Non-Point Source Air Quality Management in Alberta

Agriculture

September 6, 2013

Contents

1. Introduction

The agricultural sector in Alberta has been engaged in air quality management since the 1970s with the introduction of the 1973 Confinement Livestock Facilities Waste Management Code of Practice and voluntary Certificate of Compliance Program. Isolation (setback) distances prescribed by the code of practice served to mitigate nuisance conflicts and promote 'good neighbour' policies, among other objectives. Since then, several other initiatives, programs and policy based tools have been used to continue to promote and support air quality stewardship by the sector. This document highlights some of the efforts undertaken to manage air quality and minimize the impact on the environment by the agricultural sector in Alberta in the last 40 years.

In agriculture, sources of emission that can have an impact on ambient air quality are generally classified under two broad categories (Table 1), namely sources that release odours with a subsequent nuisance effect on humans, and those that release other air emissions that can affect human, animal or ecosystem health or well-being.

Table 1. Agricultural Sources of Odour and other Air Emissions

Contributors to Air Emissions	Contributors to Odour
▪ Confined Feeding Operations (CFOs) ▪ Manure application ▪ Animal housing ▪ Dust from tillage operations, harvesting, manure hauling, and traffic on gravel road ▪ Fertilizer application ▪ Smog from ammonia production ▪ Pesticide application ▪ Agricultural residue burning	▪ CFOs ▪ Manure application ▪ Manure storage facilities ▪ Animal housing

Dealing with air emissions of concern over the past several years has not been without its set of challenges. Some issues and challenges associated with managing air quality and odour by the agricultural sector in Alberta include:

- There is confusion between the effects of odour and other air emissions. Most often there is the perception of a human health risk especially when it comes to odour, for example, "if I smell it, then it must mean it's bad or harmful to me".
- These odour/nuisance issues are very subjective. What is an odour/nuisance for one person may not be perceived as an odour/nuisance by another.
- Odour is the number one complaint among all agriculture-related complaints.

- Air quality emissions are very complex in nature. There are many substances of interest in agricultural air emissions including ammonia, hydrogen sulphide, odour, particulate matter, pathogens/bioaerosols and volatile organic compounds, all of which may or may not be present in odour. Odour can be made up of 170 or more substances.
- It is very difficult to measure odour and air quality emissions. Due to the non-point nature of odour and air quality emissions from farms, there is no single representative location where emissions can be measured when compared to industrial point sources of emission.
- There is no agreed upon standardized measurement technique to measure odour and air quality emissions.
- There is limited baseline agricultural air emission data in Canada, and as such we tend to rely on the U.S. and Europe for agricultural air emissions data.
- Industry continues to request science-based policy development and regulations as a mechanism for dealing with odour issues.
- The cost of measuring odour and air quality emissions at the farm level is prohibitive. We must continue to be aware of the regulatory burdens on producers. There is a need to set regulations or policies that continue to encourage a competitive environment for industry.
- There are no agriculture-related air quality policies directly related to established thresholds. However, there are external pressures facing the agriculture sector to comply with thresholds such as Land-use Framework and Cumulative Effects Management.
- Alberta is growing and becoming more urban. Fewer Albertans are directly involved with agriculture and therefore have a lack of understanding of agriculture. This has led to an increase in land use pressures and rural/urban conflict.

2. CFO Air Quality Primer

This document contains a literature review compiled by Alberta's Ministry of Agriculture and Rural Development (ARD) in 2008. It provides background information on air emissions of concerns associated with CFOs in the province.

A Primer on Livestock Air Quality.pdf

3. Historical Agricultural Air Quality Related Accomplishments

The following outlines some agricultural air quality related initiatives, programs, projects, etc. completed by Alberta Agriculture and Rural Development (ARD), either solely or in partnership with the agricultural industry, universities, research organizations and other government ministries and agencies, in a little over ten years.

3.1 Odour Control Initiative

Alberta Agriculture and Rural Development (ARD), in collaboration with the University of Alberta (co-lead) and Alberta Research Council (ARC) among others, participated in research on odour, i.e., both on the fundamentals of odour measurement and odour mitigation relative to livestock production in Alberta. In 2002, the team received funding to implement the first agricultural, 'Odour Control Initiative" in Alberta. The initiative comprised of two main projects (1) Development of Odour Monitoring Procedures for Alberta Livestock Operations: Measuring Odour with Confidence and (2) Livestock Odour Control Technology Assessment and Development. The initiative also comprised of a communication/technology transfer component, housed within the report on the latter project and entitled, Technology Transfer: Meeting Odour Head On: Odour Control Manual for Livestock Producers'. This section of the report included a series of fact sheets that were published in the early stages of implementation of the two projects.

3.2 Policy Instruments

The *Agricultural Operation and Practices Act and Regulations* (AOPA) came into force on January 1, 2002. It contains legislation intended to mitigate odour issues associated with CFOs. Although ARD is responsible for creating and revising AOPA, the Natural Resources Conservation Board (NRCB), a quasi-judicial government agency, is responsible for issuing licenses and regulating CFOs in Alberta in compliance with AOPA.

3.3 CASA CFO Project Strategic Plan

ARD was an active participant on the Clean Air Strategic Alliance (CASA) Confined Feeding Operation (CFO) project team. The mandate of the team was to develop a strategic plan for 'Managing Air Emissions from CFOs in Alberta'. This was accomplished and a report released by CASA in 2008. The report included a total of 10 recommendations, 9 of which were to be implemented by 2011. The 10th recommendation was for the project team to reconvene in 2011 to review the

progress/successes of the implementation phase. ARD was responsible for implementing 5 of the 10 recommendations and served in a supporting/reporting capacity towards the implementation of some of the other recommendations. Substances of interest included ammonia, hydrogen sulphide, odour, particulate matter, pathogens/bioaerosols and volatile organic compounds. CFOs of interest included beef cattle, dairy cattle, poultry (chickens/turkeys) and swine.

ARD's sole representative on the CASA CFO Project Team was one of three co-chairs on the project team. The ARD co-chair also represented the public sector including, federal, provincial and municipal government and associated agencies such as the Natural Resources Conservation Board (NRCB). The other two co-chairs represented the CFO industry and non-government organizations (NGOs), respectively. In addition, other ARD staff actively participated in sub-groups and were instrumental in developing and meeting the terms of reference of these sub-groups.

Eight of the ten recommendations, excluding recommendations #2 and #5, were completed between 2008 and 2012. In place of a source apportionment study or studies (recommendation #2), a comprehensive literature review and workplan were completed and submitted by Alberta Environment and Sustainable resource Development (ESRD).

Literature review reports were also submitted by ARD towards the development of a management mechanisms or beneficial management practices (BMP) research plan in partial fulfillment of recommendation #5. Work on the development of a BMP research plan is being continued by ARD in collaboration with the CFO industry, while taking into account the outcomes of the nine other CASA CFO project team strategic plan recommendations.

3.4 Odour Measurement Workshop

A second odour strategic framework was initiated. ARD sponsored a workshop in Banff entitled, 'Defining Odour as a Single Parameter'. Participants from Alberta (ESRD, Alberta Health and Wellness, defunct Health Regions, NRCB, ARD, University of Alberta, private firms, non-government organizations), across Canada (Agriculture and Agri-food Canada, Saskatchewan, Manitoba, Ontario, Quebec), the United States (Minnesota and Iowa) and internationally (Germany) attended the two-day workshop. Attendance at the workshop was by invitation only. Issues pertaining to the objective measurement of odour, prospects of using a new parameter to assess odour nuisance, potential health effects and odour control and management mechanisms (including land use management) were discussed during the workshop. A series of presentations were also made by various experts both from within and outside Canada.

3.5 Odour and Air Quality Strategic Plan: 2012-2017

ARD's Environmental Stewardship Division (ESD) developed an Odour and Air Quality strategic plan that is strongly tied to Alberta's Renewed Clean Air Strategy (CAS) as well as the National Air Quality Management System (NAQMS). The 'Odour and Air Quality Strategic Plan' was developed to help define a pathway for agriculture to manage air quality into the future. It outlines ESD's strategic direction over the next three to five years. It is important to note that this document is not set in stone and will be reviewed on a yearly basis to identify shifts in direction or focus.

3.6 Agricultural Ammonia Workshop

A workshop entitled, "Agricultural Ammonia Emissions and Policy Implications - Where are We Today and What Lies Beyond the Horizon?" was held in Lethbridge, Alberta, Canada on March 19, 2013. It was attended by 45 participants in person and at least 19 participants via webinar. Workshop participants were from The Netherlands, the U.S.A. (North Carolina and Oregon), and across Canada (British Columbia, Saskatchewan, Manitoba, Ontario, Quebec and Alberta).

The workshop was intended to provide participants with a global perspective of issues pertaining to agricultural ammonia emissions and its management; create a better understanding of ammonia-related issues unique to the agricultural sector in Canada; and enhance awareness of policies for managing agricultural ammonia emissions by jurisdictions outside Canada. The workshop was also intended to provide an avenue for participants to engage in fundamental strategic discussions regarding the impacts of agricultural ammonia emissions on the environment in Canada, the role of policy and science in monitoring and managing potential effects, and the cyclical relationship between policy and science.

3.7 CFO Air Quality BMP Extension Plan

An extension plan was developed and is under implementation. The plan included the identification of select BMPs for managing air quality related emissions from CFOs in Alberta. Furthermore, the plan outlined various tools that would be used to promote the BMP adoption by the CFO industry, e.g., factsheets, on-farm demonstrations, field days, etc.

4. Current Regulations for Livestock Manure Based NPS Emissions

In Alberta the legislation governing the collection, storage, and land application of livestock manure is the Agricultural Operation Practices Act (AOPA). AOPA came into effect in this manner on January 1, 2002. AOPA consists of two parts within the act and the associated standards and matters regulations.

Part 1 of the Act is Alberta's version of "Right to Farm" legislation. Farm operations are protected from nuisance lawsuits as long as they are meeting the regulations of the day and following generally accepted practice. Citizens can request a practice review committee (PRC) to determine if a farm is following generally accepted practices.

Part 2 of the Act provides the livestock and manure focus. Under Part 2 livestock confined feeding operation (CFOs) are required to apply for a permit when constructing a new or expanding an existing operation. This permit will state the siting and construction standards for the manure collection and storage facilities; however it may also include conditions for non-point source manure management such as land application. Grazing operations, livestock seasonal feeding and bedding sites (SFBSs), equestrian stables, auction markets, race tracks, and exhibition grounds are not considered as CFOs.

With the previous information as a backdrop, we can define the primary regulatory components for NPS activity in Alberta. Land application of manure and the siting of SFBSs are the primary regulations associated with NPS.

More specifically the following regulations deal directly with NPS in AOPA:

The owner or operator of a SFBS or non-CFO livestock corral must locate the site or corral 30 metres or more from a common body of water. If they are not 30 metres away they must construct an interceptor to divert or catch runoff or they must remove the accumulated manure or bedding before runoff occurs.

There are setbacks required when spreading manure on land.

- 10 metres from a common body of water if using injection.
- 30 metres from a common body of water and incorporation within 48 hours of application.
- 30 metres from a water well.
- 150 metres from residences or people occupied structures.

Permission from the Natural Resources Conservation Board (NRCB) is required prior to spreading manure on snow covered or frozen ground.

There are application limits for manure, based on soil type and Nitrogen limits.

The final regulatory reference which can relate to the regulation of NPS manure is Section 39 of the Act. This part of the legislation is the "catch all" component. It states that "If in the opinion of the Board a person is creating a risk to the environment or an inappropriate disturbance, the Board may issue an enforcement order". This aspect of the regulations may allow for the application of discretion to all manure based activities.

In summary, NPS regulations are based on setbacks and the responsible land application of manure. The legislation also has built in processes and discretion to deal with both conflict and the challenges associated with regulating a very large and diverse industry.

5. Current Agricultural Air Quality Related Undertakings

There are a number of ongoing initiatives ARD and other stakeholders have embarked upon that relate to some of the past agricultural air quality related accomplishments.

5.1 Implementation of Odour and Air Quality Strategic Plan: 2012-2017

The plan focuses on the following four strategic outcomes:

- BMP Applied Research and Extension
  Alberta producers are encouraged to adopt BMP's that maintain or enhance air quality and minimize odour.

- Measurement/Evaluation
  Agriculture odour and AQ measurement, evaluation and reporting guides and supports ARD and the agricultural industry in managing odour and air quality emissions.

- Policy Development
  Policies are developed from enhanced knowledge and innovation that addresses odour and AQ issues related to agriculture.

- Knowledge Enhancement

Public knowledge and assurance is enhanced around agricultural odour and AQ issues.

5.2 Development of CFO Air Quality BMP Research Plan

This project is a continuation of the implementation of the CASA CFO strategic plan recommendation #5. In essence, it involves the research and development of BMPs with a high likelihood of mitigating emissions of concern from the agricultural sector in Alberta.

5.3 Implementation of CFO Air Quality BMP Extension Plan

The extension plan that was developed is under implementation. Factsheets on two air quality related BMPs are being developed. These factsheets will be reviewed by the CFO industry to assess their validity and applicability. A workbook to aid the implementation of one of the factsheets is also under development.

5.4 Development of Air Quality Public Outreach Plan

A public outreach plan is under development. Key messages on odour and air quality in relation to the agricultural industry in Alberta will include what farmers and government are doing about these issues.

6. Resource Material Summaries

The following sub-sections present summarized information (excerpts from executive summaries, reports, strategic plans, etc.) of various resource material that relate to agricultural odour and air quality in Alberta. Links to the complete documents are also contained in some of the sub-sections below.

6.1 Odour and Air Quality Strategic Plan: 2012-2017

ARD's Environmental Stewardship Division (ESD) developed an "Odour and Air Quality Strategic Plan" that is strongly tied to Alberta's Renewed Clean Air Strategy (CAS) as well as the National Air Quality Management System (NAQMS). The strategic plan was developed to define a pathway to assist the agricultural sector with managing air quality into the future. It outlines ESD's strategic direction over the next three to five years. It is important to note that this document is not set in stone and will be reviewed on a yearly basis to identify shifts in direction or focus.

Click on the following icon to access the complete strategic plan:

6.2 CASA CFO Project Strategic Plan

The Clean Air Strategic Alliance (CASA) Confined Feeding Operation (CFO) project team completed a strategic plan for 'Managing Air Emissions from CFOs in Alberta' in 2008. The strategic plan included a total of 10 recommendations aimed at addressing knowledge and information gaps.

Click on the following link to access the complete strategic plan:

http://www.assembly.ab.ca/lao/library/egovdocs/2008/ca6/casa/167070.pdf

6.2.1 CASA CFO Strategic Plan Executive Summary

In response to a statement of opportunity presented by the Intensive Livestock Working Group [ILWG] and Alberta Agriculture and Rural Development [ARD], the CASA Board established the CFO project team in September 2005. The CASA consensus process was viewed as a beneficial way to address stakeholder concerns.

The goal of the CFO project team was to develop a strategic plan to improve the management of air emissions from existing and future CFOs in Alberta and to improve relationships between stakeholders. In developing the plan, the team was to consider the following principles:

- continuous improvement and pollution prevention to protect air quality;
- prevention of short and long-term adverse effects on human, animal and ecosystem health due to air emissions; and
- assurance that air quality recommendations maximize social, economic, environmental and health benefits and minimize social, economic, environmental and health costs.

Among the substances emitted by CFOs into the air, the team identified five priority substances: ammonia, hydrogen sulphide, volatile organic compounds, particulate matter, and bioaerosols/ pathogens. It was agreed that odour is a priority issue,

recognizing that there are fundamental differences between odour and the priority substances.

The team undertook a great deal of work in subgroups to compile and assess information on emissions, health effects, potential management mechanisms, and approaches taken by other jurisdictions to address these issues. The subgroups produced detailed reports that enhanced the knowledge base of the project team and provided much of the necessary information for the strategic plan. The subgroups also suggested recommendations to the project team. All of the recommendations were considered and many became part of the project team's strategic plan.

The CFO project team strived to develop a common understanding of stakeholder concerns related to CFOs. The project team agreed that stakeholder relationships around the table were improved over the course of the team's work. Greater understanding, combined with the information gathered, enabled the team to reach consensus on the following recommendations. The recommendations are a package on which the team has full stakeholder support, and should therefore be considered in their entirety.

Recommendation 1: Development of a New Emissions Inventory

The CFO project team recommends that:

The Government of Alberta, led by Alberta Agriculture and Rural Development, with support from Alberta Environment and advice from a multi-stakeholder group formed for this purpose, compile an inventory for CFO air emissions in Alberta based on the US EPA National Air Emissions Monitoring Study, with the inventory to be completed by March 31, 2011.

Recommendation 2: Source Apportionment

The CFO project team recommends that:

Alberta Environment, with support from Alberta Agriculture and Rural Development and the intensive livestock industry, conduct specific studies in areas with CFOs, using suitable source apportionment methods to estimate the contribution of CFO emissions of the five priority substances relative to other sources of these emissions. These studies are to be completed by December 31, 2010.

Recommendation 3: Monitoring for Ammonia, H_2S, PM and VOCs

The CFO project team recommends that:

Alberta Agriculture and Rural Development,

a) develop, with input from all stakeholders, an ambient monitoring plan for ammonia, H_2S, PM and VOCs to determine current ambient levels around CFOs. The plan will include timelines, budget, methodology (with reference to the Air Monitoring Directive), and responsibilities;
b) undertake ambient air monitoring of ammonia, H2S, PM and VOCs around CFOs, based on the above plan, beginning in 2008; and
c) submit a status report by March 31, 2009, with a final report on results to be submitted by March 31, 2010 to CFO project team stakeholders and the Alberta Ambient Air Quality Objectives Stakeholder Advisory Committee.

Recommendation 4: The 24-hour AQO for Ammonia

The CFO project team recommends that:

The Alberta Ambient Air Quality Objective Stakeholder Advisory Committee defer its decision on a 24-hour ambient objective for ammonia until April 2009, at which time the AAAQOSAC will determine if they have sufficient information from the ambient air monitoring study on which to base a decision.

Recommendation 5: Management Mechanisms Research Plan

The CFO project team recommends that:

Alberta Agriculture and Rural Development and the CFO industry develop a plan to submit to the Government of Alberta and research agencies for funding to do a study to quantify the reductions in priority emissions and odour, and any other benefits, from frequent manure removal, manure application, and moisture management.

Recommendation 6: Paper Study on Potential Management Mechanisms

The CFO project team recommends that:

Alberta Agriculture and Rural Development lead a paper study on the following five management mechanisms, to assess their potential to favourably affect emissions, ambient air quality, nutrient recovery, and other potential benefits, and report back to CFO project team stakeholders by March 31, 2009, at which time consideration will be given as to where the research might be applied.

- Biocovers
- Bottom loading
- Shelterbelts
- Composting
- Dust palliatives

Recommendation 7: Odour Management Plan Template

The CFO project team recommends that:

The CFO industry develop an odour management plan template for use by operators in the intensive livestock industry. The plan will be based on economic feasibility, scientific evidence of odour reductions, and new technology, specifically best available technology economically achievable (BATEA), and will be ready for use by January 2009.

Recommendation 8: Managing Odour in Problem Areas

The CFO project team recommends that:

The CFO industry work with operators in problem areas to develop a site specific odour management plan. The Government of Alberta will provide resources (expertise, skills, knowledge) to assist with plan development and implementation. Problem areas will be identified using information from the NRCB and the industry. In working with operators, the industry and government may want to consider measuring odour around CFOs.

Recommendation 9: Improving Communications

The CFO project team recommends that:

The NRCB and Alberta Agriculture and Rural Development work with all involved parties to develop a plan by March 31, 2009 to improve communications and relationships among stakeholders regarding information related to CFOs. The following are areas where attention should be focused to improve communications and stakeholder relationships:

- Alternative dispute resolution processes[1]
- Communications between agencies and Government of Alberta departments, and
- Communications between the NRCB and complainants.

Recommendation 10: Evaluating the Strategic Plan

The CFO project team recommends that:

The CASA secretariat reconvene the CFO team in January 2011 to:

a) review the implementation status and outcomes of recommendations made in this report
b) assess the success of these activities, and
c) make any further recommendations, if needed, to reduce air emissions from CFOs in Alberta related to this strategic plan.

6.2.2 CASA CFO Strategic Plan Outcomes

The outcomes following the implementation of some of CASA CFO Project Strategic Plan recommendations are outlined below.

Recommendation 1: Development of a New Emissions Inventory

Click on the following link to access the complete project report:

http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/epw10940/$FILE/210-alberta_CFO_emission.pdf

Executive Summary

[1] Alternative dispute resolution (now referred to as Appropriate Dispute Resolution by the Energy Resources Conservation Board) includes a variety of options available to the concerned parties to manage disputes, such as direct negotiation between the affected parties, facilitation, third-party mediation, arbitration, and public hearings. ADR aims to help people explore and understand each other's interests and develop acceptable solutions together by creating an environment that supports respectful discussion. The solutions generated by the parties reflect their respective interests and are often solutions that would not have been arrived at individually. For more information, visit the ERCB's website at http://www.ercb.ca/portal/server.pt/gateway/PTARGS_0_0_314_246_0_43/http%3B/ercbContent/publishedcontent/publish/ercb_home/public_zone/ercb_process/appropriate_dispute_resolution__adr_/

In 2008, the Clean Air Strategic Alliance (CASA) Confined Feeding Operation (CFO) strategic plan recommended the development of an air emissions inventory for the CFO industry in Alberta by 2011. Alberta Agriculture and Rural Development (ARD) led the development of the inventory with assistance from Alberta Environment and Water (AEW). A technical working group (TWG) comprising staff from both ministries worked on technical aspects of the inventory. The TWG received input from a multi-stakeholder advisory group that included a CFO industry representative, a non-government organization representative, AEW staff and ARD staff. In addition, the services of Levelton Consultants Ltd. were retained to establish inventory development methodology and to create the inventory.

Scope of the New CFO Emissions Inventory

The new inventory was developed to only estimate emissions of ammonia (NH_3) and particulate matter (PM) from CFOs, and is hereby referred to as the Ammonia and Particulate Matter Emissions Inventory for CFOs in Alberta (APMEICA). Although other emissions-of interest were also identified in CASA CFO strategic plan, namely, hydrogen sulphide, bioaerosols and pathogens, volatile organic compounds, and odour, CFO-related data for these emissions-of-interest are lacking. Furthermore, APMEICA estimates emissions from beef cattle, dairy cattle, poultry, swine and sheep CFOs, including sub-categories of the various livestock types within each main livestock category.

Emission Estimation Approach

In simple terms, APMEICA estimates the emissions of NH_3 and PM ($PM_{2.5}$ and PM_{10}) from the various types of CFOs by multiplying their respective emission factors (EFs) by their respective activity factors (AFs). EF is the mass of the substance emitted per unit source of emission per unit of time, e.g., kilograms of NH_3 emitted per head of livestock per year. AF, on the other hand, represents the number of unit sources of emission in a specified geographical area, e.g., number of a particular type of livestock on CFOs in the province of Alberta.

An extensive literature search was conducted to obtain CFO EFs for NH_3 and PM. Out of 100 reviewed publications, seven publications were considered to contain comprehensive EFs that could be utilized by APMEICA namely, Canadian National Agri-Environmental Standards Initiative (NAESI), Canadian National Agri-Environmental Health Analysis and Reporting Program (NAHARP), Finnish Ammonia Emission Inventory, United Kingdom Ammonia Emission Inventory for Agriculture, German Calculation of Agricultural Emissions, European EMEP/EEA Air

Pollutant Emission Inventory Guidebook, and Swiss Ammonia Emissions Inventory for Agriculture. The shortlisted publications were reviewed further and ranked to determine the most relevant and applicable EFs for APMEICA.

Thus, of the seven shortlisted publications, NAESI ranked highest with respect to NH_3 EFs while NAHARP ranked highest with respect to PM EFs. Based on the nature of the NAESI study, the NH3 EFs used by APMEICA were derived monthly (high temporal resolution) at the municipal level (high spatial resolution). Conversely, the PM2.5 and PM_{10} EFs obtained from NAHARP were derived annually (low temporal resolution) at the provincial level (low spatial resolution).

Similarly, a number of CFO AF data sources were evaluated including, the 2006 Statistics Canada (SC) Census of Agriculture, the Natural Resources Conservation Board (NRCB) database of livestock numbers for regulated CFOs, and registries of four select municipalities in Alberta. After due consideration, the 2006 SC Census of Agriculture was selected and used to determine AFs at the municipal level (high spatial resolution) for various types of CFOs. In combination with the 2006 census data, SC semi-annual agricultural surveys for cattle and sheep, and quarterly agricultural surveys for swine, were used to derive monthly CFO AFs. The monthly poultry CFO AFs were assumed to remain constant throughout the year.
Forecasted growth profiles obtained from a ChemInfo report submitted to Environment Canada in 2007 were used by APMEICA to forecast NH_3, $PM_{2.5}$ and PM_{10} emissions from CFOs in 2011, 2016 and 2021.

Results and Conclusions

The following are estimates of NH_3 emissions from CFOs in 2006:

- CFOs in Alberta were estimated to emit 42,750 tonnes of NH_3.
- Cattle and swine CFOs jointly accounted for 91% of the NH_3 emitted annually from CFOs in Alberta.
- NH_3 emissions from CFOs were highest from May to October, due to warmer temperatures in late spring and summer and to large volumes of manure applied on land in fall.
- NH_3 emissions from CFOs were highest in the South Saskatchewan Land Use Framework (LUF) Region, representing approximately 49% of total NH_3 emissions from CFOs in Alberta.

- Municipalities with the highest CFO NH_3 emissions were Lacombe County, County of Lethbridge, County of Newell, M.D. of Taber and Wheatland County.
- CFOs were estimated to be the biggest contributor of NH_3 emissions in Alberta, emitting approximately six times more NH_3 than industrial point sources and 22 times more NH_3 than mobile sources.

The following are estimates of PM_{10} emissions from CFOs in 2006:

- CFOs in Alberta were estimated to emit 1,762 tonnes of PM_{10}.
- Cattle and swine CFOs jointly accounted for 87% of the PM_{10} emitted annually from CFOs in Alberta.
- PM_{10} emissions from CFOs were highest in the South Saskatchewan LUF Region, representing approximately 50% of total PM_{10} emissions from CFOs in Alberta.
- Municipalities with the highest CFO PM_{10} emissions were Kneehill County, Lacombe County, County of Lethbridge, County of Newell, and Wheatland County.
- CFOs were estimated to be the smallest contributor of PM_{10} emissions in Alberta, emitting approximately 15 times less PM_{10} than industrial point sources and 430 times less PM_{10} than mobile sources.

The following are estimates of $PM_{2.5}$ emissions from CFOs in 2006:

- CFOs in Alberta were estimated to emit 380 tonnes of $PM_{2.5}$ in 2006.
- Cattle and swine CFOs jointly accounted for 90% of the $PM_{2.5}$ emitted annually from CFOs in Alberta.
- $PM_{2.5}$ emissions from CFOs were highest in the South Saskatchewan LUF Region, representing approximately 50% of total $PM_{2.5}$ emissions from CFOs in Alberta.
- Municipalities with the highest CFO $PM_{2.5}$ emissions were Kneehill County, Lacombe County, County of Lethbridge, County of Newell, and Wheatland County.

- CFOs were estimated to be the smallest contributor of $PM_{2.5}$ emissions in Alberta, emitting approximately 51 times less $PM_{2.5}$ than industrial point sources and 280 times less $PM_{2.5}$ than mobile sources.

Recommendations

- APMEICA database should be maintained on an annual basis. The AFs and EFs should be updated as new data become available or improved estimation methodologies are developed.
- A finer spatial resolution (e.g. 1 km^2) should be used to report future CFO emissions. This will provide a better, more detailed assessment of CFO emissions, beyond the municipal level within each LUF region. Ultimately, it will help increase the potential for growth of the CFO industry within the various LUF regions, rather than limit such growth on a municipal basis by prohibiting growth in some municipalities within the LUF regions. It will also help industry manage emissions at the CFO level as opposed to the municipal level.
- Emissions forecasting should be improved by using new growth factors as they become available.
- Conduct a major review of APMEICA at least every 10 years to accommodate changes in Alberta's economy, agricultural policies and the CFO industry.
- To improve the accuracy of the next edition of APMEICA, an uncertainty analysis should be conducted using the best available techniques and tools.
- Higher temporal resolution PM EFs should be obtained and incorporated into the next edition of APMEICA. Research should be conducted to develop more accurate EFs and AFs that represent the weather, livestock production and manure management conditions in Alberta, towards the enhancement of APMEICA.
- Periodically track changes in farming activities by conducting formal CFO farm surveys.

Recommendation 3: Monitoring for Ammonia, H_2S, PM and VOCs

Click on the following link to access the complete project report:

http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/epw10940/$FILE/211-AQM.pdf

Executive Summary

In fulfillment of the mandate outlined in the Clean Air Strategic Alliance (CASA) Confined Feeding Operation (CFO) strategic plan, an ambient air quality measurement (AAQM) plan was developed in 2008 and the associated AAQM study implemented in 2009.

AAQM Study Objectives

The AAQM study had two objectives. The primary objective was to measure ambient air concentrations of five air quality parameters-of-interest at the category one minimum distance separation (MDS), along the path of the prevailing bi-directional wind, both upwind and downwind of a beef cattle, a dairy cattle, a poultry and a swine CFO in Alberta. The five parameters-of-interest were: ammonia (NH_3); hydrogen sulphide (H_2S); particulate matter with an aerodynamic diameter of 2.5 μm or less ($PM_{2.5}$); total suspended particulates (TSP); and volatile organic compounds (VOCs).

The study's secondary objective was to compare ambient air concentrations of the five parameters-of-interest to existing (October 2007) and proposed Alberta Ambient Air Quality Objectives (AAQOs).

Study Methodology

The AAQM study was conducted over a 14-month period. Owing to the immense scope of the study, the measurements were conducted intermittently for a minimum of 2 weeks (per measurement period) at only one of the four CFOs before relocating to the next CFO on the schedule at the end of the measurement period. A total of 18 measurement periods were completed over the course of the 14-month study.

A pair of mobile stations that housed gas analyzers and other instruments was used to conduct the measurements at each CFO. One station was located upwind of the respective CFO while the other was located downwind. In 15 of the 18 measurement periods, the mobile stations were aligned with respect to the prevailing bi-directional wind. However, for logistic reasons the stations were realigned with respect to the next most frequently occurring bi-directional wind in the remaining three measurement periods.

Electrical power supply to the mobile stations was provided using portable diesel generators. The gas analyzers were calibrated at the beginning of each measurement period and then verified at the end of the period to enhance measurement accuracy and reliability. Daily zero and span checks were also conducted on the gas analyzers. The mobile stations were usually visited and inspected at least once a week in each measurement period.

In general, ambient air concentrations of the air quality parameters-of-interest were measured continuously and then averaged on a 1-minute basis. Again, owing to the immense scope of the study, specific VOCs that may potentially be found in CFO emissions were not identified nor were their ambient concentrations measured specifically. Rather, the concentrations of the suite of potential VOCs in CFO emissions were assumed to constitute the concentration of nonmethane hydrocarbons (NMHCs), a composite mixture that included the concentrations of other volatile non-CFO related hydrocarbons minus methane. Thus, the concentration of NMHCs in the ambient air was measured during the study.

Data from each mobile station were frequently polled and checked on a daily basis. At the end of the 14-month study period, the data were statistically analyzed. Upwind and downwind concentrations were compared in order to determine if the CFOs significantly contributed to higher downwind ambient air concentrations of the respective air quality parameters-of-interest at the 5% level of significance ($\alpha = 0.05$). In addition, 1-hour, 24 hour and 3-day average concentrations of the respective air quality parameters-of-interest were compared to the provincial AAQOs, as indicated in the study's secondary objective.

Results and Conclusions

Note, because the measurements were only conducted intermittently around four CFOs over the 14-month period, the study results presented in this report are limited in scope, are site-specific, are not considered to be representative of the CFO industry in Alberta and therefore, cannot be extrapolated in time or space to signify the quality of the air around any or all CFOs in Alberta.

The results of the study indicate that the CFOs significantly contributed to higher downwind NH_3 concentrations over the entire duration of the study. Similarly, it appears that the CFOs contributed to significantly higher downwind concentrations of H2S, PM2.5, TSP and VOCs (NMHCs), 72%, 44%, 72% and 61% of the time, respectively, during the 14-month study period. The mean 1-minute average downwind NH_3, H_2S, $PM_{2.5}$, TSP and NMHC concentrations ranged between 5.45 ppb and 89.0 ppb,

0.06 ppb and 0.92 ppb, 4.16 μg m-3 and 29.3 μg m-3, 7.86 μg m^3 and 94.6 μg m^{-3}, and 0.00 ppb and 49.3 ppb, respectively.

Over the 14-month study period there were no exceedances of the 1-hour and 24-hour NH_3 AAQOs. For H_2S, one exceedance of the 1-hour average AAQO was recorded, but there was no
exceedance of the 24-hour AAQO.

For $PM_{2.5}$, 24 exceedances of the 1-hour average AAQO seemed to result from emissions that came from the direction of the CFOs. However, it is uncertain if the CFOs caused or were solely responsible for these exceedances. Some reasons for this uncertainty included: the presence of other sources of $PM_{2.5}$ emissions such as paved and unpaved roads or cultivated cropland between the upwind and downwind stations; and periods of time when the wind or PM analyzers malfunctioned, failed or were inoperable following interrupted power supply to either mobile station. There were no exceedances of the 24-hour average AAQO for $PM_{2.5}$.

Potentially, of all the air quality parameters-of-interest to this study, the highest number of possible AAQO exceedances related to NMHC. A total of 401 possible exceedances could be attributed to the CFOs over the 14-month study period. However, this result is highly uncertain primarily because CFO-related VOCs that may potentially have constituted some part of the suite of NMHCs measured upwind and downwind of the CFOs were not specifically identified nor measured. In other words, it is impossible to ascertain if any VOCs that might have been emitted by the CFOs were present in the suite of NMHCs measured at the mobile stations, but if they were, then what their respective concentrations were.

In essence, the results of this study suggest the possible presence of CFO-related VOCs in the air downwind of the CFOs. Thus, more extensive work should be conducted in the future to determine what, if any, VOCs exist in CFO emissions in Alberta. Once this is accomplished, then the downwind concentrations of specific VOCs may be targeted, measured and compared to their respective AAQOs. Future work will also have to account for the possible contributions of secondary sources of VOCs that are located along the path of the wind between the upwind and downwind monitoring stations.

Recommendation 6: Paper Study on Potential Management Mechanisms

Click on the following link to access the complete project report:

http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/all/epw10940/$FILE/213-review_BMP.pdf

Executive Summary

This report provides a comprehensive review of information pertaining to beneficial management practices (BMPs) that have the potential to mitigate air emissions of undesirable substances from confined feeding operations (CFOs). As one of 10 recommendations in the Clean Air Strategic Alliance (CASA) CFO strategic plan, it aims to document the efficiency with which a select number of BMPs can reduce undesirable emissions associated with typical CFO livestock production activities or reduce the negative socio-environmental impact of these emissions. Equally of interest are the co-benefits and limitations of each BMP and the economic and social implications of implementing the BMPs. Finally, this report identifies knowledge gaps and offers recommendations to guide future efforts related to air emission BMPs for CFOs.

Six emissions-of-concern were outlined in the CASA CFO strategic plan namely, ammonia (NH_3), hydrogen sulphide (H_2S), particulate matter (PM), odour, volatile organic compounds (VOCs) and bioaerosols (including pathogens). This report examines the effectiveness of five BMPs in mitigating the effects of the six emissions-of-concern from CFOs in Alberta. The five
BMPs are: permeable covers for manure storage facilities; windbreaks; bottom loading of manure storage facilities; manure and dead animal composting; and dust palliatives for feedlots and unpaved roads.

i. Permeable Covers for Manure Storage Facilities

Manure storage facilities are significant sources of NH_3, H_2S and odour emissions. Permeable covers can be used to reduce or control emissions of these gases from the storage facilities. Assessing the effectiveness of permeable covers for reducing emissions is extremely difficult because there are no standardized, reliable methods for measuring emissions. Based on the available research, straw covers are perhaps the most cost-effective of all permeable covers and the most producer-friendly means of reducing emissions. Most of the permeable covers evaluated in this chapter are capable of reducing emissions to some degree. NH_3 is the gas pollutant that has been most substantially reduced by the use of permeable covers. All permeable covers reviewed have operational problems, and efforts are underway to resolve these problems.

Recommendations to address key knowledge gaps

- Develop standardized, scientifically sound methods to accurately evaluate and compare the effectiveness of permeable cover technologies.
- Conduct scientifically sound, long-term measurement studies to evaluate the overall efficiency of permeable covers in mitigating NH_3, H_2S and odour emissions.
- Develop more complete information about the life expectancy of straw covers and about the impacts of permeable covers on manure quality.
- If the effectiveness of permeable covers can be scientifically proven, then develop and implement programs to encourage Alberta producers to use these covers.
- Conduct surveys to determine the adoption rate of permeable covers by Alberta producers.
- Improve the ease of use and practicality of permeable covers for Alberta producers.

ii. Natural and Artificial Windbreaks

Natural windbreaks, typically called shelterbelts, comprise of rows of trees and shrubs. Artificial windbreaks include windbreak walls, windbreak fences or straw walls. Windbreaks are thought to affect CFO air emissions either indirectly by forcing the emissions to rise to higher elevations where they can be diluted or directly by intercepting, filtering, adsorbing or absorbing the emissions.

Limited information was found in the literature on the effects of windbreaks on concentrations of NH_3, H_2S, PM and odour downwind from livestock facilities. No literature was found on their effects on bioaerosols or VOCs. Of the two types of windbreaks, significantly more information was available on the effects of shelterbelts.

A few comprehensive studies on the effects of shelterbelts were reviewed and are discussed in this chapter. Unfortunately, none of the studies provided conclusive evidence to show that shelterbelts can effectively reduce concentrations of NH_3, H_2S, PM and odour downwind from livestock facilities. In some cases, it seemed that the natural effects of the microclimate may have affected the results. In others, experimental designs and procedures used to conduct the studies raised doubts about the results.

Recommendations to address key knowledge gaps

- Although the effects of shelterbelts on CFO air emissions are inconclusive, shelterbelts have many other environmental, social and economic benefits. Thus, it may be worthwhile to further investigate their effects on air emissions despite the challenges of such studies.
- Develop a research plan to study the effectiveness of shelterbelts in mitigating the impact of NH_3, H_2S and PM emissions. Include measurement of source emission concentrations in the plan.
- Due to the complexity, uncertainty and costly nature of odour studies, considerable, detailed planning is required to evaluate the effectiveness of shelterbelts as a mechanism for odour control.
- Consider examining the effect of shelterbelts at the minimum distance separation, as per Alberta's *Agricultural Operation Practices Act* and Regulation.

iii. Bottom Loading of Liquid Manure Storage Facilities

Bottom loading and top loading are methods of transferring liquid manure from an animal housing facility to a manure storage facility. Bottom loading involves discharging the manure below the surface of the stored manure, and top loading involves discharging the manure above the surface.

Bottom loading is considered to be a practical, common sense method of transferring manure. Producer experience and limited studies indicate that bottom loading results in lower air emissions from open, outdoor manure storage facilities, than top loading. Top loading causes more emissions because it causes much more splashing and disturbance of stored liquid manure.

Recommendations to address key knowledge gaps

- Quantify and compare the effects of bottom loading and top loading on air emissions from open, outdoor manure storage facilities. Such research will require careful design and planning to minimize costs and complexities.
- If bottom loading can be scientifically proven to significantly decrease air emissions, then conduct a detailed evaluation of the costs and benefits of retrofitting to determine if it might be appropriate to require manure storage facilities with top loading systems be retrofitted with bottom loading systems.

iv. Manure and Dead Animal Composting

Composting is the biological decomposition and stabilization of organic materials that occur under conditions that allow temperatures higher than 40°C to develop from biologically produced heat. These conditions produce a final product that is stable and free of viable pathogens and plant seeds, and can be beneficially applied to the land.

Manure and dead livestock are two types of organic material that can be successfully composted. Manure composting systems can be categorized as active or passive. Typical active manure composting methods include turned windrows, in-vessel or reactor systems, and forced aeration systems, while passive methods include natural aeration and passive aeration systems. Due to their inconsistent nature, composting livestock carcasses does not follow the traditional composting process of mixing all the materials thoroughly before establishing compost piles. Instead, a layering technique consisting of carcasses and carbon material is used.

There is limited literature on the effects of manure or mortality composting on air emissions relative to livestock production. Furthermore, emission rates from non-point sources, or area sources, such as compost piles are difficult to determine accurately. There is no standardized sampling or measurement technique, and there are many uncontrollable factors and conditions that affect emission measurements.

Recommendations to address key knowledge gaps

- Develop standardized, efficient methods of measuring air emissions from animal manures and mortalities so the effects of different practices on these emissions can be determined and compared.
- Develop protocols for composting research so that, when a study is designed to determine emissions from what is supposed to be a composting medium, the necessary steps will be taken to control factors such as temperature and oxygen level to ensure that the composting process actually occurs within the medium.
- Determine emissions from composting manure and stockpiled manure under Canadian conditions. Determine emissions from traditional animal mortality disposal methods compared to mortality composting.

v. Dust Palliatives for Beef Cattle Feedlots and Unpaved Roads

The main sources of PM, or dust, related to CFOs are unpaved roads and open beef cattle feedlots. Depending on the dust particle size, dust concerns may relate to human and livestock health, the sanitary nuisance caused by dust, and driving risks associated with reduced visibility.

A few techniques have been developed to estimate dust emissions from unpaved roads. Studies have also been conducted to determine dust emissions from feedlots. However, significant variations in emissions have been reported for a variety of reasons, including meteorological influences, inaccuracies in estimation methodologies, etc.

Several types of dust palliatives are used to suppress dust from unpaved roads and feedlots. They include: water; hygroscopic salts and brines; organic non-petroleum products; synthetic polymer products; organic petroleum products; electrochemical products; clay additives; and mulches. In Alberta, the most commonly used dust palliatives are calcium chloride (CaCl2) and lignin sulphonate for unpaved roads, and water for feedlots.

The effectiveness of dust palliatives is highly variable, depending on the product, application method, site conditions and weather. The few studies for unpaved roads reported dust emission reductions ranging from 10% to 92% for different products. Their effectiveness has been reported to last from less than an hour to up to 3 years, depending on the product. CaCl2 and lignin sulphonate have been reported to be effective for 6 to 8 months. Dust palliatives for feedlots appear to be limited to water and mulch. The limited information on their effectiveness suggests reduction efficiencies ranging from 10% to 88%, but the results do not provide any degree of certainty.

Recommendations to address key knowledge gaps

- Investigate and quantify the effectiveness and potential residual effects of various dust palliatives for unpaved roads and feedlots, using sound scientific and statistical principles.
- This research will likely require significant funds, labour and time.
- Conduct an in-depth review and research of dust emission mitigation mechanisms used by other jurisdictions around the world.

vi. Social Considerations of Select Beneficial Management Practices

CFO air emissions present serious social, political and legal challenges. Social conflict is a key theme between livestock operators and their neighbours. Social concerns are often expressed by nuisance or odour complaints, and in some cases, through political and legal venues.

From social perspective, odour is the key CFO air emission issue. Although odours can be measured objectively, measurement requires sophisticated instrumentation and sampling protocols, and it is extremely difficult to identify whether an odour limit has been exceeded. The level of acceptance of odours is affected by social considerations. For example, one study found that those lacking strong ties to a rural area were more likely to harshly judge air emissions.

This chapter considers eight BMPs, including the five discussed in the preceding chapters as well as manure application techniques, frequent manure removal and solid manure moisture management. For the most part, adequate information to assess the social potential of the eight BMPs was lacking in the literature. The main BMP discussed in the literature was manure application, with liquid manure injection offering the best potential for addressing odour complaints. Covers for manure storage facilities and shelterbelts also showed promise from a social perspective; they are relatively inexpensive for CFO operators and may be more pleasing from a visual or "natural" perspective.

Introducing new BMPs or changing regulations to ensure their implementation presents significant social challenges for communities and the livestock industry. Dialogue and informed opinion were felt to be important for avoiding conflict and reducing complaints.

Recommendations to address key knowledge gaps

- Assess which BMPs work best in terms of providing societal benefits, and under which circumstances.
- Obtain and evaluate the livestock industry's views on the BMPs.
- Test acceptable emission standards and measurement techniques and communicate them to communities.

- Encourage education and dialogue among all stakeholders, and increase understanding of the social effectiveness of the BMPs. For example, CFO operators could notify neighbours when a new or modified BMP is implemented and request their feedback. This would help enhance communication, help evaluate the BMP's social value, and possibly reduce odour complaints.
- Increase knowledge of nuisance substances and their potential social and health impacts.

vii. A Review of Potential Costs and Benefits of Select Beneficial Management Practices

This chapter evaluates the same eight BMPs as the preceding chapter in terms of their potential costs and benefits from reducing CFO air emissions. For each BMP, the author attempts to identify the on-farm costs, emission reduction potential and potential public health benefits from implementing the BMP. For bottom loading and moisture management, there was not enough information on costs to conduct the evaluation. Some of the other BMPs lacked sufficient information to allow estimation of emission reduction potential, and some lacked sufficient information to allow estimation of potential health benefits.

Consequently, only four BMPs could be ranked based on their potential net benefits: permeable covers, shelterbelts, dust reduction mechanisms for beef cattle feedlots, and dust reduction mechanisms for unpaved roads. Shelterbelts rank highest in terms of potential net benefits primarily because of their impact on a suite of emissions. They are also one of the lowest cost BMPs. In addition, shelterbelts offer many other benefits not valued in this report, such as carbon offsets, erosion control and habitat for wildlife. Dust reduction mechanisms for unpaved roads have the second highest net benefits, dust reduction mechanisms for feedlots rank third, and permeable covers rank fourth.

Recommendations to address key knowledge gaps

- Determine the costs for manure storage bottom loading systems and solid manure moisture management BMPs.
- Assess the effectiveness of BMPs in reducing specific emissions.
- Evaluate the effects of chronic exposure to low levels of H2S to determine the value of emission reductions.

- Assess the value of health benefits from reducing bioaerosol emissions.

6.3 Air Quality Resources for Alberta Livestock Producers

Alberta Agriculture and Rural Development developed this website to inform and educate livestock producers in Alberta about air quality from CFOs and its impacts on health and the environment.

Click on the following link to access the resources:

http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/epw10940