CHEMINFO

Forecast of

Common Air Contaminants

in Alberta

(1995 to 2020)

Final Report

Prepared For:

Clean Air Strategic Alliance (CASA)
Alberta

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1. Executive Summary

1.1 Introduction

This forecast of Alberta's common (or criteria) air contaminant (CAC) emissions[1] between 1995 to the year 2020 is presented using the following emission categorisation:

Anthropogenic Sources

- industrial (including electric power generation);
- residential, commercial, and institutional;
- transportation;
- area sources - non-energy (e.g., road dust, construction, prescribed burning, solvents use, agriculture, etc.);

Natural Sources

- forest fires; and
- biogenic sources.

The ratio between anthropogenic and natural CAC emissions varies significantly by contaminant. Fossil fuel use for heat and electricity generation (i.e., energy-related) and mere combustion (where derived heat is not utilized or electricity is not made from the burning of fossil fuels) are prominent sources of nitrogen oxides (NO_x), sulphur oxides (SO_x) emissions, and carbon monoxide (CO) emissions.[2] In the case of total particulate (PM_T) and PM_{10} (i.e., particulate matter less than 10 microns) anthropogenic non-energy area sources dominate since they include dust from paved and unpaved roads resulting from vehicle traffic. Natural sources such as forest fires and biogenic sources[3] are major contributors to total volatile organic compound (VOC) emissions.

The main focus of this report is on the growth in anthropogenic emissions from industrial sources in Alberta. Large natural sources are documented and included in the total emissions, but in the forecast period from 1995 to 2020, these are kept constant at 1995 levels. These sources are highly variable from year to year such that any analysis regarding how they may change due to natural causes (e.g., lightning for forest fires, precipitation, temperatures, etc.) requires further detailed research and customized modelling beyond the scope of this project. By keeping emissions from natural sources constant, it focuses the

[1] Common air contaminants include nitrogen oxides (NO_x), sulphur oxides (SO_x), volatile organic compounds (VOC), carbon monoxide (CO), total particulate (PM_T), particulate matter less than 10 microns PM_{10}, fine particulate matter less than 2.5 microns $PM_{2.5}$. Ammonia NH_3 emissions are also included in this study.

[2] Primary sources only. Secondary formation not included in this forecast.

[3] Biogenic sources are largely related to vegetation and animal sources (non-agricultural).

analysis of changes in CAC emissions on anthropogenic sources. The inclusion of natural sources provides perspective on the relative contribution to total CAC air emissions and can be useful for regional ambient air quality modelling using the results of this analysis.

The starting point for this forecast is the 1995 inventory of CAC emissions in Alberta, which is the most comprehensive up-to-date inventory of CAC emissions. The 1995 inventory has been prepared by Alberta Environment in collaboration with Environment Canada[4]. While year 2000 emissions (mostly SO_x and NO_x emissions) were available for major industrial facilities, a complete inventory of all pollutants and sources for the year 2000 emissions is not currently available for Alberta. Therefore, the year 2000 estimates in this study should in most cases be considered a part of the projection period. A few modifications have been incorporated in the 1995 inventory as part of this report. These include changes to 1995 transportation and upstream oil and gas sector (specifically oil sands) estimates. These and other changes are explained in the respective sections.

Table 1: Total 1995 Alberta CAC Emissions

(kilotonnes)

Anthropogenic Sources	**PMT**	**PM10**	**PM2.5**	**SO_X**	**NO_X**	**VOC**	**CO**	**NH3**
Industrial (includes electricity generation)	84	48	35	601	444	554	402	10
Residential, commercial, institutional	9	9	8	1	12	37	62	0
Transportation	13	12	11	8	227	105	959	2
Area sources[5] (e.g., road dust, solvents, agric. etc.)	4832	1414	168	0	2	58	98	134
Natural Sources	54	46	38	0	29	1297	447	2
Total 1995	**4993**	**1530**	**261**	**609**	**715**	**2051**	**1969**	**148**
Portion of Total	**PMT**	**PM10**	**PM2.5**	**SO_X**	**NO_X**	**VOC**	**CO**	**NH3**
Industrial and electricity generation	2%	3%	13%	99%	62%	27%	20%	7%
Residential, commercial, institutional	0%	1%	3%	0%	2%	2%	3%	0%
Transportation	0%	1%	4%	1%	32%	5%	49%	1%
Area sources (e.g., road dust, solvents, agriculture, etc.)	97%	92%	64%	0%	0%	3%	5%	91%
Natural sources	1%	3%	15%	0%	4%	63%	23%	1%

Source: Environment Canada[6]. Alberta Environment. Cheminfo Services Inc.[7] AFRD[8]

[4] Environment Canada, *1995 Criteria Air Contaminant Emissions for Canada,* December 1998.

[5] Area sources include road dust, and many other emissions (such as solvents use, cooking, and fuel distribution) that have not been included in the specific categories noted above (industrial, residential, commercial, institutional, or transportation).

[6] Environment Canada, *1995 Criteria Air Contaminant Emissions for Canada,* December 1998.

[7] Cheminfo Services adjustments to 1995 emissions for Oil and Gas, and some other sectors.

[8] Agriculture emissions from: Chetner, S., Sasaki, D., Alberta Agriculture, Food and Rural Development (AFRD), *Agricultural Air Emission Inventory for Alberta and Literature Review*, November 6, 2001.

This forecast of CAC emissions is established in context of Canada's economic and energy outlook as developed by the Analysis and Modelling Group (AMG) of the National Air Issues Co-ordinating Committee on Climate Change (NAICC-CC). The AMG is made up of jurisdictional and federal government representatives, including Natural Resources Canada, as well as representatives from the Alberta government. The AMG, in collaboration with Natural Resources Canada developed a consolidated economic and energy analysis to support analysis for the National Climate Change Process. The economic and energy analysis was published in the report on greenhouse gas (GHG) emissions entitled, *Canada's Emissions Outlook: An Update*, in December 1999 (hereafter referred to as CEOU).[9] The analysis excludes the potential effects on climate change or other potential government policies that would affect energy and CAC emissions. The AMG has recently (March 2002) undertaken some modifications to that forecast, and this CAC emissions forecast incorporates those adjustments, where possible, and especially as they relate to the electric power generation sector in Alberta. While the CEOU provides a foundation for this report, substantial additional industry input was incorporated in this forecast to take into consideration emission reduction controls and other effects that relate to future CAC emissions.

1.2 Summary of CAC Emissions Growth

Overall CAC emissions in Alberta are projected to increase under business-as-usual (BAU) conditions. BAU conditions include continued economic growth as reflected by changes in total Gross Domestic Product (GDP) projected to increase 24% between 2000 and 2010, and 56% between 2000 and 2020[10]. The total increase in energy consumption by the Alberta economy is projected to increase at a slower pace, largely as a result of improvements in energy efficiency. Total energy consumption in Alberta was projected to increase by 20% between 2000 and 2020, although this has been revised upward to reflect increased oil sands developments and electric power generation.

Total CAC emissions[11] are projected to increase 18% by 2010 and 32% by 2020 over 1995 levels. These slower growth rates (versus economic growth) result from anticipated energy efficiency improvements, a general shift to less CAC-intensive fuels such as natural gas (in some sectors) and a constant level of future emissions assumed for natural and some agricultural sources. In addition, reduced emissions from transportation are anticipated in context of improved vehicle emission standards and regulated reductions in

[9] AMG/Natural Resources Canada, *Canada's Emissions Outlook: An Update,* December 1999. www.nccp.ca

[10] AMG/Natural Resources Canada, *Canada's Emissions Outlook: An Update,* December 1999. Constant 1986$. This estimate may indeed now be higher in context of additional announced oil sands projects (the effects of which are reflected in the CAC emissions forecast.)

[11] Total CAC emissions are the sum of PM_T, SO_x, NO_x, CO, VOC and NH_3..

the sulphur content of gasoline and on-road diesel. In absence of the improved energy efficiency and fuel switching throughout the economy, CAC emissions would be projected to increase at a much faster rate.

Table 2: Macroeconomic Assumptions, Energy and Environmental Performance Context for Alberta

(Excluding year 2002 AMG adjustments)

Parameter	**1995**	**2000**	**2010**	**2020**
Alberta GDP ($ billion 1986)	$73	$85	$106	$133
Total energy consumed (000s PJ)	1.4	1.5	1.7	1.8
Total CAC Emissions (000' kilotonnes)	10.5	11.0	12.3	13.8
Performance Indicators				
Energy (PJ/GDP)*	19	18	16	14
CAC Emissions (kilotonne-CAC/$billion-GDP)	144	130	116	104

* CAC emissions calculated in this study. CEOU economic data. * PJ is petajoules.

The magnitude of the projected change for each of the CAC contaminants is quite different. Total particulate emissions (PM_T) and PM_{10}, a large portion of which are from road dust, are projected to increase by the greatest percentage. By contrast, SO_x and CO emissions are projected to actually decrease, largely because of lower transportation emissions due to improved fuel and vehicle emission standards, as well as the adoption of SO_x control technologies. VOC emissions are projected to grow slowly. A large portion of VOC emissions are from natural sources (i.e., forest fires, and biogenic sources), which are kept constant through the forecast period.

Table 3: Total Alberta CAC Emission Projections

(kilotonnes)

Contaminant	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**1995 to 2010**	**1995 to 2020**
PMT	4993	5749	6368	6878	7358	8079	38%	62%
PM10	1530	1722	1889	2032	2168	2366	33%	55%
PM2.5	261	281	304	327	352	383	25%	46%
SO_x	609	515	519	561	561	562	-8%	-8%
NO_x	715	771	783	851	891	907	19%	27%
VOC	2051	2045	2098	2256	2296	2303	10%	12%
CO	1969	1728	1568	1508	1574	1614	-23%	-18%
NH3	148	235	256	279	305	333	88%	125%

Source: Cheminfo Services Inc.

Total anthropogenic CAC emissions are projected to be 21% higher than 1995 levels by 2010 and 38% higher by 2020. The industrial sectors (including electricity) and the Upstream Oil and Gas in particular are the major influence on SO_x emissions, which are projected to decline. However, these sectors will also contribute to increases in NO_x emissions. Emission reductions are anticipated in transportation sector. NO_x emissions from transportation, which constituted 32% of total NO_x emissions in Alberta in 1995, will decline to the point of making up only 10% of NO_x emissions by 2020.

Table 4: Projected Total 2020 Alberta CAC Emissions, Changes Since 1995

(kilotonnes)

Anthropogenic Sources	**PMT**	**PM10**	**PM2.5**	**SO_X**	**NO_X**	**VOC**	**CO**	**NH3**
Industrial (includes electricity generation)	117	68	48	551	769	818	579	15
Residential, commercial, institutional	17	16	16	1	12	73	121	0
Transportation	5	5	4	10	95	35	369	3
Area sources[12] (e.g., road dust, solvents, agric. etc.)	7885	2230	277	0	2	81	98	313
Natural Sources	54	46	38	0	29	1297	447	2
Total 2020	**8079**	**2366**	**383**	**562**	**907**	**2303**	**1614**	**333**
Total Percent Change Vs. 1995	**PMT**	**PM10**	**PM2.5**	**SO_X**	**NO_X**	**VOC**	**CO**	**NH3**
Industrial and electricity generation	39%	41%	38%	-8%	73%	47%	44%	48%
Residential, commercial, institutional	81%	83%	83%	-28%	-6%	98%	93%	-10%
Transportation	-60%	-62%	-65%	37%	-58%	-67%	-62%	65%
Area sources (e.g., road dust, solvents, agriculture, etc.)	63%	58%	64%	35%	0%	40%	1%	133%
Natural sources	0%	0%	0%	0%	0%	0%	0%	14%
Total 2020	**62%**	**55%**	**46%**	**-8%**	**27%**	**12%**	**-18%**	**125%**

Source: Environment Canada[13]. Alberta Environment. Cheminfo Services Inc.[14] AFRD[15]

The largest projected increases are in emissions of particulate matter (PM), a large portion of which is from road dust caused by vehicle travel. PM emissions are projected to increase in conjunction with total distance travelled by all vehicles in Alberta. The total number of vehicles in Alberta are projected to increase from 1.7 million in 1995 to 2.3 million in 2010 and 2.7 million in 2020 (CEOU). Light duty gasoline passenger cars and trucks account for close to 94% of Alberta's on-road vehicle fleet. Total distance travelled

[12] Area sources include road dust, and many other emissions (such as solvents use, cooking, and fuel distribution) that have not been included in the specific categories noted above (industrial, residential, commercial, institutional, or transportation).

[13] Environment Canada, *1995 Criteria Air Contaminant Emissions for Canada,* December 1998.

[14] Cheminfo Services adjustments to 1995 emissions for Oil and Gas, and some other sectors.

[15] Agriculture emissions from: Chetner, S., Sasaki, D., Alberta Agriculture, Food and Rural Development (AFRD), *Agricultural Air Emission Inventory for Alberta and Literature Review*, November 6, 2001.

by the total Alberta fleet is projected to increase by approximately 71% between 1995 and 2020. While PM vehicle-related emissions from road dust are projected to increase, fuel-related emissions from on-road vehicles are projected to decrease as a result of the implementation of improved standards and reduced sulphur content in gasoline. Improvements in transportation emissions make an important contribution to the projection for reduced emissions of CO, which by 2010 is projected to be 30% lower than 1995.

Table 5: Total Alberta Anthropogenic CAC Emissions Projection

(kilotonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	4938	5695	6314	6824	7304	8024	38%	62%
PM10	1483	1676	1843	1986	2122	2319	34%	56%
PM2.5	223	243	265	289	314	345	30%	54%
SO_x	609	515	519	561	561	562	-8%	-8%
NO_x	686	743	754	822	862	878	20%	28%
VOC	754	748	801	960	1000	1006	27%	33%
CO	1521	1280	1120	1061	1126	1167	-30%	-23%
NH3	147	233	254	277	303	331	89%	126%

1.3 Alberta Regional Emissions Forecast Summary

Estimates of forecasted 2010 emissions from each source category and for each CAC were developed for each of Alberta's 19 census divisions (or regions). In general, the methodology applied to estimate regional emissions combined previous 1995 regional estimates for area sources and incorporated the 2010 emission contributions from major facility point sources (i.e., mostly electric power plants and new oil sands projects) in the specific regions in which they are located. The methodology details applied to estimate regional emissions are provided in Section 7 "*2010 Regional Forecast.*"

The census regions surrounding and encompassing Calgary and Edmonton contain the largest sources of most of the pollutants. Residential fuel burning, transportation and agriculture are examples of large sources located in these areas. Upstream oil and gas operations and other manufacturing sources also contribute a significant amount to these regions. Forest fires are an important source in northern Alberta regions as are anticipated new oil sands projects. Descriptions of these and other regions that represent the majority of emissions for some of the pollutants are provided below, as well as examples of the major sources within those regions.

Table 6: Regions Contributing Major Proportions of CAC Emissions to 2010 Alberta Forecast

Census Region	Description of Region	Major Sources Within Region
6	Area surrounding Calgary	General concentration of industry, electric power generation, agriculture, transportation and residential
11	Area surrounding Edmonton	General concentration of industry, electric power generation, agriculture, transportation and residential
14	West of Edmonton, surrounding Edson and Willmore park	Unpaved roads (e.g., related forestry industry, other uses)
16	Northeast Alberta, including Wood Buffalo national park	Oil sands projects, forest fires and prescribed burning
17	Northwest Alberta	Forest fires, prescribed burning

Source: Cheminfo Services Inc.

The following table presents the year 2010 CAC emissions for each of the 19 census regions for each contaminant, excluding biogenic emissions.[16] Additional tables showing the regional emissions for each sector and source category are included in Appendix II.

Table 7: 2010 CAC Emission Contributions from 19 Census Regions (Excludes Biogenic Emissions)

Alberta Total (kilotonne) (Excluding biogenic emissions)	PM_T	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOC	CO	NH_3
	6878	2032	327	561	836	1021	1508	280
Region	**(% of Total Emissions)**							
1	3%	3%	3%	0%	4%	3%	3%	5%
2	4%	4%	3%	5%	4%	2%	2%	9%
3	2%	2%	1%	2%	2%	1%	2%	5%
4	5%	5%	4%	7%	4%	0%	0%	3%
5	3%	3%	2%	1%	3%	1%	2%	7%
6	9%	8%	5%	11%	9%	22%	10%	10%
7	4%	4%	4%	4%	3%	2%	1%	6%
8	3%	3%	2%	2%	4%	4%	3%	8%
9	1%	1%	1%	4%	2%	1%	0%	2%
10	7%	7%	6%	1%	3%	2%	2%	9%
11	10%	10%	8%	18%	19%	13%	14%	14%
12	5%	5%	5%	2%	4%	2%	3%	3%
13	3%	3%	3%	5%	3%	2%	2%	6%
14	30%	29%	28%	3%	3%	2%	4%	1%
15	1%	1%	1%	2%	1%	1%	1%	0%
16	2%	3%	10%	27%	20%	34%	24%	1%
17	4%	5%	11%	2%	6%	5%	23%	4%
18	1%	1%	1%	3%	3%	1%	4%	1%
19	3%	3%	3%	1%	2%	2%	1%	5%

Source: Cheminfo Services Inc. Percentages may not due to rounding.

[16] Biogenic emissions excluded from regional estimates at the request of CASA.

2. Introduction

2.1 Background

Forecasting common air contaminant (CAC) emissions can be a valuable management tool for governments, industries, environmental non-government organisations and other stakeholders as part of a broad continuous process to improve the state of the environment in a region. The CAC emissions for this forecast include primary sources of particulate matter (PM_T, PM_{10}, $PM_{2.5}$), nitrogen oxides (NO_x), sulphur oxides (SO_x), volatile organic compounds (VOC), carbon monoxide (CO) and ammonia (NH_3). These substances are important contributors to acidifying emissions as well as generation of ground level ozone (or smog). Sources of these pollutants can also release hazardous or toxic substances and greenhouse gases, along with CACs.

As part of managing the quality of the environment co-operative efforts between municipal, provincial and federal governments, as well as international partners and other stakeholders are often required. The forecast of CAC emissions is therefore of direct interest to these groups. In particular, Alberta's Clean Air Strategic Alliance (CASA)[17], which is a multi-stakeholder group in Alberta, commissioned this study to better understand the cumulative effects of many new emission sources for the province and its regions.

2.2 Approach and Methodology

The general approach in developing this forecast of CAC emissions to the year 2020 was to use Cheminfo's Energy/Emissions Model (CEEM). The model calculates CAC emissions by fuel type for energy related emissions. CEEM is calibrated to 1995 and 2000 estimates of CAC emissions[18] developed by Alberta Environment and Environment Canada[19] as well as BAU fuel use projections developed for the AMG established under the National Climate Change Process[20]. The process of calibration involved the development of emission factors per unit of fuel used in the sector as a whole. (i.e., tonnes-emissions/unit of fuel used). These emission factors were applied to future fuel

[17] http://www.casahome.org/for_stakeholders/issue_teams/index.asp

[18] Some year 2000 CAC data which was provided by Alberta Environment where incorporated in this forecast. 1995 data based on "Environment Canada, *1995 Criteria Air Contaminant Emissions for Canada,* December 1998."

[19] In collaboration with the NAICC's Emissions and Projections Working Group (EPWG).

[20] Analysis and Modelling Group/Natural Resources Canada, *Canada's Energy Outlook(CEO): An Update*, For the Analysis and Modelling Group, National Climate Change Process, December 1999.

consumption as defined in *Canada's Emissions Outlook: An Update (CEOU),* to estimate future energy-related emissions.

The "*1995 Criteria Air Contaminant Emissions for Canada*"[21] represents the most comprehensive provincial delineation of CAC emissions. In addition, Alberta Environment provided year 2000 emissions for some CACs emissions (mostly NO_x, SO_x and some PM_T) for many large industrial facilities in Alberta. Furthermore, Cheminfo Services incorporated available year 2000 fuel consumption data[22] for Alberta into its CEEM. In this way year 2000 estimates of energy-related emissions are estimated in many cases based on actual fuel consumption in the sector. However, year 2000 energy data were not available for all sectors delineated in this CAC forecast. Some major facilities therefore were contacted to fill in data gaps and obtain input on future sector emission changes.

Energy/combustion emissions derive from burning of fossil fuels (including biomass such as wood or spent liquor available to kraft pulp mills) for heat and production of electricity. Also included in combustion-related emission sources are forest fires, prescribed burning, incineration (e.g., biological wastes) and other sources where the heat of the combustion is not generally utilized as an energy source. Combustion sources that result in energy utilisation are sometimes referred to as energy-related sources. Non-combustion emissions (or sometimes referred to as process emissions) are from industrial processes, agriculture, general solvent uses (evaporative emissions) and other sources.

Non-energy combustion (e.g., incineration of wastes, structural fires, forest fires) and process emissions (e.g., evaporative VOC from solvents, fugitive and storage sources, road dust, etc.) are not directly related to energy consumption. These emissions are projected on the basis of various parameters. For example particulate emissions from vehicles (on-road and off-road dust) are projected on the basis of vehicle-distance-travelled. Emissions from natural sources, which are mainly forest fires and biogenic (e.g., vegetation, animals, etc.) are maintained constant to 1995 levels in the forecast period (to 2020). The complete set of parameters used to project all these emissions are provided in the report.

In some cases, facility-specific (i.e., bottom-up) input regarding changes in future emissions were provided by major industrial sources. In these cases, the forecast results are mere tabulations of that input, not modelled CAC emissions. These and other specific methodologies including key assumptions applied to estimate emissions in some areas (e.g., transportation, conventional upstream oil and gas) are documented in the report.

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[21] Report not available –refers to title of tabulated results distributed among government and industry by Environment Canada Pollution Data Branch, and NEIPTG.

[22] Statistics Canada, *Quarterly Report on Energy Supply-Demand in Canada, 2000-IV,* Catalogue no. 57-003-XPB, December 2001.

This CAC forecast is anchored to Alberta Environment/Environment Canada's 1995 CAC emissions (for base year 1995) and AMG/NRCan's Canada's Emissions Outlook figures. The accuracy of annual CAC emissions and energy supply/demand estimates is under constant consideration by many energy analysts, as well as federal and provincial emissions inventory practitioners, such that improvements continuously occur over time. While emissions and energy supply/demand estimates may both benefit from ongoing analysis to reduce uncertainty in some areas, it is beyond the scope of this project to undertake such analysis or consider such improvements.

In one notable case, this study found some emissions previously excluded from the 1995 oil sands inventory. In addition, 1995 transportation emissions have been modified to reflect recent updates to 1995 and forecast emissions prepared for Environment Canada (see Transportation section). Therefore, this forecast report includes some modifications to Alberta' s 1995 CAC emissions inventory estimates.

This forecast excludes potential environmental, energy and other government policies and programs that have no associated regulations currently in-place. The impacts of some specific known regulations and voluntary initiatives (e.g., energy efficiency programs) have been incorporated in this forecast, the specifics of which are detailed in the report.

2.3 Economic Assumptions

Canada's Emissions Outlook: An Update produced by AMG/Natural Resources Canada (NRCan), which forms the basis of this forecast reflects various economic and demographic changes expected to occur in Alberta and the rest of Canada between 1995 and 2020. The extensive set of data associated with the CEOU is available from AMG/Natural Resources Canada. Portions are contained throughout the report. Some of the data are presented in tables that follow. Two important components of the CEOU forecast that affect CAC emission projections are:

- continued economic growth in Alberta; and
- "policy as usual" for energy and environment.

CEOU' s macroeconomic forecast is based on input from macroeconomic modellers (namely Informetrica) which calls for robust growth in the United States. Given the strong trade links between the two countries, the strong U.S. economic performance translates into strong Canadian growth as well as growth in Alberta. Ontario is projected to lead the economic growth among the regions in Canada, with an average annual growth in GDP of 2.6%, or 92% total increase between 1995 and 2020. Alberta, Saskatchewan and Manitoba are also projected to register large increases in economic growth to the year 2020. Quebec, BC and the Atlantic Provinces are projected to grow more slowly.

Table 8: Projections for GDP in Alberta (and Other Regions)

(constant 1986 dollars in billions)

	1995	2000	2010	2020	1995 to 2010	1995 to 2020
Alberta	**73**	**85**	**106**	**133**	**45%**	**82%**
Ontario	214	250	320	411	50%	92%
Saskatchewan	19	22	28	34	48%	80%
Manitoba	18	21	27	32	49%	79%
Quebec	118	135	165	202	41%	72%
BC, YK, NWT	70	77	97	117	39%	67%
Atlantic Provinces	32	36	45	52	41%	64%
Total	**542**	**626**	**788**	**981**	**45%**	**81%**

Source: Analysis and Modelling Group / Natural Resources Canada (CEOU)

Energy consumption and CAC emission indicators that provide context of the general trends inherent in the CEOU projection period to 2020 are presented in the table below. Energy and GDP data for these indicators are from CEOU, while data on CAC emissions are results obtained from this study.

Table 9: Macroeconomic Assumptions, Energy and Environmental Performance Context for Alberta

(Excluding year 2002 AMG adjustments)

Parameter	**1995**	**2000**	**2010**	**2020**	**1995 to 2010**	**1995 to 2020**
Alberta GDP ($ billion 1986)	$73	$85	$106	$133	45%	82%
Total energy consumed (000s PJ)	1.4	1.5	1.7	1.8	21%	28%
Total CAC emissions[23] (000' kilotonnes)	10.5	11.0	12.3	13.8	18%	32%
Performance Indicators						
Energy (PJ/GDP)*	19	18	16	14	-16%	-26%
CAC emissions (kilotonne-CAC/$billion-GDP)	144	130	116	104	-19%	-28%

* CAC emissions calculated in this study. AMG/NRCan for energy and GHG emissions forecast and economic data.

[23] Total CAC emissions are the sum of PM_T, SO_x, NO_x, CO, VOC and NH_3.

Table 10: Economic Assumptions Used in AMG/NRCan (CEOU) Business-as-Usual Forecast Scenario for Alberta

	1995	2000	2010	2020
Total Real Domestic Product ($1986 Millions)	72521	85132	105828	133292
Total Industrial	2755	2905	3649	4911
Agriculture	25245	29545	34381	37697
Commercial & Public Administration	28099	33310	41231	52143
Industrial Gross Output: ($1986 Millions)				
Pulp & Paper	1781	2063	2555	3004
Chemical	3646	4413	5797	7618
Iron & Steel	242	249	273	299
Smelting & Refining	335	393	544	742
Mining	28110	33774	42618	44752
Other Manufacturing	12663	16532	20599	25135
Construction	10283	13590	16338	17696
Forestry	483	568	635	684
Cement	152	163	189	205
Petroleum Refining	5468	6203	6790	7727
Disposable Income				
Personal Disposable Income (Total Canada) ($1986 Millions)	49158	43371	53432	65595
Per Capita ($1986)	13730	14323	16103	17922
Per Household ($1986)	37447	38591	40778	42938
Prices And Costs: (1986=1.0)	**1995**	**2000**	**2010**	**2020**
GDP Deflator – Total	1.257	1.352	1.634	1.929
Industrial	1.26	1.338	1.627	1.941
Commercial	1.304	1.423	1.771	2.168
Consumer Price Index	1.335	1.465	1.77	2.148
Demographic:	**1995**	**2000**	**2010**	**2020**
Total Population ('000)	2752	3028	3318	3660
Total Households ('000)	1009	1124	1310	1528

Source: Analysis and Modelling Group / Natural Resources Canada (CEOU)

2.3.1 General Projection Assumptions for Energy-Related Emissions

In terms of environmental policies and programs incorporated in the CAC forecast, the general assumption was to exclude the potential impact of any programs for which actual regulations relating to technologies to reduce CAC emissions have not already been developed in the province. Exceptions to this are noted in the report. In areas where the environmental policies and program have been finalized and are being adopted, the forecast has incorporated changes.

This CAC forecast incorporates the effects of the *Lower Sulphur Levels in Motor Gasoline* regulations. Environment Canada announced new regulations to restrict the sulphur levels in motor gasoline sold in Canada in 1999.[24] The regulations set a limit of 30 parts-per-million (PPM) of sulphur content in gasoline starting in 2005. These new regulations, which will be phased in will reduce SO_x emissions and in combination with more sophisticated emission control technologies on new vehicles, will reduce other CAC emissions from vehicles. Although these regulations have a major impact on gasoline transportation-related SO_x emissions, they will necessitate capital investments in existing crude oil refineries to allow them to make fuels to meet the new standards (see Petroleum Refining below). The CEOU incorporates increased energy consumption as a result of the sulphur reduction requirements. Similar regulations that were also announced for sulphur levels for on-road diesel vehicles, which are to take effect in 2007, are also reflected in this forecast.

2.3.2 Basis of Regional Allocation of Emissions

Year 2010 emissions for each of the 19 census regions in Alberta were calculated for each source category for each contaminant. The approach to the regional allocation combines bottom-up facility forecast data with top-down allocations for area sources as well as small manufacturing facilities (not covered by the bottom-up data). The details of the methodology and results are discussed in Section 7, entitled "*2010 Regional Forecast*".

2.4 Use of this Report

This report is intended solely for the use of Clean Air Strategic Alliance (CASA) to be applied as an environmental analysis tool for determining the range in the magnitude of changes in CAC emissions over time.

In this capacity the forecast can assist environmental managers and stakeholders in the process of developing an understanding of the impacts of regional changes in CAC emissions. The results contained in the report are not indented to be the definitive representations of sectors' CAC emissions in the forecast period. Sector associations and specific entities within sectors may wish to apply unique and more detailed assumptions to develop a forecast of emissions at a greater level of resolution (i.e., association members, sectors, or facilities not covered in the scope of this report). These will inevitably yield results that are different than the base case presented in this forecast. Nevertheless, this forecast provides a useful "range-finding" tool in comparing the CAC emission contributions from various sectors and how they may change over time.

[24] Environment Canada, *Lower levels of sulphur in gasoline will result in cleaner air for all Canadians*, Press Release, June 7, 1999.

2.5 Rest of this Report

There are many ways to categorize and report CAC emissions. This analysis of projected Canadian CAC emissions to the year 2020 is presented using the following segmentation:

Anthropogenic Energy-Relates Sources
- industrial (including electric power generation);
- transportation;
- residential, commercial, and institutional;

Area Sources: Non-Energy
- area sources (e.g., road dust, construction, prescribed burning, solvents use, agriculture, etc.);

Area Sources: Natural
- forest fires; and
- biogenic.

Section 3 to 6 of this report include analyses of major industrial sectors (including electricity generation) emissions, residential, commercial/institutional[25], transportation, and all other anthropogenic area and natural sources. Section 7 provides year 2010 emissions for each of Alberta's 19 census regions, for each pollutant, along with the methodology that was applied to estimate these emissions. Section 8 contains a brief analysis of Environment Canada's recently released (March 2002) forecast of CAC emissions for Canada and each province, including Alberta. Section 9 addresses the uncertainty associated with the emissions estimates contained in this report.

The Appendix includes supplementary emission tables to provide context of major source categories. Additional data are provided in electronic form in accompanying Excel spreadsheets. This includes annual CAC emissions estimates for all sources, expressed in tonnes. Detailed regional emission data are also included as part of the Appendix.

2.6 Acknowledgements

The process of developing this CAC forecast for Alberta involved collaboration between the consultant - Cheminfo Services, and energy and environment managers at major industrial facilities in Alberta, experts at Alberta Environment (AENV), Alberta Energy and Utilities Board (EUB), Environment Canada (EC), and Natural Resources Canada.

[25] Commercial sector will include the institutional sector, unless otherwise noted.

Cheminfo Services would like to offer special and sincere thanks to: David Slubik at Alberta Environment who among other things greatly assisted the consultant in developing estimates from the upstream oil and gas sector; Randall Barrett at Alberta Environment who took time to review emission estimates from all of the new oil sands development projects; Satwant Lota (EUB, Utilities Branch) who provided input on assumptions and reviewed results for the electric power generation sector; Hy-Hein Tran (EC - PDB) who provided insight on the mechanisms applied to develop Environment Canada's March 2002 forecast of CAC emissions; Gerald Ertel (Shell Canada) who provided input and assistance on transportation emissions (and co-ordinated other input from Shell facilities); Doug Sasaki at Alberta's Agriculture, Food and Rural Development (AFRD) who reviewed and refined agriculture emission projections; and Jim Spangelo, Kim Eastlick and Earl Martin (EUB) who guided the consultant to suitable literature and provided assistance in sorting out upstream oil and gas processing activities and regulations. The technical input and assistance from these individuals as well as all other government and industry representatives contacted in preparing this study were invaluable and very much appreciated.

3. CAC Emissions From Industrial and Electric Power Generation Sectors

3.1 Summary

Industrial sectors and the electric power generation (EPG) sector encompass a great variety of processes and equipment that generate CAC emissions in the production of products and delivery of services, including electricity. Combustion of sulphur-containing fuels and un-recovered sulphur from upstream oil and gas operations are the major sources of SO_x emissions in Alberta. NO_x emissions are practically all fuel combustion-related, as are the majority of CO emissions. PM emissions include many process emissions as well as fuel combustion sources. Industrial sources are a relatively minor portion (i.e., 7%) of total estimated ammonia emissions in Alberta.

Table 11: Total Alberta Industrial and EPG CAC Emissions Projection

(kilotonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	84	73	86	103	113	117	23%	39%
PM10	48	43	49	61	66	68	26%	41%
PM2.5	35	32	35	42	47	48	20%	38%
SO_x	601	503	508	551	551	551	-8%	-8%
NO_x	444	500	574	682	746	769	53%	73%
VOC	554	564	634	795	828	818	43%	47%
CO	402	343	418	472	564	579	17%	44%
NH3	10	11	12	13	14	15	24%	48%

Includes Electric Power Generation.

The projected growth in emissions varies by contaminant. NO_x emissions are projected to grow the fastest as a result of increased use of fossil fuels. SO_x emissions are projected to decline largely as a result of the reduction at upstream oil and gas operations. Growth in ammonia emissions is related to increases in agriculture activities - namely, increased livestock populations and fertilizer application.

The analysis of industrial/EPG emissions focuses on five sectors that account for the great majority of emissions as well as energy consumption in the province. These sectors are shown in bold lettering in the list below.

- **Upstream oil and gas;**
- **Electric power generation;**
- **Petroleum refining;**
- **Cement;**
- **Chemicals;**
- Other industrial, namely
  - Pulp and paper
  - Mining
  - Non-ferrous metals smelting and refining
  - Iron and steel; and
  - Other manufacturing.

The five sectors account for over 90% of SO_x, NO_x and VOC and NH_3 as shown in the table below. However, for PM, NH_3, NO_x, CO and VOC the contribution from these 5 sectors to total Alberta emissions is much lower. SO_x emissions are largely derived from these 5 sectors.

Table 12: Estimated Emissions Contribution from 5 Major Sectors

(Based on Year 1995 Emissions)

Contaminant	Portion of Total Industrial Emissions	Portion of Total Alberta Emissions
PMT	27%	0.4%
PM10	35%	1%
PM2.5	42%	5%
SO_x	98%	81%
NO_x	95%	66%
VOC	100%	27%
CO	30%	5%
NH3	94%	7%

The table below shows the year 2010 emissions for each sector and the contribution to total industrial plus electric power generation sector emissions.

Table 13: Year 2010 Industrial Emissions by Sector for Each Pollutant

(tonnes)

Sector	PMT	PM10	PM2.5	SO_x	NO_x	VOC	CO	NH3
Cement	1149	388	118	2058	4836	40	311	0
Chemical	1831	1746	741	2979	29077	13690	9038	10397
Mining, Quarrying	9856	5456	4042	3479	2526	814	209	2
Iron & Steel	267	225	86	17	230	2	13	2
Non-Ferrous Metals Refining, Smelting	16	15	13	4181	465	2	25	1
Petroleum Refining	1069	1068	1067	11987	4757	793	1240	21
Pulp & Paper	2482	2258	2160	2814	4758	62	1976	123
Upstream Oil & Gas	33417	19823	12263	391996	505905	777095	202348	962
Other Manufacturing	44185	21944	13938	228	16230	582	244489	382
Electric Power Generation	8989	8067	7637	131348	113174	1453	12260	0
Total industrial/EPG	103262	60990	42064	551086	681958	794533	471911	11889
	PMT	**PM10**	**PM2.5**	**SO_x**	**NO_x**	**VOC**	**CO**	**NH3**
Cement	1.1%	0.6%	0.3%	0.4%	0.7%	0.0%	0.1%	0.0%
Chemical	1.8%	2.9%	1.8%	0.5%	4.3%	1.7%	1.9%	87.4%
Mining, Quarrying	9.5%	8.9%	9.6%	0.6%	0.4%	0.1%	0.0%	0.0%
Iron & Steel	0.3%	0.4%	0.2%	0.0%	0.0%	0.0%	0.0%	0.0%
Non-Ferrous Metals Refining, Smelting	0.02%	0.02%	0.0%	0.8%	0.1%	0.0%	0.0%	0.0%
Petroleum Refining	1.0%	1.8%	2.5%	2.2%	0.7%	0.1%	0.3%	0.2%
Pulp & Paper	2.4%	3.7%	5.1%	0.5%	0.7%	0.0%	0.4%	1.0%
Upstream Oil & Gas	32.4%	32.5%	29.2%	71.1%	74.2%	97.8%	42.9%	8.1%
Other Manufacturing	42.8%	36.0%	33.1%	0.0%	2.4%	0.1%	51.8%	3.2%
Electricity	8.7%	13.2%	18.2%	23.8%	16.6%	0.2%	2.6%	0.0%

May not add to totals shown due to rounding.

Emission summary tables for each of the Other Industrial sectors are also provided. However, only brief commentary is provided on forecasts for these sectors. The category of "Other Manufacturing" encompasses all of the remaining industrial sectors including a fragmented set of small manufacturing facilities. These include lumber mills, printing plants, plastics processors, light metal fabrication shops, and a host of other industrial facilities. While emissions for these facilities are encompassed in the results, they are not individually forecast or analysed.

3.2 Electric Power Generation

Alberta's electric power generation is poised to grow to meet the requirements of a rapidly growing provincial economy. There have been public announcements for major new power generating facilities. New facilities based on using coal as well as natural gas are anticipated. Additional capacity (beyond that which has been announced) has been assumed. Power generation capacity is projected to increase by approximately 40% between 2000 and 2010. Industry sources from the electric power generation sector contacted in this study also indicate that some of the smaller older units are likely to close by 2010 or soon thereafter. At some other units incremental capacity expansions are expected.

Table 14: Estimated Electric Power Generation Forecast

(Excludes power generation units announced for specific oil sands development projects)

Capacity (gigawatts)		**1995**	**2000**	**2005**	**2010**	**2015**	**2020**
Coal	GW	5.8	5.7	6.3	7.4	7.4	7.4
Gas	GW	1.5	2.3	3.3	3.8	4.3	4.8
Hydro	GW	0.3	0.3	0.3	0.3	0.3	0.3
Wind, biomass, other	GW	0.2	0.2	0.3	0.4	0.4	0.5
Total Capacity	**GW**	**7.7**	**8.5**	**10.2**	**11.8**	**12.4**	**12.9**
Power Generation							
Coal	TWH	46	45	49	65	64	64
Gas	TWH	5	11	18	21	24	28
Hydro	TWH	2	2	2	2	2	2
Wind, biomass, other	TWH	1	1	2	2	2	2
Total	**TWH**	**53**	**59**	**71**	**89**	**92**	**96**

Actual for 1995. Estimated for all other years.

The major power generation expansions include:

- Fording's coal based facility in Brooks (2006, 2007);
- TransAlta's coal based facility in Keephills (2007, 2008);
- AES Calgary's natural gas combined cycle (NGCC) based facility near Calgary (2005); and
- EPCOR's coal based facility in Genesee (2005).

Table 15: Capacities and Expansions of Major Electric Power Generating Companies in Alberta

(megawatts)

Company	Location	2000	2010	2020
TransAlta (existing)	Wabamun, Sundance, Keephills	3520	3086	3086
TransAlta (expansion)	Keephills	0	900	900
Edmonton Power (EPCOR) (existing)	Genesee	1480	1480	1480
Edmonton Power (EPCOR) (expansion)	Genesee	0	500	500
TransAlta/ATCO Electric	Sheerness	800	800	800
ATCO Electric	Battle River	675	675	675
Fording	Brooks	0	1000	1000
AES Calgary	Calgary	0	500	500

Beyond the publicly-announced capacity expansions, it has been assumed that additional increases in capacity will occur to the year 2020. Furthermore, it has been assumed that most of this incremental power generation capacity (beyond announced) will be natural gas combined cycled (NGCC). Smaller increases in wind power and other sources were also assumed. It was assumed that increases would not occur in hydro power and coal-fired generation capacity (beyond that already announced).

New power generation facilities have also been announced at specific oil sands project developments. Announced NGCC capacity that has been explicitly identified is approximately 0.5 GW. The related CAC emissions from generation units at oil sands development projects are included as part of the Upstream Oil and Gas sector (see below). This maintains sector-definition consistency of the potential CAC emission contributions from those projects. Similarly, CAC emissions from industrial cogeneration facilities are included in their respective sectors. However, some of the current industrial power generation capacity (excluding oil sands) is included in the Table 14 above.

3.2.1 Emission Trends

Alberta's electric power generating sector is a major source of SO_x and NO_x emissions, accounting for approximately 20% of total provincial SO_x and 13% of NO_x emissions. By comparison, the sector's portion of other CAC emissions is less than 3% of provincial totals. Practically all of the SO_x emissions are from the coal-fired power plants. These plants also account for 80% to 90% of NO_x emissions from the sector.

Table 16: Forecast of Emissions from Electric Power Generation

(kilotonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	10	9	9	9	9	9	-7%	-8%
PM10	9	7	7	8	8	8	-10%	-11%
PM2.5	9	6	7	8	8	8	-13%	-13%
SO_x	130	125	129	131	131	131	1%	1%
NO_x	91	94	102	113	115	117	25%	29%
VOC	1	1	1	1	1	1	32%	34%
CO	8	9	11	12	13	13	54%	64%
NH3	0.5	0.5	0.5	0.6	0.7	0.7	25%	29%

Note: Excludes emissions from power generation at oil sands developments.

Although power generation capacity and production are forecast to grow during this decade, emissions are not expected to match this growth. New power generating plants will be complying with new provincial emission performance standards. Alberta's new standards for power facilities came into effect in mid-2001. The impact of these emission standards will be to control the majority of additional potential PM, PM_{10}, $PM_{2.5}$, and SO_x emissions, as well as a portion of potential NO_x emissions from new coal-fired generating plants. Most natural gas based facilities would be in compliance with the new standards for all CACs. For example, one NGCC system in Alberta, which features continuous emissions monitoring, operates with a NO_x emissions rate of 50 to 80 nanograms/joule-in (ng/J-in). It has been assumed that new NGCC generating stations will operate close to 80 ng/joule-in. The new emission performance standards combined with the closure of some older emissions-intensive facilities should result in lower PM_T, PM_{10}, $PM_{2.5}$ and very little growth in SO_x emissions.

Table 17: Emission Performance Standards for Electric Power Generating Facilities in Alberta

(nanograms/joule-in - ng/J)

	Average Alberta Coal-Fired Facility*	Existing (New) Alberta Standards	Potential Technology Implication or Equivalent
PM_T	20	13	Baghouses
NO_x	164	125	Selective Non-Catalytic Reduction (SNCR) and Low-NO_x burners
SO_x	270	180	Wet scrubbing

* Based on 1995 consumption of coal for power generation and related estimated emissions.

In some cases, new facilities will have emission rates that are even lower than the new performance standards. For example, EPCOR's expansion at Genessee will feature SO_x levels between 75 and 80 ng/joule-in. Similarly, TransAlta's expansion at Keephills will feature SO_x emissions lower than the standards. Another factor that will dampen the growth for NO_x emissions is increased market penetration of natural gas combined cycle (NGCC) facilities that operate with lower NO_x emission rates per unit of power generated, than existing facilities (and have negligible SO_x emissions).

SO_x emissions are projected to increase slowly from year 2000 levels. The power generation share of natural gas will increase and older, coal-based units with higher sulphur emissions per unit of power generated are likely to be shut down. Any new coal-fired units will feature higher efficiency and lower SO_x emissions per unit of power generated. No new coal facilities have been assumed in period 2010 to 2020. It has been assumed that all of the increase in power generating capacity is based on natural gas.

Government, industry and other stakeholders are engaged with CASA to develop an air emissions management approach including standards and performance expectations for the Alberta electricity sector. Recommendations from this process are expected in 2003. Since it is unknown what emission standards will be required, the potential effects of these standards have not been incorporated in this forecast.

3.3 Upstream Oil and Gas

The upstream oil and gas industry is a large, vital and growing component of Alberta's economic landscape. While the industry is projected to continue to grow its production, the rate of growth of CAC emissions will not match that growth. However, most CAC emissions will continue to rise and will be significantly greater than current or 1995 levels. The exception is SO_x emissions, which will increase from year 2000 levels, but are projected to be 11% to 12% lower than 1995 levels by 2010 and 2020.

Table 18: Forecast of Total Emissions from Upstream Oil and Gas Industry

(includes oil sands, bitumen upgraders, upstream oil & gas facilities)
(kilotonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	6	7	19	33	39	40	463%	568%
PM10	4	4	10	20	22	23	463%	541%
PM2.5	3	3	7	12	15	16	329%	446%
SO_x	440	354	355	392	390	389	-11%	-12%
NO_x	298	346	413	506	564	580	70%	94%
VOC	541	548	617	777	810	799	44%	48%
CO	81	87	158	202	280	283	151%	251%
Ammonia	0.8	0.9	0.9	1.0	1.2	1.2	25%	58%

For this forecast, different emission source categories for CAC emissions have been defined, since there are different factors affecting growth in emissions from each category. These categories are:

- oil sands (including extraction, heavy oil and bitumen upgrading);
- conventional natural gas production (includes gas well testing, flaring and processing);
- conventional crude oil production (includes solution gas flaring).

3.3.1 Oil Sands and Upgraders

Many new projects have been announced for the extraction and upgrading of oil from the large oil sand reserves in Alberta. Companies involved with these projects have been providing environmental impacts assessment (EIA) reports to the regulatory authorities (i.e., Alberta Energy and Utilities Board, and Alberta Environment). EIAs are available to the public. Regulatory authorities require these EIAs to determine cumulative effects of

existing emission sources plus new sources from proposed projects. One of the more recent EIAs was submitted by Petro-Canada for its proposed development at Meadow Creek.[26] Petro-Canada and other industry representatives contacted for this study pointed out that the best source of readily available information on anticipated CAC emissions from the oil sands projects are the EIAs. These documents also have the advantage of being in the public domain and therefore can be used as a common reference point. In preparing this forecast of CAC emissions from the oil sands projects the following methodology was applied:

- obtained Petro-Canada EIA on Meadow Creek;
- used emission estimates from projects contained in Petro-Canada EIA to estimate total oil sands emissions;
- refined some facility estimates with direct input from industry representatives (e.g., Shell, Syncrude, Suncor); and
- refined and confirmed project estimates with Alberta Environment.

The table below shows estimates of capacity for various locations or projects. In some cases capacity information was not identified through the research applied. However, emission estimates were available for the projects documented in the table below. The capacity estimates in the table are not additive, since bitumen production as well as bitumen upgrading capacity are shown (and therefore should be double counted). In some cases, one or the other is shown. For example in the case of Shell, the capacity of the Scotford upgrader is shown. This facility, which is expected to start-up in 2002, will have a capacity of approximately 100,000 barrels per day. The Albian Sands project scheduled to start-up at the same time will provide the bitumen via pipeline to the facility. In the cases of Syncrude and Suncor, upgrader capacities are shown.

[26] Petro-Canada, *Application for the Approval of Meadow Creek Project,* December 2001.

Table 19: Capacity of Announced Oil Sands Projects

(barrels per day)

Company	Location/Project	2000	2005	2010
Syncrude	Fort McMurray	300,000	725,000	1,375,000
Suncor	Fort McMurray (Millenium, Firebag, Voyageur)	115,000	260,000	525,000
Shell	Scotford upgrader	0	177,000	177,000
Shell	Jackpine Mine	0	0	200,000
Albian Sands	Muskeg River Mine	0	155,000	155,000
OPTI	Burnt Lake Pilot	3,000	3,000	3,000
OPTI	Long Lake Project (in-situ and upgrader)	0	0	60,000
Northstar	Pilot (AOSTRA)	2,000	2,000	2,000
Imperial Oil Ltd.	Cold Lake	100,000	150,000	150,000
Imperial Oil Ltd.	Mahihkan and Nabiye	0	0	30,000
Conoco	Fort McMurray	0	0	50,000
Jacos	Fort McMurray Pilot	6,000	10,000	10,000
Jacos	Fort McMurray Commercial project	0	0	50,000
CNRL - Canadian Natural Resources Ltd.	Burnt Lake Pilot (capacity unknown)			
CNRL - Canadian Natural Resources Ltd.	Primerose and Wolf Lake	57,000	116,000	116,000
CNRL - Canadian Natural Resources Ltd.	Horizon Project (with onsite upgrader)	0	0	180,000
Pan Canadian	Christina Lake Thermal Project	0	0	85,000
Husky	Tucker and Lease 87	0	0	*143,000 (by 2015)*
Blackrock Ventures Inc.	Orion	0	10,000	20,000
Rio Alto Exploration Ltd.	Kirby			30,000
Alberta Energy	Foster Creek Expansion		100,000	100,000
Synenco	Firebag River		20,000	80,000
Exxon/Mobil	Kearl Oil Sands Mine (and Upgrader)			185,000
TrueNorth	Fort Hills Project			95,000
Petro-Canada	Meadow Creek			60,000
Petro-Canada	McKay River			22,000
Petro-Canada	Lewis Project			60,000

The announced capacity for production in the province does not match the announced increases in capacity for upgrading and oil refining. This study did not have the scope of developing estimates for potential new upgrader or oil refining capacities for which no public announcements have been made. The inherent implication is that the bitumen or oil will need to be exported from the province. This could result in conservatively low

estimates for future CAC emissions, in that new upgraders may follow production. On the other hand, some of the projects announced may not come to fruition due to market, investment or other factors.

The major sources of CAC emissions from the oil sands activities include:

- fuel combustion (notably SO_x from oil and coal, NO_x and CO from all fuels);
- spent solvent emissions released from upgraders (VOC) to tailing ponds;
- sulphur recovery facilities (SO_x);
- power (steam/electricity) generation equipment (all CACs); and
- operations of mining equipment (all CACs).

This is not a comprehensive list of the many more potential sources of CAC emissions from oil sands mining and upgrading operations.

3.3.1.1 Emission Trends From Oil Sands and Upgraders

Between 1995 and 2000, most emissions from oil sands operations increased. This is a result of increased production, although environmental improvements curtailed the increase to some degree. A notable exception was a sharp decline in SO_x emissions. This drop came about as a result of the installation of a flue gas desulphurization (FGD) unit at Suncor and operational improvements at Syncrude between 1996 and 2000. Suncor's FGD unit was installed to control a portion of the potential SO_x emissions from the facility. With expansions in capacity, these companies anticipate adoption of increased levels of control to address future increases in potential SO_x emissions. For example, Syncrude anticipates that their SO_x emissions will drop even though their capacity for bitumen upgrading could increase to over 1 million barrel per day by 2020. As part of the expansion involving a new coker, by 2005, the company will have installed a desulphurization unit to control coker emissions. Similar installations are anticipated for any future expansions.[27] Similarly, Suncor anticipates a probable requirement to install controls to address a greater portion of potential SO_x emissions when their Voyageur expansion comes on stream in 2008.[28] The level of controls (inherent in the EIAs reviewed for this study) are not explicitly available (although included in the emission estimates). Some facilities may not be applying any technologies to address SO_x emissions.

[27] Source: Syncrude
[28] Source: Suncor

Table 20: Forecast of Emissions from Oil Sands Developments

(Including upgraders) (kilotonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	5	6	17	32	37	38	568%	693%
PM10	2	3	9	18	20	21	669%	771%
PM2.5	2	2	6	11	13	14	520%	695%
SO_x	164	94	117	162	164	164	-1%	0%
NO_x	43	54	89	159	198	202	275%	374%
VOC	56	61	125	280	301	304	401%	444%
CO	40	41	106	147	222	223	271%	461%
NH3	1	1	2	3	4	4	271%	461%

Many of the new oil sands projects will involve use of steam assisted gravity drainage (SAGD) technology. The Suncor Firebag project and the Petro-Canada's MacKay River projects are SAGD examples. This technology involves injecting steam underground to enhance flow to the surface. A major source of emissions from this process are the steam generating power plants (boilers), which will consume fossil fuel and result in combustion related emissions. Fuels to be used for steam and power generation include: natural gas, oil and even some coal. Energy is also required for upgrading operations. In some cases, companies are installing natural gas combined cycle (NGCC) facilities at the mine site to make electricity as well as steam. The emissions from these units are included as part of the oil sands development.

Upgrading the oil sands bitumen can involve the use of hydrocarbon solvents to separate the sand from the oil. In these situations, a substantial amount of solvent is required. This solvent can be produced from the upgrader itself. While much of this solvent is internally recycled, spent solvent, which is a small fraction of the total applied, is released to tailings ponds, from which a portion will evaporate. Industry sources contacted in this study point out there is uncertainty with respect to the portion of the solvent that actually evaporates. Some components in the solvent attach to the sand particles that are also sent to the tailings pond. Industry sources have provided their estimates of the total VOC emitted from these sources. This amount of solvent, which was nearly 60 kilotonnes in 1995, was not included in Alberta Environment's provincial or Environment Canada's national 1995 CAC emissions inventory.[29] It has been included in this report.

While only a small fraction of solvent is released, the total over a year can be substantial in proportion to other industrial VOC emission sources in Alberta. Suncor's and Syncrude's operations currently have large VOC emissions from this source. Other upgraders and oil

[29] Source: Alberta Environment

sands mines expected to come into production will add to these VOC releases. One exception will be the Shell upgrader in Scotford. Shell's upgrader will receive a bitumen/solvent mix via pipeline from Albian Sands. The solvent is required to enhance the flow of the viscous bitumen. At the upgrader, the solvent will be separated from the bitumen, recovered and placed back into a pipeline for delivery back to Albian Sands. The amounts of VOC emissions from this process are anticipated to be low, although specific estimates were not available. At some other operations, spent solvents will be released to collection ponds.

3.3.2 Conventional Oil and Gas Production

NO_x, VOC and CO emissions from conventional oil and gas production are projected to increase. SO_x emissions from this segment of the oil and gas industry are projected to decline, as shown in the table below. Some of the major factors affecting forecast emissions include:

Factors that contribute to reduced emissions

- new AEUB sulphur recovery regulations for older (grandfathered) gas processing facilities;
- new AEUB gas flaring regulations for older (grandfathered) gas processing facilities;
- reduced conventional crude oil production;
- reduced solution gas flaring;

Factors that contribute to increased emissions

- increased natural gas production; and
- increased processing of gas with higher sulphur levels production.[30]

[30] The potential effects of increased sulphur levels in gas were not incorporated in this forecast.

Table 21: Forecast of Emissions from Conventional Oil and Gas Production Activities

(kilotonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	1	1	2	2	2	2	45%	74%
PM10	1	1	2	2	2	2	45%	74%
PM2.5	1	1	2	2	2	2	45%	74%
SO_x	276	260	238	230	227	225	-17%	-19%
NO_x	256	292	324	346	366	378	35%	48%
VOC	485	486	492	497	509	495	3%	2%
CO	41	47	52	55	59	60	35%	48%
NH3	0.01	0.01	0.01	0.01	0.01	0.01	35%	48%

3.3.2.1 SO_x Emissions Trends

SO_x emissions related to conventional oil and gas production are projected to decrease. The major factors contributing to this slow decline are new sulphur recovery requirements for older gas processing facilities (see below) and reduced flaring. Partially offsetting these effects will be increases in gas production.

Table 22: Forecast of SO_x Emissions from Conventional Oil and Gas Production

(kilotonnes)

Source	Basis of Projection	1995	2000	2005	2010	2015	2020
Grandfathered gas plants *	ID 2001-03 Effects	121	115	105	97	92	91
Flaring at natural gas plants	ID 2001-03	30	36	29	24	21	18
Non-grandfathered gas plants *	CEOU Gas Production	42	42	47	50	53	56
Gas well testing	CEOU Gas Production	30	34	38	41	43	44
Solution gas flaring	EUB Input	52	32	18	18	17	16
Total conventional oil and gas		**276**	**260**	**238**	**230**	**227**	**225**

* Actual year 1995, 2000 emissions from Alberta Environment.

Gas production has been forecast to grow in Alberta. The projected growth in gas production shown in the table below has been used to project SO_x emissions (beyond 2000) for gas well testing and non-grandfathered gas processing facilities, which are already operating at high sulphur recovery levels (see below).

In one respect, this forecast of SO_x emissions may be considered high, in that current programs and regulations are having a better than expected effect in reducing SO_x emissions. On the other hand, as known natural gas reserves are drawn down, there is the potential for greater concentrations of sulphur levels. This could result in greater amounts of recovered sulphur as well as sulphur emissions.

Table 23: Forecast Production of Natural Gas in Alberta

(billion cubic feet)

	2000	**2005**	**2010**	**2015**	**2020**
Production	4847	5372	5752	6076	6278
Average annual growth between periods		2.1%	1.4%	1.1%	0.7%
Total change since 1995		11%	19%	25%	30%

Source: Analysis & Modelling Group/Natural Resources Canada, Canada Emissions Outlook: An Update, December 1999 (CEOU)

The Alberta Energy and Utilities Board (EUB) and Alberta Environment (AENV) completed a review of the sulphur recovery guidelines for sour gas plants in Alberta. Interim Directive ID 2001-03, released on August 29, 2001, set out the revized new sulphur recovery guidelines applicable to sour gas plants, other upstream petroleum facilities, and downstream petroleum operations, including refineries and heavy oil and bitumen upgraders. The guidelines and requirements set out in this ID become effective January 1, 2002, and replace IL 88-13: Sulphur Recovery Guidelines—Gas Processing Operations in its entirety.[31]

[31] EUB, *Interim Directive ID 2001-03: Sulphur Recovery Guidelines For The Province Of Alberta*, August 29, 2001, http://www.eub.gov.ab.ca/bbs/ils/ids/id2001-03.htm

Table 24: Alberta 2001 Sulphur Recovery Guidelines

Sulphur Inlet Rate	% of Sulphur Inlet That Must be Recovered	
(tonnes/day)	Design Sulphur Recovery Criteria	Calendar Quarter-Year Sulphur Recovery Guidelines
1-5	70	69.7
>5-10	90	89.7
>10-50	96.2	95.9
>50-2000	98.5-98.8[1]	98.2-98.5[2]
>2000	99.8	99.5

[1] Recovery = 98.18185 + 0.187259 $\log_{10}$(sulphur inlet rate).
[2] Calendar quarter-year recovery = 97.88185 + 0.187259 $\log_{10}$(sulphur inlet rate).
Source: EUB

3.3.2.1.1 Effect of EUB ID 2001-03 Sulphur Recovery Requirements

When more stringent sulphur recovery guidelines were established by the EUB in 1988 (IL-88-13), a portion of the sour gas processing facilities were grandfathered and did not need to meet those higher sulphur recovery level requirements. The new sulphur recovery requirements (2001) have the effect of de-grandfathering processing facilities over time. By 2017, all gas processing facilities will need to meet the new requirements, set out in the table above.

Approved sulphur emissions from the 33 grandfathered sulphur recovery plants totals 495 tonnes/day (equivalent to 361 kilotonnes/year of SO_2). However, actual 1998 emissions were 176 tonnes/day (equivalent to 128 kilotonnes/year of SO_2). Comparison of current approvals with IL 88-13 quarterly sulphur recoveries at approved sulphur inlet rates suggests that elimination of grandfathering would reduce approved emissions by 255 tonnes/day or 51%. Based on actual 1998 sulphur inlet rates however, the potential reduction in sulphur emissions would only be about 64 tonnes/day (47 kilotonnes/year of SO_2) or 36%. Thus, while the potential to reduce sulphur emissions by ending grandfathering appears significant on the basis of plant approval information, analysis of operating data suggests that potential reductions in actual sulphur emissions would be significantly less at current operating levels.[32]

It is also noted that several of the grandfathered sulphur recovery plants, on the basis of average 1998 sulphur inlet and plant performance, currently already approach or exceed

[32] EUB, *Review Of The Application of Sulphur Recovery Guidelines In Alberta, Discussion Paper* For Stakeholder Consultation, September 1999.
http://www.eub.gov.ab.ca/bbs/documents/reports/s_recvry-disc-paper-9909.PDF

IL 88-13 sulphur recovery levels. When actual 1998 operating data are taken into account, however, 13 plants potentially would not need sulphur recovery facilities under IL 88-13 and the potential reduction in emissions would be 27 tonnes/day (20 kilotonnes/year of SO_2) or 15% of actual 1998 emissions.[33] The full effect of this reduction would be realized by 2017.

3.3.2.1.2 Flaring at Natural Gas Plants

With respect to acid gas flaring (AGF), on the basis of approved sulphur inlet, implementation of sulphur recovery at the 28 grandfathered acid gas flaring gas plants would reduce approved emissions from 90 tonnes/day to 20 tonnes/d, a reduction of 70 tonnes/day or 77%. When actual 1998 operating data is taken into account, however 13 plants might not need sulphur recovery facilities and the potential reduction in emissions would be 27 tonnes/day, or 30%.[34]

For this forecast, future SO_x emissions estimates were generated for natural gas well flaring facilities using a simplified interpretation of the new ID 2001-03 requirements. As per the requirements, the basis for projecting emissions assumed that grandfathered facilities would have their sulphur levels reduced by 27% in 2005 from 2001 levels, and 7.5% (versus 2001 base year) for each year thereafter until 2017. Under the requirements, natural gas flaring facilities must either reduce sulphur inlet rates or comply with the higher recovery levels shown in the table above. The requirements also indicate that facilities with inlet sulphur levels less than 1 tonne/day have no requirements to recovery sulphur. It was assumed that rather than reduce gas production (and corresponding inlet sulphur rates), that the grandfathered facilities would undertake technology changes to improve sulphur recovery, thereby de-grandfathering themselves. The net result of these assumptions is that sulphur levels are reduced by approximately 50% from year 2000 levels (and 40% from 1995 levels).

3.3.2.1.3 Solution Gas Flaring

SO_x and other CAC emissions (e.g., VOCs - see below) from solution gas flaring are projected to decline, continuing a downward trend over the last 5 years. The EUB concluded that flaring and venting of solution gas has been reduced by approximately 38% from the 1996 level, by the year 2000. A reduction target of 15% was set for year-end 2000 and 25% for year-end 2001. These were firm targets recommended by CASA. The

[33] ibid

[34] EUB, *Review Of The Application of Sulphur Recovery Guidelines In Alberta, Discussion Paper* For Stakeholder Consultation, September 1999.

reduction by industry exceeds the 25% target set for year-end 2001. Details of the context these reductions are readily available from EUB and need not be repeated here.[35]

Most of the reductions in SO_x (as well as VOC) emissions from solution gas flaring (and venting for VOC) are projected to take place between 2000 and 2005, with minor reductions after 2005. EUB representatives expect that by 2005, SO_x emissions will be 60% to 65% below 1996 levels. Post 2005, SO_x emissions are assumed to decline in proportion to reduction in the production of conventional crude oil in Alberta (as per CEOU).

It should also be noted that in September 2000, the CASA board approved formation of a second flaring/venting project team to review existing guidelines and establish a venting management framework. Venting is the major source of VOC emissions in the upstream oil and gas industry.

3.3.2.2 NO_x, VOC Emission Trends

A 1999 study conducted for the Canadian Association of Petroleum Producers (CAPP) developed an inventory of emissions from upstream oil and gas production.[36] 1995 NO_x and VOC emissions from the study were adopted by Alberta Environment and Environment Canada to establish 1995 provincial and national inventory of emissions. These same emission estimates were used as the 1995 anchor year on which projections in this report are based. In the case of CO emissions, slightly different estimates were adopted from Alberta's 1995 inventory. Using 1995 as an anchor year, projections were made by applying a variety of growth factors, with an attempt to reflect future activity data related to the actual source of the emissions. Crude oil and natural gas production forecasts, as shown in the table below, were applied to many sources.

[35] Alberta Energy and Utilities Board (EUB), Upstream Petroleum Industry Flaring Report For Year Ending December 31, 2000, July 2001. http://www.eub.gov.ab.ca/bbs/products/STs/st60b-2001.pdf

[36] Clearstone Engineering Ltd., *A Detailed Inventory of CH4 and VOC Emissions from the Upstream Oil and Gas Operations in Canada,* Calgary, AB, 1999.

Table 25: Forecast of Conventional Crude Oil and Gas Production

(Forecast estimates for 2000)

	1995	2000	2005	2010	2015	2020
Crude oil	(thousand barrels per day)					
Light crude oil	723	603	581	563	550	502
Heavy crude oil	243	271	250	233	222	199
Pentanes	147	189	201	212	216	220
Total conventional oil	1113	1063	1032	1008	988	921
	(billion ft^3)					
Total gas production	4246	4847	5372	5752	6076	6278

Source: CEOU

The major sources of NO_x and CO emissions are from fuel combustion. Fuel is required to generate heat and steam in many facilities. Most of the fuel is consumed for natural gas processing and transmission. Using 1995 emissions as an anchor, projections for combustion-related NO_x and CO emissions for natural gas and conventional oil production were made based on increased natural gas production (fuel consumption data specific to these emissions are not available). The table below shows the projection for conventional oil and gas and the natural gas forecast production on which NO_x emissions are projected. NO_x emissions for oil and gas are included in the estimates.

Table 26: Forecast of NO_x Emissions from Conventional Oil and Gas Production

Basis of Forecast	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
NO_x Emissions (kt) (Increased with natural gas production below)	256	292	324	346	366	378	35%	48%
Basis of Projection Natural Gas Production (CEOU) (billion ft^3)	4246	4847	5372	5752	6076	6278	35%	48%

VOC emissions were projected using a variety of growth factors, which attempt to reflect the actual activities from various sources. These surrogates for growth are shown in the table below.

Table 27: Forecast of VOC Emissions from Conventional Oil and Gas Production

(kilotonnes)

Source	Basis of Forecast	1995	2000	2005	2010	2015	2020
Fuel combustion	Energy Consumption	8	9	9	10	12	13
Natural gas flaring	Flaring Guides	10	6	4	4	3	3
Oil and gas well drilling	Conventional oil production	0.3	0.3	0.3	0.3	0.3	0.3
Oil and gas well servicing	Conventional oil production	0.1	0.1	0.1	0.1	0.1	0.1
Natural gas production	Gas production	81	92	102	110	116	120
Conventional oil production	Conventional oil production	301	288	279	273	267	249
Heavy oil production	Conventional HO production	29	32	29	27	26	23
Crude bitumen production	Heavy oil production	4	4	5	6	10	10
Natural gas processing	Gas production	19	22	24	26	27	28
Natural gas transmission (combustion)	Gas production	0.1	0.2	0.2	0.2	0.2	0.2
Natural gas transmission	Gas production	2	2	2	2	3	3
Liquid transportation	Total oil production	17	19	23	24	28	29
Accidents and equipment failures	Total oil production	3	3	3	4	4	4
Surface casing ventblows/gas migration	Gas production	8	9	10	11	12	12
Total		**481**	**486**	**492**	**497**	**509**	**495**

3.3.3 Additional Potential Technical and Business Considerations

There are many other technology (as well as business) factors that have the potential to influence future emissions from the upstream oil and gas sector. These can contribute to increased emissions as well as decreased emissions, versus the base case forecast presented in this report. Some of the technical considerations that should be explored and quantified through more focused work in this sector are listed below.[37]

- Energy requirements per unit of production will increase as the exploitation lifecycle of individual reserves progresses (e.g., due to increasing specific compression requirements as the pressure in gas reservoirs decreases, and increasing specific water disposal requirements as both oil and gas reservoirs are drawn down).
- All new compressor and pump engines will tend to have much lower average NO_x rates than the current industry average due to the required use of low-NO_x units in most new applications as specified in Alberta Environment's Code of Practice for Compressor and Pumping Stations and Sweet Gas Processing Plants.

[37] Identified from CASA feedback comments from on Draft Report.

- As reservoirs are depleted, plants will have to go farther a field to replace production resulting in greater gathering and transmission distance, and corresponding increased energy requirements per unit of production.
- The average H_2S content of produced gas is expected to increase as companies drill deeper to replace current gas supplies.
- Impact of changes to natural gas prices, crude oil prices, and other business factors that may affect the development of the sector.

3.4 Petroleum Refinery

There are five petroleum refiners in Alberta, although the Parkland refinery, which is currently idle, is a smaller facility largely involved with processing condensates.[38] The petroleum refining sector in Alberta, which services provincial demands as well as markets in other western Canadian provinces and the United States, is expected to continue to slowly grow its production capability. At the same time some refiners are modifying their operations to accommodate the refining of more synthetic oil, as well as meet new environmental pressures, including reduced sulphur levels in fuels. Energy requirements and related CAC emissions are therefore projected to increase.

Table 28: Petroleum Refiners in Alberta

Company	**Location**
Husky Oil Operations Ltd.	Lloydminster
Imperial Oil Ltd.	Strathcona
Parkland Refining Ltd.*	Bowden
Petro-Canada Products	Edmonton Refinery
Shell Canada Products Ltd.	Scotford

* Currently idle

[38] The inherent assumption in this forecast is that Parkland, which accounted for nearly 5% of SO_x and 1% of NO_x emissions in the sector in 2000, will resume operations by 2005.

3.4.1 Emission Trends

Most CAC emissions from the petroleum refining industry in Alberta are expected to increase slowly from year 2000 levels. Nevertheless, SO_x emissions, which dropped between 1995 and 2000, will be lower than 1995 levels by 2020. All other CAC emissions are projected to be higher than 1995 levels by 2010 and 2020.

Table 29: Forecast of Emissions from Petroleum Refining Sector

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	833	883	1043	1069	1123	1179	28%	41%
PM10	832	882	1042	1068	1122	1177	28%	41%
PM2.5	832	882	1041	1067	1121	1176	28%	41%
SO_x	15232	9755	8617	11987	12617	13247	-21%	-13%
NO_x	3956	4599	4614	4757	4986	5222	20%	32%
VOC	755	1136	767	793	832	872	5%	15%
CO	1044	1450	1200	1240	1300	1361	19%	30%
NH3	17	24	21	21	22	23	22%	34%

Refiners in the province have been making operational changes that have resulted in environmental improvements. These include: implementation of leak detection and repair (LDAR) programs that can reduce hydrocarbon losses (i.e., VOCs); adoption of technologies to improve energy consumption and related fuel combustion emissions; and improved sulphur recovery. The trend towards environmental improvements is expected to continue. Inherent in this forecast of emissions are continuous incremental improvements in energy efficiency (approximately 0.5% to 1.5% per year).

Process changes identified at some refineries will also reduce SO_x emissions by 2005, although other changes after 2005 will see SO_x emissions increase from the sector. Examples of changes at some major refineries are described below.

Petro-Canada operates a 155,000 barrel per day refinery in Edmonton. The refinery processes a mix of crude types including: synthetic crude, as well as conventional sweet (low in sulphur content) and sour crude with higher sulphur content levels. Emissions sources include:

- the CO boiler, which uses off-gases from the fluidized catalytic cracking (FCC) unit and possibly other processes. The CO boiler is a major source of SO_x and NO_x emissions;
- fuel boilers (NO_x);
- sulphur recovery units (SO_x);
- storage tanks, as source of VOCs; and
- pumps, flanges, valves, etc. (fugitive emissions of VOCs).

The company has plans for at least two major changes to the refinery that will affect future emissions, most notably SO_x emissions. One change will involve process modifications to reduce the sulphur content in gasoline. This objective will result in process changes that will reduce the sulphur content of the gas oil feed for the fluidized catalytic cracking (FCC) unit. The gas oil will be hydrotreated and the sulphur will be largely removed before it is sent to the FCC unit. As a result the gases from the FCC unit sent to the CO boiler will be substantially lower in sulphur. This project is expected to operational by 2003. Total SO_x emissions from the refinery will therefore be reduced by nearly 40% by 2004.

The second major change at the Petro-Canada refinery will be transition to use of bitumen as the crude oil feed. Petro-Canada's McKay River SAGD project will supply bitumen to the plant. The bitumen to be used will be much higher in sulphur content than the mix of synthetic and conventional crude currently being used. The feed conversion project will be developed in two phases. Phase I to be complete by 2007, will involve displacement of the conventional crude oil, which currently constitutes approximately 60% of the total crude oil feed. Phase II would displace the synthetic crude oil with bitumen by 2010. As a result, the amount of sulphur entering the refinery will be substantially higher. The great majority of the sulphur contained in the bitumen raw material will be recovered. However, SO_x emissions are anticipated to increase as a result of these changes. After Phase I, SO_x emissions are anticipated at 16.3 tonnes/day or nearly 6 kilotonnes per year, while after Phase II, SO_x emissions will climb to 21.2 tonnes/day or 7.7 kilotonnes per year.[39] Petro-Canada points out that the net SO_x emissions in the region are expected to decline, since there will be less sulphur contained in the fuels combusted.

[39] Petro-Canada, Application For Approval Of Edmonton Refinery Feed Conversion Program Volume 1 Project Description: Submitted To: Alberta Energy And Utilities Board and Alberta Environment, Calgary, Alberta, November 2001.

SO_x emissions are expected to decline at Shell's Scotford petroleum refining operations when the company's new upgrader comes on-stream late in 2002. The upgrader will feature a large and more efficient sulphur recovery system, which will process off-gases from the smaller refinery sulphur recovery unit. In this way refinery SO_x emissions will decrease. Although these small SO_x emissions and others from the upgrader are relatively minor in comparison to the total sector, they have been included as part of the Upstream Oil & Gas sector, along with emissions from other upgraders.

Imperial Oil's refinery in Strathcona continually strives to minimize emissions while slowly expanding its production capacity. The company plans to improve its energy efficiency, which will contribute to reducing energy-related combustion emissions. SO_x emissions are projected to decline slightly as sulphur recovery improvements are made. Continued improvements are also expected for other CAC emissions.

3.5 Cement

There are two cement plants in Alberta with a total capacity of nearly 2180 tonnes per day or 800 kilotonnes per year of clinker. The plants typically operate close to capacity. Much of the production of cement made in Alberta is exported out of the province. No new plants are foreseen. Although demand for cement will continue to increase in Alberta, new demand can be met with production from the Alberta plants. Each plant is projected to increase capacity by debottlenecking. Production capacity for clinker is projected to reach 2400 tonnes per day (880 kilotonnes per year), or 10% higher than current 2002 levels, by the year 2020. Production is projected to increase by similar amounts (i.e., 10% from current levels).

Lafarge Canada Ltd. operates two kilns in Exshaw and Inland Cement has one kiln in Edmonton. Inland's kiln is a preheater and precalciner type and consequently is very efficient in energy use per tonne of product. Lafarge operates one preheater kiln and a long dry kiln. Generally, long dry kilns are less energy efficient than kilns that have precalcining and/or preheating capabilities.

All kilns in Alberta have historically used natural gas as the primary fuel source. However, all kilns are in the process of converting to the use of coal. High natural gas prices in the year 2000 and 2001 were one factor that contributed to the cement plants converting to coal, as the primary fuel source. These conversions will soon be complete and certainly operational before 2005 (likely by 2003).

The plants in Alberta will continue to make incremental improvements in energy efficiency. While the current weighted average energy intensity of all cement operations is approximately 4.8 GJ/tonne-clinker, industry sources claim that this will improve slowly,

as it has in the past. By 2020, average energy efficiency is projected to be 4.4 GJ/tonne-clinker.

3.5.1 Emission Trends

Emissions from the cement industry are projected to decrease slightly. The major factors contributing to changes in emissions include:

- conversion to coal use which tends to lower NO_x emissions (versus natural gas);
- installation of new Low-NO_x burners at one facility (which could reduce NO_x emissions)[40];
- controls applied to reduce SO_x by 25% from one facility by 2007 (lime injection, process control optimisation are options the facility plans to adopt)[41]; and
- continued improvements in energy efficiency.

Table 30: Forecast of Emissions from Cement Industry

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	1788	1166	1162	1149	1155	1127	-36%	-37%
PM10	465	386	390	388	387	378	-17%	-19%
PM2.5	124	117	118	118	118	115	-5%	-8%
SO_x	3094	2790	2700	2058	2152	2149	-33%	-31%
NO_x	7638	5000	4954	4836	4936	4814	-37%	-37%
VOC	36	41	41	40	41	40	12%	12%
CO	277	317	319	311	318	310	12%	12%
NH3	0.02	0.02	0.03	0.03	0.03	0.03	39%	46%

Although the cement facilities will use more coal, which does contain sulphur, both producers claim that there should not be additional SO_x emissions. The reason is that potential SO_x emissions are "scrubbed" by the process itself (i.e., in the kiln), such that the sulphur contained in the fuel is not emitted. SO_x emissions are more related to the amount of sulphur in the raw materials used.

[40] Industry source. Highly uncertain NO_x reduction. No guaranteed reduction was available from supplier.
[41] Industry source. SO_x reduction options to be implemented to meet anticipated Alberta Environment pressures.

3.6 Chemicals

The chemicals sector (standard industry classification SIC-37, NAICS-32) encompasses a great variety of organic and inorganic chemical producers and formulators making: petrochemicals, polymers, fertilizers, coatings, oil field chemicals, inks, chlorine, acids, bases and many specialty products. The chemicals sector in Alberta may include upwards of 100 to 150 companies, although 10 major petrochemical/polymer and fertilizer producers account for more than 70% of energy consumption and most of the chemical sector CAC emissions in the province.

Table 31: Contribution to SO_x, NO_x Emissions from Petrochemical, Fertilizer and Smaller Chemical Facilities

Chemical Segment	SO_x	NO_x	Estimated Number of Companies
Major petrochemicals/polymers plants	19%	44%	8-10
Major fertilizer plants	55%	39%	7-8
Estimated emissions from all other facilities	26%	18%	80 to 120

The large petrochemical industry in Alberta has been growing quite rapidly and is projected to continue to grow. World scale ethylene plants, as well as other petrochemical and polymer facilities have come on-stream in the last 10 years. CAC emission projections reflect increases in energy consumption associated with this increased production. The CEOU projects continued use of natural gas as the major fuel for the sector.

Table 32: Major Alberta Petrochemical and Fertilizer Facilities

Company	Products	Locations
Alberta Envirofuels	Oxygenates (MTBE)	Edmonton
AT Plastics Inc	Specialty polyethylene	Edmonton
Cancarb Limited	Carbon black	Medicine Hat
Dow Chemical Canada	Ethylene and Derivatives	Fort Saskatchewan, Prentiss
Methanex	Methanol	Medicine Hat
Novacor Chemicals Ltd	Ethylene and Derivatives	Joffre
Oxyvinyls Canada Inc	Polyvinyl Chloride	Fort Saskatchewan
Shell Chemicals Canada	Benzene, styrene	Scotford
Agrium Inc.	Fertilizers	Joffre
Agrium Products Inc	Fertilizers	Carseland
Agrium Products Inc	Fertilizers	Fort Saskatchewan
Agrium Products Inc	Fertilizers	Redwater
Canadian Fertilizers	Fertilizers	Medicine Hat
Orica Canada Inc	Fertilizers	Carseland
Sherritt International Corp.	Fertilizers	Fort Saskatchewan

Ethylene plants are typically the core of a “petrochemicals” complex. This is a result of the production process, which yields ethylene as well as a broad slate of co-products that have economic value. Ethylene is used to make so-called derivative products such as: polyethylene, ethylene oxide and glycol, styrene and 1,2-dicholorethane (DCE)[42] in Alberta. These are major export products for the province. Therefore, growth in ethylene production is usually representative of the growth for the petrochemical industry, as a whole.

Ethylene capacity and production in Alberta should be at least 25% higher by 2010 versus 2000 levels. Alberta's newest ethylene plant was completed in the second half of 2000. The Alberta ethylene producers will now be seeking to debottleneck their facilities to augment their production capacity. It is assumed that plants will continue to grow their capacity slowly over time. The assumption has been that no new ethylene plants will be constructed, although there is speculation to that effect. The sufficient supply of ethane is always an issue, and with the new Alliance Pipeline moving natural gas containing ethane to the United States, it may be some time before sufficient ethane is available for Alberta's fifth ethylene plant. Some industry sources believe that the prospects for the next ethylene plant in Alberta are tied to ethane extracted from Arctic natural gas moving through the

[42] Also referred to as ethylene dichloride (EDC).

province. For this study is has been assumed that new ethylene capacity is constructed after 2010.

Table 33: Canadian Ethylene Plant Capacities

(kilotonnes per year)

Company	Location		1995	2000	2010	2020	1995 to 2010	1995 to 2020
Nova	Joffre (E I)	AB	600	725	800	800	33%	33%
Nova	Joffre (E II)	AB	800	815	900	900	13%	13%
Nova/Dow	Joffre (E III)*	AB	0	320	1300	1300		
Dow Chemical	Fort Saskatchewan	AB	0	1100	1200	1200		
New capacity						1500		
Total			1400	2960	4200	5700	200%	307%

* Start-up in Q4 2000, capacity for only 3 months shown. Source: Cheminfo Services, industry sources

3.6.1 Emission Trends

Energy consumption is the major source of CAC emissions from most chemical operations. Process emissions of VOCs and NH_3 are notable exceptions. In the petrochemicals segment, ethylene facilities are the major consumers of energy, using natural gas in heating furnaces where raw material ethane is cracked. Cracking ethane yields ethylene and co-products such as propylene, propane and heavier molecules. Energy is also required to separate the ethylene and other components. This involves compression and distillation processes. In the production of fertilizers, large amounts of energy are required to reform natural gas (mostly methane) into hydrogen and carbon monoxide (and dioxide), as well as to separate products. Hydrogen is combined with nitrogen to make ammonia. Ammonia is a basic fertilizer product that can be sold as anhydrous or combined with inorganic acids (nitric, sulphuric or phosphoric) to make inorganic fertilizers.

Emissions from the chemical sector are projected to increase with fuels used. Total energy consumption is not expected to increase at the same rate as production in the industry. Energy efficiency improvements are expected. As a notable example, Nova/Dow's E 3 cracker is approximately 2 to 3 times less NO_x emissions-intensive than the older E 1 cracker. Energy and environmental improvements are projected for all of Nova's ethylene plants, other fertilizer and petrochemical plants as well as smaller operations that are relatively minor sources of emissions. Similar improvements are projected for other chemical facilities, including fertilizer plants. Successive generation of ammonia fertilizer

facilities have been designed and operated at a lower rate of natural gas consumption to product yield.

Table 34: Forecast of Emissions from Chemicals Sector

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	1132	1556	1698	1831	2019	2197	62%	94%
PM10	1062	1477	1617	1746	1932	2106	64%	98%
PM2.5	438	621	683	741	823	901	69%	106%
SO_x	2161	2973	2976	2979	2983	2986	38%	38%
NO_x	23364	24499	26876	29077	32219	35181	24%	51%
VOC	10554	12781	13340	13690	14463	14587	30%	38%
CO	5381	7593	8344	9038	10030	10964	68%	104%
NH3	8416	8825	9641	10397	11475	12492	24%	48%

Part of the energy efficiency improvements will come from operations of natural gas based cogeneration facilities, making electricity as well as steam. A new cogeneration unit currently supplies Nova's operations at Joffre with power and steam. The CAC emissions (essentially only NO_x) from this unit are included in Chemicals sector. Alberta's fertilizer industry is similarly improving energy efficient to minimize CAC emissions.

3.6.1.1 Ammonia Emissions

The fertilizer manufacturing industry accounts for close to 95% of estimated ammonia emissions from Alberta's chemical sector. Sources of ammonia emissions from the chemicals industry include: raw material storage, process unit operations, fuel combustion and product storage. A substantial amount of ammonia emissions can come from urea production operations. Ammonia is used as a raw material for urea production (carbon dioxide is the other reactant). There are also emissions from fugitive sources, spills and granulation stages in the process.

Ammonia emissions are projected to continue to increase with total energy consumption in the sector. Inherently, this assumes that improvements occur relative to total production (as per energy efficiency improvements). Industry sources confer that improvements in reducing ammonia emissions can be expected.

3.7 Other Industrial Sectors

In the category of "Other Industrial" sectors, "Other Manufacturing" dominates PM_T, PM_{10}, $PM_{2.5}$ NO_x, CO and NH_3 emissions. Mining, which includes coal mining, as well as quarrying of aggregates is the other category with notable PM emissions. SO_x missions are largely from pulp and paper, mining, and a facility in the non-ferrous metals smelting and refining sector.

Table 35: Sector Contribution to "Other Industrial" Emissions

(Based on Estimated Year 2000 Emissions)

Sector	PMT	PM10	PM2.5	SO_x	NO_x	VOC	CO	NH3
Other Manufacturing	81%	77%	73%	2%	75%	45%	99%	69%
Pulp and Paper	4%	6%	9%	23%	15%	4%	1%	15%
Mining	15%	15%	17%	33%	8%	51%	0%	16%
Iron and Steel	0%	1%	0%	0%	1%	0%	0%	0%
Non-Ferrous Smelting & Refining	0%	0%	0%	42%	2%	0%	0%	0%
Portion of Total "Other Industrial" Emissions	100%	100%	100%	100%	100%	100%	100%	100%

3.7.1 Other Manufacturing

The industries within Other Manufacturing include thousands of small industrial facilities, making quite a variety of products, including: food products, lumber, wood products, metal parts, construction products, printed substrates, plastic products, and many other manufactured items. All CAC emissions are released from all of these facilities in substantial or small amounts, since practically all facilities burn fuels. Some facilities may also have process-related emissions.

A notable source of the PM and CO emissions are the lumber and wood products operations, which use biomass for heating purposes. There are also PM emissions from many other operations. Emissions from Other Manufacturing facilities have been projected on the basis of fuel use in the CEOU. The CEOU shows a decline in the energy consumption, including biomass (assumed to be a result of increase energy efficiency improvements). Combustion of biomass is a major source of CO and PM emissions, so that these contaminants are projected to decline from this fuel source. Other fuels, which are less PM and CO emissions-intensive, partially offset this decline.

Table 36: Forecast of Emissions from Other Manufacturing

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	54879	43012	42904	44185	46475	48352	-19%	-12%
PM10	27046	21435	21300	21944	23079	24012	-19%	-11%
PM2.5	17098	13664	13525	13938	14658	15250	-18%	-11%
SO_x	236	180	219	228	245	255	-3%	8%
NO_x	13525	19225	15389	16230	17042	17788	20%	32%
VOC	635	601	559	582	614	640	-8%	1%
CO	304678	236783	237559	244489	257118	267457	-20%	-12%
NH3	331	461	363	382	400	418	16%	26%

3.7.2 Pulp and Paper

There are four kraft pulp mills in Alberta, which represent the majority of emissions from the sector in the province. Mechanical mills (such as chemi-thermomechanical - CTMP, TMP and stone groundwood) are electricity-intensive and therefore are generally less emissions-intensive than kraft mills. However, although emissions from the kraft mills can be odorous, the total amount of emissions is not usually high considering the mass of wood processed and total energy consumed. One factor is that these mills rely on biomass as a major source of fuel. Biomass, as spent liquor, is burned in the kraft recovery boilers. It can also be fired in power boilers for the production of steam. Biomass contains a very low amount of sulphur (therefore low SO_x emissions), and with relatively high moisture content the biomass burns at temperatures and under conditions which result in relatively low NO_x emissions per unit of energy consumed.

Table 37: Major Pulp Mills in Alberta

Company	Location	Type of Mill
Alberta-Pacific Forest Industries Inc.	Boyle	Kraft
Daishowa - Marubeni Int.	Peace River	Kraft
Weldwood of Canada	Hinton	Kraft
Weyerhaeuser Canada	Grande Prairie	Kraft
Millar Western	Whitecourt	Mechanical
Slave Lake Pulp	Slave Lake	Mechanical

Two major pulp mills contacted in this study (which constituted the majority of emissions) indicate they have lowered emissions in the last five years as a result of optimisation of recovery boiler operations and application of some emission reduction technologies. Year 2000 SO_x emissions reported to Alberta Environment have decreased from 1995 levels by 45 to 50% for the major facilities. Reported NO_x emissions have decreased 10 to 15%. Emissions are projected to increase with increased energy use (as per CEOU).

Table 38: Forecast of Emissions from Pulp and Paper Sector

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	2088	1953	2217	2482	2682	2879	19%	38%
PM10	1874	1778	2017	2258	2439	2619	20%	40%
PM2.5	1770	1703	1928	2160	2333	2506	22%	42%
SO_x	3840	2036	2561	2814	3004	3193	-27%	-17%
NO_x	4430	3800	4233	4758	5171	5574	7%	26%
VOC	43	49	55	62	67	72	44%	68%
CO	1909	1577	1759	1976	2145	2310	3%	21%
NH3	84	98	109	123	133	143	45%	70%

Source: Alberta Environment for year 2000 NO_x and SO_x emission. Other year 2000 emissions and projections estimated by Cheminfo Services.

3.7.3 Mining and Rock Quarrying

The mining sector includes coal mining, mining of other inorganic minerals and rock quarrying (aggregates). PM emissions from these activities are significant. Emissions have been projected on energy consumption in the sector.

Table 39: Forecast of Emissions from Mining and Rock Quarrying

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	7685	7975	8912	9856	11189	12477	28%	62%
PM10	4242	4393	4934	5456	6189	6900	29%	63%
PM2.5	3116	3218	3660	4042	4585	5108	30%	64%
SO_x	2782	2899	3131	3479	3943	4407	25%	58%
NO_x	1957	2042	2289	2526	2875	3205	29%	64%
VOC	603	686	754	814	962	1069	35%	77%
CO	157	171	192	209	243	270	33%	72%
NH3	98	103	117	128	147	163	31%	66%

3.7.4 Iron and Steel

Alberta's iron and steel sector includes AtlaSteel's Ltd. mini-mill, which uses an electric arc furnace (EAF) process, as well as integrated billet production and rolling operations. Raw material for the steel making operations is recycled steel. Mini-mill operations are typically smaller, less energy and emissions-intensive than integrated steel mills, which include blast furnaces for iron ore reduction and basic oxygen furnaces for steel making. At AtlaSteel's mini-mill the metal is first placed in a melting furnace. Electricity - passed through graphite electrodes, and natural gas - fired through side ports - provide energy sources to heat and melt the recycled metal. The melted metal is transferred to a ladle furnace where it is formulated to meet specific application requirements. Billets are cast, rolling is carried out and bar products are made at integrated AtlaSteel Edmonton operations.

Table 40: Forecast of Emissions from Iron & Steel Sector

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	249	188	254	267	280	294	7%	18%
PM10	210	159	214	225	236	248	7%	18%
PM2.5	79	61	82	86	90	95	8%	19%
SO_x	81	17	17	17	17	17	-79%	-79%
NO_x	241	167	220	230	240	251	-5%	4%
VOC	1	1	1	2	2	2	9%	19%
CO	16	11	13	13	14	14	-18%	-12%
NH3	1	1	1	2	2	2	6%	16%

Note: 1995 emissions shown above are different than that reported by Environment Canada

Major emission sources include the combustion of fuels (mostly natural gas) and as well process emissions from the melting and ladle furnaces. The furnaces are a significant source of potential PM emissions. However, a baghouse at the AtlaSteel plant captures the majority of the potential emissions.

In 1995, there were two mini-mill operations in Alberta. Ipsco Steel operated a mini-mill that was closed during 1995. The mini-mill had lower capacity that than of AtlaSteel's facility. The closure of Ipsco's mill resulted in reduced emissions for the sector. Sulphur containing fuel oils were used in greater amounts in 1995 (CEOU). The use of fuel oils declined by 2000, and as a result the low level of estimated SO_x emissions decreased to even lower levels - remaining constant for the forecast period.

Emission projections for Alberta's iron & steel sector take into account AtlaSteel's expansion in 2001. The facility increased its capacity by 35%, and although production has yet to match the capability of the plant, production will be increased to capacity levels

before 2005. Thereafter production and emissions are projected to increase by approximately 1% per year to the year 2020.

3.7.5 Non-Ferrous Metals Smelting & Refining Sector

There are no major non-ferrous metal smelting & refining operations in Alberta (as there are in Ontario, Manitoba and BC). One facility in Alberta included in this sector is an Alcan Inc. operation making carbon raw material for the ultimate production of carbon anodes (made at other locations in Canada). Among other potential uses, carbon anodes are used in primary aluminum smelting, which is largely based in Quebec. The sector may also include any small facilities upgrading some non-ferrous minerals in Alberta.

Alcan's emissions are the major contributor to this sector's emissions in Alberta. SO_x emissions are the most notable. These result from the sulphur contained in the petroleum coke, which is heated to make the carbon product. Only a minor portion of the sulphur is vapourized from the coke. Most of it remains in the final carbon product shipped to anode manufacturing sites. The hot gas stream from the coke heating containing the sulphur as well as VOCs, hydrogen, CO and other components is burned before release to the atmosphere. Some heat is recovered, such that there is little in the way of fossil fuel purchases.

Alcan has no plans for any major new expansions, since there is always a challenge to acquire suitable grades of petroleum coke for the Alberta site. However, according to Alcan, production of carbon anodes will creep up slowly - by 1% per year - or by a total of 20% to 25% between 2000 and 2020. Even with this increase, SO_x emissions will remain below the facility's current emission limits.

Table 41: Forecast of Emissions from Non-Ferrous Metals Smelting & Refining Sector

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	13	15	15	16	17	18	25%	38%
PM10	12	14	14	15	16	17	26%	40%
PM2.5	10	12	12	13	14	14	30%	43%
SO_x	2515	3785	3978	4181	4394	4619	66%	84%
NO_x	338	421	443	465	489	514	37%	52%
VOC	1	2	2	2	2	2	39%	53%
CO	18	23	24	25	27	28	38%	53%
NH3	1	1	1	1	1	2	38%	53%

4. Transportation

4.1 Introduction

Transportation emission sources include on-road and non-road vehicles. On-road vehicles include the major vehicle emission sources, namely: light and heavy-duty gasoline and diesel vehicles (passenger cars and trucks); as well as small road vehicles such as motorcycles. Non-road vehicles include: gasoline and diesel farm vehicles (e.g., tractors, combines, etc.); rail locomotives; boats; and aeroplanes and airport vehicles.

A forecast of on-road emissions was recently prepared for Environment Canada and the Emissions and Projections Working Group (EPWG) of the National Air Issues Co-ordinating Committee (NAICC).[43] The forecast was delivered in the report entitled: "Updated Estimate of Canadian On-Road Vehicle Emissions For The Years 1995-2020" in December 2001. This forecast was in part co-ordinated by the EPWG Technical Sub-Group on Transportation Emissions Modelling. The Sub-Group is composed of industry, environmental non-government organisations (ENGOs) and government experts, including representatives from the Canadian Vehicle Manufacturers Association (CVMA) and Canadian Petroleum Producers Institute (CPPI). The resulting forecast is considered authoritative for on-road emissions and has been incorporated in this forecast. While the forecast is considered authoritative, some provincial government EPWG Sub-Group members continue to analyse the results, such that it is possible revisions may be required. A copy of the base case and sensitivity scenarios has been made available to Sub-Group members, Alberta Environment, as well as other provincial ministries of the environment for review.

The Updated Estimate was prepared using a modified, Canadianized version of the MOBILE 5 and PART 5 computer models. This version of the MOBILE model (called MOBILE 5C+ in this study)[44] very closely approximates the MOBILE 6 model, which has recently been released by the US EPA. The MOBILE 5C+ model develops emission factors for the different types of on-road vehicles. PART 5C is a model that estimates emission factors for particulates and SO_2 emissions. These emission factors are applied to suitable activity data, namely vehicle kilometres travelled (VKMT) for each type of vehicle. Dust (PM) generated from vehicle traffic on from paved and unpaved roads, and tire wear are not included as part of energy-related transportation emissions (see Non-energy Sources).

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[43] Senes Consultants Limited / Air Improvement Resource, Inc., *Updated Estimate of Canadian On-Road Vehicle Emissions For The Years 1995-2020*, December 2001.

[44] "C" stands for Canadian.

MOBILE 5C+ and PART 5C take into consideration the many factors that can affect emission rates for each on-road vehicle type. These include: vehicle-specific emission standards and emission controls; evaporative emissions; sulphur content of fuels; age of vehicles and related emission deterioration rates (older vehicles emitting more than newer vehicles); and many other factors that in some cases are regionally unique (e.g., temperatures, Reid Vapour Pressure of fuels, and other fuel characteristics). Details of the mechanisms of the MOBILE and PART 5C models are available in US EPA reference documents and the *"Updated Estimate of Canadian On-Road Vehicle Emissions For The Years 1995-2020*". These do not need to be repeated in this report.

Environment Canada's forecast submitted to the provinces incorporated the results of the Base Case transportation emissions. This case does not seem to incorporate the effects of lower sulphur levels in diesel to be incorporated by 2007. Under this scenario, SO_x emissions from on-road diesel use continue to increase over time. Correspondingly, non-road emissions, which were estimated by Environment Canada using changes to on-road diesel did not incorporate lower sulphur levels. These emissions therefore increase with increased fuel use.

Scenario 3 in "Updated Estimate of Canadian On-Road Vehicle Emissions For The Years 1995-2020" analysis incorporates the effects of low-sulphur diesel for on-road vehicles, starting in 2007. Scenario 3 also incorporates improved standards for diesel vehicles, with resultant lower NO_x, and other CAC emissions. For this forecast, Scenario 3 estimates for on-road vehicles have been incorporated, as the base case. The reason is that the low sulphur diesel regulations have been recently announced.

Future non-road vehicle emissions in Canada were recently estimated by Environment Canada.[45] Marine and aircraft emissions were estimated using projected fuel consumption for these vehicles as contained in CEOU. For non-road diesel and gasoline vehicles emissions were estimated using factors developed for on-road Light Duty Gasoline Vehicles and Trucks, Heavy Duty Gasoline Trucks by MOBILE 5C+ and PART 5C as per the Base Case (i.e., no 1997 reduction in sulphur levels).

[45] Environment Canada, Pollution Data Branch, *Development of the NAICC Base Case Consensus Forecast of Common Air Contaminants 1995 – 2020*, March 2002.

Table 42: Methods For Estimating Future Transportation Emissions

(Source: Environment Canada)

ON-ROAD Vehicles	**Method of Estimating Future Emissions**
Light-duty gasoline vehicles	MOBILE 5C+, PART 5C
Light-duty gasoline trucks	MOBILE 5C+, PART 5C
Heavy-duty gasoline trucks	MOBILE 5C+, PART 5C
Light-duty diesel trucks	MOBILE 5C+, PART 5C
Heavy-duty diesel vehicles	MOBILE 5C+, PART 5C
Light-duty diesel vehicles	MOBILE 5C+, PART 5C
Motorcycles	MOBILE 5C+, PART 5C
Propane powered vehicles	CEOU - Propane use in transportation
NON-ROAD Vehicles	
Off-road diesel and gasoline	Environment Canada based on Light Duty Gasoline Vehicles and Trucks, Heavy Duty Gasoline Trucks from MOBILE 5C+, PART 5C
Rail transportation	Rail Association of Canada, CEOU - Rail Fuel[46]
Marine transportation	CEOU - Marine Fuel
Air transportation	CEOU - Aviation Fuel

Scenario 3 results from the *"Updated Estimate of Canadian On-Road Vehicle Emissions For The Years 1995-2020*" report do not provide total PM (PMT) emissions. As a result PMT emissions have been estimated using ratios between PMT and PM10 available from Environment Canada's 1995 inventory of CAC emissions.[47]

There was no Canadian forecast of ammonia emissions identified in the course of this study. However, an inventory of 1995 ammonia emissions was developed by Environment Canada.[48] The 1995 ammonia emissions in this study are taken from that report. Ammonia emissions from vehicles continue to be investigated to understand their magnitude for different types of vehicles, age of vehicles and emission control systems. Studies have shown that NH_3 emissions increased as the sulphur content in the fuel decreased. In addition, NH_3 emissions do not necessarily decline significantly like those of other pollutants (e.g., NO_x, VOC) with progressive improvements in emission control systems.[49]

[46] Rail emissions were provided by Environment Canada. Personal conversation, June 4, 2002.
[47] Environment Canada, *Criteria Air Contaminant Emissions in Canada*, 1995.
[48] Environment Canada, *1995 Ammonia Emissions Inventory Guidebook, First Draft*, July 2000.
[49] Durbin, T. D., et al, *Emissions of Ammonia From Light Duty Vehicles* University of California, Riverside, 2001.

For this forecast, the base case ammonia emissions from vehicles have been projected based on their fuel consumption (specific to each vehicle category). This forecast therefore serves only as a first approximation, which may require refinements based on more extensive set of empirical test results and modelling that may be required to develop more accurate estimates.

4.2 Emission Trends

Most transportation emissions are projected to decrease. However, in the base case SO_x emissions are projected to remain relatively constant versus 2000 levels, since off-road emissions are dominant, especially after 2005 (when much of the sulphur has been removed from on-road gasoline). SO_x emissions are examined more closely below in the following section on "SO_x Sensitivity".

Table 43: Base Case Forecast of Emissions from Transportation in Alberta

(kilotonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	12.8	10.5	7.6	5.8	5.1	5.2	-55%	-60%
PM10	12.3	10.0	7.2	5.4	4.7	4.7	-56%	-62%
PM2.5	11.2	9.0	6.4	4.6	3.9	3.9	-59%	-65%
SO_x	7.5	11.0	10.2	9.3	9.6	10.3	23%	37%
NO_x	227.2	227.4	165.9	126.2	101.6	95.5	-44%	-58%
VOC	104.8	75.9	51.0	38.4	33.9	34.5	-63%	-67%
CO	959.3	760.4	517.5	395.0	360.3	369.3	-59%	-62%
NH3	2.1	2.5	2.7	2.9	3.2	3.4	42%	65%

Source: Environment Canada. Cheminfo Services for some non-road sources.

CAC emissions from **on-road** transportation sources are projected to decrease despite increased fleet sizes, total distances travelled and greater fuel requirements. Inherent in the reductions are the incorporation of improved emission standards. Vehicle manufacturers will be required by the US EPA to make vehicles that meet the so called Tier II standards. Tier II standards reflect major reductions in NO_x and other CAC emissions.

The reduction in CAC emissions is, in part, also due to cleaner fuels. Environment Canada's 1999 *Sulphur in Gasoline Regulations*[50], will require that gasoline have a

[50] Government of Canada, *Sulphur in Gasoline Regulations* (SOR/99-236), Registration 4 June, 1999

sulphur content of less 0.0030% by weight (or 30 ppm) after January 1, 2005. Currently, sulphur levels in gasoline in Alberta, which are in the range of 150 to 250 ppm (varying by refinery) are already low in comparison to other Canadian provinces. The higher use of synthetic crude oil is a contributing factor for lower sulphur levels. Emissions are also expected to decrease from on-road diesel vehicles. On-road national diesel standards will require 15 ppm sulphur levels by 2007.

Reducing sulphur in gasoline enables emissions control technology and yields collateral environmental benefits for CAC and toxics pollutant emissions. NO_x, CO, VOC and PM emissions are all projected to decrease as a result of market penetration of vehicles with improved emission control technologies, including improvements to combustion and catalytic systems and using lower sulphur fuels.

Table 44: Forecast of Emissions from On-Road Vehicles

(kilotonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	6.2	5.1	3.6	2.3	1.8	1.7	-63%	-73%
PM10	5.9	4.9	3.5	2.2	1.6	1.5	-63%	-74%
PM2.5	5.4	4.3	2.9	1.7	1.1	1.0	-69%	-81%
SO_x	1.9	2.5	1.4	0.2	0.2	0.3	-88%	-86%
NO_x	139.8	134.9	91.4	56.7	32.3	22.3	-59%	-84%
VOC	81.5	59.4	38.4	27.3	22.9	22.7	-67%	-72%
CO	724.7	564.3	374.1	269.6	234.5	233.5	-63%	-68%
NH3	1.9	2.2	2.5	2.6	2.8	3.0	38%	59%

Source: Environment Canada.

CAC emissions from **non-road** vehicles such as off-road diesel vehicles, rail locomotives, aircraft, and boats are projected to decrease (except for SO_x) in the base case. These changes inherently reflect new standards for off-road vehicles that are similar in nature to on-road vehicles, since the emissions for off-road were estimated based on results for on-road MOBILE 5C+ and Part 5C. New Standards for off-road gasoline and diesel vehicles under development in the United States are expected to spill over into Canada's off-road vehicle fleet in this decade.

A similar influence is expected to occur in the rail transportation. Canada's ageing fleet of rail locomotives is gradually being replaced with new locomotives that are more energy

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Canadian Environmental Protection Act, 1999. http://laws.justice.gc.ca/en/C-15.31/SOR-99-236/text.html

efficient and less emissions-intensive. These new locomotives will be purchased in the United States, where locomotive manufacturers are implementing designs to meet U.S. EPA emission standards. The result of increased market penetration of new locomotives in Canada's fleet will be to reduce NO_x emissions by at least 25% by 2020 from year 2000 levels, according to the Rail Association of Canada. This NO_x reduction has been incorporated in this forecast. While the new locomotives are also likely to feature lower emission rates for other CACs, these are more difficult to quantify and therefore have not been incorporated in the forecast.

There has been steady improvement in the overall energy-efficiency of Canada's locomotive fleet (averaging 2% to 3% per year).[51] Continued improvements are expected, albeit at lower annual improvement rates (e.g., 0.5% to 1% per year). In the context of these improvements and increased workload (tonnes carried) fuel consumption is expected to increase very slowly in the forecast period (as reflected by CEOU).

Table 45: Forecast of Emissions from Non-Road Vehicles

(kilotonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	6.6	5.4	4.0	3.5	3.3	3.5	-48%	-48%
PM10	6.4	5.1	3.8	3.2	3.0	3.2	-49%	-50%
PM2.5	5.8	4.7	3.4	2.9	2.7	2.9	-49%	-51%
SO_x	5.6	8.6	8.8	9.1	9.3	10.1	60%	78%
NO_x	87.4	92.5	74.5	69.5	69.3	73.2	-21%	-16%
VOC	23.3	16.5	12.6	11.1	11.0	11.8	-52%	-49%
CO	234.6	196.1	143.4	125.4	125.8	135.9	-47%	-42%
NH3	0.2	0.2	0.3	0.3	0.4	0.4	79%	128%

Source: Environment Canada, Cheminfo Services, Rail Association of Canada

4.2.1 Sensitivity on SO_x Emissions from Non-Road Diesel

Although there are no regulations currently in place to address sulphur levels for fuels used in non-road vehicles, such regulations are under consideration. It is probable that such regulations will begin to take effect by 2010 in Canada in concert with potential regulations in the United States. Therefore, a sensitivity analysis was conducted using

[51] Rail Association of Canada, *Locomotive Emissions Monitoring Programme 1999-2000.* http://www.ec.gc.ca/transport/publications/rail2000/rail2.htm

Cheminfo's Energy/Emissions Model (CEEM) for SO_x emissions. CEEM uses fuel consumption for each on-road vehicle type (as per the MOBILE categories, noted above), as well as for non-road vehicles. This model incorporated CEOU forecast fuel consumption data and adopted the following assumptions:

- Sulphur level in on-road gasoline at 25 ppm starting in mid 2005 (with full effect by 2010), as per national standards;
- Sulphur level in on-road diesel at 15 ppm by 2007 (with full effect by 2010), as per national standards;
- Sulphur level in off-road gasoline at 25 ppm starting in mid 2005 (with full effect by 2010); and
- Sulphur level for off-road diesel at 500 ppm by mid 2010, 50 ppm by 2015 and 15 ppm by 2020.

Table 46: Sulphur Content for Regular (Non-Road) Diesel

(parts per million – ppm)

Region	Actual 1995	Actual 1999
Prairies and Northern Regions (including Alberta)	1800	1850
Atlantic	1940	1150
Quebec	1780	4560
Ontario	2520	3280
BC, Yukon	2370	4030

Source for Actual 1995, 1999 data: Environment Canada/Mark Tushingham, et al, *Sulphur in Liquids Fuels*, 1999.

Reducing off-road diesel sulphur levels to 500 ppm achieves 60-65% reductions in SO_x emissions versus 1995 levels (as shown by the year 2010 estimates in the table below). Reducing sulphur levels to 50 and 15 PPM achieves 90 to 95% reductions in SO_x emissions versus the base case projection. Sulphur in gasoline used for off-road vehicles remains the major off-road source of SO_x emissions. It is possible that lowered sulphur levels for on-road gasoline would "spill-over" and affect gasoline production and consumption for off-road gasoline vehicles.

The result of applying these assumption to all of Alberta's non-road diesel and gasoline fuels is that emission estimates turn out much lower than the base case estimates presented above.

Table 47: Sensitivity Reflecting Lower Sulphur Non-Road Diesel (Total Transportation SO_x Emissions For Alberta)

(kilotonnes)

Basis of Calculation	2010	2015	2020
CEEM Emissions (500 ppm S in 2010, 50 ppm in 2015, 15 ppm in 2020)	2.5	0.4	0.2
Environment Canada*	9.3	9.6	10.3
Difference	6.8	9.2	10.1
Reduction vs. Total Base Case Transportation SO_x Emissions	73%	96%	98%

* Based on "Updated Emissions" report by Senes/Air Management.

4.3 Base Case Emissions By Vehicle and Fuel Type

The following series of tables provides the base case set of emissions for all vehicle types.

4.3.1 On-Road Vehicles

Table 48: Forecast of Emissions from Light Duty Vehicles Gasoline Vehicles

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020
PMT	556	648	414	437	481	526
PM10	539	628	401	424	466	510
PM2.5	380	438	200	211	232	254
SO_x	651	725	85	90	99	108
NO_x	34038	30310	19738	12377	7490	5676
VOC	40336	30751	17938	12328	10785	11073
CO	389238	308722	188019	141228	127045	128060
NH3	1096	1358	1384	1410	1486	1561

Source: Environment Canada

Table 49: Forecast of Emissions from Light Duty Gasoline Trucks (and Buses)

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020
PMT	512	437	259	286	315	357
PM10	497	424	251	277	305	346
PM2.5	368	313	130	143	156	177
SO_x	536	513	67	75	83	94
NO_x	24292	18350	13586	9692	6877	5556
VOC	30363	20470	14431	10690	8737	8448
CO	262718	181804	125302	92047	80321	80871
NH3	745	829	1009	1135	1227	1360

Source: Environment Canada

Table 50: Forecast of Emissions from Heavy Duty Gasoline Vehicles (Trucks)

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020
PMT	121	121	74	58	52	57
PM10	117	117	71	56	50	56
PM2.5	85	86	46	36	31	35
SO_x	79	86	10	10	10	11
NO_x	4240	4732	4801	3686	2503	1761
VOC	2560	2398	1799	1443	1294	1293
CO	36652	32594	20780	15298	15414	17109
NH3	28	31	38	42	46	51

Source: Environment Canada

Table 51: Forecast of Emissions from Light Duty Diesel Vehicles

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020
PMT	25	23	15	12	13	14
PM10	25	23	15	12	13	14
PM2.5	23	20	13	10	10	11
SO_x	3	5	5	0	0	0
NO_x	110	119	106	100	112	123
VOC	43	48	42	41	47	51
CO	92	109	104	106	119	131
NH3	0	0	0	0	0	0

Source: Environment Canada

Table 52: Forecast of Emissions from Light Duty Diesel Trucks

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020
PMT	338	204	171	151	156	162
PM10	25	23	15	12	13	14
PM2.5	302	178	147	126	130	134
SO_x	37	62	70	3	3	3
NO_x	1523	1172	1240	1328	1385	1457
VOC	747	531	556	614	647	695
CO	1289	1115	1249	1348	1405	1480
NH3	2	3	3	3	3	3

Source: Environment Canada

Table 53: Forecast of Emissions from Heavy Duty Diesel Trucks

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020
PMT	4663	3657	2702	1382	789	590
PM10	4663	3657	2702	1382	789	590
PM2.5	4210	3271	2383	1138	587	388
SO_x	596	1083	1130	43	45	49
NO_x	75439	80158	51830	29436	13867	7613
VOC	7110	4982	3396	1931	1186	954
CO	32423	38227	36943	17925	8779	4325
NH3	15	18	20	20	21	22

Source: Environment Canada

Table 54: Forecast of Emissions from Motorcycles and All Other Vehicles

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020
PMT	4	3	3	3	3	3
PM10	4	3	3	3	3	3
PM2.5	3	2	2	2	2	2
SO_x	3	2	1	1	1	1
NO_x	124	92	90	89	78	80
VOC	337	247	242	238	207	212
CO	2321	1734	1698	1674	1461	1497
NH3	0	0	0	0	0	0

Source: Environment Canada

4.3.2 Non-Road Vehicles

Table 55: Forecast of Emissions from Non-Road Gasoline Vehicles

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020
PMT	449	419	130	126	132	147
PM10	368	344	106	104	108	120
PM2.5	313	303	88	88	93	104
SO_x	149	156	19	21	23	25
NO_x	5158	4560	3208	2318	1828	1782
VOC	11769	6564	3952	2842	2579	2716
CO	194030	146722	90143	69289	66391	70555
NH3	33	35	33	33	34	35

Source: Environment Canada

Table 56: Forecast of Emissions from Non-Road Diesel Vehicles

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020
PMT	5264	3980	2877	2241	1987	2139
PM10	5264	3980	2877	2241	1987	2139
PM2.5	4843	3678	2668	2085	1853	1995
SO_x	3720	6733	7052	7076	7242	7928
NO_x	51910	54857	38150	34250	34205	37260
VOC	5608	3948	2894	2417	2290	2445
CO	16326	19053	20465	21129	22079	24472
NH3	138	201	249	275	334	357

Source: Environment Canada

Table 57: Forecast of Emissions from Rail Locomotives

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020
PMT	537	519	523	610	613	580
PM10	537	519	523	610	613	580
PM2.5	494	478	481	561	564	534
SO_x	1237	893	902	1052	1058	1000
NO_x	22135	21325	20170	19077	18044	17066
VOC	1039	1021	1030	1202	1208	1142
CO	4255	4177	4216	4919	4946	4675
NH3	2	3	2	2	2	2

Source: Environment Canada

Table 58: Forecast of Emissions from Marine Vehicles

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020
PMT	98	74	53	42	37	40
PM10	78	59	43	33	29	32
PM2.5	65	50	36	28	25	27
SO_x	10	18	19	19	19	21
NO_x	19	20	14	12	12	13
VOC	2853	2009	1472	1230	1165	1244
CO	9321	10878	11684	12063	12605	13972
NH3	0	0	0	0	0	0

Source: Environment Canada

Table 59: Forecast of Emissions from Aviation Vehicles

(tonnes)

Contaminant	1995	2000	2005	2010	2015	2020
PMT	269	384	425	454	499	560
PM10	149	212	235	251	276	310
PM2.5	105	150	166	177	195	218
SO_x	527	752	832	888	976	1096
NO_x	8210	11707	12961	13826	15209	17067
VOC	2048	2921	3234	3450	3795	4258
CO	10678	15227	16858	17983	19781	22198
NH3	1	1	2	2	2	2

Source: Environment Canada

5. Residential, Commercial/Institutional Heating

5.1 Residential

Most CAC emissions from residential buildings are from the combustion of fuel wood, which is quite CAC emissions intensive. Increased use of residential fuel wood drives projected increases in CAC emissions for the category as a whole. Partially offsetting this trend is increased market penetration of natural gas, which accounts for over 95% of the fossil fuel use, and reduction of sulphur-containing fuel oils. This has the effect of lowering SO_x emissions. However, an increase in the small amount of coal (1% of fossil fuel use) that is used in residential buildings will result in an increase in SO_x emissions.

Table 60: Portion of Residential CAC Emissions from Fuel Wood Combustion

Contaminant	1995	2000	2005	2010	2015	2020
PMT	87%	90%	90%	91%	91%	93%
PM10	89%	91%	92%	93%	94%	95%
PM2.5	90%	91%	93%	94%	94%	95%
SO_x	25%	46%	33%	34%	36%	43%
NO_x	9%	12%	14%	15%	16%	19%
VOC	99%	99%	99%	99%	99%	99%
CO	95%	96%	97%	97%	97%	98%

The base case CEOU energy forecast project a total reduction in the use of natural gas use in residential buildings in Alberta. Factors that contribute to projected reduction in natural gas consumption are documented in the CEOU report, as follows:

> "In the residential sector, the use of fossil fuels and wood for space heating accounts for the largest proportion of (GHG) emissions (almost 80%), followed by water heating. The contribution of fuels used in cooking, lighting and refrigeration is small. Changes in events and assumptions from CEO97 for fuel use and efficiency in the residential sector, which affected emissions, include: higher energy demand, higher wood emission factors, home energy code adoption, energy efficiencies of equipment and appliances and new thermal archetypes for housing stock. After considering these changes, (GHG) emissions in the sector increased for both the baseline (1990) and the forecast years."

Table 61: Forecast of Emissions from Residential Buildings

(tonnes)

	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
Total Energy (PJ)*	154.8	163.8	144.5	139.2	139.7	140.5	-10%	-10%
Residential Fuel Wood (PJ)	0.7	0.9	1.0	1.1	1.2	1.4	57%	100%
Contaminant								
PMT	8682	10750	11946	13029	14107	16200	50%	87%
PM10	8429	10574	11640	12702	13779	15909	51%	89%
PM2.5	7984	10057	11009	12008	13031	15069	50%	89%
SO_x	425	302	466	500	516	502	18%	18%
NO_x	7033	7450	6974	6905	7016	7166	-2%	2%
VOC	36544	46856	51965	57099	62248	72539	56%	98%
CO	61423	78188	86428	94736	103108	119796	54%	95%
NH3	104	110	97	94	94	94	-10%	-9%

5.1.1 Sensitivity Analysis on Residential Natural Gas Combustion

As a sensitivity to the above base case set of CAC emission estimates, a different growth assumption for the use of natural gas for residential use in Alberta has been applied, as shown below. In this assumption, natural gas consumption has been increased in conjunction with the number of households in Alberta, as defined by the CEOU between 2000 and 2020. This case could be considered an estimate in the higher range of potential future emissions, reflecting emissions without adoption of energy efficiency improvements within households.

Table 62: Sensitivity Analysis: Natural Gas Consumption Increased With Number of Households

	1995	2000	2005F	2010F	2015F	2020F	1995 to 2010	1995 to 2020
Number of Households in Alberta (million)	1.0	1.1	1.2	1.3	1.4	1.5	30%	51%
Total Energy (petajoules)	154.8	163.8	179.0	193.0	207.2	223.6	25%	44%
Contaminant Emissions (tonnes)								
PMT	8682	10750	12147	13342	14499	16683	54%	92%
PM10	8429	10574	11820	12983	14132	16343	54%	94%
PM2.5	7984	10057	11190	12289	13384	15503	54%	94%
SO_x	425	302	475	514	533	524	21%	23%
NO_x	7033	7450	8334	9025	9677	10441	28%	48%
VOC	36544	46856	52074	57270	62462	72803	57%	99%
CO	61423	78188	87019	95656	104263	121217	56%	97%
Ammonia	104	110	120	130	139	150	25%	44%

5.2 Commercial and Institutional

Fuel wood is not significantly used in commercial and institutional buildings. Therefore the two major factors affecting forecast estimates of emissions are continued energy efficiency improvements and reduced market share of fuel oil containing sulphur, which reduces SO_x emissions. Similar base case energy-efficiency improvements have been incorporated within CEOU's fuel consumption data, resulting in a decrease in the use of total fossil fuels in the province for these types of buildings.

Table 63: Forecast of Emissions from Commercial and Institutional Buildings

(tonnes)

	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
Total Energy (petajoules)	**115.3**	**163.8**	**107.5**	**103.3**	**100.3**	**97.9**	**-10%**	**-15%**
Contaminant								
PMT	530	500	494	475	460	449	-10%	-15%
PM10	520	489	484	466	452	442	-10%	-15%
PM2.5	510	479	475	457	445	434	-10%	-15%
SO_x	389	653	446	386	207	88	-1%	-77%
NO_x	5444	5285	5088	4877	4735	4623	-10%	-15%
VOC	260	247	242	233	227	222	-10%	-15%
CO	1016	984	949	910	883	861	-10%	-15%
NH3	27	26	25	24	23	23	-10%	-15%

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6. Non-Energy and Natural Area Sources of Emissions

6.1 Summary

Major non-energy-related and natural area sources of CAC emissions include particulate emissions of road dust, forest fires (PM, NO_x, VOC, CO), biogenic sources (mostly VOC from vegetation and decay) and many anthropogenic sources such as prescribed burning, structural fires, cooking, tobacco smoking, solvents emissions from painting, printing, adhesives, and many other sources. Projections of solvent are based on a recent Cheminfo Services study of solvent use and emissions in Canada.[52] Non-energy-related and natural area sources are large and can potentially dominate regional emissions. (Note the units in the table that follows are kilotonnes).

Table 64: Total Emissions of Non-Energy Area and Natural Sources

(kilotonnes)

Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	4886	5654	6262	6756	7225	7940	38%	62%
PM10	1460	1658	1821	1953	2084	2277	34%	56%
PM2.5	206	229	251	268	288	315	30%	53%
SO_x	0.2	0.2	0.2	0.2	0.2	0.2	14%	28%
NO_x	31	31	31	31	31	31	0%	0%
VOC	1355	1357	1361	1366	1372	1378	1%	2%
CO	545	545	545	545	545	546	0%	0%
NH3	136	221	241	263	288	315	94%	132%

Simplifying assumptions have been applied to project CAC emissions among the many sources within this broad category. The assumptions used to project these emissions are shown in the table below. The parameters on which projections are based are all derived from and contained in CEOU.

[52] Cheminfo Services Inc., *Estimation and Forecast of VOC Emissions from the Solvent Sector in Canada: 1990 to 2020*, March 2002

There are substantial ammonia emissions in this category. These are from livestock and application of fertilizers, which have been projected to increased based on input from Alberta's Agriculture, Food and Rural Development.

Table 65: Major CAC Emissions and Basis for Projections

Source	Major Contaminant	Basis for Projection
Anthropogenic Non-Combustion Sources		
Prescribed burning	CO	No change in forecast period
Incineration, cremations	CO	Population
Structural fires	CO	Population
Anthropogenic Combustion Sources		
Cigarette smoking	CO	Population
Unpaved roads (dust)	PM_T	Vehicle-kilometres-travelled
Paved roads (dust)	PM_T	Vehicle-kilometres-travelled
Construction	PM_T	Value of output for Construction Sector
Tilling & Wind Erosion	PM_T	No change in forecast period (AFRD)
Livestock	PM NH3	2% per year based on growth in livestock population (AFRD)
Mine tailings	PM	Value of output for Mining Sector
Pesticide application	PM NH3	1% per year (AFRD)
Landfills	VOC	Population
Tire wear	PM	Vehicle kilometres travelled
General solvent use	VOC	Many factors (Cheminfo Services)
Fuels marketing	VOC	Motor gasoline consumption
Surface coatings	VOC	Many factors (Cheminfo Services)
Printing	VOC	Many factors (Cheminfo Services)
Natural Sources		
Forest fires	CO VOC	No change in forecast period
Biogenic	VOC	No change in forecast period

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Table 66: CAC Emission Tables for All Non-Energy and Natural and Area Sources

(tonnes)

TIRE WEAR & BRAKE LINING								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	599	686	770	838	918	1023	40%	53%
PM10	592	678	762	829	908	1012	40%	53%
PM2.5	192	219	246	268	294	327	40%	53%
SO_x	0	0	0	0	0	0		
NO_x	0	0	0	0	0	0		
VOC	0	0	0	0	0	0		
CO	0	0	0	0	0	0		
NH3	0	0	0	0	0	0		
ROAD DUST - PAVED ROADS								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	189616	217117	243811	265163	290675	323903	40%	53%
PM10	36343	41614	46730	50823	55713	62081	40%	53%
PM2.5	8691	9951	11175	12153	13323	14846	40%	53%
SO_x	0	0	0	0	0	0		
NO_x	0	0	0	0	0	0		
VOC	0	0	0	0	0	0		
CO	0	0	0	0	0	0		
NH3	0	0	0	0	0	0		
ROAD DUST - UNPAVED ROADS								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	3242466	3712732	4169207	4534321	4970584	5538794	40%	53%
PM10	921577	1055236	1184976	1288749	1412744	1574241	40%	53%
PM2.5	138803	158934	178475	194104	212780	237104	40%	53%
SO_x	0	0	0	0	0	0		
NO_x	0	0	0	0	0	0		
VOC	0	0	0	0	0	0		
CO	0	0	0	0	0	0		
NH3	0	0	0	0	0	0		

INCINERATION (includes CREMATORIUMS, INDUSTRIAL, COMMERCIAL and MUNICIPAL INCINERATION)								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	21	23	24	26	27	28	21%	27%
PM10	16	18	19	19	20	21	21%	27%
PM2.5	11	12	13	13	14	15	21%	27%
SO_x	17	19	20	21	22	23	21%	27%
NO_x	15	17	17	18	19	20	21%	27%
VOC	1071	1179	1234	1292	1356	1425	21%	27%
CO	6	7	7	7	8	8	21%	27%
NH3	24	27	28	30	31	33	21%	27%
CIGARETTE SMOKING								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	57	63	66	69	72	76	21%	27%
PM10	57	63	66	69	72	76	21%	27%
PM2.5	57	63	66	69	72	76	21%	27%
SO_x	0	0	0	0	0	0		
NO_x	0	0	0	0	0	0		
VOC	1	1	1	1	1	1	21%	27%
CO	270	298	312	326	342	360	21%	27%
NH3	0	0	0	1	1	1	21%	27%
STRUCTURAL FIRES								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	603	663	694	727	763	801	21%	27%
PM10	597	656	687	719	755	793	21%	27%
PM2.5	542	597	625	654	686	721	21%	27%
SO_x	0	0	0	0	0	0		
NO_x	0	0	0	0	0	0		
VOC	585	643	674	705	740	777	21%	27%
CO	1205	1326	1389	1453	1525	1603	21%	27%
Ammonia	0	0	0	0	0	0		

PRESCRIBED BURNING								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	15757	15757	15757	15757	15757	15757	0%	0%
PM10	13457	13457	13457	13457	13457	13457	0%	0%
PM2.5	9420	9420	9420	9420	9420	9420	0%	0%
SO_x	43	43	43	43	43	43	0%	0%
NO_x	2070	2070	2070	2070	2070	2070	0%	0%
VOC	5808	5808	5808	5808	5808	5808	0%	0%
CO	96152	96152	96152	96152	96152	96152	0%	0%
NH3	173	173	173	173	173	173	0%	0%
FOREST FIRES								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	54325	54325	54325	54325	54325	54325	0%	0%
PM10	46177	46177	46177	46177	46177	46177	0%	0%
PM2.5	38028	38028	38028	38028	38028	38028	0%	0%
SO_x	32	32	32	32	32	32	0%	0%
NO_x	14252	14252	14252	14252	14252	14252	0%	0%
VOC	61356	61356	61356	61356	61356	61356	0%	0%
CO	447385	447385	447385	447385	447385	447385	0%	0%
NH3	959	959	959	959	959	959	0%	0%
DRY CLEANING								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	0	0	0	0	0	0		
PM10	0	0	0	0	0	0		
PM2.5	0	0	0	0	0	0		
SO_x	0	0	0	0	0	0		
NO_x	0	0	0	0	0	0		
VOC	753	249	208	174	146	123	-77%	-81%
CO	0	0	0	0	0	0		
NH3	0	0	0	0	0	0		
FUEL MARKETING								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	0	0	0	0	0	0		
PM10	0	0	0	0	0	0		
PM2.5	0	0	0	0	0	0		
SO_x	0	0	0	0	0	0		
NO_x	0	0	0	0	0	0		
VOC	9678	11125	12375	13314	14342	15535	38%	48%
CO	0	0	0	0	0	0		
NH3	0	0	0	0	0	0		

GENERAL SOLVENT USE								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	0	0	0	0	0	0		
PM10	0	0	0	0	0	0		
PM2.5	0	0	0	0	0	0		
SO_x	0	0	0	0	0	0		
NO_x	0	0	0	0	0	0		
VOC	26584	31900	34800	38000	41900	46000	43%	58%
CO	0	0	0	0	0	0		
NH3	0	0	0	0	0	0		
PRINTING								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	0	0	0	0	0	0		
PM10	0	0	0	0	0	0		
PM2.5	0	0	0	0	0	0		
SO_x	0	0	0	0	0	0		
NO_x	0	0	0	0	0	0		
VOC	2633	2000	2100	2200	2400	2500	-16%	-9%
CO	0	0	0	0	0	0		
NH3	0	0	0	0	0	0		
SURFACE COATINGS								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	0	0	0	0	0	0		
PM10	0	0	0	0	0	0		
PM2.5	0	0	0	0	0	0		
SO_x	0	0	0	0	0	0		
NO_x	0	0	0	0	0	0		
VOC	10606	7400	6800	7400	8100	8900	-30%	-24%
CO	0	0	0	0	0	0		
NH3	0	0	0	0	0	0		
ANIMALS/LIVESTOCK								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	35840	37791	41725	46067	50862	56156	29%	42%
PM10	8960	8960	10431	11517	12716	14039	29%	42%
PM2.5	1390	1539	1618	1787	1973	2178	29%	42%
SO_x	69	73	80	89	98	108	29%	42%
NO_x	0	0	0	0	0	0		
VOC	0	0	0	0	0	0		
CO	0	0	0	0	0	0		
NH3	111581	169913	187598	207123	228681	252482	86%	105%

TILLING & WIND EROSION								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	510349	510349	510349	510349	510349	510349	0%	0%
PM10	247788	247788	247788	247788	247788	247788	0%	0%
PM2.5	5104	5104	5104	5104	5104	5104	0%	0%
SO_x	0	0	0	0	0	0		
NO_x	0	0	0	0	0	0		
VOC	0	0	0	0	0	0		
CO	0	0	0	0	0	0		
NH3	0	0	0	0	0	0		
PESTICIDE & FERTILIZER APPLICATION								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	2396	2396	2518	2647	2782	2924	10%	16%
PM10	1174	1174	1234	1297	1363	1433	10%	16%
PM2.5	335	335	353	371	389	409	10%	16%
SO_x	0	0	0	0	0	0		
NO_x	0	0	0	0	0	0		
VOC	0	0	0	0	0	0		
CO	0	0	0	0	0	0		
NH3	22408	49196	51705	54343	57115	60028	143%	155%
CONSTRUCTION								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	831976	1099538	1219605	1321873	1324704	1431745	59%	59%
PM10	183035	241898	268313	290812	291435	314984	59%	59%
PM2.5	3705	4896	5431	5886	5899	6375	59%	59%
SO_x	0	0	0	0	0	0		
NO_x	0	0	0	0	0	0		
VOC	0	0	0	0	0	0		
CO	0	0	0	0	0	0		
NH3	0	0	0	0	0	0		
LANDFILLS								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	515	566	593	620	651	684	21%	27%
PM10	41	45	47	50	52	55	21%	27%
PM2.5	10	11	12	12	13	14	21%	27%
SO_x	0	0	0	0	0	0		
NO_x	0	0	0	0	0	0		
VOC	309	340	356	373	391	411	21%	27%
CO	0	0	0	0	0	0		
NH3	0	0	0	0	0	0		

MEAT COOKING								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	110	121	126	132	139	146	21%	27%
PM10	110	121	126	132	139	146	21%	27%
PM2.5	110	121	126	132	139	146	21%	27%
SO_x	0	0	0	0	0	0		
NO_x	0	0	0	0	0	0		
VOC	0	0	0	0	0	0		
CO	0	0	0	0	0	0		
NH3	0	0	0	0	0	0		
MINE TAILINGS								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	1848	2220	2357	2801	2853	2941	52%	54%
PM10	148	178	189	224	228	235	52%	54%
PM2.5	37	44	47	56	57	59	52%	54%
SO_x	0	0	0	0	0	0		
NO_x	0	0	0	0	0	0		
VOC	0	0	0	0	0	0		
CO	0	0	0	0	0	0		
NH3	0	0	0	0	0	0		
BIOGENIC								
Contaminant	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020
PMT	0	0	0	0	0	0		
PM10	0	0	0	0	0	0		
PM2.5	0	0	0	0	0	0		
SO_x	0	0	0	0	0	0		
NO_x	14377	14377	14377	14377	14377	14377		
VOC	1235410	1235410	1235410	1235410	1235410	1235410		
CO	0	0	0	0	0	0		
NH3	702	773	809	847	889	934	21%	27%

7. 2010 Regional Forecast

7.1 Methodology

Emissions for each pollutant from each source category were estimated for 19 census divisions (regions) in the province. Contaminant totals for each region were calculated. The methodology applied in developing the regional estimates began by using regional allocations of 1995 emissions for Alberta developed by RWDI.[53] One task for this part of the project was to apply these allocations to estimate regional emissions based on the forecasted 2010 emissions. The effort did not include an exhaustive analysis or critical review of the RWDI 1995 allocations. It was assumed that these were appropriate and correct. The RWDI 1995 regional allocations did not include PM_T. Also, regional ammonia emissions were only available for some source categories. PM_T and NH_3 (sources not included in RWDI analysis) were allocated to regions using appropriate surrogates to develop a first approximation of regional emissions. Facility-level forecasts were also applied to the appropriate regions for a few industrial sectors. These methodological steps are summarized in the table below and described in more detail in the following subsections.

Table 67: Summary of the Methodologies Applied to Develop a Regional Forecast for Alberta in 2010

Pollutant	Source Categories	Methodology
All CACs	Oil Sands, Electric Power Generation, Iron and Steel, Non-Ferrous Metals sector.	Facility level forecasted data applied to appropriate regions. Facility-level accounting for closures or emission reductions for specific facilities in regions.
PM_{10}, $PM_{2.5}$, NO_x, SO_x, VOC, CO	Small point-sources (Other Manufacturing, Gas Processing, etc). Area sources (transportation, road dust, biogenic, residential, agricultural, etc.)	1995 regional allocations applied to 2010 emissions, as per RWDI allocations. .
PM_T	All categories (as above)	Application of PM10 regional allocations.
NH_3	Source categories for which no RWDI regional allocations were available.	Application of surrogates based on regional allocation of other pollutants (pollutants depended on source category).

[53] RWDI West Inc., *Alberta Emissions Inventory in Support of Particulate Matter and Ozone Modelling* July 13, 2001.

Regional allocations were performed using two general methods: (i) allocations based on 1995 regional contributions (as per RWDI report); and (ii) facility-level emissions forecast to 2010 allocated to the appropriate region. The former method was applied for most existing source categories, while the latter was used to account for major point sources either commencing or ceasing operations between the baseline year (1995) and forecast year (2010). This latter method was primarily applied for facilities in the oil sands and electric power generation categories.

7.2 Maps of the Alberta Census Regions

Maps outlining the census regions in Alberta (and the other provinces) are available from Statistics Canada. Alberta is covered in two maps, showing the northern and southern census regions. Adobe Acrobat (PDF) electronic versions of these maps have been provided to CASA and form part of the electronic appendix to this report. They are also available electronically for download from the following Statistics Canada website:

http://geodepot.statcan.ca/Diss/Maps/ReferenceMaps/prov_pdf_e.cfm

Paper copies of these maps printed from the PDF files do not provide adequate resolution for viewing when printed on most common sizes of paper and are therefore not provided in this report. It is recommended that the PDF files be viewed by the reader electronically, and if hard copies are required they are ordered directly from Statistics Canada.

7.3 Area Sources and Minor Industrial Point Sources

For area sources and minor industry point sources, 1995 regional emissions contributions for the 19 regions were first applied to forecasted 2010 emissions. This was carried out by calculating the 1995 regional contributions in terms of percentage of total Alberta emissions, as previously prepared by RWDI, and applying these percentages to the forecasted 2010 source category totals (except for major point sources addressed through bottom-up forecasts in each region - see below). This methodology assumes that any growth of each source category does so within the same regions. For example, contributions from transportation sources in region 1 relative to total emissions in Alberta for the year 1995 are equal to those in year 2010 relative to forecasted 2010 transportation emissions. There are some inherent assumptions associated with this methodology, for example:

- growth in the number of sources is spread out over all regions for which those sources contributed emissions in 1995;
- any changes in the type of source (e.g. technology); emission rates or activity is spread out over all regions for which those sources contributed to emissions in 1995;
- growth in emissions are from expansion/activity growth in existing sources or new sources are within the same regions as existing sources;
- new sources do not appear within regions in which those sources did not contribute to 1995 emissions; and
- closures and emissions reductions are spread out over all appropriate regions.

These assumptions are appropriate as a first approximation of regional allocations over source categories consisting of many small sources (e.g., commercial sector, transportation, etc.) and source categories tending to grow within certain regions (e.g. chemicals sector). The assumptions are not valid for cases where large new sources appear within regions previously not containing that source category. For example, emissions from a new large chemical plant in region 2 would be allocated by this methodology to regions 1, 5, 6, 8, 10, 11 and 12, and spread out by the relative contributions of the chemical sector in these regions to 1995 emissions. Where such situations arise, and facility-level information existed, the alternate method described below was utilized (in the subsection entitled New Major Sources and Sources Closing Operations).

7.3.1 PM_T and Ammonia

PM_T emissions were not included in the 1995 RWDI report regional allocations. In addition, regional ammonia emissions for some source categories were also not available. In these cases the following steps were applied to estimate regional 2010 emissions:

- source categories for which forecasted Alberta total 2010 emissions for these two pollutants were identified;
- depending on the source category, an appropriate pollutant for which regional allocation data RWDI did exist for that source was chosen as a surrogate; and
- the pollutant of concern (PM_T, ammonia) was allocated regionally based on the same regional splits as the surrogate.

For example, PM_T emissions from each applicable source category, were allocated to the regions using the same relative regional allocations as for PM_{10}. Ammonia emissions were allocated using various surrogates depending on the source. For example, ammonia emissions from fertilizer application were allocated to regions based on PM_{10} emissions from pesticide and fertilizer application.

7.3.2 Biogenic Emissions Excluded

Biogenic emissions have been excluded from the regional analysis in this report. CASA could not provide reliable regional biogenic emission estimates to provide to the consultant (Cheminfo) for adoption in this analysis.[54] Therefore CASA concluded that they should not be incorporated in this analysis. Biogenic emissions are included as part of Alberta total emission estimates.

7.4 New Major Point Sources and Sources Closing Operations

Emission changes (new sources, emission reductions, or closing operations) from major sources for which detailed information was available were forecasted individually and added to the appropriate regional emissions for the year 2010.

As there are some electric power generation (EPG) units that have already shut down or are projected to shut down before 2010, the changes to emissions from the affected regions had to be reflected in the regional allocations for existing (1995) units. 1995 allocation ratios for existing sources in each region were recalculated for 2010 without these sources by subtracting the source-specific information from the regional contributions (in 1995) and dividing by the total source emissions less the total emissions from closing facilities. The EPG sources closing and not included in the 2010 forecast are 4 units at ATCO in Battle River, as well as 3 units at TransAlta in Wabamun.

The electric power generation sector in Alberta has projects that are expected to be new sources before 2010. Emissions from these units were projected to 2010, and information on the location/region of the new facilities was gathered. Total forecasted emissions from new major EPG sources were then deducted from the total forecasted emissions from all EPG sources. The regional allocations calculated from 1995 data were then applied to the remaining emissions. The forecasted emissions from the new sources were then added to the appropriate regions.

Table 68: EPG Projects Added as New Sources for 2010 Forecast

Facility	Location	Region
Fording (1, 2)	Brooks	2
AES	Calgary	6
EPCOR	Edmonton	11

Source: Cheminfo Services

[54] The scope of the project involved the CASA providing historical regional emission estimates to the consultant for area sources - such as biogenic emissions.

Similarly, there are many oil sands projects that are expected to be new sources before 2010. Emissions from each of these facilities sources were forecasted for the development of the forecast. Facility-specific information was combined with the co-ordinates of the projects and allocated to the appropriate regions as follows.

Table 69: Oil Sands Projects Added as New Sources for 2010

Facility	Location	Region
Shell Upgrader	Scotford	11
OPTI Upgrader	Burnt Lake	12
IOL Expansion	Cold Lake	12
CNRL	Burnt Lake	12
CNRL PAW	Wolf Lake	12
Blackrock Orion	Hilda Lake	12
Alberta Energy	Foster Creek	12
Syncrude	Fort MacKay area	16
Suncor	Fort MacKay area	16
Shell Albian Sands	Muskeg River	16
Shell Jackpine Mine	Jackpine River	16
OPTI	Long Lake	16
NorthStar UTF	West of Ft. McKay	16
Jacos	Ft. McMurray	16
Jacos SAGD	Hanging Stone	16
CNRL Horizon	Athabaska R.	16
Pan Canadian	Christina Lake	16
RIO	Kirby	16
Synenco	Firebag River	16
Exxon	Kearl	16
TrueNorth	Fort Hills	16
PetroCan	Meadow Creek	16
PetroCan	McKay River	16
PetroCan Power & Steam	McKay River	16
PetroCan	Lewis	16

Source: Cheminfo Services.

For the oil sands projects, only one region had sources contributing in 1995. Thus, total forecasted emissions from the new sources were deducted from the total forecasted emissions from oil sands sources. The remaining emissions (i.e. forecasted emissions from existing sources) were allocated to region 16. All other sources were simply added to the appropriate region. Projects operational after 2010 are not included in the 2010 emissions.

7.5 Other Considerations

There were several discrepancies between the 1995 emissions information used for the RWDI regional allocations and the emissions developed for this project. Some modifications were therefore applied to the methodology, which had to be made in order to develop consistent and accurate regional allocations. Examples of these are:

- there were no regional allocations for emissions from the iron and steel sector in the 1995 data. This was adjusted to include contributions from AltaSteel of Edmonton (region 11);
- similarly, regional emissions contributions from non-ferrous refining and smelting were adjusted to reflect the Alcan's Strathcona plant (region 11);
- discrepancies in NO_x and SO_x emissions from pulp and paper plants were adjusted, and regional allocations checked against known pulp and paper plant locations.

7.6 Results: 2010 CAC Emissions by Region

Regions 6, 11, 14, 16 and 17 make the largest contributions to Alberta's total emission pattern. These regions include many large anthropogenic as well as natural sources. Descriptions of these regions and the important emission source categories within them are provided in the table below. No one region in Alberta accounts for more than 20% of total CAC emissions, and no more than 30% of emissions of any one pollutant. The regions encompassing and surrounding Calgary (region 6) and Edmonton (region 11), and the oil sands projects (region 16) are major contributors to Alberta's emissions. Region 14, west of Edmonton, features large sources of PM emissions from unpaved roads.

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Table 70: Regions Contributing Major Proportions of CAC Emissions to 2010 Alberta Forecast

Census Region	Description of Region	Major Sources
6	Area surrounding Calgary	General concentration of industry, agriculture, transportation and residential
11	Area surrounding Edmonton	General concentration of industry, agriculture and transportation and residential
14	West of Edmonton, surrounding Edson and Willmore park	Unpaved roads
16	Northeast Alberta, including Wood Buffalo national park and most of the oil sands	Oil sands, forest fires and prescribed burning
17	Northwest Alberta	Forest fires, prescribed burning

Source: Cheminfo Services Inc.

Table 71: 2010 CAC Emissions for 19 Census Regions in Alberta

(kilotonnes - Excluding Biogenic Emissions)

Region	PM_T	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOC	CO	NH_3	Total	% of Total
1	226	68	10	2	33	28	40	14	343	3%
2	270	84	10	27	32	23	32	26	411	4%
3	115	37	4	11	15	6	33	13	191	2%
4	320	94	13	39	36	4	6	9	414	4%
5	180	56	7	7	27	12	26	20	272	2%
6	638	165	16	61	76	226	145	28	1173	11%
7	291	88	12	22	24	17	8	17	378	3%
8	233	70	7	11	35	43	40	22	384	3%
9	54	16	2	22	17	10	7	5	116	1%
10	497	147	19	4	24	20	38	25	607	5%
11	712	194	26	103	162	133	205	40	1355	12%
12	327	98	16	11	31	21	52	9	451	4%
13	206	64	8	29	24	17	25	18	319	3%
14	2053	584	91	16	23	18	53	3	2165	20%
15	46	12	2	9	12	7	20	1	96	1%
16	152	66	32	152	168	345	357	3	1178	11%
17	268	101	37	10	52	54	339	10	733	7%
18	62	20	4	16	28	13	65	3	185	2%
19	230	69	10	8	19	24	19	14	313	3%
Total	**6878**	**2032**	**327**	**561**	**836**	**1021**	**1508**	**280**	**11085**	**100%**

Source: Cheminfo Services Inc. Total emissions do not double count PM_{10} and $PM_{2.5}$ with PM_T.

Emissions are presented below in terms of the percentage that each region contributes to Alberta's total 2010 emissions. The emission contributions from the 3 highest-ranking regions for each pollutant are shown in bold.

Table 72: 2010 CAC Emissions Contributions from 19 Alberta Census Regions

(% of Total Emissions, Excluding Biogenic Emissions)

Region	PM_T	PM_{10}	$PM_{2.5}$	SO_x	NO_x	VOC	CO	NH_3
1	3%	3%	3%	0%	4%	3%	3%	5%
2	4%	4%	3%	5%	4%	2%	2%	**9%**
3	2%	2%	1%	2%	2%	1%	2%	5%
4	5%	5%	4%	7%	4%	0%	0%	3%
5	3%	3%	2%	1%	3%	1%	2%	7%
6	**9%**	**8%**	5%	**11%**	**9%**	**22%**	10%	**10%**
7	4%	4%	4%	4%	3%	2%	1%	6%
8	3%	3%	2%	2%	4%	4%	3%	8%
9	1%	1%	1%	4%	2%	1%	0%	2%
10	7%	7%	6%	1%	3%	2%	2%	**9%**
11	**10%**	**10%**	8%	**18%**	**19%**	**13%**	**14%**	**14%**
12	5%	5%	5%	2%	4%	2%	3%	3%
13	3%	3%	3%	5%	3%	2%	2%	6%
14	**30%**	**29%**	**28%**	3%	3%	2%	4%	1%
15	1%	1%	1%	2%	1%	1%	1%	0%
16	2%	3%	**10%**	**27%**	**20%**	**34%**	**24%**	1%
17	4%	5%	**11%**	2%	6%	5%	**23%**	4%
18	1%	1%	1%	3%	3%	1%	4%	1%
19	3%	3%	3%	1%	2%	2%	1%	5%

Source: Cheminfo Services Inc. May not add to 100% due to rounding.

Full details of the regional 2010 emissions by source category are presented in tabular form in Appendix II.

7.6.1 PM_T and PM_{10}

Nearly 50% of Alberta's PM_T and PM_{10} forecast 2010 emissions are in regions 14, 11 and 6. Region 14, encompassing the centre-west part of Alberta including Willmore Wilderness park, Hinton and Edson is the major contributor of PM emissions, contributing approximately 30% of total PM_T and PM_{10} emissions in Alberta in the year 2010. Over

95% of these emissions are due to road dust from unpaved roads, a portion of which, are from the logging industry in this area.

Regions 11 and 6 are the regions surrounding Edmonton and Calgary, respectively. These two regions are the 2nd and 3rd highest contributors to PM_T and PM_{10} emissions in Alberta in the year 2010, with region 11 contributing 10% of PM_T and PM_{10} emissions and region 6 contributing 9% of PM_T and PM_{10} emissions. Major contributors to emissions of PM from these two areas are construction, agricultural and unpaved road dust. These effects are pronounced in these two regions due to the concentration of vehicle traffic and agricultural activity around the Edmonton and Alberta.

There are several other regions that contribute significant amounts of PM_T and PM_{10} emissions. Other regions contributing 4% or more of the total PM_T and PM_{10} emissions in Alberta are regions 2, 4, 10, 12 and 17. The majority of the emissions in these areas are from unpaved road dust. Forest fires are also major contributors in region 17 within northwestern Alberta.

7.6.2 $PM_{2.5}$

Approximately 49% of $PM_{2.5}$ year 2010 emissions come from regions 14, 16 and 17. These regions cover some of western and most of northern Alberta, and include forested areas and oil sands.

The highest source of emissions, contributing to approximately 28% of Alberta emissions of $PM_{2.5}$ in the year 2010, is road dust from unpaved roads, in region 14. Similarly to PM_{10}, the higher populated areas, such as regions 6 and 11, also contribute significant emissions of $PM_{2.5}$.

Unlike the situation for PM_{10}, however, the 2nd and 3rd highest regions for $PM_{2.5}$ emissions are regions 17 and 16, accounting for 11% and 10% of the $PM_{2.5}$ emissions from Alberta, respectively. These two areas make up the majority of northern Alberta, and cover large areas of forested land as well as the oil sands operations in region 16. Forest fires and prescribed burning are the predominant sources of $PM_{2.5}$ in these areas, although the oil sands projects are a significant source in region 16.

7.6.3 SO_x

Approximately 56% of SO_x emissions forecasted for 2010 in Alberta come from regions 16, 11 and 6. Practically all SO_x emissions are from anthropogenic sources. Region 16 covers northeast Alberta, including most of the oil sands projects. Regions 11 and 6 are those surrounding Edmonton and Calgary, respectively.

The oil sands projects in region 16 are projected to be major sources of SO_x emissions in Alberta in 2010. The region contributes approximately 27% of provincial SO_x emissions. Upstream oil and gas is also a major contributor to emissions from regions 11 and 6. The region surrounding Edmonton contributes approximately 19% of emissions from Alberta in the year 2010. This includes significant contributions from electric power generation, one facility with in the non-ferrous metals smelting and refining sector, and petroleum refining facilities. The region surrounding Calgary contributes approximately 11% of SO_x emissions in Alberta, with the transportation and upstream oil and gas sector being important sources.

7.6.4 NO_x

Approximately 48% of 2010 NO_x emissions from Alberta are from regions 11, 16 and 6. These are the same regions that contributed the majority of SO_x emissions, and many of the sources are similar.

Region 11 surrounding Edmonton contributes 19% of the total 2010 NO_x emissions from Alberta. This is one of Alberta's more higher population density areas, and also has a concentration of various industries contributing to NO_x emissions. These sources include: electric power generation; upstream oil and gas; petroleum refinery; chemicals; other manufacturing; and transportation.

The oil sands in the northeastern region 16 contribute 20% of the 2010 NO_x emissions in Alberta. This area is a major localized are of industrial growth, as many of these oil sands projects were not in operation in 1995 or 2000. Upstream oil and gas and transportation are the major NO_x sources for the area surrounding Calgary (region 6). Other manufacturing plants also contribute a significant amount of NO_x to the emissions from this region. Overall, region 6 contributes approximately 9% of the 2010 NO_x emissions in Alberta.

7.6.5 VOC

Approximately 69% of anthropogenic VOC emissions in Alberta forecasted to the year 2010, are from regions 6, 11 and 16. Sources of VOCs in these regions are residential fuel burning, fuel marketing, general solvent use and transportation. All of these sources are concentrated around Calgary and Edmonton. VOC emissions from these two regions contribute approximately 22% and 13%, respectively to Alberta's total 2010 VOC emissions.

Region 16 contributes 34% of the 2010 VOC emissions in Alberta. The major sources for this region are the oil sands projects. Upstream oil and gas sources in that area are also important contributors.

7.6.6 CO

Approximately 61% of CO emissions come from regions 16, 17 and 11. Area combustion sources such as prescribed burning and forest fires are major sources of CO emissions, and as a result the two most northern and largest regions in Alberta contribute the highest percentage of these emissions.

Region 16, the northeast area of Alberta, contributes 24% of 2010 CO emissions from Alberta. Apart from forest fires and prescribed burning, the oil sands projects are major sources of CO emissions in this region.

Region 17, in northwest Alberta, contributes 23% of provincial 2010 CO emissions. There is little industry in this northern region, and most of these emissions are from prescribed burning and forest fires. However, upstream oil and gas activity also contributes some of the CO emissions to this region.

Region 11 surrounding Edmonton has a concentration of electric power generation and upstream oil and gas facilities. The region contributes 14% of CO emissions in 2010. Residential fuel-burning and transportation are also major sources of CO.

7.6.7 Ammonia (NH_3)

Approximately 42% of ammonia emissions from Alberta are from regions 2, 6, 10 and 11, contributing to approximately 9%, 10%, 9% and 15% of Alberta emissions, respectively. However, regions 5 and 8 each account for 7% and 8% of ammonia emissions in Alberta.

Most of the ammonia emissions for all regions are from livestock and application of fertilizers. Region 2, which encompasses parts of southern Alberta surrounding Brooks and Coaldale has a concentration of agricultural sources. Regions 6 and 11 are those that surround Edmonton and Calgary, where there is a concentration of agricultural activity. The chemicals industry also contributes to ammonia emissions in regions 5 and 11.

8. Comparison to Environment Canada's Forecast of CAC Emissions

8.1 Introduction

Environment Canada recently (March 6, 2002) released its "Updated Forecast" version (referred to here as EC-V2) of CAC emissions in Canada. The general approach applied in developing the forecast of emissions is very similar to the approach applied by Cheminfo Services in its CEEM model. The general approach in both cases is to use fuel consumption and socio-economic activity data as provided in Canada's Emissions Outlook: An Update (CEOU). CEOU provides the reference case and baseline energy consumption for subsequent modelling of CAC emissions. The methodologies applied by Environment Canada are documented in its report attached to the spreadsheets for the emissions.[55] These documents are available from Environment Canada's Pollution Data Branch.

While the approaches applied by Environment Canada and Cheminfo Services are very similar, the results differ, in some case significantly, in some cases not significantly. A case study analysis is first provided to identify some of the differences in assumptions applied and results obtained.

[55] Environment Canada, Pollution Data Branch, Development of the NAICC Base Case Consensus Forecast of Common Air Contaminants 1995 – 2020, March 6, 2002.

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8.2 Case Study of Alberta's Chemical Sector

A case study of Alberta's Chemical sector emissions identified various similarities and differences in the two forecasting methodologies and forecast results. These are summarized in the following table.

Table 73: Summary Comparison of Differences Between This Cheminfo Forecast and Environment Canada 2002 for Chemicals Sector in Alberta

Parameter of Comparison	**Cheminfo Forecast**	**Environment Canada Forecast**
Sector definitional issues	• Petrochemicals included in Chemicals sector	• Petrochemicals treated separately from Chemicals sector
Total emissions alignment to 1995	• Yes (sum of chemicals + petrochemicals+resin synthesis)	• Yes
Major point source emissions alignment for year 2000 with Alberta Environment	• Yes (based on available information from Alberta Environment)	• No (timing issue, Alberta Environment point source emissions for 2000 not likely available to Environment Canada)
Emission factors or growth factors used for fuels	• Yes (sum of chemicals + petrochemicals+resin synthesis)	• Different growth factors applied
Growth rates used for process emission	• Based on forecasted fuel use	• Based on growth in value of gross output
Use of facility specific industry input	• Partial. Input from some major facilities, only	• Yes. Through stakeholder EPWG feedback.
Analysis of NO_x Results	**(tonnes)**	**(tonnes)**
1995 energy-related emissions for NO_x	0	2000 (Including Petrochemicals)
1995 process NO_x emissions	17,168	17,168 (Including Petrochemicals)
Total NO_x emissions	23,364	23,364
2010 emissions for NO_x	29,077	40,532
2020 emissions for NO_x	35,181	47,252
Average annual growth Between 1995 and 2020	1.65%	2.86%

8.3 Other Similarities and Differences

At the total Alberta emissions level, this forecast incorporates the natural sources, such as biogenic sources and forest fires. The EC-V2 spreadsheets do not contain natural sources, which can be large sources of VOC and CO emissions. This is not an error in Environment Canada's forecast, but merely differences of inclusion, relate to the purpose of scope of the two forecasts. Natural sources are included in the Cheminfo results, since these can make large contributions to regional emission patterns. For total Alberta emissions, large differences result between this forecast and EC-V2 for VOC and CO.

The EC-V2 includes changes to Canada's 1995 emissions inventory versus previous versions.[56] For example, PM emissions from construction were decreased from previous EC estimates. 1995 transportation emissions have also been changed to incorporate the recent MOBILE output.

Another notable difference appears in the results of the SO_x emissions from the Upstream Oil and Gas Sector, and in particular oil sands. The EC-V2 did not incorporate the effects of flue-gas-desulphurization (FGD) control technologies adopted by Suncor between 1995 and 2000. Nor does it seem to incorporate SO_x controls to be incorporated by Syncrude between 2000 and 2005. This should not be considered an error - based on the top-down approach applied, since EC did not have direct input from the facilities in the upstream oil and gas sector for their forecast. However, incorporating the effects of FGD controls for SO_x emissions would have lowered year 2000 and subsequent year estimates.

This forecast of SO_x emissions from conventional oil and gas production presents different results from EC-V2. This forecast reflects the impact of new sulphur recovery regulations for grandfathered gas processing facilities. It is assumed that EC-V2 does not, since SO_x emissions continue to increase, more in line with energy use in the sector.

[56] Environment Canada, *1995 Inventory of Criteria Air Contaminants in Canada,* (Datasheet only) Pollution Data Branch, January 1998

Table 74: Emission Comparisons Between This Forecast and Environment Canada Forecast for Upstream Oil and Gas

(kilotonnes)

	SO_x		VOC	
	This Forecast	**EC-V2**	**This Forecast**	**EC-V2**
Oil sands developments	162	217	283	na
Conventional Upstream Oil & Gas	230	373	497	na
Total 2010	392	590	780	654
2010 Differences	198		126	
Total 1995	*440*	*437*	*541*	*485*
1995 Differences	3		56	

While this forecast of oil sands emissions is developed with a bottom-up process (estimating emissions for each project), EC-V2 relies on a top-down growth projection and arrives at different estimates. Again this should not be considered an error, but merely a methodological difference for projecting future emissions resulting in different estimates.

In terms of VOC, this forecast started with different 1995 emissions, which include VOC emissions from the oil sands (previously not included in Alberta's or Environment Canada's inventory). The difference by 2010 in VOC emissions between the two projections is substantial at nearly 126 kilotonnes.

9. Uncertainty

9.1 Summary

The level of uncertainty in CAC emissions and projections varies substantially by source category as well as pollutant. Overall the level of accuracy for the total contaminant projections should be considered to be order-of-magnitude. The uncertainty for specific-year emission estimates and projections for large natural sources is high. For forest fires alone, the emissions in any specific year can be 10 times different than the previous year, as a result of natural causes (e.g., lightning frequency) affecting the amount of biomass burned.

Table 75: Uncertainty Associated with NO_x, SO_x and CO Emissions for Canada 1990 Emissions Inventory

(Source: Environment Canada)[57]

Pollutant / Source Sector	Uncertainty
SO_x - all sectors	±5%
NO_x	
Non-transportation sectors	*
On-road transportation (MOBILE 5C)	*
Other gasoline use	*
Other transport	±30%
Total NO_x	±20%
CO	
Non-transportation sectors	±30%
On-road transportation (MOBILE 5C)	±25%
Other gasoline use	±20%
Other transport	*
Total CO	±30%
Electric Power Generation	±8%
Area and small fuel combustion sources (e.g., commercial, residential, small industrial)	±50%

Notes: Excludes miscellaneous categories, forest fires and other fires. * Could not be determined.

[57] Environment Canada, *Canadian Emissions Inventory of Criteria Air Contaminants (1990),* February 1996.

In general, SO_x emissions from fossil fuel combustion have low levels of uncertainty, since information on the amount of sulphur contained in commercial fuels is collected and analysed by Statistics Canada as well as Environment Canada. The mass of sulphur in fuels can be related to SO_x emissions. Environment Canada has previously estimated that SO_x emission inventory estimates had uncertainty levels of ±5% (for total Canadian 1990 SO_x emissions).[58] It is assumed that year 1995 SO_x emission estimates for Alberta would have a similar uncertainty level. Future year projections would be higher, due to the uncertainty associated with the forecasting/projection variables (energy use, economic growth, etc). Emission estimates of other CACs from fossil fuel combustion have greater levels of uncertainty.

It is difficult to estimate the overall accuracy or uncertainty of emission projections in this report since there are different uncertainties related to each source as well as each contaminant. For example, particulate emission estimates of road dust from vehicle traffic may have high levels of uncertainty due to technical difficulties in developing typical or representative conditions for each road in all seasons. Factors that vary during season and region include changing road conditions - wet, dry, snow covered, sandy, etc. - and vehicle traffic conditions – weight of vehicles on road, speed, etc. Similarly, in the case of residential fuel wood combustion, which makes a significant contribution to PM and VOC emissions from residential and commercial heating, there are uncertainties with respect to the amount of wood burned by residences in Alberta. There are also uncertainties with respect to the types and efficiencies of stoves and fireplaces in which the wood is burned. Emissions rates associated with different species of wood are also a source of uncertainty. These factors all relate to the amount of emissions from wood burning.

The uncertainty levels associated with estimates and projections of SO_x emissions can be low from some sources. These sources include gasoline, and other commercial fuels, where the amount of sulphur in the fuels is known. All of the sulphur contained in the fuel is emitted during combustion. Year 2000 SO_x emissions from natural gas processing facilities are believed to have low uncertainty levels, since the plants closely monitor gas flow rates and sulphur removal efficiency.

[58] Environment Canada, *Canadian Emissions Inventory of Criteria Air Contaminants (1990),* February 1996.

A relative uncertainty is used in this analysis to compare the levels of uncertainty in emissions and projections. More detailed, category and source-specific analysis of 1995 emissions, energy use, emission factors, controls, activity data and relationships between economic activities and emissions would be required to reduce uncertainty inherent in this projection analysis. Only a relative comparison of the emission categories is provided here, using the following scale:

- 1 Most accurate
- 2 Reasonably accurate
- 3 Low accuracy
- 4 Least accurate

Table 76: Relative Uncertainty Levels in CAC Emission Projections, By Contaminant

(1995 CAC Emissions Shown for Reference)

	PMT	PM 10	PM 2.5	SO_X	NO_X	VOC	CO
Industrial, Electric Power Generation (kilotonnes)	84	48	35	601	444	554	402
Level of Relative Uncertainty	***2***	***2***	***3***	***1***	***2***	***2***	***2***
Residential, Commercial, Institutional (kilotonnes)	9	9	8	1	12	37	62
Level of Relative Uncertainty	***3***	***3***	***3***	***1***	***3***	***3***	***3***
Transportation (kilotonnes)	13	12	11	8	227	105	959
Level of Relative Uncertainty	***2***	***2***	***2***	***1***	***2***	***2***	***2***
Anthropogenic area sources (road dust, solvents, etc.) (kilotonnes)	4896	1465	176	0	2	58	98
Level of Relative Uncertainty	***4***	***4***	***4***	***1***	***3***	***2***	***3***
Natural sources (forest fires, biogenic) (kilotonnes)	54	46	38	0	29	1297	447
Level of Relative Uncertainty	***4***	***4***	***4***	***1***	***4***	***4***	***4***
Total Alberta Emissions (kilotonnes)	5056	1581	269	609	715	2051	1969

An analysis of uncertainty associated with estimates of ammonia emissions is not available in the reference documents developed by Environment Canada[59], and Alberta Agriculture, Food and Rural Development[60] supporting the 1995 and 2000 data. However, given the magnitude of the differences for some sources identified in the AFRD report, it is assumed that the level of uncertainty is relatively high. This is in part due to differences in emission factors.

9.2 Sensitivity Analysis Recommendations

Sensitivity analysis can be applied to ascertain the potential effects of alternative assumptions on sectoral or total provincial emissions than those applied to establish the base case projections. A sensitivity analysis was not included in the scope of this project. It is recommended that a sensitivity analysis be carried as part of further work. A starting point could involve discussions (within CASA) along with documentation of the alternate projection assumptions that would be of interest to apply to the various emission sources. The discussions would serve to better establish the context of the alternative assumptions that could be applied. In some cases, additional research effort to identify the potential effect of certain assumptions to be tested may be required. The following are some of the areas of interest for sensitivity analysis that have been identified by CASA members:[61]

- potential impact of new additional regulations in the electric power sector;
- the pace and magnitude of oil sands development projects;
- the potential effects of additional bitumen upgraders;
- the potential effects of climate change policy initiatives affecting GHG and CAC emissions;
- the potential effect of new standards for non-road vehicles; and
- changes to economic projections.

[59] Environment Canada, *1995 Ammonia Emissions Inventory Guidebook*, First Draft, July 2000.
[60] Agriculture emissions from: Chetner, S., Sasaki, D., Alberta Agriculture, Food and Rural Development (AFRD), *Agricultural Air Emission Inventory for Alberta and Literature Review*, November 6, 2001.
[61] CASA, Feedback on draft report. "Comments on Cheminfo report, May 2002.

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11. Appendix I

11.1 Emission Tables (Major Categories by Contaminant)

(kilotonnes)

PMT	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**1995 to 2010**	**1995 to 2020**	**% of 2010**
Electric Power Generation	10	9	9	9	9	9	-7%	-8%	0.1%
Oil and Gas	6	7	19	33	39	40	463%	568%	0.5%
Other Industrial	69	57	58	61	65	69	-11%	0%	1%
Building Heating	9	11	12	14	15	17	47%	81%	0.2%
Transportation	13	10	8	6	5	5	-55%	-60%	0%
Other Anthropogenic	4832	5600	6208	6701	7171	7885	39%	63%	97%
Natural Sources	54	54	54	54	54	54	0%	0%	1%
Total	4993	5749	6368	6878	7358	8079	38%	62%	100%
PM10	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**1995 to 2010**	**1995 to 2020**	**% of 2010**
Electric Power Generation	9	8	7	8	8	8	-10%	-11%	0.4%
Oil and Gas	4	4	10	20	22	23	463%	541%	1%
Other Industrial	36	31	32	33	35	37	-7%	5%	2%
Building Heating	9	11	12	13	14	16	47%	83%	1%
Transportation	12	10	7	5	5	5	-56%	-62%	0%
Other Anthropogenic	1414	1612	1775	1906	2037	2230	35%	58%	94%
Natural Sources	46	46	46	46	46	46	0%	0%	2%
Total	1530	1722	1889	2032	2168	2366	33%	55%	100%
PM2.5	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**1995 to 2010**	**1995 to 2020**	**% of 2010**
Electric Power Generation	9	8	7	8	8	8	-13%	-13%	2%
Oil and Gas	3	3	7	12	15	16	329%	446%	4%
Other Industrial	23	20	21	22	24	25	-6%	7%	7%
Building Heating	8	11	11	12	13	16	47%	83%	4%
Transportation	11	9	6	5	4	4	-59%	-65%	1%
Other Anthropogenic	168	191	213	230	250	277	37%	64%	70%
Natural Sources	38	38	38	38	38	38	0%	0%	12%
Total	261	281	304	327	352	383	25%	46%	100%

SO_X	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**1995 to 2010**	**1995 to 2020**	**% of 2010**
Electric Power Generation	130	125	129	131	131	131	1%	1%	23%
Oil and Gas	440	354	355	392	390	389	-11%	-12%	70%
Other Industrial	30	24	24	28	29	31	-7%	3%	5%
Building Heating	1	1	1	1	1	1	9%	-28%	0.2%
Transportation	8	11	10	9	10	10	23%	37%	2%
Other Anthropogenic	0.1	0.1	0.1	0.2	0.2	0.2	18%	35%	0.03%
Natural Sources	0.03	0.03	0.03	0.03	0.03	0.03	0%	0%	0.01%
Total	609	515	519	561	561	562	-8%	-8%	100%
NO_X	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**1995 to 2010**	**1995 to 2020**	**% of 2010**
Electric Power Generation	91	95	102	113	115	117	25%	29%	13%
Oil and Gas	298	346	413	506	564	580	70%	94%	59%
Other Industrial	55	60	59	63	68	73	13%	31%	7%
Building Heating	12	13	12	12	12	12	-6%	-6%	1.4%
Transportation	227	227	166	126	102	95	-44%	-58%	15%
Other Anthropogenic	2	2	2	2	2	2	0%	0%	0.25%
Natural Sources	29	29	29	29	29	29	0%	0%	3.37%
Total	715	771	783	851	891	907	19%	27%	100%
VOC	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**1995 to 2010**	**1995 to 2020**	**% of 2010**
Electric Power Generation	1	1	1	1	1	1	32%	34%	0.1%
Oil and Gas	541	548	617	777	810	799	44%	48%	34%
Other Industrial	13	15	16	16	17	17	27%	37%	1%
Building Heating	37	47	52	57	62	73	56%	98%	3%
Transportation	105	76	51	38	34	35	-63%	-67%	2%
Other Anthropogenic	58	61	64	69	75	81	19%	40%	3%
Natural Sources	1297	1297	1297	1297	1297	1297	0%	0%	57%
Total	2051	2045	2098	2256	2296	2303	10%	12%	100%

CO	1995	2000	2005	2010	2015	2020	1995 to 2010	1995 to 2020	% of 2010
Electric Power Generation	8	8	11	12	13	13	54%	64%	1%
Oil and Gas	81	87	158	202	280	283	151%	251%	13%
Other Industrial	313	248	249	257	271	283	-18%	-10%	17%
Building Heating	62	79	87	96	104	121	53%	93%	6%
Transportation	959	760	517	395	360	369	-59%	-62%	26%
Other Anthropogenic	98	98	98	98	98	98	0%	1%	6%
Natural Sources	447	447	447	447	447	447	0%	0%	30%
Total	1969	1728	1568	1508	1574	1614	-23%	-18%	100%
NH3	**1995**	**2000**	**2005**	**2010**	**2015**	**2020**	**1995 to 2010**	**1995 to 2020**	**% of 2010**
Electric Power Generation	0.5	0.5	0.5	0.6	0.6	0.6	25%	29%	0.2%
Oil and Gas	0.8	0.9	0.9	1.0	1.2	1.2	25%	58%	0%
Other Industrial	8.9	9.5	10.3	11.1	12.2	13.2	24%	48%	4%
Building Heating	0.1	0.1	0.1	0.1	0.1	0.1	-10%	-10%	0.0%
Transportation	2.1	2.5	2.7	2.9	3.2	3.4	42%	65%	1%
Other Anthropogenic	134.2	219.3	239.5	261.7	286.0	312.7	95%	133%	94%
Natural Sources	1.7	1.7	1.8	1.8	1.8	1.9	9%	14%	1%
Total	148.2	234.5	255.8	279.1	305.1	333.2	88%	125%	100%

12. Appendix II:
2010 Alberta Regional Forecast Detail

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Table 77: Regional Alberta Emissions by Source Category and Contaminant

(Excluding Biogenic Emissions)

Regions 1 to 9

Source Category	Total	1	2	3	4	5	6	7	8	9
INDUSTRIAL EMISSIONS										
CEMENT & CONCRETE										
PMT	1149	9	21	3	1	5	191	3	20	2
PM10	388	3	7	1	0	2	64	1	7	1
PM2.5	118	1	3	0	0	1	24	0	3	0
SO_x	2058	0	0	0	0	0	0	0	0	0
NO_x	4836	0	0	0	0	0	0	0	0	0
VOC	40	0	0	0	0	0	0	0	0	0
CO	311	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0
CHEMICALS (including PAINT & VARNISH, PETROCHEMICALS, and PLASTICS & SYNTHETIC RESINS)										
PMT	1831	508	0	0	0	939	0	0	39	0
PM10	1746	485	0	0	0	896	0	0	37	0
PM2.5	741	60	0	0	0	389	0	0	128	0
SO_x	2979	12	0	0	0	0	0	0	23	0
NO_x	29077	5840	0	0	0	2021	17	0	3737	0
VOC	13690	706	0	0	0	2433	0	0	356	0
CO	9038	2365	0	0	0	5658	0	0	328	0
NH3	10397	2777	0	0	0	2415	0	0	24	0

Source Category	Total	1	2	3	4	5	6	7	8	9
MINING COAL MINING, IRON ORE MINING, OTHER MINING & ROCK QUARRYING										
PMT	9856	205	272	47	51	110	3275	265	622	162
PM10	5456	113	151	26	28	61	1812	147	345	89
PM2.5	4042	85	112	19	21	46	1353	110	258	67
SO_x	3479	15	20	3	4	8	236	19	45	12
NO_x	2526	10	13	2	3	5	161	13	31	8
VOC	814	5	7	1	1	3	84	7	16	4
CO	209	0	0	0	0	0	0	0	0	0
NH3	128	3	4	1	1	1	43	3	8	2
IRON & STEEL										
PMT	267	0	0	0	0	0	0	0	0	0
PM10	225	0	0	0	0	0	0	0	0	0
PM2.5	86	0	0	0	0	0	0	0	0	0
SO_x	17	0	0	0	0	0	0	0	0	0
NO_x	230	0	0	0	0	0	0	0	0	0
VOC	2	0	0	0	0	0	0	0	0	0
CO	13	0	0	0	0	0	0	0	0	0
NH3	2	0	0	0	0	0	0	0	0	0
NON-FERROUS REFINING & SMELTING										
PMT	16	0	0	0	0	0	0	0	0	0
PM10	15	0	0	0	0	0	0	0	0	0
PM2.5	13	0	0	0	0	0	0	0	0	0
SO_x	4181	0	0	0	0	0	0	0	0	0
NO_x	465	0	0	0	0	0	0	0	0	0
VOC	2	0	0	0	0	0	0	0	0	0
CO	25	0	0	0	0	0	0	0	0	0
NH3	1	0	0	0	0	0	0	0	0	0

Source Category	Total	1	2	3	4	5	6	7	8	9
OIL SANDS										
PMT	31676	0	0	0	0	0	0	0	0	0
PM10	18137	0	0	0	0	0	0	0	0	0
PM2.5	10598	0	0	0	0	0	0	0	0	0
SO_x	162382	0	0	0	0	0	0	0	0	0
NO_x	159485	0	0	0	0	0	0	0	0	0
VOC	280063	0	0	0	0	0	0	0	0	0
CO	146923	0	0	0	0	0	0	0	0	0
NH3	2838	0	0	0	0	0	0	0	0	0
PETROLEUM REFINING (including OTHER PETROLEUM & COAL PRODUCTS)										
PMT	1069	0	0	2	0	0	3	0	0	3
PM10	1068	0	0	2	0	0	3	0	0	3
PM2.5	1067	0	0	2	0	0	3	0	0	3
SO_x	11987	0	0	0	0	0	32	0	132	0
NO_x	4757	0	0	0	0	0	22	0	57	15
VOC	793	0	0	1	0	0	8	0	0	1
CO	1240	0	0	18	0	1	32	0	0	32
NH3	21	0	0	0	0	0	0	0	0	0
PULP AND PAPER										
PMT	2482	0	1	0	0	0	4	0	0	0
PM10	2258	0	1	0	0	0	4	0	0	0
PM2.5	2160	0	1	0	0	0	4	0	0	0
SO_x	2814	0	0	0	0	0	0	0	0	0
NO_x	4758	0	0	0	0	0	0	0	0	0
VOC	62	0	3	0	0	0	1	0	0	0
CO	1976	0	0	0	0	0	8	0	0	0
NH3	123	0	11	0	0	0	0	0	0	0

Source Category	Total	1	2	3	4	5	6	7	8	9
UPSTREAM OIL & GAS										
PMT	1742	292	27	76	10	28	276	27	78	145
PM10	1686	283	26	74	9	27	267	26	76	140
PM2.5	1665	283	26	74	9	27	267	26	76	140
SO_x	229614	2034	11805	10865	1301	7033	57174	7095	10361	21904
NO_x	346419	19798	13330	10278	19943	19781	35035	15985	21860	16832
VOC	497032	12011	15398	2968	3616	6795	179675	15147	34940	9505
CO	55425	3343	2043	1516	2980	2793	6813	2420	3364	3178
NH3	8	0	0	0	0	0	0	0	0	0
OTHER MANUFACTURING (including ABRASIVES, ALUMINUM, ASBESTOS, ASPHALT PAVING, BAKERIES, CLAY PRODUCTS, FERROUS FOUNDRIES, GRAIN INDUSTRIES, WOOD INDUSTRY and OTHER INDUSTRIES)										
PMT	44185	324	251	2160	18	85	4892	116	625	786
PM10	21944	161	124	1072	9	42	2429	58	311	390
PM2.5	13938	93	85	591	4	20	1646	36	264	239
SO_x	228	5	8	1	1	3	82	4	13	3
NO_x	16230	265	535	208	16	127	5032	72	537	65
VOC	582	9	17	4	0	4	177	2	19	5
CO	244489	1322	2205	14380	56	460	28521	491	3323	2064
NH3	382	6	11	2	1	3	113	3	14	4
ELECTRIC POWER GENERATION										
PMT	8989	11	1136	0	164	1	30	873	2	0
PM10	8067	10	1019	0	147	1	27	784	2	0
PM2.5	7637	10	992	0	1	1	25	821	2	0
SO_x	131348	1	14766	0	37900	1	28	14353	2	0
NO_x	113174	1940	10298	15	14922	48	3981	6807	153	14
VOC	1453	6	182	0	176	0	21	103	0	0
CO	12260	188	1221	1	1176	4	586	671	12	1
NH3	603	10	19	2	3	6	232	7	18	2

Source Category	Total	1	2	3	4	5	6	7	8	9
COMMERCIAL										
PMT	475	10	22	4	1	5	165	5	24	3
PM10	466	10	22	4	1	5	162	5	24	2
PM2.5	457	10	21	4	1	5	159	5	23	2
SO_x	386	9	18	3	1	4	134	4	20	2
NO_x	4877	108	225	43	12	52	1698	55	247	26
VOC	233	5	11	2	1	2	81	3	12	1
CO	910	20	42	8	2	10	317	10	46	5
NH3	24	1	1	0	0	0	8	0	1	0
RESIDENTIAL										
PMT	13029	1522	541	129	37	158	4012	181	582	71
PM10	12702	1484	527	126	36	154	3911	176	567	69
PM2.5	12008	1482	495	118	34	144	3670	165	532	65
SO_x	500	14	23	5	2	7	169	8	25	3
NO_x	6905	175	316	76	22	92	2346	106	340	41
VOC	57099	11433	2146	513	147	627	15921	717	2308	280
CO	94736	17935	3610	862	248	1054	26777	1206	3881	471
NH3	94	4	4	1	0	1	31	1	5	1
TRANSPORTATION TOTAL										
PM TOTAL	5801	204	323	192	22	204	1327	47	388	27
PM10	5405	190	301	179	21	190	1236	44	361	25
PM 2.5	4604	160	254	149	18	159	1067	38	305	22
SO_X	9277	318	518	270	63	331	2124	92	555	42
NO_X	126191	4705	7491	4621	769	5185	25045	1029	8448	437
VOC	38427	1520	2337	1707	144	1685	7097	233	2915	119
CO	395009	15514	23894	17354	1456	17089	73484	2527	30198	1353
NH3	2923	123	187	147	11	142	458	15	239	7

Source Category	Total	1	2	3	4	5	6	7	8	9
TRANSPORTATION EMISSIONS BY VEHICLE CATEGORY										
TRANSPORTATION										
LIGHT DUTY GASOLINE VEHICLES (CARS)										
PM TOTAL	437	19	29	24	2	23	61	2	37	1
PM10	424	18	28	23	2	22	59	2	36	1
PM 2.5	211	9	14	11	1	11	30	1	18	0
SO_X	90	4	6	5	0	5	13	0	8	0
NO_X	12377	540	814	668	45	639	1734	53	1048	23
VOC	12328	537	811	665	44	637	1727	53	1044	23
CO	141228	6157	9290	7622	508	7297	19785	603	11959	258
NH3	1410	61	93	76	5	73	198	6	119	3
TRANSPORTATION										
LIGHT-DUTY GASOLINE TRUCKS + BUSES										
PM TOTAL	286	12	19	15	1	15	40	1	24	1
PM10	277	12	18	15	1	14	39	1	23	1
PM 2.5	143	6	9	8	1	7	20	1	12	0
SO_X	75	3	5	4	0	4	10	0	6	0
NO_X	9692	422	637	521	40	502	1355	48	819	21
VOC	10690	465	703	575	44	553	1494	53	903	23
CO	92047	4004	6051	4952	377	4765	12868	453	7774	196
NH3	1135	49	75	61	5	59	159	6	96	2
TRANSPORTATION										
HEAVY-DUTY GASOLINE TRUCKS										
PM TOTAL	58	3	4	3	0	3	8	0	5	0
PM10	56	2	4	3	0	3	8	0	5	0
PM 2.5	36	2	2	2	0	2	5	0	3	0
SO_X	10	0	1	1	0	1	1	0	1	0
NO_X	3686	160	242	198	15	191	514	18	311	8
VOC	1443	63	95	78	6	75	201	7	122	3
CO	15298	666	1006	824	63	792	2133	75	1292	32
NH3	42	2	3	2	0	2	6	0	4	0

Source Category	Total	1	2	3	4	5	6	7	8	9
TRANSPORTATION										
LIGHT DUTY DIESEL VEHICLES (CARS)										
PM TOTAL	12	1	1	1	0	1	2	0	1	0
PM10	12	1	1	1	0	1	2	0	1	0
PM 2.5	10	0	1	1	0	0	1	0	1	0
SO_X	0	0	0	0	0	0	0	0	0	0
NO_X	100	4	7	5	0	5	14	0	8	0
VOC	41	2	3	2	0	2	6	0	3	0
CO	106	5	7	6	0	5	15	0	9	0
NH3	0	0	0	0	0	0	0	0	0	0
TRANSPORTATION										
LIGHT DUTY DIESEL TRUCKS										
PM TOTAL	151	7	10	8	1	8	21	1	13	0
PM10	12	1	1	1	0	1	2	0	1	0
PM 2.5	126	5	8	7	1	7	18	1	11	0
SO_X	3	0	0	0	0	0	0	0	0	0
NO_X	1328	58	87	71	6	69	185	7	112	3
VOC	614	27	40	33	3	32	86	3	52	1
CO	1348	59	89	72	6	70	188	7	114	3
NH3	3	0	0	0	0	0	0	0	0	0

Source Category	Total	1	2	3	4	5	6	7	8	9
TRANSPORTATION										
HEAVY DUTY DIESEL TRUCKS										
PM TOTAL	1382	61	91	76	2	71	195	2	118	1
PM10	1382	61	91	76	2	71	195	2	118	1
PM 2.5	1138	50	75	62	1	58	161	1	97	1
SO_X	43	2	3	2	0	2	6	0	4	0
NO_X	29436	1292	1938	1611	33	1505	4157	34	2519	13
VOC	1931	85	127	106	2	99	273	2	165	1
CO	17925	787	1180	981	20	917	2531	21	1534	8
NH3	20	1	1	1	0	1	3	0	2	0
TRANSPORTATION										
MOTORCYCLES										
PM TOTAL	2	0	0	0	0	0	0	0	0	0
PM10	2	0	0	0	0	0	0	0	0	0
PM 2.5	1	0	0	0	0	0	0	0	0	0
SO_X	0	0	0	0	0	0	0	0	0	0
NO_X	62	3	4	3	0	3	9	0	5	0
VOC	164	7	11	9	0	9	24	1	14	0
CO	1165	51	78	64	2	61	169	4	101	2
NH3	0	0	0	0	0	0	0	0	0	0
TRANSPORTATION										
PROPANE & CNG										
PM TOTAL	1	0	0	0	0	0	0	0	0	0
PM10	1	0	0	0	0	0	0	0	0	0
PM 2.5	1	0	0	0	0	0	0	0	0	0
SO_X	1	0	0	0	0	0	0	0	0	0
NO_X	27	1	2	1	0	1	4	0	2	0
VOC	74	3	5	4	0	4	10	0	6	0
CO	510	22	34	27	2	26	71	3	43	1
NH3	0	0	0	0	0	0	0	0	0	0

Source Category	Total	1	2	3	4	5	6	7	8	9
TRANSPORTATION										
OFF-ROAD + FARM GASOLINE										
PM TOTAL	126	3	5	1	0	2	43	2	6	1
PM10	104	3	4	1	0	1	35	1	5	1
PM 2.5	88	2	4	1	0	1	30	1	4	1
SO_X	21	1	1	0	0	0	7	0	1	0
NO_X	2318	58	98	24	7	33	791	31	117	22
VOC	2842	71	120	29	9	40	969	38	144	26
CO	69289	1729	2928	710	221	985	23630	938	3504	643
NH3	33	1	1	0	0	0	11	0	2	0
TRANSPORTATION										
OFF-ROAD DIESEL										
PM TOTAL	2241	56	95	23	7	32	764	30	113	21
PM10	2241	56	95	23	7	32	764	30	113	21
PM 2.5	2085	52	88	21	7	30	711	28	105	19
SO_X	7076	177	299	73	23	101	2413	96	358	66
NO_X	34250	854	1447	351	109	487	11680	464	1732	318
VOC	2417	60	102	25	8	34	824	33	122	22
CO	21129	527	893	217	67	300	7206	286	1069	196
NH3	275	7	12	3	1	4	94	4	14	3
TRANSPORTATION										
RAIL										
PM TOTAL	610	26	47	12	21	40	37	13	16	0
PM10	610	26	47	12	21	40	37	13	16	0
PM 2.5	561	24	43	11	19	37	34	12	15	0
SO_X	1052	45	81	21	36	69	63	23	27	0
NO_X	19077	816	1478	387	653	1246	1148	419	494	0
VOC	1202	51	93	24	41	78	72	26	31	0
CO	4919	211	381	100	168	321	296	108	127	0
NH3	2	0	0	0	0	0	0	0	0	0

Source Category	Total	1	2	3	4	5	6	7	8	9
TRANSPORTATION										
MARINE										
PM TOTAL	42	1	2	0	0	1	16	1	1	0
PM10	33	1	1	0	0	1	12	0	1	0
PM 2.5	28	0	1	0	0	0	11	0	1	0
SO_X	19	0	1	0	0	0	7	0	1	0
NO_X	12	0	1	0	0	0	5	0	0	0
VOC	1230	21	52	11	5	19	460	16	42	8
CO	12063	207	506	109	52	188	4513	157	409	77
NH3	0	0	0	0	0	0	0	0	0	0
TRANSPORTATION										
AVIATION - TURBOFUEL										
PM TOTAL	454	7	16	3	2	6	190	5	13	2
PM10	251	4	9	2	1	3	105	3	7	1
PM 2.5	177	3	6	1	1	2	74	2	5	1
SO_X	888	13	30	6	3	10	389	8	23	4
NO_X	13826	207	502	104	50	180	5778	150	398	73
VOC	3450	89	108	3	1	5	1726	4	32	2
CO	17983	353	651	42	20	73	7982	61	618	30
NH3	2	0	0	0	0	0	1	0	0	0
NON-ENERGY										
TRANSPORTATION										
TIRE WEAR & BRAKE LINING										
PMT	838	37	55	45	3	43	117	4	71	2
PM10	829	36	55	45	3	43	116	4	70	2
PM2.5	268	12	18	14	1	14	38	1	23	0
SO_x	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0

Source Category	Total	1	2	3	4	5	6	7	8	9
TRANSPORTATION										
ROAD DUST - PAVED ROADS										
PMT	265163	7257	10944	8703	5271	12521	37566	10071	15037	3038
PM10	50823	1391	2098	1668	1010	2400	7200	1930	2882	582
PM2.5	12153	359	549	440	207	584	1751	392	743	126
SO_x	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0
TRANSPORTATION										
ROAD DUST - UNPAVED ROADS										
PMT	4534321	159769	144656	61895	291841	110505	74536	225065	101897	26611
PM10	1288749	45410	41114	17592	82947	31408	21185	63968	28961	7563
PM2.5	194104	6713	6061	2582	12273	4608	3118	9468	4230	1106
SO_x	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0
INCINERATION/BURNING										
INCINERATION (includes CREMATORIUMS, INDUSTRIAL, COMMERCIAL and MUNICIPAL INCINERATION)										
PMT	26	26	0	0	0	0	0	0	0	0
PM10	19	19	0	0	0	0	0	0	0	0
PM2.5	13	13	0	0	0	0	0	0	0	0
SO_x	21	17	0	0	0	0	1	0	0	0
NO_x	18	18	0	0	0	0	0	0	0	0
VOC	1292	1242	2	1	0	1	17	1	2	0
CO	7	7	0	0	0	0	0	0	0	0
NH3	30	30	0	0	0	0	0	0	0	0

Source Category	Total	1	2	3	4	5	6	7	8	9
INCINERATION/BURNING										
CIGARETTE SMOKING										
PMT	69	2	3	1	0	1	23	1	3	0
PM10	69	2	3	1	0	1	23	1	3	0
PM2.5	69	2	3	1	0	1	23	1	3	0
SO_x	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	1	0	0	0	0	0	0	0	0	0
CO	326	7	15	5	1	5	108	5	16	2
NH3	1	0	0	0	0	0	0	0	0	0
INCINERATION/BURNING										
STRUCTURAL FIRES										
PMT	727	18	31	11	2	13	183	11	28	4
PM10	719	17	31	10	2	13	181	11	28	4
PM2.5	654	16	28	9	2	12	165	10	25	3
SO_x	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	705	17	30	10	2	13	178	11	27	3
CO	1453	35	63	21	4	26	366	23	56	7
NH3	0	0	0	0	0	0	0	0	0	0
INCINERATION/BURNING										
PRESCRIBED BURNING										
PMT	15757	0	0	0	0	0	0	0	0	0
PM10	13457	0	0	0	0	0	0	0	0	0
PM2.5	9420	0	0	0	0	0	0	0	0	0
SO_x	43	0	0	0	0	0	0	0	0	0
NO_x	2070	0	0	0	0	0	0	0	0	0
VOC	5808	0	0	0	0	0	0	0	0	0
CO	96152	0	0	0	0	0	0	0	0	0
NH3	173	0	0	0	0	0	0	0	0	0

Source Category	Total	1	2	3	4	5	6	7	8	9
INCINERATION/BURNING										
FOREST FIRES										
PMT	54325	0	0	0	0	0	0	0	0	0
PM10	46177	0	0	0	0	0	0	0	0	0
PM2.5	38028	0	0	0	0	0	0	0	0	0
SO_x	32	0	0	0	0	0	0	0	0	0
NO_x	14252	0	0	0	0	0	0	0	0	0
VOC	61356	0	0	0	0	0	0	0	0	0
CO	447385	0	0	0	0	0	0	0	0	0
NH3	959	0	0	0	0	0	0	0	0	0
SOLVENT USE										
SOLVENT USE										
DRY CLEANING	3318									
PMT	0	0	0	0	0	0	0	0	0	0
PM10	0	0	0	0	0	0	0	0	0	0
PM2.5	0	0	0	0	0	0	0	0	0	0
SO_x	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	174	4	7	2	0	2	65	2	8	1
CO	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0
FUEL MARKETING										
PMT	0	0	0	0	0	0	0	0	0	0
PM10	0	0	0	0	0	0	0	0	0	0
PM2.5	0	0	0	0	0	0	0	0	0	0
SO_x	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	13314	288	597	116	35	143	4617	156	669	65
CO	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0

Source Category	Total	1	2	3	4	5	6	7	8	9
SOLVENT USE										
GENERAL SOLVENT USE										
PMT	0	0	0	0	0	0	0	0	0	0
PM10	0	0	0	0	0	0	0	0	0	0
PM2.5	0	0	0	0	0	0	0	0	0	0
SO_x	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	38000	838	1684	334	84	436	13569	375	1742	180
CO	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0
SOLVENT USE										
PRINTING										
PMT	0	0	0	0	0	0	0	0	0	0
PM10	0	0	0	0	0	0	0	0	0	0
PM2.5	0	0	0	0	0	0	0	0	0	0
SO_x	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	2200	41	92	14	2	21	844	9	86	7
CO	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0
SOLVENT USE										
SURFACE COATINGS										
PMT	0	0	0	0	0	0	0	0	0	0
PM10	0	0	0	0	0	0	0	0	0	0
PM2.5	0	0	0	0	0	0	0	0	0	0
SO_x	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	7400	161	326	61	15	81	2664	63	337	33
CO	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0

Source Category	Total	1	2	3	4	5	6	7	8	9
AGRICULTURE										
ANIMALS/LIVESTOCK										
PMT	46067	1883	4606	2284	1515	3025	4853	3002	3846	867
PM10	11517	471	1151	571	379	756	1213	751	961	217
PM2.5	1787	73	179	89	59	117	188	116	149	34
SO_x	89	4	9	4	3	6	9	6	7	2
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0
NH3	207123	8468	20708	10270	6812	13603	21819	13498	17292	3898
AGRICULTURE										
TILLING & WIND EROSION										
PMT	510349	20864	51025	25306	16784	33517	53762	33259	42607	9606
PM10	247788	10130	24774	12287	8149	16273	26103	16148	20687	4664
PM2.5	5104	209	510	253	168	335	538	333	426	96
SO_x	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0
AGRICULTURE										
PESTICIDE & FERTILIZER APPLICATION										
PMT	2647	108	265	131	87	174	279	172	221	50
PM10	1297	53	130	64	43	85	137	85	108	24
PM2.5	371	15	37	18	12	24	39	24	31	7
SO_x	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0
NH3	54343	2222	5433	2695	1787	3569	5725	3541	4537	1023

Source Category	Total	1	2	3	4	5	6	7	8	9
MISCELLANEOUS (PROCESS/COMBUSTION)										
CONSTRUCTION										
PMT	1321873	32977	55856	13548	4218	18789	450807	17894	66848	12270
PM10	290812	7255	12288	2981	928	4134	99178	3937	14707	2699
PM2.5	5886	147	249	60	19	84	2007	80	298	55
SO_x	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS (PROCESS/COMBUSTION)										
LANDFILLS										
PMT	620	10	19	2	3	6	239	7	19	2
PM10	50	1	2	0	0	0	19	1	2	0
PM2.5	12	0	0	0	0	0	5	0	0	0
SO_x	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	373	6	12	1	2	4	144	4	11	1
CO	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS (PROCESS/COMBUSTION)										
MEAT COOKING										
PMT	132	3	6	1	0	2	45	2	7	1
PM10	132	3	6	1	0	2	45	2	7	1
PM2.5	132	3	6	1	0	2	45	2	7	1
SO_x	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0

Source Category	Total	1	2	3	4	5	6	7	8	9
MISCELLANEOUS (PROCESS/COMBUSTION)										
MINE TAILINGS										
PMT	2801	65	86	15	16	35	1034	84	197	51
PM10	224	5	7	1	1	3	83	7	16	4
PM2.5	56	1	2	0	0	1	21	2	4	1
SO_x	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS (PROCESS/COMBUSTION)										
BIOGENIC										
PMT	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
PM10	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
PM2.5	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
SO_x	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
NO_x	14377	NA	NA	NA	NA	NA	NA	NA	NA	NA
VOC	1235410	NA	NA	NA	NA	NA	NA	NA	NA	NA
CO	0	NA	NA	NA	NA	NA	NA	NA	NA	NA
NH3	847	NA	NA	NA	NA	NA	NA	NA	NA	NA
Grand Total* (not including biogenic emissions)										
PMT	6878282	226095	270140	114529	320058	180161	637669	291100	233123	53700
PM10	2032223	67526	83834	36683	93728	56493	165421	88093	70127	16481
PM2.5	327190	9741	9628	4402	12841	6570	16182	11641	7498	1968
SO_x	561433	2354	27074	10995	39274	7252	60777	21618	11056	21996
NO_x	836272	32568	31975	14567	35875	26989	75666	24262	34528	17482
VOC	1020914	28254	22784	5592	4245	12152	225940	16837	43214	10198
CO	1507890	40000	32291	32537	5973	25812	144917	7541	39579	7206
NH3	280170	13640	26375	13115	8615	19738	28443	17071	22135	4938

CHEMINFO

Regions 10 to 19

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
INDUSTRIAL EMISSIONS											
CEMENT & CONCRETE											
PMT	1149	10	575	4	12	7	258	5	9	3	11
PM10	388	3	194	1	4	2	87	2	3	1	4
PM2.5	118	1	60	0	2	1	19	1	1	0	1
SO_x	2058	0	3	0	0	0	2055	0	0	0	0
NO_x	4836	0	1648	0	0	0	3188	0	0	0	0
VOC	40	0	14	0	0	0	26	0	0	0	0
CO	311	0	106	0	0	0	205	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0
CHEMICALS (including PAINT & VARNISH, PETROCHEMICALS, and PLASTICS & SYNTHETIC RESINS)											
PMT	1831	5	334	6	0	0	0	0	0	0	0
PM10	1746	5	318	5	0	0	0	0	0	0	0
PM2.5	741	17	126	19	0	0	0	0	0	0	0
SO_x	2979	0	2929	0	0	0	0	0	0	0	14
NO_x	29077	43	17365	39	0	0	0	0	0	0	15
VOC	13690	1	10193	2	0	0	0	0	0	0	0
CO	9038	13	664	10	0	0	0	0	0	0	0
NH3	10397	0	5170	0	0	11	0	0	0	0	0
MINING COAL MINING, IRON ORE MINING, OTHER MINING & ROCK QUARRYING											
PMT	9856	238	1313	245	234	740	69	710	729	205	365
PM10	5456	132	727	136	130	409	38	393	403	114	202
PM2.5	4042	98	539	102	97	290	29	295	285	85	151
SO_x	3479	17	94	18	17	2067	5	51	808	15	26
NO_x	2526	12	64	12	12	1705	3	35	409	10	18
VOC	814	6	33	6	6	422	2	18	176	5	9
CO	209	0	0	0	0	209	0	0	0	0	0
NH3	128	3	17	3	3	9	1	9	9	3	5

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
IRON & STEEL											
PMT	267	0	267	0	0	0	0	0	0	0	0
PM10	225	0	225	0	0	0	0	0	0	0	0
PM2.5	86	0	86	0	0	0	0	0	0	0	0
SO_x	17	0	17	0	0	0	0	0	0	0	0
NO_x	230	0	230	0	0	0	0	0	0	0	0
VOC	2	0	2	0	0	0	0	0	0	0	0
CO	13	0	13	0	0	0	0	0	0	0	0
NH3	2	0	2	0	0	0	0	0	0	0	0
NON-FERROUS REFINING & SMELTING											
PMT	16	0	16	0	0	0	0	0	0	0	0
PM10	15	0	15	0	0	0	0	0	0	0	0
PM2.5	13	0	13	0	0	0	0	0	0	0	0
SO_x	4181	0	4181	0	0	0	0	0	0	0	0
NO_x	465	0	465	0	0	0	0	0	0	0	0
VOC	2	0	2	0	0	0	0	0	0	0	0
CO	25	0	25	0	0	0	0	0	0	0	0
NH3	1	0	1	0	0	0	0	0	0	0	0
OIL SANDS											
PMT	31676	0	209	1755	0	0	0	29712	0	0	0
PM10	18137	0	146	1249	0	0	0	16742	0	0	0
PM2.5	10598	0	73	659	0	0	0	9866	0	0	0
SO_x	162382	0	12155	7196	0	0	0	143032	0	0	0
NO_x	159485	0	3322	9533	0	0	0	146631	0	0	0
VOC	280063	0	365	1052	0	0	0	278646	0	0	0
CO	146923	0	657	7123	0	0	0	139143	0	0	0
NH3	2838	0	4	11	0	0	0	2823	0	0	0

CHEMINFO

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
PETROLEUM REFINING (including OTHER PETROLEUM & COAL PRODUCTS)											
PMT	1069	12	1045	0	1	2	0	0	0	1	0
PM10	1068	12	1043	0	1	2	0	0	0	1	0
PM2.5	1067	12	1043	0	1	2	0	0	0	1	0
SO_x	11987	22	8511	0	0	0	0	3290	0	0	0
NO_x	4757	102	4198	0	0	134	14	42	37	128	7
VOC	793	2	779	0	1	1	0	0	0	0	0
CO	1240	25	1078	0	14	19	2	0	3	13	2
NH3	21	0	21	0	0	0	0	0	0	0	0
PULP AND PAPER											
PMT	2482	0	0	0	470	234	0	0	212	0	1562
PM10	2258	0	0	0	427	213	0	0	193	0	1421
PM2.5	2160	0	0	0	396	191	0	0	178	0	1391
SO_x	2814	0	0	0	140	206	0	0	516	0	1951
NO_x	4758	0	0	0	1789	636	0	0	1132	0	1201
VOC	62	0	0	0	21	11	0	0	12	0	14
CO	1976	0	0	0	238	1317	0	0	278	0	134
NH3	123	0	104	0	0	0	0	0	8	0	0
UPSTREAM OIL & GAS											
PMT	1742	11	147	66	154	96	11	62	137	69	30
PM10	1686	11	142	64	150	93	10	60	133	67	29
PM2.5	1665	9	142	45	150	93	10	59	132	67	29
SO_x	229614	3732	11180	3940	29016	13225	7150	5585	7785	12410	6020
NO_x	346419	14339	25688	17298	18064	14030	2595	11175	32815	24154	13421
VOC	497032	13565	72006	14127	13464	13564	3886	39508	14204	12128	20524
CO	55425	2282	4128	3725	2642	2188	528	2618	3346	3544	1974
NH3	8	0	0	0	4	0	0	0	0	4	0

CHEMINFO

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
OTHER MANUFACTURING (including ABRASIVES, ALUMINUM, ASBESTOS, ASPHALT PAVING, BAKERIES, CLAY PRODUCTS, FERROUS FOUNDRIES, GRAIN INDUSTRIES, WOOD INDUSTRY and OTHER INDUSTRIES)											
PMT	44185	347	8585	1166	3256	4491	798	466	7444	5251	3123
PM10	21944	172	4263	579	1617	2231	396	232	3697	2608	1551
PM2.5	13938	111	2889	340	1017	1389	194	140	2278	1615	987
SO_x	228	5	54	5	7	6	2	11	7	4	8
NO_x	16230	262	5368	124	468	345	226	123	435	1623	400
VOC	582	10	196	9	26	25	5	5	33	11	25
CO	244489	1694	53151	3137	9563	24360	1384	1432	27857	59614	9475
NH3	382	7	126	7	15	15	3	8	19	8	18
ELECTRIC POWER GENERATION											
PMT	8989	2	5905	1	25	0	4	1	34	797	2
PM10	8067	2	5299	1	23	0	4	1	31	715	2
PM2.5	7637	2	5068	1	3	0	3	1	29	678	2
SO_x	131348	1	60901	0	2	0	2	1	17	3371	1
NO_x	113174	132	66391	39	447	23	1042	2054	3272	1478	120
VOC	1453	0	904	0	0	0	1	12	26	20	0
CO	12260	10	6452	3	598	2	14	998	157	157	10
NH3	603	16	238	5	9	3	2	6	9	3	14
COMMERCIAL											
PMT	475	13	171	6	8	4	5	5	7	1	14
PM10	466	13	168	6	8	4	5	5	7	1	14
PM2.5	457	12	165	6	8	4	5	5	7	1	13
SO_x	386	10	139	5	7	3	4	4	5	1	11
NO_x	4877	131	1758	66	84	44	49	52	69	14	144
VOC	233	6	84	3	4	2	2	2	3	1	7
CO	910	25	328	12	16	8	9	10	13	3	27
NH3	24	1	9	0	0	0	0	0	0	0	1

CHEMINFO

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
RESIDENTIAL											
PMT	13029	348	4041	223	245	117	120	154	199	57	293
PM10	12702	339	3939	217	239	114	117	150	194	56	286
PM2.5	12008	318	3696	204	224	107	109	141	182	53	268
SO_x	500	15	171	9	10	5	5	7	8	2	12
NO_x	6905	204	2363	130	143	69	70	90	116	34	171
VOC	57099	1382	16035	883	973	465	475	613	788	228	1163
CO	94736	2324	26969	1485	1637	783	799	1030	1326	383	1957
NH3	94	3	31	2	2	1	1	1	2	0	2
TRANSPORTATION TOTAL		391	1669	77	145	302	216	52	93	15	109
PM TOTAL	5801	364	1555	72	135	282	201	49	86	14	102
PM10	5405	304	1328	63	115	235	168	43	76	12	89
PM 2.5	4604	582	2523	179	248	431	332	116	289	23	239
SO_X	9277	9505	33656	1911	3341	7413	5489	1165	3241	268	2471
NO_X	126191	3329	10546	272	963	2622	1894	163	381	90	411
VOC	38427	33847	109199	2945	9984	26416	19147	1727	3704	981	4189
CO	395009	283	783	15	74	225	162	6	22	6	18
NH3	2923	283	783	15	74	225	162	6	22	6	18
TRANSPORTATION EMISSIONS BY VEHICLE CATEGORY											
TRANSPORTATION											
LIGHT DUTY GASOLINE VEHICLES (CARS)											
PM TOTAL	437	45	115	1	11	37	26	0	3	1	2
PM10	424	44	112	1	11	35	25	0	3	1	2
PM 2.5	211	22	56	1	5	18	13	0	1	0	1
SO_X	90	9	24	0	2	8	5	0	1	0	0
NO_X	12377	1277	3257	40	313	1035	739	7	77	23	44
VOC	12328	1272	3244	40	312	1031	736	7	77	23	44
CO	141228	14577	37165	459	3574	11813	8431	84	880	265	499
NH3	1410	146	371	5	36	118	84	1	9	3	5

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
TRANSPORTATION											
LIGHT-DUTY GASOLINE TRUCKS + BUSES											
PM TOTAL	286	29	75	1	7	23	17	0	2	1	1
PM10	277	29	73	1	7	23	17	0	2	1	1
PM 2.5	143	15	37	1	4	12	8	0	1	0	1
SO_X	75	8	20	0	2	6	4	0	1	0	0
NO_X	9692	998	2534	36	250	796	577	7	70	21	40
VOC	10690	1101	2795	40	275	878	637	7	77	23	44
CO	92047	9479	24064	342	2372	7561	5485	62	666	201	377
NH3	1135	117	297	4	29	93	68	1	8	2	5
TRANSPORTATION											
HEAVY-DUTY GASOLINE TRUCKS											
PM TOTAL	58	6	15	0	1	5	3	0	0	0	0
PM10	56	6	15	0	1	5	3	0	0	0	0
PM 2.5	36	4	9	0	1	3	2	0	0	0	0
SO_X	10	1	3	0	0	1	1	0	0	0	0
NO_X	3686	380	963	14	95	304	220	2	27	8	15
VOC	1443	149	377	5	37	119	86	1	10	3	6
CO	15298	1577	3997	57	394	1260	912	10	111	33	62
NH3	42	4	11	0	1	3	3	0	0	0	0
TRANSPORTATION											
LIGHT DUTY DIESEL VEHICLES (CARS)											
PM TOTAL	12	1	3	0	0	1	1	0	0	0	0
PM10	12	1	3	0	0	1	1	0	0	0	0
PM 2.5	10	1	3	0	0	1	1	0	0	0	0
SO_X	0	0	0	0	0	0	0	0	0	0	0
NO_X	100	10	26	0	3	8	6	0	1	0	0
VOC	41	4	11	0	1	3	2	0	0	0	0
CO	106	11	28	0	3	9	6	0	1	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
TRANSPORTATION											
LIGHT DUTY DIESEL TRUCKS											
PM TOTAL	151	16	39	1	4	12	9	0	1	0	1
PM10	12	1	3	0	0	1	1	0	0	0	0
PM 2.5	126	13	33	1	3	10	7	0	1	0	1
SO_X	3	0	1	0	0	0	0	0	0	0	0
NO_X	1328	137	346	5	35	108	79	1	11	3	6
VOC	614	63	160	2	16	50	37	0	5	1	3
CO	1348	139	351	5	35	109	80	1	11	3	6
NH3	3	0	1	0	0	0	0	0	0	0	0
TRANSPORTATION											
HEAVY DUTY DIESEL TRUCKS											
PM TOTAL	1382	144	374	1	32	128	83	0	2	1	1
PM10	1382	144	374	1	32	128	83	0	2	1	1
PM 2.5	1138	118	308	1	26	105	69	0	2	1	1
SO_X	43	5	12	0	1	4	3	0	0	0	0
NO_X	29436	3064	7972	28	681	2723	1773	6	46	14	27
VOC	1931	201	523	2	45	179	116	0	3	1	2
CO	17925	1866	4855	17	415	1658	1080	3	28	8	16
NH3	20	2	5	0	0	2	1	0	0	0	0
TRANSPORTATION											
MOTORCYCLES											
PM TOTAL	2	0	1	0	0	0	0	0	0	0	0
PM10	2	0	1	0	0	0	0	0	0	0	0
PM 2.5	1	0	0	0	0	0	0	0	0	0	0
SO_X	0	0	0	0	0	0	0	0	0	0	0
NO_X	62	6	17	0	2	4	4	0	0	0	0
VOC	164	17	45	0	4	11	10	0	1	0	0
CO	1165	122	316	2	30	78	72	0	7	2	4
NH3	0	0	0	0	0	0	0	0	0	0	0

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
TRANSPORTATION											
PROPANE & CNG											
PM TOTAL	1	0	0	0	0	0	0	0	0	0	0
PM10	1	0	0	0	0	0	0	0	0	0	0
PM 2.5	1	0	0	0	0	0	0	0	0	0	0
SO_X	1	0	0	0	0	0	0	0	0	0	0
NO_X	27	3	7	0	1	2	2	0	0	0	0
VOC	74	8	19	0	2	6	4	0	1	0	0
CO	510	52	133	2	13	42	30	0	4	1	2
NH3	0	0	0	0	0	0	0	0	0	0	0
TRANSPORTATION											
OFF-ROAD + FARM GASOLINE											
PM TOTAL	126	3	41	3	3	1	1	2	2	1	4
PM10	104	3	34	2	3	1	1	2	2	0	3
PM 2.5	88	2	29	2	2	1	1	1	1	0	3
SO_X	21	1	7	0	1	0	0	0	0	0	1
NO_X	2318	60	760	50	57	24	23	38	38	11	77
VOC	2842	74	932	62	70	29	28	46	47	13	94
CO	69289	1796	22726	1501	1695	717	683	1132	1146	315	2291
NH3	33	1	11	1	1	0	0	1	1	0	1
TRANSPORTATION											
OFF-ROAD DIESEL											
PM TOTAL	2241	58	735	49	55	23	22	37	37	10	74
PM10	2241	58	735	49	55	23	22	37	37	10	74
PM 2.5	2085	54	684	45	51	22	21	34	34	9	69
SO_X	7076	183	2321	153	173	73	70	116	117	32	234
NO_X	34250	888	11233	742	838	354	338	560	566	156	1133
VOC	2417	63	793	52	59	25	24	39	40	11	80
CO	21129	548	6930	458	517	219	208	345	349	96	699
NH3	275	7	90	6	7	3	3	4	5	1	9

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
TRANSPORTATION											
RAIL											
PM TOTAL	610	43	54	42	28	27	33	22	103	0	45
PM10	610	43	54	42	28	27	33	22	103	0	45
PM 2.5	561	40	49	39	26	25	30	21	95	0	42
SO_X	1052	74	92	73	48	47	57	39	177	0	78
NO_X	19077	1349	1677	1317	869	856	1031	702	3214	0	1422
VOC	1202	85	106	83	55	54	65	44	202	0	90
CO	4919	348	432	339	224	221	266	181	829	0	367
NH3	2	0	0	0	0	0	0	0	0	0	0
TRANSPORTATION											
MARINE											
PM TOTAL	42	1	14	1	1	1	1	1	1	0	1
PM10	33	1	11	0	1	0	0	0	1	0	1
PM 2.5	28	1	9	0	1	0	0	0	1	0	1
SO_X	19	0	6	0	0	0	0	0	0	0	1
NO_X	12	0	4	0	0	0	0	0	0	0	0
VOC	1230	32	400	18	29	16	16	16	25	6	38
CO	12063	310	3924	180	288	153	153	162	247	60	370
NH3	0	0	0	0	0	0	0	0	0	0	0
TRANSPORTATION											
AVIATION - TURBOFUEL											
PM TOTAL	454	10	147	5	9	5	5	6	8	2	13
PM10	251	5	81	3	5	3	3	4	4	1	7
PM 2.5	177	4	57	2	4	2	2	3	3	1	5
SO_X	888	17	288	10	17	8	8	13	15	3	25
NO_X	13826	300	4457	173	286	147	147	186	245	58	384
VOC	3450	33	1059	5	41	4	4	82	47	2	201
CO	17983	362	5538	70	464	60	60	504	282	24	789
NH3	2	0	1	0	0	0	0	0	0	0	0

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
NON-ENERGY											
TRANSPORTATION											
TIRE WEAR & BRAKE LINING											
PMT	838	86	220	3	21	70	50	0	5	2	3
PM10	829	86	218	3	21	69	49	0	5	2	3
PM2.5	268	28	71	1	7	22	16	0	2	1	1
SO_x	0	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0
TRANSPORTATION											
ROAD DUST - PAVED ROADS											
PMT	265163	24846	50958	7268	10893	12098	16450	1151	15693	4325	11071
PM10	50823	4762	9767	1393	2088	2319	3153	221	3008	829	2122
PM2.5	12153	1152	2472	283	467	610	761	45	612	170	429
SO_x	0	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0
TRANSPORTATION											
ROAD DUST - UNPAVED ROADS											
PMT	4534321	384487	131113	262858	120281	2014815	12895	70045	162720	38558	139774
PM10	1288749	109279	37265	74710	34186	572653	3665	19908	46249	10959	39727
PM2.5	194104	16141	5461	11052	5065	88304	546	2950	6890	1640	5895
SO_x	0	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0

CHEMINFO

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
INCINERATION/BURNING											
INCINERATION (includes CREMATORIUMS, INDUSTRIAL, COMMERCIAL and MUNICIPAL INCINERATION)											
PMT	26	0	0	0	0	0	0	0	0	0	0
PM10	19	0	0	0	0	0	0	0	0	0	0
PM2.5	13	0	0	0	0	0	0	0	0	0	0
SO_x	21	0	1	0	0	0	0	0	0	0	0
NO_x	18	0	0	0	0	0	0	0	0	0	0
VOC	1292	1	17	1	1	1	1	1	1	0	1
CO	7	0	0	0	0	0	0	0	0	0	0
NH3	30	0	0	0	0	0	0	0	0	0	0
INCINERATION/BURNING											
CIGARETTE SMOKING											
PMT	69	2	23	1	1	1	1	1	1	0	2
PM10	69	2	23	1	1	1	1	1	1	0	2
PM2.5	69	2	23	1	1	1	1	1	1	0	2
SO_x	0	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	1	0	0	0	0	0	0	0	0	0	0
CO	326	9	110	7	7	3	3	5	7	2	9
NH3	1	0	0	0	0	0	0	0	0	0	0
INCINERATION/BURNING											
STRUCTURAL FIRES											
PMT	727	15	299	44	9	3	14	7	15	6	13
PM10	719	14	296	44	9	3	14	7	15	6	13
PM2.5	654	13	269	40	8	3	13	6	13	5	12
SO_x	0	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	705	14	290	43	9	3	14	7	14	6	13
CO	1453	29	599	88	18	7	28	14	29	12	26
NH3	0	0	0	0	0	0	0	0	0	0	0

CHEMINFO

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
INCINERATION/BURNING											
PRESCRIBED BURNING											
PMT	15757	0	0	944	0	0	0	6063	8750	0	0
PM10	13457	0	0	806	0	0	0	5178	7472	0	0
PM2.5	9420	0	0	565	0	0	0	3625	5231	0	0
SO_x	43	0	0	3	0	0	0	16	24	0	0
NO_x	2070	0	0	124	0	0	0	797	1150	0	0
VOC	5808	0	0	348	0	0	0	2235	3225	0	0
CO	96152	0	0	5762	0	0	0	36998	53392	0	0
NH3	173	0	0	10	0	0	0	66	96	0	0
INCINERATION/BURNING											
FOREST FIRES											
PMT	54325	0	0	3256	0	0	0	20904	30166	0	0
PM10	46177	0	0	2767	0	0	0	17768	25641	0	0
PM2.5	38028	0	0	2279	0	0	0	14632	21116	0	0
SO_x	32	0	0	2	0	0	0	12	18	0	0
NO_x	14252	0	0	854	0	0	0	5484	7914	0	0
VOC	61356	0	0	3677	0	0	0	23609	34070	0	0
CO	447385	0	0	26811	0	0	0	172147	248427	0	0
NH3	959	0	0	57	0	0	0	369	532	0	0
SOLVENT USE											
SOLVENT USE											
DRY CLEANING											
PMT	0	0	0	0	0	0	0	0	0	0	0
PM10	0	0	0	0	0	0	0	0	0	0	0
PM2.5	0	0	0	0	0	0	0	0	0	0	0
SO_x	0	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	174	4	61	3	3	1	3	2	2	1	5
CO	0	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
FUEL MARKETING											
PMT	0	0	0	0	0	0	0	0	0	0	0
PM10	0	0	0	0	0	0	0	0	0	0	0
PM2.5	0	0	0	0	0	0	0	0	0	0	0
SO_x	0	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	13314	366	4803	184	242	119	124	143	200	45	403
CO	0	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0
SOLVENT USE											
GENERAL SOLVENT USE											
PMT	0	0	0	0	0	0	0	0	0	0	0
PM10	0	0	0	0	0	0	0	0	0	0	0
PM2.5	0	0	0	0	0	0	0	0	0	0	0
SO_x	0	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	38000	952	13588	509	845	440	331	355	662	164	914
CO	0	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0
SOLVENT USE											
PRINTING											
PMT	0	0	0	0	0	0	0	0	0	0	0
PM10	0	0	0	0	0	0	0	0	0	0	0
PM2.5	0	0	0	0	0	0	0	0	0	0	0
SO_x	0	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	2200	43	825	15	55	29	12	10	40	9	46
CO	0	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
SOLVENT USE											
SURFACE COATINGS											
PMT	0	0	0	0	0	0	0	0	0	0	0
PM10	0	0	0	0	0	0	0	0	0	0	0
PM2.5	0	0	0	0	0	0	0	0	0	0	0
SO_x	0	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	7400	178	2673	90	166	89	64	63	130	30	179
CO	0	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0
AGRICULTURE											
ANIMALS/LIVESTOCK											
PMT	46067	4275	5851	1646	3128	485	196	28	1655	508	2415
PM10	11517	1069	1463	411	782	121	49	7	414	127	604
PM2.5	1787	166	227	64	121	19	8	1	64	20	94
SO_x	89	8	11	3	6	1	0	0	3	1	5
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0	0
NH3	207123	19220	26304	7399	14064	2180	880	126	7441	2285	10857
AGRICULTURE											
TILLING & WIND EROSION											
PMT	510349	47358	64814	18230	34653	5371	2169	310	18334	5629	26752
PM10	247788	22993	31469	8851	16825	2608	1053	150	8902	2733	12989
PM2.5	5104	474	648	182	347	54	22	3	183	56	268
SO_x	0	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
AGRICULTURE											
PESTICIDE & FERTILIZER APPLICATION											
PMT	2647	246	336	95	180	28	11	2	95	29	139
PM10	1297	120	165	46	88	14	6	1	47	14	68
PM2.5	371	34	47	13	25	4	2	0	13	4	19
SO_x	0	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0	0
NH3	54343	5043	6901	1941	3690	572	231	33	1952	599	2849
MISCELLANEOUS (PROCESS/COMBUSTION)											
CONSTRUCTION											
PMT	1321873	34255	433552	28631	32337	13676	13037	21601	21857	6007	43713
PM10	290812	7536	95381	6299	7114	3009	2868	4752	4808	1322	9617
PM2.5	5886	153	1931	127	144	61	58	96	97	27	195
SO_x	0	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS (PROCESS/COMBUSTION)											
LANDFILLS											
PMT	620	16	245	5	9	3	2	6	9	3	14
PM10	50	1	20	0	1	0	0	1	1	0	1
PM2.5	12	0	5	0	0	0	0	0	0	0	0
SO_x	0	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	373	10	147	3	5	2	1	4	5	2	9
CO	0	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
MISCELLANEOUS (PROCESS/COMBUSTION)											
MEAT COOKING											
PMT	132	4	46	2	3	1	1	2	2	1	4
PM10	132	4	46	2	3	1	1	2	2	1	4
PM2.5	132	4	46	2	3	1	1	2	2	1	4
SO_x	0	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS (PROCESS/COMBUSTION)											
MINE TAILINGS											
PMT	2801	75	412	78	74	75	22	225	76	65	116
PM10	224	6	33	6	6	6	2	18	6	5	9
PM2.5	56	2	8	2	1	2	0	5	2	1	2
SO_x	0	0	0	0	0	0	0	0	0	0	0
NO_x	0	0	0	0	0	0	0	0	0	0	0
VOC	0	0	0	0	0	0	0	0	0	0	0
CO	0	0	0	0	0	0	0	0	0	0	0
NH3	0	0	0	0	0	0	0	0	0	0	0
MISCELLANEOUS (PROCESS/COMBUSTION)											
BIOGENIC											
PMT	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PM10	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
PM2.5	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SO_x	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NO_x	14377	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
VOC	1235410	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
CO	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
NH3	847	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

CHEMINFO

Source Category	Alberta	10	11	12	13	14	15	16	17	18	19
Grand Total											
PMT	6878282	497005	712087	326636	206150	2052583	46316	151529	268309	61534	229558
PM10	2032223	146896	194121	97700	63867	584121	11708	65663	101385	19575	68801
PM2.5	327190	19023	26383	16079	8211	91356	1951	31932	37459	4438	9887
SO_x	561433	4110	103120	11418	29450	15661	9371	152177	9502	15840	8389
NO_x	836272	23697	162113	30625	24435	23347	12127	167991	51645	27735	18645
VOC	1020914	19639	133480	21264	16768	17580	6712	345478	54129	12734	23914
CO	1507890	37595	204741	51596	24758	52796	20440	356880	339395	64738	19096
NH3	280170	24569	39715	9451	17861	3012	1277	3449	10091	2909	13765

13. Appendix III: Alberta Census Region Map

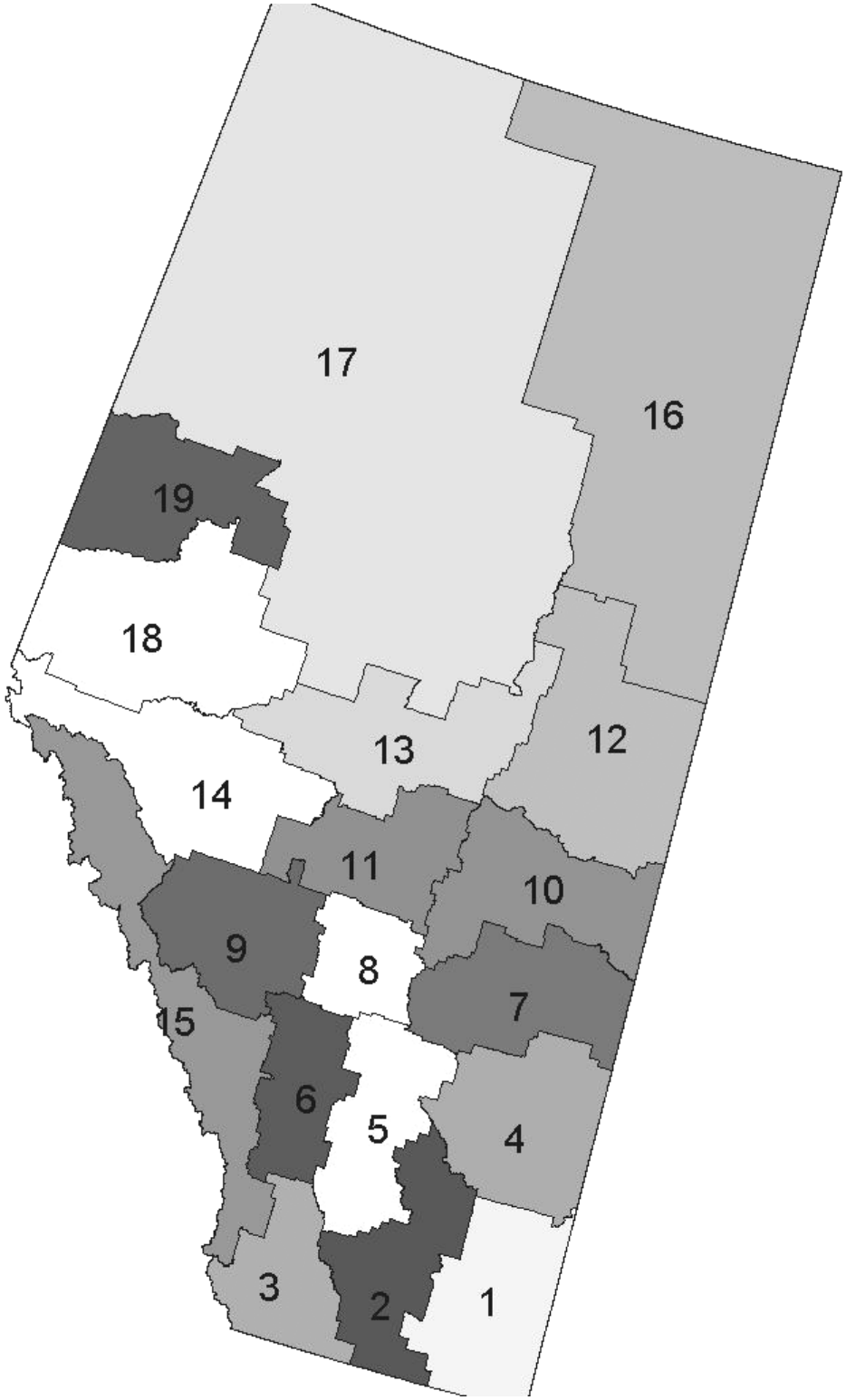

Figure 1: Map of Alberta's 19 census regions. Source: Alberta Environment