

MANAGING AIR EMISSIONS FROM CONFINED FEEDING OPERATIONS IN ALBERTA

Ammonia and Particulate Matter
Emissions Inventory for Confined
Feeding Operations in Alberta

Third Edition



Alberta
Government

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**Ammonia and Particulate Matter Emissions Inventory
For Confined Feeding Operations in Alberta**

Addendum: APMEICA 2016

Alberta Agriculture and Forestry

Contents

Acronyms.....	ii
Figures.....	iii
Tables.....	iv
Preface.....	v
12 Update to APMEICA 2011.....	1
12.1 APMEICA 2016 versus APMEICA 2011.....	1
12.2 Ammonia Emissions.....	1
12.2.1 Distribution by Livestock Category.....	1
12.2.2 Temporal Distribution.....	4
12.2.3 Spatial Distribution.....	4
12.2.3.1 LUF Regional Scale.....	4
12.2.3.2 Municipal Scale.....	5
12.2.4 Apportionment of Ammonia Emissions in Alberta to CFOs.....	5
12.2.5 Ammonia Emission Forecasts.....	6
12.3 Particulate Matter Emissions.....	7
12.3.1 Distribution by Livestock Category.....	7
12.3.2 Temporal Distribution.....	8
12.3.3 Spatial Distribution.....	8
12.3.3.1 Land Use Framework Regional Scale.....	9
12.3.3.2 Municipal Scale.....	10
12.3.4 Apportionment of Particulate Matter Emissions in Alberta to CFOs.....	11
12.3.5 Particulate Matter Emission Forecasts.....	11
12.4 Conclusions and Recommendations.....	12
12.4.1 Recommendations.....	13
12.5 References.....	14
12.6 APMEICA 2016 Tables.....	15

Acronyms

AF	Activity Factor
AAF	Alberta Agriculture and Forestry
APMEICA	Ammonia and Particulate Matter Emissions Inventory for CFOs in Alberta
CFO	Confined Feeding Operation
ECCC	Environment Canada and Climate Change
EF	Emission Factor
LUF	Land-Use Framework
M.D.	Municipal District
NH ₃	Ammonia
PM	Particulate Matter
SC	Statistics Canada

Figures

Figure 12-1	Distribution of CFO NH ₃ emissions in Alberta by livestock category in 2016.....	3
Figure 12-2	Distribution of CFO NH ₃ emissions in Alberta by swine sub-category in 2016.....	3
Figure 12-3	Monthly variations in NH ₃ emissions from all CFO livestock categories in 2016.....	4
Figure 12-4	Distribution of CFO NH ₃ emissions in Alberta sorted by LUF Region.....	5
Figure 12-5	CFO NH ₃ emission forecasts for 2021, 2026 and 2031.....	7
Figure 12-6	Distribution of CFO PM ₁₀ emissions in Alberta by livestock category in 2016.....	9
Figure 12-7	Distribution of CFO PM _{2.5} emissions in Alberta by livestock category in 2016.....	9
Figure 12-8	Distribution of CFO PM ₁₀ and PM _{2.5} emissions in Alberta sorted by LUF Region..	10
Figure 12-9	CFO PM ₁₀ emission forecasts for 2021, 2026 and 2031.....	11
Figure 12-10	CFO PM _{2.5} emission forecasts for 2021, 2026 and 2031.....	12

Tables

Table 12-1	Breakdown of NH ₃ emissions by livestock category in Alberta in 2006, 2011 and 2016.....	2
Table 12-2	Annual CFO NH ₃ emissions in 2016 compared to emissions from other sources in Alberta.....	6
Table 12-3	Annual CFO NH ₃ emissions in 2016 (estimated versus forecast).....	6
Table 12-4	Breakdown of PM ₁₀ and PM _{2.5} emissions by livestock category in 2006, 2011 and 2016.....	7
Table 12-5	Annual CFO PM emissions in 2016 compared to emissions from other sources in Alberta.....	10
Table 12-6	Annual CFO PM emissions in 2016 (estimated versus forecast).....	12
Table 12-7	Summary of 2016 NH ₃ and PM Emissions from Alberta CFOs by LUF Region.....	15
Table 12-8	Summary of 2016 NH ₃ Emissions from Alberta CFOs by Month.....	17
Table 12-9	Summary of 2016 PM ₁₀ Emissions from Alberta CFOs by Month.....	18
Table 12-10	Summary of 2016 PM _{2.5} Emissions from Alberta CFOs by Month.....	19
Table 12-11	NH ₃ Emission Forecasts for Alberta CFOs.....	20
Table 12-12	PM ₁₀ Emission Forecasts for Alberta CFOs.....	21
Table 12-13	PM _{2.5} Emission Forecasts for Alberta CFOs.....	22

Preface

This is the third edition of the Ammonia and Particulate Matter Emissions Inventory for Confined Feeding Operations in Alberta (APMEICA 2016). The inventory has been updated to reflect changes in livestock numbers on CFOs across Alberta. The first edition of the inventory (APMEICA 2006) was published based primarily on livestock numbers in 2006, which were derived from SC's 2006 census data. The second edition, included APMEICA 2011 as an addendum to the first. APMEICA 2011 was derived using SC's 2011 census data as well as corrected emissions information associated with one of the CFO livestock categories. For the latter reason, the second edition addendum included revisions to APMEICA 2006 emission estimates associated with the affected livestock category.

Copies of the first and second editions of the inventory are available in print form from the Ministry of Agriculture and Forestry. The second edition of the inventory (APMEICA 2006 and APMEICA 2011) can also be accessed on-line (electronically) via the Ministry's website.

12. Update to APMEICA 2011

APMEICA 2011 was updated using 2016 AFs obtained from SC. Subsequently, APMEICA 2016 reflects changes in estimated NH₃ and PM (PM_{2.5} and PM₁₀) emissions from CFOs in the province in 2016. All EFs used in the updated 2016 emission inventory are the same as the ones used in APMEICA 2011.

12.1 APMEICA 2016 versus APMEICA 2011

A summary of the differences between the two emission inventories is outlined below.

- Emissions of NH₃ and PM from beef cattle CFOs increased slightly from 2011 to 2016 due to a modest increase in AFs. This result further indicates that the number of beef cattle in the province, and subsequently NH₃ and PM emissions, has continued on an upward trend over the past 10 years.
- Emissions of NH₃ and PM from dairy cattle CFOs did not change from 2011 to 2016 because the number of dairy cattle remained relatively the same.
- There was almost a 20% increase in NH₃ and PM emissions from poultry CFOs between 2011 and 2016. Similar to beef cattle CFOs, an increase in poultry AFs occurred over the 5-year interval.
- NH₃ emissions from sheep CFOs showed a continuous decline from 2011 to 2016, similar to the decline experienced between 2006 and 2011. Total sheep numbers in the province appear to be decreasing continuously resulting in the declining NH₃ emissions. Conversely, APMEICA 2016 showed relatively no change in PM emissions from sheep CFOs compared to APMEICA 2011 (due to rounded values), and dating back to APMEICA 2006.
- Emissions of NH₃ from swine CFOs decreased slightly by less than 1% from 2011 to 2016, with relatively no change in PM emissions over the same time period. The negligible decrease in NH₃ emissions was proportional to the negligible decrease in pig numbers.

12.2 Ammonia Emissions

12.2.1 Distribution by Livestock Category

Compared to APMEICA 2011, CFOs in Alberta were estimated to emit 43,593 tonnes of NH₃ in 2016 (Table 12-1). This represents approximately a 9% increase in CFO NH₃ emissions from 2011 to 2016, and a little over a 2% decrease compared to 2006 estimates. The change compared to 2011 was mainly due to a proportional increase in beef cattle CFO emissions in 2016 (about 17% higher). However, the continued increase in beef cattle CFO NH₃ emissions since 2006 could not compensate for the prominent decline in swine CFO emissions from 2006 to 2011, and further on to 2016. The decline in swine emissions was negligible from 2011 to 2016.

Subsequently, APMEICA 2016 indicates that beef cattle CFOs remained the largest contributors to NH₃ emissions, accounting for approximately 57% of the total CFO emissions in Alberta (Figure 12-1), a 3.5% increase compared to APMEICA 2011 estimates. Similarly, despite the

overall decline in emissions between 2006 and 2016, swine CFOs remained the second largest contributors to NH₃ emissions in 2016. According to APMEICA 2016, swine CFOs accounted for about 30% of the total CFO emissions (Figure 12-1), with growers accounting for about 88% of these emissions (Figure 12-2), versus approximately 89% in 2011. Collectively, the two livestock categories (beef and swine) accounted for about 86% of annual NH₃ emissions in Alberta in 2016, a 0.5% increase from 2011.

Table 12-1 Breakdown of NH₃ emissions by livestock category in Alberta in 2006, 2011 and 2016

Livestock		NH ₃ Emissions (tonnes)		
Category	Sub-Category	2006*	2011	2016
Beef	Heifers	8,711	8,473	11,340
	Steers	11,337	12,742	13,387
Subtotal (beef)		20,048	21,215	24,727
Dairy	Heifers	416	493	462
	Cows	2,822	2,779	2,788
Sub-total (dairy)		3,238	3,272	3,249
Poultry	Broilers	1,068	949	1,107
	Layers	603	540	639
	Pullets	226	184	245
	Turkeys	358	366	397
Sub-total (poultry)		2,255	2,039	2,388
Sheep	Ewes	193	176	165
	Lambs	182	170	150
	Rams	10	9	9
Sub-total (sheep)		385	354	324
Swine	Boars	35	24	25
	Growers	16,811	11,575	11,323
	Sows	816	589	593
	Weaners	1,064	802	964
Sub-total (swine)		18,726	12,990	12,905
Total (all CFOs)		44,652	39,870	43,593

* 2006 estimates for dairy cows were revised (from 920 tonnes to 2,822 tonnes) using corrected EFs.

Similar to APMEICA 2011, dairy cattle CFOs contributed the third highest amount of NH₃ emissions estimated by APMEICA 2016 (Figure 12-1). However, this represented a 0.7% decrease in emissions compared to the former inventory, while emissions from poultry CFOs were estimated to be about 17% higher in the latter inventory.

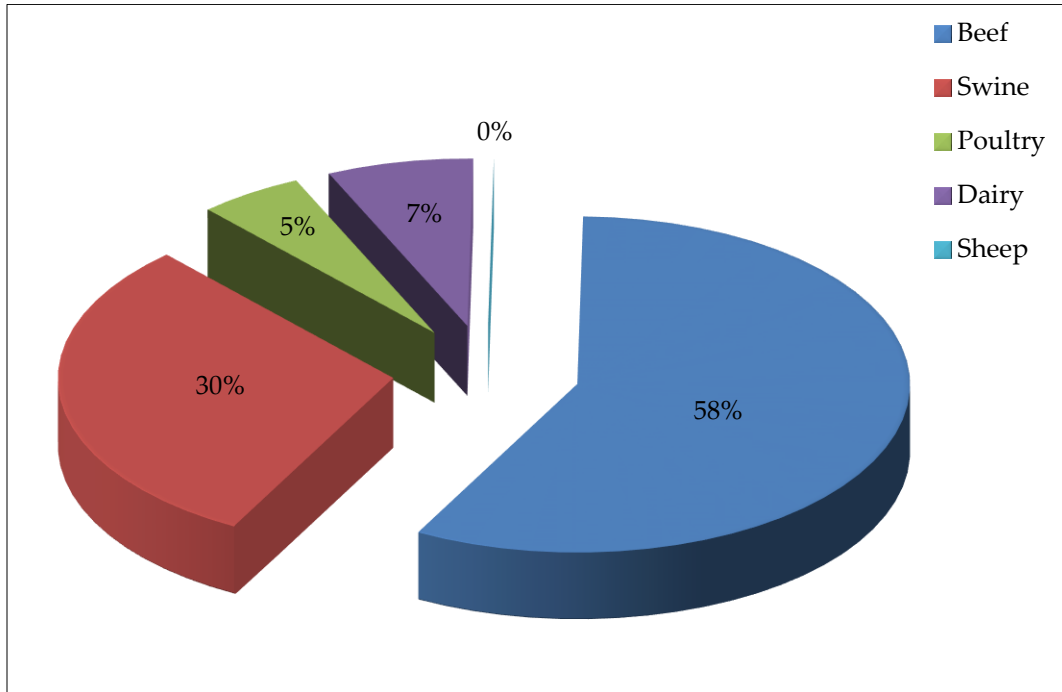


Figure 12-1 Distribution of CFO NH₃ emissions in Alberta by livestock category in 2016

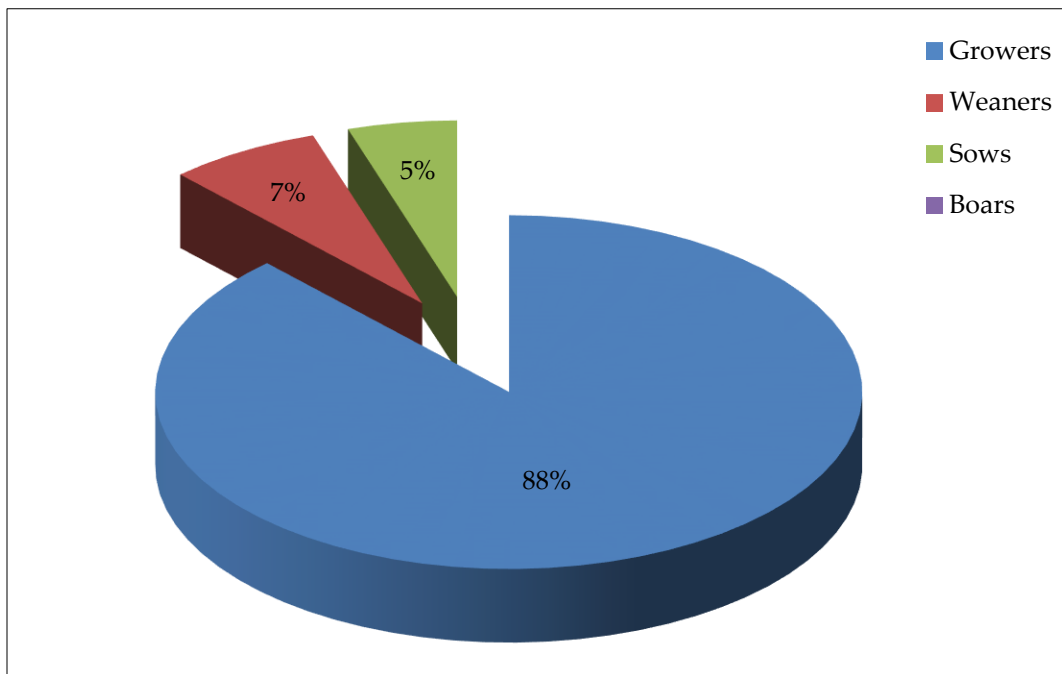


Figure 12-2 Distribution of CFO NH₃ emissions in Alberta by swine sub-category in 2016

12.2.2 Temporal Distribution

Figure 12-3 shows a similar temporal distribution of CFO NH₃ emissions in 2016 as in 2011, with lower emissions occurring in late fall and winter. No noticeable differences were observed in the temporal trend between 2011 and 2016.

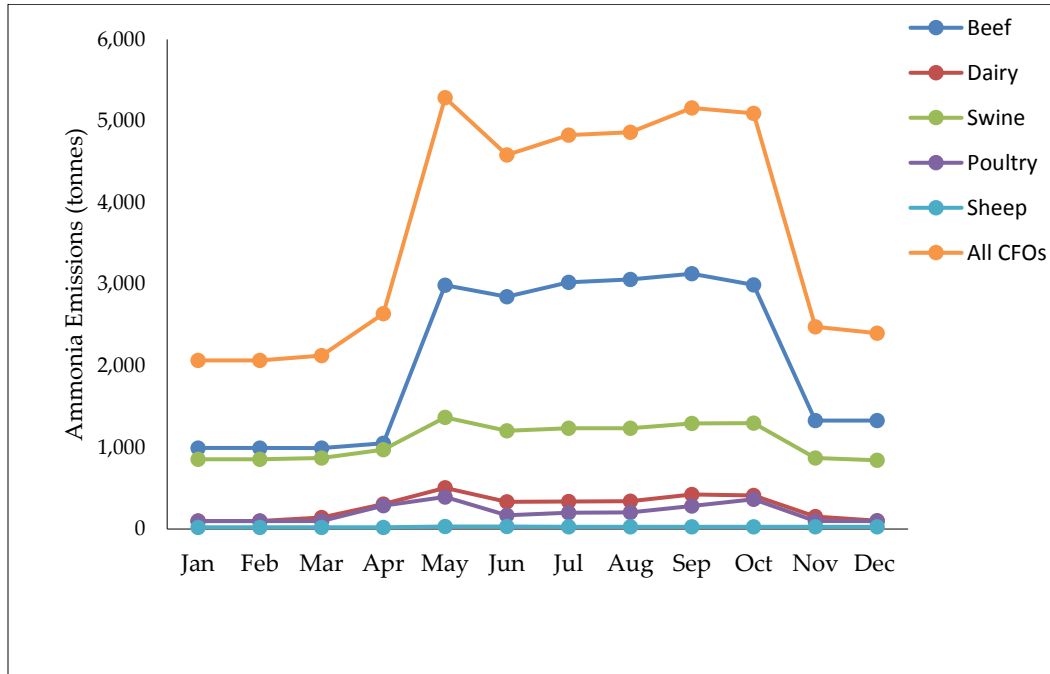


Figure 12-3 Monthly variations in NH₃ emissions from all CFO livestock categories in 2016

12.2.3 Spatial Distribution

APMEICA 2016 estimated NH₃ emissions spatially with respect to Alberta's Land Use Framework regions and municipalities. Although the updated emissions inventory also estimated NH₃ and PM emissions at the 2016 Census Agricultural Regional scale and AAF-defined regional scale, estimates associated with spatial boundaries within either scale are not discussed or presented in this addendum.

12.2.3.1 LUF Regional Scale

A comparison of LUF regional CFO NH₃ emissions in 2016 (Figure 12-4, Table 12-6) to regional emissions in 2011 signifies a general increase in emissions in three (South Saskatchewan, Red Deer and North Saskatchewan) of the seven LUF regions in 2016, with slight decreases in emissions in the remaining four regions.

Ammonia emissions in the North Saskatchewan region increased by about 30% in 2016 compared to 2011. A detailed review of the 2016 census data indicated an increase in swine numbers in the North Saskatchewan region, specifically Wainwright County. Emissions in the South Saskatchewan region increased by about 14% in 2016 compared to 2011 emissions. A detailed review of the 2016 census data indicated an increase in beef numbers in the South

Saskatchewan region, specifically Lethbridge County. Although there was almost a 40% decrease in swine numbers in Red Deer Region (Red Deer County), there was a 22% increase in dairy numbers, which seemed to have helped keep the regional emissions high in that region.

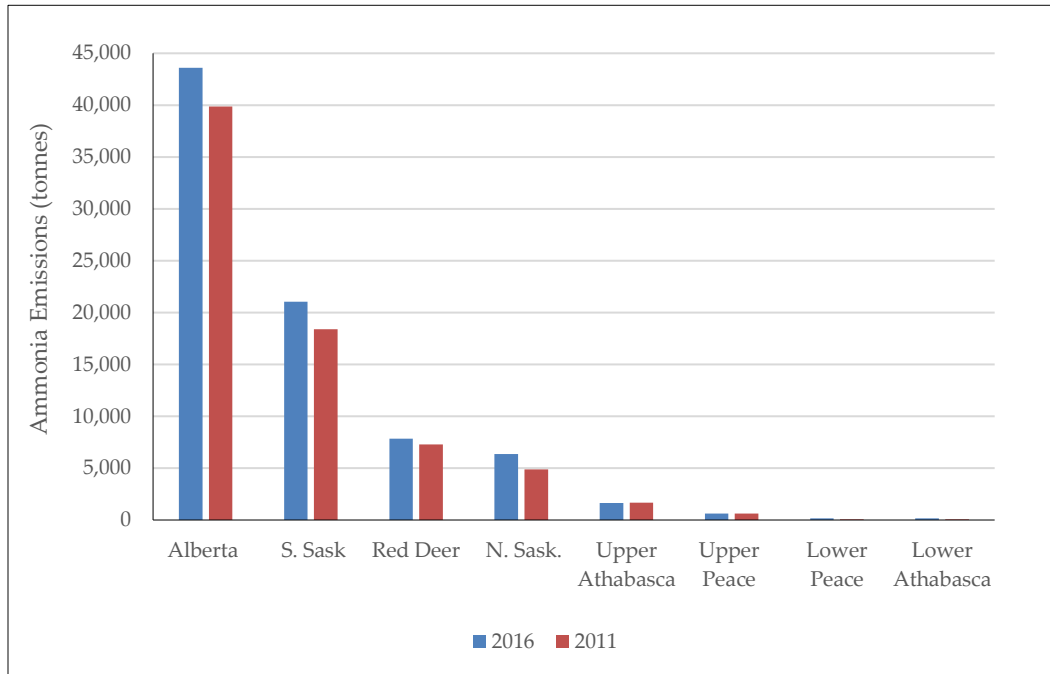


Figure 12-4 Distribution of CFO NH₃ emissions in Alberta sorted by LUF Region

12.2.3.2 Municipal Scale

Relative to APMEICA 2011, NH₃ emissions in 2016, in decreasing order of magnitude, were highest in Lethbridge County, M.D. of Taber, County of Vulcan, County of Newell, and Lacombe County (Table 12-6). The 2016 census data indicated that beef numbers increased by 49,992 head and 101,313 head in the County of Newell and Lethbridge County, respectively, but decreased in Taber County and County of Vulcan by 31,582 head and 28,764 head, respectively.

Overall, Lethbridge County accounted for approximately 15% of total CFO NH₃ emissions in Alberta in 2016, with beef cattle CFOs contributing approximately 82% of the NH₃ emissions in the county. CFOs in Taber and Vulcan counties ranked second highest, contributing about 5% each to the total CFO emission of NH₃ in Alberta, with approximately 70% and 63% of the emissions within each county attributable to beef cattle CFOs, respectively.

12.2.4 Apportionment of Ammonia Emissions in Alberta to CFOs

Table 12-2 shows a comparison of NH₃ emissions from CFOs determined using APMEICA to the emissions from other sources in Alberta in 2016. The results signify that, of the three sources, CFOs contributed about 81% of the total estimated NH₃ emissions.

Table 12-2 Annual CFO NH₃ emissions in 2016 compared to emissions from other sources in Alberta

Sector	NH ₃ Emissions (tonnes)
CFOs (APMEICA)	43,593
Industrial point sources*	8,859
Mobile sources*	1,168

*Environment Canada and Climate Change NPRI (2015)

12.2.5 Ammonia Emission Forecasts

Similar to APMEICA 2006 and 2011, APMEICA 2016 forecast NH₃ emissions in 2021, 2026 and 2031 using the same emission growth factors used by the previous inventories (Figure 12-5). Interestingly, APMEICA 2011 forecasts for 2016 fell short of APMEICA 2016 estimates by about 8%, 14% and 14% for all CFOs, beef cattle CFOs and poultry CFOs, respectively. Forecasts by APMEICA 2011 for NH₃ emissions from swine, dairy and sheep CFOs in 2016 were approximately 1%, 1% and 10% higher than APMEICA 2016 estimates, respectively. These results suggest that the accuracy of the growth factors used for the forecasts is within a 15% margin of error, and provides a relatively high level of confidence in APMEICA forecasts.

Table 12-3 shows a comparison of total CFOs NH₃ emissions in 2016 as estimated by APMEICA 2016 versus the forecast by APMEICA 2011. The table shows a higher estimate by the former inventory compared to the forecast by the latter, suggesting that the growth factors underestimated the general increase in CFO livestock numbers in the province by about 8%, which still provides relative confidence in the precision of the factors and forecasted emissions. It also points to the need for considerable practice change in order to significantly reduce NH₃ emissions, given the projected, continual, 5-year net increases in livestock numbers.

Table 12-3 Annual CFO NH₃ emissions in 2016 (estimated versus forecast)

Sector	NH ₃ Emissions (tonnes)
Total emissions in 2016 as estimated by APMEICA 2016	43,593
Total emissions in 2016 as forecast by APMEICA 2011	40,110

A more detailed forecast is presented in Table 12-11.

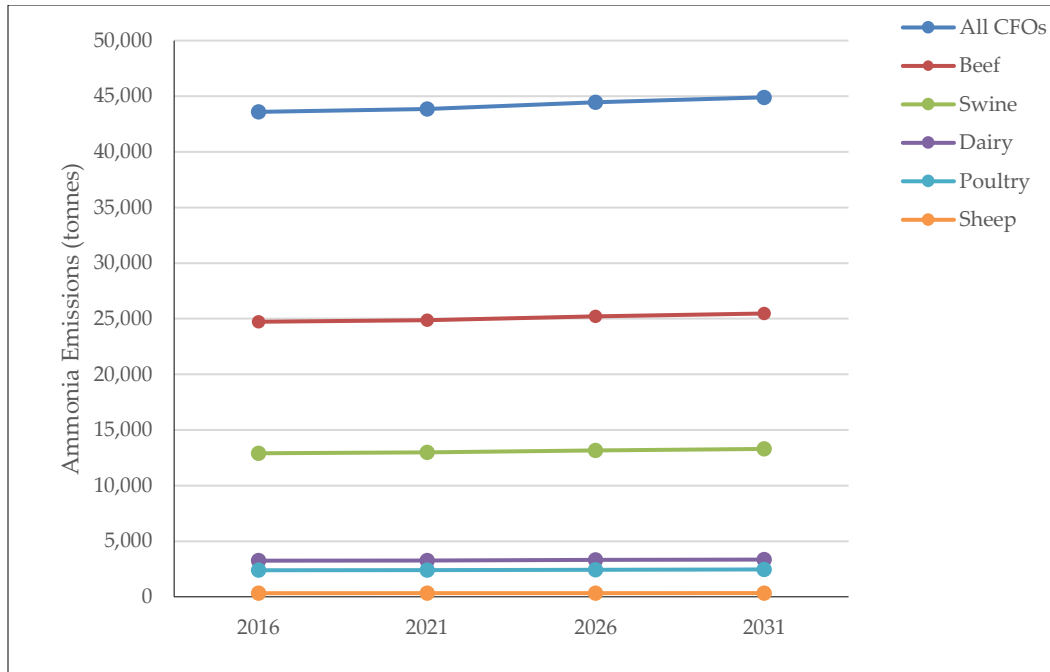


Figure 12-5 CFO NH₃ emission forecasts for 2021, 2026 and 2031

12.3 Particulate Matter Emissions

12.3.1 Distribution by Livestock Category

Estimated emissions of PM₁₀ and PM_{2.5} from all CFOs in Alberta increased by approximately 12% between 2011 and 2016. Except for beef cattle and poultry CFOs, estimated PM₁₀ and PM_{2.5} emissions in 2016 did not appear to vary considerably among the other livestock categories and sub-categories compared to 2011 estimates (Table 12-4). PM₁₀ and PM_{2.5} emission estimates for beef cattle CFOs increased by approximately 18% from 2011 to 2016, while poultry CFO emissions of PM₁₀ and PM_{2.5} were estimated to increase by approximately 17% and 19%, respectively. Similar to 2011, estimates of swine CFO PM₁₀ and PM_{2.5} emissions in 2016 remained second highest after beef cattle CFOs (Figure 12-6).

Table 12-4 Breakdown of PM₁₀ and PM_{2.5} emissions by livestock category in 2006, 2011 and 2016

Livestock		PM ₁₀ (tonnes)			PM _{2.5} (tonnes)		
Category	Sub-Category	2006	2011	2016	2006	2011	2016
Beef	Heifers	470	417	562	105	93	125
	Steers	485	494	513	108	110	114
Sub-total (beef)		955	912	1,075	213	203	239
Dairy	Cows	72	70	70	16	16	16

Livestock		PM ₁₀ (tonnes)			PM _{2.5} (tonnes)		
Category	Sub-Category	2006	2011	2016	2006	2011	2016
	Heifers	23	25	23	5	6	6
Sub-total (dairy)		95	95	93	21	22	22
Poultry	Broilers	86	88	103	11	11	13
	Layers	26	24	29	3	3	4
	Pullets	10	8	11	1	1	1
	Turkeys	17	7	8	1	1	1
Sub-total (poultry)		130	128	150	17	16	19
Sheep	Ewes	3	3	3	1	1	1
	Lambs	3	3	3	1	1	1
	Rams	0	0	0	0	0	0
Sub-total (sheep)		7	6	6	2	2	2
Swine	Boars	3	2	2	1	0	0
	Growers	455	307	300	101	68	66
	Sows	69	49	49	15	11	11
	Weaners	49	35	42	11	8	9
Sub-total (swine)		576	392	392	128	87	87
Total (all CFOs)		1,762	1,532	1,717	380	330	368

12.3.2 Temporal Distribution

No new monthly or seasonal PM EFs have been developed for CFOs since APMEICA 2006 was published in 2012. Therefore, APMEICA 2016 estimates were determined on an annual basis similar to APMEICA 2006 and APMEICA 2011.

12.3.3 Spatial Distribution

Similar to NH₃ emissions, APMEICA 2016 estimated PM emissions spatially with respect to Alberta's Land Use Framework regions and municipalities. There is no discussion or presentation of estimates associated with the 2016 Census Agricultural Regions and AAF-defined regions in this addendum.

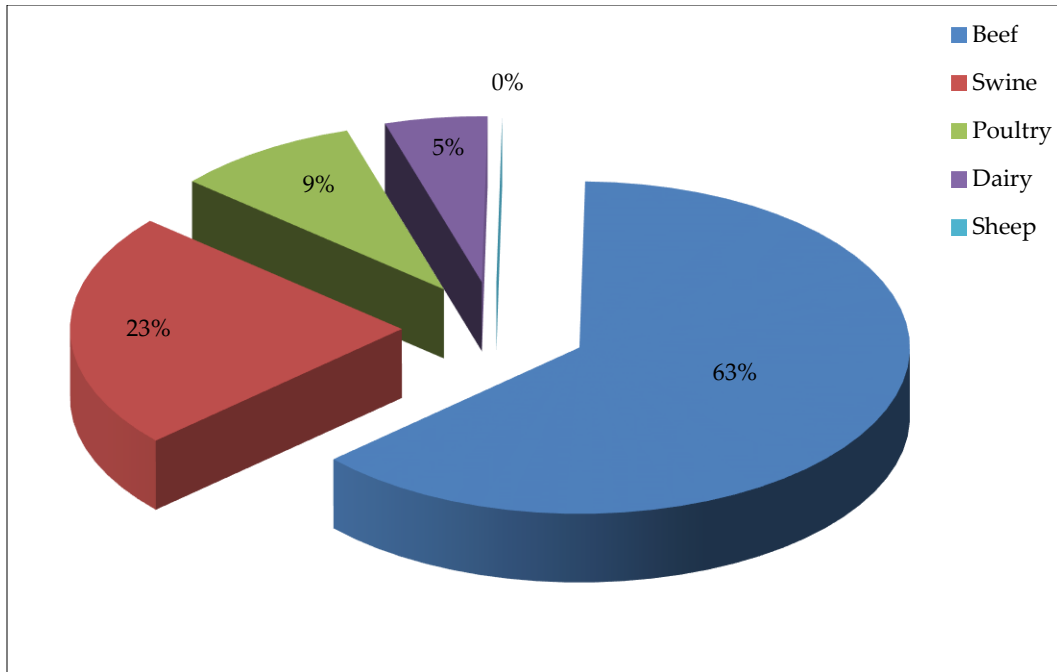


Figure 12-6 Distribution of CFO PM₁₀ emissions in Alberta by livestock category in 2016

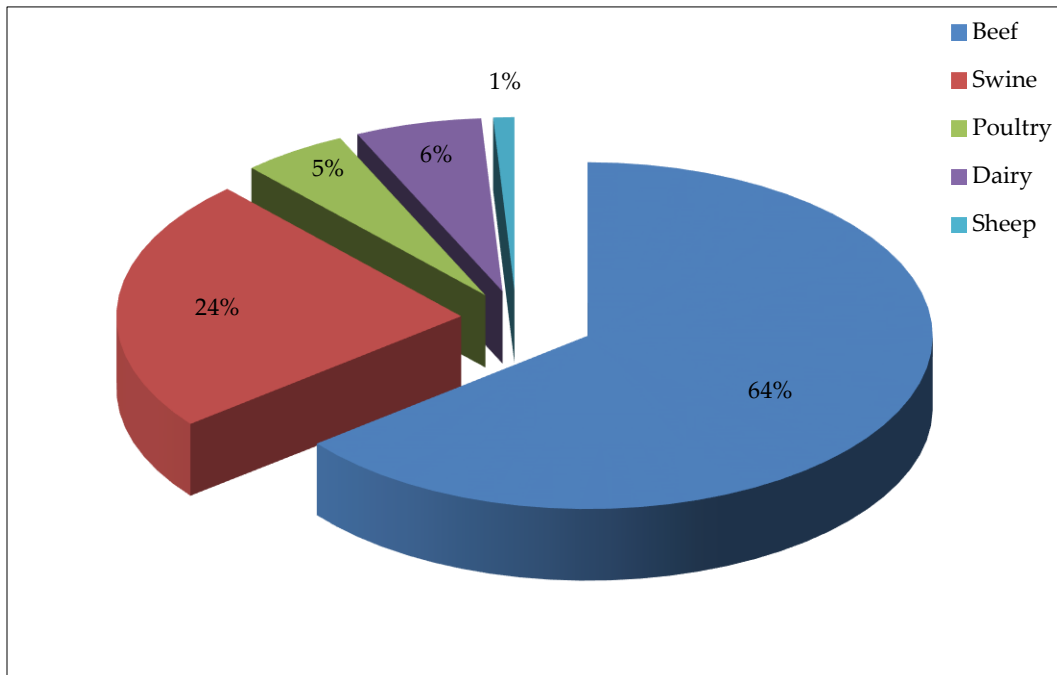


Figure 12-7 Distribution of CFO PM_{2.5} emissions in Alberta by livestock category in 2016

12.3.3.1 Land Use Framework Regional Scale

Estimated emissions of PM₁₀ and PM_{2.5} showed an increase in 2016 compared to 2011 in four of the seven LUF regions in Alberta, namely South Saskatchewan, Red Deer, North Saskatchewan

and Upper Peace, with the greatest increases (approximately 32% and 35%, respectively) occurring in the North Saskatchewan LUF region. A detailed review of the 2016 census data indicated an increase in swine numbers in the North Saskatchewan region, specifically Wainwright County. There were little or no changes in PM emissions in the remaining 3 regions in 2016 compared to 2011.

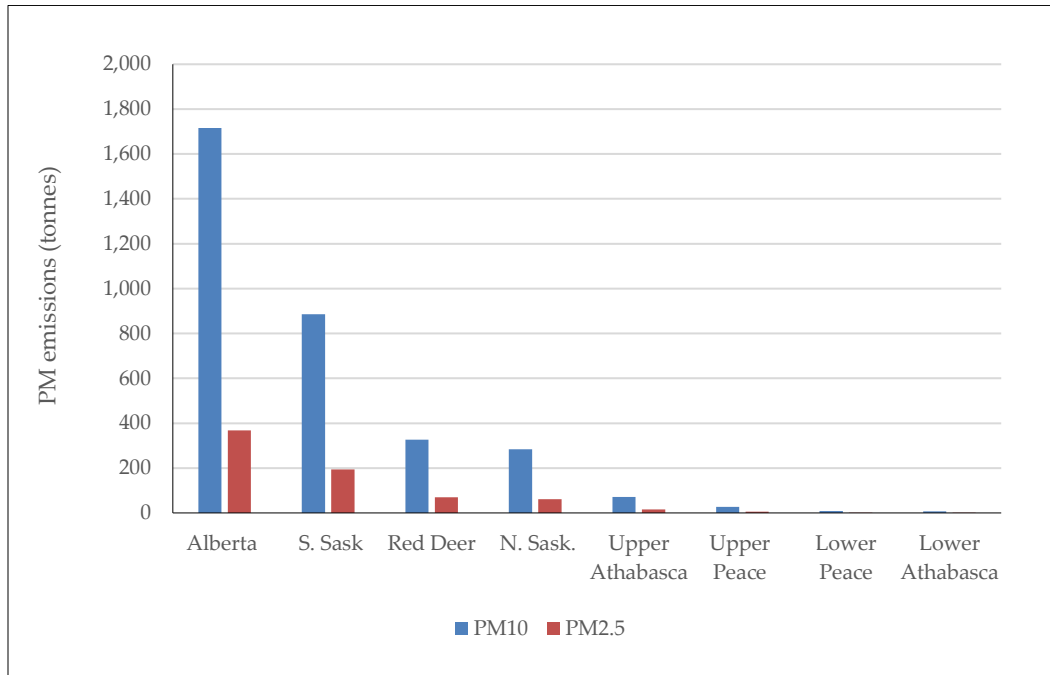


Figure 12-8 Distribution of CFO PM₁₀ and PM_{2.5} emissions in Alberta sorted by LUF Region in 2016

12.3.3.2 Municipal Scale

As indicated in Table 12-5, Lethbridge County, County of Vulcan, M.D. of Taber, Newell County and Wheatland County were estimated to release the most PM emissions in Alberta in 2016, in declining order of magnitude. Newell County replaced Lacombe County as one of the top five emitters of PM in 2016, a return to the top five classification as in 2006. The county experienced an increase in the number of cattle by 49,992 head in 2016 (SC). Conversely, the County of Lacombe experienced a modest decrease in pig numbers by 10,190 head in 2016 (SC).

Table 12-5 Annual CFO PM emissions in 2016 compared to emissions from other sources in Alberta

Sector	PM Emissions (tonnes)	
	PM ₁₀	PM _{2.5}
CFOs (APMEICA)	1,717	368
Industrial point sources*	26,326	11,932
Mobile sources (includes paved and unpaved road dust)*	1,126,238	179,985

* Environment Canada NPRI (2015)

12.3.4 Apportionment of Particulate Matter Emissions in Alberta to CFOs

As indicated in Table 12-5, CFOs in Alberta emitted approximately 7% and 0.2% of the PM₁₀ emissions from industrial point sources and mobile sources, respectively, in 2016. Similarly, CFO PM_{2.5} emissions were approximately 3% and 0.2% of the emissions from industrial point sources and mobile sources, respectively.

12.3.5 Particulate Matter Emission Forecasts

Similar to APMEICA 2011 forecasts, APMEICA 2016 forecast an increase in PM emissions for all CFOs from 2016 to 2031 with noticeable increases associated with beef cattle and to some extent swine CFOs (Figures 12-9 and 12-10). There were little or no changes in the forecasts for dairy, poultry and sheep CFOs. Although the magnitude of the emissions were higher in the APMEICA 2016 forecast, the rate of change in emissions with time remained the same as forecast by APMEICA 2011, considering that the only difference between the two emission inventories were the changes in AFs, with no changes in EFs or growth factors.

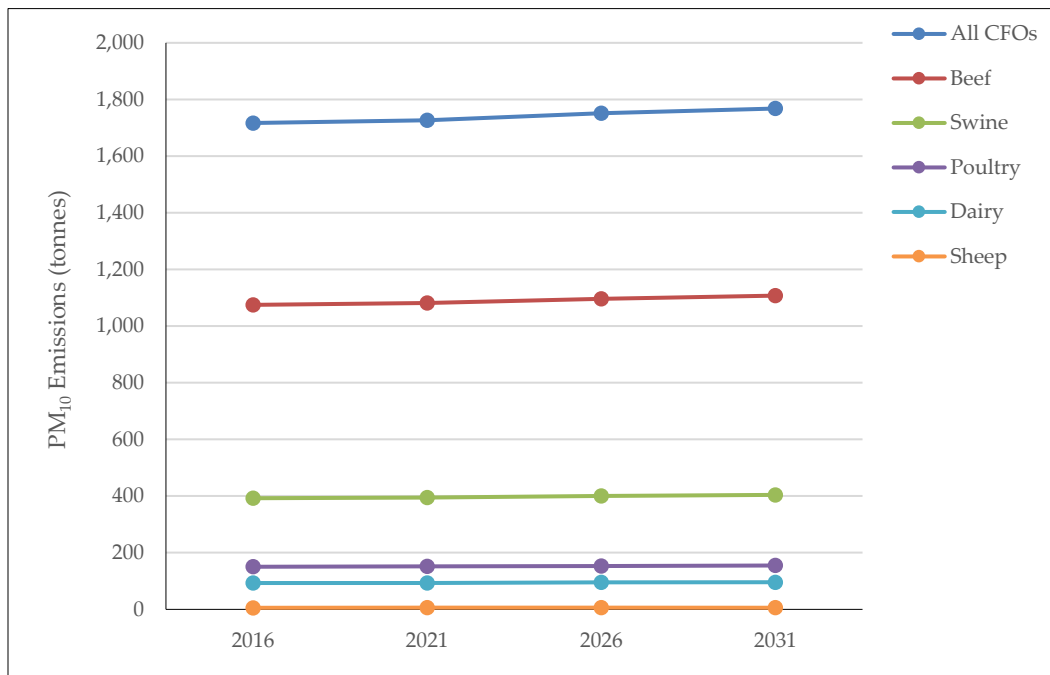


Figure 12-9 CFO PM₁₀ emission forecasts for 2021, 2026 and 2031

Table 12-6 shows a comparison of total CFOs PM emissions in 2016 as estimated by APMEICA 2016 versus forecast by APMEICA 2011. The table shows a higher estimate by the former inventory compared to the 2011 forecasts, indicating that the growth factors forecast lower PM emissions in the province in 2016 by about 10%. Once again, this appears to be within a relatively acceptable margin of error.

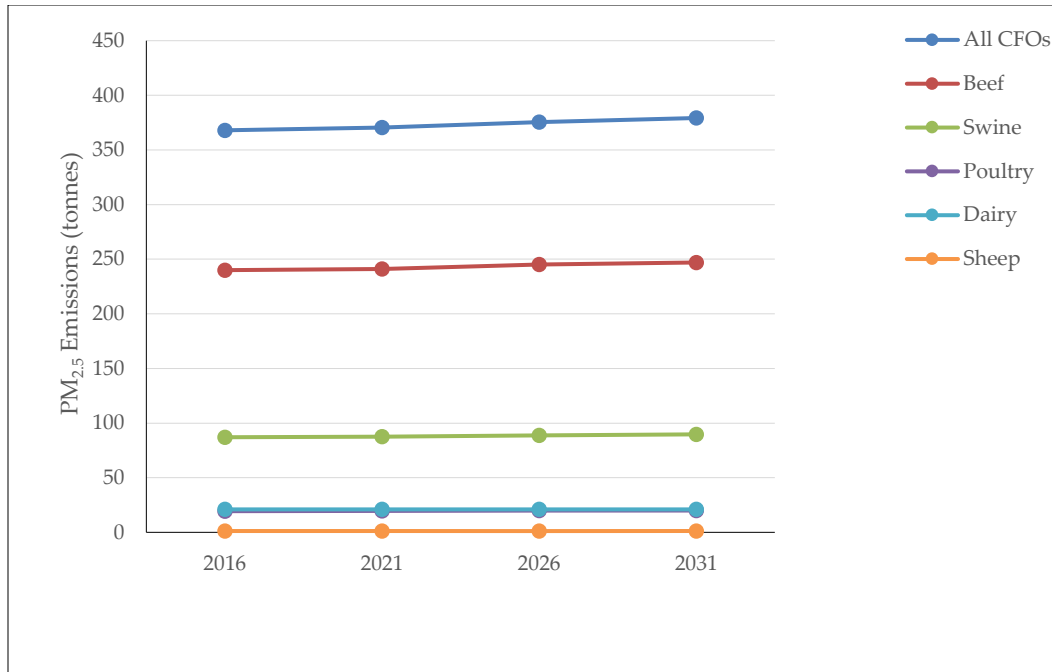


Figure 12-10 CFO PM_{2.5} emission forecasts for 2021, 2026 and 2031

Table 12-6 Annual CFO PM emissions in 2016 (estimated versus forecast)

Sector	PM Emissions (tonnes)	
	PM ₁₀	PM _{2.5}
Total emissions in 2016 as estimated by APMEICA 2016	1,717	368
Total emissions in 2016 as forecast by APMEICA 2011	1,541	331

12.4 Conclusions and Recommendations

Beef CFOs in Alberta experienced a modest increase in livestock numbers between 2011 and 2016. The increase in beef numbers category AFs was primarily responsible for the noticeable increase in NH₃, PM₁₀ and PM_{2.5} emission estimates from all CFOs in Alberta by APMEICA 2016 relative to APMEICA 2011 estimates.

The following conclusions were drawn with respect to APMEICA 2016:

- CFOs in Alberta were estimated to emit 43,593 tonnes of NH₃, 1717 tonnes of PM₁₀, 368 tonnes of PM_{2.5} compared to 39,816 tonnes of NH₃, 1,532 tonnes of PM₁₀ and 330 tonnes of PM_{2.5} in 2011.

- Beef Cattle and swine CFOs jointly accounted for approximately 88% of NH₃, 86% of PM₁₀ and 88% of PM_{2.5} annual emissions in 2016, compared to approximately 86% of NH₃, 86% of PM₁₀ and 87% of PM_{2.5} emissions in 2011.
- In comparison to industrial point sources and mobiles sources, CFOs were estimated to be the biggest contributor of NH₃ emissions in Alberta in 2016, emitting approximately five times more NH₃ than industrial point sources and thirty-seven times more NH₃ than mobile sources.
- Conversely, in comparison to industrial point sources and mobiles sources, CFOs were estimated to be the smallest contributor of PM emissions in Alberta in 2016, emitting approximately fifteen times less PM₁₀ and thirty-two times less PM_{2.5} than industrial point sources, and six hundred and fifty-six times less PM₁₀ and four hundred and eighty-nine times less PM_{2.5} than mobile sources.
- Similar to 2011, NH₃ emission estimates from CFOs in 2016 were highest between May and October.
- Newell County (South Saskatchewan LUF region) was one of five municipalities in Alberta that accounted for the highest NH₃ emissions from CFOs in 2016, displacing the County of Warner County (South Saskatchewan LUF region) from 2011.
- For PM₁₀ and PM_{2.5} emission estimates, the Newell County was one of five municipalities in Alberta that accounted for the highest PM emissions in 2016, displacing the County of Lacombe (Red Deer LUF region) from 2011.
- Similar to 2011, forecasts for NH₃, PM₁₀ and PM_{2.5} emissions from CFOs in Alberta continue to show an increase in emissions in the future, i.e. from 2016 to 2031, particularly from beef cattle and swine CFOs.

12.4.1 Recommendations

The following recommendations continue to aim at the future enhancement of APMEICA:

- The 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 should be used to report future CFO emissions with the assistance of GIS techniques. For example, NARSTO (2006) recommended that emissions from major source categories in North America should be reported at a spatial resolution of 1 km².

- Emissions forecasting should be refined and improved by using new growth factors as they become available.
- To improve the accuracy of APMEICA 2021, an uncertainty analysis should be conducted using most effective techniques and tools, for example Monte Carlo Simulation.
- High temporal resolution PM EFs should be obtained and incorporated into APMEICA 2021.
- Conduct research studies to develop more accurate EFs (e.g., using process-based modelling) and AFs that represent the weather, livestock production and manure management conditions in Alberta. For 2021 emission inventory use soon-to-be-released ammonia emissions factors for dairy operations which are currently under development by Environment and Climate Change Canada (ECCC).
- Periodically track changes in farming activities by conducting formal farm surveys.
- Where necessary, reconcile gaps between estimated emissions of NH₃ and PM, and measured ambient concentrations by using techniques such as “inverse modeling”.

12.5 References

NASTRO. 2006. Improving emission inventories for effective air quality management across North America. A NARSTO Assessment Report. http://narsto.org/emission_inventory_1. (Accessed: March 21, 2018).

SC. 2016. 2016 Census of Agriculture. Statistics Canada. <https://www.statcan.gc.ca/eng/ca2016> (Accessed: March 2018).

12.6 APMEICA 2016 Tables

Table 12-7 Summary of 2016 NH₃ and PM Emissions from Alberta CFOs by LUF Region

Livestock_Category	(All)			
Livestock_Sub_Category	(All)			
Year	2016			
	Unit : Tonnes			
Sum of Tonnes		Substance_Name		
LUF_Name	County_Name	Ammonia (Total)	PM10 - Particulate Matter <= 10 Microns	PM2.5 - Particulate Matter <=2.5 Microns
Lower Athabasca	Bonnyville	151.937	7.365	1.639
	Lac La Biche County	0.00	0.00	0.00
Lower Athabasca Total		151.937	7.365	1.639
Lower Peace	Mackenzie No 23	42.343	1.926	0.408
	Northern Light 22	113.057	5.218	1.161
	Northern Sunrise	11.097	0.583	0.130
Lower Peace Total		166.497	7.727	1.699
North Saskatchewan	Beaver	343.868	13.322	2.832
	Brazeau County	50.37	2.509	0.566
	Brazeau No. 77	0.00	0.00	0.00
	Camrose	572.570	28.242	4.950
	Clearwater	156.620	7.225	1.607
	Edmonton	7.964	0.436	0.097
	Flagstaff	158.558	8.302	1.850
	Green View No 16	11.083	0.684	0.095
	Lamont	837.839	42.128	9.389
	Leduc County	312.068	13.376	2.760
	Minburn	440.529	20.606	4.565
	Parkland County	174.766	7.859	1.749
	Provost	318.082	15.352	3.422
	Smokey Lake	74.656	3.695	0.822
	St. Pual	239.259	11.925	2.639
	Strathcona County	110.268	7.131	1.133
	Sturgeon County	421.968	14.129	3.031
	Thothid No 7	31.514	1.574	0.336
	Two Hills	125.464	6.496	1.386
	Vermilion	432.596	22.324	4.906
	Wainwright	1172.038	39.463	8.737
	Wetaskiwin No 10	370.774	17.293	3.688
North Saskatchewan Total		6362.854	284.070	60.551
Red Deer	Acadia No 34	0.00	0.00	0.00
	Kneehill	1257.830	56.376	11.937
	Lacombe	1427.411	51.534	10.987
	Mountain view	371.974	18.963	3.746
	Paintearth No. 18	392.492	14.684	3.224
	Ponka	1130.327	51.591	10.092
	Red Deer	1108.221	42.775	9.426
	Specail area No 4	326.317	15.011	3.346
	Special area No 2	127.850	5.885	1.312

Livestock_Category	(All)			
Livestock_Sub_Category	(All)			
Year	2016			
	Unit : Tonnes			
Sum of Tonnes		Substance_Name		
LUF_Name	County_Name	Ammonia (Total)	PM10 - Particulate Matter <= 10 Microns	PM2.5 - Particulate Matter <=2.5 Microns
	Special area No 3	297.742	14.239	3.174
	Starland	575.348	21.709	4.540
	Stettler	833.241	33.369	7.326
Red Deer Total		7848.754	326.137	69.111
South Saskatchewan	Bighorn No. 8	64.717	3.172	0.705
	Calgary	22.762	1.167	0.260
	Cardston	958.384	34.946	7.600
	Cypress	459.038	21.090	4.682
	Foothill No 4	311.752	16.997	3.525
	Fortymile	330.135	13.359	2.815
	Lethbridge	6584.529	298.086	65.011
	Newell	1824.536	71.526	15.866
	Pincher Creek	550.939	24.280	5.357
	Ranchland	60.428	2.931	0.653
	Rocky View	857.675	34.731	7.730
	Taber	2332.374	93.047	20.637
	Vulcan	2330.725	98.431	21.598
	Warner	1537.631	57.004	12.228
	Wheatland	1612.812	63.516	13.882
	Willow Creek	1218.592	51.350	11.346
South Saskatchewan Total		21057.028	885.632	193.895
Upper Athabasca	Athabasca county 12	115.190	5.701	1.267
	Barrhead County No. 11	687.630	27.130	5.991
	Big Lake	9.895	0.545	0.121
	Lac Ste. Anne County	162.835	7.885	1.753
	Lesser Slave	13.963	0.726	0.161
	Westlock	281.471	12.390	2.629
	Woodland	62.411	2.999	0.667
	Yellowhead county	292.372	13.153	2.929
Upper Athabasca Total		1625.767	70.528	15.519
Upper Peace	Birch Hill	172.436	6.311	1.402
	Clear Hills	90.792	4.199	0.932
	Fairview No 136	26.850	1.281	0.285
	Grand Prairie No 1	231.601	10.863	2.403
	Peace No 135	16.622	0.778	0.173
	Saddle Hill	48.081	2.333	0.518
	Smokey River	14.108	0.698	0.155
	Spirit River	8.091	0.391	0.087
Upper Peace Total		608.580	26.853	5.955
Grand Total		37821.418	1608.312	348.369

Table 12-8 Summary of 2016 NH₃ Emissions from Alberta CFOs by Month

County_ Name	(All)													
Year	2016													
Substance_ Name	Ammonia (Total)													
	Unit : Tonnes													
Sum of Tonnes		Month												
Livestock_ Category	Livestock_ Sub_Category	January	February	March	April	May	June	July	August	September	October	November	December	Grand Total
Cattle	Beef Heifers	481.76	481.76	481.91	509.60	1303.05	1233.01	1401.63	1409.36	1443.01	1379.04	607.91	607.69	11340
	Dairy Cows	75.61	75.61	118.26	282.32	444.65	275.71	284.97	288.89	371.26	359.34	130.96	80.08	2788
	Dairy Heifers	22.75	22.75	22.76	24.07	59.68	56.47	51.79	52.07	53.32	50.95	22.46	22.45	462
	Steers	511.96	511.96	512.12	539.78	1684.23	1612.75	1623.23	1648.10	1685.67	1614.25	721.83	721.59	13387
Cattle Total		1092.09	1092.09	1135.05	1355.78	3491.61	3177.94	3361.62	3398.42	3553.26	3403.59	1483.16	1431.81	27976
Poultry	Broilers	42.13	42.13	42.13	135.75	188.02	77.61	93.31	93.68	134.10	173.72	42.13	42.13	1107
	Layers	28.09	28.09	28.24	74.50	101.19	46.42	54.07	54.25	74.39	93.75	28.34	28.09	639
	Pullets	10.75	10.75	10.81	28.50	38.71	17.76	20.69	20.76	28.46	35.87	10.84	10.75	245
	Turkeys	16.06	16.06	16.06	47.93	65.72	28.14	33.48	33.61	47.37	60.85	16.06	16.06	397
Poultry Total		97.02	97.02	97.23	286.68	393.65	169.92	201.54	202.30	284.32	364.19	97.37	97.02	2388
Sheep	Ewes	13.77	13.77	13.77	13.77	14.37	14.37	13.50	13.50	13.50	13.50	13.50	13.50	165
	Lamb	7.18	7.18	7.18	7.18	15.99	15.99	14.95	14.95	14.95	14.95	14.95	14.95	150
	Rams	0.70	0.70	0.70	0.70	0.76	0.76	0.70	0.70	0.70	0.70	0.70	0.70	9
Sheep Total		21.65	21.65	21.65	21.65	31.12	31.12	29.14	29.14	29.14	29.14	29.14	29.14	324
Swine	Boars	1.52	1.52	1.56	1.76	2.81	2.44	2.37	2.37	2.50	2.50	1.65	1.59	25
	Growers	757.64	757.64	771.45	854.96	1194.19	1062.22	1079.35	1078.71	1128.60	1130.32	765.62	744.09	11323
	Sows	37.87	37.87	39.02	46.01	60.99	50.95	58.89	58.84	63.04	63.19	39.27	37.46	593
	Weaners	58.59	58.59	60.38	71.18	110.46	92.29	94.12	94.03	100.75	100.98	62.76	59.86	964
Swine Total		855.62	855.62	872.40	973.92	1368.45	1205.91	1234.73	1294.89	1294.89	1296.98	869.30	843.00	12905
Grand Total		2066.37	2066.37	2126.33	2638.03	5284.82	4584.88	4827.04	5161.60	5161.60	5093.91	2479.98	2400.97	43593

Table 12-9 Summary of 2016 PM₁₀ Emissions from Alberta CFOs by Month

County_ Name	(All)													
Year	2016													
Substance_ Name	PM10 - Particulate Matter <= 10 Microns													
	Unit : Tonnes													
Sum of Tonnes		Month												
Livestock_ Category	Livestock_ Sub_Category	January	February	March	April	May	June	July	August	September	October	November	December	Grand Total
Cattle	Beef Heifers	40.94	40.94	40.94	40.94	44.17	44.17	51.64	51.64	51.64	51.64	51.64	51.64	562
	Dairy Cows	5.63	5.63	5.63	5.63	5.78	5.78	5.96	5.96	5.96	5.96	5.96	5.96	70
	Dairy Heifers	1.93	1.93	1.93	1.93	2.02	2.02	1.91	1.91	1.91	1.91	1.91	1.91	23
	Steers	33.76	33.76	33.76	33.76	46.46	46.46	47.58	47.58	47.58	47.58	47.58	47.58	513
Cattle Total		82.25	82.25	82.25	82.25	98.44	98.44	107.08	107.08	107.08	107.08	107.08	107.08	1168
Poultry	Broilers	8.56	8.56	8.56	8.56	8.56	8.56	8.56	8.56	8.56	8.56	8.56	8.56	103
	Layers	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41	2.41	29
	Pullets	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	11
	Turkeys	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	8
Poultry Total		12.54	12.54	12.54	12.54	12.54	12.54	12.54	12.54	12.54	12.54	12.54	12.54	150
Sheep	Ewes	0.24	0.24	0.24	0.24	0.28	0.25	0.23	0.23	0.23	0.23	0.23	0.23	3
	Lamb	0.12	0.12	0.12	0.12	0.28	0.28	0.26	0.26	0.26	0.26	0.26	0.26	3
	Rams	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0
Sheep Total		0.37	0.37	0.37	0.37	0.54	0.54	0.50	0.50	0.50	0.50	0.50	0.50	6
Swine	Boars	0.14	0.14	0.14	0.14	0.15	0.15	0.14	0.14	0.14	0.14	0.14	0.14	2
	Growers	25.27	25.27	25.27	25.27	24.79	24.79	24.82	24.82	24.82	24.82	24.82	24.82	300
	Sows	4.21	4.21	4.21	4.21	3.69	3.69	4.16	4.16	4.16	4.16	4.16	4.16	49
	Weaners	3.44	3.44	3.44	3.44	3.54	3.54	3.52	3.52	3.52	3.52	3.52	3.52	42
Swine Total		33.05	33.05	33.05	33.05	32.17	32.17	32.64	32.64	32.64	32.64	32.64	32.64	392
Grand Total		128.22	128.22	128.22	128.22	143.68	143.68	152.76	152.76	152.76	152.76	152.76	152.76	1717

Table 12-10 Summary of 2016 PM_{2.5} Emissions from Alberta CFOs by Month

County_ Name	(All)													
Year	2016													
Substance_ Name	PM2.5 - Particulate Matter <=2.5 Microns													
	Unit : Tonnes													
Sum of Tonnes		Month												
Livestock_ Category	Livestock_ Sub_Category	January	February	March	April	May	June	July	August	September	October	November	December	Grand Total
Cattle	Beef Heifers	9.12	9.12	9.12	9.12	9.85	9.85	11.51	11.51	11.51	11.51	11.51	11.51	125
	Dairy Cows	1.26	1.26	1.26	1.26	1.30	1.30	1.34	1.34	1.34	1.34	1.34	1.34	16
	Dairy Heifers	0.43	0.43	0.43	0.43	0.45	0.45	0.43	0.43	0.43	0.43	0.43	0.43	5
	Steers	7.53	7.53	7.53	7.53	10.36	10.36	10.61	10.61	10.61	10.61	10.61	10.61	114
Cattle Total		18.35	18.35	18.35	18.35	21.95	21.95	23.88	23.88	23.88	23.88	23.88	23.88	261
Poultry	Broilers	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	13
	Layers	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	0.31	4
	Pullets	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	1
	Turkeys	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	1
Poultry Total		1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	1.61	19
Sheep	Ewes	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	1
	Lamb	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	1
	Rams	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Sheep Total		0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	2
Swine	Boars	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0
	Growers	5.60	5.60	5.60	5.60	5.49	5.49	5.50	5.50	5.50	5.50	5.50	5.50	66
	Sows	0.93	0.93	0.93	0.93	0.82	0.82	0.92	0.92	0.92	0.92	0.92	0.92	11
	Weaners	0.77	0.77	0.77	0.77	0.79	0.79	0.79	0.79	0.79	0.79	0.79	0.79	9
Swine Total		7.33	7.33	7.33	7.33	7.14	7.14	7.24	7.24	7.24	7.24	7.24	7.24	87
Grand Total		27.37	27.37	27.37	27.37	30.82	30.82	32.84	32.84	32.84	32.84	32.84	32.84	368

Table 12-11 NH₃ Emission Forecasts for Alberta CFOs

Substance Name	Ammonia (Total)				
	Unit : Tonnes				
Sum of Tonnes/Year		Year			
Livestock Category	Livestock_Sub_Category	2016	2021	2026	2031
Cattle	Beef Heifers	11,339.72	11,407.76	11,566.52	11,679.91
	Dairy Cows	2,787.67	2,804.40	2,843.43	2,871.30
	Dairy Heifers	461.53	464.30	470.76	475.38
	Steers	13,387.47	13,467.80	13,655.22	13,789.09
		27,976.40	28,144.26	28,535.93	28,815.69
	Broilers	1,106.82	1,113.47	1,128.96	1,140.03
Cattle Total	Layers	639.42	643.26	652.21	658.60
Poultry	Pullets	244.64	246.10	249.53	251.98
	Turkeys	397.38	399.77	405.33	409.31
		2,388.26	2,402.59	2,436.03	2,459.91
	Ewes	164.80	165.78	168.09	169.74
Poultry Total	Lamb	150.37	151.27	153.37	154.88
Sheep	Rams	8.52	8.57	8.69	8.78
		323.68	325.63	330.16	333.40
	Boars	24.59	24.74	25.09	25.33
Sheep Total	Growers	11,322.79	11,390.73	11,549.25	11,662.48
Swine	Sows	593.41	596.97	605.27	611.21
	Weaners	963.97	969.76	983.25	992.89
Swine Total		12,904.77	12,982.20	13,162.86	13,291.91
Grand Total		43,593.12	43,854.68	44,464.98	44,900.91

Table 12-12 PM₁₀ Emission Forecasts for Alberta CFOs

Substance Name	PM10 - Particulate Matter <= 10 Microns				
	Unit : Tonnes				
Sum of Tonnes/Year		Year			
Livestock Category	Livestock_Sub_Category	2016	2021	2026	2031
Cattle	Beef Heifers	561.91	565.28	573.14	578.76
	Dairy Cows	69.82	70.24	71.22	71.92
	Dairy Heifers	23.23	23.37	23.69	23.92
	Steers	513.41	516.49	523.68	528.82
		1,168.37	1,175.38	1,191.74	1,203.42
	Broilers	102.70	103.31	104.75	105.78
Cattle Total	Layers	28.91	29.08	29.49	29.78
Poultry	Pullets	11.06	11.13	11.28	11.39
	Turkeys	7.76	7.81	7.92	8.00
		150.43	151.33	153.44	154.94
	Ewes	2.85	2.86	2.90	2.93
Poultry Total	Lamb	2.60	2.61	2.65	2.68
Sheep	Rams	0.15	0.15	0.15	0.15
		5.59	5.63	5.70	5.76
	Boars	1.70	1.71	1.74	1.76
Sheep Total	Growers	299.56	301.36	305.55	308.55
Swine	Sows	49.16	49.46	50.15	50.64
	Weaners	41.97	42.22	42.80	43.22
Swine Total		392.39	394.75	400.24	404.16
Grand Total		1,716.78	1,727.08	1,751.12	1,768.29

Table 12-13 PM_{2.5} Emission Forecasts for Alberta CFOs

Substance Name	PM2.5 - Particulate Matter <=2.5 Microns				
	Unit : Tonnes				
Sum of Tonnes/Year		Year			
Livestock Category	Livestock Sub Category	2016	2021	2026	2031
Cattle	Beef Heifers	125.23	125.99	127.74	128.99
	Dairy Cows	15.68	15.78	16.00	16.15
	Dairy Heifers	5.18	5.21	5.28	5.33
	Steers	114.49	115.18	116.78	117.92
Cattle Total		260.58	262.15	265.80	268.40
Poultry	Broilers	13.22	13.30	13.48	13.62
	Layers	3.72	3.74	3.80	3.83
	Pullets	1.42	1.43	1.45	1.47
	Turkeys	1.00	1.01	1.02	1.03
Poultry Total		19.36	19.48	19.75	19.94
Sheep	Ewes	0.60	0.61	0.62	0.62
	Lamb	0.55	0.55	0.56	0.57
	Rams	0.03	0.03	0.03	0.03
Sheep Total		1.19	1.19	1.21	1.22
Swine	Boars	0.38	0.38	0.39	0.39
	Growers	66.39	66.79	67.71	68.38
	Sows	10.92	10.99	11.14	11.25
	Weaners	9.37	9.42	9.55	9.65
Swine Total		87.05	87.58	88.79	89.67
Grand Total		368.19	370.39	375.55	379.23



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