through the requirement for air emissions plans are for large AFOs.

From a regulatory perspective, we recommend building on the existing foundation of the new Minnesota Feedlot Rule. Both state and county regulators are responsible for implementation and, with the new rule, each should have adequate tools to safeguard the public's health as more detailed information is gathered about some of the outputs previously discussed.

We also recommend that the regulatory structure be augmented by an aggressive implementation of flexible incentives and additional operator education as discussed above. In the end, we believe that employing a BMP approach to all aspects of the AFO operation is the best way to ensure that health impacts are kept below thresholds of concern. We suggest that additional efforts should be made to achieve that goal as soon as reasonably possible. As a practical matter, this goal will be most efficiently achieved by employing reasonable regulatory tools along with customized flexible incentives.

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APPENDIX A

SUMMARY OF OUTPUTS FROM ANIMAL AGRICULTURE THAT COULD ADVERSELY IMPACT HUMAN HEALTH

LIST OF OUTPUTS FROM ANIMAL AGRICULTURE THAT COULD NEGATIVELY IMPACT HUMAN HEALTH

1.0 Environmental and Occupational Transmission

This topic is divided into transmission through air, through soil, and through water.

1.1 Air

1.1.1 Gases

- Ammonia [1, 2]
- Hydrogen sulfide [2]
- Target list of volatile organic compounds (VOCs) with documented toxicity values[3]
    - Acetaldehyde
    - Acetone
    - Acetophenone
    - Acrolein (2-propenal)
    - Benzaldehyde
    - Benzene
    - Bis (2-ethylhexyl) phthalate
    - Carbon disulfide
    - Carbonyl sulfide
    - Chloroform
    - Crotonaldehyde (2-butenal)
    - Ethyl acetate
    - Formaldehyde
    - Formic acid
    - Hexane
    - Isobutyl alcohol
    - Methanol
    - 2-Methoxyethanol (methyl cellosolve™)
    - Naphthalene
    - Phenol
    - Pyridine
    - Toluene
    - Triethylamine
    - Xylene
- Other gases
    - Hydrazine
    - Sulfur dioxide
    - Carbon dioxide
    - Carbon monoxide
    - Methane
- VOCs produced by microbes

1.1.2 Dust

- Allergenic particles [4,5,6]
  - Skin flakes, hair, feathers, urinary proteins, dried fecal protein [7,8,9,10,11]
  - Fungi
  - Bacterial allergens [12]
- Livestock feed particles [6]
- PM_{10} (Note: The terms "respirable" and PM_{10} are used interchangeably in this document)
- Respirable particles with irritants (such as ammonia) adsorbed onto them [13,14,15]
- Endotoxin [14,16,17]
- Mycotoxins
- (1→3) - β -D-Glucan [18]

1.1.3 Odors [19]

- Volatile fatty acids (such as butyric acid)
- Phenolic compounds
- Aldehydes (such as butyraldehyde)
- Esters
- Alcohols (may overlap with VOCs produced by microbes)
- Heterocyclic nitrogen conpounds (such as pyridine and indole compounds)

1.1.4 Pathogens

1.1.4.1 Spore-forming bacteria, such as *Bacillus anthracis* [20,21]

1.1.4.2 Viruses

1.1.4.3 Fungi

- *Histoplasma capsulatum* [18]
- *Cryptococcus neoformans* [22]

1.2 Soil (primarily that impacted by manure or dead animal carcasses)

1.2.1 Gases

1.2.2 Dust

- Allergenic particles [4, 5, 6]
  - Skin flakes, hair, feathers, urinary proteins, dried fecal protein [7,8,9,10,11]
  - Fungi
  - Bacterial allergens [12]
- Livestock feed particles [6]
- Respirable particles with irritants such as ammonia adsorbed onto them [13, 14, 15]
- Metals above background levels in the soil
  - Arsenic
  - Copper
  - Zinc
- Endotoxin [14, 16, 17]
- Mycotoxins
- (1→3) - β -D-Glucan [18]

1.2.3 Odors

1.2.4 Pathogens (includes some diseases carried by flies and other insects)

1.2.4.1 Bacteria [18]

- *Salmonella* spp.
- *Escherichia coli*

- *Leptospira* spp.
- *Listeria monocytogenes*
- *Campylobacter jejuni*
- *Cryptosporidium parvum*
- *Mycobacterium* spp.
- *Yersinia enterocolitica*
- *Shigella* spp.
- *Bacillus anthracis*
- Bacteria resistant to antibiotics

1.2.4.2 Protozoa

- *Giardia lamblia*

1.2.4.3 Viruses
1.2.4.4 Fungi
1.2.4.5 Parasites
1.2.4.6 Pathogens not yet characterized, such as bovine spongiform encephalopathy (BSE)

1.3 Water (including water resources impacted by manure or dead animal carcasses)

1.3.1 Dissolved gases and ionic species

- Volatile organic compounds (VOCs)
- VOCs produced by microbes
- Nitrate nitrogen from ammonia deposited through precipitation
- Nitrate nitrogen from animal waste (urea and uric acid)
- Phosphate
- Arsenic
- Copper
- Zinc

1.3.2 Suspended solids

- Algae
- Endotoxin
- Fungi and mycotoxins

1.3.3 Odors
1.3.4 Pathogens

1.3.4.1 Bacteria [18]

- *Salmonella* spp.
- *Escherichia coli*
- *Leptospira* spp.
- *Listeria monocytogenes*
- *Campylobacter jejuni*
- *Cryptosporidium parvum*
- *Mycobacterium* spp.
- *Yersinia enterocolitica*
- *Shigella* spp.
- *Bacillus anthracis*
- Bacteria resistant to antibiotics

1.3.4.2 Protozoa

- *Giardia lamblia*
- *Toxoplasma* spp.

1.3.4.3 Viruses
1.3.4.4 Fungi and mycotoxins
1.3.4.5 Parasites
1.3.4.6 Pathogens not yet characterized, such as bovine spongiform encephalopathy (BSE)

1.3.5. Potential mutagens or endocrine disruptors in runoff [23]

- Naturally-occurring hormones
- Synthetic hormones

2.0 Injury in the Workplace (This topic is beyond the scope of the human health TWP; the topic of transmission in the workplace is covered under Topic 1.0)

2.1 Traumatic injury
2.2 Noise
2.3 Musculoskeletal (including cumulative trauma) disorders

3.0 Transmission via Consumer Commodities (This topic is beyond the scope of the human health TWP)

3.1 Pathogens

3.1.1 Bacteria

- *Salmonella* spp.
- *Escherichia coli*
- *Leptospira* spp.
- *Listeria moncytogenes*
- *Campylobacter jejuni*
- *Cryptosporidium parvum*
- *Mycobacterium* spp.
- *Yersinia enterocolitica*
- *Shigella* spp.
- *Bacillus anthracis*
- Bacteria resistant to antibiotics

3.1.2 Viruses
3.1.3 Fungi and mycotoxins
3.1.4 Parasites

- *Trichinella*

3.1.5 Pathogens not yet characterized, such as bovine spongiform encephalopathy (BSE)

3.2 Environmental toxicants

3.2.1 Natural

3.2.1.1 Plant toxicants
3.2.1.2 Mycotoxins
3.2.1.3 Trace heavy metals in grazing areas, such as phosphorus in phytate [18]

3.2.2 Anthropogenic

3.2.2.1 Feed supplements containing phosphorus [18]

3.2.2.2 Toxicants accidentally or incidentally introduced into livestock feed (such as in the dioxin-contaminated feed used in Belgium), including heavy metals (such as mercury)

3.2.2.3 Bioaccumulation of pesticides and industrial chemicals (such as PCBs)

3.2.2.4 Antibiotics

3.2.2.5 Steroid implants [18,23]

- Estradiol
- Progesterone
- Testosterone
- Synthetic hormones [18]
    - Zeranol
    - Melengesterol acetate
    - Trenbolone acetate

3.2.2.6 Other hormones

- Bovine somatotropin (bST)

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APPENDIX B

SUMMARY OF MANURE PIT FATALITIES IN MINNESOTA (1980 - 2000)

Minnesota Manure Pit Deaths 1980-2000

Date	County	Age	Sex	Brief Summary
5/25/84	Stearns	2	male	Drowned in liquid manure tank.
8/17/84	Lyon	28	male	Overcome by gas while inside liquid manure tank repairing it.
8/28/84	Morrison	43	male	Fell into manure pit trying to save calf.
6/2/87	Redwood	48	male	Overcome by manure pit gases.
8/8/92	Dakota	27	male	He went in a manure pit to work on a pump and was overcome by the methane gas.
8/8/92	Dakota	47	male	He went in the pit to help another victim, who was overcome by manure pit gases, when he was overcome by manure pit gases as well.
8/11/92	Yellow Medicine	21	male	Father and son were overcome by manure pit gases when they entered the pit to work on it.
8/11/92	Yellow Medicine	43	male	Father and son were overcome by manure pit gases when they entered the pit to work on it.
7/21/94	Wright	2	male	died of asphyxiation after falling into a manure pit on his family's farm in Maple Lake, MN
8/25/94	Nobles	32	male	He was emptying a manure pit with his wife when the hose fell into the pit. He entered the pit, which still contained approximately two feet of manure to retrieve the hose and was overcome by the noxious gases.
9/24/94	Stearns	25	male	The victim and another man were cleaning out the liquid manure pit when the victim went into the pit to change a nozzle. He collapsed after being overcome by fumes. The second man went in to rescue the first and also collapsed (did not die, was hospitalized]. Both men were extricated by the Rescue squad.

Date	County	Age	Sex	Brief Summary
6/26/97	Mc Leod	41	male	Victim was attempting to save a calf that had fallen into the manure pit. Victim had put a ladder into the pit to get the calf and at some point fell in. After he became submerged his wife attempted to rescue him but she too was overcome by fumes. She was later helped out by rescue workers. Her husband was pulled out but attempts to revive him failed. Brad Emans, Hutchinson fire chief, said, "I suspect that the methane gas played a major part [in the accident]."
11/28/97	Fillmore	58	male	A dairy farmer scraping his one- year old four row barn and barnyard lot dumped himself and his skid steer loader into his manure holding pit and was killed. His manure holding area was designed for very short term storage--some 5 to 7 days. "I was told he went in backwards and they did an autopsy with the idea he may have had a heart attack. I guess it was one heck of a challenge and mess to get he and the skid steer out of the manure pit." .
4/20/98	Douglas	61	male	Victim and another man were fencing around a manure pit when he tripped and fell into the pit. The fire department found the victim completely submerged in the manure. The Douglas County Dive Team was paged but the victim was pulled out before divers arrived.
10/18/00	Waseca	1	male	19 month old victim drowned in a manure pit on his paren'ts farm. Victim was wandering around the farm site while parent was digging dirt near a grain bin. When parent couldn't find the boy, he began searching for him. He checked inside the house and around the farm site before noticing the boy's body in the pit. The pit is an 8 ft by 35 ft concrete rectangle that rises about 18 in above the ground. Parent pulled the boy from the pit and called for help. By the time the ambulence crew arrived, the boy was in cardiac arrest. Preliminary cause of death is drowning. Victim's mother was not home at the time.