RECOMMENDATIONS TO REDUCE NON-POINT SOURCE AIR EMISSIONS IN ALBERTA

CASA

March 2018

Acknowledgements

The Clean Air Strategic Alliance thanks the members of the Non-Point Source Project Team, their member organizations and the Technical Task Group for their contributions in completing this work. Many other individuals and organizations provided content feedback as the report was developed, including Energy Efficiency Alberta, the Motor Dealers Association of Alberta, the Calgary Region Airshed Zone Particulate Matter and Ozone Committee, the Alberta Motor Transport Association, the Capital Region Air Quality Oversight Advisory Committee, and the Red Deer Particulate Matter Response Advisory Committee.

Several people greatly assisted project team members in gaining a common understanding of non-point sources. Particularly Frauke Spurrell, Maxwell Mazur, Phoenix Le, and Yayne-abeba Aklilu of Alberta Environment and Parks, and Sanjay Prasad of the Wood Buffalo Environmental Association. John Englert of Alberta Transportation is acknowledged for his contributions to the Transportation Subgroup, and David Dodge of Energy Efficiency Alberta for providing insight into his organization's work.

Corresponding members diligently stayed abreast of the project. The administrative and other support provided by the CASA Secretariat, as well as the work of Nancy Mackenzie of Bronze Horse Communications for transforming the Technical Task Group's raw drafts into a coherent report are also acknowledged.

MEMBERS OF THE NON-POINT SOURCE PROJECT TEAM

Name	Stakeholder Group
Atta Atia	Alberta Agriculture and Forestry
Nadine Blaney	Fort Air Partnership and the Alberta Airsheds Council
Jill Bloor	Calgary Region Airshed Zone and the Alberta Airsheds Council
Tasha Blumenthal	Alberta Association of Municipal Districts and Counties
Bill Calder (Co-chair)	Prairie Acid Rain Coalition and the Alberta Environmental Network
Rhonda Lee Curran (Co-chair)	Alberta Environment and Parks
Mandeep Dhaliwal	Calgary Region Airshed Zone and the Alberta Airsheds Council
Jim Hackett	ATCO Power Canada Ltd.
Nancy Hackett	City of Red Deer
Rob Hoffman	Canadian Fuels Association
Carolyn Kolebaba	Alberta Association of Municipal Districts and Counties
Lauren Maris	City of Red Deer
Steve Marshman	Alberta Canola Producers
Alison Miller (Co-chair)	Imperial Oil Ltd. (representing the Canadian Association of Petroleum Producers and the Chemistry Industry Association of Canada)
Corinna Mulyk	Alberta Transportation
Rupesh Patel	Alberta Transportation
Andrew Read	Pembina Institute and the Alberta Environmental Network
Tanya Sakamoto	City of Calgary
Bob Scotten	West Central Airshed Society and the Alberta Airsheds Council
David Spink	Prairie Acid Rain Coalition and the Alberta Environmental Network
Chandra Tomaras	City of Edmonton
Martin Van Olst	Environment and Climate Change Canada
Scott Wilson	Alberta Motor Association
Ruth Yanor	Mewassin Community Council and the Alberta Environmental Network

MEMBERS OF THE TECHNICAL TASK GROUP

Name	Stakeholder Group
Patrick Andersen	West Central Airshed Society and the Alberta Airsheds Council
Randy Angle	Alberta Environmental Network
Rhonda Lee Curran	Alberta Environment and Parks
Mandeep Dhaliwal	Calgary Region Airshed Zone and the Alberta Airsheds Council
Ike Edeogu	Alberta Agriculture and Forestry
Richard Melick	Alberta Environment and Parks
Bob Myrick	Alberta Environment and Parks
Koray Onder	Canadian Association of Petroleum Producers
Victoria Pianarosa	Parkland Fuel Corporation
David Spink	Prairie Acid Rain Coalition and the Alberta Environmental Network
Frauke Spurrell	Alberta Environment and Parks
Martin Van Olst	Environment and Climate Change Canada

Contents

APPENDICES:

LIST OF FIGURES

LIST OF TABLES

Recommendations

For the electronic version only, each recommendation in the following list is hyperlinked to the associated text in the body of the report.

Recommendation 1: Reduce Emissions from In-Use On-Road Light-Duty Vehicles

Recommendation 2: Increase the Percentage of Zero and Lower Emission On-Road Light-Duty Vehicles

Recommendation 3: Anti-Tampering Requirements for Light-Duty and Heavy-Duty Vehicles

Recommendation 4: Inspect Commercial (On-Road Heavy-Duty) Vehicle Emission Controls

Recommendation 5: Increase the Percentage of Zero and Lower Emission On-Road Heavy-Duty Vehicles

Recommendation 6: Increase On-Road Heavy-Duty Fleet Fuel Efficiencies

Recommendation 7: Support and Develop Freight Strategies

Recommendation 8: Conduct an On-Road Emission Testing Study

Recommendation 9: Energy Efficiency Alberta and the Transportation Sector

Recommendation 10: Best Practices Guide for Construction Operations and Road Dust

Recommendation 11: Review Open-Air Burning Requirements

Recommendation 12: Review Residential Wood Burning Practices

Recommendation 13: Discourage Wood Burning Practices During Periods of Degraded Air Quality

Recommendation 14: Consider the Benefits of Stage 1 Vapour Recovery Units for Fuel Terminals

Recommendation 15A: Develop Land-Use Planning Protocols to Support Air Quality Outcomes

Recommendation 15B: Support Collaboration on Land-Use Planning

Recommendation 16: Address Gaps and Uncertainties in Knowledge of Non-Point Sources

Recommendation 17A: Consider Air Quality Impacts of Proposed New Climate Change and Energy Efficiency Initiatives

Recommendation 17B: Consider and Update Air Quality Impacts of Existing Climate Change and Energy Efficiency Initiatives

Executive Summary

The Alberta: Air Zones Report 2011-2013 (Government of Alberta, 2015) indicates five of the six air zones in Alberta are either approaching or not achieving the Canadian Ambient Air Quality Standards (CAAQS) for fine particulate matter ($PM_{2.5}$), and the North Saskatchewan Air Zone is approaching the CAAQS for ozone.

Air quality can be affected by both natural and human sources. When substances from natural and anthropogenic (i.e., human) sources accumulate in the atmosphere, air quality can degrade and affect human and ecosystem health.

Alberta's 2012 Clean Air Strategy highlighted the importance of addressing both point and non-point sources to sustain good air quality. Non-point source emissions are dispersed, which makes them difficult to quantify and challenging to manage. Additional management tools and/or approaches are required, which led to the Clean Air Strategic Alliance (CASA) being tasked with this project.

The CASA Non-Point Source Project focused on non-point source emissions that contribute to ambient $PM_{2.5}$ and ozone in Alberta where air quality is approaching or not achieving the CAAQS. Since November 2015 CASA has been working to better understand non-point sources in the province and to develop recommendations to better manage them. Stakeholders involved in this project came from government, non-government organizations, Airshed Organizations, and industry. The project had four objectives:

1. Compile and review information and agree on a common understanding of non-point source air emissions in Alberta.
2. Identify non-point source air emissions reduction opportunities in Alberta where CASA's multi-stakeholder approach could add the most value.
3. Identify and recommend management actions, which could include recommending policy change, to address the highest value non-point source air emissions reduction opportunities in Alberta (from Objective 2).
4. Develop and implement a strategy and action plan for communicating with and engaging stakeholders and the public on the work of the project.

NON-POINT SOURCES OF FOCUS IN THIS PROJECT

It is recognized that there are limitations in the current understanding of the relative significance of different anthropogenic non-point sources and the impact of their emissions. The complexity of air quality issues is such that some level of additional knowledge and data detail will always be desirable; however, lack of full information should not prevent actions based on best available information. Furthermore, efforts need to be made to address critical gaps and uncertainties that notably influence the ability to understand and effectively manage air quality issues in an air zone or provincially.

A Technical Task Group (TTG) addressed much of Objective 1, producing in 2016 the Final Technical Report: A Knowledge Synthesis of Non-Point Source Air Emissions and their Potential Contribution to Air Quality in Alberta. The TTG reviewed and synthesized best available information from ambient air quality monitoring, emissions inventories, air quality simulation models, and receptor models to estimate the possible contributions of non-point source emissions to ambient air quality levels. The TTG ultimately provided a refined list of non-point sources for consideration, understanding that supporting information was limited. This list was subsequently reviewed and further refined based on additional criteria as part of the work on Objective 2.

Through Objectives 2 and 3, non-point source air emission reduction opportunities and recommended actions, summarized below, were identified for mobile sources (transportation), construction operations and road dust, open-air burning, commercial and residential heating, industrial non-point sources, land-use planning, addressing non-point source knowledge gaps and uncertainties, and considering air quality co-benefits with climate change initiatives. No actions were recommended for non-point source categories on the TTG list if management actions were already in place or planned. Timeline and capacity constraints prevented CASA from making recommendations, or limited the number of recommendations developed, for some other sources on the TTG list.

The relative significance of various sources in the sub-regions in the orange or red CAAQS management level was also considered. In the absence of full information, best judgement was used for sources that were most important in sub-regions where red or orange CAAQS monitoring results were obtained.

Potential co-benefits for NO_x reduction were also a factor. A new nitrogen dioxide (NO_2) CAAQS has been approved by Canada's environment ministers and will have an impact on Alberta's future air quality management.

SUMMARY OF RECOMMENDATIONS

Transportation

1. That Alberta Environment and Parks and Alberta Transportation collaborate with municipalities, Airshed Organizations, and other appropriate stakeholders to develop and implement a strategy to:
   - i. increase the public's understanding of emissions resulting from vehicle use and their impact on air quality
   - ii. increase the public's awareness of the practical actions they can take to reduce emissions from vehicle use
   - iii. encourage individuals to reduce emissions from vehicle use

2. That Alberta Environment and Parks, Alberta Transportation, municipalities, motor dealers, and related organizations collaborate to develop and implement a strategy to accelerate and support increasing the percentage of all substantially lower emitting vehicles in Alberta, with the following goals:
   - i. to increase the available charging or fueling infrastructure where required for these vehicles
   - ii. to increase the purchase of these vehicles

3. That Alberta Transportation prohibit vehicle emission control system tampering of future model year vehicles and engines through revisions to applicable provincial legislation and associated vehicle inspection criteria

4. That Alberta Transportation amend the *Commercial Vehicle Safety Regulation* and associated Commercial Vehicle Inspection Manual to require inspection of commercial vehicle emission controls in accordance with the Canadian Council of Motor Transport Administrators 2014 National Safety Code Standard 11, Part B (NSC 11B) of future model year vehicles

5. That Alberta Transportation:
   - i. work with partners to expand the availability of infrastructure for zero and lower emission vehicles (e.g., charging/fueling infrastructure) for long-haul heavy-duty vehicles
   - ii. in coordination with municipalities, support and develop programs to remove barriers and expand the purchase and use of zero and lower emission vehicles for municipal services (transit, municipal fleets, etc.)

6. That Alberta Environment and Parks and Alberta Transportation work with appropriate stakeholders to:
   - i. provide education and promotion of commercial freight membership in the SmartWay Transport Partnership
   - ii. encourage, through the SmartWay Transport Partnership, increasing fleet fuel efficiencies through education and promotion of the use of fuel efficiency technologies, such as aerodynamic devices, idle reduction devices, or low rolling resistance tires
   - iii. encourage SmartWay participation as a consideration for procurement

7. That Alberta Transportation and municipalities, in collaboration with appropriate stakeholders, support the development of urban and long-haul freight strategies for the movement of goods in Alberta

8. That Alberta Environment and Parks and Alberta Transportation, in collaboration with appropriate stakeholders, undertake an innovative on-road emission testing study

9. That Energy Efficiency Alberta (EEA) consider the transportation sector as an area for future EEA programs that provide greenhouse gas and air emission reduction co-benefits

Construction Operations and Road Dust

10. That Alberta Environment and Parks and Alberta Transportation work with municipalities, construction companies, and other stakeholders to develop and disseminate a best practices guide to address dust from construction and roads that:
    - i. identifies why this issue is important and what can be done to address it
    - ii. provides templates for environmental policies and plans
    - iii. prepares for potential requirements in the future

Open-Air Burning

11. That Alberta Environment and Parks with involvement from Alberta Agriculture and Forestry, the Alberta Urban Municipalities Association, and the Alberta Association of Municipal Districts and Counties:
    i. review provincial and municipal open-air burning requirements and management practices
    ii. initiate reasonable measures to help ensure that in the future the potential air quality impacts of open-air burning are appropriately considered, recognizing that prescribed burning is a necessary tool to protect communities, human life, infrastructure, and natural resources, and can be an important agricultural or ecosystem management tool

Commercial and Residential Heating

12. That Alberta Environment and Parks:
    i. evaluate and identify the barriers to fuel-switching from biomass to a cleaner alternative or retrofitting old wood burning space-heating equipment to meet the Canadian Standards Association Standard for Performance Testing of Solid-Fuel-Burning Heating Appliances, edition B415.1-10 (CSA B415.1-10) or Environmental Protection Agency Title 40 Code of Federal Regulations (EPA 40 CFR) standards
    i. develop strategies and programs as needed to motivate fuel-switching, replacement, or retrofitting

13. That Alberta Environment and Parks, municipalities, and Airshed Organizations:
    i. develop a coordinated notification process to discourage indoor and outdoor wood burning during periods when air quality is, or is forecasted by the air monitoring network to be, degraded
    ii. provide general education and awareness on the air emissions associated with wood burning

Industrial Non-Point Sources—Gasoline Distribution

14. That Alberta Environment and Parks consider the benefits of requiring Stage 1 vapour recovery units for fuel terminals, but only in the context of other potential actions that could be taken by industry to reduce ambient $PM_{2.5}$ and ozone

Land-Use Planning

15A. That municipalities and their neighbouring communities work together and with relevant stakeholders to:
    i. identify and promote opportunities to design urban form and infrastructure to reduce environmental impacts and improve air quality
    ii. educate the public and others about the importance of these opportunities
    iii. work to implement environmentally responsible land-use planning by updating bylaws, statutory plans, and policies

15B. That the Government of Alberta support collaboration among municipalities and other stakeholders on environmentally responsible urban development and land-use planning through financial mechanisms, education, and engagement

Gaps and Uncertainties – Knowledge of Non-Point Sources

16. That Alberta Environment and Parks address, as a priority in its future air quality work, gaps and uncertainties in ambient air quality monitoring (e.g. $PM_{2.5}$ and ozone), emission inventory, source characterization, modelling, and atmospheric chemistry as identified by the Non-Point Source Technical Task Group

Climate Change and Air Quality

17A. That the Alberta Climate Change Office and Energy Efficiency Alberta consider the air quality impacts of any proposed new policy, program, or action they consider adopting related to non-point sources and place value on those measures with substantial air quality co-benefits

17B. That the Alberta Climate Change Office and Energy Efficiency Alberta, as resources permit, also consider the air quality impacts of their existing policies, programs, and actions related to non-point sources and make adjustments to increase air quality co-benefits where warranted

CASA considers this project to be a starting point for continued, coordinated effort to manage non-point source emissions to improve air quality for the benefit of Albertans.

BACKGROUND

1 Background

1.1 ABOUT CASA

The Clean Air Strategic Alliance (CASA) was established in March 1994 as a new way to manage air quality in Alberta. CASA is a multi-stakeholder partnership composed of representatives selected by industry, government, and non-government organizations. Every partner is committed to a comprehensive air quality management system for Alberta.

CASA's mandate is to:

1. implement the comprehensive Air Quality Management System for Alberta
2. conduct strategic air quality planning for Alberta through shared responsibility and use of a consensus-building, collaborative approach
3. prioritize concerns about air quality in Alberta, and develop specific actions or action plans and activities to resolve those concerns

Effective management of Alberta's air quality requires a broad range of stakeholders to work together to ensure that policy meets societal needs. Economic prosperity, a clean environment, and thriving communities must all be furthered in an integrated way to provide the kind of sustainable future Albertans expect.

CASA has a long and successful history of building collaborative solutions to important air quality issues and developing policy recommendations for the Government of Alberta's consideration. It provides a forum for its members to explore each other's interests, propose regulatory and other options, test and evaluate new approaches, and jointly commit to implementation. Most importantly, agreement is reached through consensus.

A collaborative and structured decision-making process is used to help multi-stakeholder teams:

- strengthen cross-sector stakeholder relationships and networks
- ensure that decisions fit stakeholder interests
- increase innovation and creativity in decision making
- improve project deliverables, including developing sustainable solutions for air quality

This approach recognizes that stakeholders are better able to identify and agree upon an optimal solution when the task is accepted as a mutual problem.

CASA has a history of working with stakeholders to develop an understanding of non-point source emissions in Alberta (see Appendices 1 and 3 for background information and the project charter). The work undertaken for the Non-Point Source Project was informed by the following definition provided by the Government of Alberta[1] for point and non-point source emissions:

> *Point source pollution is a term used to describe emissions from a single discharge source that can be easily identified. Non-point source pollution originates from many different and diffuse sources (aggregated sources of emissions), which collectively can have a significant impact on air quality. This aggregation is done because the emission sources are either too small and numerous, too geographically dispersed, or too geographically large to be estimated or represented by a single point. There are four types of non-point sources (Table 1).*

1 Clean Air Strategic Alliance. 2013.

TABLE 1: FOUR TYPES OF NON-POINT SOURCES	
Area	Area sources are spatially diffuse and/or numerous sources that can only be measured or estimated using the accumulation of numerous point sources or as estimation of an entire area (e.g., forest fires, tailings ponds).
Volume	A volume source is a three-dimensional source of air emissions. Essentially, it is an area source with a third dimension. Examples include particulate emissions from the wind erosion of uncovered piles of materials, and fugitive gaseous emissions from various sources within industrial facilities.
Line	A line source is a source of air pollution that emanates from a linear (one-dimensional) geometric shape, usually a line. Examples include dust from roadways, and emissions from aircraft along flight paths. There can be several different segments in a line source (e.g., road network).
Mobile	Mobile sources are broad area sources that are the accumulation of non-stationary operations. These include transportation sources such as cars, trucks, boats, and non-stationary construction equipment. Mobile sources can include both on-road and off-road sources. On-road sources refer to emissions from on-road engines and on-road vehicles. Examples include cars, trucks, and motorcycles. Off-road sources refer to emissions from off-road engines and off-road vehicles. Examples include mine fleets, farm and construction equipment, and gasoline-powered lawn and garden equipment.

This CASA Non-Point Source Project is a unique attempt in Alberta to address non-point sources of fine particulate matter ($PM_{2.5}$) and ozone directly and holistically. The provincial government's regulatory system, which has been effective for point sources, is not suited to the wide variety of non-point source emissions, so non-traditional mechanisms may be needed. To successfully and cost-effectively tackle air quality issues, both point and non-point source emissions must be reduced.

1.2 THE CASA NON-POINT SOURCE PROJECT

The Canadian Ambient Air Quality Standards (CAAQS) were established to protect human health and the environment and are the driver for air quality management across the country. They establish ambient air quality levels and outline associated management actions for harmful air pollutants, including $PM_{2.5}$ and ozone, in air zones. These standards are intended to drive continuous improvement in air quality across Canada and are not "pollute up to levels." They are designed to become increasingly stringent over time and to be periodically reviewed to ensure continuous improvement in protecting the health of Canadians and the environment. The CAAQS are a key part of both the national and Alberta Air Quality Management Systems.

Alberta Environment and Parks completed a province-wide assessment against the CAAQS (see Appendix 1) for $PM_{2.5}$ and ozone for 2011-2013, and determined the CAAQS management level for each ambient air monitoring station and associated air zone. Individual air zones in Alberta have been assigned different management levels, requiring actions to address identified and emerging air quality issues within the specified air zone. Necessary actions include reducing emissions from the various types of anthropogenic sources, recognizing that naturally-occurring and anthropogenic point and non-point sources all contribute to cumulative effects on air quality.

The 2011-2013 assessment[2] showed that four of Alberta's six air zones (Lower Athabasca, North Saskatchewan, South Saskatchewan, and Upper Athabasca) were in the orange management level (requiring actions for preventing CAAQS non-achievement) for the annual $PM_{2.5}$ CAAQS. The Red Deer Air Zone was in the red management level (requiring actions for achieving CAAQS) for both the annual and 24-hour CAAQS for $PM_{2.5}$. The North Saskatchewan Air Zone was in the orange management level for ozone. Non-point sources are large contributors of air emissions and it is recognized that meaningful reductions in emissions from non-point sources will be required to reduce ambient $PM_{2.5}$ and ozone levels.

The Non-Point Source Project began in November 2015 with the goal of recommending management actions to reduce air emissions from non-point sources in Alberta, focusing on areas that were approaching or not achieving the CAAQS. The scope of the project was non-point source emissions of primary $PM_{2.5}$ and precursors of secondary $PM_{2.5}$ and ozone (i.e., sulphur oxides [SO_x], nitrogen oxides [NO_x], volatile organic compounds [VOCs], and ammonia [NH_3]). The work to reduce these substances is expected to have the co-benefit of reducing other emissions.

2 Government of Alberta, 2015.

The project objectives were to:

1. compile and review information and agree on a common understanding of non-point sources in Alberta
2. identify non-point source opportunities in Alberta where CASA's multi-stakeholder approach could add the most value
3. identify and recommend management actions, which could include recommending policy change, to address the highest value non-point source air emissions opportunities in Alberta
4. develop and implement a strategy and action plan for communicating the work of the Non-Point Source Project Team and engaging stakeholders and the public

1.3 WORK OF PROJECT TEAM SUPPORT GROUPS

1.3.1 Technical Task Group Report Overview

The Technical Task Group (TTG), a sub-committee of the Non-Point Source Project Team, was struck in March 2016 to compile and review information and reach a common understanding of non-point sources in Alberta (Objective 1). TTG representatives were largely external to the project team. Relying on in-kind contributions from members, the TTG recommended eight non-point sources of focus.

The TTG's Final Technical Report: A Knowledge Synthesis of Non-Point Source Air Emissions and their Potential Contribution to Air Quality in Alberta (TTG report) presents what was known about non-point source emissions and their relative contribution to air quality at the time of the report, particularly for the Alberta air zones in the red or orange management levels under the CAAQS Framework (see Appendix 2 for the TTG report).

The TTG report synthesized four major sources of information:

1. point and non-point source emission inventories, retrospective trends in emissions for 2000-2014, and emissions forecasting
2. ambient monitoring data and information for ozone, $PM_{2.5}$, VOCs, total hydrocarbons (THC)/ non-methane hydrocarbons (NMHC), sulphur dioxide (SO_2), NO_x, and NH_3 (as available) and trends in ambient levels
3. air quality modelling studies of ozone and/or $PM_{2.5}$ and ozone, and $PM_{2.5}$ precursors with a focus on modelling that includes non-point sources, and any relevant studies from similar jurisdictions in the United States
4. available receptor modelling studies to identify potential sources contributing to $PM_{2.5}$ and ozone concentrations in the air zones at the red and orange CAAQS management levels

The TTG approached its examination of point and non-point sources that potentially contribute to and influence air quality in Alberta through ambient air monitoring information, emissions inventories, and modelling studies for the air zones. TTG members discussed a number of issues surrounding the use of these resources, including interpretation of ambient air monitoring data, the uncertainties in emissions inventories, and the shortage of receptor modelling and air quality simulation modelling studies for the air zones. The TTG report discusses some of these limitations, identifies the gaps and uncertainties encountered, and provides overall conclusions. Appendices to the TTG report include air zone specific reports that summarize: 1) assessments against the CAAQS, 2) air emissions inventory data, and 3) air modelling and receptor modelling studies carried out for each region or sub-region.

The TTG report focuses on both non-point sources directly emitting $PM_{2.5}$ and on sources emitting the precursor substances that contribute to the formation of $PM_{2.5}$ and ozone in the atmosphere, including NO_x, SO_2, VOCs, and NH_3. The ten largest non-point sources in Alberta as a whole are identified for emissions of primary $PM_{2.5}$, NO_x, VOCs, NH_3, and SO_2 along with the important non-point sources in the individual air zones. Unfortunately, information on the relative significance of various non-point sources in sub-regions within air zones where red or orange management levels have been reached is limited. General emissions trends since 2000 were considered, both retrospective and forecasted.

The air zone summaries contained in the TTG report and the complete reports for each air zone appended to the TTG's report present findings and conclusions for supporting improved air quality in each of Alberta's air zones. The CAAQS management levels and the identified non-point sources for each air zone are summarized in Table 2; the non-point sources are listed based on their emissions inventory category rather than by the four broad non-point source types (area, volume, line, and mobile) to focus recommendations on specific sectors. The orange CAAQS management level requires actions to prevent a CAAQS exceedance, the yellow level requires actions to prevent air quality deterioration, the red level requires actions to achieve the CAAQS, and the green level requires actions to keep clean areas clean.

TABLE 2: AIR ZONE CAAQS MANAGEMENT LEVELS AND NON-POINT SOURCES IDENTIFIED BY THE TTG FOR FURTHER CONSIDERATION

AIR ZONE	$PM_{2.5}$ CAAQS MANAGEMENT LEVEL	OZONE CAAQS MANAGEMENT LEVEL	IDENTIFIED NON-POINT SOURCES*
Lower Athabasca	Orange Management Level (Actions for Preventing CAAQS Exceedance)	Yellow Management Level (Actions for Preventing Air Quality Deterioration)	• Oil Sands Specific (NO_X from mine fleets, VOCs from tailings ponds and mines, $PM_{2.5}$ from mining and tailings operations) • Industrial non-point sources (VOCs) • Construction ($PM_{2.5}$) • Road dust ($PM_{2.5}$) • Transportation (NO_X, VOCs) • Prescribed burning for oil sands land development ($PM_{2.5}$)
Upper Athabasca	Orange Management Level (Actions for Preventing CAAQS Exceedance)	Yellow Management Level (Actions for Preventing Air Quality Deterioration)	• Industrial non-point sources (VOCs) • Road dust ($PM_{2.5}$) • Agriculture (VOCs, $PM_{2.5}$, NH_3) • Transportation (NO_X, VOCs) • Construction ($PM_{2.5}$)
North Saskatchewan	Orange Management Level (Actions for Preventing CAAQS Exceedance)	Orange Management Level (Actions for Preventing CAAQS Exceedance)	• Transportation (NO_X, $PM_{2.5}$) • Agriculture (NH_3) • Commercial and residential heating (NO_x) • Road dust ($PM_{2.5}$) • Construction ($PM_{2.5}$) • Industrial non-point sources (VOCs)
South Saskatchewan	Orange Management Level (Actions for Preventing CAAQS Exceedance)	Yellow Management Level (Actions for Preventing Air Quality Deterioration)	• Road dust ($PM_{2.5}$) • Construction ($PM_{2.5}$) • Transportation (NO_X, VOCs) • Industrial non-point sources (VOCs) • Agriculture (NH_3, VOCs, $PM_{2.5}$)
Red Deer	Red Management Level (Actions for Achieving CAAQS)	Yellow Management Level (Actions for Preventing Air Quality Deterioration)	• Road dust ($PM_{2.5}$) • Construction ($PM_{2.5}$) • Agriculture ($PM_{2.5}$, NH_3, VOCs) • Transportation (NO_X, VOCs) • Industrial non-point sources (VOCs)
Peace	Yellow Management Level (Actions for Preventing Air Quality Deterioration)	Green Management Level (Actions for Keeping Clean Areas Clean)	• Agriculture ($PM_{2.5}$, NH_3) • Construction ($PM_{2.5}$) • Industrial non-point sources (NO_X, VOCs, NH_3) • Road Dust ($PM_{2.5}$) • Transportation (NO_X, VOCs)

*The parameters associated with the source type that were considered particularly relevant in the context of CAAQS management in that air zone are also identified; e.g., for the agriculture category only NH_3 emissions are considered of high relevance in the North Saskatchewan Air Zone whereas in the South Saskatchewan Air Zone, $PM_{2.5}$, NH_3, and VOCs from this category are considered relevant. Details on the information and assessments conducted to identify priority emission categories and associated priority pollutants can be found in the individual air zone reports appended to the TTG report.

The TTG report identified eight categories of non-point sources for further consideration (Table 3).

TABLE 3: NON-POINT SOURCES IDENTIFIED BY THE TTG FOR FURTHER CONSIDERATION

Non-Point Source Category	Description of Non-Point Source	Air Zone Where Non-Point Sources Identified as Relevant[5]	Emissions Identified as Relevant
Transportation	Emissions from on- and off-road, rail, air, and marine vehicles and equipment	All Zones	NO_x, VOCs
Construction Operations[1]	Fugitive particulate matter emissions resulting from disturbances on construction sites	All Zones	$PM_{2.5}$
Road Dust	Re-suspension of particulate matter by vehicles travelling on paved and unpaved roads	All Zones	$PM_{2.5}$
Prescribed Burning	Emissions from controlled fires used for land management treatments, specifically land clearing for industrial development in the Lower Athabasca Air Zone	Lower Athabasca	$PM_{2.5}$, VOCs, NO_x
Agriculture[2]	Emissions from agricultural activities, including: manure handling, tilling and wind erosion, fertilizer application, crop harvesting, and crop drying	All Zones except Lower Athabasca	NH_3, VOCs, $PM_{2.5}$
Commercial and Residential Heating	Emissions from combustion sources used for space or water heating in residential and commercial establishments, health and educational institutions, and government/ public administration facilities	North Saskatchewan	NO_x
Industrial Non-point Sources[3]	Emissions from non-point sources at industrial operations from various sectors (e.g., oil and gas, chemical, cement, petroleum refining, hydrocarbon storage and transportation), including: plant fugitive leaks, materials storage and handling, non-stationary equipment, space heating, and storage tanks	All Zones	NO_x, VOCs
Oil Sands Specific[4]	Emissions from non-point sources specific to oil sands mining operations, including: tailings ponds, mine fleets, mine faces, and mining disturbances	Lower Athabasca	NO_x, VOCs, $PM_{2.5}$,

1 Emissions from construction equipment fuel combustion are captured under the off-road transportation categories.

2 Emissions from agricultural equipment fuel combustion are captured under the off-road transportation categories.

3 Plant fugitive emissions from oil sands mining operations are captured under the Industrial Non-point Sources category.

4 Emissions from road dust at industrial operations are captured under the Road Dust category, oil sands specific non-point sources (emissions from tailings ponds, mine faces, mine fleets and mining disturbances) are captured under the Oil Sands Specific category.

5 All the non-point source categories are present and influence air quality in all the air zones but the Technical Task Group identified these air zones as the ones in which the noted source category may be relevant in the context of current CAAQS management issues within that zone.

The TTG report also identified information gaps and uncertainties as well as several areas for potential future work to help improve the overall understanding of the contribution of non-point sources to air quality in the province. Gaps and uncertainties identified for future work are the need:

- for more $PM_{2.5}$ speciation data with adequate supporting information
- to develop emissions inventories with clear source categories
- for resources and capacity to do region-specific and province-wide modelling to account for transport from one air zone to another
- to improve the use and reliability of receptor modelling to better identify the sources of primary pollutants contributing to ambient $PM_{2.5}$ and ozone concentrations
- to improve confidence in receptor modelling for secondary pollutants
- for more atmospheric profiling (e.g., wind and temperature) and better information on plume behaviour and atmospheric transformations occurring in the atmospheric boundary layer near ambient monitoring stations experiencing elevated $PM_{2.5}$ and ozone concentrations
- for a better understanding of fugitive emissions, which are a large source of VOCs and primary $PM_{2.5}$ emissions from many industrial operations in Alberta

Finally, the TTG report noted that to improve overall understanding of the atmospheric chemistry underlying the formation of secondary $PM_{2.5}$ and ozone, there is a need to better understand specific air quality events where data are available from individual monitoring stations. Some questions that could be considered during future work are described in recommendation 16 (Section 2.8).

1.3.2 Transportation (Mobile Sources) Subgroups

To help fulfill Objectives 2 and 3, a Transportation Subgroup was formed to undertake comprehensive discussions outside of regular meetings on the wide variety of transportation-related (mobile) sources and potential management actions to address them. Its purpose was to identify potential management actions where CASA's multi-stakeholder approach could add the most value. This subgroup included representatives from the project team and additional support from Alberta Transportation.

The subgroup reviewed potential management actions, both regulatory and voluntary, using several criteria including what is already being done in Alberta, gaps between what is being done in Alberta and in other jurisdictions, potential cross-cutting impact across multiple regions, feasibility, time needed for implementation, and anticipated success of implementation based on available information. The potential management actions resulting from the screening process were then fleshed out for further discussion.

The team established three subgroups to further review and refine the potential management actions. Based on transportation categories (on-road light-duty vehicles, on-road heavy-duty vehicles, and off-road equipment [both vehicles and engines]), the subgroups determined potential priority management actions or next steps for consideration. The subgroups then developed recommendations based on the agreed upon priorities for on-road light-duty and on-road heavy-duty vehicles. Off-road vehicles and engines are discussed in Section 3.1.2.

1.3.3 Communications Subgroup

Communicating the work of the project team to CASA stakeholders and the public was acknowledged early in the process as an important objective throughout the project and a Communications Subgroup was formed to assist with Objective 4.

The Communications Subgroup prepared a strategy to develop and distribute communications materials during and following completion of the project. The Communications Plan (see Appendix 4) had three objectives:

- raise awareness of CASA, the CASA process, and the Non-Point Source Project as a foundation for the future dissemination of information
- communicate the impact of non-point source emissions on the state of air quality in Alberta
- communicate the findings and recommendations of the project to address non-point source emissions in Alberta

The subgroup produced a background document and a non-point source message map (see Appendices 5 and 6). It also held a workshop on April 12, 2017 during which organizations involved in communications and outreach on air quality and non-point source emissions shared information on their programs and discussed complementary future directions. The workshop identified organizations and programs that could share messaging from CASA and who could potentially help carry the project results to a wider audience.

1.4 REFINING THE PROJECT FOCUS

1.4.1 Rationale for Selecting Non-Point Sources for Potential Recommendations

The non-point sources identified by the TTG along with three additional non-point source topic areas were considered in the context of the project scope to determine which sources would be the focus of the final recommendations (Table 4).

The relative impact of various sources in the sub-regions in the orange or red CAAQS management levels was also considered. In the absence of full information, best judgement was used on the sources that were most important in these sub-regions.

Potential co-benefits for NO_x reduction were also a factor. A new nitrogen dioxide (NO_2) CAAQS has been approved by Canada's environment ministers and will have an impact on Alberta's future air quality management.

As noted in Table 4, some aspects of transportation, agriculture, commercial and residential heating, industrial non-point sources, and oil sands specific sources already have existing or planned management actions and CASA has not made specific recommendations for further action on these emission sources. It was assumed that ongoing initiatives will continue and that planned initiatives will be implemented. If this does not happen, those sources or areas will need to be revisited and may require additional action. These categories are discussed in Section 3.

Three non-point source topic areas that relate to the identified non-point source categories were added, but for some sources on the TTG list, timeline and capacity constraints prevented or limited the development of recommendations.

TABLE 4: REFINED LIST OF NON-POINT SOURCE TOPIC AREAS FOR POTENTIAL RECOMMENDATIONS

Non-Point Source Topic Area	Description of Non-Point Source Topic Area	Recommendations
Transportation	Emissions from on-road and off-road, rail, air, and marine vehicles and equipment	Recommendations for selected sources See Section 2.2 and Recommendations 1-9
Construction Operations[1] and Road Dust	Fugitive particulate matter emissions resulting from disturbances on construction sites Re-suspension of particulate matter by vehicles travelling on paved and unpaved roads	Recommendations for selected sources See Section 2.3 and Recommendation 10
Prescribed Burning	Emissions from open-air burning activities such as controlled fires used for forestry, agricultural land, and biomass management with specific reference to land clearing for industrial development in the Lower Athabasca Air Zone	See Section 2.4 and Recommendation 11
Agriculture[2]	Emissions from agricultural activities including manure handling, tilling and wind erosion, fertilizer application, crop harvesting, and crop drying	No recommendation at this time See Section 3.2
Commercial and Residential Heating	Emissions from combustion sources used for space or water heating in residential and commercial establishments, health and educational institutions, and government/public administration facilities	Recommendations for selected sources See Section 2.5 and Recommendations 12-13
Industrial Non-point Sources[3]	Emissions from non-point sources at industrial operations from various sectors (e.g., oil and gas, chemical, cement, petroleum refining, hydrocarbon storage and transportation), including plant fugitive leaks, materials storage and handling, non-stationary equipment, space heating, and storage tanks	Recommendation for selected sources See Section 2.6 and Recommendation 14

Non-Point Source Topic Area	Description of Non-Point Source Topic Area	Recommendations
Oil Sands Specific[4]	Emissions from non-point sources specific to oil sands mining operations, including tailings ponds, mine fleets, mine faces, and mining disturbances	No recommendation at this time See Section 3.6
Land-Use Planning	Emissions from transportation modes and distances, as well as building and housing types	See Section 2.7 and Recommendations 15A and 15B
Gaps and Uncertainties	Information and data to define the amount that each non-point source category contributes to pollution concentrations	See Section 2.8 and Recommendation 16
Climate Change	Greenhouse gas sources addressed by Climate Change Office and Energy Efficiency Alberta policy, programs and actions	See Section 2.9 and Recommendations 17A and 17B

1 Emissions from construction equipment fuel combustion are captured under the off-road transportation categories.

2 Emissions from agricultural equipment fuel combustion are captured under the off-road transportation categories.

3 Plant fugitive emissions from oil sands mining operations are captured under the Industrial Non-point Sources category.

4 Emissions from road dust at industrial operations are captured under the road dust category, oil sands specific non-point sources (emissions from tailings ponds, mine faces, mine fleets and mining disturbances) are captured under the Oil Sands Specific category.

RECOMMENDATIONS

2 Recommendations

2.1 INTRODUCTION

Alberta Environment and Parks has led work over several years directly focused on managing and reducing ambient $PM_{2.5}$ and ozone in regions where the levels of these substances are a concern. The CASA project aimed to complement and add value to this region-specific work by recommending cross-cutting action on non-point sources that provides benefits to more than one region. Several recommendations also propose processes that may result in policy changes or other action that would be difficult to develop or support in one region alone.

New CAAQS for NO_2 that were published in Fall 2017 may pose their own challenges for Alberta's air quality management. Given this, CASA kept the possibility of co-benefits for NO_2 reduction in mind when determining what sources to focus on and in crafting recommendations.

Consistent with the CASA consensus approach, extensive stakeholder review influenced the final content of the recommendations presented in this report.

This project and its report should be considered as an important first step in effectively managing the contribution of non-point source emissions to Alberta's air quality. Managing Alberta's non-point source emissions, like the broader effort to ensure good air quality, will be an ongoing effort.

This report presents recommendations related to mobile sources (transportation), construction operations and road dust, open-air burning, commercial and residential heating, industrial non-point sources, land-use planning, addressing non-point source knowledge gaps and uncertainties, and considering air quality co-benefits with climate change initiatives.

Some non-point sources do not have associated recommendations and the rationale is provided in Section 3.

The recommendations are directed to the expected implementers at the time the project was completed. Several recommendations also call on one or more parties to "support" various actions and initiatives. This "support" may, but need not necessarily, include financial support or contributions.

2.2 TRANSPORTATION

Transportation is a major non-point source in Alberta and is a large emission source in the air zones that are approaching or not achieving the CAAQS, and in urban sub-regions. For the purpose of this project, transportation includes on- and off-road, rail, air, and marine vehicles and equipment. The recommendations focus on on-road light-duty and on-road heavy-duty vehicles, and other transportation sources are included in Section 3.

In 2014, on-road light-duty gasoline cars and trucks (e.g., personal vehicles) were responsible for 26.1 kilotonnes and 3.8% of the total anthropogenic NO_x emissions in Alberta. On-road heavy-duty diesel vehicles were responsible for 51 kilotonnes and 7.4% of the total anthropogenic NO_x emissions, as well as 2.2 kilotonnes and 0.3% of the anthropogenic $PM_{2.5}$ emissions in Alberta. Light-duty gasoline cars and trucks produced 22.7 kilotonnes and 3% of VOCs emitted in Alberta. Reducing tailpipe emissions also helps reduce potential exposure to vehicle exhaust.

Recommendations 1-9 reflect the importance of transportation emission sources in Alberta and detailed rationale is provided for each recommendation.

2.2.1 Mobile Sources: On-Road Light-Duty and Heavy-Duty Vehicles

RECOMMENDATION 1: REDUCE EMISSIONS FROM IN-USE ON-ROAD LIGHT-DUTY VEHICLES

That Alberta Environment and Parks and Alberta Transportation collaborate with municipalities, Airshed Organizations, and other appropriate stakeholders to develop and implement a strategy to:

i. increase the public's understanding of emissions resulting from vehicle use and their impact on air quality
ii. increase the public's awareness of the practical actions they can take to reduce emissions from vehicle use
iii. encourage individuals to reduce emissions from vehicle use

Performance Measures

i. Creation of a charter or memorandum of understanding (MOU) formalizing the collaboration by January 2020

ii. Development of an appropriate strategy satisfying the recommendation by December 2021

iii. Implementation of the strategy satisfying the recommendations by December 2022

Performance Indicators

i. Number of Albertans subscribed, number of trips taken, and total hours driven in sharing economy vehicles

ii. Number of people entering downtown by sustainable transportation (transit, pedestrians, and cyclists) compared to vehicles

iii. Ridership on public transit

Rationale and Background

Increasing the understanding of emissions from transportation and their impacts on air quality provides a foundation for increasing public awareness of the need to reduce emissions. Empowering and encouraging the public to use viable, lower emitting transportation options may lead to increases in carpooling, use of public transit, purchases of more fuel-efficient vehicles, and active transportation (e.g., walking, bicycling). Individuals could also benefit from multi-mode transportation trip planning tools to increase their use of lower emitting transportation options.

Environmental and Health Value

The use of high occupancy vehicles (carpooling, public transit), active transportation choices, and the use of lower emitting vehicles will reduce vehicle emissions, which is particularly important in areas in the orange or red CAAQS management levels.

Compatibility with Existing Initiatives

This recommendation aligns with many national, provincial, and municipal initiatives aimed at reducing emissions via increased carpooling, active transportation, fuel efficient driver education, purchase of fuel efficient vehicles, and others. Examples are provided below.

National:

- Buying a Fuel-Efficient Vehicle (Natural Resources Canada – Office of Energy Efficiency)
- Eco Driving, Fuel-Efficient Driving Techniques (Natural Resources Canada – Office of Energy Efficiency)
- Mobile Sources Working Group under the national Air Quality Management System (Canadian Council of Ministers of the Environment [CCME])
- Pan-Canadian Framework on Clean Growth and Climate Change
- Strategy on Short-Lived Climate Pollutants – 2017 (Environment and Climate Change Canada [ECCC])

Provincial:

- Clean Air Strategy (Government of Alberta)
- Climate Leadership Plan (Government of Alberta)
- Green Transit Incentives Program (GreenTRIP) (Alberta Transportation)
- Draft Provincial Public Transportation Strategy (Alberta Transportation)

Municipal:

- 2016 Edmonton Metropolitan Growth Plan
- Calgary Parking Authority Carpool Parking Program (City of Calgary)
- Calgary Transportation Plan (City of Calgary)
- Edmonton Community Energy Transition Strategy (City of Edmonton)
- Pedestrian Strategy (City of Calgary)
- The Way We Green (City of Edmonton)
- The Way We Move, City of Edmonton Transportation Master Plan (City of Edmonton)
- Various vehicle idling reduction bylaws and initiatives; e.g., Be Idle Be Free (City of Edmonton), Idle Free (City of Red Deer)

Other:

- Carpool.ca (Trans-Canada Carpool.ca)
- Commuter Challenge (annual event), https://commuterchallenge.ca/
- Smart Drive Challenge (Scout Environmental, Government of Ontario, Canadian Fuels Association, Natural Resources Canada)
- Smart Fuelling (Canadian Fuels Association, Canadian Independent Petroleum Marketers Association, Canadian Convenience Stores Association, Canadian Automobile Association)

Potential Stakeholders

- Academics working on public health and air quality
- Alberta Association of Municipal Districts and Counties
- Alberta Motor Association
- Alberta School Boards

- Alberta Urban Municipalities Association
- Energy Efficiency Alberta
- Government of Alberta (Alberta Health, Alberta Culture and Tourism)
- Private sector (e.g., energy companies, ride-sharing companies, car manufacturers and dealerships)
- Transportation-related non-profit organizations (e.g., Electric Vehicle Association of Alberta, Paths for People, Edmonton Bicycle Commuters)

Advice to Implementers

This recommendation focuses on education and awareness, and implementers may be able to leverage, link to, or partner with existing programs and organizations. Examples of existing initiatives include driver education (eco-driving), reducing unnecessary idling, carpooling, public transit, active transportation, purchase of low emission and/or right-sized vehicles, and highlighting efforts of companies with innovative programs that provide carpooling for staff or use lower emission vehicle fleets. Alignment with Alberta Environment and Parks' Environmental Education Framework would be appropriate.

An initial step may be to conduct an inventory of existing programs and initiatives to identify opportunities for stakeholders to leverage and amplify their impact. Many relevant initiatives in other jurisdictions could be adapted for use in Alberta.

As an innovative example, the Smart Drive Challenge[3] is an eco-driving program that uses actual participant driving data collected through a smartphone app. Drivers establish a three-week baseline of their typical driving patterns and then complete an online training course, after which they are challenged to implement their new knowledge with the goal of improving their efficiency by 5% and reducing their driving by 10%. Drivers are given access to an online dashboard where they can review their progress. Participants are entered into a draw for financial incentives awarded at the end of the challenge period. Smart Drive Challenge is a partnership involving Scout Environmental, the Canadian Fuels Association, and the Governments of Ontario and Canada and is working to actively expand the regions in which it operates.[4]

The Government of Alberta may wish to consider this recommendation as an area of future work for CASA.

RECOMMENDATION 2: INCREASE THE PERCENTAGE OF ZERO AND LOWER EMISSION ON-ROAD LIGHT-DUTY VEHICLES

That Alberta Environment and Parks, Alberta Transportation, municipalities, motor dealers, and related organizations collaborate to develop and implement a strategy to accelerate and support increasing the percentage of all substantially lower emitting vehicles in Alberta, with the following goals:

i. to increase the available charging or fueling infrastructure where required for these vehicles

ii. to increase the purchase of these vehicles

Performance Measures

i. Creation of a team charter or MOU formalizing the collaboration by January 2020

ii. Implementation of a strategy to increase the percentage of zero and low emission vehicles by December 2021

Performance Indicators

i. Percentage of zero and low emission vehicles available and sold by car dealerships

ii. Percentage of plug-in hybrid and electric vehicles registered for use in Alberta

iii. Number of level 2 and level 3 electric vehicle charging stations installed and active in Alberta

Rationale and Background

Incentives that reduce the purchase price premium for some of these vehicles and increase availability of the necessary charging infrastructure have been key factors in other jurisdictions. The effect of the price premium for electric vehicles is noticeable, in that 96% of recent electric vehicle sales in Canada occurred in Ontario, Quebec, and British Columbia, all of which offer financial incentives.[5]

Evidence and experience from Norway, the Netherlands, and California indicate that strong supportive policy in the form of incentives, infrastructure, and vehicle availability can increase the percentage of zero and low emission vehicles.[6] However, analysis by the Montreal

3 Smart Drive Challenge. 2017.
4 Personal conversation with Mike Driedger, Program Director, Scout Environmental. April 28, 2017.
5 Marcon. 2016.
6 Axsen, J., Goldberg, S., and Melton, N. 2016.

Economic Institute[7] indicates that financial incentives for the purchase of electric vehicles are not the most efficient policy mechanism to reduce greenhouse gas emissions on a cost per tonne basis but that policies providing incentives do have a positive impact on electric vehicle sales and uptake.

Incentives may be applied at the time of purchase or based on the maintenance and operation of the vehicle. Non-financial incentives such as designated parking places for low emitting vehicles and preferred registration rates are also options. Expanding the availability of zero and low emission vehicles in combination with purchase and use incentives and an expanded network of charging infrastructure could encourage broader consumer uptake and use, eventually leading to a reduction of emissions from light-duty vehicles.

Internal combustion engine (ICE) gasoline and diesel-powered vehicles will continue to be viable options and, likely, the preference for many Albertans for years to come. Progressively stringent federal regulations, advances in technology, and reductions in weight have increased efficiency and will continue to reduce emissions from ICE vehicles.

Environmental and Health Value

An increase in use of substantially lower emitting personal vehicles and a corresponding decrease in the use of, or emissions from, gasoline or diesel personal vehicles will help reduce $PM_{2.5}$ and ozone levels in urban areas that are approaching or not achieving the CAAQS.

A recent University of Calgary study examined the impact of electric vehicles and suggested that they would substantially reduce emissions. The report states, "Even in Alberta, with its high-carbon electricity, there are greenhouse gas benefits associated with fuel production and use in shifting from gasoline to electric-powered personal vehicles. For a typical personal-use vehicle driven 15,000 km/year, the benefit is 1 to 1.5 t CO_2e (tonnes of carbon dioxide equivalent) per vehicle per year. For new vehicles in 2015, that represents approximately 33% reduction in emissions, but by 2040, the reduction is estimated to be 50%."[8]

Compatibility with Existing Initiatives

This recommendation aligns with several national, provincial, and municipal initiatives aimed at emissions reductions via increased use of alternatively fueled vehicles. Examples are provided below.

National:

- Mobile Sources Working Group under the national Air Quality Management System (CCME)
- Pan-Canadian Framework on Clean Growth and Climate Change (Government of Canada)
- Strategy on Short-Lived Climate Pollutants – 2017 (ECCC)

Provincial:

- Clean Air Strategy (Government of Alberta)
- Climate Leadership Plan (Government of Alberta)
- Truck Stop Electrification Feasibility Study (Alberta Transportation)
- Zero Emission Vehicle Impact Study (Alberta Transportation)

Municipal:

- Electric Vehicle Strategy (City of Calgary, under development)
- Electric Vehicle Strategy (City of Edmonton, under development)

Potential Stakeholders

- Alberta Association of Municipal Districts and Counties
- Alberta Motor Dealers Association
- Alberta Motor Vehicle Industry Council
- Alberta Urban Municipalities Association
- Canadian Natural Gas Vehicle Alliance
- Car share programs
- Electric Vehicle Association of Alberta
- Energy Efficiency Alberta
- Government of Alberta (Economic Development and Trade)

7 Belzile, G. and Milke, M. 2017.
8 Layzell, D. B. and Straatman, B. 2016, p.3.

Advice to Implementers

Incentives

An electric vehicle incentive program[9] was introduced in Ontario in 2010, with new parameters developed and implemented in 2016. The results of this program provide information on cost and environmental and health benefits. Similar financial incentive programs exist in British Columbia, Prince Edward Island, and Quebec (which also provides incentives for hybrid electric vehicles and used electric vehicles[10]).[11] British Columbia's program is funded by the province's Innovative Clean Energy Fund and administered by the New Car Dealers Association of BC.[12]

British Columbians also benefit from the BC Scrap-It Program, a supportive initiative operated by a not-for-profit organization. This program relies on funding from government and program partners so that it can offer incentives to individuals choosing to scrap a vehicle so they can purchase a zero or lower emitting option, including hybrid electric vehicles, plug-in hybrid electric vehicles, electric vehicles, ICE vehicles, bicycles, Car2Go and car share credits, transit passes, and others.[13]

The intent of financial incentives is to equalize the cost premium between low emitting vehicles and conventional vehicles which, depending on the vehicle, can be substantial. For vehicle replacements, the vehicles to be replaced should emit more than those intended for purchase, and should be scrapped if certain criteria are not met.

Increasing Zero and Low Emission Vehicle Sales

In Alberta, provincial registered motor vehicle statistics indicate that zero and low emission vehicles comprise a very small proportion of registered motor vehicles overall and have been increasing at a very slow rate. The vehicle registry figures classify vehicles by fuel type and not by their emission categories; therefore, separate statistics exist for electric and hybrid vehicles. Low emission ICE vehicles, however, are not included as a category in the vehicle registry data. As of March 31, 2017, 377 electric vehicles and 16,678 hybrid vehicles were registered for use in Alberta.[14] Taken together, electric and hybrid vehicles represented less than one-half of one percent of all registered motor vehicles in the province. Increasing the percentage of zero and low emission vehicles in use needs to be accompanied by efforts to increase public awareness regarding real-world expectations of such vehicles as well as the availability of charging infrastructure. Urban fleet vehicle users such as car-sharing companies should also be encouraged to examine the broader use of zero and low emission vehicles in their fleets.

In Ontario, a non-profit organization called Plug 'n Drive,[15] which is sponsored by the provincial government, utilities, the auto industry, charging industry, and others, works to increase the adoption of electric vehicles in that province. A key component of its education and outreach strategy is the Electric Vehicle Discovery Centre. Visitors to the Centre learn how electric vehicles help reduce emissions, get accurate information regarding their environmental and economic benefits, and test drive electric vehicles from a variety of auto manufacturers. Plug 'n Drive also maintains a comprehensive website featuring electric vehicles and related topics, including charging.

Some jurisdictions increase the percentage of zero and low emission vehicles through regulation. An example is California, which uses the Zero Emission Vehicle (ZEV) regulation to help achieve its long-term emission reduction goals by requiring manufacturers to offer specific numbers of the cleanest cars available for sale. ZEV program technologies include battery electric, fuel cell, and plug-in hybrid electric vehicles. The regulation was adopted in 1990 and several decades of data are available to assess the program's costs and benefits. Nine other states have since adopted the California regulation (Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont),[16] and Quebec has implemented a zero-emission standard as well. CASA considered a similar approach involving a regulation to require minimum numbers of zero and lower emission vehicles to be sold in Alberta, but did not recommend it because of stakeholder concerns.

The Government of Canada recently announced that, under the Pan-Canadian Framework on Clean Growth and Climate Change, it would collaborate with provincial and territorial governments, industry, and stakeholders to

9 Bronson Consulting. 2013.
10 Used Vehicles Pilot Project. Government of Quebec [vehiculeselectriques.gouv.qc.ca].
11 Bronson Consulting. 2013.
12 Clean Energy Vehicles for British Columbia [www.cevforbc.ca/clean-energy-vehicle-program].
13 BC Scrap-It Program [scrapit.ca].
14 Alberta Transportation. 2016.
15 Plug 'n Drive Canada. 2017.
16 Alliance of Automobile Manufacturers. 2017

develop a national ZEV strategy by 2018.[17] The framework will enhance existing initiatives including light-duty vehicle regulations and provincial ZEV programs. A national advisory group was struck to help inform the strategy by identifying options to address barriers to ZEV adoption, including vehicle supply, costs and benefits of ownership, infrastructure readiness and requirements, and public awareness.

Infrastructure

Initiatives to expand charging infrastructure at the federal, municipal, and regional levels are underway. Coordination helps to ensure alignment, leverage expertise, and prevent duplication of efforts. The document prepared for the CCME Mobile Sources Working Group provides valuable background and context for expanding electric vehicle charging infrastructure.[18] With various stakeholders focused on this task, it is important to work toward a relatively seamless experience for users. To increase acceptance and use of electric vehicles for long distance travel, charging infrastructure along key travel routes such as the Trans-Canada Highway and similar corridors will need to be expanded.

Greening the Vehicle Fleet

Implementers may wish to consider an approach that focuses on greening the vehicle fleet overall with appropriate emphasis on encouraging consumers to replace older, higher-emitting vehicles with newer, lower-emitting ones. Alberta could realize the benefits of leveraging financial and other incentives such as vehicle scrappage programs.

Increasing consumer awareness, knowledge, and understanding of zero and low emission vehicles and their benefits is crucial to improving uptake. Stakeholders may wish to partner or collaborate on the development of an initiative like Ontario's Plug 'n Drive to provide Alberta consumers with a provincial source of information and opportunities to test such vehicles in real-world conditions.

Dealership salespeople have an important role to play in informing consumers about electric vehicles and the availability of charging stations as well as addressing range anxiety. They must also be familiar with the types of incentives, financial and otherwise, available to eligible purchasers.

RECOMMENDATION 3: ANTI-TAMPERING REQUIREMENTS FOR LIGHT-DUTY AND HEAVY-DUTY VEHICLES

That Alberta Transportation prohibit vehicle emission control system tampering of future model year vehicles and engines through revisions to applicable provincial legislation and associated vehicle inspection criteria

Performance Measures

i. Existing vehicle equipment legislation (e.g., *Vehicle Equipment Regulation*) is modified by January 2022 to prohibit emission control system tampering of future model year vehicles registered in Alberta

ii. Existing vehicle inspection manuals (e.g., Automotive and Light Truck Inspection Manual) are modified to include vehicle emission control criteria and associated inspections (e.g., out-of-province inspections) commencing by January 2023

Rationale and Background

Emission control systems or devices are standard design requirements for new vehicles and engines to ensure that stringent national emission standards are met. Tampering with emission control systems or devices circumvents the objectives of federal regulations. Tampering-related activities include altering mechanical or computer systems, advertising tampering services, and selling or operating a tampered vehicle or engine.

The scope and environmental impact of tampering in Alberta is not known, but limited Alberta-specific information from a past CASA program is available. The Breathe Easy program was a CASA-sponsored pilot project conducted in Calgary in 2003 that focused on scrapping pre-1988 vehicles. Scrapped vehicles were inspected to determine whether emission control systems had been subject to tampering. More than one in five (21%) showed evidence of emission control system tampering.[19]

17 Transport Canada. May 26, 2017.
18 Marcon. 2016.
19 Clean Air Strategic Alliance, Vehicle Emissions Team. 2003.

Environmental and Health Value

Modifying existing legislation to include anti-tampering requirements will provide direction for acceptable practices for mechanics and send a signal to the public that such activity is unlawful. Currently there is nothing in place to prevent mechanics or the public from removing emission controls in Alberta, although most other Canadian provinces and territories have anti-tampering legislation. Including anti-tampering information in the Automotive and Light Truck Inspection Manual would increase general awareness and apply to inspection criteria for vehicles entering the province from elsewhere.

Compatibility with Existing Initiatives

Implementation of anti-tampering legislation aligns with several existing national and provincial initiatives designed to reduce emissions. Examples are provided below.

National:

- Mobile Sources Working Group under the national Air Quality Management System (CCME)
- Legislation for in-use vehicles would complement federal requirements for emission controls on new and imported vehicles to help ensure proper maintenance after sale.
- Strategy on Short-Lived Climate Pollutants – 2017 (ECCC)

Provincial:

- Clean Air Strategy (Government of Alberta)

Potential Stakeholders

- Alberta Motor Association
- Alberta Motor Transport Association
- Canadian Trucking Alliance
- Government of Alberta (Alberta Environment and Parks)
- Private sector (automotive repair industry, mechanics, training schools, etc.)

Advice to Implementers

Implementing anti-tampering requirements for future model years would provide notice to Alberta stakeholders including owners, operators, and mechanics that tampering is unacceptable; requirements would not apply retroactively. These requirements should also be considered for any vehicle coming into the province to be registered; i.e., those undergoing out-of-province inspections as of a specific implementation date. Exemptions may need to be considered in unique circumstances; e.g., antique vehicles.

Anti-tampering legislation in other Canadian jurisdictions can be used to gauge the impacts of implementing a similar program in Alberta; for example:

- Drive Clean Program (Government of Ontario)
- Heavy Vehicle Inspection and Maintenance Program (PIEVAL[20] – Government of Quebec) – roadside emission inspections of heavy-duty vehicles
- Anti-Tampering Legislation (Governments of British Columbia, Ontario, Quebec, Manitoba, Nova Scotia, Prince Edward Island, Newfoundland and Labrador, Northwest Territories, Yukon)[21]

Alberta's *Vehicle Equipment Regulation and Commercial Vehicle Safety Regulation* may be the appropriate legislation to revise to prohibit emission control system tampering. The Automotive and Light Truck Inspection Manual and Commercial Vehicle Inspection Manual should reflect such changes. See Recommendation 4 for additional benefits that could accrue from amendments to this regulation.

RECOMMENDATION 4: INSPECT COMMERCIAL (ON-ROAD HEAVY-DUTY) VEHICLE EMISSION CONTROLS

That Alberta Transportation amend the *Commercial Vehicle Safety Regulation* and associated Commercial Vehicle Inspection Manual to require inspection of commercial vehicle emission controls in accordance with the Canadian Council of Motor Transport Administrators 2014 National Safety Code Standard 11, Part B (NSC 11B) of future model year vehicles

Performance Measures

i. Modifications are made to the *Commercial Vehicle Safety Regulation* and the associated Commercial Vehicle Inspection Manual by January 2022 to require inspection of emissions controls for future model year vehicles

ii. Vehicle emissions controls are included in commercial vehicle inspections by January 2023

---

20 Societé de l'assurance automobile Quebec. 2017.

21 Bronson Consulting. 2013.

Performance Indicator

i. Number of non-compliant vehicles, beginning in January 2023

Rationale and Background

Emission control systems or devices are standard design requirements for new vehicles and engines to ensure that stringent national emission standards are met. Tampering with emission control systems or devices circumvents the objectives of federal regulations. Tampering-related activities include altering mechanical or computer systems, advertising tampering services, and selling or operating a tampered vehicle or engine.

In Alberta, commercial trucks and buses that exceed the applicable weight threshold must pass the Periodic Motor Vehicle Inspection annually and semi-annually, respectively. They must also be inspected using the National Safety Code (NSC) 11B criteria, excluding Emission Controls (sections B, C, D, and E of NSC 11B) and Exterior Sun Visor (section A and Figures 1 – 4) until such time as the *Commercial Vehicle Safety Regulation* is amended to support their inclusion.

The New West Partnership was established to create an economic partnership to advance shared provincial interests in strengthening the regional economy. It was recognized that achieving the full potential of the Partnership would require removal of unnecessary barriers to trade, investment, and labour mobility. Work is underway through this forum to harmonize trucking regulations and remove irritants and impediments to commercial transportation within the region.

Environmental and Health Value

Aligning the inspection criteria with the up-to-date National Safety Code will help identify poorly maintained vehicles and require them to be repaired or prohibit their use. Reducing commercial vehicle emissions would help reduce ambient levels of $PM_{2.5}$ and ozone and would also improve overall air quality.

Compatibility with Existing Initiatives

This recommendation aligns with several national and provincial initiatives. Examples are provided below.

National:

- Mobile Sources Working Group under the national Air Quality Management System (CCME)
- National Safety Code criteria
- Strategy on Short-Lived Climate Pollutants – 2017 (ECCC)

Provincial:

- Clean Air Strategy (Government of Alberta)
- Most Canadian provinces have adopted NSC 11B in their requirements

Potential Stakeholders

- Government of Alberta (Alberta Environment and Parks)
- Alberta Motor Vehicle Industry Council
- Trucking industry and relevant associations
- Mechanic associations and training schools

Advice to Implementers

Implementing commercial vehicle emission control inspection criteria for future model years would provide notice to Alberta stakeholders including owners, operators, and mechanics and would be consistent with the complementary recommendation to prohibit emissions control system tampering of future model year vehicles and engines (Recommendation 3). These inspection criteria would not apply retroactively for compliance purposes but could be applied for other purposes, such as gathering data to help inform adjustments to emission inventories.

Commercial vehicle inspections are already required under Section 19 of the *Vehicle Inspection Regulation*. Implementing emission control criteria for commercial vehicle inspections would require revisions to existing legislation and the associated inspection manual.

NSB 11B provides minimum criteria for visual inspections of emission controls; additional criteria such as on-board diagnostics testing or tailpipe emissions testing could also be considered as part of commercial vehicle inspections.

RECOMMENDATION 5: INCREASE THE PERCENTAGE OF ZERO AND LOWER EMISSION ON-ROAD HEAVY-DUTY VEHICLES

That Alberta Transportation:

i. work with partners to expand the availability of infrastructure for zero and lower emission vehicles (e.g., charging/fueling infrastructure) for long-haul heavy-duty vehicles

ii. in coordination with municipalities, support and develop programs to remove barriers and expand the purchase and use of zero and lower emission vehicles for municipal services (transit, municipal fleets, etc.)

Performance Measures

i. Percentage of zero and lower emission buses in municipal transit fleets

ii. Percentage of zero and lower emission heavy-duty vehicles in service in Alberta

iii. Number of electrified truck stops installed on major freight corridors

Performance Indicators

i. Number of freight vehicles that used electrified truck stops

Rationale and Background

One method of reducing emissions is to encourage the uptake of alternatively fueled vehicles for heavy-duty on-road use. Generally, electric vehicles provide the largest reduction, completely eliminating direct emissions. Other fuel sources such as compressed natural gas (CNG) or hydrogen fuel cells also lower air emissions. Although CNG reduces emissions compared to standard diesel fuel, tailpipe emissions are still generated. Hydrogen fuel cell technologies can reduce emissions but require further demonstration for commercialization.

Feasibility studies have identified the cost effectiveness of electric transit buses compared to standard fossil-fueled vehicles based on available technology (see Table 5). Generally, the uptake of electric buses has been inhibited by the higher initial capital costs and lack of fueling and maintenance infrastructure rather than by technical issues.

TABLE 5: COMPARATIVE LIFECYCLE COST OF DIESEL AND E-BUS TECHNOLOGIES (2016 DOLLARS)

Cost elements for a fleet of 40 buses	Diesel buses	Trickle-charged e-buses	En-route charged e-buses
Capital Investment Costs			
Bus acquisition & rebuild (40 units)	$ 28 075 180	$ 45 865 569	$ 57 281 973
Building and infrastructure cost	None required	$ 750 000	$ 1 154 992
Charging stations cost	None required	Included with bus	$ 6 767 923
Other soft, non-recurring costs	None required	$ 119 843	$ 126 822
Capital expenses total	**$ 28 075 180**	**$ 46 735 412**	**$ 65 331 710**
Operating Costs			
Maintenance and service costs	$ 26 201 313	$ 18 260 531	$ 18 064 388
Charging/Fueling equipment maintenance	Negligible	$ 66 899	$ 1 131 926
Fuel and electricity cost	$ 14 015 707	$ 4 831 981	$ 5 310 479
Carbon levy	$ 1 303 976	$ 21 496	$ 21 496
Operating expenses total	**$ 41 520 996**	**$ 23 180 907**	**$ 24 528 289**
Total NPV Lifecycle Cost	**$ 69 596 176**	**$ 69 916 319**	**$89 859 999**
% difference with diesel buses	-	**+0.46%**	**+29.12%**

Source: City of Edmonton Transportation Committee. 2016.

Electric long-haul heavy-duty vehicles are being commercialized, and expanding the necessary charging and fueling infrastructure would help reduce a major barrier to their future uptake. In addition, providing truck stop electrification infrastructure, increased education, and uptake of anti-idling devices (such as auxiliary power units and shore power options) as part of a suite of measures can reduce idling from current long-haul heavy-duty fleets by allowing for the use of electric truck cab heaters during downtime instead of heat provided by the engine. This recommendation speaks to the need to work with industry to reduce idling from current long-haul heavy-duty fleets and increase the uptake of alternative fuel and electric auxiliary units to power necessary onboard systems.

Environmental and Health Value

Diesel is the dominant fuel used for bus services. An increase in use of substantially lower emission vehicles for municipal services and a corresponding decrease in the use of, or emissions from, gasoline or diesel vehicles will help reduce $PM_{2.5}$ and ozone, which is especially important in the areas that are in the orange or red management levels for CAAQS.

Compatibility with Existing Initiatives

This recommendation aligns with national, provincial, and municipal initiatives aimed at supporting emissions reductions via increased usage of alternatively fueled vehicles. Examples are provided below.

National:

- Mobile Sources Working Group under the national Air Quality Management System (CCME)
- Pan-Canadian Framework on Clean Growth and Climate Change (Government of Canada)
- Strategy on Short-Lived Climate Pollutants – 2017 (ECCC)

Provincial:

- Clean Air Strategy (Government of Alberta)
- Climate Leadership Plan (Government of Alberta)
- Truck Stop Feasibility Study (Alberta Transportation)
- GreenTRIP (Alberta Transportation)

Municipal:

- Calgary has focused on CNG buses, but has been trialing other vehicle technologies.
- Construction on Calgary's Stoney CNG Bus Storage and Transit Facility started in 2017. This facility will provide storage and maintenance space for Calgary Transit's new fleet of CNG buses, as well as on-site CNG fueling infrastructure.
- The Edmonton Goods Movement Strategy has an objective to mitigate community, environmental, and safety impacts which includes advocating for fuel efficiency and emissions testing on heavy vehicles.
- Edmonton undertook a feasibility study of electric buses, endorsed their inclusion in the fleet, and is procuring multiple units.[22]
- Grande Prairie is considering purchasing electric buses based on an August 2016 report on viability. It is also considering the feasibility of using a solar energy storage system for charging stations.
- Medicine Hat has incorporated eight CNG buses in its fleet.
- Red Deer has eight CNG buses and has plans to convert its entire fleet to CNG in the next five years.
- Under GreenTRIP (Alberta Transportation), St. Albert tested electric buses and has subsequently purchased multiple units and is investigating full electrification.

Potential Stakeholders

- Alberta Motor Dealers Association
- Alberta Motor Vehicle Industry Council
- Cities of Calgary, Edmonton, Leduc, Lethbridge, Medicine Hat, Red Deer
- Energy Efficiency Alberta
- Government of Alberta (Alberta Environment and Parks, Alberta Municipal Affairs)
- Strathcona County
- Trucking Associations

Advice for Implementers

The availability of zero and low emission vehicles as well as the necessary fueling and maintenance infrastructure are the primary barriers to expanding the use of such vehicles. Developing the correct infrastructure in the best locations will require considerable coordination among industry and provincial and municipal governments.

Numerous feasibility studies have been undertaken for use of electric or CNG buses, and successful deployment has occurred. These feasibility studies have indicated similar financial viability of zero and

22 City of Edmonton Transportation Committee. 2016.

low emission vehicles compared to standard fossil fuel based equipment (see Table 5). However, zero and low emission vehicles generally have a larger up-front cost compared to standard fossil fuel vehicles, but lower fuel and maintenance costs over the life of the vehicle. Any support provided should focus on infrastructure costs and developing the business case to help expand their use.

While reduced fuel and maintenance costs for zero or low emission vehicles make their use financially viable, the higher initial cost may remain a barrier, so there could be a role for financial incentives or special debt services to encourage their uptake. These may be applied at the time of purchase or be based on the maintenance and operation of the vehicle (e.g., preferred vehicle registration rates, less frequent inspection requirements).

This recommendation must build on the work already undertaken by municipalities, and target expansion of the most beneficial technologies. This requires coordination among municipalities, with a clear role for Alberta Transportation in providing overall strategic direction.

Partners for Climate Protection has developed a resource guide to help reduce emissions from municipal heavy-duty vehicles, which can help guide municipal strategy development.[23]

Substantial research has been undertaken to evaluate the current status of alternate fueling modes for on-road heavy-duty vehicles. The Electric Power Research Institute summarized this in 2017.[24]

The Electric Power Research Institute has also investigated additional benefits to electric vehicle use as a grid-tied resource. This facilitates the collection and sharing of revenue from grid services and electric vehicles connected to the grid.

Support for the uptake of zero and lower emission vehicles requires developing the necessary infrastructure to facilitate their use, specifically new fueling and maintenance infrastructure for electric and CNG-fueled vehicles. Targeted support to municipalities to develop this infrastructure would help reduce the barriers to expanding the use of these fuels for on-road heavy-duty vehicles.

23 Partners for Climate Protection. 2010

24 Electric Power Research Institute (EPRI). 2017.

RECOMMENDATION 6: INCREASE ON-ROAD HEAVY-DUTY FLEET FUEL EFFICIENCIES

That Alberta Environment and Parks and Alberta Transportation work with appropriate stakeholders to:

i. provide education and promotion of commercial freight membership in the SmartWay Transport Partnership

ii. encourage, through the SmartWay Transport Partnership, increasing fleet fuel efficiencies through education and promotion of the use of fuel efficiency technologies, such as aerodynamic devices, idle reduction devices, or low rolling resistance tires

iii. encourage SmartWay participation as a consideration for procurement

Performance Measures

i. Alberta Environment and Parks and Alberta Transportation have established promotion of SmartWay by January 2019

ii. Number of SmartWay partners and affiliates (membership number)

Performance Indicator

i. Average diesel consumption per kilometre travelled among all Alberta carriers in the program

Rationale and Background

One method of reducing emissions is to improve the data and knowledge available on fleet fuel efficiencies and promote the use of fuel-efficient equipment and retrofits. Improving the data and knowledge of the current state of fleet fuel efficiencies will assist the transport sector in identifying opportunities to improve fuel consumption and associated emissions. Purchasing strategies can be developed to guide improvements in fleet fuel efficiencies based on each fleet's unique situation.

The SmartWay Transport Partnership, a program delivered in Canada by Natural Resources Canada under a license agreement with the United States Environmental Protection Agency (EPA), is a collaboration among freight shippers, carriers, and logistics companies to voluntarily improve fuel efficiency and reduce emissions from freight transport. Shippers and carriers can participate as SmartWay partners, while others such as governments and non-government organizations may participate as affiliate members to help promote the program. The key program message is "Save Fuel, Save Money, Reduce Emissions."

To mitigate the environmental impact of the movement of their goods, shippers are increasingly turning to their supply chain to become more efficient. The concept that "you can't manage what you don't measure" is key for companies trying to manage their operations and fuel use, and that is what SmartWay offers them. The program includes:

- free standardized reporting tools and resources to help freight transport carriers become more fuel efficient
- benchmarking and data reports that allow carriers to measure their progress against their industry peers
- carrier data that freight shippers can use to accurately report their carbon footprint
- environmental performance recognition for carriers to help market their business

SmartWay provides access to real data allowing companies to make informed business decisions. When the data are used, carriers gain insight into how to improve their performance (e.g., whether they should buy new tractors, trailers, or aerodynamic add-ons; undergo training; or develop anti-idling programs). SmartWay also helps shippers identify which carriers to work with and how they can alter their transportation practices, such as co-loading, to improve performance.

Environmental and Health Value

Improving fleet fuel efficiency and associated emissions can help reduce $PM_{2.5}$ and ozone levels. Heavy-duty diesel vehicles are a major source of NO_x, and a source of $PM_{2.5}$ emissions in Alberta.

Compatibility with Existing Initiatives

This recommendation aligns with several national, provincial, and municipal initiatives aimed at supporting emissions reductions via improved fleet fuel efficiency. Examples are provided below.

National:

- Mobile Sources Working Group under the national Air Quality Management System (CCME)
- Pan-Canadian Framework on Clean Growth and Climate Change (Government of Canada)
- SmartWay (Natural Resources Canada)
- Strategy on Short-Lived Climate Pollutants – 2017 (ECCC)

Provincial:

- Clean Air Strategy (Government of Alberta)
- Climate Leadership Plan (Government of Alberta)
- Truck Stop Electrification Feasibility Study (Alberta Transportation)

Municipal:

- The Edmonton Goods Movement Strategy has an objective to mitigate community, environmental, and safety impacts which includes advocating for fuel efficiency and emissions testing on heavy-duty vehicles

Potential Stakeholders

- Energy Efficiency Alberta
- Government of Alberta (Service Alberta)
- Natural Resources Canada
- Private industry requiring procurement for transportation of goods
- Trucking industry and relevant associations, including the Alberta Motor Transport Association
- NGOs

Advice to Implementers

SmartWay is an established program with free tools and free training and information sessions. The SmartWay program in Canada is fully aligned with the US program. The SmartWay online membership database contains all members, which is convenient for those who transport across the Canada-US border.

Natural Resources Canada already actively supports and promotes the use of SmartWay. Alberta could further expand SmartWay's use by coordinating engagement with Canadian carriers.

More directed promotion could take the form of reduced registration fees for SmartWay carriers, reduced inspection obligations, and procurement requirements including preferential selection of SmartWay carriers.

In 2010 the "Trucks of Tomorrow" pilot incentive program[25] was launched by Climate Change Central to address barriers preventing the trucking industry from adopting fuel efficiency technologies. Results from this pilot could be reviewed and applied as appropriate. A longer-term financial commitment to an incentive program may help planning by trucking companies, but

25 Climate Change Central. 2012.

participation in SmartWay is expected to pay for itself through fuel savings.

The trucking industry, including the Alberta Motor Transport Association, has been investigating technology upgrades that reduce fuel use and emissions, such as aerodynamic devices, idle reduction devices or low rolling resistance tires. Promotion of SmartWay may support the industry in implementing these upgrades more broadly.

If any direct financial support is considered under this recommendation or other strategies for on-road heavy-duty vehicles, participation in the SmartWay Transport Partnership should be considered as a condition for receiving assistance.

2.2.2 Freight Strategies

RECOMMENDATION 7: SUPPORT AND DEVELOP FREIGHT STRATEGIES

That Alberta Transportation and municipalities, in collaboration with appropriate stakeholders, support the development of urban and long-haul freight strategies for the movement of goods in Alberta

Performance Measure

i. Establishment or expansion of goods movement strategies within and between urban centres by January 2020

Performance Indicators

i. Proportion of tonnes of goods moved by rail in Alberta

ii. On-road time measured through electronic logging devices

Rationale and Background

Some methods of decreasing emissions include adjusting delivery schedules away from peak congestion times, developing local delivery strategies for coordination, and using real-time traffic data to optimize urban delivery systems to reduce idle times and optimize fuel use. Similar strategies can be developed for province-wide transportation routes and corridors to optimize the overall movement of goods throughout Alberta. The focus of this recommendation is to help reduce congestion specifically in urban areas as other initiatives already exist to move goods on a broader scale.

Environmental and Health Value

Reducing congestion in urban centres increases the efficiency of vehicle traffic movement overall, thereby reducing idling and lowering emissions through reduced fuel use.

Streamlining and increasing coordination for long-haul goods transportation similarly helps improve overall fleet efficiencies and ultimately reduces fuel use and associated air pollution.

Compatibility with Existing Initiatives

This recommendation aligns with several national, provincial, and municipal initiatives. Examples are provided below.

National:

- Mobile Sources Working Group under the national Air Quality Management System (CCME)
- Pan-Canadian Framework on Clean Growth and Climate Change (Government of Canada)
- The Canadian Council of Motor Transport Administrators Electronic Logging Device Mandate (to take effect December 2017)
- Strategy on Short-Lived Climate Pollutants – 2017 (ECCC)

Provincial:

- Clean Air Strategy (Government of Alberta)
- Climate Leadership Plan (Government of Alberta)

Municipal:

- Calgary Goods Movement Strategy (City of Calgary; to be completed in 2018)
- Edmonton Goods Movement Strategy (City of Edmonton)

Potential Stakeholders

- Delivery and logistics companies
- Government of Alberta (Alberta Climate Change Office, Alberta Economic Development and Trade)
- Northern Alberta Development Council
- Rail and air industry and associations
- Trucking industry and associations (Canadian Trucking Alliance, Alberta Motor Transport Association)

Advice to Implementers

Various institutes and agencies are researching the status of goods movement in Alberta and other jurisdictions; these include the Pacific Gateway Alliance, the Van Horne Institute, the Regional Plan Association, Volvo Research and Educational Foundations, and the Pembina Institute. This research can help identify activities to be evaluated as part of developing an Alberta-specific goods movement strategy.

Recognizing the benefits from reduced congestion, some urban centres have already established goods movement strategies.

Alberta's rail system capacity has been reduced in recent years with some lines being removed rather than maintained. Better integration of the rail system into commercial shipping can create efficiencies and reduce or remove the need for on-road heavy-duty vehicle transportation. Key corridors for rail transportation should be identified, preserved, and incorporated into freight strategies. A cost-benefit analysis of rail versus on-road freight would help demonstrate the best mode to use for specific transportation needs.

Heavy-duty vehicle use restrictions could be implemented for certain times and areas but would not be considered as effective and efficient as implementing a comprehensive strategy.

2.2.3 On-Road Emission Testing Study

RECOMMENDATION 8: CONDUCT AN ON-ROAD EMISSION TESTING STUDY

That Alberta Environment and Parks and Alberta Transportation, in collaboration with appropriate stakeholders, undertake an innovative on-road emission testing study

Performance Measure

i. The study is complete by January 2020 and provides $PM_{2.5}$ and NO_x emissions data, at minimum, for a variety of vehicles and model years used in Alberta

Rationale and Background

On-road heavy-duty vehicles were identified as a source of primary $PM_{2.5}$, NO_X, and VOCs. An innovative on-road emission testing study could help:

- characterize emissions from in-use vehicles (e.g., determine which ages and classes of vehicles have highest and lowest emissions, and whether emissions reality matches perception) in a particular area such as the Edmonton-Calgary corridor
- identify potential impacts of program and policy options (e.g., design the study to target highest emitters)
- test the feasibility of integrating emission testing into program options (e.g., for identifying gross-emitters)

A similar, short-term study was conducted in British Columbia in 2012[26] in which emissions data were collected for a variety of diesel vehicles and model years through the use of a remote sensing device and a heavy-duty emissions tunnel. These newer technologies provide data beyond the snap acceleration smoke test which has limitations for measuring particulate matter and does not measure NO_x.

Environmental and Health Value

Heavy-duty diesel vehicles are known to be an important source of NO_x and $PM_{2.5}$ emissions in Alberta. An innovative emissions testing study would increase understanding of actual emissions from heavy-duty vehicles and inform targeted management actions for these non-point sources for highest benefit.

Compatibility with Existing Initiatives

This recommendation aligns with national and provincial initiatives. Examples are provided below.

National:

- Mobile Sources Working Group under the national Air Quality Management System (CCME)
- Strategy on Short-Lived Climate Pollutants – 2017 (ECCC)

Provincial:

- Clean Air Strategy (Government of Alberta)

Municipal:

- Greater Vancouver Regional District Remote Sensing Device Trial for Monitoring Heavy-duty Vehicle Emissions (City of Vancouver)

Potential Stakeholders

- Airshed Organizations
- Municipalities

26 Envirotest Canada. 2013.

- Trucking industry and associations

Advice to Implementers

An innovative emission testing study could gather valuable information on emissions and potential management actions in Alberta and enhance public awareness and education. This study can include both heavy-duty and light-duty vehicles, and its results could be compared with previous and any future studies (e.g., to gauge improvements). The 2012 British Columbia study could help inform the remote sensing device study design, as a limitation of the BC study was the option for drivers to avoid the test site. The historical CASA Vehicle Emissions Team projects included studies titled ROVER I and ROVER II (Roadside Optical Vehicle Emissions Reporter). This study would link with Recommendation 16, Knowledge of Non-Point Sources.

CASA could potentially lead such a project through its multi-stakeholder process, which has a demonstrated track record of success. In 1998, the ROVER project assessed actual in-use vehicle emissions using a remote sensing van equipped to measure exhaust emissions from more than 42,000 light-duty vehicles in Edmonton, Calgary, Red Deer, and Canmore. In 2006, the project was repeated as ROVER II, testing more than 66,000 vehicles in the same four municipalities. ROVER II found emissions per kilometre were falling, but vehicle use had increased. It is important to recognize that the lower emission rates per vehicle are partly offset by the increased number of vehicles.[27]

Undertaking the project through CASA would allow lessons learned from previous studies to be applied, thus leveraging opportunities for a) awareness and education, b) consideration of future studies to gauge effectiveness of implemented management actions, and c) engagement with all stakeholders, particularly willing participants in the trucking industry. Additional benefits can be derived from this research by considering both air contaminants and greenhouse gases.

This study would be a mechanism to ground-truth actual emissions from vehicles in Alberta and help focus potential management actions on the highest polluters. With the more stringent CAAQS for NO_2, additional NO_x reduction actions will likely be required from large sources such as heavy-duty vehicles.

2.2.4 Energy Efficiency Alberta and the Transportation Sector

RECOMMENDATION 9: ENERGY EFFICIENCY ALBERTA AND THE TRANSPORTATION SECTOR

That Energy Efficiency Alberta (EEA) consider the transportation sector as an area for future EEA programs that provide greenhouse gas and air emission reduction co-benefits

Performance Measures

i. EEA to inform CASA of the result of its consideration of action on transportation by January 2019

ii. If warranted by the review, the number of EEA transportation programs in place by January 2020

Rationale and Background

EEA is a new provincial agency that is delivering programs and services to help Albertans save both energy and money and reduce emissions. Alberta's Climate Leadership Plan includes a commitment to reinvest all revenue from the carbon levy into Alberta's economy, including $645-million to EEA over five years. EEA was launched in October 2016 and began rolling out programs in 2017, including:

- Direct Install Residential Program offering direct, no-charge installation of low-cost energy efficiency products to residences, such as lighting, water, and heating components
- Residential Consumer Products Program offering point of sale rebates to residential consumers at retail outlets with products such as lighting, insulation, and appliances
- Business, Non-Profit, and Institutional Rebate Program offering incentives for high-efficiency products and the installation of electric and gas-based products such as lighting, heating and cooling systems, and hot water systems

EEA evaluates potential programs and decides which to implement based on where incentives are most cost-effective at reducing energy use.

27 ESP and McClintock, P.M. 2007.

Environmental and Health Value

Increasing the use of high occupancy vehicles (carpooling, public transit), individuals choosing active transportation (e.g., walking, bicycling), and the use of more fuel-efficient vehicles will reduce vehicle emissions, which is of particular concern in areas in the orange or red CAAQS management levels.

EEA programs in the transportation sector could reduce emissions through, for example, incentives for the purchase or use of lower emitting vehicles or for increased use of alternative modes of transportation (e.g., active transportation, sharing economy vehicles, and public transit).

Compatibility with Existing Initiatives

This recommendation potentially aligns with several national, provincial, and municipal initiatives aimed at emissions reductions in the transportation sector. Examples are provided below.

National:

- Mobile Sources Working Group under the national Air Quality Management System (CCME)
- Buying a Fuel-Efficient Vehicle (Natural Resources Canada – Office of Energy Efficiency)
- Eco Driving, Fuel-Efficient Driving Techniques (Natural Resources Canada – Office of Energy Efficiency)
- Pan-Canadian Framework on Clean Growth and Climate Change (Government of Canada)
- Strategy on Short-Lived Climate Pollutants – 2017 (ECCC)

Provincial:

- Clean Air Strategy (Government of Alberta)
- Climate Leadership Plan (Government of Alberta)
- GreenTRIP (Alberta Transportation)

Municipal:

- Electric Vehicle Strategy (City of Calgary, under development)
- Electric Vehicle Strategy (City of Edmonton, under development)
- Various vehicle idling reduction bylaws and initiatives (e.g., Be Idle Free [City of Edmonton], Idle Free [City of Red Deer])

Others:

- Smart Drive Challenge (Scout Environmental, Government of Ontario, Canadian Fuels Association, Natural Resources Canada)
- Smart Fuelling (Canadian Fuels Association, Canadian Independent Petroleum Marketers Association, Canadian Convenience Stores Association, Canadian Automobile Association)

Potential Stakeholders

- Alberta Motor Dealers Association
- Alberta Motor Vehicle Industry Council
- Canadian Natural Gas Vehicle Alliance
- Carpool programs
- Electric Vehicle Association of Alberta
- Government of Alberta (Alberta Transportation, Alberta Environment and Parks, Alberta Economic Development and Trade)
- Municipalities

Advice to Implementers

EEA could expand into the transportation sector using a variety of approaches, such as promoting methods to drive less or drive more efficiently, incenting the use of public and alternative transit options, incenting the purchase or use of lower emission vehicles, and assisting individuals in assessing transportation costs and emissions associated with where they choose to live.

Efficiency Vermont[28] is an example of an energy efficiency agency that has incorporated transportation efficiency into its programming with the aim of helping people drive less and drive more efficiently to lower energy costs and protect the environment.

28 https://www.efficiencyvermont.com/

2.3 CONSTRUCTION OPERATIONS AND ROAD DUST

RECOMMENDATION 10: BEST PRACTICES GUIDE FOR CONSTRUCTION OPERATIONS AND ROAD DUST

That Alberta Environment and Parks and Alberta Transportation work with municipalities, construction companies, and other stakeholders to develop and disseminate a best practices guide to address dust from construction and roads that:

i. identifies why this issue is important and what can be done to address it
ii. provides templates for environmental policies and plans
iii. prepares for potential requirements in the future

Performance Measure

i. The best practices guide is complete, disseminated, and in use by January 2021

Performance Indicators

i. From January 2021, number or percentage of municipalities with construction and road dust plans
ii. From January 2021, where complaints are tracked, the number of complaints related to construction and road dust
iii. From January 2021, the number of times the guide has been downloaded

Rationale and Background

Construction dust is defined as fugitive particulate matter resulting from disturbances on construction sites; this dust is the main source of primary $PM_{2.5}$. Over the past few years, $PM_{2.5}$ emissions from construction sources have been increasing and are projected to increase even more in the future.[29] Furthermore, construction dust is a relevant source of $PM_{2.5}$ in all air zones.

Municipalities typically manage dust issues reactively through Community Standards bylaws. The Government of Alberta requires the potential impacts of dust emissions, including emissions during project construction, to be addressed in environmental impact assessments and also requires details on the applied emission control technologies or what is being presented as the best available technology; however, there are no provincial guidance documents on what constitutes best available dust control technology or strategies. Municipalities indicated that templates for environmental policies and plans would be helpful.

Environmental and Health Value

Reducing particulate matter from construction and road operations can reduce the impact of dust on residents and improve visibility, therefore improving safety. It also improves air quality conditions for workers, residents, and others nearby; better protects soils and vegetation in the vicinity of dust sources; and reduces erosion and sediment issues from materials tracked from a site or entering watercourses.

Compatibility with Existing Initiatives

This recommendation aligns with several provincial initiatives. Examples are provided below.

Provincial:

- Clean Air Strategy (Government of Alberta)
- Environmental Construction Operation (ECO) plans are required for work done on behalf of Alberta Transportation
- New project construction related dust emission assessments and management plans are required as part of project environmental impact assessments

Potential Stakeholders

- Alberta Association of Municipal Districts and Counties
- Alberta Chamber of Commerce
- Alberta Roadbuilders and Heavy Construction Association
- Alberta Urban Municipalities Association
- Industrial associations (to represent industry project proponents and who hire contractors)

Advice to Implementers

Calgary, Edmonton and Alberta Transportation have addressed this issue by requiring ECO plans for contractors performing work on their behalf. However, ECO plans have a much broader mandate than construction dust and include other environmental impacts such as riparian disturbances, prevention of sediment reaching watercourses, and tree protection. The ECO Plan Framework does not provide specific guidance on dust mitigation measures. Contractors who do work for any of these three organizations will be familiar with ECO plans, so this process is not new to a

29 Government of Alberta. 2016c.

portion of industry. The ECO Plan Framework is in place[30] and an ECO Plan template is being tested.

The City of Calgary has dedicated full-time resources to reviewing ECO plans and conducting construction site inspections. These individuals have knowledge and expertise in environmental best practices for construction sites. A similar resource commitment may not be feasible for smaller municipalities.

The recommended best practices guide may be relevant for all types of construction operations and roads (residential, commercial, institutional, highway, coal mine, oil sands mine, other industrial, etc.). The guide could feature a section that includes common topics for all sectors, as well as separate sections for any unique issues for specific sectors. The guide should also include multi-media considerations for a holistic approach; that is, address not only air emissions but also consider water conservation and impacts to surrounding soils and vegetation.

The Government of Alberta may wish to consider this recommendation as an area of future work for CASA.

2.4 OPEN-AIR BURNING

RECOMMENDATION 11: REVIEW OPEN-AIR BURNING REQUIREMENTS

That Alberta Environment and Parks with the involvement of Alberta Agriculture and Forestry, the Alberta Urban Municipalities Association, and the Alberta Association of Municipal Districts and Counties:

i. review provincial and municipal open-air burning requirements and management practices
ii. initiate reasonable measures to help ensure that in the future the potential air quality impacts of open-air burning are appropriately considered, recognizing that prescribed burning is a necessary tool to protect communities, human life, infrastructure, and natural resources, and can be an important agricultural or ecosystem management tool

Performance Measures

i. By January 2020, Alberta Environment and Parks, in conjunction with relevant stakeholders, has completed a review of open-air burning practices and requirements in the province in relation to air quality management
ii. By January 2021, Alberta Environment and Parks has informed CASA on the findings from the review, and if applicable, identified opportunities for improvements and related possible implementation strategies

Rationale and Background

Existing open-air burning requirements and restrictions in Alberta focus on hazard and safety management. Open-air burning, if not managed and conducted appropriately, can have substantial and adverse effects on health, safety, and the environment, including influencing the CAAQS management level that applies to an air zone.

All levels of government and different government departments have an interest in, and some legislative authority over, open-air burning and need to work together in implementing this recommendation. While the recommendation is directed to the Government of Alberta and municipalities, open-air burning in national parks can affect provincial air quality so possible engagement of the federal government in implementation should be considered. The 2016 CCME Guidance Document for Canadian Jurisdictions on Open-Air Burning and the Parkland Airshed Management Zone Municipal Burning Bylaw Survey Report represent starting points for the recommended review in terms of regulatory and non-regulatory management options, best practices, public education, and addressing the air quality issues associated with open-air burning. These documents recognize that open-air burning is necessary for certain forestry and agricultural management practices.

The CCME[31] defines open-air burning as:

> *Any fire or burning practice conducted outside a building and includes but is not limited to, small confined fires and large confined fires, fires in burn barrels, in air curtain incinerators, outdoor recreational fireplaces, prescribed burning, and construction site and demolition site fires.*

30 Alberta Transportation, City of Calgary, and City of Edmonton. 2017.
31 CCME. 2016a, p.35.

Localized burning activities can contribute to elevated $PM_{2.5}$ readings, which over time can lead to an air zone being assigned to the orange or red CAAQS management level.

Environmental and Health Value

The 2016 CCME Guidance Document for Canadian Jurisdictions on Open-Air Burning[32] outlines some of the potential health effects, most notably impacts on young children and older adults especially those whose respiratory and cardiovascular systems are already compromised. Long-term exposure to elevated levels of airborne particulate matter can reduce lung function and contribute to asthma and chronic bronchitis, heart problems and premature mortality. Even short-term exposure has been associated with acute respiratory reactions and increased susceptibility to respiratory infections. The CAAQS for $PM_{2.5}$ are intended to reduce these types of health impacts. The management of open-air burning should consider possible air quality and health effects.

Compatibility with Existing Initiatives

Enough information was reviewed for this project to obtain a general overview of the type and nature of open-air burning requirements in Alberta. The Parkland Airshed Management Zone (PAMZ) conducted a detailed open-air burning review for Central Alberta in 2012[33] resulting in a Municipal Burning Bylaw Survey Report. Together, the PAMZ review and a review conducted as part of the CASA Non-Point Source Project, indicate that open-air burning is a well-recognized non-point source with potential to impact air quality. A number of Alberta urban and rural municipalities have bylaws to address open-air burning.

Prescribed burning is also covered by provincial legislation[34] and is defined as:[35]

> *The knowledgeable and controlled applications of fires on a specific land area to accomplish planned and well-defined resource management objectives.*

Alberta's prescribed fire program is a proactive approach to wildfire and forest management. The intent is to remove fuels that may contribute to wildfires that could threaten communities and human life, infrastructure, wildlife, and natural resources. They are managed to minimize emission of smoke, and Government of Alberta staff work with communities and stakeholders to ensure that prescribed fires are handled in a safe and efficient manner.

Existing controls focus on addressing the fire hazard and safety issues associated with open-air burning with restrictions on what can be burned and the details of where, when, and how the burning is conducted. In certain cases, permits are required. The Government of Alberta provides requirements and guidance about what can and cannot be open-air burned and possible approval requirements that may apply,[36] and provides guidance on specific options, including open-air burning, that can be used to manage certain materials.[37]

Potential nuisance issues associated with open-air burning are also often considered, but apart from a bylaw in the Regional Municipality of Wood Buffalo (RMWB), impacts on air quality are not.[38]

This recommendation is compatible with existing provincial and municipal initiatives to manage open-air burning activities and would provide additional guidance on open-air burning practices and management in terms of air quality considerations and controls.

Potential Stakeholders

- Agricultural sector
- Airshed Organizations
- Forestry sector
- Municipalities
- Parks Canada

Advice to Implementers

The CCME and PAMZ documents noted previously identify a number of regulatory tools and management options for reducing air quality impacts associated with open burning. These include:

- Municipal bylaws: These bylaws can include requirements that address air quality impacts associated with open-air burning.
- Provincial regulations: Regulations could specifically prohibit open-air burning practices that result in certain air quality impacts, like those

32 CCME. 2016a.
33 Parkland Airshed Management Zone. 2012.
34 Government of Alberta. 2017b.
35 Alberta Agriculture and Forestry. 2017a.
36 Alberta Environment and Parks. 2015.
37 Alberta Agriculture and Forestry. 2017b.
38 Regional Municipality of Wood Buffalo. 2001.

in the RMWB bylaw. The material allowed to be open-air burned could be reviewed.

- Burn restrictions and air quality advisories: These can be used at the municipal and provincial level as a community or air zone air quality management tool along with the CAAQS and/or Alberta Ambient Air Quality Objectives as reference points to identify burn restrictions and notifications.
- Requirement for burn permits and/or burn plans: These generally already apply to agricultural, forestry, and large-scale vegetative burning, but options for ambient air quality monitoring could be added as modelling and monitoring technology improves.
- Enhanced public education: The province and municipalities should emphasize public education activities to build awareness about existing fire bylaws and regulations, the impacts of open-air burning, and alternatives to avoid burning.

The CCME guidance document provides examples of educational material that could assist jurisdictions wanting to establish or expand regulations, bylaws, or programs for managing open-air burning. CASA recognizes the need for open-air burns in certain circumstances such as land clearing and agriculture (e.g., removing un-harvestable crops), and ecosystem management. The management of open-air burning should address these needs, but activities should be conducted in a manner that considers and, to the extent practicable, manages the air impacts of the burning.

The Government of Alberta may wish to consider this recommendation as an area of future work for CASA.

2.5 COMMERCIAL AND RESIDENTIAL HEATING

Commercial and residential heating is a source of NO_x emissions. Gas and oil-fired commercial and residential heating and carbon pricing are discussed in Sections 3.3 and 3.4. Home heating with wood fuel is not a large contributor to air quality issues generally in Alberta, but in large urban centres, these emissions can combine with emissions from other local and regional sources to elevate ambient levels. Residential wood burning was a focus for the project as it was in the top 10 highest emitters of $PM_{2.5}$ and VOCs. In 2014, residential fuel wood combustion was responsible for 6.6 kilotonnes and 1% of anthropogenic $PM_{2.5}$ emissions, and 8.7 kilotonnes and 1.2% of anthropogenic VOC emissions in Alberta.

2.5.1 Residential Wood Burning

RECOMMENDATION 12: REVIEW RESIDENTIAL WOOD BURNING PRACTICES

That Alberta Environment and Parks:

i. evaluate and identify the barriers to fuel-switching from biomass to a cleaner alternative or retrofitting old wood burning space-heating equipment to meet the Canadian Standards Association Standard for Performance Testing for Solid-Fuel-Burning Heating Appliances, edition B415.1-10 (CSA B415.1-10) or Environmental Protection Agency Title 40 Code of Federal Regulations (EPA 40 CFR) standards

ii. develop strategies and programs as needed to motivate fuel-switching, replacement, or retrofitting

Performance Measure

i. By March 2019, Alberta Environment and Parks has completed the evaluation and identification of barriers to fuel-switching from biomass to a cleaner alternative or retrofitting old equipment and has informed CASA on the findings of the review

Rationale and Background

Burning wood for home heating or to supplement other fuels for home heating produces more emissions than natural gas. Recent years have seen advancements in residential wood burning equipment, and the EPA and CSA have established high efficiency standards. Ensuring adherence to these standards in all new construction and incenting the retrofit of older equipment would reduce the contribution from wood burning. In general, the use of wood for heating should be minimized and wood burning equipment that conforms to CSA or EPA efficiency and emissions standards (CSA B415.1-10; EPA 40 CFR, Part 60, Subpart AAA)[39] should be used.

As of 2011, natural gas met approximately 91% of primary home heating needs in Alberta, with most of the remaining 9% met by electric furnaces.[40] The use of wood and wood pellets, oil, propane, and other fuels together accounted for less than 1% of total primary

39 CSA B415.1-10: Canadian Standards Association developed the *Performance Testing of Solid Fuel Burning Heating Appliances* (B415.1) by basing the standards on the US Environmental Protection Agency *Standards of Performance for New Residential Wood Heaters, Section 60-532 of the 1988 Clean Air Act, subpart AAA*, which is under the US Code of Federal Regulations (Title 40 CFR).
40 Statistics Canada. 2015.

heating in Alberta. As many wood-burning fireplaces are used occasionally for secondary heating and personal enjoyment, the percentage of overall fireplace use might be greater than the "less than 1%" figure, and it is difficult to determine the precise contribution of fireplaces to overall residential heating-related emissions.

Table 6 provides information about the amount of wood burned by different types of appliances in Alberta in 2005.

TABLE 6: WOOD BURNED BY DIFFERENT WOOD-BURNING EQUIPMENT IN ALBERTA

Category	Annual Wood Burned in Alberta (tonnes)	Proportion of Total Wood Burning Emissions by %
Conventional Fireplaces — Without Glass Doors	66,273	25
Conventional Fireplaces — With Glass Doors	59,896	22
Fireplaces with an Insert — Conventional	6,658	2
Fireplaces with an Insert — Advanced Technology	11,344	4
Fireplaces Advanced Technology	6,211	2
Wood Stoves — Conventional Not Air Tight	40,107	15
Wood Stoves — Conventional Air-Tight	45,893	17
Wood Stoves — Advanced Technology	19,228	7
Central Furnaces/Boilers	5,804	2
Others (including pellet stoves)	5,323	2
Total	**266,737**	

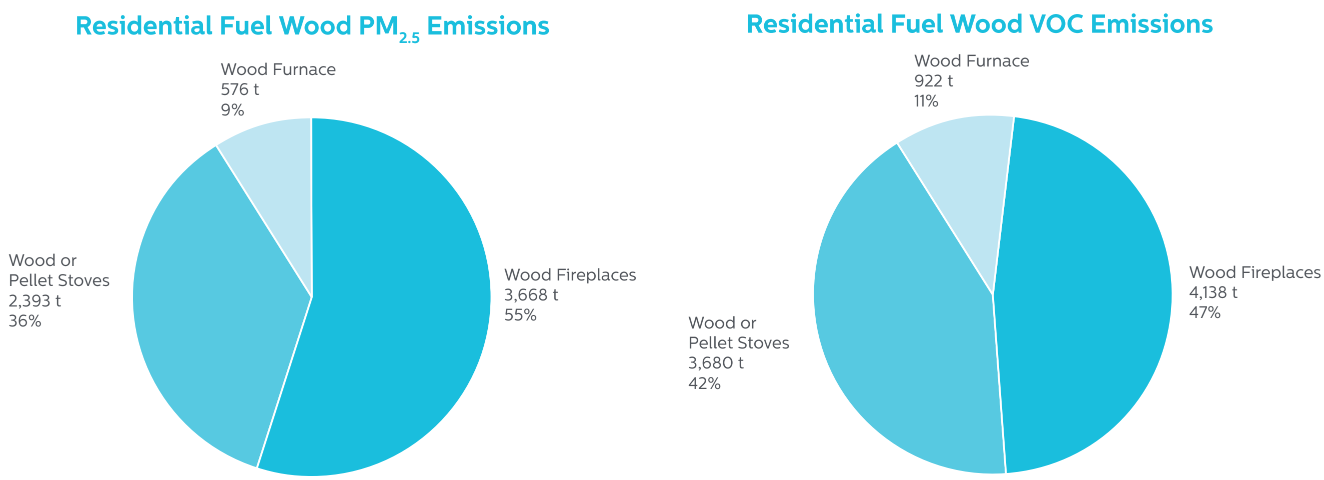
Data Source: Environment Canada. 2005b.

Fireplaces burn the most wood, followed by wood stoves, furnaces and boilers. Although the number of people and dwellings in Alberta has increased greatly since 2005, the number of wood burning appliances (particularly fireplaces) might not have increased as quickly. Typically, new homes built over the last 10-15 years have natural gas fireplaces rather than wood fireplaces. It is now a requirement that new installations of wood burning equipment must meet CSA B415.1-10 or EPA 40 CFR standards under Alberta Building Code 2014 energy efficiency section 9.36.3.10 (effective November 1, 2016).

Environmental and Health Value

Incenting the retrofit of old equipment would reduce particulate matter and VOCs from existing sources, and promote reductions from the inventory baseline. Figure 1 shows the breakdown of $PM_{2.5}$ and VOC emissions in 2014 in Alberta by type of wood burning appliance; wood burning fireplaces were the leading source of both $PM_{2.5}$ and VOCs.

FIGURE 1: 2014 ALBERTA $PM_{2.5}$ AND VOC EMISSIONS BY TYPE OF APPLIANCE



Data Source: Environment and Climate Change Canada, 2014 emissions from the 1990-2015 Air Pollutant Emissions Inventory

Table 7 shows the emission factors of different wood burning equipment in Canada, and highlights the improved performance from advanced technology.

TABLE 7: THE EMISSION RATES OF DIFFERENT WOOD BURNING EQUIPMENT IN CANADA

Wood combustion appliances	Estimated number of appliances ('000)	Emission factors			
		$PM_{2.5}$ g/kg	CO g/kg	VOCs g/kg	PAHs g/kg
Wood burning fireplaces					
Fireplaces					
Without glass doors	846	18.4	77.7	6.5	0.0375
With glass doors	897	12.9	98.6	21	0.0375
Fireplaces with an insert					
Conventional	129	13.6	115.4	21.3	0.215
Advanced technology (catalytic)	22	4.8	70.4	7	0.064
Fireplaces advanced technology (any)	57	4.8	70.4	7	0.064
Wood burning stoves					
Conventional stoves					
Not air-tight	445	23.2	100	35.5	0.215
Air-tight	777	13.6	115.4	21.3	0.276
Advanced technology stoves	142	4.8	70.4	7	0.064
Central furnaces/boilers	278	13.3	68.5	21.3	0.288
Other wood burning equipment	41	13.6	115.4	21.3	0.215
Pellet stoves	13	1.1	8.8	1.5	0.0015

Data Source: Environment Canada. 2005a.

Compatibility with Existing Initiatives

This recommendation aligns with several national, provincial, and municipal initiatives. Examples are provided below.

National:

- Code of Practice for Residential Wood Burning Equipment (CCME)
- Model municipal bylaw for regulating wood-burning appliances (Environment Canada)
- CSA B-365 code for Solid-Fuel-Burning Appliances and Equipment specifies requirements for the installation, alteration, and maintenance of solid fuel-burning appliances and equipment installed indoors or outdoors, and equipment requirements for solid fuel-burning appliances
- Strategy on Short-Lived Climate Pollutants – 2017 (ECCC)

Provincial:

- Clean Air Strategy (Government of Alberta)
- Wood Burning SmokeFact Sheet (Government of Alberta)
- Requirements to meet the CSA B-365 code for installation, operation, and equipment requirements for solid fuel burning appliances (Alberta Building Code)

Municipal:

- Woodstove Changeout Rebate Program to provide incentive to retrofit old wood burning equipment (City of Nanaimo)

Potential Stakeholders

- Government of Alberta (Alberta Climate Change Office)
- Municipal Planning Departments

Advice to Implementers

For new construction and retrofits of factory-built wood burning appliances for space heating, the Alberta Building Code now requires that the CSA B-365 installation Code for Solid-Fuel-Burning Appliances and Equipment requirements for solid fuel burning appliances be met. Municipal building permits, including information on standards approvals for factory-built units, are needed to install new wood burning equipment in some major centres.

Some assessment of the typical cost of converting from wood fuel to natural gas would be useful to assess the likelihood of residential fuel switching as a potential cost avoidance measure with respect to the carbon levy.

With greater emphasis on reducing greenhouse gas emissions, there is potential to see an increase in the use of biomass (mainly wood) as a home heating alternative. Biomass, when sustainably harvested, is considered carbon-neutral due to the carbon sequestered during plant growth. However, biomass combustion releases proportionally more emissions than natural gas, so the increased use of biomass could exacerbate air quality concerns. This implication is not broadly recognized and general public education could help.

This recommendation should be considered in conjunction with Recommendation 13.

RECOMMENDATION 13: DISCOURAGE WOOD BURNING PRACTICES DURING PERIODS OF DEGRADED AIR QUALITY

That Alberta Environment and Parks, municipalities, and Airshed Organizations:

i. develop a coordinated notification process to discourage indoor and outdoor wood burning during periods when air quality is, or is forecasted by the air monitoring network to be, degraded

ii. provide general education and awareness on the air emissions associated with wood burning

Performance Measure

i. By January 2019, a coordinated notification process has been established and implemented

Performance Indicators

i. Enactment and total number of wood burning advisories or bans linked to poor air quality events

ii. Where information is available, number of bylaw complaints about wood burning during poor air quality events

Rationale and Background

During periods of stable weather conditions (e.g., low winds, inversions), particularly in the wintertime, burning wood can have a greater impact on air quality. With a lack of dispersion, emissions from wood burning can become trapped near the ground and, combined with emissions from the many other sources in urban environments, contribute to elevated ambient air pollution. Thus, wood burning should be minimized when atmospheric conditions do not provide sufficient dispersion.

Environmental and Health Value

Stable atmospheric conditions are already a challenge in terms of ambient air quality management. During these periods, particulate matter and NO_x levels (as with most air pollutants) typically increase and often lead to air quality issues. Discouraging wood burning during stable weather conditions can help reduce peak levels of ambient air emissions and reduce the public's exposure to harmful substances.

Active notification for the public about these conditions helps raise the profile of ambient air quality so people can take measures to reduce their exposure and contribution to unsafe ambient levels.

Compatibility with Existing Initiatives

This recommendation aligns with several provincial and national initiatives. Examples are provided below.

National:

- Strategy on Short-Lived Climate Pollutants – 2017 (ECCC)

Provincial:

- Air Quality Health Index (AQHI) related messaging (Government of Alberta)
- Clean Air Strategy (Government of Alberta)
- Wood Burning Smoke Factsheet (Government of Alberta)

Potential Stakeholders

- Environment and Climate Change Canada (AQHI system)
- Alberta Health Services (AHS)
- Municipal Bylaw Departments
- Municipal or Regional Fire Chiefs and fire departments

Advice to Implementers

Implementation of a fire advisory or restriction is straightforward and this authority may already be included in municipal bylaws. However, enforcement of municipal bylaws typically focuses first on education and is complaint-driven, potentially requiring some time for full implementation of a change and for outcomes to be realized. Despite enforcement challenges, these advisories or restrictions will advance broader public education on air quality. The first focus should be on public education, both proactively and during poor air quality events.

Establishing or enhancing a public notification system that builds on the AQHI notification system (Alberta AQHI app, Tweets) when stable weather conditions are present would require further development, cooperation, and coordination with AHS, Airshed Organizations, and municipalities to define roles and responsibilities.

Alberta Environment and Parks has established a social media notification system via Twitter that could be used to notify the public of poor air quality events. Given its role in ambient air monitoring, leveraging the department's notification system would reduce duplication.

Encouragement to reduce wood burning during poor air quality events in the winter should be targeted to those who use wood burning for secondary heating, and not primary heating.

The Government of Alberta published a Wood Burning Smoke Fact Sheet[41] that should accompany any public messaging. For other education initiatives, alignment with Alberta Environment and Parks' Environmental Education Framework would be appropriate.

2.6 INDUSTRIAL NON-POINT SOURCES

2.6.1 Gasoline Distribution

RECOMMENDATION 14: CONSIDER THE BENEFITS OF STAGE 1 VAPOUR RECOVERY UNITS FOR FUEL TERMINALS

That Alberta Environment and Parks consider the benefits of requiring Stage 1 vapour recovery units for fuel terminals, but only in the context of other potential actions that could be taken by industry to reduce ambient $PM_{2.5}$ and ozone

Performance Measure

i. By June 2019, a review is completed by Alberta Environment and Parks that considers the value of Stage 1 vapour recovery units (VRUs) for fuel terminals

Rationale and Background

Stage 1 controls are the integrated equipment systems used to recover gasoline vapours when 1) tank trucks are loaded with gasoline at fuel terminals, and 2) tank truck deliveries of gasoline are made to service stations. Stage 1 controls at the terminal consist of VRUs and these controls are not currently regulated in Alberta. Certain jurisdictions in Canada (i.e., Lower Mainland BC, the Windsor to Quebec City corridor, and Newfoundland)

41 Alberta Environment and Parks. 2014b.

regulate Stage 1 controls. Stage 1 controls have been demonstrated to recover more than 95% of the VOCs associated with loading and off-loading gasoline.

Table 8 shows the 2014 VOC emissions to air as reported to the National Pollutant Release Inventory (NPRI) by the larger fuel distribution terminals in Alberta. This reporting is required by industrial facilities that exceed designated release reporting volume thresholds under the *Canadian Environmental Protection Act*, 1999 (CEPA). The VOC emissions for all facilities shown in the table are attributable to the individual facility (combination of point and non-point sources) indicated.

VOC emissions from tank truck deliveries to individual service stations are not reportable under NPRI as service stations do not meet the minimum reporting threshold.

TABLE 8: 2014 VOC EMISSIONS FROM CANADIAN FUELS MEMBER FUEL TERMINALS IN ALBERTA

Facility	City	Releases of VOCs to Air (tonnes)
Imperial Oil – Edmonton Terminal	Edmonton	1,310
Suncor Energy Products Partnership – Edmonton Terminal	Edmonton	846
Imperial Oil – Calgary Terminal	Calgary	713
Shell Canada Products – Sherwood Marketing Terminal	Edmonton	636
Shell Canada Energy Ltd. – Calgary Terminal	Calgary	294

Source: NPRI 2014: VOC Emissions to Air

VOCs are well controlled for the thousands of daily motor vehicle refueling transactions at service stations. Recent technical advancements in automotive systems have led to the development of Onboard Refueling Vapour Recovery (ORVR). This technology has been installed in fuel tanks in all light-duty cars and trucks in North America,[42] beginning in 1998 for cars and 2001 for trucks. As a result, nearly all of the on-road fleet of gasoline powered vehicles in Canada and the US are equipped with ORVR. According to the US EPA, extensive testing of ORVR systems in the on-road fleet has demonstrated approximately 98% vapour capture for ORVR.

Environmental and Health Value

VOCs can react with NO_x in the atmosphere on warm sunny days and contribute to the formation of ozone and $PM_{2.5}$. Gasoline vapours contain a number of VOCs including butane, pentane, benzene, toluene, and xylenes, as well as other compounds that are considered toxic. The 1991 CCME Environmental Code of Practice for Vapour Recovery in Gasoline Distribution Networks indicates that implementing gasoline vapour recovery in distribution networks could reduce total anthropogenic VOC emissions in Canada by 2-3%.

Compatibility with Existing Initiatives

This recommendation aligns with several national and provincial initiatives. Examples are provided below.

National:

- Environmental Code of Practice for Vapour Recovery in Gasoline Distribution Networks (CCME)

Provincial/Regional:

- Clean Air Strategy (Government of Alberta)
- Recovery of Gasoline Vapour in Bulk Transfers (Government of Ontario)
- Gasoline Distribution Emission Regulation Bylaw No. 1085 (Greater Vancouver Regional District)
- Gasoline Vapour Control Regulation (Government of British Columbia)
- Air Pollution Control Regulations (Government of Newfoundland and Labrador)

Potential Stakeholders

- Government of Alberta (Alberta Transportation)
- Municipalities
- Oil and gas industry
- Trucking industry and associations

Advice to Implementers

Either reducing NO_x at a refinery or reducing VOC emissions from fuel terminals would help reduce ambient $PM_{2.5}$. However, it is important that Alberta Environment and Parks consider potential reductions resulting from implementing Stage 1 VRUs in the broader context of actions that could be taken to reduce a facility's contribution to ambient $PM_{2.5}$, ozone, and NO_x,

42 Helsel, Z. R. and Grubinger, V. 2012.

given the size of the potential investments from the same companies.

The potential benefits of emissions controls on gasoline distribution from fuel terminals could be considered along with the information collected as part of the Industrial Air Emissions Management Program, which is focused on NO_x.

VRUs at fuel terminals require substantial capital investment, estimated at $10-15-million for each fuel terminal.[43] There is an economic return on VRU investments at terminals, as vapours that would otherwise have been lost to the atmosphere are captured and returned to storage. Actual realized economic return at each facility will depend on many highly variable factors including size of investment, facility volume, and product margins. For the trucking industry, tank trucks would also need to be equipped or retrofitted at an estimated cost of between $5,000 and $10,000 per unit.[44] For the retail gasoline sector, service stations must be equipped with tank fittings to enable vapour recovery connections. Most underground tank systems constructed in the last 20 years already include such fittings. Based on the experience of the Canadian Fuels Association, most tanker trucks in Alberta would require retrofitting. Because of the investment in the trucking industry, it is recommended that if the Government of Alberta decides to pursue VRUs it should be a regulatory requirement for the whole province.

2.7 LAND-USE PLANNING

RECOMMENDATION 15A: DEVELOP LAND-USE PLANNING PROTOCOLS TO SUPPORT AIR QUALITY OUTCOMES

That municipalities and their neighbouring municipalities work together and with relevant stakeholders to:

i. identify and promote opportunities to design urban form and infrastructure to reduce environmental impacts and improve air quality
ii. educate the public and others about the importance of these opportunities
iii. work to implement environmentally responsible land-use planning by updating bylaws, statutory plans, and policies

Performance Measures

i. By January 2019, municipalities have tools to incent brownfield development
ii. Number of municipal bylaws, statutory plans, and policies such as municipal development plans, transportation plans, and growth plans, identifying air quality as an issue to address through complete and compact communities

RECOMMENDATION 15B: SUPPORT COLLABORATION ON LAND-USE PLANNING

That the Government of Alberta support collaboration among municipalities and other stakeholders on environmentally responsible urban development and land-use planning through financial mechanisms, education, and engagement

Performance Measure

i. By January 2020, the Government of Alberta to inform CASA on the support provided for collaboration among municipalities and other stakeholders

Rationale and Background

Urban form refers to the physical characteristics that define built-up areas, including the shape, size, density, and configuration of settlements. It can be considered at different scales – regional, urban, neighbourhood, block, and street.[45]

Urban development patterns greatly influence personal choices and options related to transportation modes and distances, as well as building and housing types. Non-point source air emissions may directly result from these choices. Once built, the urban form lasts for many decades and retrofits can be costly and difficult. If cities continue to develop as they have, emissions can be expected to increase.

The Government of Alberta's Climate Leadership Report to Minister states that:

> *The design of cities and neighbourhoods matters profoundly, because urban form, once set, is hard to change, and has consequences for future energy use well beyond this century. … Attracting development to mixed-use and transit/active mobility-oriented neighbourhoods in already-developed urban areas is a key strategy in reducing emissions across the*

43 Rob Hoffman. 2017. Personal communication.
44 Rob Hoffman. 2017. Personal communication.
45 UK Government Office for Science/Foresight. 2014.

long-term, and a critical focus for empowering the role for Alberta's municipal governments. (p.73)

The environmental impacts of development are not restricted to urban areas. For example, a lack of coordination in land-use planning across and between regions can result in increased transportation distances. Overall, land-use planning practices can be improved to consider and address the environmental impacts of development.

Transportation is a substantial source of NO_x emissions and also contributes VOCs and $PM_{2.5}$. In addition, residential and commercial heating contribute to NO_x, VOCs, and $PM_{2.5}$ emissions, and these emissions are related to building types and efficiencies (e.g., single detached homes compared to apartments, or individual boilers compared to district heating).

For various reasons, stakeholders may want to preserve the status quo of existing low density neighbourhoods or maintain a preference for greenfield suburban expansion and single-family homes. Complete communities require that a range of choices for transportation, housing, and other activities, such as employment, shopping, and recreation be incorporated into the design, planning, and implementation phases. It is important to address how communities are built to provide the best possible environmental and health outcomes, including a reduction in non-point source emissions.

Environmental and Health Value

Reducing transportation distances and the need for single occupant vehicles, as well as improving the efficiency of commercial and residential heating systems through land-use planning may help to reduce NO_x, VOCs, and $PM_{2.5}$ in urban areas, which is particularly important for areas that are in the orange or red management levels for CAAQS.

Building complete, compact communities with a variety of housing and transportation options has other co-benefits:

- reduced greenhouse gas emissions
- reduced costs for residents resulting from lower transportation and heating fuel consumption
- improved health through active modes of transportation and access to local recreation and amenities
- reduced infrastructure operation and maintenance costs for the municipality especially for streets, transit, and water and wastewater systems

AHS is creating a Healthy Community by Design guidance document to help municipalities and other stakeholders plan and build communities with consideration given to air quality and other health indicators. Already, a healthy public policy information sheet by AHS states that motor vehicles make a significant contribution to air pollution, and that exposure is increasing. Further, "Improved air quality and healthier neighbourhoods overall could be achieved by emphasizing public transit and infrastructure that supports active transportation over the building of more roads, and promoting transportation demand management as well as other strategies that reduce automobile dependence."[46]

Compatibility with Existing Initiatives

This recommendation aligns with several provincial and municipal initiatives. Examples are provided below.

Provincial:

- Capital Region Fine Particulate Matter Response (Government of Alberta)
- Clean Air Strategy (Government of Alberta)
- Climate Leadership Report to Minister (Government of Alberta)
- Healthy Community by Design Guidance Document (in development, AHS)
- *Modernized Municipal Government Act* (Government of Alberta)
- Red Deer Fine Particulate Matter Response (Government of Alberta)
- Regional Plans under the Alberta Land Stewardship Act, including the South Saskatchewan Regional Plan (Government of Alberta)

Municipal:

- Municipal Development Plans, transportation plans and associated targets

The benefits of complete, compact communities with active and public transportation options are recognized by a wide variety of stakeholders, including but not limited to:

- AHS, who supports healthy initiatives put forward by government, municipalities, and all other stakeholders that recognize the importance of community design, natural environments, and

46 Alberta Health Services. 2008.

active public transportation. AHS believes these options improve health by providing simple alternatives for physical and social activity, in addition to reducing air pollution exposure and generation. AHS receives support for these initiatives through staff interactions with provincial and local agencies including the establishment of a Healthy Communities by Design cross-professional sub-committee.

- Canadian Institute of Planners, whose Healthy Communities Practice Guide[47] states, "Achieving health oriented goals of the Community Plan may require communities to re-align their land development regulations," and that, "Car-dependent communities created by extensive single-use, low-density land use have important implications for health: people are less active because they walk less, vehicle exhaust degrades air quality, motor vehicle injuries increase, and mental health and social capital are adversely affected."
- Federation of Canadian Municipalities Standing Committee on Environmental Issues and Sustainable Development, whose policy statement recommends that the Government of Canada, "Develop, with municipal governments, initiatives to assist municipalities in reducing vehicle use through improved public and active transportation and sustainable urban-planning practices."[48]
- The Government of Alberta, whose Efficient Use of Land Implementation Tools Compendium (2014) sets out a series of tools and best practices that can be used by land-use planners, land users, and decision makers to help implement efficient land-use strategies and reduce the footprint of human activities on Alberta's landscape.

Given the agreement on the importance of development patterns and land-use planning on the health of communities, barriers to implementation need to be identified and mitigated.

An example of a program to support collaboration is British Columbia's Plan H, which supports local government engagement and partnerships across sectors to create healthier communities. This program has a toolkit to help governments link planning principles to a variety of health outcomes.[49]

Potential Stakeholders

- Airshed Organizations
- Alberta Airsheds Council
- Alberta Association of Municipal Districts and Counties
- Alberta Professional Planners Institute
- Alberta Urban Municipalities Association
- Building Industry and Land Development Alberta
- Government of Alberta (Alberta Climate Change Office and Alberta Municipal Affairs)

Advice to Implementers

In Alberta, land-use planning is under the direct control of municipalities, through their authority under the *Municipal Government Act*. However, as has been noted, developers, builders, existing and new home owners, and municipalities themselves may be motivated to preserve the status quo of existing low density neighbourhoods or maintain a preference for greenfield suburban expansion and single-family homes. There can also be an imbalance in that greenfield development often has fewer time delays or financial costs than infill, brownfield, or denser forms of urban development. If there are perceived to be undesirable constraints on development, there is potential for developers and prospective home owners to choose to build in outlying municipalities, exacerbating transportation and related emission issues.

These factors make a collaborative approach to regional growth management important to avoid shifting environmental problems to other jurisdictions. For example, to manage non-point source transportation emissions, municipalities may need to work together on regional transportation strategies at the same time they are considering improvements to development patterns within their boundaries. This is a sensitive issue with many components but a solution has many co-benefits. It is not as simple as just increasing density. It is about building vibrant, complete communities with choices for transportation, housing, and services. It is also about

47 Canadian Institute of Planners. 2017, p. 34.
48 Federation of Canadian Municipalities. 2017, p. 10.
49 Government of British Columbia. 2017.

facilitating regional collaboration and coordination of land-use planning.

Potential areas in which the Government of Alberta could support collaboration on environmentally responsible urban development and land-use planning are:

- considering improved land-use form and environmental protection when making transportation and infrastructure funding allocations to municipalities and school boards
- providing more funding and planning support for developing and coordinating regional, public, and active transportation systems
- supporting education of the public and specific stakeholder groups about the impact of land-use planning on the environment to influence behavioural change. To assist this, municipalities could identify opportunities to align their public communication and education with Alberta Environment and Parks' Environmental Education Framework
- providing forums for municipalities to share ideas and experiences and learn from each other
- engaging the Alberta Professional Planners Institute to integrate air quality into their professional outcomes
- empowering municipal governments to attract mixed-use development and transit or active mobility-oriented neighbourhoods in already developed urban areas

To encourage remediation and redevelopment of brownfield sites, under the *Modernized Municipal Government Act*, municipalities would be allowed to establish a tax exemption framework for brownfield properties that cancels, defers, or reduces the municipal portion of the property taxes owing on a brownfield property for a number of years. By bylaw, a municipality must outline the special tax treatment conditions and factors for qualifying properties (e.g., number of years a site must remain vacant).

Under the *Modernized Municipal Government Act*, there may be an opportunity for municipalities in the Calgary and Edmonton regions to use Growth Management Boards to advance stakeholder discussion and collaboration on urban development patterns and land-use planning in general. These groups would implement mandatory regional planning mechanisms for land-use planning and require municipalities to work together on service delivery and cost-sharing matters.

The Alberta Airsheds Council and regional Airshed Organizations could be key stakeholders in facilitating the discussion about the impact of regional growth and development on air quality, potential options for improvement, and for multi-stakeholder engagement. A suggested starting point for collaboration is the spillover effect of urban development decisions on the regional transportation network.

Greensburg, Kansas, provides an interesting case study of a city that rebuilt after a natural disaster with a focus on sustainable urban form and infrastructure.[50]

Urban development and land-use planning are complex and sensitive issues. As such, this issue requires more investigation, collaboration, and consensus in areas that include:

- education of planners about the connection of development patterns to air quality and non-point source emissions
- education of the development community about changing what they offer. The public can only buy, or not buy, what is on the market, and developers design communities they think the public wants
- education of municipal leaders on the effects of development patterns on air pollution and the relative benefits of complete, compact communities with transportation options
- incentives to develop complete, compact communities; for example, when Edmonton wanted developers to preserve heritage buildings, incentives were offered to support this approach and cover some of the financial risk
- consideration of regional growth management in conjunction with changes to the development patterns within a municipality's boundaries

50 Billman, L. 2009.

2.8 GAPS AND UNCERTAINTIES

2.8.1 Knowledge of Non-Point Sources

RECOMMENDATION 16: ADDRESS GAPS AND UNCERTAINTIES IN KNOWLEDGE OF NON-POINT SOURCES

That Alberta Environment and Parks address, as a priority in its future air quality work, gaps and uncertainties in ambient air quality monitoring (e.g., $PM_{2.5}$ and ozone), emission inventory, source characterization, modelling, and atmospheric chemistry as identified by the Non-Point Source Technical Task Group

Performance Measures

The following measures are intended to advance the understanding of a) the sources contributing to, and b) the dominant factors affecting the formation of secondary contaminants at, CAAQS monitoring stations measuring elevated ambient concentrations through focused improvements to current gaps and uncertainties.

i. Beginning in 2019, Alberta Environment and Parks, to communicate to CASA biennially the status of progress in reducing these gaps and uncertainties.

ii. By January 2020, Alberta Environment and Parks, in conjunction with partners as appropriate, will have:

   a. implemented a process for identifying and publicly communicating areas that are approaching or not achieving the CAAQS

   b. developed, and publicly communicated, a monitoring plan with clear scientific questions and hypotheses for focused studies

   c. initiated focused studies in priority areas (which may include monitoring, modelling, emissions inventories, source characterization, and atmospheric chemistry work) with subsequent data analysis that inform the next steps and help address gaps and uncertainties

Performance Indicator

i. By January 2019, Alberta Environment and Parks will communicate to the CASA board of directors the monitoring plans or strategies for air zones assigned to the red or orange management levels for the 2014-2016 CAAQS assessment period

Rationale and Background

The Non-Point Source Project has identified some specific uncertainties and gaps under each of the air quality activities and categories noted in Recommendation 16 that should be given priority. Many other agencies and organizations such as Alberta Agriculture and Forestry (AAF), ECCC, Airshed Organizations, and others are already involved in work related to some or all of the knowledge gaps and uncertainties identified in the TTG report. They can play an important role in addressing many of these gaps and uncertainties.

It is also hoped that all of the gaps and uncertainties identified in the TTG report will be further considered as a priority when air quality related programs are being planned.

As outlined in Section 1, the TTG was established to help address the two identified potential outcomes and deliverables under Objective 1 from the project Terms of Reference. In general, these were to:

- prepare a technical document, using available information from emission inventories, ambient monitoring, air quality modelling, and receptor modelling to synthesize what is known about non-point source air emissions and their potential contribution to air quality in Alberta, and to identify any information and data-related knowledge gaps encountered
- use this compilation, with emphasis on areas in the orange or red CAAQS management levels in Alberta, to then provide a refined list of non-point sources for further consideration

The TTG identified a number of gaps and uncertainties that greatly limited its ability to specify and understand the direct linkages between non-point sources and their impacts on air quality. These gaps and uncertainties included:

- a lack of certain air quality monitoring data
- emission inventory uncertainties
- limited air quality modelling and related source apportionment assessments
- limitations in understanding of how certain atmospheric processes are affecting secondary $PM_{2.5}$ and ozone formation in specific areas

These gaps and uncertainties led to the conclusion that overall, there is insufficient information and data to confidently define the amount that each non-point source category contributes to ambient concentrations at the specific monitoring stations seeing elevated $PM_{2.5}$ or ozone levels. However, the available resources did help narrow the number of potentially relevant non-point sources to a more manageable number for further consideration and also helped identify priority information needs.

Environmental and Health Value

Effectively managing air quality and addressing CAAQS management level issues requires a good understanding of the factors affecting air quality in an air zone. The complexity of air quality management is such that additional knowledge and data detail will always be desirable, but efforts need to be made to address critical gaps and uncertainties that influence the ability to understand, and therefore effectively manage, air quality issues in an air zone or provincially. Addressing the gaps and uncertainties identified below would greatly advance the objectives of CAAQS-related air quality management, and air quality management in general, in the province.

Compatibility with Existing Initiatives

This recommendation aligns with several national and provincial initiatives. Examples are provided below.

National:

- National Air Quality Management System (CCME)

Provincial:

- Clean Air Strategy (Government of Alberta)

Potential Stakeholders

- Airshed Organizations
- Environment and Climate Change Canada

Advice to Implementers

Gaps and Uncertainties Identified for Monitoring, Inventory, Modelling, and Science

The following knowledge gaps and uncertainties were identified as priorities for consideration when developing future air quality monitoring and assessment plans. These priorities are grouped by issue to help determine the party (or parties) that might be involved in filling the gaps and reducing the uncertainties. Each category is individually important, but it is the combination of information and understanding from each category that provides the comprehensive insight required to improve understanding and inform effective air quality management.

- Monitoring: Comprehensive ambient air quality and meteorological data are essential if the emission sources and other factors influencing air quality at a particular location or in a region are to be fully understood. A lack of $PM_{2.5}$ speciation and gas mixture composition data limit the ability to conduct source apportionment receptor modelling, while the lack of vertical atmospheric wind and temperature profiles limits the ability to evaluate and validate source apportionment air quality simulation modelling outputs. These limitations affect the ability to understand and address CAAQS-related air quality issues. Filling these monitoring gaps at certain critical air monitoring sites and locations needs to be considered when developing and implementing air zone monitoring and management plans, with priority given to $PM_{2.5}$ speciation. Furthermore, analysis of the monitoring data should be leveraged in cases where data are already collected. The Canadian National Air Pollution Surveillance $PM_{2.5}$ speciation program is an example of the type of program that can provide the detailed particulate matter composition data necessary to conduct source apportionment studies. The vertical atmospheric profiling and gas mixture composition monitoring being conducted by the Wood Buffalo Environmental Association and ECCC as part of air zone and oil sands monitoring programs are examples of the type of detailed air quality and meteorological data collection programs that need to be strategically applied in areas where CAAQS management actions are or may in the future be triggered. These enhanced monitoring activities could be campaign-based, periodic, or permanent depending on the location and circumstances.
- Emission inventories: Assessing the relevance of different emission sources and different emission source types on air quality locally, regionally, or provincially requires information on the quantities and characteristics of all significant emission sources, including point sources, non-point sources, natural sources, and anthropogenic sources. While Alberta has, in general, good emission inventory data, there are specific gaps and uncertainties which, if addressed, would significantly improve the ability to understand where and how different emission sources and source types are influencing air quality. All the non-point source emission categories should be reviewed in terms of:
  - the method(s) being used to estimate emissions for that category
  - what if any validation of these methods has been undertaken

- the uncertainties associated with the current estimation method and options to improve and validate the current emission estimates
- implementation of a non-point source emission estimate validation program for those non-point sources by categories and parameters identified as a priority (Table 2)

- Source characterization: Similarly, characterization of certain non-point source emissions should be undertaken (with an emphasis on non-point sources) in the areas requiring CAAQS air quality management, and in areas where that non-point source is considered to be a potential contributor to elevated $PM_{2.5}$ and/or ozone levels; the individual air zone reports appended to the TTG report provide information on what these non-point sources are or may be. Better quantification and the development of chemical characterizations ("fingerprints") of various types of emission sources is regarded as a priority for reducing the uncertainty associated with current emission datasets and for assisting in CAAQS-related air quality management. Of particular interest are fugitive VOCs and NH_3 emissions from certain industries (upstream oil and gas, refineries and fuel handling/transfer operations and oil sands operations) and certain agricultural operations and practices (intensive livestock operations and crop fertilization practices), as well as $PM_{2.5}$ (dust) emissions from agricultural activities, construction operations, roads, and certain industrial activities (oil sands mines, quarries, and sand and gravel operations).
- Modelling: Models can be valuable air quality assessment and management tools. A need to expand the use and reliability of air quality simulation and receptor modelling, at both the air zone and provincial scales, has been identified. To date, they have been used sparingly, and a large gap exists in the available resources and capacity to do region-specific and province-wide modelling to account for transport from one air zone to another. Finally, model validation has been limited, in part due to the monitoring and emission gaps identified above and gaps in understanding of the underlying atmospheric processes affecting ozone and secondary particulate matter formation. Enhancements in the ability to conduct both of these types of modelling and validation of the models used would greatly facilitate understanding and the ability to address existing and possible future CAAQS exceedances and other air quality issues.
- Atmospheric Chemistry (e.g., particulate matter and ozone formation): Atmospheric processes play a major role in determining where, how, and how much $PM_{2.5}$ and ozone are formed, making it essential to understand these processes when developing air quality improvement plans. Several questions arise in an Alberta context:
  - What are the physical and/or chemical mechanisms involved in the formation of ozone and secondary $PM_{2.5}$ near specific individual monitoring stations, for specific air quality incidents?
  - What sources and pollutants are contributing to secondary $PM_{2.5}$ and ozone formation near specific individual monitoring stations, for specific air quality events?
  - What changes are occurring as an air parcel passes over different sources and land uses near specific individual monitoring stations, for specific air quality events?
  - What is the relative importance of natural versus anthropogenic VOCs in ozone formation?
  - What is the relative importance of NO_x versus VOCs in ozone formation in different local and regional areas?

Work that advances understanding in these areas would contribute to the development of better models and most importantly improve our ability to develop effective $PM_{2.5}$ and ozone management plans. It is suggested that all relevant parties work together in a coordinated and co-operative manner to address this recommendation.

2.9 CLIMATE CHANGE AND AIR QUALITY

2.9.1 Energy Efficiency Air Quality Co-Benefits

RECOMMENDATION 17A: CONSIDER AIR QUALITY IMPACTS OF PROPOSED NEW CLIMATE CHANGE AND ENERGY EFFICIENCY INITIATIVES

That the Alberta Climate Change Office and Energy Efficiency Alberta consider the air quality impacts of any proposed new policy, program, or action related to non-point sources they consider adopting and place value on those measures with substantial air quality co-benefits

Performance Measure

i. By January 2019, the adoption of a policy or process by the Climate Change Office and Energy Efficiency Alberta to systematically consider the air quality impacts of any new policies, programs, and actions related to non-point sources they consider adopting and give value to those with higher air quality co-benefits. Information to be shared with CASA on the policy or process by March 2019

RECOMMENDATION 17B: CONSIDER AND UPDATE AIR QUALITY IMPACTS OF EXISTING CLIMATE CHANGE AND ENERGY EFFICIENCY INITIATIVES

That the Alberta Climate Change Office and Energy Efficiency Alberta, as resources permit, also consider the air quality impacts of their existing policies, programs, and actions related to non-point sources and make adjustments to increase air quality co-benefits where warranted

Performance Measure

i. By January 2019, the adoption of a policy or process by the Climate Change Office and Energy Efficiency Alberta to consider the air quality impacts of their existing policies, programs, and actions and make adjustments to increase co-benefits where warranted. Information to be shared with CASA on the policy or process by March 2019

Rationale and Background

Alberta has committed extensive effort and substantial funding within an overall Climate Leadership Plan and energy efficiency agenda to reduce greenhouse gases in the province. Lower greenhouse gas emissions are often accompanied by reductions of other substances that affect air quality. Intentionally considering the air quality implications, both positive and inadvertently negative, of proposed actions, programs, and strategies will ensure alignment between the Climate Leadership Plan and the Air Quality Management System.

Governments and stakeholders are working to manage levels of ambient $PM_{2.5}$ and ozone through existing and planned initiatives and through the recommendations of this project. Focusing on the important efforts to reduce greenhouse gas emissions, then evaluating and selecting those strategies that reduce both greenhouse gases and other emissions could provide greater benefits for the investment made.

Within the Government of Alberta, different organizational units manage climate change and air quality. This recommendation would help ensure a stronger linkage where it could add the most value. In the end, the air is a single environmental medium and the cumulative effects of differing actions on that single medium need to be considered fully.

Generally, greenhouse gas emissions and air emissions are often confused because they are closely related. While climate change action helps address a world-scale problem, air pollution typically has more local or regional impacts, affecting people directly and immediately. Providing a better understanding of air quality and environmental benefits of climate change actions and energy efficiency programs would highlight the full benefits provided by these programs.

While Alberta's climate and energy efficiency programs focus on saving energy and reducing greenhouse gas emissions, improved community well-being is considered within the overall outcomes of the Climate Leadership Plan, thus linking with air quality and health. The evaluation of Climate Leadership Plan funding proposals also involves many considerations, including air quality. As a result, this project's recommendations are a logical next step from the current climate and energy efficiency frameworks and programs.

Environmental and Health Value

$PM_{2.5}$ has significant negative acute and chronic health effects, and also negatively affects the environment. The current CAAQS for $PM_{2.5}$ has not been achieved in one of Alberta's air zones and is close to not being achieved in several others. Greenhouse gas and energy efficiency actions that intentionally benefit both air quality and greenhouse gas levels would contribute more systematically to health and environmental benefits.

Compatibility with Existing Initiatives

This recommendation aligns with overarching national and provincial initiatives. Examples are provided below.

National:

- National Air Quality Management System (CCME)

Provincial:

- Alberta Climate Leadership Plan (Government of Alberta)
- Clean Air Strategy (Government of Alberta)

Potential Stakeholders

- Government of Alberta (Alberta Environment and Parks)
- Municipalities
- Home Builder Associations

Advice to Implementers

The scope of these recommendations is limited to non-point sources because of the terms of reference of this project, but considering the air quality and health impacts of all climate change and energy efficiency initiatives would be beneficial. Alberta Health is encouraged to strengthen its capability to assess the health impacts of these initiatives.

Of particular concern for some stakeholders is the impact on air quality from the increased use of biomass for heat and energy. While biomass burning is considered carbon neutral, the combustion of biomass releases numerous emissions that can create air quality problems under certain conditions. With the introduction of carbon pricing in Alberta (see Section 3.4 for more information), there may be a shift towards greater use of biomass, possibly compounding air quality challenges.

Many factors affect the development and selection of climate change policies or strategies and energy efficiency programs. It is not intended that air quality become the focus of these programs, but consideration of the air quality benefits could provide additional useful information that might lead to the selection of one strategy or program over another based on its benefit to both the Alberta Climate Leadership Plan and the Air Quality Management System. The air quality impacts of proposed policies, strategies, programs, and actions can be considered with the expertise available within Alberta Environment and Parks.

An appropriate and knowledgeable stakeholder organization could provide feedback on the programs selected by Energy Efficiency Alberta for delivery. The feedback would facilitate the adaptation of the programs to meet the needs of specific stakeholders and Albertans more broadly. This organization could also evaluate air quality components of the energy efficiency programming and offer feedback on potential future programs to achieve both greenhouse gas and air quality benefits.

INFORMATION FROM REFINING THE PROJECT FOCUS

3 Information from Refining the Project Focus

The recommendations in the previous sections do not address all non-point source categories or their subcategories, based on the project refinement process described in Section 1. One consideration was existing management actions that are already addressing a non-point source. This section provides an overview of some of the key existing management actions that were taken into account.

3.1 TRANSPORTATION

The management of transportation-related emissions involves the complementary roles of federal, provincial, and local governments and other stakeholders.

The federal government sets emission standards for new and imported on-road and off-road vehicles and engines in Canada, as noted in Sections 3.1.1 and 3.1.2; these regulations align with those of the US EPA and are updated from time to time. For transportation fuels, there are accompanying federal[51] and provincial[52] standards.

Potential provincial and municipal level actions were considered as part of this project (see Section 1.3.2). The regulation of in-use vehicles and engines falls under provincial government jurisdiction. Local governments contribute to provincial efforts through land-use planning and local bylaws (e.g., anti-idling).

Various initiatives are underway to help reduce emissions from in-use vehicles and engines in various jurisdictions, as described below and in the transportation-related recommendations. Some key reference documents to help inform potential management actions in Alberta through this project and future opportunities include the International Review of Non-Attainment Area Air Quality Management Tools and Techniques (2016) by Ramboll Environ for the Government of Alberta and those available through the CCME Mobile Sources Working Group.

3.1.1 On-Road Transportation

The on-road sector includes light-duty vehicles (e.g., passenger cars), light-duty trucks (e.g., vans, pickup trucks, sport utility vehicles), heavy-duty vehicles (e.g., trucks and buses), motorcycles, and engines.

Federal regulations include *On-Road Vehicles and Engine Emission Regulations, Passenger Automobile and Light Truck Greenhouse Gas Emissions Regulations,* and *Heavy-duty Vehicle and Engine Greenhouse Gas Emission Regulations* for new and imported vehicles and engines.

Once on-road vehicles or engines are sold, any management actions for these sources would fall under provincial or municipal jurisdiction. Various ongoing efforts in Alberta through governments, industry, non-governmental organizations, and Airshed Organizations, include:

- encouraging use of carpooling, public transit, and active transportation
- public awareness campaigns
- driver education (eco-driving)
- reducing unnecessary idling
- purchase of low emission and/or right-sized vehicles
- carpooling for staff or use of low emission vehicle fleets

CASA supports the goals of these initiatives and their positive contribution to air quality management in Alberta, noting there may be benefits from increased coordination among similar initiatives.

Mandatory emissions testing for light-duty in-use vehicles was considered as a possible management action to reduce non-point source emissions, but was not recommended for several reasons:

- the potential for Albertans driving older vehicles who are unable to afford newer vehicles being disproportionally affected by mandatory emissions testing and associated costs
- the discontinuation of similar programs for light-duty vehicles such as AirCare in British Columbia because of reduced failure rates and decreasing emissions due to improved vehicle emission control system technologies[53]
- the anticipated costs to government to establish and operate a provincial mandatory

51 Environment and Climate Change Canada. 2017d.
52 Alberta Environment and Parks. 2016.
53 Government of British Columbia. 2014.

- emissions testing mechanism in the current fiscal environment
- the anticipated negative reception by some Alberta drivers to additional costs associated with mandatory emissions testing and repairs, if required. This might also be viewed as "piling on" given the reaction by some members of the public to the carbon levy, which also impacts vehicle operation costs
- the continued improvement in vehicle emission control system technology and the rate of Alberta vehicle fleet renewal and replacement

3.1.2 Off-Road Transportation

The off-road sector includes a broad range of vehicle and engine applications ranging from small engines that power lawn and garden equipment to much larger engines used to power mining, construction, agricultural, and forestry equipment. This sector also includes engines used to power recreational equipment such as snowmobiles and personal watercraft.

Federal regulations include *Off-Road Compression-Ignition Engine Emission Regulations, Off-Road Small Spark-Ignition Engine Emission Regulations,* and *Marine Spark-Ignition Engine, Vessel and Off-Road Recreational Vehicle Emission Regulations* for new and imported vehicles and engines.[54]

Excluding rail and aviation equipment that remains under federal jurisdiction, once off-road vehicles and equipment are sold, any management actions for these sources would fall under provincial or municipal jurisdiction. Off-road mobile equipment data for gasoline and diesel fueled equipment from the 2014 Air Pollutant Emissions Inventory were reviewed for this project.[55] Based on provincial totals, the highest off-road emitters of NO_x included agricultural equipment and construction and mining equipment (excluding oil sands mine fleets, which are included in the oil-sands specific category), and the highest off-road emitters of VOCs were recreational equipment followed by construction and mining equipment (excluding oil sands mine fleets) and lawn and garden equipment. Some sources are largely in urban areas and others are more localized or dispersed in rural areas.

While existing off-road vehicles and equipment will be replaced with newer, lower emitting versions over time, management actions could include using existing equipment in a more fuel-efficient manner or accelerating fleet turnover through replacement or retrofit, for example. Selected off-road mobile emissions sources are discussed below.

Construction Equipment

Examples of construction equipment include excavators, tractors, dozers, loaders, backhoes, graders, and cranes. The Government of Alberta and the Alberta Roadbuilders and Heavy Construction Association have an MOU to support increasing energy efficiency and reducing greenhouse gas emissions in Alberta, under which they developed A Guide to Energy Efficient Best Practices for Alberta's Road Building and Heavy Construction Industry.[56] The expiry of the current MOU in 2017 provided an opportunity to reinvigorate the conversation to reduce both greenhouse gas and air emissions from construction equipment. Alberta Transportation has initiated this discussion with stakeholders and a draft updated MOU is in progress.

Agricultural Equipment

Examples of agricultural equipment include tractors, combines, swathers, irrigation sets, sprayers, balers, tillers, and agricultural mowers. Various management practices aimed at improving agricultural equipment fuel efficiency can reduce air emissions as a co-benefit and a number of these have been adopted by most Alberta farmers. These practices, some of which are described below, can reduce fuel consumption and improve fuel efficiency.

Direct Drilling and Minimum Tillage: Switching to direct drilling and minimum tillage can reduce fuel use by more than 80%. In Alberta, the Reduced Tillage LINKAGES program, which ended in 2009, helped increase the adoption rate of no-till practices in Alberta.[57]

Precision Agriculture: With this practice, producers use global positioning systems, geographic information systems, equipment guidance (autosteer), yield monitoring, site specific nutrient mapping and precision crop input application to farming. This approach tailors the use of site-specific practices of agricultural technology that reduce fuel consumption, increase fuel efficiency of agricultural machinery, increase yield,

54 Environment and Climate Change Canada. 2013b.
55 Environment and Climate Change Canada. 2017b.
56 Alberta Roadbuilders and Heavy Construction Association. 2013.
57 Alberta Agriculture and Forestry. 2016

and reduce or mitigate environmental damage.[58] For example, a soil test defines the precise amounts of fertilizer the crops require and identifies the best plant variety for each crop.

Controlled Traffic Farming: "Controlled traffic farming is a crop production system in which the crop zone and traffic lanes are distinctly and permanently separated."[59] This practice saves energy in tillage operations.

Machine Maintenance: Regular preventative maintenance of tractors and heavy equipment, such as replacing tractor air and fuel filters, and maintaining and repairing planters, tillage, and harvest equipment, helps improve fuel efficiency and reduce emissions from agricultural machinery.

Matching Tractor Size with Implement Size:[60] This practice involves selecting the right tractor size for the right implement load (avoiding use of large tractors for light load implements).

Ballasting Tractors for Fuel Efficiency:[61 62 63] Tractor fuel efficiency can be adversely affected by using too much ballast or too little ballast. Too much ballast can cause excessive rolling resistance while too little ballast can cause excessive tractor wheel slip. Using the right ballast is key for tractor fuel efficiency.

Recreational and Lawn-and-Garden Equipment

Examples of recreational equipment include snowmobiles, ATVs, off-road motorcycles, and recreational marine equipment (personal watercraft). Examples of lawn-and-garden equipment include lawn and garden tractors, lawn mowers, chain saws, turf equipment, leaf blowers and vacuums, and trimmers, edgers, and brush cutters, many of which have both residential and commercial applications. Management actions have included programs by Scout Environmental (formerly Summerhill Impact) in Ontario called Mow Down Pollution, Clean Wake Engine Take-back, and Fuel Can Flip, where the accelerated turnover of older equipment was incented for emissions reductions.[64] Similar programs are not recommended for Alberta at this time, but there may be future opportunities in this area, such as for education and awareness initiatives that highlight what individuals can do to improve air quality or where individual businesses could support Clean Air Day.

Mining Equipment

For mine fleets, which relate to the off-road sector and oil-sands specific categories, facility *Environmental Protection and Enhancement Act* approvals include requirements for new and replacement mining vehicles, typically requiring those that meet the most up-to-date federal standards. Furthermore, the pending oil sands Base Level Industrial Emission Requirements (BLIERs) discussions have included in-use mine fleets within their scope to date. Irrespective of the outcome of the BLIERs discussions, the fleet will reduce emissions as lifecycle turnover occurs. While the newest federal standards (Tier 4) are still being implemented, during the next federal review of vehicle emissions standards, the importance of increasingly stringent federal standards for diesel engines greater than 750 horsepower in size should be highlighted as they are a large emitter of NO_x in Alberta. Oil sands mine fleet emissions are particularly relevant to the Lower Athabasca Zone, as described in the TTG report. Available information[65,66] suggests that further emission reductions are possible. See also Section 3.6: Oil-Sands Specific.

3.2 AGRICULTURE

As numerous existing actions to help manage emissions from agricultural sources already exist (Appendix 7), and their effectiveness in improving air quality is unclear, there was not consensus to develop recommendations for this source. Primary agricultural production is categorized as a non-point source of emissions. These emissions are complex and vary from season to season and from location to location. Agricultural air emissions of interest include, in no particular order, ammonia, odours, VOCs, hydrogen sulphide (H_2S), and particulate matter.

Agriculture contributes 92% of total ammonia emissions in Alberta. Ammonia is a valuable crop nutrient so minimizing emissions provides both economic and environmental benefits. In the agriculture sector, ammonia emissions occur primarily from livestock buildings, open feedlots, fertilizer use, manure storage

58 Biggs, L. and Giles, D. 2012
59 Controlled Traffic Farming Alberta. 2014
60 Gellings, C. W. 2008.
61 Helsel, Z. R. and Grubinger, V. 2012
62 NSW Farmers. 2013
63 Hanna, H. Mark; Harmon, Jay D.; and Petersen, Dana. 2010.
64 Scout Environmental. 2017.
65 USEPA. 2004.
66 Environment Canada. 2008.

facilities, and during manure handling, treatment, and application to land. The *Agricultural Operation Practices Act* (AOPA) and its associated regulations apply to all agricultural operations in Alberta. Part one of the Act defines how nuisance issues such as odour, dust, noise, and smoke resulting from agricultural activities are addressed. Part two of the Act sets the permitting process for the construction or expansion of confined feeding operations, the compliance process, and offences related to, and penalties for, contravening the Act. The Natural Resources Conservation Board is responsible for delivering AOPA, permitting of confined feeding operations, and addressing complaints regarding the management of manure on agricultural operations in Alberta.

Agriculture in Alberta also produces emissions of $PM_{2.5}$ and VOCs. While AAF recognizes the importance of these substances, its current prioritized focus is on ammonia emissions.

Mobile agricultural equipment falls under the transportation category (Section 3.1.2).

3.2.1 Management Actions

Monitoring and characterizing air emissions, particularly VOCs from agricultural operations, is expensive and technically challenging. AAF and agricultural commodity groups and organizations have invested considerable human, material, and financial resources to provide guidance and support to the agricultural industry to:

- manage odour and other air emissions
- develop beneficial management practices (BMPs) for producers to manage agricultural air emissions and minimize their impacts on air quality
- develop a strategic approach to manage potential air quality impacts associated with agricultural production in Alberta

As described in Section 3.1.2, agricultural practices have shifted toward more precise methods that may help improve air quality management. Data in the Canadian Field Print Initiative[67] indicates that energy used in the production of spring wheat decreased by 6% between 1981 and 2011 on a per hectare basis. During that same period, energy use per tonne was reduced by 39% and the yield of spring wheat increased by 59%. As more recent data become available, it will be shown if these promising trends are continuing.

Since 1998, AAF has engaged in more than 22 different air quality research projects, often in collaboration with stakeholders. Current projects include:

- Air Quality (Ammonia) Management
- Managing Greenhouse Gases and Ammonia
- Reducing NH_3 emissions
- Targeting Nitrous Oxide (N_2O) Emissions

From 2012 to 2017, AAF's Environmental Stewardship Branch implemented an Odour and Air Quality Strategy that facilitated the management of odour and other agricultural industry air emissions. Associated accomplishments following the implementation of the strategy are described in Appendix 7. These include the strategic plan released in 2008 by the CASA Confined Feeding Operations (CFO) Project Team. This plan focused on managing six emissions of concern (NH_3, H_2S, particulate matter, pathogens and bio-aerosols, VOCs, and odour). Based on the recommendations, AAF implemented the following initiatives and provided support to others:

- development of a new emission inventory for NH_3 and particulate matter
- monitoring for NH_3, H_2S, particulate matter, and VOCs
- prioritization of research into BMPs to reduce emissions of NH_3 from CFOs

In 2012, AAF developed the CFO Air Quality BMP Extension Plan. Related products include fact sheets and workbooks, workshops, online source emission calculators and web links on the AAF website, and manuals for managing CFO air quality. Every two years, AAF conducts the Environmentally Sustainable Agricultural Tracking Survey (ESATS) to measure producers' awareness and adoption of key BMPs. AAF uses the survey results to investigate the effectiveness and barriers to adoption of BMPs. ESATS 2014 survey results indicated that there are low adoption rates of some BMPs. AAF will continue to investigate the effectiveness and barriers to adoption of these BMPs (see Figure 1 in Appendix 7).

67 Canadian Field Print Initiative. 2017.

3.3 NATURAL GAS AND OIL-FIRED COMMERCIAL AND RESIDENTIAL HEATING

As there are existing, planned, or anticipated actions to help reduce emissions from natural gas and oil-fired heating equipment, CASA did not develop recommendations to address this source of emissions from the commercial and residential heating sector (recommendations were developed for wood-burning equipment, Section 2.5.).

Natural Resources Canada *Energy Efficiency Regulations* contain increasingly stringent energy efficiency standards for products and equipment across Canada, including requirements for new gas furnaces and boilers, oil-fired furnaces and boilers, and gas-fired unit heaters. For energy efficiency as a system, the National Energy Code of Canada for Buildings 2011, and Section 9.36 "Energy Efficiency" of the Alberta Building Code 2014, set out technical requirements for the energy efficient design and construction of new buildings. The Alberta Building Code now incorporates these requirements, including requirements for the building envelope, lighting, service water heating, and heating, ventilation, and air-conditioning (HVAC).[68]

EEA also delivers programs targeting commercial and residential heating to allow consumers to save energy and money and reduce emissions, as noted in Section 2.2.4. The next programs are to be determined.

3.4 LINKAGES WITH THE ALBERTA CARBON LEVY AND CARBON PRICING

As of January 1, 2017, the Government of Alberta began charging a carbon levy on all transportation and heating fuels that emit greenhouse gases when combusted, at a rate of $20/tonne in 2017 and $30/tonne in 2018. The rate is based on the amount of carbon released by the combusted fuel, not on the mass of fuel itself, and includes diesel, gasoline, natural gas, and propane. Thus, the levy is applied to the transportation, heating and industrial non-point source categories discussed in this report. The levy does not apply to electricity.

Under the Climate Leadership Plan, the carbon levy is the first economy-wide pricing of carbon in Alberta. The principle of carbon pricing is that a levy on carbon intensive activities will reflect the full social cost of these activities and, by making them more expensive for consumers, will incent innovation and reduced use of fossil fuels. The increased cost is intended to change behaviour and encourage less-carbon-intensive activities. Consequently, individuals and businesses that rely to a greater degree on carbon emitting activities, such as driving, will pay a greater share of the carbon levy and may be motivated to improve or implement efficiencies. Some exemptions to the levy are in place, including exemptions for biofuels and for marked fuels used for on-farm agricultural purposes.

In March 2016, the Government of Canada and most of Canada's premiers committed to putting Canada on the path to meet or exceed the national target of reducing greenhouse gas emissions by 30% below 2005 levels by 2030. To support these efforts, the Government of Canada released the Pan-Canadian Framework on Clean Growth and Climate Change, which includes a benchmark for carbon pricing throughout Canada. Due to take effect in 2018, the emission reduction requirements will become more stringent over time to reduce Canada's greenhouse gas emissions at lowest cost to business and consumers, and to support innovation and clean growth. Since Alberta has already implemented a greenhouse gas reduction framework and carbon pricing, this provides the opportunity for Alberta to pursue an equivalency agreement that would meet the intent of the federal policy and ensure that the approach to carbon pricing in Alberta is unique to its emissions profile and to the industries and natural resources that operate in the province.

3.5 INDUSTRIAL NON-POINT SOURCES

Current provincial and federal government action is expected to reduce non-point source emissions of VOCs from the oil and gas sector. Under the *Canadian Environmental Protection Act*, ECCC has an ongoing review process through the Chemical Management Plan to reduce risk of exposure to VOCs. As a result, additional measures to reduce fugitive emissions of VOCs from the petroleum industry are being developed. ECCC has released draft regulations (Canada Gazette Part I, May 27, 2017) targeting refining (including upgraders) and integrated petrochemical industries to reduce petroleum refining gases. This will result in reductions of VOCs more broadly from the petrochemical industry. ECCC has also released draft regulations (Canada Gazette Part I, May 27, 2017) targeting the upstream oil and gas sector to reduce VOCs and methane by 40 to 45% by 2025. Similarly, the Alberta Government's parallel initiative to reduce methane by 45% from the oil and gas industry by 2025 will have a co-benefit of also reducing VOCs from these sources.

68 Natural Resources Canada. 2017b.

Industry non-point sources of NO_x include non-stationary equipment (mobile sources) and space heating. Mobile sources including on-road and off-road vehicles at industrial sites are included in the transportation category (see Section 3.1). The carbon levy (see Section 3.4) also applies to transportation and heating fuels at industrial sites.

3.6 OIL-SANDS SPECIFIC

Minimization of VOC Emissions from the Petroleum Industry

Canada's Oil Sands Innovation Alliance (COSIA) is an alliance of oil sands producers focused on accelerating the pace of improvement in environmental performance in Canada's oil sands through collaborative action and innovation. Several initiatives are underway related to VOC emissions. For example, COSIA and the Canada-Alberta Oil Sands Monitoring Program are working to better quantify both methane and VOC emissions from tailing ponds and mine faces. As the price on carbon increases (see Section 3.4), the incentive to reduce methane emissions will increase. In the oil and gas industry, methane emissions are associated with VOC emissions, so reducing methane will also reduce VOC emissions. See also Section 3.1.2 for reference to mine fleets.

SUMMARY AND NEXT STEPS

4 Summary and Next Steps

The goal of the CASA Non-Point Source Project was to recommend actions, which could include policy changes, to help address non-point source air emissions contributing to ambient $PM_{2.5}$ and ozone levels in Alberta, focusing on areas where the orange or red management levels have been assigned under the CAAQS framework.

CASA has made recommendations in eight areas: mobile sources (transportation), construction operations and road dust, open-air burning, commercial and residential heating, industrial non-point sources, land-use planning, addressing non-point source knowledge gaps and uncertainties, and considering air quality co-benefits with climate change initiatives.

Recommendations for other sources were not included in this project, but some opportunities are identified for consideration. Furthermore, where the project team assumed that a source would be addressed through another initiative, future verification will be needed to determine whether the initiative was implemented or further action is needed.

The nature of non-point source air emissions management is such that there is typically not one simple solution and the mechanisms for management may be unclear. Also, some categories of non-point emission sources involve many different individual emitters. For this reason, many of the recommendations are multi-faceted with actions that include elements of policy and regulation, public education and awareness, and planning. There is an important role to play for a variety of stakeholders, including different levels and departments of government. In addition, while some sources are cross-cutting, not all regions of the province have the same challenges. As a result, some recommendations may lead to greater benefits in some regions than others.

A communications network of stakeholders was initiated as part of the project to facilitate coordinated messaging on air quality in education and public communication work, including communication on the recommendations of this project. It will be beneficial to sustain this network beyond completion of the project.

CASA is pleased to have been able to undertake this work and advises that this project should be seen as only a first important step in what needs to be an ongoing, coordinated effort to manage Alberta's non-point source emissions.

BIBLIOGRAPHY

5 Bibliography

Alberta Agriculture and Forestry. 2016. *Environmentally Sustainable Agriculture Tracking Survey Report*. Retrieved from http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/aesa15117

———. 2017a. *Prescribed Fire*. Edmonton, AB: Government of Alberta. Retrieved from www.wildfire.alberta.ca/prevention/prescribed-fire/default.aspx.

———. 2017b. *Un-harvested Crops? Know your Options.* Edmonton, AB: Government of Alberta. Retrieved from http://www1.agric.gov.ab.ca/$Department/deptdocs.nsf/All/com16303.

Alberta Building Code. 2014. Retrieved from http://www.chbaalberta.ca/alberta-building-code-2014?mid=1228

Alberta Capital Airshed. 2015. Municipal Idle-Free Toolkit. Online at http://capitalairshed.ca/idle-free-toolkit.

Alberta Environment and Parks. 2014a. Capital Region Fine Particulate Matter Response. Edmonton, AB: Government of Alberta.

———. 2014b. *Wood Burning Smoke Factsheet*. Edmonton, AB: Government of Alberta.

———. 2015. *Prohibited Debris: Before you Burn… Learn!* Edmonton, AB: Government of Alberta.

———. 2016. *Renewable Fuels Standard Regulation*. Retrieved from http://aep.alberta.ca/climate-change/guidelines-legislation/renewable-fuels-standard-regulation.aspx.

———. 2016a. Red Deer Fine Particulate Matter Response. Edmonton, AB: Government of Alberta.

———. n.d. *Environmental Education Framework.*

Alberta Health Services. 2008. *Healthy Public Policy Information Sheet: Land Use Planning and Health*. Edmonton, AB: Government of Alberta.

———. 2016. *Environmental Public Health Week September 26-30, 2016*. Edmonton, AB: Government of Alberta. Retrieved from www.albertahealthservices.ca/news/Page13405.aspx.

Alberta Municipal Affairs. 2016. *Information on Energy Codes*. Edmonton, AB: Government of Alberta. Retrieved from www.municipalaffairs.alberta.ca/CP_Energy_Codes_Information.

Alberta Roadbuilders and Heavy Construction Association. 2012. *A Guide to Energy Efficient Best Practices for Alberta's Road Building and Heavy Construction Industry*. Edmonton, AB: Alberta Roadbuilders and Heavy Construction Association.

———. 2013. *Alberta Roadbuilders and Heavy Construction Association – Memorandum of Understanding (MOU) with Alberta Environment and Sustainable Resource Development and Alberta Transportation*. Edmonton, AB: Alberta Transportation. Retrieved from www.transportation.alberta.ca/4058.htm.

Alberta Transportation, City of Calgary, and City of Edmonton. 2017. *Environmental Construction Operations (ECO) Plan Framework Instructions for Preparing ECO Plans for Alberta Transportation, City of Calgary, and City of Edmonton Construction Projects*. Calgary, AB: Environmental and Safety Management, City of Calgary.

Alberta Transportation. 2016. Alberta Vehicle Statistics: Number of Registered Motorized Vehicles by Fuel Type.

———. 2016. C*limate Change and Emissions – Policy and Program Options Report*. Internal document for discussion purposes only.

———. 2017. Green Transit Incentives Program (GreenTRIP). Retrieved from http://www.transportation.alberta.ca/5409.htm.

Alliance of Automobile Manufacturers. 2017. ZEV Mandate States. Retrieved from autoalliance.org/energy-environment/state-electric-vehicle-mandate/.

Axsen, J., Goldberg, S., and Melton, N. 2016. Canada's Electric Vehicle Policy Report Card. Vancouver, BC: Simon Fraser University, Sustainable Transportation Action Research Team.

Becker, J. M. and Hastings-Simon, S. 2017. *Kick-Starting Energy Efficiency in Alberta – Best Practices in the use of Efficiency as an Energy Resource*. Calgary, AB: The Pembina Foundation.

Belzile, G. and Milke, M. 2017. *Are Electric Vehicle Subsidies Efficient?* Montreal, QC: Montreal Economic Institute.

Biggs, L. and Giles, D. 2012. *Current and Future Agricultural Practices and Technologies which affect Fuel Efficiency*. Brussels, Belgium: Intelligent Energy Europe.

Billman, L. 2009. *Rebuilding Greensburg, Kansas, as a Model Green Community: A Case Study.* Golden, Colorado: National Renewable Energy Laboratory.

Bronson Consulting. 2013. *Clearing the Air: 2012 Canadian Vehicle Emissions-Reduction Program Inventory*. Canadian Council of Ministers of the Environment (CCME).

Cairns, S. and Arros, P. 2014. *Policy Bundles for Reducing Transportation Emissions in Large Cities.* Ottawa: Sustainable Prosperity Institute.

Calgary Parking Authority. 2017. Carpool Parking Program. Retrieved from https://www.calgaryparking.com/findparking/carpool

Canadian Council of Ministers of the Environment (CCME). 1991. *Environmental Code of Practice for Vapour Recovery in Gasoline Distribution Networks.* Winnipeg, MB: Canadian Council of Ministers of the Environment.

———. 2012a. *Code of Practice for Residential Wood Burning Appliances.* Winnipeg, MB: Canadian Council of Ministers of the Environment.

———. 2012b. *Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone.* Winnipeg, MB: Canadian Council of Ministers of the Environment.

———. 2014. *Advanced Vehicle Technologies – Federal and Provincial Incentive Programs*. CCME Mobile Sources Working Group internal document. Winnipeg, MB: Canadian Council of Ministers of the Environment.

———. 2016a. *Guidance Document for Canadian Jurisdictions on Open-Air Burning.* Winnipeg, MB: Canadian Council of Ministers of the Environment.

———. 2016b. *Vehicle and Engine Tampering: Description and Examples of Acceptable Practices*. Winnipeg, MB: Canadian Council of Ministers of the Environment. Online at http://www.ccme.ca/files/Resources/air/mobile_sources/Tampering%20Description_EN.pdf.

Canadian Field Print Initiative. 2017. Retrieved from http://fieldprint.ca/.

Canadian Fuels Association. 2017. Smart Fuelling Tips to Save on Fuel, and Save the Planet. Retrieved from http://www.canadianfuels.ca/Blog/April-2016/Smart-Fuelling-tips-to-save-on-fuel,-and-save-the-planet/.

Canadian Institute of Planners. 2017. *Healthy Communities Practice Guide.* Ottawa: Canadian Institute of Planners. Retrieved from www.cip-icu.ca/Issues/Healthy-Communities.

City of Edmonton. 2015. Edmonton's Community Energy Transition Strategy. Online at https://www.edmonton.ca/city_government/documents/EnergyTransitionStrategy.pdf.

———. 2017. *The Way We Move*. Retrieved from https://www.edmonton.ca/city_government/city_vision_and_strategic_plan/the-way-we-move.aspx.

———. 2017. *Walk Edmonton*. Retrieved from https://www.edmonton.ca/transportation/walk-edmonton.aspx.

City of Edmonton Transportation Committee. 2016. *Electric Bus Feasibility Study*. Edmonton, AB: City of Edmonton.

City of Nanaimo. 2017. "Rebates." Nanaimo: Property and Development, City of Nanaimo. www.nanaimo.ca/property-development/rebates.

Clean Air Strategic Alliance (CASA) Non-Point Source Technical Task Group. 2017. *Final Technical Report: A Knowledge Synthesis of Non-Point Source Air Emissions and their Potential Contribution to Air Quality in Alberta*. Edmonton, AB: Clean Air Strategic Alliance.

Clean Air Strategic Alliance, Vehicle Emissions Team. 1999. *The Alberta ROVER Project Summary Report.* Online at http://www.casahome.org/uploads/source/Alberta%20ROVER%20Project%20(March%201999).pdf.

———. 2003. *Breathe Easy Vehicle Scrappage Program Report.*

———. 2010. Final Report to the CASA board. Online at http://www.casahome.org/uploads/source/PDF/VET%20Final%20Report.pdf.

———. 2013. *NPS Workshop, October 23, 2013*. Background Information. Prepared by: Government of Alberta.

Climate Change Central. 2012. *Trucks of Tomorrow Final Report.*

Controlled Traffic Farming Alberta. 2014. *Controlled Traffic Farming Alberta*. Edmonton, AB: Controlled Traffic Farming Alberta. Retrieved from www.controlledtrafficfarming.org.

CSA Group. 2017. CSA B365-10 (R2015): Installation Code for Solid-Fuel-Burning Appliances and Equipment. Retrieved from http://shop.csa.ca/en/canada/fuels-and-appliances/b365-10-r2015/invt/27013182010.

Electric Power Research Institute (EPRI). 2017. Initial Data for Non-Light-Duty Electric Transportation Options. Palo Alto, CA: EPRI.

Energy Efficiency Alberta. 2017. *Energy Efficiency Alberta.* Edmonton, AB: Government of Alberta. Retrieved from www.efficiencyalberta.ca.

Environment and Climate Change Canada. 2013a. *Canadian Ambient Air Quality Standards*. Environment and Climate Change Canada. www.ec.gc.ca/default.asp?lang=En&n=56D4043B-1&news=A4B2C28A-2DFB-4BF4-8777-ADF29B4360BD.

———. 2013b. *Vehicle and Engine Regulations.* Gatineau, QC: Environment and Climate Change Canada. Retrieved from www.ec.gc.ca/air/default.asp?lang=En&n=AE4ECEC1-1.

———. 2017a. Canadian Ambient Air Quality Standards. Retrieved from http://www.ec.gc.ca/default.asp?lang=En&n=56D4043B-1&news=A4B2C28A-2DFB-4BF4-8777-ADF29B4360BD.

———. 2017b. *Air Pollutant Emissions Inventory*. Retrieved from https://ec.gc.ca/pollution/default.asp?lang=En&n=E96450C4-1.

———. 2017c. *ECCC Strategy on Short-Lived Climate Pollutants.* Gatineau, QC: Environment and Climate Change Canada.

———. 2017d. *Fuel Regulations*. Retrieved from https://www.ec.gc.ca/energie-energy/default.asp?lang=En&n=EE068DA8-1.

———. 2017e. *Strategy on Short-Lived Climate Pollutants – 2017.* Retrieved from https://ec.gc.ca/GES-GHG/FF677357-F627-463A-A7C4-9068CEF3C3D9/5003-SLCP%20Strategy%202017_EN.pdf.

———. 2017f. *The Pan-Canadian Framework on Clean Growth and Climate Change: Canada's Plan to Address Climate Change and Grow the Economy.* Ottawa, ON: Government of Canada

Environment Canada. 2005a. Impact of Residential Wood Stove Replacement on Air Emissions in Canada. Montreal, QC: Government of Canada.

———. 2005b. Provincial distribution of wood burned by each category of appliances in Canada. Montreal, QC: Government of Canada.

———. 2006. *Model Municipal By-law for Regulating Woodburning Appliances.* Ottawa: Government of Canada.

———. 2008. Evaluation of Vehicle Emissions Reduction Options For the Oil Sands Mining Fleet. Prepared by M. J. Bradley and Associated. March 2008.

Envirotest Canada. 2013. *Greater Vancouver Regional District Remote Sensing Device Trial for Monitoring Heavy-duty Vehicle Emissions*. Burnaby, BC: Envirotest Canada.

ESP and McClintock, P.M. 2007. *The Alberta Rover II On-road Vehicle Emissions Survey: Prepared for the Clean Air Strategic Alliance*. Tuscon, AZ: ESP.

Federation of Canadian Municipalities. 2017. *Environmental Issues and Sustainable Development Policy Statement.*

Frank, L., Kavage, S., and Litman, T. 2006. *Promoting Public Health through Smart Growth: Building Healthier Communities through Transportation and Land Use Policies and Practices.* Vancouver, BC: Smart Growth BC.

Gellings, C. W. 2008. "Energy Efficiency in Agricultural Equipment." Efficient Use and Conservation of Energy, vol. 2.

Germain, A. 2005. *Impact of Residential Wood Stove Replacement on Air Emissions in Canada.* Environmental Protection Branch, Environment Canada.

Government of Alberta. 2009. *Automotive and Light Truck Vehicle Inspection Manual*. Online at http://www.transportation.alberta.ca/content/doctype41/production/amltmanualdec2009.pdf.

———. 2012. *Clearing the Air: Alberta's Renewed Clean Air Strategy*. Edmonton, AB: Government of Alberta.

———. 2013a. *Alberta Land Stewardship Act.* Edmonton, AB: Alberta Queen's Printer.

———. 2013b. *Issue: Application and Use of the National Base-Level Industrial Emissions Requirements (BLIERs) Within the Alberta Regulatory Policy System.* Edmonton, AB: retrieved from https://open.alberta.ca/dataset/2024a1f6-801c-432d-bdc8-aec090854b45/resource/1dce8704-6adc-44c5-bb7c-a05a1692e278/download/2013-BaseLevelIndustrialEmissions-Jun18-2013.pdf.

———. 2014. *Efficient Use of Land Implementation Tools Compendium.* Edmonton, AB: Government of Alberta.

———. 2015. *Alberta: Air Zones Report 2011-2013.* Air and Climate Change Policy Branch, Alberta Environment and Parks.

———. 2016a. *Commercial Vehicle Inspection Manual.*

———. 2016b. *Energy Efficiency Alberta Helps Save People Money.* Edmonton, AB: Government of Alberta. Retrieved from www.alberta.ca/release.cfm?xID=4370646a37239-e955-7d4e-646cb8636d0063b3.

———. 2016c. *Summary Report on Major Non-Point Source Air Emission Sources in Alberta.* Edmonton, AB: Air Policy Section, Government of Alberta.

———. 2017a. *Climate Leadership Plan.* Retrieved from https://www.alberta.ca/climate-leadership-plan.aspx#toc-0

———. 2017b. *Forest and Prairie Protection Act. Forest and Prairie Protection Regulation*. Edmonton, AB: Alberta Queen's Printer.

———. 2017c. *South Saskatchewan Regional Plan 2014 – 2024*. Edmonton, AB: Government of Alberta.

———. *Energy Efficiency Advisory Panel.* Edmonton, AB: Government of Alberta. Retrieved from www.alberta.ca/energy-efficiency.aspx.

Government of British Columbia. 2014. Aircare Program Comes to an End. News Release. Retrieved from https://news.gov.bc.ca/stories/aircare-program-comes-to-an-end.

———. 2017. *Plan H.* Retrieved from http://planh.ca.

Government of Canada. 1999. *Canadian Environmental Protection Act* (CEPA). Ottawa, ON: Queen's Printer for Canada.

Hanna, H. Mark; Harmon, Jay D.; and Petersen, Dana. 2010. "Farm Energy: Ballasting tractors for fuel efficiency." Agriculture and Environment Extension Publications. 29. http://lib.dr.iastate.edu/extension_ag_pubs/29

Helsel, Z. R. and Grubinger, V. 2012. *Introduction to Energy-Efficient Tractor and Field Operations*. Extension.org. Retrieved from http://articles.extension.org/pages/29604/introduction-to-energy-efficient-tractor-and-field-operations#top.

IBI Group.2009. *The Implications of Alternative Growth Patterns on Infrastructure Costs.* Calgary, AB: City of Calgary.

Layzell, D. B. and Straatman, B. 2016. "The Potential Impact of Electric Vehicles on Alberta's Energy Systems" in *CESAR Scenarios.* Vol. 1, No. 2.

Leach, A, Adams, A., Cairns, S., Coady, L., and Lambert, G. 2015. *Climate Leadership Report to Minister.* Edmonton, AB: Alberta Environment and Parks

Lees + Associates. 2014. *Healthy Built Environment Linkages: A Toolkit for Design, Planning, Health.* Vancouver, BC: Provincial Health Services Authority.

Marcon. 2016. *Business Case for Investing in Electric Vehicle Direct Current Fast Charge Station Infrastructure*. Prepared for the Mobile Sources Working Group, Canadian Council of Ministers of the Environment. Online at http://www.ccme.ca/files/Resources/air/mobile_sources/Final%20DCFC%20Report.pdf.

Natural Resources Canada. 2016. ecoDriving, Fuel-Efficient Driving Techniques. Retrieved from http://www.nrcan.gc.ca/energy/efficiency/transportation/cars-light-trucks/fuel-efficient-driving-techniques/7507.

———. 2017a. *Buying a Fuel-Efficient Vehicle* (Natural Resources Canada. Retrieved from http://www.nrcan.gc.ca/energy/efficiency/transportation/cars-light-trucks/buying/7477.

———. 2017b. *Canada's Energy Efficiency Regulations.* Ottawa, ON: Government of Canada. Retrieved from www.nrcan.gc.ca/energy/regulations-codes/standards-6845.

NSW Farmers. 2013. *Monitoring Wheel Slip to Achieve Fuel Efficiency*. Australia: NSW Farmers Association.

Ontario Ministry of Transportation. 2011. Sustainability Implementation Plan. Retrieved from http://www.mto.gov.on.ca/english/sustainability/MTO-SIP-English-rnd8-forprint.pdf

Parkland Airshed Management Zone. 2012. *Parkland Airshed Management Zone (PAMZ) Municipal Burning Bylaw Survey Report.* Sundre, AB: PAMZ.

Partners for Climate Protection. 2010. Enviro-fleets: Reducing Emission from Municipal Heavy-duty Vehicles: A Guide to Helpful Resources. Ottawa, ON: Federation of Canadian Municipalities.

Plug 'n Drive Canada. 2017. Retrieved from https://plugndrive.ca/.

Ramboll Environ. 2016. *International Review of Non-Attainment Area Air Quality Management Tools and Techniques.* Edmonton, AB: Government of Alberta, Environment and Parks Department. Retrieved from http://aep.alberta.ca/air/reports-data/documents/ReviewNonAttainmentAirQuality-Jul29-2016.pdf.

Regional Municipality of Wood Buffalo. 2001. *Regional Municipality of Wood Buffalo Bylaw No. 01/084 Open Air Fire Bylaw.* Fort McMurray, AB: Regional Municipality of Wood Buffalo.

RWDI. 2016. *Emissions, Air Quality and Health Impacts of Widespread Electric Vehicle Use: Literature Review and Relevance to the Canadian Situation.* Prepared for Health Canada.

Scout Environmental. 2017. *Our Programs.* Toronto, ON: Scout Environmental. Retrieved from scoutenvironmental.com/site/programs.

Smart Drive Challenge. 2017. smartdrivechallenge.ca.

Societé de l'assurance automobile Quebec. 2017. Mechanical Inspection and Maintenance of Heavy Vehicles. Quebec: Retrieved from https://saaq.gouv.qc.ca/en/transportation-goods/heavy-vehicles/mechanical-inspection-and-maintenance/ [mddelcc.gouv.qc.ca/air/pieval/] [this is the French version]

Statistics Canada. 2015. *Households and the Environment: Energy Use.* Ottawa, ON: Environment Accounts and Statistics Division, Statistics Canada, Catalogue no. 11-526-S, Table 2, 2015.

Trans Canada Carpool.ca. 2017. Carpool.ca. Retrieved from https://www.carpool.ca/.

Transport Canada. May 26, 2017. *Government of Canada to Develop a National Zero-Emissions Vehicle Strategy by 2018*. News release. Retrieved from https://www.canada.ca/en/transport-canada/news/2017/05/government_of_canadatodevelopanationalzero-emissionsvehiclestrat.html.

UK Government Office for Science/Foresight. 2014. *Urban Form and Infrastructure: A Morphological Review.* Retrieved from: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/324161/14-808-urban-form-and-infrastructure-1.pdf.

USEPA. 2004. Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel. Federal Register. Vol. 69, No. 124, Tuesday, June 29, 2004, Rules and Regulations. Retrieved from https://www.gpo.gov/fdsys/pkg/FR-2004-06-29/pdf/04-11293.pdf

World Health Statistics 2016: Monitoring Health for the SDGs, Sustainable Development Goals. 2016. Geneva, Switzerland: World Health Organization.
http://www.who.int/gho/publications/world_health_statistics/2016/en/.

ACRONYMS

6 Acronyms

AAC	Alberta Airsheds Council
AAF	Alberta Agriculture and Forestry
AEP	Alberta Environment and Parks
AHS	Alberta Health Services
AOPA	Agricultural Operation Practices Act
AQHI	Air Quality Health Index
BLIERS	Base-level Industrial Emission Requirements
BMPs	Beneficial (or Best) Management Practices
CAAQS	Canadian Ambient Air Quality Standards
CASA	Clean Air Strategic Alliance
CCME	Canadian Council of Ministers of the Environment
CEPA	Canadian Environmental Protection Act
CFOs	Confined feeding operations
CNG	Compressed natural gas
CO	Carbon monoxide
COSIA	Canada's Oil Sands Innovation Alliance
CRAZ	Calgary Region Airshed Zone
CSA	Canadian Standards Association
ECCC	Environment and Climate Change Canada
ECO (plan)	Environmental Construction Operation
EEA	Energy Efficiency Alberta
(US) EPA	(US) Environmental Protection Agency
ESATS	Environmentally Sustainable Agricultural Tracking Survey
GHG	Greenhouse Gases
ICE	Internal combustion engine
MOU	Memorandum of Understanding
NH_3	Ammonia
NMHC	Non-methane hydrocarbons
NO_2	Nitrogen dioxide
NO_x	Nitrogen oxides
NPRI	National Pollutant Release Inventory
NPS	Non-point source
ORVR	Onboard Refueling Vapour Recovery
PAHs	Polycyclic aromatic hydrocarbons
PAMZ	Parkland Airshed Management Zone
$PM_{2.5}$	Fine particulate matter (2.5 microns or less in diameter)
RMWB	Regional Municipality of Wood Buffalo
SO_2	Sulphur dioxide
SO_x	Sulphur oxides
THC	Total hydrocarbons
TTG	Technical Task Group (of the Non-Point Source Project Team)
VOCs	Volatile Organic Compounds
VRU	Vapour Recovery Unit
ZEV	Zero Emission Vehicle

APPENDICES

1 ALBERTA AIR ZONES REPORT: 2011-2013

2 FINAL TECHNICAL REPORT: A KNOWLEDGE SYNTHESIS OF NON-POINT SOURCE AIR EMISSIONS AND THEIR POTENTIAL CONTRIBUTION TO AIR QUALITY IN ALBERTA

3 AIR ZONE REGION REPORTS

4 CASA NON-POINT SOURCE PROJECT CHARTER

5 CASA NON-POINT SOURCE TEAM COMMUNICATIONS PLAN

6 CASA NON-POINT SOURCE PROJECT: PROJECT & COMMUNICATIONS PLAN BACKGROUNDER

7 CASA NON-POINT SOURCE MESSAGE MAP

8 AGRICULTURAL PRACTICES

APPENDIX 1

ALBERTA AIR ZONES REPORT: 2011–2013

Government

Alberta: Air Zones Report 2011-2013

September 2015

Any comments or questions regarding the content of this document may be directed to:

Air and Climate Change Policy Branch
Alberta Environment and Parks
12th Floor, Baker Centre
10025 – 106 Street
Edmonton, Alberta T5J 1G4
AEP.alberta.ca

Date of Publication: September 2015

ISBN No. 978-1-4601-2312-6 (Print)
ISBN No. 978-1-4601-2313-3 (PDF)

Table of Contents

List of Tables

List of Figures

List of Appendices

1.0 Summary

Alberta Environment and Parks has completed the 2011-2013 Canadian Ambient Air Quality Standards (CAAQS) $PM_{2.5}$ and ozone assessment. This report is the first such annual assessment applying the new CAAQS standards and approach.

Alberta's six air zones have been assessed for achievement against the CAAQS using thirty three ambient air monitoring stations distributed throughout the province. A summary of the CAAQS achievement status and the air management level for each air zone is presented in Table 1.

Management actions have already been initiated within some air zones as part of Alberta's implementation of the former Canada-wide standards for $PM_{2.5}$ and ozone.

Table 1 Summary of CAAQS Achievement Status and Air Zone Management Level

Air Zone	Results			Management Actions
	$PM_{2.5}$ 24-hour ($\mu g\ m^{-3}$)	$PM_{2.5}$ Annual ($\mu g\ m^{-3}$)	Ozone 8-hour (ppb)	
Peace	19	7.0	59	Actions for preventing air quality deterioration due to $PM_{2.5}$
Lower Athabasca	41*	9.3	60	Actions for preventing $PM_{2.5}$ CAAQS exceedance and air quality deterioration due to ozone
Upper Athabasca	19	8.1	62	Actions for preventing $PM_{2.5}$ CAAQS exceedance and air quality deterioration due to ozone
North Saskatchewan	30*	10.1*	62	Actions for preventing $PM_{2.5}$ and ozone CAAQS exceedance
Red Deer	30	11.4	57	Actions for achieving $PM_{2.5}$ CAAQS and preventing air quality deterioration due to ozone
South Saskatchewan	23	8.5	60	Actions for preventing $PM_{2.5}$ CAAQS exceedance and air quality deterioration due ozone

* Air zone achieves the CAAQS after removing influence of transboundary flows or exceptional events.

2.0 Canadian Ambient Air Quality Standards

In October 2012, the Canadian Council of Ministers of the Environment endorsed the Air Quality Management System (AQMS), a comprehensive approach to protect and improve ambient air quality. The Canadian Ambient Air Quality Standards (CAAQS) are air standards to protect human health and the environment and form the driver for AQMS. In October 2012, the Canadian Council of Ministers of the Environment agreed to new CAAQS for fine particulate matter ($PM_{2.5}$) and ozone. The CAAQS management levels for $PM_{2.5}$ and ozone are presented in Table 2. These CAAQS replace the former Canada-wide Standards for $PM_{2.5}$ and ozone.

This report summarizes the Canadian Ambient Air Quality Standards (CAAQS) achievement status and management levels for Alberta's air zones for fine particulate matter and ground-level ozone ambient concentrations measured in the years 2011, 2012 and 2013.

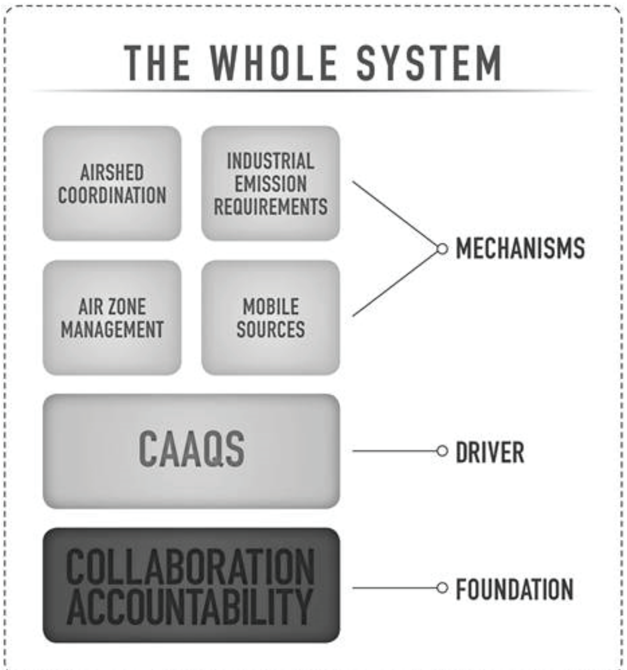


Figure 1 The Air Quality Management System
(from http://www.ccme.ca/en/resources/air/aqms.html)

Table 2 Canadian Ambient Air Quality Standards Management Levels

Management Level	Ozone 8 Hour (ppb)	$PM_{2.5}$ 24 hour (µg m^{-3})	$PM_{2.5}$ Annual (µg m^{-3})
Red	**Actions for Achieving CAAQS**		
Standard (2015)	63	28	10.0
Orange	**Actions for Preventing CAAQS Exceedances**		
Threshold	56	19	6.4
Yellow	**Actions for Preventing Air Quality Deterioration**		
Threshold	50	10	4.0
Green	**Actions for Keeping Clean Areas Clean**		

3.0 $PM_{2.5}$ and Ozone

Significant health and environmental effects have been associated with both ozone and $PM_{2.5}$ (US Environmental Protection Agency, 2007 and 2009).

Ground level ozone is a pollutant and a component of summer time smog. Ozone is produced by a series of chemical reactions in the atmosphere. During hot weather conditions, emissions of volatile organic compounds (VOCs) and oxides of nitrogen (NO_x) from automobiles, industry and other sources can react to produce elevated concentrations of ground level ozone. At times, ozone can also be transported down to the surface from the ozone rich upper atmosphere.

$PM_{2.5}$ refers to particles in the air with diameter less than 2.5 micrometres. These fine particles are small enough to penetrate the lungs. $PM_{2.5}$ may form in the atmosphere through reactions of precursor gases, or be emitted by any combustion source including automobiles, industry, and wood burning. Precursor gases that can react to form $PM_{2.5}$ include VOCs, NO_x, ammonia and sulphur dioxide. At time, smoke from forest fires and other types of biomass burning can be a major source of $PM_{2.5}$. Emissions of precursor gases by sector are discussed in Section 8.

4.0 Alberta Air Zones and Ambient Monitoring

Six air zones have been delineated in Alberta (Figure 2). The Alberta air zone delineation has been based on the Land Use Framework regional boundaries. Land Use Framework regions are the areas by which Alberta manages environmental cumulative effects. To assess achievement under the CAAQS, jurisdictions at a minimum are required to use one station for each centre with a population equal to or greater than 100,000. Alberta has a network of air quality monitoring stations across the province and has used thirty three ambient monitoring stations (Figure 2) located in varying monitoring environments including large urban centres to conduct this assessment. These monitoring stations are operated in accordance with a prescribed provincial standard by local multi-stakeholder airsheds and the Alberta Environmental Monitoring Evaluating and Reporting Agency. The data go through a set of quality assurance and quality control process and are available from a publicly-accessible database.

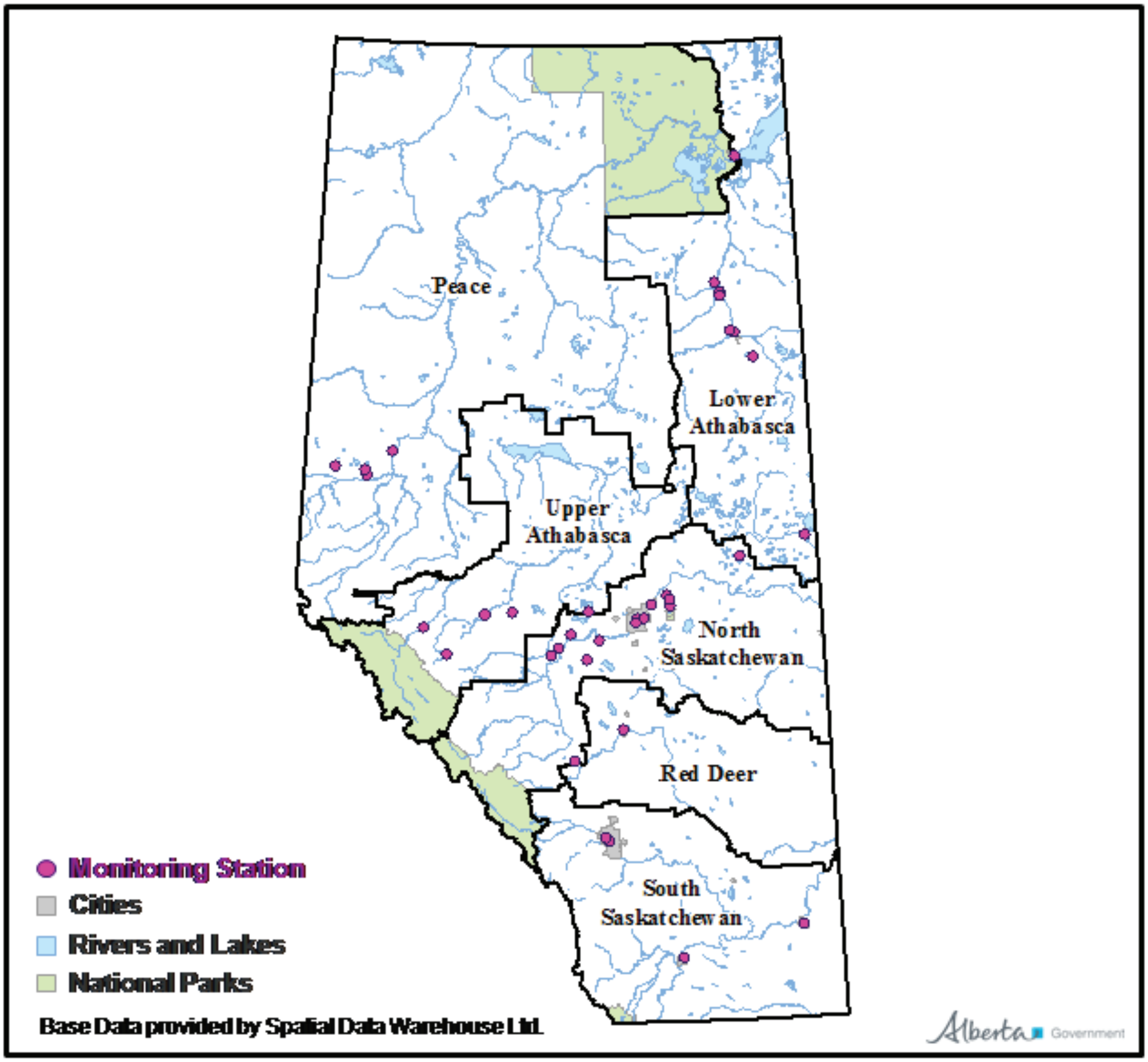


Figure 2 Air Zones and Location of Ambient Stations Used for CAAQS Reporting

5.0 Achievement Status

The achievement status of Alberta air zones for the $PM_{2.5}$ 24-hour standard, the $PM_{2.5}$ annual standard and the ozone standard is based on concentrations measured at CAAQS reporting stations (hereafter referred to as stations) in 2011, 2012 and 2013.

Briefly, achievement status is determined by:

- averaging the concentrations measured at each station and converting to the metric values required by the respective standards;
- comparing the highest metric value from all the stations in an air zone to the standard; and

- if a metric value for a station exceeds the standard,
  - the data are examined for transboundary flows (TF) and exceptional events (EE) and removed from the data if identified; and
  - metric values are recalculated after TF/EE influenced events are removed and compared again against the standard.

Metric values are stated without removal of TF/EE influences. If a station achieved the standard after removal of TF/EE influences, this is described in the comments and footnotes. See Appendix 1 for information demonstrating the influence of TF/EE on achievement status.

The complete requirements and procedures for determining the CAAQS achievement status of an air zone are presented in the Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone (Canadian Council of Ministers of the Environment, 2012).

5.1 $PM_{2.5}$ 24-hour Standard

The 2015 $PM_{2.5}$ 24-hour standard is 28 µg m^{-3}. The form of the standard is the 3-year average of the annual 98th percentile of the daily 24-hour average concentrations for each of three consecutive years. Table 3 presents the $PM_{2.5}$ concentrations in the form of the standard. There are data completeness criteria at each stage of the calculation. For a complete description of these criteria, and exceptions to them, see the Guidance Document on Achievement Determination.

Before analysis of transboundary flows and exceptional events:

- all stations in the Peace, Upper Athabasca and South Saskatchewan air zones achieved the 24-hour $PM_{2.5}$ standard; and
- five stations in the Lower Athabasca air zone, one in the North Saskatchewan air zone, and the only station in the Red Deer air zone exceeded the standard.

In the Lower Athabasca air zone, a number of forest fire events were identified:

- in 2011 at 5 stations: Bertha Ganter – Fort McKay; CNRL Horizon; Fort McKay South (Syncrude UE1); Fort McMurray – Athabasca Valley; and Fort McMurray – Patricia McInnes; and
- in 2012 at two stations: Bertha Ganter – Fort McKay; and CNRL Horizon.

In 2011, the fires occurred between May 15 and June 1, between June 6 and June 15, and on June 26 and 27. In 2012, the fires occurred between June 1 and June 8, between July 12 and July 14, and on August 20 and 22. In 2013, all stations in the Lower Athabasca air zone were below the standard. After removing these forest fire influences of 2011 and 2012, the recalculated metric values achieved the standard at all stations within the air zone. Therefore, the standard was achieved in the Lower Athabasca air zone after removal of exceptional events.

In the North Saskatchewan air zone, one station (Edmonton East) had a metric value above the standard in 2013. Two dates in 2013 (May 21 and 22) were influenced by an exceptional windblown dust event. Removing these two dates resulted in a metric value which achieved the standard. Therefore, the standard was achieved at Edmonton East and in the North Saskatchewan air zone after removal of exceptional events.

There is only one station in the Red Deer air zone, the Red Deer – Riverside station. This station had metric values above the standard in 2011 and 2013. There were no TF/EE events above the 98^{th} percentile values identified in these years at this station. As a result, the Red Deer air zone did not achieve the standard.

The Calgary Central station in the South Saskatchewan air zone had insufficient data in 2011 and 2012, and the Beaverlodge station in the Peace air zone had insufficient data in 2013. This is a result of specific periods of $PM_{2.5}$ concentration data at these stations having been determined to be of unknown quality and therefore not suitable for use in assessment of the CAAQS. These periods of data were not used in the calculation of the 24-hour or annual average metrics.

5.2 $PM_{2.5}$ Annual Standard

The 2015 $PM_{2.5}$ annual standard is 10.0 µg m^{-3}. The form of the standard is the 3-year-average of the annual 1-year average of the daily 24-hour average concentrations for each of three consecutive years. Table 4 presents the $PM_{2.5}$ concentrations in the form of the standard. There are data completeness criteria at each stage of the calculation. For a complete description of these criteria, and exceptions to them, see the Guidance Document on Achievement Determination.

All stations in the Peace, Lower Athabasca, Upper Athabasca and South Saskatchewan air zones achieved the annual $PM_{2.5}$ standard before analysis of TF/EE. Therefore, these air zones achieved the standard.

One station in each of the North Saskatchewan and Red Deer air zones exceeded the standard before analysis of TF/EE influences.

In the North Saskatchewan air zone, the Edmonton East station had an annual average above the standard in 2013. As noted in Section 5.1, there were two dates in May which were affected by a high wind speed dust event. Additionally, there were influences from forest fire smoke in May and June 2011 and in July 2012. Removing these influences resulted in a metric value which was below the standard. Therefore, this station achieved the standard after the removal of these exceptional events.

The only station in the Red Deer air zone is the Red Deer – Riverside station. This station had annual averages above the standard in all three years. There were a number of dates in each year which were affected by forest fire smoke, resulting in 24-hour averages above the standard. However, after removing the affected dates, this station still exceeded the annual $PM_{2.5}$ standard.

Table 3 $PM_{2.5}$ 24-hour Metric Values

Air Zone	Station	Station Number	Annual 98th Percentile (µg m^{-3}) 2011	2012	2013	3-Year Average 2011-2013
Peace	Beaverlodge	91501	20.2	26.5	n/a[a]	23[b]
	Evergreen Park	93001	15.6	17.2	13.2	15
	Grande Prairie (Henry Pirker)	92001	20.2	19.5	17.6	19
	Smoky Heights	94001	16.2	18.2	12.9	16
	Peace Air Zone					**19**
Lower Athabasca	Anzac		29.2[c]	16.3	14.0	20[d]
	Bertha Ganter - Fort McKay	90801	59.6	32.5	19.3	37*
	CNRL Horizon		61.0	36.9	20.9	40*
	Cold Lake South	94301	15.6	n/a[a]	16.8	16[b]
	Fort Chipewyan	91801	12.8	27.5	13.8	18
	Fort McKay South (Syncrude UE1)	90806	49.2	25.0	13.1	29*
	Fort McMurray-Athabasca Valley	90701	79.9	22.2	19.6	41*
	Fort McMurray-Patricia McInnes	90702	64.8	19.4	14.4	33*
	Lower Athabasca Air Zone					**41***
Upper Athabasca	Edson	92901	11.5	13.3	12.5	12
	Hinton	93202	14.5	23.4	20.1	19
	Power	93901	11.3	14.7	9.3	12
	Steeper	91701	7.8	10.6	9.1	9
	Upper Athabasca Air Zone					**19**
North Saskatchewan	Bruderheim	90606	28.1	24.8	23.8	26
	Caroline	91901	12.9	16.9	16.2	15
	Drayton Valley	92801	14.3	17.4	13.5	15
	Edmonton Central	90130	26.5	21.1	26.5	25
	Edmonton East	90121	26.8	23.5	38.2	30*
	Edmonton South	90120	27.4	n/a[a]	23.9	26[b]
	Elk Island	91101	12.4	13.3	15.2	14
	Fort Saskatchewan	90601	23.8	18.8	24.1	22
	Genesee	93101	11.2	11.3	8.6	10
	Lamont County	92201	n/a[a]	16.9	17.7	17[b]
	St. Lina	94401	16.0	19.5	n/a[a]	18[b]
	Tomahawk	91301	10.3	11.1	8.2	10
	North Saskatchewan Air Zone					**30***
Red Deer	Red Deer - Riverside	90302	34.2	22.2	34.5	30†
	Red Deer Air Zone					**30†**
South Saskatchewan	Calgary Central	90228	n/a[a]	n/a[a]	18.7	n/a[e]
	Calgary Northwest	90222	24.4	20.7	22.9	23
	Crescent Heights	90402	18.3	23.4	n/a[a]	21[b]
	Lethbridge	90502	18.7	n/a[a]	17.1	18[b]
	South Saskatchewan Air Zone					**23**

a: The year is not available as it did not meet the data completeness criteria.
b: One of 2011, 2012 or 2013 years did not meet completeness criteria. The 3-year average is based on 2 years.
c: The year did not meet the data completeness criteria, but is included because it exceeded the standard.
d: One or two of 2011, 2012 or 2013 years did not meet completeness criteria, but was included because it exceeded the standard.
e: The 3-year average cannot be calculated because only one year is available.
* Station or air zone achieves the CAAQS after removing influence of transboundary flows or exceptional events.
† Station or air zone does not achieve the CAAQS.

Table 4 PM$_{2.5}$ Annual Metric Values

Air Zone	Station	Station Number	Annual Average (µg m^{-3}) 2011	2012	2013	3-Year Average 2011-2013
Peace	Beaverlodge	91501	6.7	8.3	n/a[a]	7.5[b]
Peace	Evergreen Park	93001	5.1	5.2	3.8	4.7
Peace	Grande Prairie (Henry Pirker)	92001	8.3	6.4	6.3	7.0
Peace	Smoky Heights	94001	4.0	5.0	4.1	4.4
	Peace Air Zone					**7.0**
Lower Athabasca	Anzac		n/a[a]	4.9	4.3	4.6[b]
Lower Athabasca	Bertha Ganter - Fort McKay	90801	8.2	8.0	7.4	7.9
Lower Athabasca	CNRL Horizon		10.2	9.3	8.4	9.3
Lower Athabasca	Cold Lake South	94301	5.7	n/a[a]	7.4	6.6[b]
Lower Athabasca	Fort Chipewyan	91801	3.2	5.5	3.6	4.1
Lower Athabasca	Fort McKay South (Syncrude UE1)	90806	7.3	6.8	5.4	6.5
Lower Athabasca	Fort McMurray-Athabasca Valley	90701	10.3	6.7	7.1	8.0
Lower Athabasca	Fort McMurray-Patricia McInnes	90702	6.0	5.1	5.7	5.6
	Lower Athabasca Air Zone					**9.3**
Upper Athabasca	Edson	92901	3.8	4.8	4.0	4.2
Upper Athabasca	Hinton	93202	7.9	8.5	8.0	8.1
Upper Athabasca	Power	93901	3.6	4.5	3.5	3.9
Upper Athabasca	Steeper	91701	2.0	2.5	2.3	2.3
	Upper Athabasca Air Zone					**8.1**
North Saskatchewan	Bruderheim	90606	8.2	8.7	8.5	8.5
North Saskatchewan	Caroline	91901	4.2	4.9	4.4	4.5
North Saskatchewan	Drayton Valley	92801	7.2	7.9	7.3	7.5
North Saskatchewan	Edmonton Central	90130	10.1	8.0	8.6	8.9
North Saskatchewan	Edmonton East	90121	9.9	9.4	11.0	10.1*
North Saskatchewan	Edmonton South	90120	9.1	n/a[a]	6.5	7.8[b]
North Saskatchewan	Elk Island	91101	3.8	5.3	5.5	4.9
North Saskatchewan	Fort Saskatchewan	90601	6.5	6.8	6.8	6.7
North Saskatchewan	Genesee	93101	3.5	4.0	3.1	3.5
North Saskatchewan	Lamont County	92201	n/a[a]	7.0	6.9	7.0[b]
North Saskatchewan	St. Lina	94401	6.0	6.3	n/a[a]	6.2[b]
North Saskatchewan	Tomahawk	91301	3.2	3.8	3.1	3.4
	North Saskatchewan Air Zone					**10.1***
Red Deer	Red Deer – Riverside	90302	13.7	10.2	10.4	11.4†
	Red Deer Air Zone					**11.4†**
South Saskatchewan	Calgary Central	90228	n/a[a]	n/a[a]	7.5	n/a[c]
South Saskatchewan	Calgary Northwest	90222	8.4	8.4	8.7	8.5
South Saskatchewan	Crescent Heights	90402	7.9	9.4	n/a[a]	8.7[b]
South Saskatchewan	Lethbridge	90502	6.7	n/a[a]	7.0	6.9[b]
	South Saskatchewan Air Zone					**8.5**

a: The year is not available as it did not meet the data completeness criteria.
b: One of 2011, 2012 or 2013 years did not meet completeness criteria. The 3-year average is based on 2 years.
c: The 3-year average cannot be calculated because only one year is available.
* Station or air zone achieved the CAAQS after removing influence of transboundary flows or exceptional events.
† Station or air zone does not achieve the CAAQS.

5.3 Ozone Standard

The 2015 8-hour ozone standard is 63 ppb. The form of the standard is the 3-year-average of the annual 4th highest of the daily maximum 8-hour average concentration for each of three consecutive years. Table 5 presents the ozone concentrations in the form of the standard. There are data completeness criteria at each stage of the calculation. For a complete description of these criteria, and exceptions to them, see the Guidance Document on Achievement Determination.

Over the 2011-2013 period, all stations achieved the ozone standard, before removal of any influences from transboundary flows or exceptional events. In some cases, individual years within the three year period exceeded the standard, but the three-year averages all achieved the standard. Most stations were influenced by exceptional events, including forest fire influences and transport of ozone-rich air from the upper troposphere to ground level. This is discussed further in Section 6.0.

Table 5 Ozone Metric Values

Air Zone	Station	Station Number	Annual 4th Highest (ppb)			3-Year Average
			2011	2012	2013	2011-2013
Peace	Beaverlodge	91501	60.8	56.2	59.0	59
	Grande Prairie (Henry Pirker)	92001	58.1	53.4	53.9	55
	Peace Air Zone					**59**
Lower Athabasca	Anzac		63.1	56.1	58.3	59
	Bertha Ganter - Fort McKay	90801	74.0	51.1	55.6	60
	Cold Lake South	94301	59.4	56.9	65.1	60
	Fort Chipewyan	91801	58.0	51.3	50.4	53
	Fort McKay South (Syncrude UE1)	90806	67.4	56.1	53.0	59
	Fort McMurray-Athabasca Valley	90701	62.8	51.4	53.3	56
	Fort McMurray-Patricia McInnes	90702	62.4	59.5	52.8	58
	Lower Athabasca Air Zone					**60**
Upper Atha-basca	Carrot Creek	91601	58.3	60.1	59.9	59
	Edson	92901	n/a[a]	62.4	59.4	61[b]
	Steeper	91701	62.6	66.3	57.9	62
	Upper Athabasca Air Zone					**62**
North Saskatchewan	Breton	92601	64.4	59.8	60.3	62
	Bruderheim	90606	65.6[c]	48.1	68.3	61[d]
	Caroline	91901	59.0	59.3	65.8	61
	Edmonton Central	90130	55.6	50.8	52.4	53
	Edmonton East	90121	58.9	53.9	56.9	57
	Edmonton South	90120	64.5	57.3	60.9	61
	Elk Island	91101	67.5	50.6	60.4	60
	Fort Saskatchewan	90601	63.6	54.8	55.1	58
	Genesee	93101	58.8	58.9	65.4	61
	Lamont County	92201	64.5	56.9	59.6	60
	St. Lina	94401	57.3	55.0	63.4	59
	Tomahawk	91301	61.8	61.0	62.0	62
	Violet Grove	91401	62.5	58.9	59.1	60
	North Saskatchewan Air Zone					**62**
Red Deer	Red Deer – Riverside	90302	54.1	58.6	56.8	57
	Red Deer Air Zone					**57**
South Saskatch-ewan	Calgary Central	90228	54.3	48.6	52.5	52
	Calgary Northwest	90222	55.9	58.1	65.8	60
	Crescent Heights	90402	59.4	61.6	56.1	59
	Lethbridge	90502	60.5	63.3	56.4	60
	South Saskatchewan Air Zone					**60**

a: The year is not available as it did not meet the data completeness criteria.
b: One of 2011, 2012 or 2013 years did not meet completeness criteria. The 3-year average is based on 2 years.
c: 2nd and 3rd quarters less than 75% complete, but the year is included because it exceeded the standard.
d: One or two of 2011, 2012 or 2013 years did not meet completeness criteria, but was included because it exceeded the standard. The 3-year average includes such a value.

6.0 Air Zone Management Levels

The four colour-coded management levels for $PM_{2.5}$ and ozone are presented in Table 2.

A brief description of the steps taken to determine the management level for each air zone is as follows:

- Metric values are calculated for each station within an air zone for each pollutant.
- Transboundary flows (TF) and exceptional events (EE) are determined and removed from the data.
- Metric values are recalculated after TF/EE influenced events are removed.
- If an air zone has more than one station, the highest metric value is used for comparison against the threshold values and the CAAQS to determine the management level for the air zone.
- As there are two CAAQS averaging times for $PM_{2.5}$, a management level is first determined for each of $PM_{2.5}$ 24-hour and $PM_{2.5}$ annual for a given air zone. The final management level for the air zone is the most stringent of the two (e.g., if the 24-hour is orange and the annual is yellow, the management level for the air zone is orange).

Detailed information on the management levels is in the Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone (Canadian Council of Ministers of the Environment, 2012).

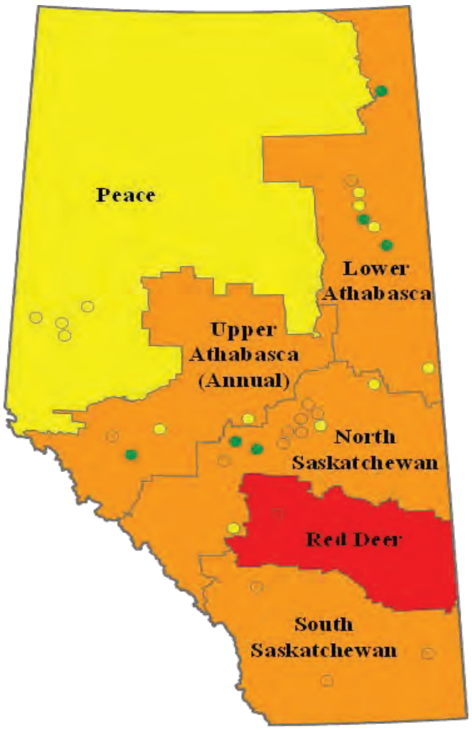
6.1 Determination of Management Levels for $PM_{2.5}$ and Ozone

Alberta Environment and Parks has performed weight of evidence analysis for the influence of exceptional events for all stations in Alberta for the 2011 to 2013 period. This followed the procedures set out in the Guidance Document on Air Zone Management. After removing influences from transboundary flows and exceptional events, the $PM_{2.5}$ and ozone metric values were recalculated, and the recalculated metric values were used to determine the management levels for the air zones. See Appendix 2 for a table detailing management level assignments for each station for both $PM_{2.5}$ metrics and ozone. See Section 7.0 for information on management actions taken to date.

Figure 3 presents the management levels for the $PM_{2.5}$ 24-hour and $PM_{2.5}$ annual metrics. In the case of air zones where each metric provided a different management level, the higher management level was used, and is stated in parentheses. In all other cases, both metrics provided the same management level.

The Red Deer air zone did not achieve the $PM_{2.5}$ CAAQS, and it has been determined to be in the red, Actions for Achieving CAAQS management level, based on the Red Deer – Riverside station.

Figure 3 Management Levels for $PM_{2.5}$



The Lower Athabasca and North Saskatchewan air zones achieve the CAAQS after removing forest fire influences and high-wind dust events, and have been determined to be in the orange, Actions for Preventing CAAQS Exceedances, management level. In Lower Athabasca, this is based on the CNRL Horizon station, in North Saskatchewan this is based on the Edmonton East station.

The South Saskatchewan and Upper Athabasca air zones achieve the CAAQS. After removing forest fire influences, these air zones are still determined to be in the orange level. In South Saskatchewan, this is based on the Calgary Northwest station. In the case of the Upper Athabasca air zone, this is based on the annual average metric at the Hinton station.

The Peace air zone achieves the CAAQS. After removing forest fire influences, it has been determined to be in the yellow, Actions for Preventing Air Quality Deterioration, management level. This is based on the Grande Prairie - Henry Pirker station.

Figure 4 Management Levels for Ozone

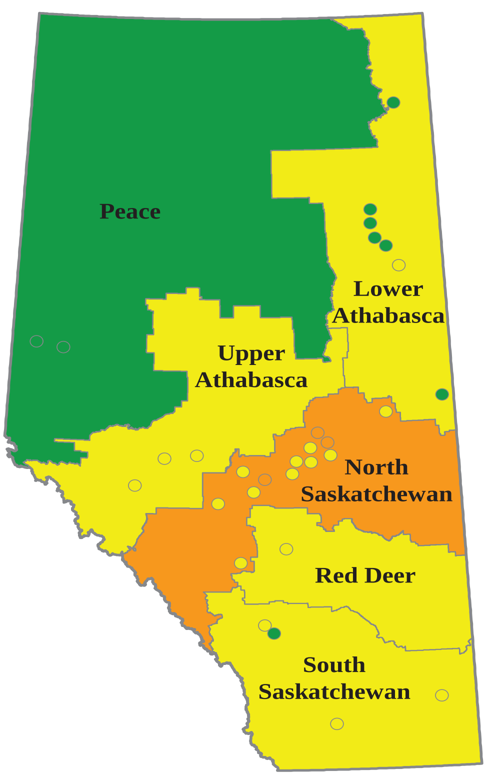


Figure 4 presents the management levels for ozone. All air zones in the province achieved the CAAQS for ozone. All areas of the province were affected by exceptional events, including forest fire influences, transport of upper-tropospheric ozone to ground level, and ozone arriving from outside North America.

After removing these influences, the North Saskatchewan air zone was determined to be in the orange, Actions for Preventing CAAQS Exceedances, management level. This is based on the Lamont County station.

The Lower Athabasca air zone was determined to be in the yellow, Actions for Preventing Air Quality Deterioration, management level, based on the Anzac station. The Upper Athabasca, Red Deer and South Saskatchewan air zones were also assigned to the yellow level, based on the Carrot Creek, Red Deer – Riverside and Calgary Northwest stations, respectively.

The Peace air zone was determined to be in the green, Actions for Keeping Clean Areas Clean, management level.

7.0 Management Actions

Air zones assigned to the red and orange management levels, as outlined in Section 6.0 require the development of management plans to reduce levels of $PM_{2.5}$ and ozone. In the cases of the North Saskatchewan, Red Deer and South Saskatchewan air zones, some management actions have already been initiated, as described below. These plans will require review to ensure that they meet the requirements outlined in the Guidance Document on Air Zone Management. In the cases of the Lower Athabasca and Upper Athabasca air zones, plans for preventing exceedances of the $PM_{2.5}$ CAAQS will need to be developed within two years. These plans may be developed through regional plans, or through local stakeholder groups.

In 2003, the Clean Air Strategic Alliance developed a management framework for $PM_{2.5}$ and ozone, which was adopted by the Government of Alberta as Alberta's implementation of the Canada-wide Standards (CWS) for $PM_{2.5}$ and ozone. Under this framework, action levels were developed which were comparable to the management levels now in place under the CAAQS. As a result of this framework some areas of the province have or are in the process of developing air quality management plans for one or both of $PM_{2.5}$ and ozone.

Following the 2001 to 2003 CWS assessment, stations in and around Edmonton, Red Deer, Calgary, Fort Saskatchewan and West Central Alberta were assigned to a management plan action level, equivalent to the orange CAAQS management level. Stakeholder groups in these areas developed ozone management plans, which were finalized and submitted to Alberta Environment and Parks in 2008. The plan for the Calgary area also included management of $PM_{2.5}$.

More recently, following the 2008 to 2010 CWS assessment, stations in Edmonton exceeded the numerical CWS for $PM_{2.5}$. In the 2009 to 2011 CWS assessment, the Red Deer station exceeded the CWS for $PM_{2.5}$. In response, Alberta Environment and Parks led the development of mandatory plans to reduce particulate matter in both of these areas.

The plan for the Capital Region has been developed, and was finalized in December 2014. The Capital Region Fine Particulate Matter Response, as well as a science report and other documents are available on the department website.

The plan for the Red Deer area is presently in development. More information on the Red Deer Fine Particulate Matter Response is available on the department website.

The Calgary Region Airshed Zone Particulate Matter and Ozone Management Plan from 2008 covers particulate matter. This plan has been reviewed and was updated and submitted by the Calgary Region Airshed Zone to Alberta Environment and Parks to ensure that the standards are not exceeded in future.

Further information about the history of $PM_{2.5}$ and ozone management in Alberta, including links to the ozone management plans previously developed, can be found on the department website.

8.0 Emissions

The following tables provide emissions of selected parameters, by sector and air zone. This is based on the 2008 Alberta Air Emissions Inventory. While these data are a few years old, they represent the best known data, including non-point sources, and small sources.

Table 6 Primary $PM_{2.5}$ Emissions by Sector and Air Zone

Primary $PM_{2.5}$ (tonnes)	Lower Athabasca	North Saskatchewan	Red Deer	South Saskatchewan	Peace	Upper Athabasca	Total
Agriculture	214	5,243	4,353	6,292	1,275	1,268	18,645
Cement and Concrete	26	303	53	642	33	22	1,079
Chemical	0	51	481	59	4	0	594
Construction	4,853	50,342	9,894	54,336	6,326	4,198	129,949
Conventional Oil and Gas*	329	1,241	550	649	1,122	655	4,546
Electrical Power Generation	56	1,821	483	190	102	22	2,674
Fertilizer	0	146	0	73	0	0	219
Oil Sands	3,848	12	0	0	15	0	3,874
Pulp and Paper	0	0	0	0	183	431	614
Road Dust	13,282	56,687	23,406	61,836	25,159	22,964	203,335
Transportation	267	2,934	1,377	3,408	782	496	9,265
Wood Products	0	53	20	19	97	212	401
Other Sources	1,012	1,591	413	1,187	696	581	5,480
Non-Industrial Sources	113	1,552	313	1,753	171	154	4,057
Natural Sources	1,592	7	1	6	469	50	2,125

*Conventional oil and gas includes both upstream and downstream oil and gas.

Table 7 SO_2 Emissions by Sector and Air Zone

SO_2 (tonnes)	Lower Athabasca	North Saskatchewan	Red Deer	South Saskatchewan	Peace	Upper Athabasca	Total
Agriculture	0	0	0	0	0	0	0
Cement and Concrete	0	54	4	1,615	0	0	1,674
Chemical	0	724	8	60	0	0	792
Construction	0	0	0	0	0	0	0
Conventional Oil and Gas*	324	32,416	10,106	30,287	18,146	25,135	116,413
Electrical Power Generation	5	59,367	62,464	14	2,001	1	123,851
Fertilizer	0	1,960	0	0	0	0	1,961
Oil Sands	106,893	7,218	0	0	3,439	0	117,550
Pulp and Paper	0	0	0	0	4,148	2,730	6,879
Road Dust	0	0	0	0	0	0	0
Transportation	101	730	279	913	196	117	2,335
Wood Products	0	56	15	23	23	40	157
Other Sources	162	5,296	61	550	193	198	6,460
Non-Industrial Sources	45	599	122	693	72	57	1,589
Natural Sources	1	0	0	0	0	0	2

SO_2 is sulphur dioxide.
*Conventional oil and gas includes both upstream and downstream oil and gas.

Table 8 NO_X Emissions by Sector and Air Zone

NO_X (tonnes)	Lower Athabasca	North Saskatchewan	Red Deer	South Saskatchewan	Peace	Upper Athabasca	Total
Agriculture	0	0	0	0	0	0	0
Cement and Concrete	0	1,768	4	3,967	0	0	5,740
Chemical	0	2,870	2,660	751	0	0	6,281
Construction	11	115	23	124	14	10	297
Conventional Oil and Gas*	18,601	63,301	62,409	58,846	76,607	48,354	328,117
Electrical Power Generation	1,355	59,069	21,893	5,569	3,996	1,589	93,471
Fertilizer	0	2,166	44	3,535	0	0	5,745
Oil Sands	62,203	680	0	0	172	0	63,055
Pulp and Paper	0	0	0	0	1,981	2,004	3,985
Road Dust	0	0	0	0	0	0	0
Transportation	6,402	69,760	26,916	81,095	15,650	10,331	210,153
Wood Products	0	336	71	98	489	839	1,833
Other Sources	1,651	2,530	110	857	121	282	5,552
Non-Industrial Sources	222	3,032	613	3,431	336	301	7,935
Natural Sources	4,551	2,650	1,322	2,333	10,697	3,218	24,770

NO_X is oxides of nitrogen.
*Conventional oil and gas includes both upstream and downstream oil and gas.

Table 9 VOC Emissions by Sector and Air Zone

VOCs (tonnes)	Lower Athabasca	North Saskatchewan	Red Deer	South Saskatchewan	Peace	Upper Athabasca	Total
Agriculture	831	32,535	27,053	39,113	3,536	7,771	110,839
Cement and Concrete	0	16	4	16	0	0	37
Chemical	0	808	782	20	0	0	1,611
Construction	0	0	0	0	0	0	0
Conventional Oil and Gas*	7,103	65,701	25,423	26,817	39,550	19,078	183,672
Electrical Power Generation	41	560	31	146	53	67	899
Fertilizer	0	278	2	476	0	0	756
Oil Sands	45,900	263	0	0	991	0	47,154
Pulp and Paper	0	0	0	0	401	397	798
Road Dust	0	0	0	0	0	0	0
Transportation	2,079	25,873	6,361	30,280	3,841	2,764	71,199
Wood Products	0	3,224	852	1,313	2,785	3,251	11,425
Other Sources	2,829	17,563	3,357	22,870	2,117	1,660	50,396
Non-Industrial Sources	127	1,732	350	1,957	191	172	4,529
Natural Sources	568,480	378,829	189,090	333,596	1,506,529	457,927	3,434,451

VOCs are volatile organic compounds.
*Conventional oil and gas includes both upstream and downstream oil and gas.

Table 10 NH_3 Emissions by Sector and Air Zone

NH_3 (tonnes)	Lower Athabasca	North Saskatchewan	Red Deer	South Saskatchewan	Peace	Upper Athabasca	Total
Agriculture	757	31,769	25,983	36,550	4,525	6,872	106,456
Cement and Concrete	0	0	0	0	0	0	0
Chemical	0	1	3	2	0	0	6
Construction	0	2	0	2	0	0	5
Conventional Oil and Gas*	221	437	383	404	518	323	2,286
Electrical Power Generation	2	93	6	35	76	3	215
Fertilizer	0	2,831	54	3,439	0	0	6,324
Oil Sands	997	0	0	0	0	0	997
Pulp and Paper	0	0	0	0	165	131	296
Road Dust	0	0	0	0	0	0	0
Transportation	82	1,072	254	1,245	150	111	2,914
Wood Products	0	82	20	34	34	48	219
Other Sources	18	653	49	510	12	7	1,250
Non-Industrial Sources	2	32	6	36	4	3	83
Natural Sources	40	0	0	0	12	1	54

NH_3 is ammonia.
*Conventional oil and gas includes both upstream and downstream oil and gas.

9.0 References

Canadian Council of Ministers of the Environment. (2012). *Guidance Document on Achievement Determination Canadain Ambient Air Quality Standards for Fine Particulate Matter and Ozone.*

US Environmental Protection Agency. (2007). *Review of the National Ambient Air Quality Standards for Ozone: Policy Assessment of Scienctific and Technical Information.*

US Environmental Protection Agency. (2009). *Integrated Science Assessment for Particulate Matter*.

Appendix 1 Demonstrating the Influence of Exceptional Events on $PM_{2.5}$

This appendix provides a brief description and tables outlining the analysis of transboundary flows and exceptional events and the recalculated metrics after removing these influences, demonstrating achievement of the CAAQS. In order to determine the management levels for each station, further analysis was performed in those cases where these stations exceeded thresholds below the CAAQS. This was performed until a 98th percentile value not influenced by TF/EE had been found for the 24-hour metric, and on dates between the annual average and the next lower threshold for the annual average metric. As such, the maps in Section 4.0 should be referred to for the management levels designated for each air zone.

24-Hour CAAQS Analysis

The following tables provide the top 20 dates which contributed to the metric values at those stations which exceeded the 24-hour CAAQS for $PM_{2.5}$. The tables contain two sections with listings of dates and the 24-hour average PM2.5 concentrations recorded on those dates. In the left columns are dates before analysis of TF/EE influences, with the removed dates indicated with a double asterisk (**), while in the right columns are the list of dates which remain after removal of those affected by TF/EE. In both sections, the annual metric values are identified in bold.

For the forest fire smoke events removed at stations in the Lower Athabasca air zone, the weight of evidence analysis considered back-trajectory analysis of air parcel movement and satellite-detected forest fire activity to indicate whether known forest fires were a potential source of $PM_{2.5}$ in the events in question, as well as satellite imagery showing visible smoke plumes, and other indications.

In the case of the windblown dust events removed at the Edmonton East station, eye-witness reporting by station technicians, wind speed and direction data, satellite imagery showing relative positions of the station and the indicated source of dust, the correlation with other measured air quality parameters, and the low likelihood of the activities which generated the dust recurring were factors considered in the decision to remove the two dates.

After removing the forest-fire influenced dates at the stations in the Lower Athabasca air zone and the windblown dust events removed at the Edmonton East station, these stations do not exceed the CAAQS. Therefore, it is demonstrated that if not for the exceptional events, the standard would have been achieved.

Table A-1 Demonstration of TF/EE Analysis at Bertha Ganter Fort McKay

Station:	**Bertha Ganter - Fort McKay (Formerly Fort McKay (WBEA))**											
Air Zone:	**Lower Athabasca**											
	Daily 24hr-$PM_{2.5}$ ($\mu g\ m^{-3}$) Before Removing TF/EE (Identified with **)						Daily 24hr-$PM_{2.5}$ ($\mu g\ m^{-3}$) After removing TF/EE					
Rank	2011		2012		2013		2011		2012		2013	
Highest	May 27	164.4 **	Jul 13	138.3 **	Jul 4	62.1	Nov 7	32.1	Jan 23	42.6	Jul 4	62.1
2nd Highest	May 29	144.5 **	Jul 14	63.3 **	Jul 5	53.0	Nov 8	31.7	Jul 10	28.1	Jul 5	53.0
3rd Highest	May 28	132.1 **	Jul 12	54.7 **	May 27	25.3	Jun 16	26.0	Jul 11	27.7	May 27	25.3
4th Highest	Jun 7	122.1 **	Jun 2	43.0 **	Nov 21	24.8	Sep 13	25.8	Jun 8	27.3	Nov 21	24.8
5th Highest	May 23	86.7 **	Jan 23	42.6	Aug 5	21.8	Jun 28	25.6	Jul 15	26.7	Aug 5	21.8
6th Highest	Jun 8	69.8 **	Jun 1	35.7 **	Nov 12	21.6	Jun 9	22.9	Jul 17	25.3	Nov 12	21.6
7th Highest	**Jun 12**	**59.6 ** **	Jun 3	32.5 **	Jan 26	21.4	**Jun 6**	**22.8**	Jul 9	24.2	Jan 26	21.4
8th Highest	Jun 13	48.9 **	**Aug 22**	**32.5 ** **	**Jan 27**	**19.3**	Dec 21	20.8	**Jul 16**	**23.1**	**Jan 27**	**19.3**
9th Highest	Jun 26	39.9 **	Jul 10	28.1	Aug 6	18.9	Oct 16	20.2	Dec 16	22.3	Aug 6	18.9
10th Highest	Nov 7	32.1	Jul 11	27.7	Dec 16	18.5	May 15	18.3	Jul 21	20.1	Dec 16	18.5
11th Highest	Nov 8	31.7	Jun 8	27.3	Feb 27	16.5	Nov 15	17.8	Aug 21	20.1	Feb 27	16.5
12th Highest	Jun 1	30.9 **	Jul 15	26.7	Aug 9	16.0	Jul 18	17.7	Jan 31	18.5	Aug 9	16.0
13th Highest	Jun 16	26.0	Jul 17	25.3	Feb 26	15.5	Dec 18	16.3	Nov 29	18.3	Feb 26	15.5
14th Highest	Sep 13	25.8	Jul 9	24.2	Dec 17	15.3	Jun 27	16.0	Sep 26	18.0	Dec 17	15.3
15th Highest	Jun 28	25.6	Jul 16	23.1	Jun 5	15.1	Oct 17	15.1	Nov 28	18.0	Jun 5	15.1
16th Highest	Jun 9	22.9	Dec 16	22.3	Aug 8	14.6	Sep 15	14.6	Dec 3	17.5	Aug 8	14.6
17th Highest	Jun 6	22.8	Jul 21	20.1	Jun 24	14.4	Dec 28	14.6	Jul 18	17.1	Jun 24	14.4
18th Highest	Dec 21	20.8	Aug 21	20.1	Jul 6	14.0	Jun 23	14.3	Aug 20	17.0	Jul 6	14.0
19th Highest	Oct 16	20.2	Jan 31	18.5	Jun 4	13.5	Sep 16	14.0	Aug 19	16.8	Jun 4	13.5
20th Highest	May 15	18.3	Nov 29	18.3	Jul 3	13.5	Jul 7	13.6	Jul 8	16.1	Jul 3	13.5
# of Valid Days:	345		358		360		335		351		360	
98P Rank:	7		8		8		7		8		8	
3-Year average:	(59.6+32.5+19.3)/3=37.1						(22.8+23.1+19.3)/3=21.7					
After rounding:	37 - Exceeds CAAQS						22 - Achieves CAAQS					
Note: All TF/EE events for this site in 2011 and 2012 were due to forest fire smoke.												

Table A-2 Demonstration of TF/EE Analysis at CNRL Horizon

Station:	**CNRL Horizon**											
Air Zone:	**Lower Athabasca**											
	Daily 24hr-$PM_{2.5}$ ($\mu g\ m^{-3}$) Before Removing TF/EE (Identified with **)						Daily 24hr-$PM_{2.5}$ ($\mu g\ m^{-3}$) After removing TF/EE					
Rank	2011		2012		2013		2011		2012		2013	
Highest	May 23	190.6 **	Jul 13	117.3 **	Jul 4	115.0	Sep 27	37.3	Jan 22	83.1	Jul 4	115.0
2nd Highest	May 24	175.8 **	Jan 22	83.1	Jul 5	85.5	Jun 2	24.5	Jan 23	70.5	Jul 5	85.5
3rd Highest	Jun 7	132.4 **	Jul 12	71.8 **	Jan 19	26.8	Oct 16	19.1	Jan 21	42.8	Jan 19	26.8
4th Highest	May 19	121.0 **	Jan 23	70.5	Jan 7	26.6	Aug 12	18.5	Jan 24	34.7	Jan 7	26.6
5th Highest	May 16	82.9 **	Jul 14	67.5 **	Aug 24	25.6	Jun 28	18.0	Feb 7	29.1	Aug 24	25.6
6th Highest	Jun 12	72.6 **	Jun 2	47.9 **	Jun 22	21.8	Nov 7	17.9	Jan 15	27.2	Jun 22	21.8
7th Highest	**Jun 8**	**61.0 ** **	Jan 21	42.8	Nov 22	21.4	**Oct 17**	**17.6**	**May 28**	**27.2**	Nov 22	21.4
8th Highest	Jun 15	55.8 **	**Jun 8**	**36.9 ** **	**Aug 6**	**20.9**	Jul 11	17.3	Nov 29	26.7	**Aug 6**	**20.9**
9th Highest	Jun 13	54.6 **	Jun 4	35.1 **	Aug 9	20.2	Sep 8	16.5	Jul 10	26.5	Aug 9	20.2
10th Highest	Jun 1	42.5 **	Jan 24	34.7	Jan 11	19.9	Sep 15	16.4	Jul 11	26.2	Jan 11	19.9
11th Highest	Sep 27	37.3	Jun 3	33.4 **	Jan 21	19.9	Jul 17	15.8	Dec 20	26.0	Jan 21	19.9
12th Highest	Jun 6	31.7 **	Aug 20	31.7 **	Dec 27	19.9	Jun 5	15.6	Jul 15	25.6	Dec 27	19.9
13th Highest	May 15	30.6 **	Feb 7	29.1	Jul 6	19.8	Jul 14	15.2	Aug 21	25.2	Jul 6	19.8
14th Highest	Jun 9	28.5 **	Jan 15	27.2	Jan 23	19.7	Sep 30	15.1	Jan 20	24.3	Jan 23	19.7
15th Highest	Jun 2	24.5	May 28	27.2	Jul 7	19.6	Jun 20	14.8	Feb 10	23.0	Jul 7	19.6
16th Highest	Oct 16	19.1	Nov 29	26.7	Nov 4	19.6	Jul 3	14.8	Jul 9	22.5	Nov 4	19.6
17th Highest	Aug 12	18.5	Jul 10	26.5	Nov 5	19.6	Jun 10	14.7	Jul 16	22.4	Nov 5	19.6
18th Highest	Jun 28	18.0	Jul 11	26.2	Nov 6	19.5	Jun 16	14.6	Jul 17	20.8	Nov 6	19.5
19th Highest	Nov 7	17.9	Dec 20	26.0	Jun 16	18.9	Jun 18	14.4	Jul 25	20.3	Jun 16	18.9
20th Highest	Oct 17	17.6	Jul 15	25.6	Sep 15	18.4	Sep 5	14.3	Jun 1	20.1	Sep 15	18.4
# of Valid Days:	343		353		361		330		345		361	
98P Rank:	7		8		8		7		7		8	
3-Year average:	(61.0+36.9+20.9)/3=39.6						(17.6+27.2+20.9)/3=21.9					
After rounding:	40 - Exceeds CAAQS						22 - Achieves CAAQS					
Note: All TF/EE events for this site in 2011 and 2012 were due to forest fire smoke.												

Table A-3 Demonstration of TF/EE Analysis at Fort McKay South - Syncrude UE1

Station:	**Fort McKay South (Syncrude UE1) (Formerly Syncrude UE1)**											
Air Zone:	**Lower Athabasca**											
	Daily 24hr-$PM_{2.5}$ ($\mu g\ m^{-3}$) Before Removing TF/EE (Identified with **)						Daily 24hr-$PM_{2.5}$ ($\mu g\ m^{-3}$) After removing TF/EE					
Rank	2011		2012		2013		2011		2012		2013	
Highest	May 19	221.4 **	Jul 13	123.3	Jul 4	59.3	Jun 13	27.9	Jul 13	123.3	Jul 4	59.3
2nd Highest	May 20	193.6 **	Jul 12	55.0	Jul 5	53.8	Jun 1	26.7	Jul 12	55.0	Jul 5	53.8
3rd Highest	May 29	138.8 **	Jul 14	51.4	Jan 26	21.0	Jun 2	23.6	Jul 14	51.4	Jan 26	21.0
4th Highest	Jun 14	127.9 **	Jun 2	40.9	Jan 27	18.9	May 15	22.1	Jun 2	40.9	Jan 27	18.9
5th Highest	May 28	123.5 **	Jun 1	30.4	Aug 5	16.9	May 17	21.1	Jun 1	30.4	Aug 5	16.9
6th Highest	Jun 7	83.4 **	Jun 3	29.5	Aug 14	13.4	Jun 6	20.9	Jun 3	29.5	Aug 14	13.4
7th Highest	**Jun 8**	**49.2 ****	Jul 15	27.6	Aug 6	13.2	**May 18**	**20.0**	Jul 15	27.6	Aug 6	13.2
8th Highest	Jun 12	38.2 **	**Jul 11**	**25.0**	**Aug 9**	**13.1**	Jun 16	17.7	**Jul 11**	**25.0**	**Aug 9**	**13.1**
9th Highest	Jun 15	37.7 **	Jun 4	24.0	Feb 26	13.0	Jun 28	17.0	Jun 4	24.0	Feb 26	13.0
10th Highest	Jun 13	27.9	Jul 10	23.6	Aug 8	12.9	Jul 12	16.5	Jul 10	23.6	Aug 8	12.9
11th Highest	Jun 1	26.7	Jul 17	23.2	Nov 6	12.9	Jun 9	14.3	Jul 17	23.2	Nov 6	12.9
12th Highest	Jun 2	23.6	Jan 23	22.7	Jun 16	12.5	Oct 16	13.8	Jan 23	22.7	Jun 16	12.5
13th Highest	May 15	22.1	Jul 9	22.4	Nov 12	12.5	Jun 27	13.0	Jul 9	22.4	Nov 12	12.5
14th Highest	May 17	21.1	Jul 16	22.0	Sep 21	12.2	Jun 23	12.3	Jul 16	22.0	Sep 21	12.2
15th Highest	Jun 6	20.9	Jun 8	20.5	Jul 9	12.0	Sep 15	12.0	Jun 8	20.5	Jul 9	12.0
16th Highest	May 18	20.0	Aug 22	19.0	Aug 24	11.9	May 16	11.8	Aug 22	19.0	Aug 24	11.9
17th Highest	Jun 16	17.7	Dec 3	18.6	May 29	11.8	Jul 11	11.5	Dec 3	18.6	May 29	11.8
18th Highest	Jun 28	17.0	Nov 29	18.5	Jul 8	11.8	Mar 8	10.4	Nov 29	18.5	Jul 8	11.8
19th Highest	Jul 12	16.5	Aug 21	18.2	Feb 27	11.7	Jul 7	10.4	Aug 21	18.2	Feb 27	11.7
20th Highest	Jun 9	14.3	Jan 31	16.2	Mar 27	11.5	Feb 21	10.2	Jan 31	16.2	Mar 27	11.5
# of Valid Days:	341		358		358		332		358		358	
98P Rank:	7		8		8		7		8		8	
3-Year average:	(49.2+25.0+13.1)/3=29.1						(22.8+23.1+19.3)/3=19.4					
After rounding:	29 - Exceeds CAAQS						19 - Achieves CAAQS					
Note: All TF/EE events for this site in 2011 were due to forest fire smoke.												

Table A-4 Demonstration of TF/EE Analysis at Fort McMurray - Athabasca Valley

Station:	**Fort McMurray - Athabasca Valley**											
Air Zone:	**Lower Athabasca**											
	Daily 24hr-$PM_{2.5}$ ($\mu g\ m^{-3}$) Before Removing TF/EE (Identified with **)						Daily 24hr-$PM_{2.5}$ ($\mu g\ m^{-3}$) After removing TF/EE					
Rank	2011		2012		2013		2011		2012		2013	
Highest	May 21	137.1 **	Jul 13	73.3	Jul 5	68.8	Jun 2	28.1	Jul 13	73.3	Jul 5	68.8
2nd Highest	May 19	95.0 **	Jul 12	39.0	Jul 4	33.4	Jun 26	24.0	Jul 12	39.0	Jul 4	33.4
3rd Highest	May 27	94.6 **	Jul 15	36.3	Aug 5	27.9	Jun 12	23.7	Jul 15	36.3	Aug 5	27.9
4th Highest	May 24	91.8 **	Jun 2	33.0	Jan 27	27.8	Jun 9	20.7	Jun 2	33.0	Jan 27	27.8
5th Highest	May 31	86.0 **	Jul 17	23.0	Jan 26	21.7	May 15	19.4	Jul 17	23.0	Jan 26	21.7
6th Highest	May 29	83.0 **	Jun 3	22.9	Nov 12	20.8	Jun 28	18.5	Jun 3	22.9	Nov 12	20.8
7th Highest	**May 30**	**79.9 ****	**Jul 11**	**22.2**	Aug 26	20.0	**Aug 13**	**16.3**	**Jul 11**	**22.2**	Aug 26	20.0
8th Highest	Jun 7	76.0 **	Jun 4	21.8	**Aug 6**	**19.6**	May 22	15.7	Jun 4	21.8	**Aug 6**	**19.6**
9th Highest	Jun 15	65.7 **	Sep 23	20.0	Jun 5	16.4	Dec 3	15.5	Sep 23	20.0	Jun 5	16.4
10th Highest	May 28	57.6 **	Jul 16	19.7	Jan 22	16.0	Jul 18	14.9	Jul 16	19.7	Jan 22	16.0
11th Highest	May 25	56.6 **	Aug 22	18.3	Jun 16	15.0	Nov 7	14.8	Aug 22	18.3	Jun 16	15.0
12th Highest	Jun 14	50.5 **	Feb 4	17.7	Jul 8	15.0	Jun 13	14.5	Feb 4	17.7	Jul 8	15.0
13th Highest	May 26	48.8 **	Jul 9	17.0	Jul 17	14.3	Aug 9	14.4	Jul 9	17.0	Jul 17	14.3
14th Highest	Jun 8	47.2 **	Sep 28	16.6	Jul 18	14.0	Sep 23	13.8	Sep 28	16.6	Jul 18	14.0
15th Highest	May 23	33.3 **	Aug 7	16.4	Jun 24	13.8	Jun 10	13.4	Aug 7	16.4	Jun 24	13.8
16th Highest	Jun 6	33.1 **	Aug 21	16.2	Jul 21	13.8	Nov 6	13.0	Aug 21	16.2	Jul 21	13.8
17th Highest	Jun 1	31.7 **	Aug 20	16.0	Dec 8	13.5	Nov 23	12.9	Aug 20	16.0	Dec 8	13.5
18th Highest	Jun 27	29.5 **	Jul 26	15.2	Jul 9	13.3	Oct 19	12.6	Jul 26	15.2	Jul 9	13.3
19th Highest	Jun 2	28.1	Jul 25	14.4	Jul 7	13.0	Feb 13	12.3	Jul 25	14.4	Jul 7	13.0
20th Highest	Jun 26	24.0	Aug 6	14.3	Oct 14	13.0	May 17	12.3	Aug 6	14.3	Oct 14	13.0
# of Valid Days:	343		348		354		325		348		354	
98P Rank:	7		7		8		7		7		8	
3-Year average:	(79.9+22.2+19.6)/3=40.6						(16.3+22.2+19.6)/3=19.4					
After rounding:	41 - Exceeds CAAQS						19 - Achieves CAAQS					
Note: All TF/EE events for this site in 2011 were due to forest fire smoke.												

Table A-5 Demonstration of TF/EE Analysis at Fort McMurray - Patricia McInnes

Station:	**Fort McMurray - Patricia McInnes**											
Air Zone:	**Lower Athabasca**											
	Daily 24hr-$PM_{2.5}$ ($\mu g\ m^{-3}$) Before Removing TF/EE (Identified with **)						Daily 24hr-$PM_{2.5}$ ($\mu g\ m^{-3}$) After removing TF/EE					
Rank	2011		2012		2013		2011		2012		2013	
Highest	May 31	118.9 **	Jul 13	67.4	Jul 5	62.4	Jun 26	26.7	Jul 13	67.4	Jul 5	62.4
2nd Highest	May 19	115.5 **	Jul 12	50.1	Jul 4	37.0	Jun 12	25.6	Jul 12	50.1	Jul 4	37.0
3rd Highest	May 25	87.5 **	Jul 14	38.3	Aug 5	28.9	Jun 1	21.3	Jul 14	38.3	Aug 5	28.9
4th Highest	May 26	82.2 **	Jun 2	37.6	Jan 26	22.6	Jun 2	17.6	Jun 2	37.6	Jan 26	22.6
5th Highest	May 27	78.7 **	Jul 15	36.9	Aug 6	18.2	Jun 27	17.3	Jul 15	36.9	Aug 6	18.2
6th Highest	May 24	74.2 **	Jul 11	33.8	Aug 26	16.2	Jun 9	14.1	Jul 11	33.8	Aug 26	16.2
7th Highest	**Jun 7**	**64.8 ****	Jul 26	21.0	Jan 27	15.0	**Jun 28**	**14.0**	Jul 26	21.0	Jan 27	15.0
8th Highest	May 28	63.3 **	**Jul 25**	**19.4**	**Nov 12**	**14.4**	May 15	12.9	**Jul 25**	**19.4**	**Nov 12**	**14.4**
9th Highest	Jun 14	55.6 **	Aug 22	18.8	Jun 16	14.0	Jun 13	12.4	Aug 22	18.8	Jun 16	14.0
10th Highest	Jun 8	40.7 **	Jul 16	18.4	Jul 7	13.8	May 17	12.2	Jul 16	18.4	Jul 7	13.8
11th Highest	May 23	31.5 **	Jul 17	17.2	Jul 8	13.1	Jul 18	10.1	Jul 17	17.2	Jul 8	13.1
12th Highest	Jun 6	30.4 **	Jun 3	16.0	May 29	12.5	Nov 6	10.1	Jun 3	16.0	May 29	12.5
13th Highest	Jun 26	26.7	Jun 4	15.5	May 28	12.4	Jun 5	9.9	Jun 4	15.5	May 28	12.4
14th Highest	Jun 12	25.6	Aug 20	15.3	Jul 21	12.3	Aug 13	9.9	Aug 20	15.3	Jul 21	12.3
15th Highest	Jun 1	21.3	Sep 26	14.7	Jun 20	11.9	Dec 9	9.7	Sep 26	14.7	Jun 20	11.9
16th Highest	Jun 2	17.6	Aug 21	14.3	May 30	10.9	Dec 10	9.4	Aug 21	14.3	May 30	10.9
17th Highest	Jun 27	17.3	Jul 10	13.9	Mar 27	10.7	Jul 21	9.0	Jul 10	13.9	Mar 27	10.7
18th Highest	Jun 9	14.1	Jun 1	13.4	Feb 1	10.6	Jun 11	8.9	Jun 1	13.4	Feb 1	10.6
19th Highest	Jun 28	14.0	Sep 28	12.5	May 31	10.2	Jun 23	8.5	Sep 28	12.5	May 31	10.2
20th Highest	May 15	12.9	Jul 9	12.3	Jun 15	10.2	Nov 23	8.5	Jul 9	12.3	Jun 15	10.2
# of Valid Days:	347		356		360		335		356		360	
98P Rank:	7		8		8		7		8		8	
3-Year average:	(64.8+19.4+14.4)/3=32.9						(14.0+19.4+14.4)/3=15.9					
After rounding:	33 - Exceeds CAAQS						16 - Achieves CAAQS					
Note: All TF/EE events for this site in 2011 were due to forest fire smoke.												

Table A-6 Demonstration of TF/EE Analysis at Edmonton East

Station:	**Edmonton East**											
Air Zone:	**North Saskatchewan**											
	Daily 24hr-$PM_{2.5}$ ($\mu g\ m^{-3}$) Before Removing TF/EE (Identified with **)						Daily 24hr-$PM_{2.5}$ ($\mu g\ m^{-3}$) After removing TF/EE					
Rank	2011		2012		2013		2011		2012		2013	
Highest	Jun 27	66.7	Jul 13	63.7	May 21	76.3 **	Jun 27	66.7	Jul 13	63.7	Feb 7	59.8
2nd Highest	Mar 15	41.2	Jul 14	41.4	Feb 7	59.8	Mar 15	41.2	Jul 14	41.4	May 20	56.6
3rd Highest	May 28	32.1	Feb 29	33.6	May 20	56.6	May 28	32.1	Feb 29	33.6	Mar 29	45.9
4th Highest	Mar 13	29.8	Jul 15	30.9	Mar 29	45.9	Mar 13	29.8	Jul 15	30.9	Mar 28	44.8
5th Highest	Jun 26	28.8	Sep 24	25.7	Mar 28	44.8	Jun 26	28.8	Sep 24	25.7	Mar 27	40.9
6th Highest	Mar 14	27.6	Nov 17	25.3	Mar 27	40.9	Mar 14	27.6	Nov 17	25.3	Oct 25	38.2
7th Highest	**Nov 21**	**26.8**	**Sep 23**	**23.5**	May 22	38.5 **	**Nov 21**	**26.8**	**Sep 23**	**23.5**	Mar 26	37.1
8th Highest	Mar 17	25.8	Nov 16	23.5	**Oct 25**	**38.2**	Mar 17	25.8	Nov 16	23.5	**Mar 8**	**32.7**
9th Highest	May 20	23.1	Jun 2	22.4	Mar 26	37.1	May 20	23.1	Jun 2	22.4	Mar 25	32.5
10th Highest	Oct 10	23.1	Nov 27	22.3	Mar 8	32.7	Oct 10	23.1	Nov 27	22.3	Jan 4	32.2
11th Highest	Jun 13	22.2	Dec 6	22.3	Mar 25	32.5	Jun 13	22.2	Dec 6	22.3	Feb 6	29.4
12th Highest	Jun 9	22.1	Aug 20	22.2	Jan 4	32.2	Jun 9	22.1	Aug 20	22.2	Nov 29	27.3
13th Highest	Jan 31	20.8	Aug 28	21.9	Feb 6	29.4	Jan 31	20.8	Aug 28	21.9	Feb 1	23.9
14th Highest	Jun 8	20.8	Nov 19	21.6	Nov 29	27.3	Jun 8	20.8	Nov 19	21.6	Jul 2	23.4
15th Highest	Jun 12	20.7	Sep 25	21.5	Feb 1	23.9	Jun 12	20.7	Sep 25	21.5	Nov 21	23.0
16th Highest	Jan 12	20.5	Feb 28	21.4	Jul 2	23.4	Jan 12	20.5	Feb 28	21.4	May 30	22.8
17th Highest	Mar 28	19.9	Jul 26	20.7	Nov 21	23.0	Mar 28	19.9	Jul 26	20.7	Nov 26	22.3
18th Highest	Apr 2	19.9	Aug 21	20.0	May 30	22.8	Apr 2	19.9	Aug 21	20.0	Jan 27	22.0
19th Highest	Mar 16	19.8	Sep 9	20.0	Nov 26	22.3	Mar 16	19.8	Sep 9	20.0	Aug 16	21.3
20th Highest	Jan 11	19.7	Jul 27	19.9	Jan 27	22.0	Jan 11	19.7	Jul 27	19.9	Feb 28	20.7
# of Valid Days:	336		328		360		335		350		358	
98P Rank:	7		7		8		7		7		8	
3-Year average:	(26.8+23.5+38.2)/3=29.5						(26.8+23.5+38.2)/3=27.7					
After rounding:	30 - Exceeds CAAQS						28 - Achieves CAAQS					
Note: Both TF/EE events for this site in 2013 were due to windblown dust.												

Table A-7 Demonstration of TF/EE Analysis at Red Deer – Riverside

Station:	**Red Deer - Riverside**											
Air Zone:	**Red Deer**											
	Daily 24hr-$PM_{2.5}$ ($\mu g\ m^{-3}$) Before Removing TF/EE (Identified with **)						Daily 24hr-$PM_{2.5}$ ($\mu g\ m^{-3}$) After removing TF/EE					
Rank	2011		2012		2013		2011		2012		2013	
Highest	Mar 8	46.6	Feb 29	33.0	Mar 8	50.1	Mar 8	46.6	Feb 29	33.0	Mar 8	50.1
2nd Highest	Mar 9	44.5	Dec 5	25.2	Feb 6	43.5	Mar 9	44.5	Dec 5	25.2	Feb 6	43.5
3rd Highest	Mar 16	42.8	Nov 25	24.6	Mar 27	41.2	Mar 16	42.8	Nov 25	24.6	Mar 27	41.2
4th Highest	Mar 18	42.4	Jul 13	24.4	Mar 25	41.0	Mar 18	42.4	Jul 13	24.4	Mar 25	41.0
5th Highest	Mar 17	41.8	Dec 20	24.1	Mar 28	37.0	Mar 17	41.8	Dec 20	24.1	Mar 28	37.0
6th Highest	Mar 10	39.6	Dec 6	23.3	Mar 9	36.4	Mar 10	39.6	Dec 6	23.3	Mar 9	36.4
7th Highest	Mar 19	36.8	Dec 27	22.7	**Feb 7**	**34.5**	Mar 19	36.8	Dec 27	22.7	**Feb 7**	**34.5**
8th Highest	**Mar 12**	**34.2**	**Mar 26**	**22.2**	Feb 28	29.8	**Mar 12**	**34.2**	**Mar 26**	**22.2**	Feb 28	29.8
9th Highest	Jan 31	32.6	Feb 28	22.1	Mar 5	29.0	Jan 31	32.6	Feb 28	22.1	Mar 5	29.0
10th Highest	Jun 27	32.1	Dec 13	22.0	Mar 13	27.3	Jun 27	32.1	Dec 13	22.0	Mar 13	27.3
11th Highest	Feb 19	31.6	Dec 7	21.6	Mar 7	26.6	Feb 19	31.6	Dec 7	21.6	Mar 7	26.6
12th Highest	May 28	31.6	Dec 12	21.2	Feb 27	26.5	May 28	31.6	Dec 12	21.2	Feb 27	26.5
13th Highest	Mar 4	31.5	Dec 18	21.2	Jan 4	25.8	Mar 4	31.5	Dec 18	21.2	Jan 4	25.8
14th Highest	Mar 20	31.1	Mar 1	20.7	Feb 20	25.8	Mar 20	31.1	Mar 1	20.7	Feb 20	25.8
15th Highest	Mar 7	29.6	Dec 9	20.4	Mar 10	25.8	Mar 7	29.6	Dec 9	20.4	Mar 10	25.8
16th Highest	Feb 18	27.0	Dec 19	20.4	Mar 29	25.7	Feb 18	27.0	Dec 19	20.4	Mar 29	25.7
17th Highest	Feb 23	26.4	Dec 28	20.4	Jan 22	25.5	Feb 23	26.4	Dec 28	20.4	Jan 22	25.5
18th Highest	Mar 11	26.4	Dec 1	20.0	Jan 24	24.9	Mar 11	26.4	Dec 1	20.0	Jan 24	24.9
19th Highest	Dec 28	26.4	May 16	19.2	Jan 25	24.8	Dec 28	26.4	May 16	19.2	Jan 25	24.8
20th Highest	Feb 20	26.2	Sep 23	19.0	Mar 4	24.3	Feb 20	26.2	Sep 23	19.0	Mar 4	24.3
# of Valid Days:	357		355		343		357		354		343	
98P Rank:	8		8		7		8		8		7	
3-Year average:	(34.2+22.2+34.5)/3=30.3						(34.2+22.2+34.5)/3=30.3					
After rounding:	30 - Exceeds CAAQS						30 - Exceeds CAAQS					
Note: There were no TF/EE Events above the 98th percentile identified in 2011 or 2013												

Annual Average CAAQS Analysis

Table A-8 illustrates the dates removed from the calculation of the annual average $PM_{2.5}$ metric at Edmonton East. As described previously, two windblown dust events were removed in 2013. In each of 2011 and 2012, there were three dates identified as being influenced by forest fire smoke and have been removed from the calculation of the annual average for those years. After removing them, the annual average standard is not exceeded. Therefore, it is demonstrated that if not for the influence of these events, the standard would have been achieved.

Table A-8 Demonstration of TF/EE Analysis at Edmonton for Annual Average Metric

Station:	**Edmonton East**					
Air Zone:	**North Saskatchewan**					
Year		2011		2012		2013
Number of Valid Days		336		328		360
Sum of $PM_{2.5}$ Concentrations (µg m^{-3})		3325.4		3072.8		3969.9
Average		9.9		9.4		11.0
3-Year average:	(9.9+9.4+11.0)/3=10.1 - Exceeds CAAQS					
Dates removed after TF/EE Analysis	Jun 27	66.7	Jul 13	63.7	May 21	76.3
	May 28	32.1	Jul 14	41.4	May 22	38.5
	Jun 26	28.8	Jul 15	30.9		
Adjusted Number of days		333		325		358
Sum of $PM_{2.5}$ Concentrations (µg m^{-3})		3197.8		2936.8		3855.1
Average		9.6		9.0		10.8
3-Year average:	(9.6+9.0+10.8)/3=9.8 - Achieves CAAQS					

Appendix 2 Management Level Assignments at All Stations

Table A-9 **$PM_{2.5}$ and Ozone Management Level Assignments at All Stations, 2011-2013 Assessment Period**

Air Zone	Station	Station Number	$PM_{2.5}$ 24-hour	$PM_{2.5}$ Annual	Ozone 8-Hour
Peace	Beaverlodge	91501	Yellow	Yellow	Green
	Evergreen Park	93001	Yellow	Yellow	-[a]
	Grande Prairie (Henry Pirker)	92001	Yellow	Yellow	Green
	Smoky Heights	94001	Yellow	Green	-[a]
Lower Athabasca	Anzac		Green	Green	Yellow
	Bertha Ganter - Fort McKay	90801	Yellow	Yellow	Green
	CNRL Horizon		Orange	Orange	-[a]
	Cold Lake South	94301	Yellow	Yellow	Green
	Fort Chipewyan	91801	Green	Green	Green
	Fort McKay South (Syncrude UE1)	90806	Yellow	Yellow	Green
	Fort McMurray-Athabasca Valley	90701	Yellow	Yellow	Green
	Fort McMurray-Patricia McInnes	90702	Green	Green	Green
Upper Atha-basca	Carrot Creek	91601	-[a]	-[a]	Yellow
	Edson	92901	Yellow	Green	Yellow
	Hinton	93202	Yellow	Orange	-[a]
	Power	93901	Yellow	Green	-[a]
	Steeper	91701	Green	Green	Yellow
North Saskatchewan	Breton	92601	-[a]	-[a]	Yellow
	Bruderheim	90606	Orange	Orange	Orange
	Caroline	91901	Yellow	Green	Yellow
	Drayton Valley	92801	Yellow	Orange	-[a]
	Edmonton Central	90130	Orange	Orange	Yellow
	Edmonton East	90121	Orange	Orange	Yellow
	Edmonton South	90120	Orange	Orange	Yellow
	Elk Island	91101	Yellow	Yellow	Yellow
	Fort Saskatchewan	90601	Orange	Yellow	Yellow
	Genesee	93101	Green	Green	Orange
	Lamont County	92201	Yellow	Orange	Orange
	St. Lina	94401	Yellow	Yellow	Yellow
	Tomahawk	91301	Green	Green	Yellow
	Violet Grove	91401	-[a]	-[a]	Yellow
Red Deer	Red Deer - Riverside	90302	Red	Red	Yellow
South Saskatc h-ewan	Calgary Central	90228	n/a[b]	n/a[b]	Green
	Calgary Northwest	90222	Orange	Orange	Yellow
	Crescent Heights	90402	Yellow	Orange	Yellow
	Lethbridge	90502	Yellow	Orange	Yellow

a: No assessment is possible as this substance is not monitored at this station.
b: No assessment is possible because only one year is available.
Green, yellow, orange and red correspond to the CAAQS management levels.

APPENDIX 2

FINAL TECHNICAL REPORT: A KNOWLEDGE SYNTHESIS OF NON-POINT SOURCE AIR EMISSIONS AND THEIR POTENTIAL CONTRIBUTION TO AIR QUALITY IN ALBERTA

Clean Air Strategic Alliance

A Knowledge Synthesis of Non-Point Source Air Emissions and their Potential Contribution to Air Quality in Alberta

Final Technical Report to the Non-Point Source Project Team

by the CASA Non-Point Source Technical Task Group

November 2016

This Final Technical Report to the Non-Point Source Project Team is supported by the following supplemental Air Zone Reports which provide detailed summaries of the available information on non-point source emissions and their possible relevance to air quality in the respective Air Zone relative to the Canadian Ambient Air Quality Standards, but does not include any information updates between Fall 2016 and Fall 2017 when the Project Team final report was completed:

- Lower Athabasca Air Zone Report
- Upper Athabasca Air Zone Report
- North Saskatchewan Air Zone Report
- South Saskatchewan Air Zone Report
- Red Deer Air Zone Report
- Peace Air Zone Report

10th Floor, 10035 - 108 Street
Edmonton, AB T5J 3E1
T: 780 427 9793
F: 780 422 3127
E: casa@casahome.org
www.casahome.org

Contents

List of Tables

List of Figures

Acknowledgements

The Technical Task Group would like to thank Alberta Environment and Parks and Alberta Environmental Monitoring, Evaluation and Reporting Agency staff for their assistance in completing this work. Special requests related to ambient monitoring data and information (e.g. related to monitoring methods) were filled through the efforts of Yayne-abeba Aklilu, Andrew Clayton, Janine Ross, Cristen Adams, Maxwell Mazur, and Phoenix Le. The Technical Task Group greatly appreciates the work of Nancy Mackenzie, Bronze Horse Communications, for transforming disparate raw drafts into a coherent report.

Technical Task Group Members

Name	Stakeholder group
Patrick Andersen	West Central Airshed Society/Alberta Airsheds Council (WCAS/AAC)
Randy Angle	Alberta Environmental Network (AEN)
Rhonda Lee Curran	Alberta Environment and Parks (AEP)
Mandeep Dhaliwal	Calgary Region Airshed Zone/Alberta Airsheds Council (CRAZ/AAC)
Ike Edeogu	Alberta Agriculture and Forestry (AAF)
Richard Melick	Alberta Environment and Parks (AEP)
Bob Myrick	Alberta Environment and Parks (AEP)
Koray Onder	Canadian Association of Petroleum Producers (CAPP)
Victoria Pianarosa	Parkland Fuel Corporation
David Spink	Prairie Acid Rain Coalition/ Alberta Environmental Network
Frauke Spurrell	Alberta Environment and Parks (AEP)
Martin Van Olst	Environment and Climate Change Canada (ECCC)
Amanda Stuparyk	Clean Air Strategic Alliance (CASA) Project Manager
Keith Denman	Clean Air Strategic Alliance (CASA) Executive Director

Executive Summary

There are thousands of different sources releasing substances into the air in Alberta, each of which may individually or cumulatively be influencing air quality at ground-level. These sources can vary greatly in size and number and are typically classified as being either "point" or "non-point," depending on the type and nature of the release. Point source emissions are stationary sources responsible for the release of a substance to the atmosphere from a single identifiable source, such as a smokestack, and are generally associated with industrial or commercial facilities. Non-Point source emissions are not considered or classified as having a single point of origin. They are: i) area (e.g. lagoon or tailings ponds, on-road mobile, non-road mobile), ii) volume (e.g. small leaks from pumps, valves, tanks etc. at industrial complexes), iii) line (e.g. railways), or iv) grouped point sources (e.g. household furnaces), and in certain locations and under certain circumstances can have a major influence on air quality.

The CASA Non-Point Source Project is to help address non-point source air emissions contributing to particulate matter ($PM_{2.5}$) and ozone (O_3) in Alberta. As a first step the Project Team, who will ultimately be recommending potential management actions for non-point sources, established a Technical Task Group to synthesize what is known about non-point source emissions and their relative contribution to air quality, particularly for the Alberta air zones in the "red" or "orange" management level under the Canadian Ambient Air Quality Standards (CAAQS) Framework. The Technical Task Group was to focus on non-point sources directly emitting $PM_{2.5}$ and on sources emitting the substances that contribute to the formation of $PM_{2.5}$ as well as O_3 in the atmosphere, including nitrogen oxides (NO_X), sulphur dioxide (SO_2), total hydrocarbons (THC) / non-methane hydrocarbons (NMHC) or volatile organic compounds (VOCs), and ammonia (NH_3). The Technical Task Group's aim was to compile and review relevant available information, agree on a common understanding of non-point sources in Alberta, and recommend potential non-point sources of focus for the Project Team based on their possible contribution to $PM_{2.5}$ and O_3 levels. This report presents the results of the Technical Task Group's work.

Methodology

There are four main tools that are typically used to examine point and non-point sources potentially contributing to and influencing air quality in a given region. These tools are:

1. ambient air quality monitoring,
2. emissions inventories,
3. air quality simulation models, and
4. receptor models.

1. ***Ambient air quality monitoring*** consists of continuous or periodic measurements of atmospheric concentrations of pollutants to understand the amounts and types of substances in the air at ground-level.

2. ***Emissions inventories*** are databases used to identify and quantify the sources, emission rates, and release parameters in a particular area, for a specific period of time.

3. ***Air quality simulation models*** (e.g. dispersion models) link pollutant emissions and the resulting ambient concentrations using meteorological conditions, geophysical features and formulations for atmospheric physics and chemistry and the influence of release characteristics.,

4. ***Receptor models*** are statistical procedures for identifying and quantifying the sources that contribute to measured air quality at a specific location.

The Technical Task Group began its work by identifying, and conducting an initial review of, dozens of available reports and papers on air studies related to non-point sources in Alberta. The next task was an examination of air emission sources, trends, and projections for the entire province, which helped identify several of the largest non-point sources for the province in terms of quantity of emissions. The Technical Task Group also examined provincial ambient monitoring data provided by the Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA).

The Technical Task Group then reviewed the CAAQS assessments for 2011-2013 and associated management levels that had been assigned to each air zone, and conducted a more thorough examination of the available information for each air zone. Reports were prepared for each air zone to summarize the: (1) assessments against the CAAQS; (2) air emissions inventory data; and (3) air modelling and receptor modelling studies carried out for each region.

The culmination of the analysis was the development of a list of provincial and air zone-specific non-point sources identified for further consideration by the Project Team. Various information gaps and uncertainties were also identified, as were several areas for potential future work to help improve the overall understanding of the contribution of non-point sources to air quality issues in the province.

Provincial Emissions and Non-Point Source Overview

There are both industrial and non-industrial non-point air emission sources in Alberta. The contribution of industrial versus non-industrial non-point sources varies by individual pollutant, and is highly influenced by the types of activities associated with the release of each pollutant.

Alberta Environment and Parks prepared a report, a Summary Report on Major Non-Point Air Emission Sources in Alberta (AEP, 2016b), in support of the work of the Non-Point Source Technical Task Group. This AEP report provides an analysis of major non-point sources in Alberta and is the basis for historical emissions trends, emissions projections, and non-point source emission inventories cited below.

Based solely on emissions, ***the major industrial non-point sources in Alberta*** as a whole include: plant fugitive leaks, liquid tailings ponds, mine fleets, mine faces, solid mine tailings, materials storage and handling, non-stationary equipment, space heating, and storage tanks. Based solely on emissions, ***the major non-industrial non-point sources in Alberta*** as a whole include: road dust (unpaved and paved roads), construction (industrial, transportation, municipal, residential, and commercial), agriculture (agricultural animals, fertilizer application, harvesting, tilling, drying, and wind erosion), and transportation (on-road vehicles, off-road vehicles, rail transportation, etc.).

Construction, road dust, and agriculture are the three largest sources of primary $PM_{2.5}$ emissions in Alberta, together accounting for 94% of total anthropogenic $PM_{2.5}$ emissions. Total Alberta anthropogenic $PM_{2.5}$ emissions have generally been increasing over the last 15 years and are projected to continue to increase over the next 20 years. Some of the other large non-point sources of $PM_{2.5}$ emissions in Alberta include: prescribed burning, residential fuel wood combustion, off-road use of diesel, heavy-duty diesel vehicles, and fugitive dust from industrial sites.

In terms of precursors of $PM_{2.5}$ (i.e. NOx, VOCs, NH_3 and SO_2), industrial sources (including both point and non-point) are the largest source of NO_X emissions in Alberta, representing 70% of total anthropogenic emissions. Transportation non-point sources are the second largest source of NO_X emissions in Alberta, representing 28% of anthropogenic emissions. Total Alberta anthropogenic NO_X emissions are estimated to have decreased by 9% over the last 15 years. Alberta's anthropogenic NO_X emissions are projected to continue to remain fairly constant over the next 20 years. Some of the large Alberta non-point sources of NO_X emissions include: off-road use of diesel, heavy-duty diesel vehicles, rail transportation, light-duty gasoline trucks, air transportation, light-duty gasoline vehicles, oil sands mining fleets, industrial non-stationary equipment, and space heating.

Industrial non-point sources are estimated to account for roughly two-thirds of anthropogenic VOC emissions in Alberta, with the conventional oil and gas and oil sands sectors being the dominant sources. Agriculture and transportation sources were the second and third largest sources of anthropogenic VOC emissions. Total Alberta anthropogenic VOC emissions have generally been fairly stable over the last 15 years and are projected to continue to remain fairly constant over the next 20 years. Some of the other large Alberta non-point sources of VOC emissions include: solvent use, light-duty gasoline trucks, off-road use of gasoline, light-duty gasoline vehicles, residential fuel wood combustion, surface coatings, and gas stations.

Agriculture is the largest source of NH_3 emissions in Alberta, representing an estimated 91% of anthropogenic emissions. Total Alberta anthropogenic NH_3 emissions have been fairly stable, increasing only slightly over the last 15 years, and are projected to continue to increase over the next 20 years. Some of the other large Alberta non-point sources of NH_3 emissions include: waste, light-duty gasoline trucks, light-duty gasoline vehicles, heavy-duty diesel vehicles, and industrial plant leaks.

Industrial point sources are responsible for nearly all SO_2 emissions in Alberta. Total Alberta anthropogenic SO_2 emissions have greatly decreased over the last 15 years, and there are conflicting projections about how SO_2 emissions may change in the future. Some of the large Alberta non-point sources of SO_2 emissions include: commercial fuel combustion, rail transportation, and waste management.

Air Zone Summaries

The following summaries represent a very brief synopsis of the Air Zone reports found in the appendix; for more detailed and in-depth information please consult those reports. It is worth noting that the data and information reflected in the Air Zone reports and in the brief summaries here, reflect science and investigations that are ongoing and as such the state of knowledge is continuously changing.

The Lower Athabasca Air Zone is assigned an orange management level for $PM_{2.5}$ and a yellow management level for O_3 for the 2011-2013 assessment period. Based on the available emissions inventory data, the largest potential non-point sources in the Lower Athabasca Air Zone as a whole include: road dust, construction, transportation, and industry (particularly oil sands mining and processing). Due to the concentration of very large oil sands mining operations, there is fairly extensive ambient monitoring carried out in the Lower Athabasca Air Zone. There have also been a significant number of scientific studies carried out to examine the potential impacts of air emission sources on air quality and the environment in the region.

The Upper Athabasca Air Zone is assigned an orange management level for $PM_{2.5}$, and a yellow management level for O_3 for the 2011-2013 assessment period. Based on the available emissions inventory data, the largest non-point sources in the Upper Athabasca Air Zone as a whole include: road dust, construction, transportation, agriculture, and industry (particularly conventional oil and gas). There have been relatively few air and related studies carried out for the Upper Athabasca. The $PM_{2.5}$ issue at the Hinton monitoring station is believed to be a localized issue and a second monitoring station is being used to further understand air quality and air quality influences in the Hinton area.

The North Saskatchewan Air Zone is assigned an orange management level for $PM_{2.5}$, and for O_3 for the 2011-2013 assessment period. Based on the available emissions inventory data, the largest non-point sources in the North Saskatchewan Air Zone as a whole include: road dust, construction, industrial (various sectors), agriculture, and transportation. A Capital Region Particulate Matter Air Modelling Assessment has been carried out to examine the sources contributing to elevated $PM_{2.5}$ concentrations.

The South Saskatchewan Air Zone is assigned the orange management level for $PM_{2.5}$, and is assigned the yellow management level for O_3 for the 2011-2013 assessment period. Based on the available emissions inventory data, the largest non-point sources in the South Saskatchewan Air Zone as a whole are road dust, construction, agriculture, transportation, and industry (various sectors). There have been several studies investigating the contributions of various sources to air quality issues in the South Saskatchewan Air Zone.

The Red Deer Air Zone did not achieve the $PM_{2.5}$ CAAQS, and is therefore in the red management level, and is assigned the yellow management level for O_3 for the 2011-2013 assessment period. Based on the available emissions inventory data, the largest non-point sources in the Red Deer Air Zone as a whole are road dust, construction, agriculture, transportation, and industry (various sectors). However, the more local sources contributing to non-achievement in this air zone are not well understood based on data limitations.

The Peace Air Zone is assigned the yellow management level for $PM_{2.5}$ and the green management level for O_3 for the 2011-2013 assessment period. Based on the available emissions inventory data, the largest non-point sources in the Peace Air Zone as a whole are road dust, construction, agriculture, transportation, and industry (various sectors). As the Peace Air Zone has a relative small population, with fairly dispersed and few large industrial operations, there have been very few studies examining the sources contributing to $PM_{2.5}$ and O_3 concentrations in the region.

Differences between Air Zones

There are a great number of differences between Alberta's air zones in terms of air quality influences and the information that is available to understand and quantify these influences. It is critical to note these differences when attempting to understand and address air quality issues for individual air zones and at the provincial level. Differences between air zones include:

- Differences in the nature and magnitude of the human activities occurring (e.g., population, industrial sectors);
- Differences in the environment (e.g., topographic land-cover, relief and elevation, climate and meteorological conditions);
- Differences in the amounts, types, and purposes of monitoring being carried out; and
- Differences in the amount of information and specific studies available related to emission sources and their influence on air quality.

Natural VOCs and Primary $PM_{2.5}$ Sources

Natural non-point sources (vegetation and soils) account for 95% of total VOC emissions in Alberta. Conversely, anthropogenic dust-related NPS represent about 94% of total primary $PM_{2.5}$ emissions in the province. It should not be simply concluded that managing anthropogenic non-point sources of VOC would have minimal air quality benefits and that managing dust emission would have a major impact on ambient $PM_{2.5}$ levels. $PM_{2.5}$ composition data, which is largely limited to the Lower Athabasca and North Saskatchewan Air Zones, suggest that the precursor emissions are the most relevant in terms of elevated ambient $PM_{2.5}$ levels and that anthropogenic sources of VOCs may be contributing more to secondary $PM_{2.5}$, even though they are emitted in relatively smaller quantities (and are often different species of VOCs) than natural sources. Natural sources of VOCs do contribute to O_3 formation, but the importance of natural versus anthropogenic sources appears to vary greatly by specific rural and urban location.

Gaps and Uncertainties

During the course of its work, the Technical Task Group identified a number of gaps and uncertainties that greatly limit our ability to identify and understand the possible linkages between non-point sources and their impacts on air quality.

Ambient Monitoring – Speciation

A critical information gap is the paucity of $PM_{2.5}$ speciation data with adequate supporting information. Such complete datasets are necessary for the application of a variety of receptor modelling tools. The speciation of emissions from various sources is also needed if receptor modelling is being used to identify the most likely sources from the factors that are generated

Emissions Inventories

Emissions inventories are typically carried out for specific purposes, which may not fully meet the requirements of other projects or assessments that need to be carried out. Emissions inventories are also typically made up of emission values quantified by a variety of different measurement and estimation methods whose accuracy and representativeness can vary greatly.

Air Quality Simulation Models

A large gap exists in the limited resources and capacity to do region-specific and province-wide modelling to account for transport from one air zone to another. There is also the need to carry out refinements and improvements to existing air quality simulation (e.g. dispersion) models to ensure they are being run appropriately for Alberta's unique meteorological conditions and the specific conditions and issues facing individual air zones.

Receptor Modelling

The tools available for receptor modelling (such as those described in Section 2.4) all have inherent uncertainties even under ideal conditions. In practical real-world situations, even larger uncertainties may be present. Our confidence in using receptor modelling to identify the sources contributing to secondary pollutants is much lower than our confidence in using receptor models to identify the sources of primary pollutants.

Atmospheric Profiles

The absence of atmospheric profiles can hinder our ability to interpret data. Wind and temperature profiles are needed for calculations to determine the sources that may be responsible for observed high concentrations of pollutants.

Fugitive Sources and Emissions

Fugitive sources are large emitters of VOCs and primary $PM_{2.5}$ from many industrial operations in Alberta. Because of the difficulties in measuring these non-point sources, there is often high uncertainty around the emission estimates.

Overall Secondary $PM_{2.5}$ and O_3 Formation

There are some fundamental scientific questions that have not been fully answered, in particular:

- How is secondary $PM_{2.5}$ and O_3 being formed near specific individual monitoring stations, for specific air quality incidents?

- What sources and pollutants are contributing to the secondary $PM_{2.5}$ and O_3 formation near specific individual monitoring stations, for specific air quality events?
- What chemical mechanisms are involved near specific individual monitoring stations, for specific air quality events?
- What changes are occurring as an air parcel passes over different sources and land uses near specific individual monitoring stations, for specific air quality events?

Potential Future Work

In order to begin to address the identified gaps and uncertainties, the following potential future work items have been identified.

Ambient Monitoring – Speciation

- Investigate expanding speciation monitoring at monitoring stations seeing elevated concentrations versus the CAAQS, to help better understand contributing point and non-point sources.
- Examine monitoring issues stemming from air monitoring stations originally established for a variety of different purposes, and now being used for purpose of assessing against the CAAQS. The Ambient Monitoring Strategic Plan for Alberta is now several years old, and CASA likely has a role in helping to update this plan, through which the specific monitoring gaps from this project (such as speciation) should be considered.

Emissions Inventories

- Review and assess more recent emissions inventory information that becomes available, to identify any large changes in major point and non-point sources in the various air zones.
- Provide input into future emissions inventory projects being carried out by the Government of Alberta and Environment and Climate Change Canada, to ensure that there are adequate breakdowns of point and non-point sources, and that acceptable measurement and estimation methods are being used to quantify non-point source emissions.

Air Quality Simulation Models

- Encourage more air quality simulation modelling to define the contributions of various sources to secondary pollutant formation.
- Provide input into the planning of provincial and regional modelling projects being carried out by the Government of Alberta, and Environment and Climate Change Canada, to ensure adequate investigation of the science questions.

Receptor Modelling

- Provide input into the development of a Long-term Receptor Modelling Plan. Such a plan should include full speciation of $PM_{2.5}$ and related pollutants, development of emission characterization profiles, application of receptor models, and use of air quality simulation models to quantify secondary pollutant formation from precursor emissions.

Atmospheric Profiles

- Consider monitoring stations at the red management level as prime candidates for enhanced monitoring to aid in the understanding of the atmospheric conditions and substances present in the atmosphere near these stations.
- Use aircraft flights when possible to shed light on these atmospheric profile issues and improve our scientific understanding of what is going on in the atmosphere at specific places in Alberta.

Fugitive Sources and Emissions

- Improve measurement and estimation methods being used for EPEA approval required monitoring of non-point sources. Remote sensing tools, like differential absorption LIDAR (DIAL) and other quantification methods could be applied systematically in the future to enhance the current catalog of fugitive emission rates from various industrial operations.
- Provide input to the Government of Alberta during their development of the new Oil Sands non-point sources Monitoring Chapter of the Air Monitoring Development.

Overall Secondary $PM_{2.5}$ and O_3 Formation

- Examine, and consider management actions for, specific non-point source subcategories within the list of identified major non-point sources (see Tables 7 and 8). In particular, examine the potential management actions for addressing the four categories of non-point sources that are common to all the air zones (transportation, construction, road dust, and agriculture).
- Examine background concentrations, the significance of anthropogenic versus natural sources, and calculated ratios of NO_x/VOC to further understand specific NO_x versus VOC limited areas.
- Review prescribed burning practices in areas where prescribed burning has been identified as a potential contributor to high concentrations of $PM_{2.5}$.
- Examine management actions for some of the anthropogenic non-point sources of VOC emissions that have been identified as a major contributor to secondary $PM_{2.5}$ formation in several air zones.
- Continue to identify additional relevant resources and, when available, use updated versions of the referenced documents and datasets.

Conclusions

Overall, there is **insufficient data** to define with confidence the amount that each non-point source category contributes to secondary pollutant concentrations at the specific monitoring stations seeing elevated concentrations. However, the available information does help to narrow down the number of potentially relevant non-point sources to a more manageable number for further consideration by the Project Team. There are many gaps and uncertainties that cannot be easily or quickly addressed, but several potential future work items have been identified to try to work towards a more complete understanding of how non-point sources may be contributing to air quality issues.

Based on the available information, there are four larger categories of non-point sources common to all air zones as a whole: transportation, construction, road dust, and agriculture. Several region-specific non-point sources have also been identified. The tables below list non-point sources that have been identified for further consideration by the Project Team, and also provide a summary of each air zone's CAAQS management levels with the identified non-point sources. This is intended to assist the Project Team in refining its list of non-point sources to focus on, recognizing our incomplete understanding of non-point sources in relevant sub-regions where "red" or "orange" levels have been registered.

The source(s) contributing to individual air quality episodes will vary based on many factors, including the location of the monitoring station relative to the emission patterns and meteorological conditions. There are no "silver bullets" that will guarantee that elevated $PM_{2.5}$ or O_3 concentrations will be prevented in the future, or that there will be measurable positive impact on air quality at any one station. However, there is sufficient evidence for the Project Team to progress with its work. It is expected that the Project Team will further refine its list of non-point sources using additional criteria.

Non-Point Sources Identified by the Technical Task Group for the Project Team's Consideration

Non-Point Source Category	Description of Non-Point Source	Air Zone Where Non-Point Sources Identified as Relevant	Emissions Identified as Relevant
Transportation	Emissions from on and off-road, rail, air, and marine vehicles and equipment	All Zones	NO_x, VOC
Construction Operations*	Fugitive particulate matter emissions resulting from disturbances on construction sites	All Zones	$PM_{2.5}$
Road Dust	Re-suspension of particulate matter by vehicles travelling on paved and unpaved roads	All Zones	$PM_{2.5}$
Agriculture**	Emissions from agricultural activities, including: manure handling, tilling, wind erosion, fertilizer application, crop harvesting, and crop drying	All Zones except Lower Athabasca	NH_3, VOC, $PM_{2.5}$
Commercial / Residential Heating	Emissions from combustion sources used for space/water heating in residential and commercial establishments, health and educational institutions, and government/public administration facilities	North Saskatchewan	NO_x
Industrial non-point sources***	Emissions from non-point sources at industrial operations from various sectors (oil and gas, chemical, cement, petroleum refining, hydrocarbon storage and transportation, etc.), including: plant fugitive leaks, materials storage and handling, non-stationary equipment, space heating, and storage tanks	All Zones	NO_x, VOC
Oil Sands Specific****	Emissions from non-point sources specific to oil sands mining operations, including: tailings ponds, mine fleets, mine faces, and mining disturbances	Lower Athabasca	NO_x, VOC, $PM_{2.5}$,
Prescribed Burning	Emissions from controlled fires used for land management treatments, specifically land clearing for industrial development in the Lower Athabasca Air Zone	Lower Athabasca	$PM_{2.5}$, VOC, NO_x

*Emissions from construction equipment fuel combustion are captured under the off-road transportation categories.

**Emissions from agricultural equipment fuel combustion are captured under the off-road transportation categories.

***Plant fugitive emissions from oil sands mining operations are captured under the Industrial non-point sources category.

****Emissions from road dust at industrial operations are captured under the road dust category, oil sands specific non-point sources (emissions from tailings ponds, mine faces, mine fleets and mining disturbances) are captured under the Oil Sands Specific category.

Air Zone CAAQS Management Levels and Non-Point Sources Identified by the Technical Task Group for the Project Team's Consideration

Air Zone	$PM_{2.5}$ CAAQS Management Level	O_3 CAAQS Management Level	Identified Non-Point Sources
Lower Athabasca	Orange Management Level	Yellow Management Level	• Oil Sands Specific (NO_X from mine fleets, VOCs from tailings ponds and mines, $PM_{2.5}$ from mining and tailings operations) • Industrial non-point sources (VOC); • Construction ($PM_{2.5}$); and • Prescribed burning for oil sands land development ($PM_{2.5}$).
Upper Athabasca	Orange Management Level	Yellow Management Level	• Industrial non-point sources (VOCs); • Road dust ($PM_{2.5}$); • Agriculture (VOCs, $PM_{2.5}$, NH_3); • Transportation (NO_X, VOCs); and • Construction ($PM_{2.5}$).
North Saskatchewan	Orange Management Level	Orange Management Level	• Transportation (NO_X, $PM_{2.5}$); • Agriculture (NH_3); • Commercial/residential heating ($PM_{2.5}$); and • Industrial non-point sources (VOC).
South Saskatchewan	Orange Management Level	Yellow Management Level	• Road dust ($PM_{2.5}$); • Construction ($PM_{2.5}$); • Transportation (NO_X, VOC); • Industrial non-point sources (VOC); and • Agriculture (NH_3, VOC, NH_3).
Red Deer	Red Management Level	Yellow Management Level	• Road dust ($PM_{2.5}$); • Construction ($PM_{2.5}$); • Agriculture ($PM_{2.5}$, NH_3, VOC); and • Transportation (NO_X, VOC). • Industrial non-point sources (NO_X, VOCs)
Peace	Yellow Management Level	Green Management Level	• Agriculture ($PM_{2.5}$, NH_3); • Construction ($PM_{2.5}$); • Industrial non-point sources (NO_X, VOC, NH_3); • Road Dust ($PM_{2.5}$); and • Transportation (NO_X, VOC).

1 Introduction

The Canadian Ambient Air Quality Standards (CAAQS) are established with the goal of protecting human health and the environment. CAAQS are goals for maximum ambient concentrations of harmful air pollutants and are intended to drive continuous air quality improvement across Canada. The CAAQS are a key part of both the Canadian and Alberta Air Quality Management Systems. Alberta Environment and Parks completed a province-wide assessment of the CAAQS for fine particulate matter ($PM_{2.5}$) and ozone (O_3) for 2011-2013, and assigned ambient air monitoring stations and associated air zones to various CAAQS management levels. Individual air zones in Alberta have been assigned different management levels, requiring that actions be taken to address identified and emerging air quality issues within the specified air zone. These actions will need to include addressing the various types of anthropogenic sources present in Alberta, recognizing both point and non-point sources contribute to cumulative effects.

The CASA Non-Point Source Project is to help address non-point source air emissions contributing to particulate matter $PM_{2.5}$ and O_3 in Alberta. The Project Team will ultimately be recommending potential management actions for non-point sources. As a first step, the Project Team established a Technical Task Group to synthesize what is known about non-point source emissions and their relative contribution to air quality, particularly for the Alberta air zones in the “red” or “orange” management level under the CAAQS Framework. This will help refine the broad list of non-point sources on which to focus the project work.

1.1 Scope of Work

CASA’s Non-Point Source Project Team began its work in November 2015. To assist the team with its pursuit of understanding non-point sources potentially contributing to ambient $PM_{2.5}$ and O_3 levels, a Technical Task Group was established in February 2016.

The Technical Task Group was given the overall task of synthesizing what is known about $PM_{2.5}$ and O_3 sources/formation/composition and the contribution/relevance of related non-point source air emissions to measured air quality, to recommend potential non-point sources of focus for the Project Team’s work. Emphasis was to be on the areas in the orange or red management levels under the CAAQS Framework. (Appendix A provides numerical values for the CAAQS.) Existing information was to be reviewed and interpreted, but there was no expectation that new data would be generated.

The synthesis was to examine four major sources of information:

1. Point and non-point source emission inventories, retrospective trends in emissions for 2000-2014, and emissions forecasting where available;
2. Ambient monitoring data and information for O_3, $PM_{2.5}$, VOCs, THC/NMHC, SO_2, NO_x, and NH_3 (as available) and trends in ambient levels;
3. Air quality modelling studies of O_3 and/or $PM_{2.5}$ and O_3 and $PM_{2.5}$ precursors with a focus on modelling that includes non-point sources, and any relevant studies from similar jurisdictions in the United States if readily-available; and
4. Available receptor modelling studies to identify potential sources contributing to $PM_{2.5}$ and O_3 concentrations in the air zones at the red and orange management levels.

The synthesis was expected to contain:

1. The information above, and any other relevant sources of information identified by the Technical Task Group.
2. A list of all the references and identification of those which are regarded as *key references.*
3. Identification of any relevant limitations/assumptions in the references.
4. Best estimates of the relative and absolute contributions of point and non-point sources of emissions on a provincial scale and regional/sub-regional scale to ambient O_3 and $PM_{2.5}$ levels.
5. The different types of non-point source emissions in terms of potential to influence provincial, regional, or local ambient air quality.
6. Similarities and differences between non-point sources in the areas designated as in the orange or red CAAQS management levels for $PM_{2.5}$ and O_3 and non-point sources in areas that are in the green and yellow levels.
7. Any significant gaps or uncertainties in the available data or information.
   a. An assessment of how critical it is to fill these gaps or address these uncertainties.
   b. Advice on what work, time and financial resources would be required to address the critical gaps or uncertainties.
   c. Advice on ways to proceed if the gaps/uncertainties are not addressed. Potential non-point sources of focus for the non-point sources Project Team based on their possible contribution to $PM_{2.5}$ and O_3 levels.

1.2 Point and Non-Point Sources

There are thousands of different sources releasing substances into the air in Alberta, each of which may be individually and cumulatively influencing air quality at ground-level. These sources can vary greatly in size and are typically classified as being either “point” or “non-point,” depending on the type of release. The Alberta Air Monitoring Directive (AMD) defines a non-point source as “any area, on-road mobile, non-road mobile, volume, line or group of point sources responsible for the release of a substance to the atmosphere which cannot be practically inventoried as separate individual sources or release points because they are too small, too large, too numerous, too geographically dispersed, or because they are non-stationary." The AMD defines a point source (release point) as “a stationary source responsible for the release of a substance to the atmosphere that can be practically traced back to a single identifiable source, such as, but not limited to, a smokestack.”

Non-Point sources are large emitters of many air pollutants and are likely contributing to some of the emerging air quality issues in Alberta. The importance of non-point sources to air management in the province has been highlighted in the Alberta Clean Air Strategy and in Alberta’s responses to the $PM_{2.5}$ and O_3 CAAQS assessments that identified varying levels of management planning being required for specific air zones in the province.

$PM_{2.5}$ in the atmosphere has two difference sources. Primary particulate is emitted directly, while secondary particulate is formed in the atmosphere through reactions of various precursors. Such precursors include nitrogen oxides, sulphur dioxide, ammonia, and volatile organic compounds, which lead to the formation of nitrates, sulphates, and organic aerosols. $PM_{2.5}$ has a very small settling velocity and will remain suspended in the atmosphere for long periods during which it can be transported over large distances.

O_3 is a secondary pollutant formed through photochemical reactions in the atmosphere, primarily with oxides of nitrogen and volatile organic compounds, while other substances can play various roles in its complex chemistry.

1.3 Types of Non-Point Sources

There are many different types of non-point sources present in Alberta, each falling within any one of hundreds of various inventory source categories. However, many non-point sources emit in relatively small amounts and therefore investigation of non-point sources should likely focus mainly on the few larger emitting non-point source categories, while still factoring in emissions from all the smaller sources.

There are both industrial and non-industrial non-point sources emitting to the atmosphere in Alberta. The contribution of industrial versus non-industrial non-point sources varies by individual pollutant, and is highly influenced by the types of activities associated with the release of each pollutant. Appendix C provides definitions for the non-industrial non-point source categories identified in this report.

The major industrial non-point sources in Alberta include:

- plant fugitive leaks;
- liquid tailings ponds;
- mine fleets;
- mine faces;
- solid mine tailings;
- materials storage and handling;
- non-stationary equipment;
- space heating; and
- storage tanks.

The major non-industrial non-point sources in Alberta include:

- road dust (unpaved and paved roads);
- construction (industrial, transportation, municipal, residential, and commercial);
- agriculture (agricultural animals, fertilizer application, harvesting, tilling, and wind erosion); and
- transportation (on-road vehicles, off-road vehicles, rail transportation, etc.).

1.4 Important Considerations

An important consideration when examining non-point sources is the assessment about which non-point sources are actually contributing to air quality issues in a particular region. The largest emission sources of a specific pollutant may not necessarily be the main contributor to a particular air quality issue. Emissions from nearby ground-level sources will have a larger impact on local air quality than will emissions from nearby elevated sources of similar magnitude. The greatest contribution to measured air quality may be from tall stacks or source regions at some distance upwind.

Another important consideration when examining non-point sources and how they relate to a particular air quality issue is whether the issue is resulting from primary (directly emitted) air pollutants or secondary air pollutants that form in the atmosphere as a result of complex reactions and chemical transformations. The primary and secondary precursor emissions from non-point sources should be considered.

The time of year an air quality issue is occurring is also important when examining the contribution of non-point sources, as many non-point sources emit mainly during the non-winter months. Non-Point sources such as road dust, construction and agriculture generally emit at much lower levels during the winter months, as the ground in usually frozen and these activities are minimal or not occurring at all. Other non-point sources may emit more during the colder winter months, as they may be associated with increased need for heating and short distance transportation.

Another consideration when examining the contribution of non-point sources to air quality issues is the zone of influence that may affect an individual monitoring station showing elevated or increasing ambient concentrations. Management of air in Alberta may be conducted on the basis of air zones, but the boundaries of these areas may not actually correspond to the areas influencing specific measured ambient concentrations. The zone of influence on a particular monitoring station may well cross various management boundaries and could also vary depending on the specific pollutant of interest. It is therefore necessary to look not only at the sources within air zones, but potentially at larger, less standardized geographic areas.

2 Methodology

There are four main tools that are typically used to examine the point and non-point sources potentially contributing and influencing air quality in a given region. These tools, which are described in the following subsections, are: ambient air quality monitoring, emissions inventories, air quality simulation models, and receptor models.

The Technical Task Group began its work by gathering and conducting an initial review of dozens of available reports and papers on air studies related to non-point sources in Alberta. The next task was an examination of air emission sources, trends, and projections for the entire province, which helped identify several major non-point sources for Alberta. The Technical Task Group also examined provincial ambient monitoring data provided by the Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA).

As the CAAQS assessments assigned management levels to specific air zones, and many of the studies focused on the specific air zones, a more thorough examination of the available information for each air zone was carried out. Reports were prepared for each air zone to summarize the:

- assessments against the CAAQS;
- relevant ambient air monitoring data;
- air emissions inventory data; and
- air modelling and source apportionment studies carried out.

The six Air Zone Reports are published as Supplements to this report are the:

- Lower Athabasca Air Zone Report;
- Upper Athabasca Air Zone Report;
- North Saskatchewan Air Zone Report;
- South Saskatchewan Air Zone Report;
- Red Deer Air Zone Report; and
- Peace Air Zone Report.

The culmination of the analysis was the development of a list of provincial and air zone-specific non-point sources identified for further consideration by the Project Team. Information gaps and uncertainties, and items of potential future work were identified; when addressed, the resultant findings would help improve the overall understanding of the impact of non-point sources on air quality issues in the province.

2.1 Ambient Monitoring

Ambient air quality monitoring consists of continuous or periodic measurements of atmospheric concentrations of pollutants over relatively long periods to establish trends. Ambient monitoring data alone will not provide source apportionment; however, it can be suggestive of sources, especially if used in conjunction with other information. It is also important to understand that the ground-level measured concentrations will be a combination of primary (directly emitted) $PM_{2.5}$ and secondary (formed in the atmosphere) $PM_{2.5}$ and also O_3 (formed in the atmosphere).

A trend coinciding with the emissions trend of a particular source type may be indicative of the responsible source. High concentration events may be associated with a particular wind direction, which points to the location of the contributing source(s). The trajectory of air parcels arriving at the monitoring station during the episode will also be indicative of the source region and potentially the source type. Some sources are differentiated by the presence of a particular substance or specific ratio between pollutants and these can be used to identify the responsible source types. If a number of monitoring stations experience the same high concentration episode, this may eliminate some sources and suggest the source type responsible.

A description of the methods used for monitoring $PM_{2.5}$ and O_3 in Alberta is provided in Appendix B.

2.2 Emission Inventories

Air emissions inventories are databases used to document and track the sources, emission rates, and release parameters in a particular area, for a specific period of time (typically a year). Emission amounts alone cannot determine which sources are contributing to the measured air quality at any location. Ground-level concentrations are influenced by the height of release, for example, at the point of the maximum ground-level concentration; the magnitude will be reduced from that of an equivalent ground-level release by roughly the inverse square of the release height. However, once primary pollutants become distributed throughout the mixed atmospheric boundary layer, their potential contribution to secondary pollutant formation will be proportional to their emission rate. Although annual totals are provided in the inventory, the emissions may be seasonal and not make a contribution to air quality during the “off-season.” Because air pollution travels long distances, the responsible sources may be far upwind, outside the boundaries of any arbitrary zone boundary.

Many emissions, especially for non-point sources, are not measured, but must be estimated from other available information. Typically, the emissions rate is calculated by multiplying an activity rate by an emission factor. An emission factor is usually derived from a short-term study of the activity referenced. Different investigators may find emission factors differing by 50% or more. There are many variables in short term studies and many different ways of normalizing results for an activity. The US Environmental Protection Agency (EPA) maintains a list of average emission factors known as AP-42; however most of these emission factors were based on studies conducted decades ago often from very small sample sets of varying quality. A 2011 study found emission factor uncertainties ranging from 25% to 92% (Pouliot et al., 2012).

2.3 Air Quality Simulation Modelling

Air quality simulation models (e.g. dispersion models) link pollutant emissions and the resulting ambient concentrations using formulations for atmospheric physics and chemistry and the influence of release characteristics, the underlying geophysical features, and meteorological conditions. They can estimate air quality at various scales and time frames but are demanding in terms of input data and computational power. The contribution of individual source types can be examined by making model runs with only that source or by making model runs with that source turned off (zeroed out).

An air quality simulation model typically consists of three sub-models: meteorological, emissions, and transport-transformation. The meteorological model uses pertinent information to generate meteorological "fields"— wind speed and direction, temperatures, and humidity—that are inputs to the emissions and transport-transformation models. The emissions model calculates emissions from natural and anthropogenic sources. The transport-transformation model contains descriptions of physical changes, chemical reactions, movement, and diffusion. The emissions model component will include formulas for estimating emissions from stationary point, area, on- and off-road mobile, and biogenic emissions. In addition, a geographic information system may be used to organize and manipulate spatially resolved data, and post-processing systems may summarize and display results graphically. Mathematical description of the dynamics of gases and aerosols in the atmosphere is achieved using conservation equations for mass, momentum, and energy. Pollutant transport and transformation is tracked temporally and spatially using the advection-diffusion equation, which describes the time rate of change of concentration due to five processes: (1) advection by the mean wind components, (2) turbulent diffusion, (3) production and destruction through chemical reactions, (4) addition by emission sources, and (5) removal at the surface or by other physical processes.

Each of the component models is subject to uncertainty. Inaccuracies in the emission inventory will be compounded by errors in meteorological conditions and in the representation of physical and chemical processes. Many model performance evaluations have been undertaken. With optimized input data in urban areas, it is possible to estimate peak ozone concentrations within 35% (Seinfeld, 1988). In regional applications with high quality input data the difference between observed and modeled one-hour ozone concentrations range from 20%–35% (Fine, 2003).

2.4 Receptor Modelling

Receptor models are statistical procedures for identifying and quantifying the sources that contribute to measured air quality at a specific location. Since they do not necessarily require emissions, meteorology, or geophysical data to calculate concentrations, they offer an advantage over dispersion models for situations where the sources of a pollutant are difficult or impossible to characterize. Instead, receptor models use the chemical and physical characteristics of gases and particles measured at the monitoring site.

The first such model was a Chemical Mass Balance (CMB). The CMB model finds a solution to linear equations that expresses each receptor chemical concentration as a linear sum of products of source profile abundances and source contributions. The source profile abundances (mass fraction of a chemical or other property in the emissions from each source type) and the receptor concentrations, with appropriate uncertainty estimates, serve as input data to the CMB model. The output consists of the amount contributed by each source type to the total mass and each chemical species.

Receptor modelling evolved in subsequent years culminating in Positive Matrix Factorization (PMF). The PMF model uses species concentrations and uncertainties, and the number of sources to calculate source profiles or fingerprints, source contributions, and source profile uncertainties. The PMF model results are constrained to provide positive source contributions and the uncertainty-weighted difference between the observed and predicted species concentration is minimized.

Receptor models can only identify the source types associated with primary pollutants. Secondary pollutants are identified, but there is no information about the contributing sources of the precursors. Receptor modelling is often limited by the availability of suitably speciated monitoring data and the lack of emission composition profiles for various source types (Hopke, 2016).

3 Provincial Emissions and Non-Point Sources Overview

The Summary Report on Major Non-Point Air Emission Sources in Alberta (AEP, 2016b) provides Alberta Environment and Parks' analysis of major non-point sources in Alberta that was conducted to support the work of the Non-Point Source Technical Task Group. The following subsections are based on the findings of this analysis, and specifically examine the point and non-point sources emitting fine particulate matter and the $PM_{2.5}$ and O_3 precursor substances in Alberta. This includes identification of the largest non-point sources in Alberta, general emission trends since 2000, and whether emissions are projected to increase or decrease in the future. As detailed in the report, several emissions inventory datasets were used to examine the point and non-point sources and emission trends. Emissions projections were done using the Emissions-Economy Model for Canada (E3MC) which are now a few years old, and do not account for the recent declines in economic growth and industrial activity in Alberta.

3.1 Major Sources of Primary $PM_{2.5}$ Emissions

The ten largest sources of primary $PM_{2.5}$ emissions (Table 1) account for 98% of Alberta's $PM_{2.5}$ emissions. Construction, road dust, and agriculture are the three largest sources, together accounting for 94% of total anthropogenic $PM_{2.5}$ emissions. Total Alberta anthropogenic $PM_{2.5}$ emissions have generally been increasing over the last 15 years and are projected to continue to increase over the next 20 years. $PM_{2.5}$ emissions from agricultural sources have been decreasing over the last 15 years, but are projected to increase over the next 20 years. $PM_{2.5}$ emissions from construction sources have been increasing over the past few years and are projected to increase further in the future. Road dust has been increasing over the last 15 years and is projected to continue increasing in the future. Some of the other large non-point sources of $PM_{2.5}$ emissions in Alberta include: prescribed burning, residential fuel wood combustion, off-road use of diesel, heavy-duty diesel vehicles, and fugitive dust from industrial sites.

Table 1. Ten Largest Sources of $PM_{2.5}$ Emissions in Alberta

Rank	Sector Category	2014 $PM_{2.5}$ Emissions (kt)	% of 2014 AB Anthropogenic Total
1	Construction Operations	279.9	42.8
2	Dust from Unpaved Roads	221.7	33.9
3	Agriculture	94.7	14.5
4	Dust from Paved Roads	14.9	2.3
5	Prescribed Burning	8.7	1.3
6	Residential Fuel Wood Combustion	6.6	1.0
7	Upstream Petroleum Industry (Including Oil Sands)	6.2	1.0
8	Off-road Use of Diesel	4.3	0.7
9	Electric Power Generation	2.6	0.4
10	Heavy-duty Diesel Vehicles	2.2	0.3

3.2 *Major Sources of NO_X Emissions*

Industry is the largest point and non-point source of NO_X emissions in Alberta, accounting for 70% of total anthropogenic emissions. Transportation is the second largest source of NO_X emissions in Alberta, representing 28% of anthropogenic emissions. The ten largest individual sources of NO_X (Table 2) account for over 94% of Alberta's emissions. Total Alberta anthropogenic NO_X emissions are estimated to have decreased by 9% over the last 15 years, but have decreased overall. Alberta's anthropogenic NO_X emissions are projected to remain fairly constant over the next 20 years. However, some individual air zones, such as those with oil sands development, may see increases in NO_X emissions associated with additional industrial development. NO_X emissions from transportation sources are estimated to have decreased by 9% over the last 15 years and are projected to remain steady over the next 20 years. Some of the large individual Alberta non-point sources of NO_X emissions include: off-road use of diesel, heavy-duty diesel vehicles, rail transportation, light-duty gasoline trucks, air transportation, light-duty gasoline vehicles, oil sands mining fleets, industrial non-stationary equipment, and space heating.

Table 2. Ten Largest Sources of Emissions of Nitrogen Oxides (NO_x) in Alberta

Rank	Sector Category	2014 AB NO_x Emissions (kt)	% of 2014 AB Anthropogenic Total
1	Upstream Petroleum Industry (Including Oil Sands)	343.3	50.1%
2	Electric Power Generation	82.1	12.0%
3	Off-road Use of Diesel	56.7	8.3%
4	Heavy-duty Diesel Vehicles	51.0	7.4%
5	Rail Transportation	50.9	7.4%
6	Light-duty Gasoline Trucks	17.2	2.5%
7	Chemicals Industry	13.5	2.0%
8	Petroleum Product Transportation and Distribution	10.2	1.5%
9	Air Transportation	9.4	1.4%
10	Light-duty Gasoline Vehicles	8.9	1.3%

3.3 Major Sources of VOC Emissions

VOCs are emitted in large quantities by natural sources (vegetation and soils). In 2011, these biogenic sources accounted for about 85% of total VOC emissions in Alberta. Excluding natural sources, industrial non-point sources account for roughly two thirds of anthropogenic VOC emissions in Alberta, with the conventional oil and gas and oil sands sectors being the dominant sectors. Agriculture and transportation sources were the second and third largest sources of anthropogenic VOC emissions. Of total Alberta anthropogenic VOC emissions in 2014, the ten largest sources (Table 3) accounted for over 94%. Some of the other large Alberta non-point sources of VOC emissions include: solvent use, light-duty gasoline trucks, off-road use of gasoline, light-duty gasoline vehicles, residential fuel wood combustion, surface coatings, and gas stations.

Total Alberta anthropogenic VOC emissions have generally been fairly stable over the last 15 years and are projected to continue to remain fairly constant over the next 20 years. Total Alberta industrial VOC emissions have been fairly constant over the last 15 years and are projected to decrease slightly over the next 20 years. VOCs from agricultural sources decreased slightly between 2000 and 2014, but are projected to increase by 28% between 2015 and 2035. Transportation sources have been decreasing over the last 15 years and are projected to remain nearly constant over the next 20 years.

Table 3. Ten Largest Sources of VOC Emissions in Alberta

Rank	Sector Category	2014 AB VOC Emissions (kt)	% of 2014 AB Anthropogenic Total
1	Upstream Petroleum Industry (Including Oil Sands)	494.1	66.1
2	Agriculture	99.0	13.2
3	General Solvent Use	41.6	5.6
4	Light-duty Gasoline Trucks	13.6	1.8
5	Off-road Use of Gasoline Two-stroke	10.2	1.4
6	Light-duty Gasoline Vehicles	9.1	1.2
7	Residential Fuel Wood Combustion	8.7	1.2
8	Off-road Use of Gasoline Four-stroke	8.6	1.2
9	Surface Coatings	7.5	1.0
10	Refined Petroleum Products Retail	6.6	0.9

3.4 Major Sources of NH_3 Emissions

Agricultural activities are the largest source of NH_3 emissions in Alberta, representing 91% of total anthropogenic emissions. The ten largest individual sources of ammonia emissions in Alberta (Table 4) accounted for over 99% of 2014 Alberta emissions. Some of the other large Alberta non-point sources of NH_3 emissions include: waste, light-duty gasoline trucks, light-day gasoline vehicles, heavy-duty diesel vehicles, and industrial plant leaks. Total Alberta anthropogenic NH_3 emissions have been fairly stable over the last 15 years, increasing only slightly. Agricultural emissions of ammonia have also remained steady over the last 15 years, but are projected to increase over the next 20 years. Industrial NH_3 emissions have been variable over the last 15 years and are projected to increase slowly over the next 20 years.

Table 4. Ten Largest Sources of Ammonia (NH_3) Emissions in Alberta

Rank	Sector Category	2014 AB NH_3 Emissions (kt)	% of 2014 AB Anthropogenic Total
1	Agriculture	131.0	91.6
2	Chemicals Industry	5.6	3.9
3	Upstream Petroleum Industry (Including Oil Sands)	2.5	1.8
4	Waste	0.7	0.5
5	Electric Power Generation	0.7	0.5
6	Light-duty Gasoline Trucks	0.6	0.4
7	Light-duty Gasoline Vehicles	0.4	0.3
8	Pulp and Paper Industry	0.3	0.2
9	Heavy-duty Diesel Vehicles	0.2	0.2
10	Non-Ferrous Mining and Smelting Industry	0.2	0.1

3.5 Major Sources of SO_2 Emissions

Industrial point sources are responsible for nearly all SO_2 emissions in Alberta. Table 5 provides a ranked list of the ten largest Alberta SO_2 emitting sources. The only non-point sources to make the top ten list were commercial fuel combustion, rail transportation, and waste, collectively contributing only 0.5% of emissions. Total Alberta anthropogenic SO_2 emissions have greatly decreased over the last 15 years, and there are conflicting projections about how SO_2 emissions may change in the future.

Table 5. Ten Largest Sources of Sulphur Dioxide (SO_2) Emissions in Alberta

Rank	Sector Category	2014 AB SO_2 Emissions (kt)	% of 2014 AB Anthropogenic Total
1	Upstream Petroleum Industry (including oil sands)	150.9	51.8
2	Electric Power Generation	117.0	40.2
3	Downstream Petroleum Industry	8.0	2.7
4	Chemicals Industry	7.8	2.7
5	Pulp and Paper Industry	4.0	1.4
6	Cement and Concrete Industry	1.1	0.4
7	Commercial Fuel Combustion	0.8	0.3
8	Grain Industries	0.2	0.1
9	Rail Transportation	0.2	0.1
10	Waste	0.2	0.1

4 Alberta Air Zone Summaries

Six Alberta air zones, based on the Guidance Document on Air Zone Management and in alignment with regional Land-use Framework boundaries, have been delineated in Alberta for the purposes of air quality management (Figure 1).

For the Alberta: Air Zones Report 2011-2013 (AEP, 2015a), the province used 33 ambient monitoring stations located in a variety of monitoring environments, including large urban centres, to assess achievement of the CAAQS for $PM_{2.5}$ and O_3. As the CAAQS assessments and management levels were assigned to specific air zones, and many of the available air quality and emission studies focused on specific air zones, the Technical Task Group conducted a more thorough examination of the available information for each air zone. The Technical Task Group prepared Air Zone Summary Reports for each air zone to describe the: (1) assessments against the CAAQS; (2) air emissions inventory data; and (3) air modelling and receptor modelling studies carried out for each air zone.

This Final Technical Report to the Non-Point Source Project Team is therefore supported by the following supplemental Air Zone Reports, while this section of the report provides summaries of each report.

- Lower Athabasca Air Zone Report
- Upper Athabasca Air Zone Report
- North Saskatchewan Air Zone Report
- South Saskatchewan Air Zone Report
- Red Deer Air Zone Report
- Peace Air Zone Report

Figure 1: Alberta's Six Air Zones and the Locations of Ambient Stations used for CAAQS Reporting

4.1 Lower Athabasca Air Zone

4.1.1 Assessments against the CAAQS

The Alberta: Air Zones Report 2011-2013 summarizes the CAAQS achievement status and management levels for the Lower Athabasca Air Zone for $PM_{2.5}$ and O_3 monitoring results. Eight stations in the Lower Athabasca Air Zone were used in the 2011 to 2013 assessment for $PM_{2.5}$ and 7 stations for O_3. These stations are located within communities or in areas accessed by members of the public. Figure 2 provides a map of the ambient monitoring stations in the Lower Athabasca Air Zone used in the 2011-2013 CAAQS assessment.

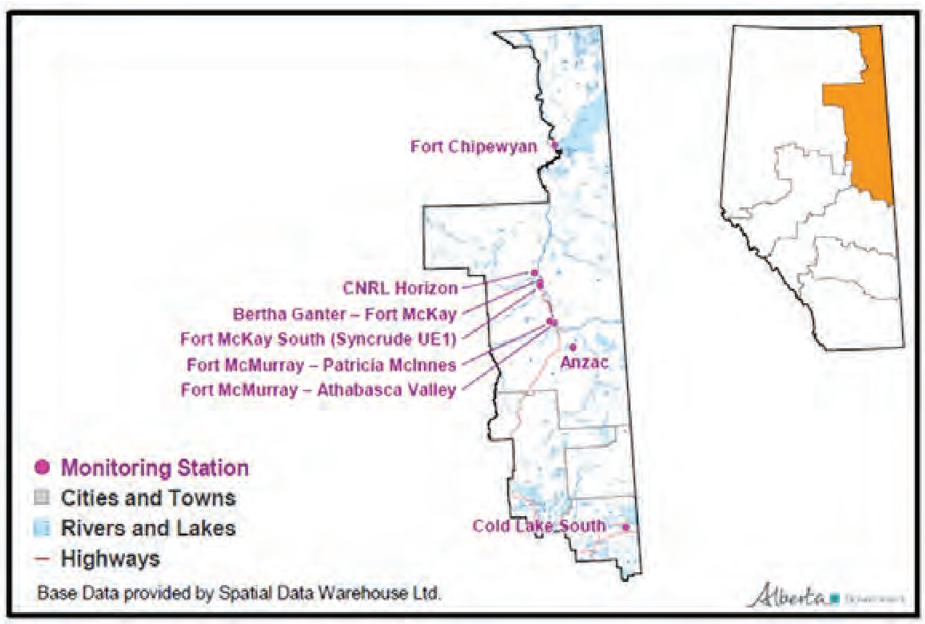


Figure 2. Ambient Monitoring Stations in the Lower Athabasca Air Zone used to Assess Air Zone Status Relative to the CAAQS

The Alberta: Air Zones Report 2011-2013 assigned the CNRL Horizon air monitoring station and the Lower Athabasca Air Zone to the CAAQS orange management level, based on the 3 year average of the 98th Percentile 24-Hour Average and the 3 year average of the annual average.). This management level indicates that $PM_{2.5}$ concentrations are approaching the highest level of CAAQS and proactive actions are needed to prevent exceedance. All other stations in the Lower Athabasca Air Zone were assigned lower management levels.

A review and assessment of: point and non-point source emissions; ambient air quality data; air quality studies; and air quality modelling studies was undertaken to determine the possible relevance of non-point sources to $PM_{2.5}$ and O_3 levels in the Lower Athabasca Air Zone, in general, and to $PM_{2.5}$ levels at the CNRL Horizon station, in particular. The following is a summary of the key findings and recommendations/advice from this review and assessment.

4.1.2 Non-Point Emission Sources and Emissions Inventories

4.1.2.1 Non-Point Sources

The following categories and sub-categories of non-point sources associated with industrial and non-industrial development in the Lower Athabasca Air Zone were evaluated and emission estimates for these sources reviewed.

Industrial

- Mine faces;
- Mine fleets;
- Industrial activity-related dust sources e.g., mining and haul road activities;
- Prescribed burning;
- Tailings ponds; and
- Plant facilities e.g., integrated extraction and upgrading facilities, extraction plants, in-situ plants, gas processing plants, and others (e.g., terminals).

Non-Industrial

- Residential heating;
- Road dust (unpaved and paved roads);
- Construction (industrial, transportation, municipal, residential, and commercial);
- Agriculture (agricultural animals, fertilizer application, harvesting, tilling, and wind erosion);
- Transportation (on-road vehicles, off-road vehicles, rail transportation); and
- Natural sources (e.g., biogenic VOC emissions).

4.1.2.2 Non-Point Source Emissions Inventories

Lower Athabasca emission inventories, and their uses and limitations, have been discussed in a number of reports and presentations with the general conclusion being that emission estimates for most sources are subject to variability and uncertainty, and are in large part based on professional judgement and emission factors that often have had limited validation. There is no "formal" officially recognized emission inventory for the Lower Athabasca Air Zone, and a number of emission inventories have been developed, generally, to support Environmental Impact Assessment (EIA)-related modelling or focused assessments. Inventories from the Government of Alberta and the Cumulative Environmental Management Association (CEMA) were assessed. The substances examined were particulates directly emitted, and nitrogen oxides (NO_x), volatile organic compounds (VOC), sulphur dioxide (SO_2) and carbon monoxide (CO), all of which can contribute to secondary $PM_{2.5}$ formation and/or O_3 formation. Ammonia (NH_3) is also a potentially important contributor to secondary $PM_{2.5}$ formation, but there is limited information on NH_3 sources and emission amounts for the Lower Athabasca Air Zone.

The available emission inventory data and predicted trends in air zone emissions provide the following information relevant to assessing the possible non-point sources of interest in terms of air quality impacts in the Lower Athabasca Air Zone.

- **VOCs** – anthropogenic VOC sources are largely associated with non-point sources and represent ~85-95% of Lower Athabasca Air Zone anthropogenic VOC emissions. These emissions are expected to increase. The major emission sources of VOCs in the Lower Athabasca Air Zone are however biogenic, and the significance of anthropogenic VOC emissions as $PM_{2.5}$ and O_3 precursors needs to be assessed to determine if management of anthropogenic non-point source VOC emissions would significantly impact regional $PM_{2.5}$ and O_3 levels.

- **NO_x** – non-point sources represent ~35-40% of Lower Athabasca Air Zone NO_x emissions with approximately 80% of these emissions associated with oil sands mining fleets, and approximately 20% associated with highway and community traffic and community heating. Emissions from these sources are expected to increase.
- **SO_2** – These emissions are almost exclusively from stack sources. Non-Point source contribution to Lower Athabasca Air Zone SO_2 emissions is negligible at approximately 1%.
- **Primary $PM_{2.5}$** – non-point sources represent ~25-33% of primary $PM_{2.5}$ emissions in the Lower Athabasca Air Zone with 67% of these emissions from the oil sands and 33% from highway and community traffic and community heating. However, these figures, which are largely based on the CEMA (2015) inventory, do not include primary $PM_{2.5}$ emissions associated with road dust and construction activities which, based on the Government of Alberta estimates, represent approximately 75% of total Lower Athabasca Air Zone primary particulate emissions. (Primary $PM_{2.5}$ levels are predicted to decline.)

4.1.3 Assessment and Highlights

The Lower Athabasca Air Zone is unique in that its air quality is heavily influenced by oil sands development-related air emissions, which occur throughout the air zone, but are concentrated in the area north of Fort McMurray. Unlike the situation in other provincial air zones, the air monitoring station in the Lower Athabasca Air Zone that triggered the orange management level is distant from a large urban centre.

The CAAQS determination for the period 2011-2013 for stations in the Lower Athabasca Air Zone indicate that several stations in the region are, in some years, close to the $PM_{2.5}$-24 hour orange management level of 19 $\mu g/m^3$ and in some years have been above the annual orange management level threshold value of 6.4 $\mu g/m^3$. The stations with these orange management levels and higher yellow levels span the Lower Athabasca Air Zone, e.g., Cold Lake, Fort McMurray, and Fort McKay/CNRL Horizon, indicating that $PM_{2.5}$ may be a an issue for much of the air zone, rather than just an localized issue near an individual monitoring station. The Lower Athabasca Air Zone levels for ozone, unlike those for $PM_{2.5}$, are almost entirely within the green management level. This indicates that the focus of regional non-point source management efforts should be on primary $PM_{2.5}$ and secondary $PM_{2.5}$ precursors.

Oil sands non-point source emissions are a major source of primary particulate emissions, and emissions of ozone and secondary particulate emissions precursors.

The large amount of oil sands activity in the Lower Athabasca Air Zone has resulted in an extensive and relatively comprehensive air monitoring program in the Regional Municipality of Wood Buffalo (RMWB). This program is operated by the Wood Buffalo Environmental Association (WBEA), which also manages numerous other monitoring programs, and conducts many focused studies on emissions and their impact on air quality, including air quality trending and forecasting. The Joint Federal/Provincial Oil Sands Monitoring Program (JOSM) also has an extensive air quality monitoring plan. Collectively, these monitoring programs and studies provide insights into the potential significance of various non-point sources on air quality in the Lower Athabasca Air Zone and possible priorities in terms of managing air quality in the air zone relative to the CAAQS.

4.1.4 Key Findings

Based on the review of the information from the above sources related to possible considerations and management of non-point sources in the Lower Athabasca Air Zone in relation to improving air quality, as determined under the CAAQS Framework, the following are the key findings:

1. While there is considerable emission and air quality information available for the Lower Athabasca Air Zone, there are considerable gaps and/or uncertainties in much of the information that complicates relating emission sources to resultant air quality impacts.
2. Relative to the CAAQS management levels, current regional $PM_{2.5}$ levels are higher than O_3 levels.
3. Air quality modelling indicates that regional $PM_{2.5}$ levels and O_3 levels are likely to increase under current planned development scenarios with $PM_{2.5}$ level increases greater than O_3 level increases relative to the current CAAQS levels for $PM_{2.5}$ and O_3.
4. Non-Point sources associated with oil sands development have a major influence on regional $PM_{2.5}$ and O_3 levels.
5. Considerable air quality and emission monitoring work in the region is underway and/or planned which, with some enhancements or modifications, represents an opportunity to help inform and guide future CAAQS-related air quality management plans and strategies.
6. There appear to be opportunities to reduce emissions and/or enhance management of certain non-point sources that are relevant to improving air quality as measured by the CAAQS.

4.1.5 Conclusions

Based on the available emissions inventory information, there are several major industrial non-point sources in the Lower Athabasca Air Zone that may warrant consideration when responding to CAAQS and other air quality issues. These industrial non-point sources are:

- mine fleets (NO_x emissions);
- tailings ponds and mines (VOC emissions);
- plant fugitive emissions (VOC emissions);
- mining and tailings operations (primary $PM_{2.5}$ emissions i.e., dust);
- construction activities (primary $PM_{2.5}$ emissions i.e., dust); and
- oil sands related prescribed burning (primary $PM_{2.5}$ emissions i.e., smoke).

The following is a summary of some additional conclusions from the review:

1. $PM_{2.5}$ levels in the Lower Athabasca Air Zone are a much higher management priority than O_3 based on both monitoring and modelling of current and future development scenarios. On-road transportation in terms of primary $PM_{2.5}$ emissions (dust) is a non-industrial non-point sources that that may warrant consideration in relation to CAAQS $PM_{2.5}$ management actions.
2. Of the anthropogenic non-point sources emissions, VOCs and primary $PM_{2.5}$ emissions (dust and smoke) appear to be the largest contributors to $PM_{2.5}$ levels.
3. All of the anthropogenic non-point sources may contribute to ambient $PM_{2.5}$ and therefore warrant consideration for enhanced management.
4. In terms of regional O_3 formation, anthropogenic non-point sources of NO_x are the most relevant although secondary to point NO_x emission sources.

5. There is limited $PM_{2.5}$ composition data, which hinders developing a full understanding of the sources and factors contributing to the $PM_{2.5}$ levels being measured in the region. This information is essential to the development of $PM_{2.5}$ air quality management strategies.
6. There is considerable uncertainty regarding the magnitude and character of most anthropogenic non-point sources in the Lower Athabasca Air Zone with emerging information indicating that non-point source emissions are higher than previously estimated. Better emission information is necessary to help identify priority emission sources for enhanced management in relation to the CAAQS.
7. Air quality modelling indicates that point and non-point sources are important to regional $PM_{2.5}$ levels. This modelling provides insights into possible source management priorities and such modelling should be further developed and used as part of CAAQS related management plans.
8. There appear to be opportunities to improve or advance management and reduction of certain anthropogenic non-point sources such as dust, smoke, and mine fleet emissions, but for other sources such as VOC emissions from mines, management may be difficult and/or challenging.
9. Monitoring and modelling of NO_2 would indicate that NO_2 levels are increasing and will increase further under planned regional development scenarios. Since CAAQS for NO_2 are currently being developed, proactive management of regional NO_x sources should be considered.

The review report provides the context and basis for the above conclusions as well as specific advice and recommendations related to:

- further emission quantification and characterization work to address information gaps;
- additional ambient air quality and $PM_{2.5}$ speciation sampling that would provide the information necessary to better identify and assess the sources and/or source types contributing to elevated $PM_{2.5}$ levels in the Lower Athabasca Air Zone;
- improving and using air quality modelling to better understand the spatial and temporal effects of existing and planned emissions on regional air quality;
- further analysis of existing datasets and new and/or existing air quality monitoring programs that should be supported.

In summary, opportunities appear to exist in the Lower Athabasca Air Zone for improved:
- air quality monitoring and studies;
- emissions monitoring and characterization;
- air dispersion and quality modelling; and
- non-point sources management.

These efforts would collectively result in a better understanding of the contribution of non-point sources to ambient $PM_{2.5}$ and O_3 levels. This understanding would assist in focussing specific non-point sources emission management enhancements to maximize their benefits in terms of improving overall regional air quality and in particular reducing regional $PM_{2.5}$ and O_3 levels in the Lower Athabasca Air Zone.

4.2 Upper Athabasca Air Zone

4.2.1 Assessments against the CAAQS

The Alberta: Air Zones Report 2011-2013 (AEP, 2015a) summarized the CAAQS Achievement Status and air zone management level for each air zone in Alberta. Concentrations of criteria air contaminants at five ambient air monitoring stations in the Upper Athabasca Air Zone were used for the assessment.

These stations are located within communities or in areas accessed by members of the public. Figure 3 provides a map of the ambient monitoring stations in the Upper Athabasca Air Zone used in the 2011-2013 CAAQS assessment.

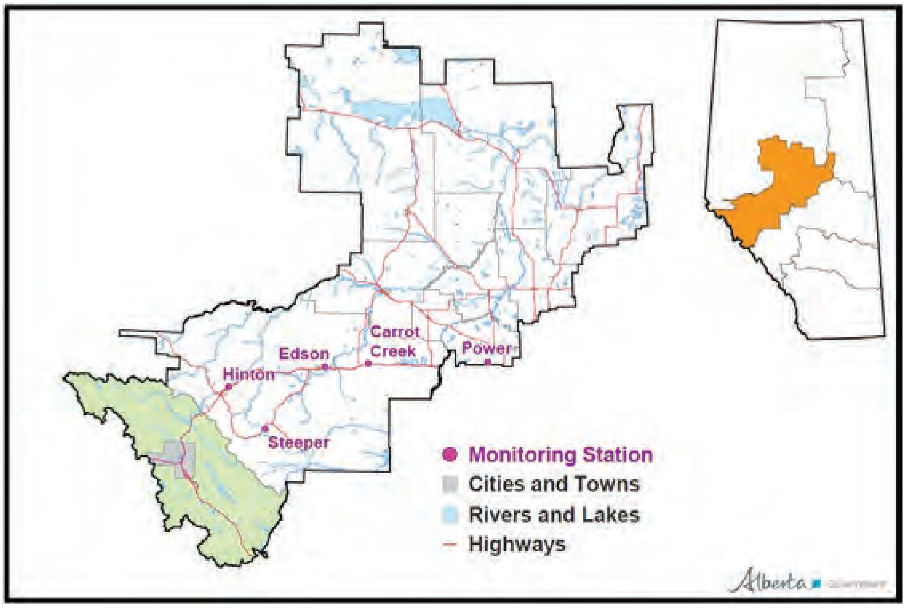


Figure 3. Ambient Air Monitoring Stations in the Upper Athabasca Air Zone used to Assess Air Zone Status Relative to the CAAQS

One station—the Hinton monitoring station—was assigned the orange management level for $PM_{2.5}$, Actions for Preventing CAAQS Exceedance. The other stations in the zone were assigned to lower management levels. As such, the Upper Athabasca Air Zone was assigned the orange management level for $PM_{2.5}$. This management level indicates that $PM_{2.5}$ concentrations are approaching CAAQS and proactive action is needed to prevent exceedance.

All stations were assigned the yellow management level for ozone. As such, the Upper Athabasca Air Zone was assigned the yellow management level for ozone, Actions for Preventing Air Quality Deterioration. This management level calls for improvement to air quality using early and ongoing actions for continuous improvement.

4.2.2 Non-Point Emission Sources and Emissions Inventories

The *Alberta: Air Zone Report 2011-2013* (AEP 2015a), in addition to assessing the status of air zones relative to the CAAQS, also provided emission inventory data by sector and region for primary $PM_{2.5}$, NO_x, SO_2, and NH_3. The inventory is based on the 2008 Alberta Air Emissions Inventory. Based on the available emissions inventory data, the largest non-point sources in the Upper Athabasca Air Zone include: road dust, construction, transportation, agriculture, and industry (particularly conventional oil and gas).

4.2.3 Assessment and Regional Highlights

The total emissions for the Upper Athabasca Air Zone ($PM_{2.5}$, SO_2, NO_x, VOCs, and NH_3) are comparable to that of the Peace Air Zone and anywhere from a third to a half of that from the other more populated air zones. The emissions trend for the past 14 years has been insignificant for all non-point sources.

Generally, the Upper Athabasca Air Zone is expected to remain in the green to yellow level for both $PM_{2.5}$ and O_3. Assuming the Upper Athabasca Air Zone follows the projected provincial trend in population and industrial growth, $PM_{2.5}$ (road dust), and NH_3 (agriculture) are also projected to rise over the next 20 years and there may be more occurrences of CAAQS non-attainment at the orange level for both $PM_{2.5}$ and O_3.

Topography and meteorology are significant factors in elevated $PM_{2.5}$ levels in Hinton as the monitoring station is situated in the town site, which is located in the Athabasca River Valley. However, there are concerns that the station is not representative of the Upper Athabasca Air Zone. The monitoring station is located in an industrial area of Hinton near a settling pond, gravel road, and other sources of particulate matter. The West Central Airshed Society will install a second monitoring station in Hinton by the end of 2016 and will compare the results of the two stations, once a requisite amount of data has been obtained.

4.2.4 Conclusions

Based on the available emissions inventory data, the largest anthropogenic sources of $PM_{2.5}$ and precursor emissions in the Upper Athabasca Air Zone are:

- conventional oil and gas (NO_x, VOCs);
- road dust ($PM_{2.5}$);
- agriculture (VOCs, $PM_{2.5}$, NH_3);
- transportation (NO_x, VOCs); and
- construction ($PM_{2.5}$).

These are the main contributors to anthropogenic non-point sources and are also the most likely sources to increase over the next two decades at the provincial level.

Based on the available information, there are a couple of non-industrial non-point sources in the Upper Athabasca Air Zone that may warrant consideration when responding to CAAQS and other air quality issues. These non-industrial sources include: transportation (on-road and off-road) and agriculture.

4.3 North Saskatchewan Air Zone

4.3.1 Assessments against the CAAQS

The Alberta: Air Zones Report 2011-2013 (AEP, 2015a) summarized the CAAQS Achievement Status and air zone management level for each air zone in Alberta. Fourteen ambient air monitoring stations located in the North Saskatchewan Air Zone were used in the 2011-2013 CAAQS assessment. These stations are located within communities or in areas accessed by members of the public. Figure 4 provides a map of the ambient monitoring stations in the North Saskatchewan Air Zone used in the 2011-2013 CAAQS assessment.

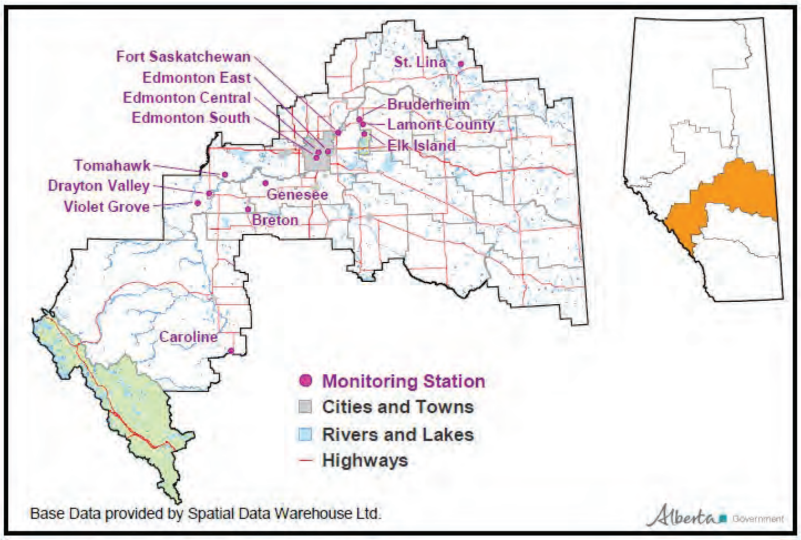


Figure 4. Ambient Air Monitoring Stations in the North Saskatchewan Air Zone used to Assess Air Zone Status Relative to the CAAQS

Based on the 2011-2013 CAAQS assessment, several stations were assigned the orange management level for $PM_{2.5}$, Actions for Preventing CAAQS Exceedance. This included: the Edmonton Central, Edmonton East, and Edmonton South stations, as well as the Bruderheim, Drayton Valley, Fort Saskatchewan, and Lamont County stations. All other stations in the North Saskatchewan Air Zone were assigned lower management levels. As there were stations in the orange management level, the entire North Saskatchewan Air Zone was assigned the orange management level for $PM_{2.5}$. This management level indicates that $PM_{2.5}$ concentrations are approaching the CAAQS and proactive action is needed to prevent exceedance.

Based on the 2011-2013 CAAQS assessment, several stations were assigned the orange management level for O_3, as concentrations are approaching the CAAQS. This included: the Bruderheim, Lamont County, and Genesee stations. All other stations in the North Saskatchewan Air Zone were assigned lower management levels. As there were stations in the orange management level, the entire North Saskatchewan Air Zone was assigned the orange management level for O_3 and proactive action is needed to prevent exceedance of the standard.

4.3.2 Non-Point Emission Sources and Emissions Inventories

The Alberta: Air Zone Report 2011-2013 (AEP 2015a), in addition to assessing the status of air zones relative to the CAAQS, also provided emission inventory data by sector and region for primary PM, NO_x, SO_2, and NH_3. The inventory is based on the 2008 Alberta Air Emissions Inventory. Based on the available emissions inventory data, the largest non-point sources in the North Saskatchewan Air Zone include: road dust, construction, industrial (various sectors), agriculture, and transportation.

4.3.3 Assessment and Highlights

Examining the preliminary 2001 to 2015 annual mean concentrations for $PM_{2.5}$ and O_3 identified that there were no significant increasing or decreasing trends for annual mean $PM_{2.5}$ concentrations at monitoring stations within the North Saskatchewan Air Zone. During this period, there were notable changes to $PM_{2.5}$ monitoring technology (see Appendix B) that drastically improved capture of some

$PM_{2.5}$ species. However, the Edmonton Central monitoring station showed an increasing trend in annual mean O_3 concentrations, while the Breton, Genesee, Steeper, and Violet Grove monitoring stations showed decreasing trends in annual mean O_3 concentrations.

Road dust and construction sources were responsible for the largest portions of primary $PM_{2.5}$ emissions in the North Saskatchewan Air Zone. Transportation, electric power generation, and conventional oil and gas were the largest sources of NO_x emissions. Electric power generation, conventional oil and gas, petroleum refining, and oil sands upgrading were the largest sources of SO_2 emissions. Conventional oil and gas, agriculture, transportation, petroleum refining, and bulk storage terminals were the largest sources of VOC emissions. Agricultural sources were the dominant emitting source of NH_3 in the North Saskatchewan Air Zone, followed by industrial sources.

Non-Point sources were responsible for ~95% of industrial VOC emissions in the North Saskatchewan Air Zone. Point sources were the major source of industrial $PM_{2.5}$, NO_x, SO_2, and NH_3 emissions. The largest industrial non-point sources of VOC emissions were plant fugitives, storage and handling, and spills, and accidental releases. The largest industrial non-point sources of $PM_{2.5}$ emissions were fugitive dust sources and the storage and handling of on-site materials. The largest industrial non-point sources of NO_x and SO_2 emissions were space heating and non-stationary equipment. The largest industrial non-point sources of NH_3 emissions were plant fugitive leaks and storage tanks.

Examining the preliminary 1985 to 2013 total annual anthropogenic emissions time series within the North Saskatchewan Air Zone identified that primary $PM_{2.5}$ emissions from combined major sources increased between 1985 and 2013, driven mainly by increases from road dust and construction sources. Emissions of many of the secondary $PM_{2.5}$ and O_3 precursors showed a mix of decreasing and increasing emissions. NO_x emissions from combined major sources decreased between 1985 and 2013, led by decreases from transportation sources. SO_2 emissions from combined major sources decreased between 1985 and 2013, mainly due to decreases from conventional oil and gas sources. VOC emissions from combined major sources decreased between 1985 and 2013, as the result of large decreases from transportation sources. NH_3 emissions from combined major sources increased between 1985 and 2013, primarily due to increases from agricultural sources and to a lesser extent from increases from the chemical manufacturing sector.

4.3.4 Additional Studies – Key Findings and Local Considerations

Key relevant studies carried out for a large portion of the North Saskatchewan Air Zone included the Capital Region Particulate Matter Air Modelling Assessment (Environ and Novus Environmental, 2014) and Formation of Secondary $PM_{2.5}$ in the Capital Region Study: Final Report (Environ International Corporation, 2015). These studies utilized photochemical modelling and source apportionment analysis to simulate elevated wintertime $PM_{2.5}$ concentrations and assess the effects of alternative emission control strategies. Environ and Novus Environmental (2014) identified that $PM_{2.5}$ in the Capital Region appears to originate mainly from local sources within the region.

The first phase of the Capital Region Particulate Matter Air Modelling Assessment found sulphate to be a key component of high wintertime $PM_{2.5}$ concentrations that could be predicted in the Capital Region. Much of the sulphate was attributable to several different stationary point sources, including: petroleum refineries, bulk storage terminals, oil sands upgraders, and to a lesser extent, electric power generation. This modelling finding was inconsistent with monitoring data that indicated high wintertime $PM_{2.5}$ concentrations were associated with elevated $PM_{2.5}$ fractions consisting largely of ammonium nitrate and organic matter. Refinements made for the second phase of the Capital Region Assessment reduced the significance of sulphate and brought the speciation breakdown closer to monitoring station observations. Overall, the Capital Region Assessment identified sulphate, nitrate, ammonium, and organics as the four key species of $PM_{2.5}$ in the Capital Region.

Other anthropogenic sources—specifically off-road transportation and agriculture—were identified as the dominant contributors to nitrate in the region, while agricultural sources contributed the most to ammonium. The contributions of on-road transportation sources to the average $PM_{2.5}$ concentrations were found to be small. The nitrate contributions from this source generally followed highway and road networks. Commercial and residential heating and off-road transportation were the dominant source of primary $PM_{2.5}$ in the Capital Region.

4.3.5 Conclusions

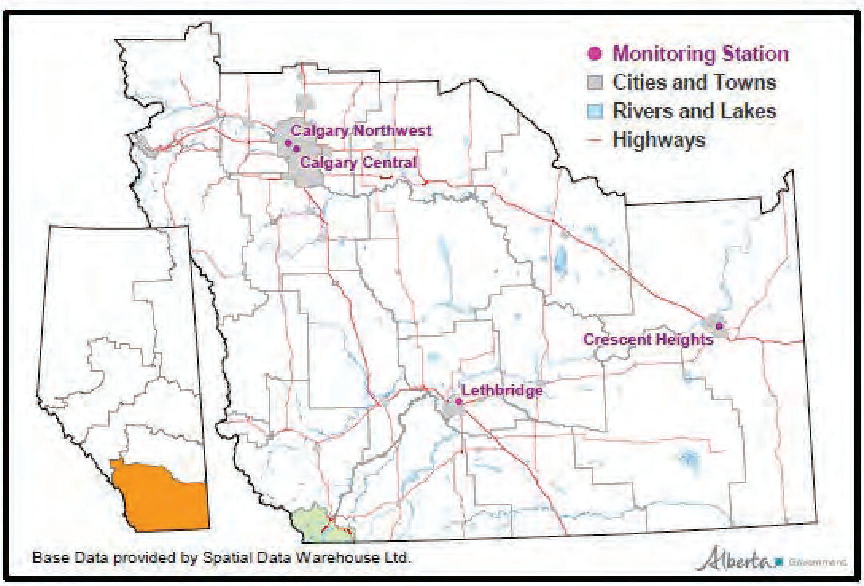
Based on the available information, there are several major non-point sources in the air zone that may warrant consideration when responding to CAAQS and other air quality issues. These include:

- on-road transportation;
- off-road transportation;
- agriculture;
- commercial/residential heating; and
- industrial plant fugitives, storage and handling, spills, and accidental release (particularly from the petroleum refining, bulk storage terminals, and conventional oil and gas sectors).

4.4 South Saskatchewan Air Zone

4.4.1 Assessments against the CAAQS

The Alberta: Air Zones Report 2011-2013 (AEP, 2015a) summarized the CAAQS Achievement Status and air zone management level for each air zone in Alberta. Four ambient air monitoring stations located in the South Saskatchewan Air Zone were used in the 2011-2013 CAAQS assessment. These stations are located within communities or in areas accessed by members of the public. Figure 5 provides a map of the ambient monitoring stations in the South Saskatchewan Air Zone used in the 2011-2013 CAAQS



assessment.

Figure 5. Ambient Air Monitoring Stations in the South Saskatchewan Air Zone used to Assess Air Zone Status Relative to the CAAQS

The 2011-2013 CAAQS assessment assigned the Calgary Northwest (24-hour and annual average), Crescent Heights (Medicine Hat), and Lethbridge monitoring stations (annual average) to the orange management level for $PM_{2.5}$, Actions for Preventing CAAQS Exceedance. An orange management level for $PM_{2.5}$ was assigned for the South Saskatchewan Air Zone. This management level indicates that $PM_{2.5}$ concentrations are approaching CAAQS and proactive action is needed to prevent exceedance. The CAAQS assessment assigns the Calgary Northwest in the orange level for the 24-hour $PM_{2.5}$ metric and the Calgary Northwest, Lethbridge, and Medicine Hat stations in the orange $PM_{2.5}$ annual metric level of at or above 6.4 µg/m³. This indicates that $PM_{2.5}$ may be an issue in all urban centres of the region. The air zone levels for ozone, unlike those for $PM_{2.5}$, are almost entirely within the green and yellow management levels of Keeping Clean Areas Clean and Actions for Preventing Air Quality Deterioration.

4.4.2 Non-Point Emission Sources and Emissions Inventories

The relative fractional estimates of the contribution of different sources to primary $PM_{2.5}$ and precursor (VOC, NO_x, and SO_2) emissions in the South Saskatchewan Air Zone were analyzed to identify the major contributors to primary emissions. Based on the available emissions inventory data, the largest anthropogenic sources of $PM_{2.5}$ and precursor emissions in the South Saskatchewan Air Zone are road dust, construction, industry (specifically the conventional oil and gas, fertilizer manufacturing, and cement and concrete sectors), transportation, and agriculture.

4.4.3 Assessment and Highlights

The event dates at the Calgary Northwest Station were evaluated to identify possible trends or causes of elevated concentrations leading to assignment of the air zone into the orange management level (AEMERA, 2016a). "Events" are defined as days where the 24-h daily average was greater than 19 µg/m³, the threshold into the orange management level, Actions for Preventing CAAQS Exceedance. Events occurred in both the winter and summer and were attributed to both wintertime and summertime anthropogenic smog. Average winds experienced on "event" days were generally from the WNW/NW and SSE/SE, ranging in speed from 2-13 km/hr.

Although both the Crescent Heights and Lethbridge stations were not assigned the orange management level for 24hr $PM_{2.5}$, the annual levels of $PM_{2.5}$ were at or above the 6.4 µg/m³ orange, Actions for Preventing CAAQS Exceedance level. The annual average concentration is calculated from the total daily 24-hour $PM_{2.5}$ and the total number of valid daily 24-hour $PM_{2.5}$ in the year. The annual $PM_{2.5}$ metric value is calculated from the valid annual average concentrations for the first, second, and third years, thus being an average of an average. The annual values triggering the orange management level suggests that there are chronic air quality issues in the smaller urban centres of the South Saskatchewan Air Zone.

4.4.4 Other Related Studies

The following are a summary of the findings of studies that have investigated the possible effects or contributions of non-point sources in the South Saskatchewan Air Zone, or other relevant topics.

- CMAQ modelling of the South Saskatchewan Land-use Framework Region in 2012 (Environ Canada and Novus Environmental, 2013) further demonstrated non-point sources as the common largest contributor of primary indicator emissions and precursors in the region.
- A study in 2011 was conducted to identify drivers of local anthropogenic ozone in the Calgary area (CRAZ, 2011). A VOC-limited regime was identified within the City of Calgary, likely extending to nearby suburban/rural communities that are immediately downwind. Ozone reduction measures

should be focused on VOC emission reduction strategies within the city. A NO_x-limited Regime was identified for rural areas, outside the influence of Calgary emissions, thus ozone reduction should be focused on measures to limit NO_x emissions in the rural areas.

- AEP conducted source apportionment analysis on the Calgary Central data from 2004-2011 (Ladha et al., 2015). The samples were analyzed for up to 160 individual VOCs, and the receptor model—positive matrix factorization (PMF)—was applied to the ambient data. A variety of non-point sources were identified as the largest contributing factors to the reconstructed mass.

4.4.5 Conclusions

Modelling and source apportionment studies conducted in the South Saskatchewan Air Zone also indicated that transportation, construction, and road dust sectors had the largest impact on modelling predictions or source contributions. Non-Point sources were identified as the common largest contributor of primary indicator emissions and precursors in the areas of study.

Based on the available information, there are several major anthropogenic non-point sources affecting ambient air quality in the South Saskatchewan Air Zone that may warrant consideration when responding to CAAQS and other air quality issues. These include:

- road dust ($PM_{2.5}$);
- construction ($PM_{2.5}$);
- transportation (NO_x, VOCs);
- industry (NO_x, VOCs); and
- agriculture (NH_3, VOCs, $PM_{2.5}$).

4.5 Red Deer Air Zone

4.5.1 Assessments against the CAAQS

The Alberta: Air Zones Report 2011-2013 (AEP, 2015a) summarized the CAAQS Achievement Status and air zone management level for each air zone in Alberta. One ambient air monitoring station located in the Red Deer Air Zone was used in the 2011-2013 CAAQS assessment. This station is located within the City of Red Deer. Figure 6 provides a map showing the location of the Red Deer – Riverside ambient monitoring station in the Red Deer Air Zone used in the 2011-2013 CAAQS assessment for the Red Deer Air Zone. Note that the Lancaster air monitoring station did not commence monitoring of the CAAQS parameters and precursors until 2012; the Lancaster air monitoring station was used temporarily (for a few months at a time) in 2012 and 2013 and became a permanent station in late 2014.

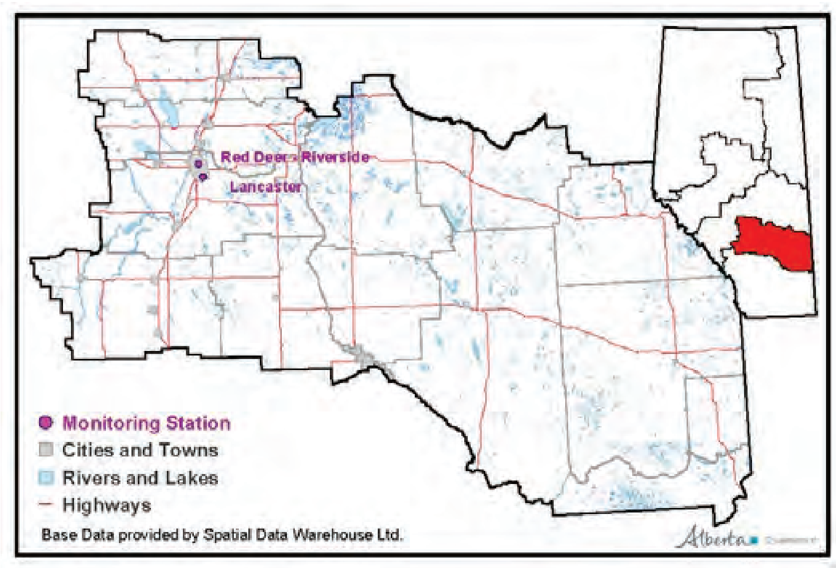


Figure 6: Ambient Air Monitoring Stations in the Red Deer Air Zone used to Assess Air Zone Status Relative to the CAAQS

According to the Alberta: Air Zones Report 2011-2013, Red Deer Air Zone was assigned a red management level, Actions for Achieving CAAQS with respect to the CAAQS for $PM_{2.5}$ (i.e., both the annual 98th percentile for the 24-h $PM_{2.5}$ metric and the average annual $PM_{2.5}$ metric), and to the yellow management level, Actions for Preventing Air Quality Deterioration with respect to O_3. These determinations were ascertained based on ambient air quality data monitored solely at Red Deer-Riverside air monitoring station in the City of Red Deer between January 1, 2011 and December 31, 2013.

Higher concentrations in 2011 and 2013 resulted in the Red Deer air zone not achieving the CAAQS. The 98th percentile concentration for 2012 was below the CAAQS threshold. As the CAAQS are based on a 3 year average, 2011 and 2013 influenced the management level assigned for 2011-2013. A review of information pertaining to the monitoring data obtained over the three-year period revealed that a majority of the elevated 24-h $PM_{2.5}$ events occurred in March during wintertime smog. In addition, several of the events recorded at the air station were associated with southerly winds. However, there is insufficient information available at this time to determine what non-point or other sources may have contributed to the wintertime smog.

With respect to annual $PM_{2.5}$ concentrations, the adjusted average annual concentration in each of the three years was either at or above the threshold value associated with the red management level. This suggests that $PM_{2.5}$ concentrations that pose a risk to human health tend to occur in the immediate vicinity of Red Deer – Riverside air monitoring station annually.

The annual, 4th highest, daily maximum, 8-h average O3 concentrations in 2012 and 2013 were also at or above the threshold value associated with the yellow management level, Actions for Preventing Air Quality Deterioration. Had the 2011 concentrations been maintained across the 3 years, the air zone would have been assigned a green management level. There is insufficient information available at this time with which to determine the influence of potential non-point sources of emission on O_3 formation in the vicinity of Red Deer – Riverside air monitoring station.

4.5.2 Non-Point Emission Sources and Emissions Inventories

Non-Point sources estimated to contribute directly to $PM_{2.5}$ emissions (primary particulate) or its formation (secondary particulate) and O_3 formation within Red Deer Air Zone include (in decreasing order of magnitude) are shown in Table 6.

Table 6. Non-Point Sources of Emissions for the Red Deer Air Zone

Air Quality Parameter	Non-Point sources of emissions
Primary $PM_{2.5}$:	• Road Dust • Construction • Agriculture
Precursors of Secondary $PM_{2.5}$:	
NH_3	• Agriculture
NO_x	• Transportation • Industrial non-point sources
VOC	• Transportation • Industrial non-point sources
Precursors of O_3:	
NO_x	• Transportation
VOC	• Agriculture • Transportation • Industrial non-point sources

4.5.3 Assessment and Highlights

Since the red management level with respect to the CAAQS for $PM_{2.5}$ in Red Deer Air Zone were attributed to data logged solely at Red Deer – Riverside air monitoring station, most of the emphasis to understand why this level of management was triggered in the air zone has been placed on that specific location and its immediate vicinity within the City of Red Deer. Red Deer – Lancaster air monitoring station, also located within the City of Red Deer, did not commence monitoring of the CAAQS parameters and precursors until late 2012; it was used as a temporary site until the station became permanent in late 2014. A reference check based on the Caroline air monitoring station (North Saskatchewan Air Zone) that is located in a rural area approximately 73 km southwest (SW) of the City of Red Deer, reported low concentrations of $PM_{2.5}$, especially in winter when Red Deer – Riverside station was reporting elevated values.

Although the emission inventory data suggests that specific non-point sources of emissions were likely to have played a role in triggering the red management level for $PM_{2.5}$ in Red Deer Air Zone, there is insufficient information with which to confirm this. Rather, a detailed scientific investigation is warranted in order to identify what sources contributed to the elevated $PM_{2.5}$ concentrations. Such detailed investigation would include receptor modelling along with the associated speciation profiling for the total $PM_{2.5}$ mass. Pending the outcome of the latter, additional investigation would require monitoring of NH_3 among other precursors, exploration of the relationship between associated non-point source emissions and $PM_{2.5}$ ambient air concentrations, as well as the mechanisms that govern atmospheric chemistry with respect to the precursors and their formation of secondary particulate, respectively.

4.5.4 Conclusions

Based on the available information, there are several major anthropogenic non-point sources affecting ambient air quality in the Red Deer Air Zone that may warrant consideration when responding to CAAQS and other air quality issues. These include:

- road dust ($PM_{2.5}$);
- construction ($PM_{2.5}$);
- agriculture ($PM_{2.5}$, NH_3, VOC)
- transportation (NO_X, VOC); and
- industrial non-point sources (NO_x, VOC)

The Red Deer Air Zone is in the red management level with respect to the CAAQS for $PM_{2.5}$. Consequently, in order to adequately manage the corresponding risks by effectively reducing emissions of primary $PM_{2.5}$ and precursors of secondary $PM_{2.5}$, there needs to be clearer understanding of the impact and influence of all potential non-point sources on the emissions. This implies that the associated mechanisms that govern the emission and formation of fine particulate matter need to be explored further and in-depth.

4.6 Peace Air Zone

4.6.1 Assessments against the CAAQS

The Alberta: Air Zones Report 2011-2013 (AEP, 2015a) summarized the CAAQS achievement status and air zone management level for each air zone in Alberta. Four stations in the Peace Air Zone were used in the 2011 to 2013 assessment. These stations are located within communities or in areas accessed by members of the public. Ambient air quality monitoring is conducted by Peace Airshed Zone Association (PAZA), a non-profit, multi-stakeholder organization. Figure 7 provides a map of the ambient monitoring stations in the Peace Air Zone used in the 2011-2013 CAAQS assessment.

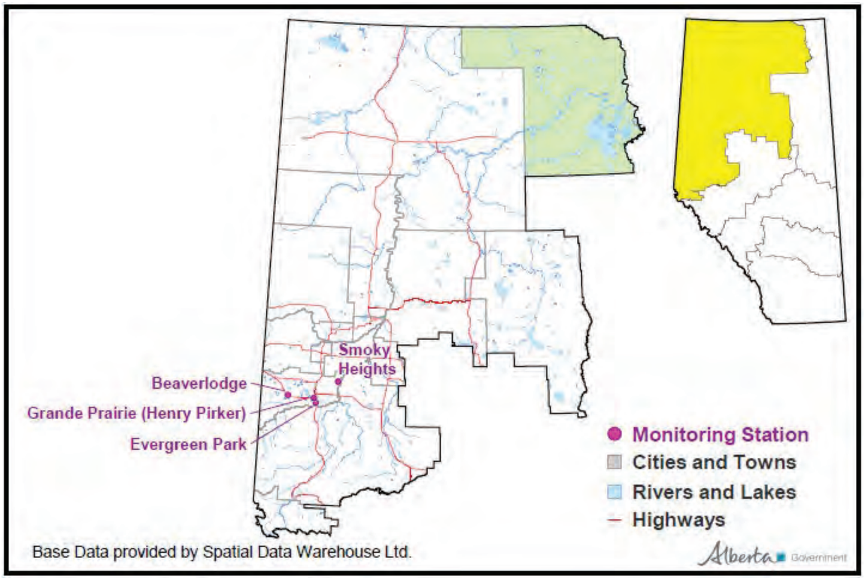


Figure 7. Ambient Air Monitoring Stations in the Peace Air Zone used to Assess Air Zone Status Relative to the CAAQS

The 2011-2013 CAAQS assessment determined that the Peace Air Zone achieved the CAAQS and was assigned the yellow management level, Actions for Preventing Air Quality Deterioration, for $PM_{2.5}$ (24-hour and annual). Peace Air Zone achieved the CAAQS and was assigned the green management level, Actions for Keeping Clean Areas Clean, for O_3.

4.6.2 Non-Point Emission Sources and Emissions Inventories

Based on the available emissions inventory data, the largest non-point sources in the Peace Air Zone are: road dust, construction, agriculture, transportation, and industry (various sectors). The three major sources, by tonnes emitted in Peace Air Zone, of each criteria air contaminant, are itemized in Table 6. Struck out emission sources are those found to be outside of the top three sources of the individual substances.

Table 6. Major Sources of Criteria Air Contaminant Emissions in Peace Air Zone

Emission Source	Primary $PM_{2.5}$	SO_2	NO_X	VOCs	NH_3
Agriculture	3				1
~~Cement and Concrete~~					
~~Chemical~~					
Construction	2				
Conventional Oil and Gas		1	1	2	2
~~Electrical Power Generation~~					
~~Fertilizer~~					

Emission Source	Primary $PM_{2.5}$	SO_2	NO_X	VOCs	NH_3
Oil Sands		3			
Pulp and Paper		2			3
Road Dust	1				
Transportation			2	3	
~~Wood Products~~					
~~Other Sources~~					
~~Non-industrial Sources~~					
Natural Sources			3	1	

Note: Emission sources listed with strikethrough text are sources <u>outside</u> of the three main non-point sources of emissions.

4.6.3 Conclusions

Based on the available information, there are several major anthropogenic non-point sources affecting ambient air quality in the Peace Air Zone that may warrant consideration when responding to CAAQS and other air quality issues. These include:

- road dust;
- transportation;
- industrial (conventional oil and gas, pulp and paper, and oil sands);
- agriculture; and
- construction.

5 Discussion

During the course of its work, the Technical Task Group discussed a number of issues surrounding the interpretation of ambient air monitoring data, the uncertainties in emissions inventories and the shortage of receptor modelling and air quality simulation modelling studies for the air zones. The following subsections discuss some of these issues, identify the gaps and uncertainties encountered, and provide the overall conclusions and recommended potential non-point sources of focus for the Project Team.

5.1 Differences between Air Zones

There are a great number of differences between Alberta's six air zones that can influence air quality and the information available to examine the air in each zone. It is critical to note these differences when attempting to understand and address air quality issues for individual air zones and at the provincial level.

Differences in Human Activities

Each Alberta air zone differs somewhat in the population and the types of human activities within the air zone. The cities of Edmonton, Calgary, and Red Deer are large emission sources in their respective air zones, in particular for their transportation, and residential and commercial fuel use sources. Population centres and related land-use types are often large influencers on the measured air quality at a given monitoring station. Some air zones only have smaller population centres and thus have lower urban development related emissions.

However, the major industrial and non-industrial sectors present in an air zone also influence the potential major emission sources. Large industrial facilities (such as power plants, conventional oil and gas facilities, oil sands mining and in-situ facilities, chemical manufacturing plants, and refineries, etc.) often have both point and non-point sources emitting large quantities of air pollutants. Other sectors, such as agriculture, forestry, and construction, can also represent large non-point emission sources in an air zone.

Differences in Environment

Each Alberta air zone also differs in the make-up of the environment, including the types of vegetation, topographic land-cover, elevation, and even differences in typical and individual specific meteorological conditions. The differences in the make-up of the environment can be important when examining air quality influences in a given air zone.

Differences in Monitoring

Each air zone typically has its own ambient air monitoring network, developed in response to the types of sources present and the specific air quality issues faced by the stakeholders in the air zone. Monitoring stations may be used to represent large urban centers, small communities, rural areas, industrial regions, or background sites. The air quality measured at each of these stations may be influenced by entirely different sources. Urban stations are influenced by large urban sources. Smaller communities may be influenced by similar sources, but of lesser magnitude.

Although the CAAQS are typically intended to be compared with results from community-based monitoring stations, in some air zones the CAAQS management levels have been triggered by non-urban stations that may be quite close to an individual industrial facility. Some questions have been expressed about the representativeness of certain monitoring stations, and there can be challenges with assessing

CAAQS achievement with data from stations established for quite different purposes. These types of monitoring issues should be considered when examining future monitoring efforts within air zones, and provincially.

Differences in Available Studies and Information

There are large differences in the data and information available for each air zone. There have been a multitude of studies for the Lower Athabasca Air Zone, but virtually no studies for the Upper Athabasca and Peace air zones. Further analysis of existing data, plus carrying out additional studies for all air zones could be fruitful. The Technical Task Group's efforts were limited to examining the existing information for each air zone, which was lacking for some air zones.

5.2 Natural versus Anthropogenic Emissions

Natural non-point sources account for 95% of total VOC emissions in Alberta. Dust-related sources represent about 94% of total primary $PM_{2.5}$ emissions in the province. It should not be simply concluded that managing anthropogenic non-point sources of VOC emissions would have minimal air quality impacts and that managing dust emission would have a major impact on ambient $PM_{2.5}$ levels. The $PM_{2.5}$ composition data available for days with elevated $PM_{2.5}$ levels indicate that the majority of the measured $PM_{2.5}$ concentrations are the result of secondary formation.

In general, it is often the precursor emissions that are most relevant in terms of reducing ambient $PM_{2.5}$ levels, although in specific locations (e.g., Hinton and CNRL Horizon monitoring stations) primary $PM_{2.5}$ emissions may be the dominant contributor to elevated $PM_{2.5}$ levels. Available $PM_{2.5}$ composition data also point to organic compounds as a large constituent component of $PM_{2.5}$. The limited provincial $PM_{2.5}$ composition monitoring, modelling and formation studies suggest that anthropogenic VOC emissions contribute to elevated $PM_{2.5}$ levels and therefore their management can improve air quality.

Some available studies suggest that anthropogenic sources of VOCs may be contributing more to secondary $PM_{2.5}$, even though they are emitted in relatively smaller quantities (and different VOC species) than from natural sources. VOCs also contribute to O_3 formation and it is unclear how significant natural versus anthropogenic VOC emissions are in terms of relative contribution to elevated O_3 levels. Limited photochemical modelling in Alberta indicates that natural VOC sources are major contributors to O_3 formation. However, studies elsewhere have shown that in areas with both anthropogenic and natural VOC emissions, anthropogenic VOC emissions are also important contributors to O_3 formation. This is an issue that requires more study, firstly to determine whether or not O_3 formation in an area is NO_x or VOC-limited, and secondly, if VOC-limited, whether reductions in anthropogenic VOC emissions would have a measurable impact on O_3 formation.

Relative emission amounts, from emission inventories for $PM_{2.5}$ and VOC sources, are not necessarily the best measure of the importance of natural and anthropogenic sources in influencing ambient air quality. Atmospheric chemistry is very complex and is affected by many different factors. Anthropogenic sources of precursor emissions are likely large contributors to secondary $PM_{2.5}$ formation, and there is greater ability to potentially manage these human-made sources.

5.3 Gaps and Uncertainties

Ambient Monitoring – Speciation

A critical information gap is the paucity of $PM_{2.5}$ speciation data with adequate supporting information. Complete speciations, including: ions, black carbon, and gas concentrations, are necessary to begin to understand the sources that are contributing to secondary $PM_{2.5}$ formation. Such complete datasets are necessary for the application of a variety of receptor modelling tools.

The speciation of emissions from various sources is also needed if receptor modelling is being used to identify the most likely contributing sources. Some emission characterization has been carried out in the oil sands regions, but that type of work needs to be extended to the most common point and non-point sources that influence ambient air quality in all air zones, and particularly for those zones in the red management level.

Emissions Inventories

Emissions inventories are typically carried out for specific purposes, which may not fully meet the requirements of other projects or assessments that need to be carried out. For example, some emissions inventories do not clearly break out point and non-point sources for industrial activities. With the source categories used in some emissions inventories, assumptions have to be made about the fraction of emissions that are from non-point sources. For some of the emissions inventories, the Technical Task Group had to assume that that all industrial VOCs came from non-point sources.

Emissions inventories are also typically made up of emission values quantified by a variety of different measurement and estimation methods. The accuracy and representativeness of these methods can vary greatly. Many methods, particularly those used for non-point sources, can also have high uncertainty associated with the emission numbers. This means that some individual and cumulative emission numbers could actually be much higher or lower than the available value.

Air Quality Simulation Models

A large gap exists in the limited resources and capacity to do region-specific and province-wide modelling to account for transport from one air zone to another. Modelling studies have been done for several, but not all air zones, and the results are typically focused to examine specific regional issues. Results may not be applicable to use for other purposes, or to examine air issues in other air zones. Overall, more air quality simulation modelling is needed to estimate the contributions of various sources to secondary pollutant formation.

There is also the need to carry out refinements and improvements to existing air quality simulation models to ensure they are being run appropriately for Alberta's unique meteorological conditions and the specific conditions and issues facing individual air zones. Additional testing and verification of the models being used in Alberta would increase confidence in model predictions.

Receptor Modelling

The tools available for receptor modelling (such as those described in Section 2.4) all have inherent uncertainties even under ideal conditions. In practical real-world situations, even larger uncertainties may be present. Our confidence in using receptor modelling to identify the sources contributing to secondary pollutants is much lower than our confidence in using receptor models to identify the sources of primary pollutants.

Atmospheric Profiles

The absence of atmospheric profiles can hinder our ability to interpret data. Wind and temperature profiles are needed for calculations to determine the sources that may be responsible for observed high concentrations of pollutants. There are also considerable gaps in information on the plumes and atmospheric transformations going on in the elevated atmosphere near ambient monitoring stations experiencing elevated $PM_{2.5}$ and O_3 concentrations.

Fugitive Sources and Emissions

Fugitive sources are large emitters of VOCs and primary $PM_{2.5}$ from many industrial operations in Alberta. Because of the difficulties in measuring these non-point sources, there is often high uncertainty around the emission estimates. The available emissions inventories often rely on estimates using emission factors or extrapolations from source-term measurements. There is therefore high uncertainty when using emissions inventories to examine non-point source contributions.

Overall Secondary $PM_{2.5}$ and O_3 Formation

There are some fundamental scientific questions that have not been fully answered, in particular:

- How is secondary $PM_{2.5}$ and O_3 being formed near specific individual monitoring stations, for specific air quality incidents?
- What sources and pollutants are contributing to the secondary $PM_{2.5}$ and O_3 formation near specific individual monitoring stations, for specific air quality events?
- What chemical mechanisms are involved near specific individual monitoring stations, for specific air quality events?
- What changes are occurring as an air parcel passes over different sources and land uses near specific individual monitoring stations, for specific air quality events?

5.4 Potential Future Work

In order to begin to address the identified gaps and uncertainties, the following potential future work items have been identified. These actions will help to improve our understanding of how non-point sources contribute to air quality issues in Alberta. These are potential future items where the CASA non-point sources Project Team could contribute to or should at least provide advice to ensure non-point source data requirements are being considered.

Ambient Monitoring – Speciation

- Work with the Government of Alberta to investigate expanding speciation monitoring at monitoring stations with elevated concentrations versus the CAAQS, to help better understand contributing point and non-point sources.
- Work with the Government of Alberta to examine monitoring issues stemming from air monitoring stations originally established for a variety of different purposes, and now being used for purpose of assessing against the CAAQS. The Ambient Monitoring Strategic Plan for Alberta is now several years old, and CASA likely has a role in helping to update this plan, through which the specific monitoring gaps from this project (such as speciation) should be considered.

Emissions Inventories

- Review and assess more recent emissions inventory information that becomes available, to identify any large changes in major point and non-point sources in the various air zones.
- Provide input into future emissions inventory projects being carried out by the Government of Alberta and Environment and Climate Change Canada, to ensure that there are adequate breakdowns of point and non-point sources, and that acceptable measurement and estimation methods are being used to quantify non-point source emissions.

Air Quality Simulation Models

- Refine and improve existing air quality simulation models to ensure they are being run appropriately for Alberta's unique meteorological conditions and the specific conditions and issues facing individual air zones.

- In regional modelling projects being carried out by the Government of Alberta, and Environment and Climate Change Canada provide input to ensure adequate investigation of the science questions related to the major point and non-point sources responsible for elevated concentrations versus the CAAQS.

Receptor Modelling

- Work with the Government of Alberta by providing input into the development of a Long-term Receptor Modelling Plan. Such a plan should include full speciation of $PM_{2.5}$ and related pollutants, development of emission characterization profiles, application of receptor models, and use of air quality simulation models to quantify secondary pollutant formation from precursor emissions. This plan is need to make sure that adequate monitoring data is available to assess the contributing sources and that adequate research is carried out on source profiles to allow for the identification of potential contributing sources to the measured concentrations at specific locations.

Atmospheric Profiles

- Work with the Government of Alberta to ensure that monitoring stations at the red management level be considered as prime candidates for enhanced monitoring to aid in the understanding of the atmospheric conditions and substances present in the atmosphere near these stations. Enhanced monitoring would gather valuable information about elevated sources and deposition velocities by obtaining atmospheric pollutant profiles, including meteorological and $PM_{2.5}$ measurements at several heights.
- Aircraft flights, such as those conducted in the oil sands development regions as part of the Joint Oil Sands Monitoring (JOSM) work, could be used to shed light on these atmospheric profile issues and improve our scientific understanding of what is going on in the atmosphere at specific places in Alberta. Although very expensive, efforts could be made by the CASA non-point sources Project Team to try to ensure that any future planned aircraft measurement studies being carried out by Environment and Climate Change Canada and the Government of Alberta are gathering information necessary to help understand the contributions of non-point sources to secondary pollutant formation.

Fugitive Sources and Emissions

- Work with the Government of Alberta to ensure that acceptable measurement and estimation methods are being used for EPEA approval required monitoring of non-point sources. Remote sensing tools, like differential absorption LIDAR (DIAL), have been used in the past to determine emission rates. These and other quantification methods could be applied systematically in the future to enhance the current catalog of fugitive emission rates from various industrial operations.

- Provide input to the Government of Alberta during their development of the new Oil Sands non-point sources Monitoring Chapter of the Air Monitoring Development.

Overall Secondary $PM_{2.5}$ and O_3 Formation

- Examine, and consider management actions for, specific non-point source subcategories within the list of identified major non-point sources (see Tables 7 and 8). In particular, examine the potential management actions for addressing the four categories of non-point sources that are common to all the air zones (transportation, construction, road dust, and agriculture).
- Where appropriate, work with the Government of Alberta to examine background concentrations, the significance of anthropogenic versus natural sources, and calculated ratios of NO_x/VOC to further understand specific NO_x versus VOC ozone formation limited areas.
- Prescribed burning is a potential contributor to high concentrations of $PM_{2.5}$ at some locations in some air zones. The CASA non-point sources Project Team could carry out a review of prescribed burning practices for areas where there is a large amount of prescribed burning.
- As VOCs have been identified as a major contributor to secondary $PM_{2.5}$ formation in several air zones, the CASA non-point sources Project team could consider examining management actions for some of the identified anthropogenic non-point sources of VOC emissions in these zones.
- A considerable amount of information, see section 6, was gathered and reviewed by the Technical Task Group for this project. It is suggested that the CASA non-point sources Project Team continue to identify additional relevant resources and, when available, use updated versions of the referenced documents and datasets.

5.5 Conclusions

The Technical Task Group examined the available emissions inventories, ambient monitoring, air quality simulation modelling, and receptor modelling studies available for Alberta and each of its six air zones. Currently, the best estimates of contributing non-point sources are based mainly on emissions inventories, supplemented in a few instances with receptor modelling and air quality simulation modelling.

Overall, there is insufficient data to define with confidence the amount that each non-point source category contributes to secondary pollutant concentrations at the specific monitoring stations seeing elevated concentrations. However, the available information does help to narrow down the number of potentially relevant non-point sources to a more manageable number, for further investigation. There are many gaps and uncertainties that cannot be easily or quickly addressed, but several potential future work items have been identified that would work towards a more complete understanding of how non-point sources may be contributing to air quality issues.

Based on the available information, there are four categories of larger non-point sources identified as common to all air zones: transportation, construction, road dust, and agriculture. Table 7 lists the non-point sources identified for further consideration by the Project Team. Several region-specific non-point sources have also been identified. A summary of each air zone's CAAQS management levels with the identified non-point sources is provided in Table 8.

The contributions to individual air quality episodes will vary based on many factors, including the location of the monitoring station relative to the emission patterns and meteorological conditions.

There are no “silver bullets” that will guarantee that elevated $PM_{2.5}$ or O_3 concentrations will be prevented in the future, or that there will be measurable positive impact on air quality at any one station. However, there is sufficient evidence assist the Project Team in refining its broad list of non-point sources of focus and for the Project Team to progress with its work. It is expected that the Project Team will further refine its list of non-point sources using additional criteria. Therefore, the non-point sources in Tables 7 and 8 are recommended for further consideration by the Project Team.

Table 7. Non-Point Sources Identified by the Technical Task Group for the Project Team's Consideration

Non-Point Source Category	Description of Non-Point Source	Air Zone Where Non-Point Sources Identified as Relevant	Emissions Identified as Relevant
Transportation	Emissions from on and off-road, rail, air, and marine vehicles and equipment	All Zones	NO_x, VOC
Construction Operations*	Fugitive particulate matter emissions resulting from disturbances on construction sites	All Zones	$PM_{2.5}$
Road Dust	Re-suspension of particulate matter by vehicles travelling on paved and unpaved roads	All Zones	$PM_{2.5}$
Agriculture**	Emissions from agricultural activities, including: manure handling, tilling and wind erosion, fertilizer application, crop harvesting, and crop drying	All Zones except Lower Athabasca	NH_3, VOC, $PM_{2.5}$
Commercial / Residential Heating	Emissions from combustion sources used for space/water heating in residential and commercial establishments, health and educational institutions, and government/public administration facilities	North Saskatchewan	NO_x
Industrial non-point sources***	Emissions from non-point sources at industrial operations from various sectors (oil and gas, chemical, cement, petroleum refining, hydrocarbon storage and transportation, etc), including: plant fugitive leaks, materials storage and handling, non-stationary equipment, space heating, and storage tanks	All Zones	NO_x, VOC
Oil Sands Specific****	Emissions from non-point sources specific to oil sands mining operations, including: tailings ponds, mine fleets, mine faces, and mining disturbances	Lower Athabasca	NO_x, VOC, $PM_{2.5}$,
Prescribed Burning	Emissions from controlled fires used for land management treatments, specifically land clearing for industrial development in the Lower Athabasca Air Zone	Lower Athabasca	$PM_{2.5}$, VOC, NO_x

*Emissions from construction equipment fuel combustion are captured under the off-road transportation categories.

**Emissions from agricultural equipment fuel combustion are captured under the off-road transportation categories.

***Plant fugitive emissions from oil sands mining operations are captured under the Industrial non-point sources category.

****Emissions from road dust at industrial operations are captured under the road dust category, oil sands specific non-point sources (emissions from tailings ponds, mine faces, mine fleets and mining disturbances) are captured under the Oil Sands Specific category.

Table 8. Air Zone CAAQS Management Levels and Non-Point Sources Identified by the Technical Task Group for the Project Team's Consideration

Air Zone	$PM_{2.5}$ CAAQS Management Level	O_3 CAAQS Management Level	Identified Priority Non-Point Sources
Lower Athabasca	Orange Management Level	Yellow Management Level	• Oil Sands Specific (NO_X from mine fleets, VOCs from tailings ponds and mines, $PM_{2.5}$ from mining and tailings operations) • Industrial non-point sources (VOC); • Construction ($PM_{2.5}$); and • Prescribed burning for oil sands land development ($PM_{2.5}$).
Upper Athabasca	Orange Management Level	Yellow Management Level	• Industrial non-point sources (VOCs); • Road dust ($PM_{2.5}$); • Agriculture (VOCs, $PM_{2.5}$, NH_3); • Transportation (NO_X, VOCs); and • Construction ($PM_{2.5}$).
North Saskatchewan	Orange Management Level	Orange Management Level	• Transportation (NO_X, $PM_{2.5}$); • Agriculture (NH_3); • Commercial/residential heating ($PM_{2.5}$); and • Industrial non-point sources (VOC).
South Saskatchewan	Orange Management Level	Yellow Management Level	• Road dust ($PM_{2.5}$); • Construction ($PM_{2.5}$); • Transportation (NO_X, VOC); • Industrial non-point sources (VOC); and • Agriculture (NH_3, VOC, NH_3).
Red Deer	Red Management Level	Yellow Management Level	• Road dust ($PM_{2.5}$); • Construction ($PM_{2.5}$); • Agriculture ($PM_{2.5}$, NH_3, VOC), • Transportation (NO_X, VOC); and • Industrial non-point sources (NO_X, VOC)
Peace	Yellow Management Level	Green Management Level	• Agriculture ($PM_{2.5}$, NH_3); • Construction ($PM_{2.5}$); • Industrial non-point sources (NO_X, VOC, NH_3); • Road Dust ($PM_{2.5}$); and • Transportation (NO_X, VOC).

6 References/Source Documents

(key references are in **bold**)

Alberta Agriculture and Rural Development. 2001. Agricultural Air Emission Inventory for Alberta and Literature Review. Prepared for the Intensive Livestock Operations Working Group by Shane Chetner and Doug Sasaki. Edmonton, AB: Government of Alberta.

______. 2013. Ammonia and Particulate Matter Emissions Inventory for Confined Feeding Operations in Alberta by Atia, A. Edmonton, AB: Government of Alberta.

Alberta Environmental Monitoring, Evaluation, and Reporting Agency (AEMERA). 2016a. CASA PM_O3 CAAQS 2011 to 2015.docx. Unpublished material provided to CASA NPS project technical task group upon request. Edmonton, AB: Alberta Environmental Monitoring, Evaluation and Reporting Agency.

______. 2016b. CASA NPS Data Request_May17 AEMERA.docx. Unpublished material provided to CASA NPS project technical task group upon request. Edmonton, AB: Alberta Environmental Monitoring, Evaluation and Reporting Agency.

______. 2016c. AnnualAvg_2001_2015_(Data and Stn Loc).xlsx. Unpublished material provided to CASA NPS project technical task group upon request. Edmonton, AB: Alberta Environmental Monitoring, Evaluation and Reporting Agency.

______. 2016d. CAAQS Trends from 2001 to 2014 (PM_O3).docx. Unpublished material provided to CASA NPS project technical task group upon request. Edmonton, AB: Alberta Environmental Monitoring, Evaluation and Reporting Agency.

Alberta Environment. 2009. Particulate Matter and Ozone Assessment for Alberta: 2001 – 2007. Edmonton, AB: Air Policy Section, Environmental Assurance Division, Government of Alberta.

______. 2014. Capital Region Fine Particulate Matter Science Report. Prepared for the Capital Regional Oversight Advisory Committee by the Capital Regional Fine Particulate Matter Technical Sub-Committee. Edmonton, AB: Government of Alberta.

______. 2015a. Alberta: Air Zones Report 2011-2013. Edmonton, AB: Government of Alberta.

______. 2015b. Non-Point Sources Background Information. Prepared for the CASA Non-Point Sources Team. Edmonton, AB: Government of Alberta.

______. 2016a. Red Deer Fine Particulate Matter Response Science Report. Edmonton, AB: Government of Alberta.

______. 2016b. Summary Report on Major Non-Point Air Emission Sources in Alberta. Edmonton, AB: Air Policy Section, Government of Alberta.

Atia, A *See* Alberta Environment

Calgary Region Airshed Zone (CRAZ). 2011. Identifying Drivers for Local Anthropogenic Ozone in the Calgary Region prepared by Novus Environmental for CRAZ. Calgary: Calgary Region Airshed Zone (CRAZ).

Canadian Council of Ministers of the Environment (CCME). 2012. Guidance Document on Air Zone Management. Winnipeg, MB: CCME.

Chetner, Shane and Doug Sasaki. *See* Alberta Agriculture and Rural Development.

Cumulative Environmental Management Association. 2015. *Lower Athabasca Region Source and Emission Inventory.* Retrieved from Cumualtive Environmental Management Association: http://library.cemaonline.ca/ckan/dataset/2011-0038/resource/fba8a3b0-72df-45ed-bf12-8ca254fdd5b1 January 28.

Environ Canada and Novus Environmental. 2013. Air Quality Modelling Exercise Using Community Multiscale Air Quality (CMAQ) Model for South Saskatchewan Regional Plan. Summary Report. Prepared for Land-Use Framework Strategy Division, Alberta Environment and Sustainable Resource Development.

Environ and Novus Environmental. 2014. *Capital Region Particulate Matter Air Modelling Assessment: Final Report*. Prepared for Alberta Environment and Sustainable Resource Development. Environmental International Corporation, Novato, California.

Environ International Corporation. 2015. *Formation of Secondary $PM_{2.5}$ in the Capital Region Study: Final Report*. Prepared for Alberta Environment and Sustainable Resource Development. Environmental International Corporation, Novato, California.

Evans, Greg J.; C. Jeong and M. McGuire. 2009. PMF Source Apportionment for PM2.5 at the Five National Air Pollution Surveillance (NAPS) Sites across Canada. Prepared for Environment Canada by Southern Ontario Centre for Atmospheric Aerosol Research, University of Toronto, June 22, 2009. SOCAAR Report No. : CR-WB-2009-01.

Fine, J.D.; L. Vuilleumier, S. Reynolds, P. Roth, and N.J. Brown. 2003. Evaluating Uncertainties in Regional Photochemical Air Quality Modeling. Environmental Energy Technologies Division, Ernest Orlando Lawrence Berkeley National Laboratory.

Finlayson-Pitts, B.J. and J.N. Pitts Jr. 1993. Atmospheric Chemistry of Tropospheric Ozone Formation: Scientific and Regulatory Implications, Air & Waste, 43:8, 1091-1100, DOI: 10.1080/1073161X.1993.10467187.

Fox, D., and M. Kellerhals. 2007. *Modelling Ozone Levels in Alberta: Base Case, Sectoral Contributions and a Future Scenario.* Edmonton: Environment Canada, Prairie and Northern Region.

Health Canada Fuels Assessment Section. 2016. Human Health Risk Assessment for Diesel Exhaust. Ottawa, ON: Water and Air Quality Bureau.

Hopke, Philip K. 2016. Review of Receptor Modeling Methods for Source Apportionment. Journal of the Air & Waste Management Association, 66:3, 237-259, DOI: 10.1080/10962247.2016.1140693.

Government of Alberta. 2013. Clean Air Strategic Alliance Non-Point Source Workshop Background Information. Edmonton, AB.

Jeong, Cheol-Heon and Greg J. Evans. 2015. Identification and Apportionment of Fine Particulate Matter Sources in Toronto, Edmonton, and Montreal: Follow-up receptor modeling analysis using positive matrix factorization. Prepared for Environment Canada by Southern Ontario Centre for Atmospheric Aerosol Research, University of Toronto, June 5, 2015. SOCAAR Report No.: CR-WB-2015-01 (Rev. Ver.3).

Kindzierski, W. and Md. Aynul Bari. 2015. Investigation of Fine Particulate Matter Characteristics and Sources in Edmonton, Alberta (Final Report). University of Alberta School of Public Health. 19 Nov 2015.

Ladha, Rabia; Y. Aklilu, and D. A. Lyder. 2015. Source Apportionment of Volatile Organic Compounds Measured in Downtown Calgary . Abstract # 33133.

McCarthy, Michael C.; Yayne-Abeba Aklilu, and Steven G. Brown, David A. Lyder. 2013. Source Apportionment of Volatile Organic Compounds Measured in Edmonton, Alberta. Atmospheric Environment 81: 504-516.

Morris, Ralph; Tejas Shah, Uarporn Nopmongcol, Jeremiah Johnson, Jaegun Jung, Piti Piyachaturawat, Ted Pollock, Rakesh Singh, Mike Thompson, Jan Shi and Piotr Staniaszek. 2010. PM and Ozone Chemistry Modelling in the Alberta Oil Sands Area Using the Community Multiscale Air Quality (CMAQ) Model. Prepared for Cumulative Environmental Management Association by Environ International, Environ Canada and Millennium EMS Solutions Ltd. 11 June 2010.

Nopmongcol, Uaporn; Jeremiah Johnson, Bart Brashers, DJ Rasmussen, Tejas Shah, Justin Zagunis, Zhen Liu, Ralph Morris, Ted Pollock and William Allan. 2015. Formation of Secondary PM2.5 in the Capital Region Study – Final Report. Prepared for Environment and Sustainable Resource Development by Environ International and Environ Canada. March 2015.

Nopmongcol, Uarporn; Jaegun Jung, Justin Zagunis, Tejas Shah, Ralph Morris, Ted Pollock, William Allan, Xin Qiu, Nick Walters and Fuquan Yang. 2014. Capital Region Particulate Matter Air Modelling Assessment Final Report. Prepared for Environment and Sustainable Resource Development by Environ International, Environ Canada and Novus Environmental. March 2014.

Philip K. Hopke. 2016. Review of Receptor Modeling Methods for Source Apportionment, *Journal of the Air & Waste Management Association*, 66:3, 237-259, DOI: 10.1080/10962247.2016.1140693.

Pouliot, George; Emily Wisner, David Mobley, and William Hunt Jr. 2012. Quantification of Emission Factor Uncertainty. *Journal of the Air & Waste Management Association* 62:3, 287-298, DOI: 10.1080/10473289.2011.649155.

Seinfeld JH. 1988. Ozone Air Quality Models: A Critical Review. J Air Poll Ctrl Assoc. 38(5):616-647.

Vijayaraghavan, Krish; Jaegun Jung, Lan Ma, Justin Zagunis, Ralph Morris, Mervyn Davies and Reid Person. 2015. Assessment of Ozone Precursor Emissions, Ambient Monitoring Data, and Current and Planned Emission Management Requirements in Support of the Ozone Management Framework. Prepared for Cumulative Environmental Management Association - Air Working Group by Ramboll Environ Canada Inc. and Stantec Consulting.

Wang, X.; Chow, J. C., Kohl, S. D., Percy, K. E., Legge, A. H., & Watson, J. G. 2015. Characterization of $PM_{2.5}$ and PM_{10} fugitive dust source profiles in the Athabasca Oil Sands Region. *Journal of Air and Waste Management Association*, 1421-1433.

Wilson, W.E., J. C. Chow, C. Claiborn, W. Fusheng, J. Engelbrecht, and J. G. Watson. 2002. Monitoring of particulate matter outdoors, *Chemosphere*, 49(9), pp 1009-1043.

7 Appendix A. Canada-Wide Standards (CWS) & Canadian Ambient Air Quality Standards (CAAQS)

The Canadian Council of Ministers of the Environment (CCME) established Canada Wide Standards for $PM_{2.5}$ and O_3 in June 2000. Achievement of the CWS was based on the following numerical values and calculation method: $PM_{2.5}$ 30 µg/m3 (micrograms per cubic meter), averaged over 24 hours, by year 2010; achievement to be based on the 98th percentile ambient measurement annually, averaged over three consecutive years. Ozone 65 parts per billion (ppb), eight-hour averaging time, by 2010; achievement to be based on the 4th highest measurement annually averaged over three consecutive years.

The CASA PM and Ozone Management Framework was Alberta's commitment to develop an implementation plan to achieve the standards. Three action triggers and four action levels were established under the framework.

In October 2012, through the Canadian Council of Ministers of the Environment (CCME 2012), Canadian provinces and territories, except Quebec, agreed to implement a national Air Quality Management System including:

- new Canadian Ambient Air Quality Standards (CAAQS) to set the bar for outdoor air quality management across the country;
- industrial emission requirements that set a base level of performance for major industries in Canada;
- a framework for air zone air management within provinces and territories that enables action tailored to specific sources of air emissions in a given area;
- regional airsheds that facilitate coordinated action where air pollution crosses a border; and
- improved intergovernmental collaboration to reduce emissions from the transportation sector.

Table 9 outlines the CAAQS for ozone and fine particulate matter, effective 2015, the threshold levels for each colour coordinated management level, and the colour identifier for that management level[1]:

In 2015 Alberta Environment and Parks completed an assessment of air quality in Alberta applying the new CAAQS standards and approach. Alberta's six air zones have been assessed for achievement against the CAAQS using thirty three ambient air monitoring stations distributed throughout the province. A summary of the CAAQS achievement status and the air management level for each air zone was presented. Management actions have already been initiated within some air zones as part of Alberta's implementation of the former Canada-wide standards for PM2.5 and ozone.

[1] Alberta Implementation of the Air Zone Management Framework for Fine Particulate Matter and Ozone - AEP, Air Policy, 2015, No. 2

Table 9. Management Levels and the Canadian Ambient Air Quality Standards (CAAQS)

Management Level	Ozone (ppb)	$PM_{2.5}$ 24 hour ($\mu g\ m^{-3}$)	$PM_{2.5}$ Annual ($\mu g\ m^{-3}$)
Effective	**2015**	**2015**	**2015**
Red	**Actions for Achieving CAAQS**		
Threshold	63	28	10.0
Orange	**Actions for Preventing CAAQS Exceedances**		
Threshold	56	19	6.4
Yellow	Actions for Preventing Air Quality Deterioration		
Threshold	50	10	4.0
Green	**Actions for Keeping Clean Areas Clean**		

The metrics for the determination of management levels are calculated after removing influences from transboundary flows and exceptional events (like forest fires because such TFEE (Transboundary Flow/Exceptional Events) are beyond the control of the jurisdiction. The remaining "smog" episodes can be examined to determine the responsible sources and potential management actions. Summertime smog, wintertime smog, anthropogenic smog, and smog are not TFEE and remain in the CAAQS calculations for the assignment of management levels.

"Smog" is a pollution mixture of gases and particles that can appear in the air as a visibility reducing haze. (Historically the term arose as a combination of smoke and fog, referring to the infamous London pollution episodes of the 1950s).

In the wintertime, smog is primarily due to $PM_{2.5}$ especially when the winds are calm and a temperature inversion is present. A temperature inversion takes place when cold, stagnant air close to the ground is trapped by a layer of warm air above. Under such conditions, air pollutants build up close to the ground.

In the summertime when it is sunny and hot, higher levels of ozone contribute to the formation of photochemical smog, which has a light brown colour and can reduce visibility. It is the product of chemical reactions of sunlight, nitrogen oxides and volatile organic compounds.

8 Appendix B. Ambient Monitoring Methods

8.1 Continuous $PM_{2.5}$ Analyzers

The CAAQS and CWS metrics for $PM_{2.5}$, as described in Appendix A, were calculated using 1-hour averages from $PM_{2.5}$ continuous analyzers deployed throughout Alberta. There are several types of $PM_{2.5}$ analyzers used to report the CAAQS and CWS metrics, as described below.

The $PM_{2.5}$ monitors can be broadly categorized based on whether or not they are designated US EPA Federal Equivalent Methods (FEM). Instruments designated as FEM measure and report ambient concentrations that are comparable to a reference method. Thus FEM $PM_{2.5}$ monitors measure concentrations that are a more standardized representation of ambient concentrations.

To measure mass associated with "dry" particles and reduce analyzer maintenance, $PM_{2.5}$ analyzers condition the sampled air to reduce the relative humidity of the sample flow. Such conditioning can result in a loss of the semi-volatile component of the particle mass, especially when the sample is heated such that there is notable difference between the resulting sample flow temperature and ambient temperature (Wilson et al. 2002).

- Non-FEM $PM_{2.5}$ monitors may lose the semi-volatile components of the particle sample as the sample is heated to drive off water. This can cause non-FEM monitors to measure less $PM_{2.5}$ than FEM monitors.
- FEM $PM_{2.5}$ monitors have improved processes for removing particle-bound water, and are therefore better able to account for the semi-volatile fraction and provide a more accurate measurement of ambient fine particulate matter concentration.

In Alberta, station operators are replacing older monitors with FEM monitors at the end of the instrument's life cycle. This means that the $PM_{2.5}$ monitoring network in the province still contains non-FEM analyzers. However, any new continuous ambient air analyzer that is purchased after July 30, 2015, and any existing analyzer operating beyond July 30, 2017, must meet the minimum performance specifications in Chapter 4 of Alberta's Air Monitoring Directive.

A list of $PM_{2.5}$ monitoring instruments used in Alberta is provided in Table 10, along with a brief description of the methodology and whether the monitor is designated FEM. The instruments used to collect continuous $PM_{2.5}$ measurements across Alberta use a wide range of techniques, all of which are based on indirect methods, where one or more physical properties of the sample are used to derive particulate mass loading. For this reason, there may be some variability even between different types of FEM $PM_{2.5}$ monitoring methods.

Even $PM_{2.5}$ measurements from the same type of instruments can vary, depending on how the instrument is operated. For example, when converting mass loading to $PM_{2.5}$ concentration, the flow rates of the instruments can be calibrated to either standard or actual temperature and pressure, which can affect the calculated $PM_{2.5}$ mass by up to ~10% for some temperatures/pressures (see detailed description below). Furthermore, $PM_{2.5}$ measuring equipment is more difficult than other monitors to keep in optimum working order, and reliability can vary from unit to unit. Parts- or unit-changeout can have a noticeable impact on monitored concentrations, appearing as a sudden increase in concentrations.

Therefore, trends in $PM_{2.5}$ measurements or the CAAQS/CWS metrics can include influences from several factors. At most stations, the type of $PM_{2.5}$ monitoring instrument has changed over the course of the time series, often from a non-FEM monitor to a FEM monitor. Even when the same instrument measured the entire time series, variations in the instrument operation could affect the data. Trend analysis of $PM_{2.5}$ mass concentration is further complicated by the temporal variability of particulate matter composition over time. Therefore, it is difficult to interpret calculated trends in $PM_{2.5}$, as changes in instrumentation could affect the data.

Table 10: Continuous $PM_{2.5}$ Analyzers Deployed at CAAQS-reporting Stations in Alberta

Instrument Name	Description of Method	FEM Equivalent?
TEOM (older series)	Gravimetric instrument that draws air at a constant flow rate through a sample filter for collection. Filter is continuously weighed to calculate mass concentrations in real-time.	No
BAM (older series)	Records PM concentrations using beta attenuation. Air is drawn through a filter tape, which is passed between the beta particle source and the detector, causing reduction of the beta particle signal, proportional to the mass of particulate collected on the filter.	No
TEOM-FDMS[2]	Same principal methodology as the TEOM, with added filter dynamics measurement system (FDMS) unit that accounts for both non-volatile and volatile PM components.	Yes
BAM 1020[3]	Same principal methodology as the older series of the BAM but with advance system to control sample relative humidity.	Yes
SHARP[4]	Hybrid nephelometric/radiometric PM mass monitor. First a light source is passed through the sampled air, scatters, and yields a signal that is linear with PM concentration. Next, air is drawn through a filter tape and PM mass is measured using beta ray attenuation. These two measurements are combined to calculate $PM_{2.5}$ mass.	Yes
GRIMM[5]	Orthogonal light scattering. A laser light source passes through air and is scattered by PM. Light that is scattered by approximately 90º is detected and used to infer levels of PM.	Yes

[2] Thermo Scientific, TEOM 1405-F Ambient Particulate Monitor with FDMS Option, 2009, Available at: https://tools.thermofisher.com/content/sfs/manuals/EPM-manual-1405F.pdf

[3] Met One Instruments Inc., BAM-1020 Particulate Monitor Operation Manual, 2008

[4] Thermo Scientific, Model 5030 Instrument Manual Synchronized Hybrid Ambient Real-time Particulate Monitor, 2007, Available at: https://tools.thermofisher.com/content/sfs/manuals/EPM-manual-Model%205030%20SHARP.pdf

[5] GRIMM, The Approved Environmental Dust Monitor EDM180 Stationary 19" Rack Unit for Measurement Networks, Available at: http://wiki.grimm-aerosol.de/images/7/7c/D_E_180_rev1p1.pdf

8.2 Conversion of $PM_{2.5}$ Mass Loading to Ambient Concentration

Mass loading is converted into ambient concentration using the analyzer flow. Analyzer flow can be calibrated and reported as standard or actual flow rates. The standard flow rate is the flow rate to a set temperature and pressure. In Alberta, most of the flow calibrators used by Airsheds are factory calibrated to the standard temperature of 25 degrees C and atmospheric pressure of 760 mm of Hg. The difference between the actual and standard volumetric flows depends on the ambient conditions. Equation 1 relates the standard (Q_s) and actual (Q_a) volumetric flow.

$$Q_s = Q_a \times \frac{BP_a}{BP_s} \times \frac{T_s}{T_a} \qquad \text{Eq. 1}$$

Where BP_s and BP_a are standard and actual atmospheric pressure and T_s and T_a are standard and actual temperatures in degrees Kelvin. For example, for a winter temperature and pressure of minus 17 degrees C and 750 mm of Hg, the standard flow is a factor of 1.13 times the actual flow. Similarly for warmer temperature of 20 degrees and pressure of 762 mm of Hg the standard volumetric flow is 1.02 times the actual volumetric flow. Particulate matter concentration is inversely proportional to the flow rate; mass concentration determined using the standard flow rate can be 0.98 to 0.88 times the mass concentration determined using actual flow rate for the above mentioned concentrations. **The new Reporting Chapter of Alberta's Air Monitoring Directive requires that all ambient concentration be reported at actual ambient temperature and pressure.**

8.3 Continuous Ozone Analyzers

The CAAQS and CWS metrics for ozone were calculated using 1-hour averages from Thermo Environmental Instrument (TEI) Model 49 analyzers[6]. The TEI analyzer is a dual cell photometer, which measures the amount of UV light that passes through the sample gas (air sample) and the reference gas (air sample that has passed through an ozone scrubber). That amount of ozone in the sample gas is inferred based on the absorption of UV light by ozone. Since most stations use the similar monitoring technology to measure ozone throughout the CWS/CAAQS measurement period, it is much easier to interpret trends for ozone.

[6] Thermo Scientific, Model 49i Instruction Manual UV Photometric O_3 Analyzer, 2011, Available at: https://tools.thermofisher.com/content/sfs/manuals/EPM-manual-Model%2049i.pdf

Appendix C: Definitions for Identified Non-Point Sources

<u>Transportation Sources:</u>

Air Transportation: Emissions from piston and turbine military, commercial and general aviation (landing and take-off only), and in-flight (cruise) emissions for turbine aircraft.

Heavy-duty Diesel Vehicles: Emissions from diesel vehicles over 3856 kilograms.

Heavy-duty Gasoline Trucks: Emissions from gasoline trucks over 3856 kilograms.

Light-duty Diesel Trucks: Emissions from diesel trucks under 3856 kilograms.

Light-duty Diesel Vehicles: Emissions from diesel vehicles under 3856 kilograms.

Light-duty Gasoline Trucks: Emissions from gasoline trucks under 3856 kilograms.

Light-duty Gasoline Vehicles: Emissions from gasoline vehicles under 3856 kilograms.

Marine Transportation: Emissions from marine craft in anchored, berth, and underway phases.

Motorcycles: Emissions from motorcycles.

Off-road use of Diesel: Emissions from off-road vehicles using diesel fuel in mining, construction, agriculture, commercial purposes, logging, railway maintenance, airport ground support, and lawn and garden equipment, along with recreational vehicles.

Off-road use of Gasoline/LPG/CNG: Emissions from off-road vehicles using gasoline, liquid petroleum gas, and compressed natural gas in mining, construction, agriculture, commercial purposes, logging, railway maintenance, airport ground support, and lawn and garden equipment, along with recreational vehicles.

Rail Transportation: Emissions from freight and passenger trains, including yard-switching activities.

Tire Wear and Brake Lining: Emissions released from tire and brake lining wear from all categories of road transportation.

<u>Industrial Non-Point Sources:</u>

Oil Sands Specific: Emissions from non-point sources specific to oil sands mining operations, including: tailings ponds, mine fleets, mine faces, and mining disturbances.

Industrial non-point sources: Emissions from non-point sources at industrial operations from various sectors (oil and gas, chemical, cement, petroleum refining, hydrocarbon storage, and transportation, etc.), including: plant fugitive leaks, materials storage and handling, non-stationary equipment, space heating, and storage tanks.

Prescribed Burning: Emissions from controlled fires used for land management treatments, specifically land-clearing for industrial oil sands development in the Lower Athabasca Air Zone.

Agriculture:
Emissions from agricultural operations and facilities, including:

- the volatilization of ammonia from nitrogen in manure, including: animal housing, transport to long-term storage, storage, and application of manure to the field;
- wind erosion and mechanical disturbances, such as seeding and tilling operations;
- the application of synthetic nitrogen fertilizers for annual and perennial crop production; and
- primarily external combustion sources used for space/water heating in agricultural facilities and for crop-drying.

Note that emissions from fuel combustion from agricultural equipment are captured under the off-road transportation categories.

Construction Operations:
Emissions resulting from soil disturbance on construction sites (residential, industrial-commercial-institutional, engineering). Emissions from fuel combustion from construction equipment are captured under the off-road transportation categories.

Road Dust:
Dust from Paved Roads: Emissions resulting from the re-suspension of particulate matter by vehicles travelling on paved roads.

Dust from Unpaved Roads: Emissions resulting from the re-suspension of particulate matter by vehicles travelling on unpaved roads.

Commercial / Residential Heating:

Commercial Fuel Combustion: Emissions resulting primarily from external combustion sources used for space/water heating in commercial establishments, health, and educational institutions and government/public administration facilities.

Residential Fuel Combustion: Emissions resulting primarily from combustion of fossil fuels used for space/water heating in residences.

Residential Fuel Wood Combustion: Emissions from burning of fuel wood and pellets for space heating and hot water. This category includes emissions from fireplaces, wood stoves, and wood-fired boilers.

2016

CASA Air Zone Region Reports

Lower Athabasca Region Air Zone

Summary of Information, Studies, Papers, and Reports of Possible Relevance to the Work of the CASA Non-Point Source (NPS) Technical Task Group Related to: Air Monitoring, Ambient Air Quality Trending, Air Dispersion Modelling, Source Characterization, and Air Emission Inventories for the Lower Athabasca Region (LAR) Air Zone

David Spink

8/26/2016

Contents

1 Context

1.1 Purpose

This document has been prepared to summarize information pertaining to Lower Athabasca Region (LAR) Air Zone and the possible significance of non-point sources (NPS) on fine particulate matter ($PM_{2.5}$) and ground-level ozone (O_3) as measured against the Canada Wide Standards (CWS) and Canadian Ambient Air Quality Standards (CAAQS).

The focus is on:

1 past and current LAR air quality assessments based on determining achievement of the CWS and CAAQS and air zone management level designations;
2 trends in LAR air quality based on ambient monitoring data;
3 air emissions inventory data and emission trends for the LAR; and
4 air modelling and source apportionment studies for the Lower Athabasca Region Air Zone.

This information can be used to assess and understand which, and how, non-point sources may be contributing to ambient concentrations of fine particulate matter ($PM_{2.5}$) and ozone (O_3) in the LAR Air Zone relative to the CAAQS and where there are gaps in information and understanding. Table 1 summarizes the CAAQS for $PM_{2.5}$ and O_3.

Table 1: The CAAQS and Associated Management Levels

Management Level	Ozone (ppb)	$PM_{2.5}$ 24 hour ($\mu g\ m^{-3}$)	$PM_{2.5}$ Annual ($\mu g\ m^{-3}$)
Effective	**2015**	**2015**	**2015**
Red	**Actions for Achieving CAAQS**		
Threshold	63	28	10.0
Orange	**Actions for Preventing CAAQS Exceedances**		
Threshold	56	19	6.4
Yellow	Actions for Preventing Air Quality Deterioration		
Threshold	50	10	4.0
Green	**Actions for Keeping Clean Areas Clean**		

1.2 Ambient Monitoring in the Lower Athabasca Air Zone

The *Alberta: Air Zones Report 2011-2013* summarizes the CAAQS achievement status and management levels for Alberta's air zones for $PM_{2.5}$ and O_3 monitoring results. Eight stations in the LAR Air Zone were used in the 2011 to 2013 assessment. These stations are located within communities or in areas accessed by members of the public. Figure 1 provides a map of the ambient monitoring stations in the LAR Air Zone used in the 2011-2013 CAAQS assessment.

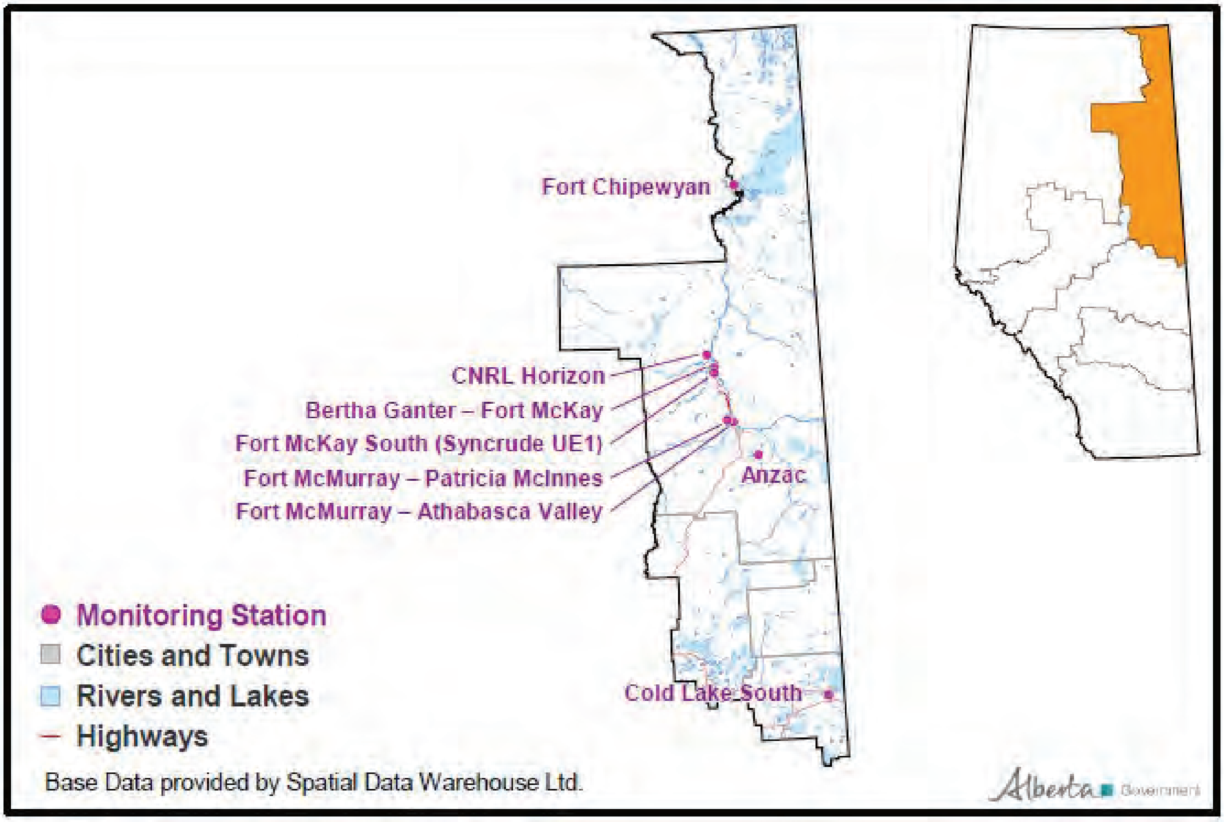


Figure 1: Ambient Monitoring Stations in the Lower Athabasca Region Air Zone used to Assess Air Zone Status relative to the CAAQS

1.3 CAAQS $PM_{2.5}$ and O_3 Assessments for the Lower Athabasca Air Zone

The Alberta: Air Zones Report 2011-2013 assigned the CNRL Horizon air monitoring station to the CAAQS orange management level, Actions for Preventing CAAQS Exceedances for $PM_{2.5}$ (3 year average of the 98th Percentile 24-Hour Average and the 3 year average of the annual average). This management level indicates that $PM_{2.5}$ concentrations are approaching the highest level of CAAQS and proactive actions are needed to prevent exceedance. Figure 2 shows the location of the CNRL Horizon air monitoring station relative to Fort McKay and some of the surrounding oil sands developments.

The LAR Air Zone air monitoring stations used to assess air quality relative to the CAAQS are listed in Table 2 along with the 2011-2013 levels for $PM_{2.5}$ (24-hour and annual) and O_3 (8-hour), and their assigned management level. If an air zone has more than one station, the highest metric value is used for comparison against the threshold values and the CAAQS to determine the management level for the entire air zone.

Note: An analysis for the 24 hour $PM_{2.5}$ and 8-hour ozone CAAQS metrics was conducted for the 2012-2014 reporting period and the results are very similar to those for the 2011-2013 period with the CNRL Horizon air monitoring station still being at the orange management level for $PM_{2.5}$ (see Tables 3 & 4).

Figure 2: The Location of the CNRL Horizon Air Monitoring Station (which triggered the orange management level under the CAAQS for the LAR) in Relation to Area Oil Sands Developments, Fort McKay, and the Fort McKay and the Syncrude UE1 Air Monitoring Stations

The CAAQS values in the Table 2 indicate that only the CNRL Horizon was in the orange level for the two $PM_{2.5}$ metrics. Table 2 also shows the CAAQS colour coding for individual years. Note that this colour coding does not indicate the CWS/CAAQS status of that station that year, but does provide an indication of that year's value relative to the CAAQS management levels. This type of analysis shows that some of the other CAAQS determination stations in the LAR Air Zone are, in some years, close to the $PM_{2.5}$-24 hour orange level of 19 µg/m³ and in some years have been above the annual orange threshold value of 6.4 µg/m³. The stations with these orange and higher yellow levels span the LAR e.g., Cold Lake, Fort McMurray, and Fort McKay/CNRL Horizon, indicating that $PM_{2.5}$ may be a LAR Air Zone, rather than a localized area issue. The LAR Air Zone levels for O_3, unlike those for $PM_{2.5}$, are almost entirely within the green level. This indicates that the focus of regional NPS management efforts should be focused on primary $PM_{2.5}$ and secondary $PM_{2.5}$ precursors.

Table 2 CAAQS Concentration Determination and Assigned Level for Noted Stations in the Lower Athabasca Air Zone*

Station	$PM_{2.5}$ -24 hr 98th %ile (µg/m³)				$PM_{2.5}$ Annual (µg/m³)				Daily Maximum 8 hour Average (ppb)			
	2011	2012	2013	**2011-13**	2011	2012	2013	**2011-13**	2011	2012	2013	**2011-13**
Anzac		9.1	8.3	**9**[1]		3.7	3.8	**3.8**[1]	50.1	50.3	53.3	**51**
CNRL Horizon	16.5	27.2	19.9	**21**	7.1	7.4	7.3	**7.3**	O_3 not monitored			
Cold Lake South	11.2		15.6	**13**[1]	5		7.1	**6.1**[1]	50.4	50.3	50.1	**50**
Fort Chipewyan	6.6	9	7.7	**8**	1.9	3.4	2.8	**2.7**	48.8	49.3	47.2	**48**
Fort McKay	17.7	17.5	15.5	**17**	5.3	6	6.8	**6**	48.5	49.3	49.3	**49**
Fort McMurray Lower Athabasca Valley	13	11	13.5	**13**	6.8	5.2	6.5	**6.2**	48.4	48.4	49.3	**49**
Fort McMurray Patricia McInnis	9	9.7	10.7	**10**	3.2	3.6	5.1	**4**	48.5	54	48.8	**50**
Fort McKay South (Syncrude UE-1)	10.2	12.5	11.8	**12**	3.8	4.8	4.8	**4.5**	48.8	49.8	49	**49**
[1] 3 years of data req'd												

*(Note: the Colour Coding in the Table for the 2011-2013 Period is the Management Level that the station falls into under the CAAQS – see Table 1. The Colour Coding for each individual year is not directly relevant to the CAAQS but is intended to depict on an annual basis where the station levels were relative to the CAAQS management levels.)

1.4 The CNRL Horizon $PM_{2.5}$ Dataset used to determine the Status of the Station Relative to the CAAQS $PM_{2.5}$ (24 hr) Metric

AEMERA (2016) provided the dataset that was used to determine the status of the CNRL Horizon air monitoring station relative to the CAAQS $PM_{2.5}$ (24 hr) metric for the period 2011-2013 and this dataset is presented in Table 3. This data provides some insights into the possible conditions and factors that contributed to the elevated $PM_{2.5}$ readings at this station that resulted in the station and the LAR Air Zone being designated as at the orange management level for $PM_{2.5}$.

The data in Table 3 would indicate that:

1. Elevated $PM_{2.5}$ levels occur throughout the year. For example, in 2011 all CAAQS determination values occurred in the July to early November period whereas in 2012 all but one of the CAAQS determination values occurred in the January to February period, and in 2013 all but two of the CAAQS determination values occurred in the summer and the other six occurred in the winter. This would indicate that while wintertime ground-level inversions likely contribute to some of the anthropogenic related elevated $PM_{2.5}$ readings at this station, there are also non-winter meteorological, emission and/or atmospheric chemistry factors that result in elevated $PM_{2.5}$ readings at this station.
2. Average daily wind speeds varied between 3 km/h and 16 km/h for the elevated $PM_{2.5}$ level days with no apparent pattern. The dataset therefore does not provide any obvious indication that wind speed is an important contributing factor to elevated $PM_{2.5}$ levels. An analysis of hourly wind speeds and hourly $PM_{2.5}$ levels for the elevated $PM_{2.5}$ level days should be undertaken to determine if there is a relationship between wind speed and $PM_{2.5}$ levels.

Table 3 shows the daily $PM_{2.5}$ levels used in the CAAQS compliance/management level determination for the period 2011-2013. It also shows data on temperature, wind speed, wind direction, and AEMERA/AEP's assessment of the cause of the elevated levels. The highlighted rows represent the 98th percentile values used to determine the status of the station. $PM_{2.5}$ as measured at Fort McKay (the next nearest AMS) is provided for comparison purposes.

Table 3: The Daily $PM_{2.5}$ Levels as Measured at the CNRL Horizon Air Monitoring Station (AMS) and Related Meteorological and Assessment Information

Year	Date	$PM_{2.5}$ Level	Temp. (°C)	Predominant Ground-Level Wind Direction	Wind Speed	Maximum Concentrations (ppb) of other Parameters that Day			Suspected Cause	$PM_{2.5}$ Level @ Fort McKay
						NO_2	NO	SO_2		
2011	27-Sep, 11	37.3 µg/m³	19°	SW	5 km/h	8	1	0	Cause: Summertime Smog	5.5 µg/m³
	16-Oct, 11	19.1 µg/m³	10°	SSW	5 km/h	14	4	5	Cause: Wintertime Smog	19.2 µg/m³
	12-Aug, 11	18.5 µg/m³	28°	WNW	3 km/h	5	6	0	Cause: Summertime Smog	7.9 µg/m³
	7-Nov, 11	17.9 µg/m³	1°	SSW	6 km/h	20	19	8	Cause: Wintertime Smog	27.4 µg/m³
	17-Oct, 11	17.6 µg/m³	11°	S	7 km/h	12	13	4	Cause: Wintertime Smog	15.9 µg/m³
	11-Jul, 11	17.3 µg/m³	26°	S	4 km/h	14	12	26	Cause: Summertime Smog	7.7 µg/m³
	8-Sep, 11	16.5 µg/m³	32°	SW	7 km/h	14	3	0	Cause: Summertime Smog	4.2 µg/m³
2012	22-Jan, 12	83.1 µg/m³	-12°	SSW	11 km/h	29	16	1	Cause: Wintertime Smog	9.7 µg/m³
	23-Jan, 12	70.5 µg/m³	-8°	SSW	11 km/h	29	12	1	Cause: Wintertime Smog	42.2 µg/m³
	21-Jan, 12	42.8 µg/m³	-12°	N	6 km/h	31	14	0	Cause: Wintertime Smog	11.9 µg/m³
	24-Jan, 12	34.7 µg/m³	-5°	S	8 km/h	27	40	1	Cause: Wintertime Smog	14.8 µg/m³
	7-Feb, 12	29.1 µg/m³	-6°	S	15 km/h	36	50	7	Cause: Wintertime Smog	10.3 µg/m³
	15-Jan, 12	27.2 µg/m³	-18°	NNW	15 km/h	8	3	2	Cause: Wintertime Smog	4.3 µg/m³
	28-May, 12	27.2 µg/m³	25°	SE	7 km/h	21	0	13	Cause: Unknown local event.	3.8 µg/m³
2013	19-Jan, 13	26.8 µg/m³	-23°	SSW & SW	3 km/h	28	9	0	Cause: Wintertime Smog	5.3 µg/m³
	7-Jan, 13	26.6 µg/m³	-7°	S	7 km/h	18	3	2	Cause: Wintertime Smog	6.8 µg/m³
	24-Aug, 13	25.6 µg/m³	27°	S	5 km/h	35	57	21	Cause: Unknown local event	11.8 µg/m³
	22-Jun, 13	21.8 µg/m³	26°	SE	9 km/h	27	16	21	Cause: Unknown local event	12.8 µg/m³
	22-Nov, 13	21.4 µg/m³	-18°	S	8 km/h	24	30	7	Cause: Wintertime Smog	7.7 µg/m³
	11-Jan, 13	19.9 µg/m³	-12°	S	10 km/h	37	53	0	Cause: Wintertime Smog	7.1 µg/m³
	21-Jan, 13	19.9 µg/m³	-21°	SSE	7 km/h	28	10	0	Cause: Wintertime Smog	8.2 µg/m³
	27-Dec, 13	19.9 µg/m³	-20°	NNE	16 km/h	1	0	1	Cause: Wintertime Smog	5.1 µg/m³

3. Wind direction during elevated events has a southerly component approximately 85% of the time. This would indicate that the CNRL Horizon project, which is to the NE of the CNRL Horizon air monitoring station, is likely not a major contributor to the elevated $PM_{2.5}$ events being measured at this station. It would also indicate that the sources contributing to elevated $PM_{2.5}$ levels at the CNRL Horizon station are located to the south of the station. Wind directions can shift during the day and ground-level wind directions may not be the same as elevated, e.g., 100 to 200m, wind directions. An analysis of hourly wind directions and hourly $PM_{2.5}$ levels for the elevated $PM_{2.5}$ level days should be undertaken to better assess the relationship between wind direction and $PM_{2.5}$ levels. This analysis should also consider ground-level versus elevated wind direction data as measured at the WBEA Lower Camp Met Station.
4. The maximum concentration of NO_2, NO, and SO_2 on the CAAQS determination value days would indicate that elevated $PM_{2.5}$ levels are generally associated with elevated NO_2 levels and, to a slightly lesser extent, associated with elevated NO levels. Elevated SO_2 levels occur during some of the elevated $PM_{2.5}$ days, but SO_2 was not present on other days. Elevated SO_2 levels are generally associated with warmer event days. Additional analysis of this data, which represents daily maximum values and may therefore not be reflective of daily average values, would need to be undertaken to assess possible linkages between the levels of these $PM_{2.5}$ precursors and the $PM_{2.5}$ levels being measured at the CNRL Horizon station. Total hydrocarbon (THC) readings should also be part of this analysis as a surrogate measure of the potential contribution of volatile organic compounds (VOC) to secondary particulate formation and levels. The time for SO_2 and NOx to form H_2SO_4 and HNO_3, and contribute to secondary particulate levels, takes hours to days. The monitored presence of precursors is therefore only relevant to co-measured $PM_{2.5}$ levels if the source of the precursors is sufficiently distant from the monitoring location to have undergone the atmospheric processing necessary to result in secondary particulate formation. This processing depends on many factors such as temperature, solar radiation and atmospheric moisture and wind speed, which determine the travel time between the emission source(s) and the downwind monitoring location.
5. $PM_{2.5}$ levels at Fort McKay for the days when there were elevated $PM_{2.5}$ levels at the CNRL Horizon station are also shown in Table 3. The Fort McKay station is the nearest monitoring station to the CNRL Horizon station (approximately 18 km to the SSE – see Figure 2). This data was included to determine if there might be a relationship between $PM_{2.5}$ levels at the two stations during elevated events at the CNRL Horizon stations. While there is no consistent relationship between $PM_{2.5}$ levels at the two stations, on several days it is clear that elevated $PM_{2.5}$ levels occur at both stations and on two of the elevated $PM_{2.5}$ days in 2011 the levels were higher in Fort McKay than at the CNRL Horizon station. This would indicate that at times the same emission sources are likely affecting both stations. The CAAQS $PM_{2.5}$ levels noted in Table 2 relative to the CNRL Horizon levels would also indicate that both stations are subject to elevated $PM_{2.5}$ levels which, based on the proximity of the two stations, suggests the likelihood that there are some common $PM_{2.5}$ source influences. For the days on which elevated $PM_{2.5}$ levels occurred at both stations the possible availability of $PM_{2.5}$ composition data at Fort McKay was ascertained (see Section 5.1). Such data could provide insights into the sources and nature of the elevated $PM_{2.5}$ levels at the CNRL Horizon since sampling for PM composition is not done at the CNRL Horizon station. Unfortunately, the sampling dates for $PM_{2.5}$ composition at Fort McKay, which is on a six-day cycle, did not coincide with any of the joint elevated $PM_{2.5}$ days noted in Table 3.

1.5 Annual Ambient Air Quality Trends in CWS/CAAQS $PM_{2.5}$ (24 hr) and O_3 Levels in the Lower Athabasca Region Air Zone

In addition to examining the most recent monitoring years, it is also important to analyze the current CAAQS determination levels in the context of data from previous years, and whether or not trends are evident. Figure 3 provides the results of a linear trending analysis of the TF/EE adjusted annual 98th percentile 24-hr $PM_{2.5}$ data for the CWS/CAAQS assessment stations in the LAR Air Zone starting in 2001, or when the station was installed, whichever is later. Figure 4 provides the results of a similar linear trending analysis of the TF/EE adjusted annual 4th highest daily maximum 8-hr O_3 concentration for the CWS/CAAQS assessment stations in the LAR Air Zone starting in 2001, or when the station was installed, whichever is later. Table 4 (TF/EE adjusted annual 98th percentile 24-hr $PM_{2.5}$ data) and Table 5 (TF/EE adjusted annual 4th highest daily maximum 8-hr O_3 concentration are the datasets used for the Figures 3 and 4 trending plots. In Table 4, there are 2 years when the datasets for that year did not meet the quality requirements to determine the CAAQS metric. These are denoted as "n/a*". For trending analysis purposes, the CAAQS value before and after the "n/a*"year were used to interpolate a value for that year.

This trending indicates a downward trend for annual 4th highest daily maximum 8-hr O_3 concentrations at all stations and a downward trend for annual 98th percentile 24-hr $PM_{2.5}$ concentrations at four stations, a near zero trend at the Syncrude UE1 and upward trends at the CNRL Horizon, Fort McKay, and Cold Lake South stations. Based on this trending analysis, $PM_{2.5}$ levels in the areas North of Fort McMurray and around Cold Lake would appear to warrant focus in terms of air quality management in the LAR Air Zone. The trends for ozone levels do not indicate any areas that warrant specific attention based on trends which, in combination with the stations all being in the green level, further confirms that ozone is not a priority in the LAR Air Zone in terms CAAQS compliance and management.

Figure 3: Plots and Linear Regression of the Annual 98th Percentile $PM_{2.5}$ Concentration CWS/CAAQS Determination Values for the LAR Air Zone (note: vertical axis scale varies between plots)

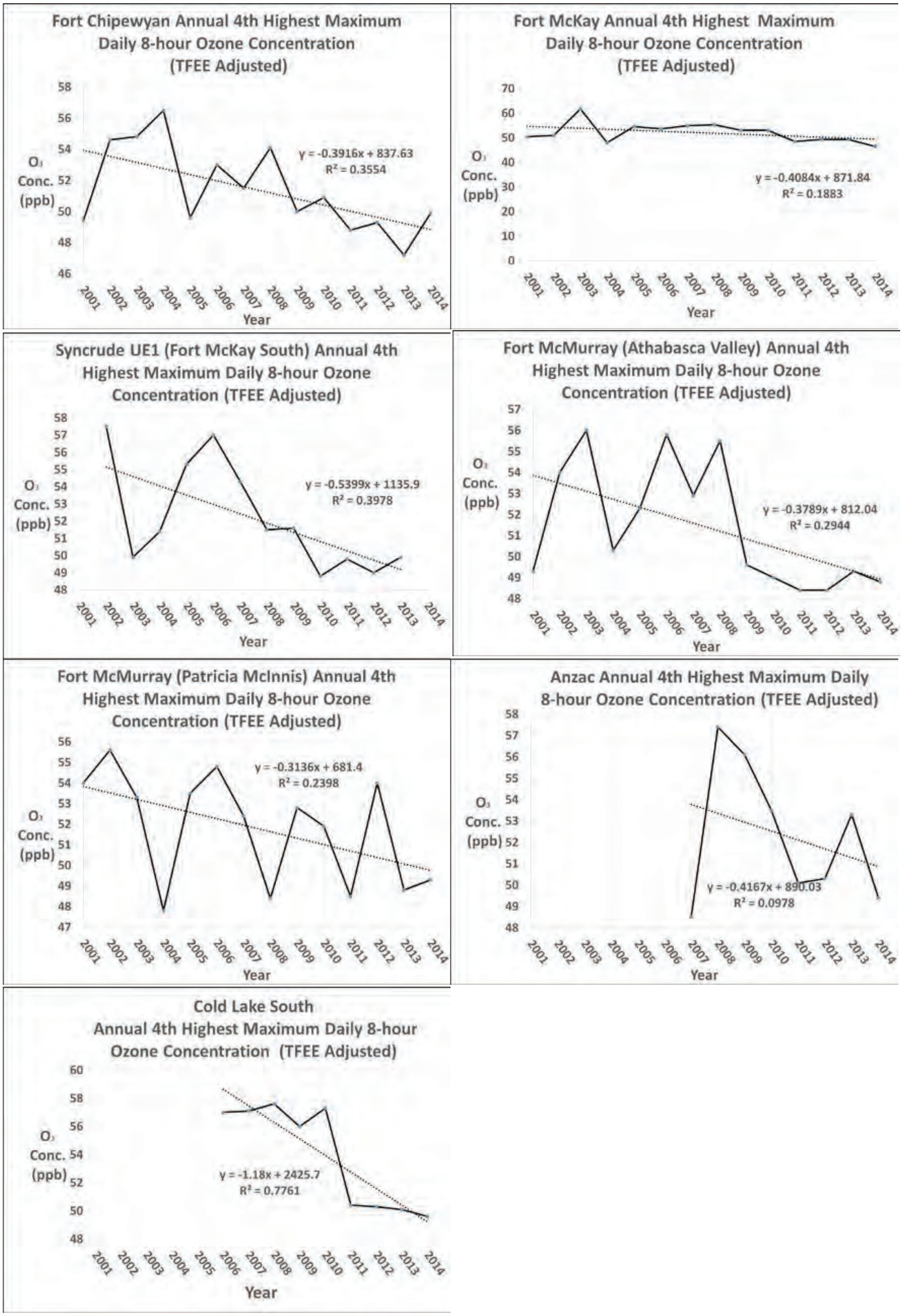


Figure 4: Plots and Linear Regression of the Annual 4th Highest Maximum Daily 8-hr Ozone Concentration CWS/CAAQS Determination Values for the LAR Air Zone (note: vertical axis scale varies between plots)

Table 4: The Annual 98th Percentile 24-hr $PM_{2.5}$ Data Used to Assess the Status of the Noted Air Monitoring Station Relative to the CWS/CAAQS Compliance/Management Levels

Station	One-year 98th percentile Daily $PM_{2.5}$ Averages – After TF/EE Removal													
	Yearly Values Calculated according to CWS										Yearly Values Calculated according to CAAQS			
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Anzac	No data						13.7	9.7	11.5	13.5	n/a*	9.1	8.3	10.5
CNRL	No data							17.8	15.4	16.4	16.5	27.2	19.9	19.8
Cold Lake S	No data					11	9.2	9	14.8	16.9	11.2	n/a*	15.6	15.3
Fort Chip	7.6	11	7.8	13.6	12.2	10.5	10.2	14.6	8.1	8.3	6.6	9	7.7	10.2
Ft. McMurray Athabasca Valley	17.5	16.2	11.3	11.1	12.7	15	14.2	16	14.3	11.1	13	11	13.5	15.3
Fort McKay	14.6	12.7	14.8	9.4	12.5	13.3	14.6	14.4	13.6	13.3	17.7	17.5	15.5	14
Ft. McMurray Patricia McInnis	14.3	14.2	11.6	11.4	9.4	13.1	13.2	13.3	13.2	11.6	9	9.7	10.7	12.8
Syncrude UE1	No data	10.9	12.8	13.5	13	13.3	12.1	12.5	13	14.1	10.2	12.5	11.8	11.1

Table 5: The Annual 4th Highest Daily Maximum 8-hour Average Ozone Concentration Used to Assess the Status of the Noted Air Monitoring Station Relative to the CWS/CAAQS Compliance/Management Levels

Station	Annual 4th highest daily maximum 8-hr ozone concentration – After TF/EE Removal													
	Yearly Values Calculated according to CWS										Yearly Values Calculated according to CAAQS			
	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Anzac	No data						48.5	57.4	56.1	53.5	50.1	50.3	53.3	49.4
CNRL Horizon	No data													
Cold Lake S	No data					57	57.1	57.6	56	57.3	50.4	50.3	50.1	49.6
Fort Chipewyan	49.4	54.6	54.8	56.5	49.6	53	51.5	54.1	50	50.9	48.8	49.3	47.2	49.9
Ft. McMurray Athabasca Valley	49.3	54	56	50.3	52.3	55.8	52.9	55.5	49.6	n/a*	48.4	48.4	49.3	48.8
Fort McKay	50.4	50.9	61.7	48	54.6	53.6	54.9	55.3	53	53	48.5	49.3	49.3	46.5
Ft. McMurray Patricia McInnis	54	55.6	53.3	47.8	53.5	54.8	52.4	48.4	52.8	51.9	48.5	54	48.8	49.3
Syncrude UE1	No data	n/a*	57.5	49.9	51.4	55.3	57	54.3	51.5	51.6	48.8	49.8	49	49.9

2 Non-Point Emission Sources and LAR Emissions Inventories in the LAR Air Zone

2.1 Alberta Non-point Sources

AEP 2016b lists the following industrial and non-industrial sources as the major NPS types in Alberta.

Industrial Non-point Sources

- Plant fugitive leaks;
- Liquid tailings ponds;
- Mine fleets;
- Mine faces;
- Solid mine tailings;
- Materials storage and handling;
- Non-stationary equipment;
- Space heating; and
- Storage tanks.

Non-industrial, Non-point Sources

- Road dust (unpaved and paved roads);
- Construction (industrial, transportation, municipal, residential, and communications);
- Agriculture (agricultural animals, fertilizer application, harvesting, tilling, and wind erosion); and
- Transportation (on-road vehicles, off-road vehicles, and rail transportation).

For the LAR, CEMA (2015) undertook a detailed estimate of all regional emissions to support CMAQ and CALPUFF modelling as part of implementation of the CEMA Ozone Management Framework (OMF) (CEMA, 2006), the CEMA Acid Deposition Management Framework (ADMF) (CEMA, 2005) and the CEMA Interim Nitrogen Management Framework (INMF) (CEMA, 2008). This emission inventory work included sections on fugitive emissions, which included VOC speciation. The following categories and sub-categories of fugitive emission sources s associated with industrial and non-industrial development in the LAR were evaluated and assigned emission estimates.

- ***Industrial***
    - Mine faces;
    - Mine Fleets;
    - Tailings ponds; and
    - Plant facilities which were subcategorized as follows;
        - Integrated Extraction and Upgrading Facilities,
        - Extraction Plants,
        - In situ Plants,
        - Gas Processing Plants, and
        - Others (e.g. terminals).

Non-Industrial

- Community sources which were subcategorized as follows;
    - Residential and commercial sources, and
    - Traffic sources.
- Aircraft emissions

Note: Dust sources were not specifically addressed in the CEMA inventory and it appears that sources like prescribed burning were also not considered.

2.2 Relative Significance of Different Sources to NPS Emissions in the Lower Athabasca Region Air Zone

Figure 5 (AEP 2016b) provides the relative fractional estimates of the contribution of different sources to primary $PM_{2.5}$, VOC, NOx, and SO_2 emissions in the LAR. In this figure, the "other sources" include all other source categories, each of which individually contributed to less than 5% of the region's emissions total of the particular pollutant.

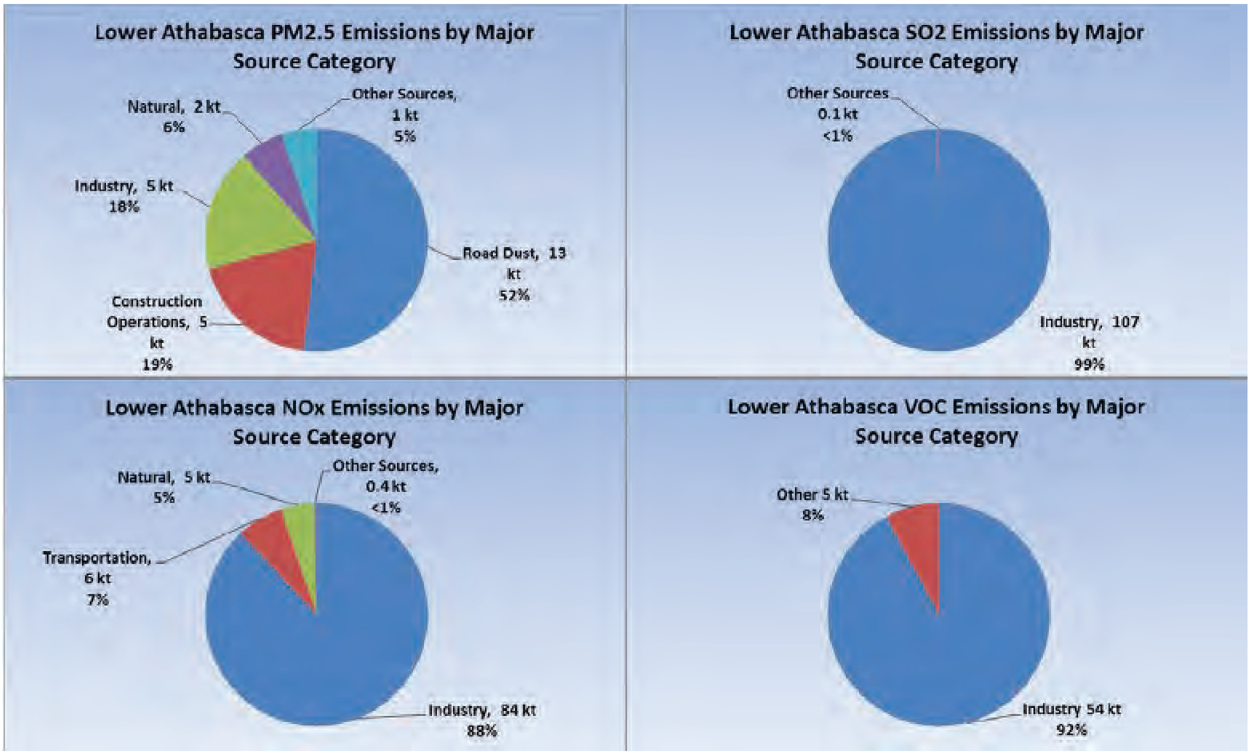


Figure 5: Relative Contribution of Different Emissions Source Types to Primary $PM_{2.5}$, VOC, NOx, and SO_2 Emissions in the LAR Air Zone

Figure 6 was generated by using the CEMA (2015) emission inventory data, which shows the percentage of different emission parameters attributable to NPS in the LAR Air Zone. This chart is generally consistent with the data in Figure 5, but provides an indication of the amount of the industry source in Figure 5 that is NPS, i.e., not associated with stack emissions. It needs to be noted again that in Figure 6 the $PM_{2.5}$ estimates may not include, or only partially include, dust emissions. In addition, these emission estimates do not include natural VOC emissions, which, based on the data in Table 6, are estimated to represent 91% of total LAR VOC emissions.

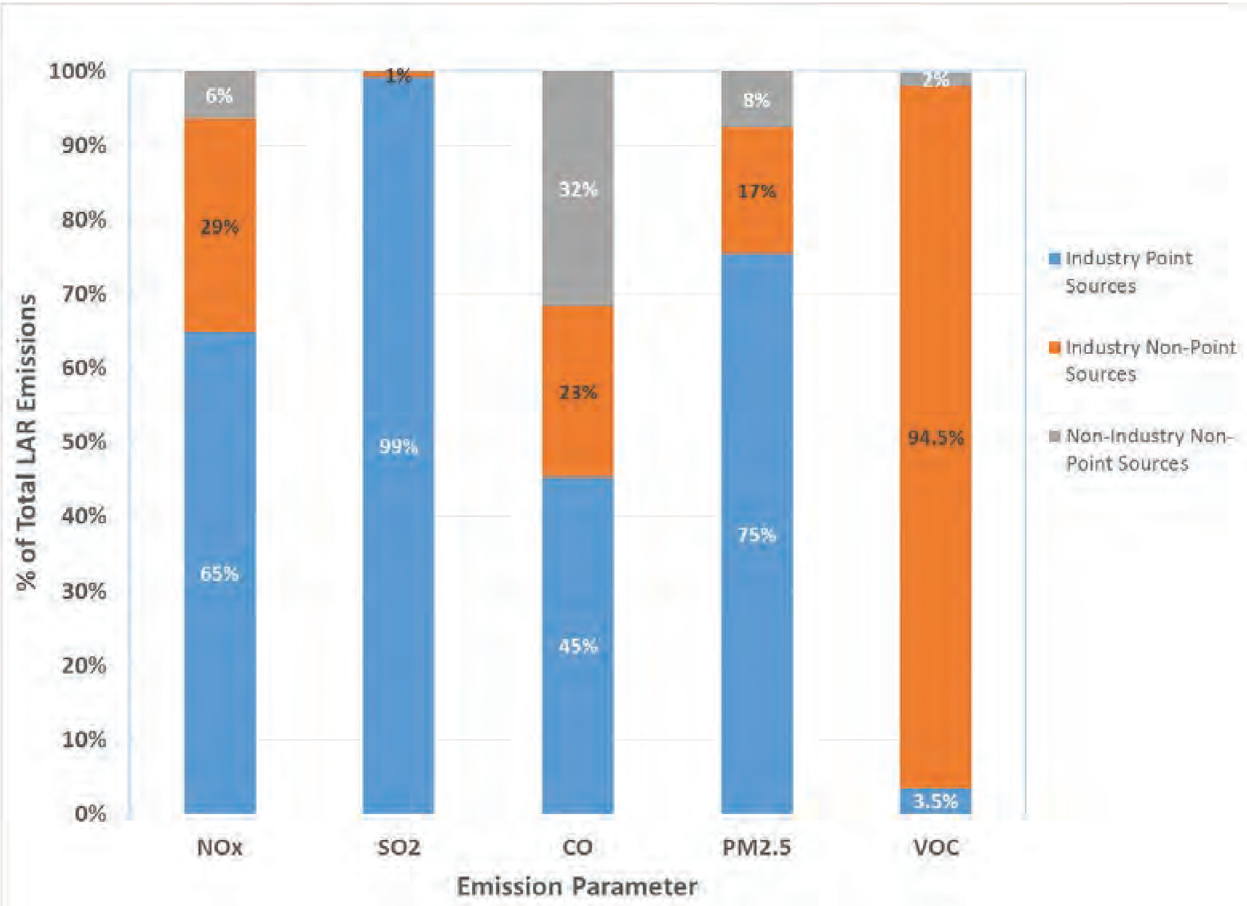


Figure 6: Relative Contribution of Industrial and Non-Industrial Non-point Sources to Total Primary $PM_{2.5}$, VOC, NOx, and SO_2 Emissions in the LAR Air Zone

2.3 Emission Inventories in the LAR

There is no "formal" officially recognized emission inventory for the LAR Air Zone, and a number of emission inventories have been development, generally, to support EIA related modelling or focused assessments. The following is a summary of some of the emission inventory data for the LAR that may be relevant to the management of ambient $PM_{2.5}$ and O_3 levels in the LAR.

Emission inventory data by sector and region for primary PM, NOx, SO_2 and NH_3 is based on the 2008 Alberta Air Emissions Inventory found in the Alberta: Air Zones Report 2011-2013. Table 6 summarizes the emission inventory for the LAR Air Zone from this report.

This inventory would indicate that oil sands and conventional oil and gas combined are either the major source, or a large contributing source, of primary $PM_{2.5}$, SO_2, NOx, VOC, and NH_3 emissions in the LAR Air Zone. However, road dust and construction are the major primary $PM_{2.5}$ sources and natural sources are the major VOC emission source.

Table 6: Breakdown by Sector/Source of Emissions of Noted Parameters in the LAR Air Zone (AEP 2016a)

Sector/Source	Emissions of Noted Parameter in the Lower Athabasca Region by Sector (tonnes)									
	Primary $PM_{2.5}$	% of Total	SO_2	% of Total	NOx	% of Total	VOC	% of Total	NH_3	% of Total
Agriculture	214	1%	0	0%	0	0%	831	0%	757	36%
Cement and Concrete	26	0%	0	0%	0	0%	0	0%	0	0%
Chemical	0	0%	0	0%	0	0%	0	0%	0	0%
Construction	4,853	19%	0	0%	11	0%	0	0%	0	0%
Conventional Oil and Gas*	329	1%	324	0%	18,601	20%	7,103	1%	221	10%
Electrical Power Generation	56	0%	5	0%	1,355	1%	41	0%	2	0%
Fertilizer	0	0%	0	0%	0	0%	0	0%	0	0%
Oil Sand	3,848	15%	106,893	99%	62,203	65%	45,900	7%	997	47%
Pulp and Paper	0	0%	0	0%	0	0%	0	0%	0	0%
Road Dust	13,282	52%	0	0%	0	0%	0	0%	0	0%
Transportation	267	1%	101	0%	6,402	7%	2,079	0%	82	4%
Wood Products	0	0%	0	0%	0	0%	0	0%	0	0%
Other Sources	1,012	4%	162	0%	1,651	2%	2,829	0%	18	1%
Non-Industrial Sources	113	0%	45	0%	222	0%	127	0%	2	0%
Natural Sources	1,592	6%	1	0%	4,551	5%	568,480	91%	40	2%
Total	25,592	100%	107,531	100%	94,996	100%	627,390	100%	2,119	100%

*Conventional oil and gas includes both upstream and downstream oil and gas.

As noted above, to support modelling of acid deposition, ozone formation, and nitrogen deposition, CEMA had a contractor prepare a detailed emission inventory for the LAR (CEMA, 2015). The work involved developing four emission inventories for the following periods:

- An historical period (~1994);
- A current period (~2010);
- A future case 1 (~2025/30); and
- A future case 2 (~2040/45).

The emission sources included in the inventory were:

- Stacks;
- Fugitive plant emissions;
- Mine fleets;
- Fugitive mine face;
- Fugitive tailings;
- Non-industrial community heating and community traffic; and
- Non-industrial highway traffic.

The industry related emission data is based on what were determined to be the most reliable and representative estimates of past, current, and future emissions and therefore is considered to represent the best available estimate of industrial emissions. However, the non-industrial community heating and community traffic emissions, and the highway traffic emissions, are based on previous EIA values, use 2006 data, and are therefore dated. The emission inventories from this project are presented in the following four tables.

Table 7: Historical Case LAR Emissions (circa 1994)

Source Type	Emission Rate (t/d)				
	NO_X	SO_2	CO	$PM_{2.5}$	VOC
Stacks – Oil Sands	33.11	402.97	77.17	4.64	0.39
Stacks – Others	74.37	2.16	61.22	1.01	4.23
Plant Fugitives	0.00	0.00	0.00	0.00	23.47
Mine Fleet	25.90	1.140	6.80	0.63	1.17
Mine Face	0.00	0.00	0.00	0.00	4.17
Tailings Management Areas	0.00	0.00	0.00	0.00	98.38
Non-Industrial	23.56	0.76	79.28	1.86	5.77
Historical Case Total	**156.94**	**407.03**	**224.47**	**8.14**	**137.58**
Note: The tailings pond VOC emissions are likely overstated by a factor of two due to the estimation approach adopted by the early assessments.					

Table 8: Existing Case LAR Emissions (circa 2010)

Source Type	Emission Rate (t/d)				
	NO_X	SO_2	CO	$PM_{2.5}$	VOC
Stacks – Oil Sands	115.87	315.07	68.13	9.42	3.58
Stacks – Others	74.37	2.16	61.22	1.01	4.23
Plant Fugitives	0.00	0.00	0.00	0.00	41.22
Mine Fleet	106.39	2.041	48.77	2.86	6.99
Mine Face	0.00	0.00	0.00	0.00	10.01
Tailings Management Areas	0.00	0.00	0.00	0.00	26.67
Non-Industrial	23.56	0.76	79.28	1.86	5.77
Existing Case Total	**320.19**	**320.03**	**257.40**	**15.15**	**98.47**

Table 9: Future Case 1 LAR Emissions (circa 2025/30)

Source Type	Emission Rate (t/d)				
	NO_X	SO_2	CO	$PM_{2.5}$	VOC
Stacks – Oil Sands	275.19	283.12	317.20	18.15	10.27
Stacks – Others	75.60	2.27	63.29	1.01	4.25
Plant Fugitives	0.00	0.00	0.00	0.00	102.06
Mine Fleet	150.28	3.65	171.41	1.99	7.35
Mine Face	0.00	0.00	0.00	0.00	33.23
Tailings Management Areas	0.00	0.00	0.00	0.00	85.87
Non-Industrial	20.72	0.72	108.04	1.90	5.96
Future Case 1 Total	**521.79**	**289.76**	**659.94**	**23.05**	**248.99**

Table 10: Future Case 2 LAR Emissions (circa 2040-45)

Source	**Emission Rate** (t/d)				
	NO_X	SO_2	CO	$PM_{2.5}$	VOC
Stacks – Oil Sands	329.00	305.80	379.86	21.57	13.22
Stacks – Others	75.60	2.27	63.29	1.01	4.25
Plant Fugitives	0.00	0.00	0.00	0.00	114.52
Mine Fleet	142.54	2.74	159.15	2.13	8.60
Mine Face	0.00	0.00	0.00	0.00	30.83
Tailings Management Areas	0.00	0.00	0.00	0.00	96.33
Non-Industrial	20.72	0.72	108.04	1.90	5.96
Future Case 2 Total	**567.86**	**311.53**	**710.34**	**26.61**	**273.71**
Note: The Future Case 2 mine face emissions are less than the Future Case 1 values because some mines are projected to close down for the Future Case 2.					

The above two emission inventories for oil sands emissions i.e., Alberta Government and CEMA, are generally similar for the present case, with the greatest difference between NOx and VOC emission estimates as Table 11 below indicates.

Table 11: Comparison between CEMA and Government of Alberta LAR Emission Inventories

Data Source and Emission Type(s)	Parameter and Emissions (tonnes/d)			
	NO_X	SO_2	$PM_{2.5}$	VOC
Oil Sands Total (~2010)(CEMA, 2015)	222	317	12	88
Oil Sands Emissions (2008) (Alberta Government, 2016)	170	293	11	126

The data from the CEMA (2015) inventory, which provides a breakdown of oil sands emissions, is very useful in terms of assessing the magnitude of oil sands non-point sources relative to both point sources and also to non-industrial emissions, which are all non-point sources i.e., highway and community traffic and community heating.

2.4 Emission Trends

The data from the CEMA (2015) inventory can be used to provide an indication of possible expected primary $PM_{2.5}$, SO_2, NOx, CO, and VOC emission trends in the LAR over the next 25 to 30 years. These trends are plotted in Figure 7. Non-industry NPS emissions were not included in these plots because the emission inventory assumed no or little change in non-industry NPS emissions between 1994 and 2040-2045.

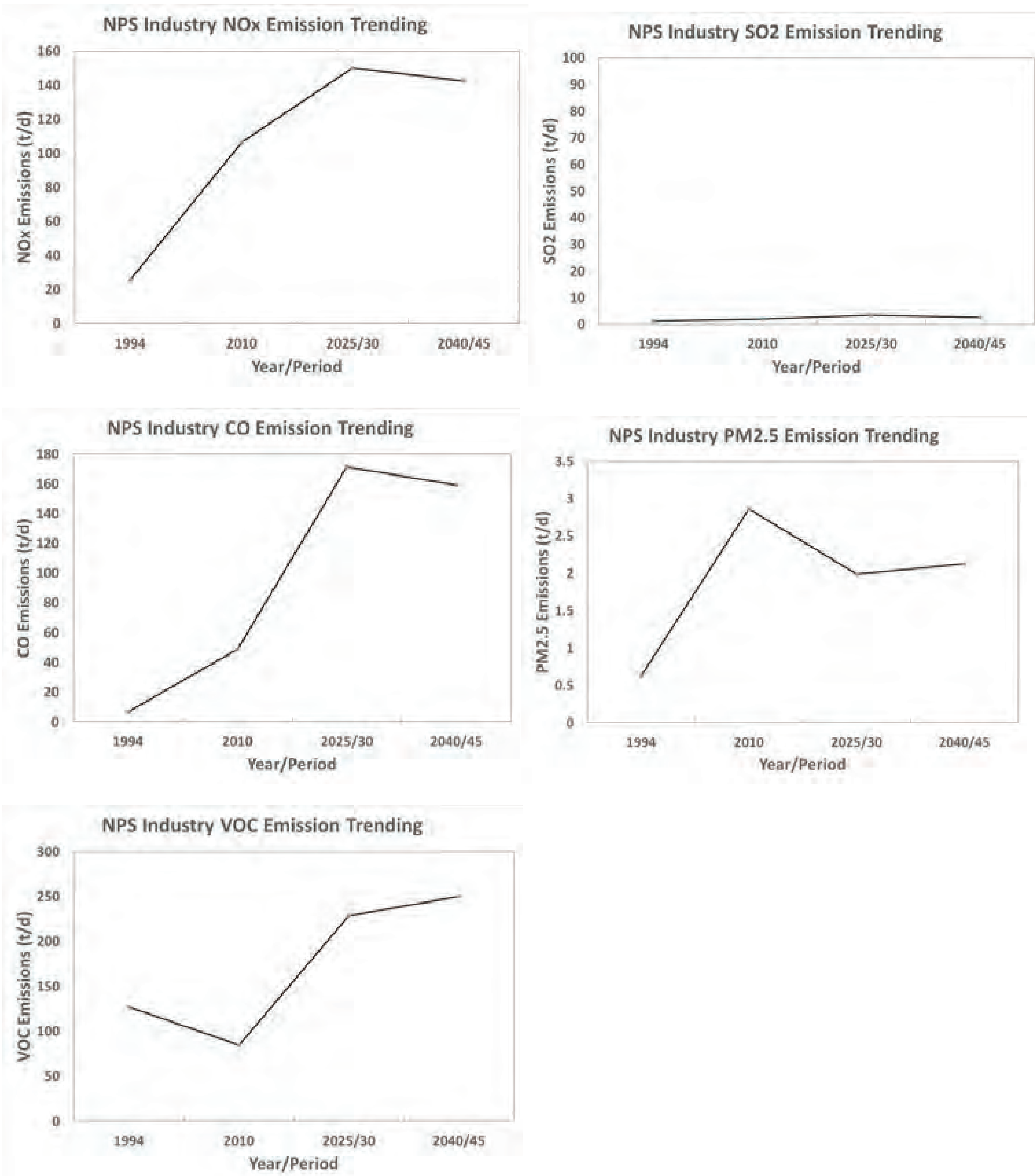


Figure 7: Predicted Trends in Industry related NPS Emissions based on CEMA (2015) Data

2.5 Summary

The above inventory data and trending provide the following information regarding possible NPS of interest in terms of air quality impacts in the LAR Air Zone.

- **VOCs** – anthropogenic VOC sources are largely associated with NPS and represent ~85-95% of LAR Air Zone anthropogenic VOC emissions. These emissions are expected to increase. The major emission sources of VOCs in the LAR Air Zone are however biogenic, and the significance of anthropogenic VOC emissions as $PM_{2.5}$ and O_3 precursors needs to be assessed to determine if management of anthropogenic NPS VOC emissions would significantly impact regional $PM_{2.5}$ and O_3 levels).
- **NOx** – NPS represent ~35-40% of LAR Air Zone NOx emissions with approximately 80% of these NPS NOx emissions associated with oil sands mining fleets, and approximately 20% associated with highway and community traffic and community heating. Emission levels from these sources are expected to increase.
- **SO_2** - SO_2 emissions are almost exclusively from stack sources and NPS contribution to LAR Air Zone SO_2 emissions is negligible at approximately 1%.
- **Primary $PM_{2.5}$** – NPS represent ~25-33% of primary $PM_{2.5}$ emissions in the LAR Air Zone with 67% of these emissions from the oil sands and 33% from highway and community traffic and community heating. **However** these figures, which are largely based on the CEMA (2015) inventory, do not include primary $PM_{2.5}$ emissions associated with road dust and construction activities which, based on the Government of Alberta estimates, represent approximately 75% of total LAR Air Zone primary particulate emissions (see Table 6) Primary $PM_{2.5}$ levels are predicted to decline.
- **CO** – NPS represent ~55% of LAR Air Zone CO emissions with 40% of these emissions from oil sands mining fleets and 60% from highway and community traffic and community heating. Regional emission levels are projected to increase.

3 Non-Point Emission Source Studies, Uncertainties, and Needs

LAR Air Zone inventories, and their uses and limitations, have been discussed in a number of reports and presentations with the general conclusion being that emission estimates for most sources are subject to variability and uncertainty, and are in large part based on professional judgement and emission factors that have often had limited validation (CEMA, 2012; Marson, 2015; CEMA, 2016). The following is a brief summary of some of the recent work related to LAR Air Zone emission sources, with an emphasis on the work's relevance to the CASA NPS Project.

3.1 Tailings Ponds and Mine Faces

1. The "Joint Canada Alberta Oil Sands Monitoring Program" (JOSM) (Government of Canada and Alberta Government, 2012) identified tailings ponds as an emission source that required additional study. Mine faces were identified as another one of the many oil sands sources of emissions. In general, tailings pond emissions have received more attention and study than mine faces. This is likely due, in part, to the challenges of conducting mine face monitoring, which include the continuous temporal and spatial changes associated with mining activities.
2. The possibility of polycyclic aromatic hydrocarbon (PAH) emissions from tailings ponds has been studied (Galarneau, Hollebone, Yang, & Schuster, 2014). It was concluded that tailings ponds could represent an important PAH emission source to the atmosphere and one that is missing from current inventories in the LAR Air Zone.

3. Environment Canada conducted aircraft based oil sands plume monitoring and determined that VOC emissions from mines, as opposed to tailings ponds, may be a more important contributor to secondary $PM_{2.5}$ formation downwind of mining operations (Stroud, et al., 2015).
4. A recent review of tailings ponds emissions (Small, Cho, Hashisho, & Ulrich, 2015) presents current knowledge on factors and parameters influencing emission estimates, and identifies challenges pertaining to the development of current emissions factors. It recommends improvements in emission measurement and calculation methods; better sampling; and increased research to develop a more accurate and representative understanding of emissions from oil sands tailings ponds.
5. It has been speculated, based on regional air quality monitoring data, that tailings ponds may be a source of NH_3 emissions (study proposal from Dr. Watmough, Trent University, January 2016). While oil sands may be a major regional source of NH_3 emissions, it has been noted that there is limited information on oil sands related NH_3 emissions other than from some specific sources and since NH_3 is an important contributor to total nitrogen deposition (and to secondary PM formation) these emissions need to be investigated (Vijayaraghavan, et al., 2014).
6. The Government of Alberta has a directive (GoA, 2014) that provides a standard minimum procedure for flux chamber measurements to quantify area fugitive greenhouse gas emissions from mine faces and tailings ponds at oil sands mines. This directive is used by operators for reporting under the Specified Gas Emitters Regulation (Province of Alberta, 2015) and Specified Gas Reporting Regulation (GoA 2015b). Some data from this reporting is publically available and provides detailed quantification and characterization information on tailings pond and mining area fugitive emissions. However, the monitoring method prescribed in the directive i.e., flux chambers, has temporal and spatial limitations and therefore there is a high degree of uncertainty associated with these emission estimates. Also these monitoring requirements only apply to GHGs and therefore the characterization and monitoring related to the quantification of tailings ponds and mine emissions that are relevant to $PM_{2.5}$ and O_3 formation is at the discretion of industry and/or government, and no formal requirements have been established.
7. To address the many issues associated with tailings ponds and mine emissions, a committee under AEMERA was formed to develop a 3-year fugitive emission monitoring plan for oil sands mines and tailings ponds. The plan has 2 initiatives currently underway, namely:
    a. A contract was issued to a consortium of 3 consultants to provide a comprehensive "state-of-knowledge" report on mine and tailings pond fugitive emissions (i.e., GHGs, volatile organic compounds [VOCs], reduced sulphur compounds [RSCs], polycyclic aromatic compounds [PACs], inorganic pollutants, semi-volatile organic acids, primary particulate matter, and ammonia [NH_3]). The report is to include a compilation of current tailings pond and mine face emissions data and related sampling/monitoring program information from publically available sources. The intent is that this work will establish a baseline fugitive emissions report and the associated inventory will represent the current state-of-knowledge of gaseous compound emissions. The report from this work should be available in the summer of 2016.
    b. A comprehensive fugitive emissions monitoring program at Suncor's tailings pond 2/3 that will involve an evaluation and comparison of a number of area source and/or flux monitoring methods such as Eddy Covariance, Relaxed Eddy Accumulation, OP-FTIR, DIAL and Gradient Fluxes- Inverse Dispersion methods. The results from this monitoring will be

compared to flux chamber measurements that will be taken at the same time. Results from this monitoring are expected in the spring/summer of 2017. The plan is to possibly conduct similar monitoring at one or more mines in 2017.

3.1.1 Conclusion

There is currently considerable uncertainty around the composition and quantity of tailings pond and mine emissions. As VOC emissions can contribute to secondary $PM_{2.5}$ and O_3 formation, and since tailings ponds and mines are a large source of NPS anthropogenic VOC emissions, obtaining estimates of tailings pond and mine emissions is important in order to inform air quality management in the LAR Air Zone.

NH_3 can also be an important factor in secondary $PM_{2.5}$ formation, so it is also important to identify and quantify emission sources of this compound. Work is currently underway to address the emission gaps related to tailings ponds and mines. A possible action by the CASA NPS Task Group would be to highlight the need for good industrial NPS fugitive emission data from tailings ponds and mines and to endorse/support the current work on this issue being undertaken by Alberta and Parks' (AEP) Science and Monitoring Division (formerly AEMERA). Another recommendation could be that further work be undertaken in order to better understand the potential for $PM_{2.5}$ formation downwind of mines and tailings ponds VOC emissions. This issue is discussed further in Section 5.6.

3.2 Plant Fugitive Emissions

1. Plant fugitive emissions were assessed and estimated by CEMA (2015). Plant fugitive emissions were attributed to leaks from valves, flanges, shaft seals, and open ended lines, from vents and evaporation losses from open-top sumps and process vessels and hydrocarbon storage facilities (i.e., fuel, diluent, or final product storage tanks), and from hydrocarbon stream handling, and treatment and processing areas, which individually might be relatively quite small, but collectively very large. The CEMA (2015) VOC emissions estimates presented in Tables, 8, 9, and 10 indicate that plant fugitive VOC emissions are estimated to be greater than VOC emissions from tailings pond management areas and are very similar in magnitude to the combined estimated VOC emissions from tailings ponds and mine faces.
2. A recent draft of the report from the AEMERA contract referred to in point 7a. above, under "Tailings Ponds and Mine Faces," discusses the method(s) used to estimate plant fugitive emissions at mining facilities (Stantec Consulting Ltd., Clearstone Engineering Ltd. and Intrinsik Environmental Sciences Inc., 2016). The conclusion is that Leak Detection and Repair (LDAR) programs are being used to estimate plant fugitive VOC emissions and the report notes that: "While an LDAR program's primary objective is to find and prioritize the repair of fugitive equipment leaks (i.e., "leakers"), it is not clear that the LDAR approach can provide reliable quantification or characterization of fugitive emission rates (page 3.2)."
3. A recent oil sands project EPEA approval renewal for CNRL Horizon (August 5, 2015), included the following clauses that address both LDAR and actual emissions monitoring:
   - The approval holder shall submit an updated Fugitive VOC Emissions and Leak Detection and Repair Program (previously Fugitive Emissions Leak Detection and Correction Program) to the Director by August 5, 2016, unless otherwise authorized in writing by the Director.

     And

- The approval holder shall submit an updated VOC and RSC Emissions Monitoring Plan (previously VOC/TRS Monitoring Plan) to the satisfaction of the Director to quantify and characterize the emissions of VOCs (including PAHs) and RSC compounds from fugitive and point sources, unless otherwise authorized in writing by the Director.

- The recent Husky Sunrise project EPEA renewal (January 25, 2016) however did not have any conditions related to LDAR or quantifying or characterizing fugitive plant emissions.

4. This review found no specific studies on the quantification and/or characterization of total plant fugitive emissions. The comprehensive fugitive emission monitoring program planned for summer 2016 at Suncor's tailings pond 2/3 (point 7b. above, under "Tailings Ponds and Mine Faces") will involve an evaluation of some monitoring methods that may have application in conducting integrated plant fugitive emission monitoring e.g., Open Path Fourier Transform Infrared Spectroscopy (OP-FTIR), Mobile Flux Tower and Inverse Dispersion Flux Modelling, and Differential Absorption Light Detection and Ranging (DIAL). Integrated fugitive plant site monitoring was undertaken at a refinery in the Edmonton area using DIAL technology (Chambers & Strosher, 2006) with the results indicating that plant VOC fugitive emissions might be higher than assumed/estimated.

3.2.1 Conclusion

Plant wide oil sands facility fugitive emissions are estimated to represent a large fraction of total oil sands development VOC emissions. However, there has been no monitoring specifically directed at quantifying and characterizing oil sands plant site fugitive emissions on an integrated basis. This means that there is a great deal of uncertainty around fugitive emissions from oil sands facilities and whether or not current management approaches to minimize these emissions e.g., LDAR, are achieving their intended/expected results. In addition, there does not appear to be consistency in terms of the fugitive monitoring requirements being applied to oil sands operations. As with tailings ponds and mine faces, plant fugitive VOC emissions may contribute to secondary $PM_{2.5}$ and O_3 formation, and since plant fugitive emissions appear to be a large source of NPS anthropogenic VOC emissions, getting reliable estimates of plant fugitive emissions is important in order to inform air quality management in the LAR Air Zone. As NH_3 can be an important factor in secondary $PM_{2.5}$ formation, it is also important to identify emission sources of this compound and the possible significance of plant fugitive emissions as a contributor to regional NH3 emissions should be assessed. A possible action by the CASA NPS Task Group would be to highlight the need for integrated plant-wide NPS fugitive emission monitoring data to determine how significant plant sites are in terms of VOC and NH_3 emissions. Another recommendation could be that further work be undertaken to better understand the potential for $PM_{2.5}$ formation downwind of plant sites.

3.3 Mine Fleet Emissions

1. In the LAR Air Zone, oil sands mine fleets currently represent a large source of NOx (33%), CO (19%), $PM_{2.5}$ (19%), and VOC (7%) emissions (Table 8). The CEMA (2015) emission inventory discusses the basis for its mine fleet emission estimates, which involves the use of the USEPA NONROAD Model (https://www3.epa.gov/otaq/nonrdmdl.htm#epanonroad) and assumptions regarding the transition of existing fleet units to newer units that are required to meet more stringent emission limits.

2. To determine if the mine fleet emission estimates being calculated /estimated were representative of actual real world mine fleet emissions the WBEA retained the Desert Research Institute (University of Nevada) to conduct monitoring of emissions from in-use heavy haulers. Results from this work (Watson, et al., 2011; Wang, et al., 2015), which was conducted in 2009 and 2010, are summarized in Table 12. This data indicates that the estimates of CO, VOC, and $PM_{2.5}$ emissions for CAT 797B heavy hauler units may be much higher than actual emissions whereas NOx emission estimates agree closely with measured emissions. A Liebherr T282B heavy hauler was also monitored in 2010 and had higher emissions than the CAT 797B units for CO (3.1–5.0 times), $PM_{2.5}$ (1.1–1.7 times), and NOx (2.2–2.4 times) but lower NMHC than all but one of the CAT 797B units (Watson, et al., 2011).

Table 12: Comparison of Estimated versus Measured Emissions from CAT 797B Heavy Hauler (average 4 haulers) (Wang, et al., 2015)

Species	USEPA NONROAD Estimation Method (t/unit/yr)	Measured Emissions (t/unit/yr)	% Difference ([Estimated - Measured]/Measured)
CO	121.7	19	541%
NMHC (Non-methane hydrocarbon)*	13.9	1.3	969%
NOx	98.2	91.8	7%
PM2.5	5.8	1.2	383%
* Provides an indication of VOC emissions)			

3. Since NOx is the major emission associated with mine fleets, and is a precursor for both $PM_{2.5}$ and O_3 formation, a brief assessment of NOx emission controls that apply to mine fleets is included in this review. NOx emissions for heavy haulers in Canada (Environment Canada, 2015) are based on USEPA Regulations (USEPA, 2016) established in 2004. The USEPA Tier 4 NOx emission limit for vehicles greater than 750 hp that apply to new vehicles after 2015 is 2.6 g NOx/hp-hr (note: this size category includes heavy haulers, which are in the ~2500-3500 hp range). For vehicles less than 750 hp, the NOx limit is 0.3 g NOx/hp-hr.

In setting NOx limits for >750 hp mobile units the USEPA (USEPA, 2004) noted that:

> … the magnitude of NO_X reductions determined in the final rule analysis is somewhat less than what was reported in the proposal's preamble and RIA, especially in the later years when the fleet has mostly turned over to Tier 4 designs. The greater part of this is due to the fact that we have deferred setting a long-term NO_X standard for mobile machinery over 750 horsepower to a later action. When this future action is completed, we would expect roughly equivalent reductions between the proposal and the overall final program, though there are some other effects reflected in the differing NOX reductions as

well, due to updated modeling assumptions and the adjusted NO_X standards levels for engines over 750 horsepower.

- The USEPA also noted that:
  - The long-term NO_X standard for engines not used in generator sets (mobile machinery) will be addressed in a future action (we are currently considering such an action in the 2007 time frame).
- This action did not occur with the result that much less stringent NOx emissions are being applied to NOx emissions from heavy haulers than for off road diesel engines less than 750 hp in size.
- Environment Canada had a study conducted in 2008 looking at retrofit possibilities for heavy haulers (M. J. Bradley and Associates, 2008). The following is an excerpt from that report:

> The authors could not uncover evidence of prior retrofit activity on large mining trucks, but many of these technologies, in particular SCR in combination with a DOC or DPF, have previously been applied to many diesel engines greater than 2,000 hp used for stationary power generation, and to power marine vessels and locomotives. Virtually all of these technologies are considered technically viable for application to large mining trucks. In addition, at least one engine manufacturer is already conducting validation tests of new, cleaner replacement engines installed in older mining trucks used in Alberta.
>
> The application of these technologies to large mining trucks could provide significant and cost effective reductions of both NOx and PM from the oil sands mining truck fleet. The authors investigated two retrofit/upgrade scenarios that can reduce NOx emissions by 40% or more compared to projected 2015 baseline levels. Under these scenarios, total NOx emissions from the mining truck fleet could be reduced by 40,000 – 65,000 tonnes and total PM emissions could be reduced by 700 – 2,500 tonnes over a 12 year period from 2012 to 2024, compared to projected baseline emissions. The net present value of total costs over the same time period (capital and on-going operating costs) for these scenarios ranged from $113 million to $181 million. The average cost of emissions reductions achieved by these scenarios ranged from $1,600 - $3,400/tonne for NOx and $9,400 - $30,000/tonne for PM.

Options therefore appear to exist to reduce NOx and PM emissions from mine fleets.

3.3.1 Conclusion

Mine fleets are a large NPS in the LAR Air Zone, particularly for NOx emissions. Real world emission monitoring of in-use heavy haulers in oil sands mines indicates that current emission estimates from such units may be high except for NOx emissions. NOx emission from heavy haulers are the major source of mine fleet emissions (~65% (Teck Resources Limited, 2015)). The current NOx emission limits for heavy haulers are currently much less stringent than for smaller diesel equipment. The CASA NPS Task Group could recommend that consideration be given to developing more stringent NOx limits for these size of off road vehicles and, that for existing units, consideration be given to applying more stringent NOx limits based on practical retrofit NOx control options.

3.4 Fugitive Dust Emissions from Oil Sands Operations and Other LAR Air Zone Sources

1. From a review of recent mine project EIAs (and project updates) it is unclear how fugitive dust emissions are estimated (including how dust sources are fractionated into total suspended solids (TSP), PM_{10}, and $PM_{2.5}$). The estimates appear to be based on the application of the U.S. AP-42 emission factors for unpaved industrial roads. Estimating dust emissions is complicated by the fact that such emissions are a function of the physical properties of the dust source surface, the nature of the disturbance creating the dust, e.g., the size and speed of vehicle in the case of roads, if and how dust suppressants are used, and meteorological conditions.
2. Ledcor CMI Ltd. has proposed an unpaved road on the east side of the Athabasca River, north of Fort McMurray, and submitted a: Clearwater Multi-User Access Road Environmental Assessment Screening Report (July 2011) to Transport Canada, and Fisheries and Oceans Canada. This report provided detailed calculations on predicted dust emissions from road use, dust transport, and deposition, and the measures that would be taken to control/minimize dust emissions.
3. WBEA contracted the Desert Research Institute (DRI) to study fugitive dust emissions in the Regional Municipality of Wood Buffalo (RMWB). The study characterized the potential for windblown dust generation from 64 sites, including oil sands mining facilities, quarry operations, and roadways near Ft. McMurray and Ft. McKay (Wang, et al., 2015). The study provides insights into which surfaces have the greatest potential to generate windblown dust, and the effectiveness of surface watering to reduce dust generation potential.
4. As part of the DRI study noted above, the PM_{10} and $PM_{2.5}$ fractions from different dust source types were characterized based on mineral, organic, and elemental carbon, and ion composition (Wang, et al., 2015). This study provides information that can be used in source apportionment if ambient $PM_{2.5}$ composition data is available.
5. An issue associated with oil sands development has been the discrepancies between ambient measurements of polycyclic aromatic carbons (PAC) in both ambient air (Hsu, Harner, Li, & Fellin, 2015) and various media e.g., snow (Kelly, et al., 2009), peat and moss, (Zhang, et al., 2016) and lake sediment (Kurek, et al., 2013), and PAC emission sources and associated emission estimates (Galarneau, Hollebone, Yang, & Schuster, 2014). A recent study identified fugitive dust emissions from coke piles as a potential emission source of the "missing" PAC s and noted that: "Petcoke dust has not previously been considered in environmental impact assessments of oil sands upgrading, and improved dust control from growing stockpiles may mitigate future risks." (Zhang, et al., 2016).
6. Fugitive dust emissions have been identified as a potential source of base cation deposition that mitigates the potential for acidification from oil sands development SO_2 and NOx emissions, at least near dust sources (Watmough, Whitfield, & Fenn, 2014). In studying this possibility, the authors noted that:

> This work shows that despite extremely low soil base cation weathering rates in the region, the risk of soil acidification is mitigated to a large extent by high base cation deposition, which in contrast to S emissions is derived from fugitive dust sources in the mines, and is poorly quantified for regional modeling studies.

3.4.1 Conclusion

There appears to be considerable uncertainty regarding estimates of fugitive dust emissions associated with mining operations in the LAR Air Zone. Recent studies have identified the conditions under which fugitive dust emissions would be expected and estimated emissions associated with these conditions. This should improve future fugitive dust emission estimating. Monitoring of ambient PM levels in the vicinity of major potential dust sources could be used to validate predictions. Using the recent fugitive dust characterization in conjunction with characterization of the composition of $PM_{2.5}$ levels at sites with levels approaching or above the CAAQS orange level would allow the contribution of fugitive dust emission to these ambient $PM_{2.5}$ levels to be assessed. It is not clear whether best practices for fugitive dust management have been reviewed and are being applied to the major fugitive dust emission sources in the LAR. The CASA NPS Task Group could recommend that additional work is required to quantify and characterize fugitive dust emissions from oil sands mining operations and that consideration be given to assessing and establishing best management practices for fugitive dust emissions associated with oil sands developments. Alternately, a provincial good practices dust management guide that covered all major dust generating activities, including oil sands mining, could be developed analogous to the CASA's recent Good Practices Guide for Odour Management in Alberta document.

3.4.1.1 Prescribed Burning

1. Prescribe burning is defined as: "… the knowledgeable and controlled applications of fires on a specific land area to accomplish planned and well-defined resource management objectives." (Alberta Agriculture and Forestry: http://www.wildfire.alberta.ca/prescribed-fires/default.aspx). The burning of woody debris is covered by the *Alberta Forest and Prairie Protection Act* and the Forest and Prairie Protection Regulations Parts I and II (http://www.qp.alberta.ca/570.cfm). RMWB also has an Open Air Fire Bylaw (Bylaw No. 01/084) (http://www.rmwb.ca/Assets/Departments/Legislative+and+Legal+Services/Bylaws/OpenAirBurning.pdf). The provincial burning legislation focuses on fire hazard and safety management issues, as is the RMWB Bylaw. However the RMWB bylaw references the CWS limit for fine particulate matter and indicates that burning should be conducted such that:

    > Weather conditions immediately prior to and during the burning are such as to ensure smoke obscuration levels are maintained below 75 percent of the specified 24 hours average pursuant to the Canada-Wide Standards for Particulate Matter accepted by the Canadian Council of Ministers of the Environment.

2. Prescribed burning is of interest in the context of the CAAQS orange management trigger level for 24-hr $PM_{2.5}$ readings at the CNRL Horizon station. In the 2011-2013 period, smoke from prescribed burning in the area has been identified by Alberta Environment and Parks as a possible contributor to elevated $PM_{2.5}$ readings at this station (Avis, 2016). Fort McKay, a First Nation and Métis community approximately 18 km south of the CNRL Horizon station, through its Fort McKay Sustainability Department, raised concerns in early 2013 that prescribed burning in the area was impacting air quality in its community and discussions were held with two oil sands operations that were burning land clearing debris at the time (Spink, 2016).

3.4.2 Conclusion

It appears that prescribed burning may contribute to elevated $PM_{2.5}$ levels in the LAR Air Zone, at least in areas where significant land clearing and associated woody debris burning is prevalent. Most of the burning of this material occurs in the "non-fire hazard" period that is defined as November 1 to March 31. This is also the period when boundary layer mixing is reduced and as such, smoke generated from such burning may affect any area air monitoring station $PM_{2.5}$ measurements levels. The CASA NPS Task Group could recommend that a review of prescribed burning practices and associated control requirements in the LAR Air Zone be undertaken as this practice may be significantly influencing regional $PM_{2.5}$ levels at times, and contributing to CAAQS determination levels.

3.5 Point Source Emission Monitoring

Emissions from certain point sources are required to be monitored as part of facility operating approvals and, depending on the nature of an activity, and the type and quantity of its emission, reporting of those emissions may be required under the National Pollutant Release Inventory (NPRI) program (Environment and Climate Change Canada, 2016). Emission data from these sources is important in order to put NPS emissions into context. In addition, detailed point source emission characterization facilitates source apportionment evaluations, which can be used to determine the contribution of point versus NPS to primary $PM_{2.5}$ levels and to secondary $PM_{2.5}$ formation. WBEA has had studies done that have focused on characterizing certain key oil sands related point emissions sources (Wang, et al., 2012; Proemse & Mayer, 2012) which have been used in source apportionment studies (Proemse & Mayer, 2012; Landis, et al., 2012).

3.5.1 Conclusion

Source characterization and source apportionment analysis methods can be useful tools in establishing relationships between specific emission sources and/or emission source types and ambient $PM_{2.5}$ levels and composition.

4 Ambient Air Quality Data and Trending

A number of ambient air quality and trending studies have been conducted in the LAR. The results of these studies are briefly summarized to provide an indication of possible general air quality trends for $PM_{2.5}$ and O_3 and certain $PM_{2.5}$ and O_3 precursors such as THC, NOx, and SO_2.

4.1 RMWB: Air Quality Data Trending (1998-2007)

A comprehensive ambient air quality trending analysis conducted by the WBEA for the period 1998-2007 covered 12 air monitoring stations in the RMWB (Kindzierski, Chelma-Ayala, & Gamel El-Din, 2009). The CNRL Horizon and Anzac stations were not included in the study because at that time the period of record for these stations was less than four years. The study examined trends using time-series linear regression of a range of percentiles values taken from a cumulative frequency distribution of annual datasets. In general, NOx levels showed increases, $PM_{2.5}$ showed decreasing trends, and O_3, SO_2, and THC generally showed no trend.

4.2 RMWB: Community Air Quality Data Trending (1998-2012)

Linear trend analysis of hourly average percentile concentrations of air pollutants at Bertha Ganter-Fort McKay, Fort McMurray – Athabasca Valley and Fort McMurray – Patricia McInnis was undertaken covering the period 1998-2012 inclusive (Bari & Kindzierski, 2015). The results were similar to the results for these stations in the 1998-2007 period with increases or no change in NOx compounds and decreases or no change in $PM_{2.5}$, SO_2, and O_3. However, increasing trends in THC levels were noted for Fort McKay and Fort McMurray – Pat McInnis.

4.3 VOC Trending in Fort McKay (2001-2012)

Trends in emissions and ambient VOC concentrations in Fort McKay over a 12-year (2001–2012) period were examined (Bari, Kindzierski, and Spink 2016). An upward trend was found for ambient concentrations of total VOCs, which was correlated with bitumen production and mined oil sands quantities.

4.4 $PM_{2.5}$ Monitoring and Trending: Fort McMurray – Patricia McInnis (1999-2014)

A study was conducted at the Fort McMurray – Patricia air monitoring station from June 2011 to May 2013 comparing three different $PM_{2.5}$ monitoring methods (Hsu, Wang, Chow, Watson, & Percy, 2016). As part of this study, some of the earlier $PM_{2.5}$ data for the station was corrected based on the results of the monitoring methodology comparison to provide a consistent dataset that could be trended. This trending analysis for the period 1999-2014 for the period showed a statistically significant decrease in 24-hour $PM_{2.5}$ concentrations.

4.5 RMWB Passive Air Quality Monitoring and Trending (2000-2009)

The WBEA has a passive monitoring network throughout the RMWB that involves integrated monthly or bi-monthly passive sampling that includes O_3, NO_2, and SO_2. Trending analysis of data from this monitoring program was undertaken for the period 2000-2009 (Hsu, 2013). This analysis indicated that O_3 concentrations did not change, NO_2 concentrations increased with increases greater at monitoring sites closer to stationary and mobile sources, and SO_2 concentration were relatively stable over this period.

4.6 Satellite Air Quality Monitoring in LAR (2004-2014)

Assessments of air quality (SO_2 and NO_2) over the oil sands region using satellite imagery data have been conducted (McLinden, et al., 2012; McLinden, et al., 2016). These assessments indicate significant increases in NO_2 and relatively stable levels of SO_2 over the period 2005-2014.

4.7 Conclusion

Ambient air quality data and trending has generally not shown any consistent and/or strong increasing trends in air quality parameters in the LAR Air Zone with the exception of NOx/NO_2 levels and, more recently, THC/VOC levels in the area north of Fort McMurray. The absence of trends in O_3 levels may in general be attributable to monitoring sites being located close to NOx sources and the titration of O_3 by NO emissions.

SO_2 emissions in the LAR have been relatively constant since 2006 and therefore an upward trend over the last 10 years would not be expected. Starting in 2014, Syncrude's SO_2 emissions have been significantly reduced with the commissioning of a flue gas desulphurization unit on its main stack. This should result in a decrease in overall regional SO_2 levels in the area north of Fort McMurray.

The absence of an upward trend in ambient $PM_{2.5}$ levels is difficult to explain since primary $PM_{2.5}$ emissions have been increasing and, as noted in the following section, secondary $PM_{2.5}$ formation in the region can be large. However, the existing monitoring network may not be fully capturing secondary $PM_{2.5}$, which would be expected to be at maximum some distance downwind of precursor emission sources. The significant wildfire activity on the LAR Air Zone complicates $PM_{2.5}$ trending. It also needs to be noted that linear trending using parametric or non-parametric methods, which is how trending analysis has been conducted, has limitations in an industrialized region like the oil sands. In this regard

Bari & Kindzierski (2016) note that there are limitations to parametric and non-parametric linear trending and that:

> [i]ndications of statistically significant trends for datasets that are limited in duration (years) or where only small changes are occurring from year-to-year are unlikely to be truly representative of the trends that are actually occurring. This would only be captured with a much longer time period e.g., two to three decades... .

The step nature of oil sands development, extended plant upsets and/or shutdowns, the natural and annual variability in wind direction patterns, and the relationship between these patterns and facility emissions and downwind monitoring site locations, all contribute a considerable amount of “noise” to ambient air quality datasets for the LAR Air Zone. Trending and air quality change analyses therefore need to use methods and approaches that consider and address these “noise” issues in order to better understand the air quality effects of emissions sources in the region. The CASA NPS Task Group could recommend that efforts be made to find ways to consider and/or reduce the “noise” in regional air quality datasets in order to obtain a better representation of regional air quality trends in relation to anthropogenic emissions and activities. Better trending methods would help determine parameters and/or sources that should be the focus of management efforts in preventing or responding to existing or future LAR Air Zone orange or red CAAQS management levels.

5 $PM_{2.5}$ Composition and Source Attribution

Data on the composition of $PM_{2.5}$ can be used to identify whether or not the particulate matter is primary i.e., emitted directly by sources, or secondary i.e., formed in the atmosphere as a result of physical and chemical process. Composition data can also be used to identify the type and nature of the emission sources that may be contributing to the $PM_{2.5}$ levels being measured and to determine how meteorological conditions e.g., temperature, may be influencing $PM_{2.5}$ levels at a specific location. A number of studies and evaluations have been conducted in the LAR Air Zone to examine $PM_{2.5}$ composition and possible contributing sources. These studies provide insights into the potential significance of NPS as a contributor to $PM_{2.5}$ levels in the LAR Air Zone.

5.1 Wood Buffalo Environmental Associated (WBEA) Routine Integrated $PM_{2.5}$ Sampling and Composition Analysis

WBEA conducts $PM_{2.5}$ integrated monitoring at four community stations: Bertha Ganter-Fort McKay; Fort McMurray- Athabasca Valley; Fort McMurray Patricia McInnis; and Anzac. Samples are collected over 1 day (24 hours) every 6 days and analyzed for metals and ions. A review of the ion data for the period 2009-2014 (Hsu 2013; WBEA 2012, 2013, 2014) indicates that most of the ion composition of $PM_{2.5}$ is associated with atmospheric formation processes, i.e., secondary aerosols, with ammonium, nitrate, and sulphate being the major ion constituents. Sulphate and ammonium are the dominant ion species in $PM_{2.5}$ based on annual mean values, but during the winter period, the nitrate fraction increases. This would indicate that SO_2 and NOx emissions contribute to a relatively constant base level of secondary particulate formation in the area around Fort McMurray and that on average NOx emissions are a smaller contributor to secondary particulate formation than SO_2 emissions during all seasons at the monitor stations.

A review of the metal data from the WBEA $PM_{2.5}$ integrated monitoring program indicates that, with the exception of aluminium and iron, metal concentration in $PM_{2.5}$ are relatively small. Even aluminum and iron concentrations, which are likely associated with dust particles, are low based on annual average values since the majority of $PM_{2.5}$ is from the secondary formation, including heterogeneous (e.g., condensation) or homogeneous reactions. A much more detailed analysis of these datasets, linked to periods when regional $PM_{2.5}$ levels are high, would be required to determine if they could provide insights into the emissions types that might be contributing to these elevated $PM_{2.5}$ levels. This very preliminary review would indicate that, in general, SO_2 and NOx emissions are only contributing a few µg/m^3 of mass to $PM_{2.5}$ levels in the Fort McMurray area. However, the intermittent nature of this sampling program i.e., every six days, means that the dataset has limitations in terms of capturing and therefore being representative of $PM_{2.5}$ composition during the days that are used to determine the 24 hour $PM_{2.5}$ CWS/CAAQS compliance and management levels. Metal and ion fractions generally account for less than 50 to 80% of the total $PM_{2.5}$ mass being measured. This means fractions like organic carbon and black carbon are significant and these constituents were only measured at one station (AMS 1). These datasets also include fire events. This complicates the use of these dataset in relation to the CWS/CAAQS since fire events are removed from the datasets used to assess a station's compliance and status with respect to the CWS and now the CAAQS.

5.2 Wood Buffalo Environmental Associated (WBEA) Integrated $PM_{2.5}$ Sampling and Enhanced Composition Analysis at Fort McKay

WBEA has recently been conducting elemental carbon and organic carbon analysis on the integrated $PM_{2.5}$ samples it collects at the Bertha Ganter-Fort McKay air monitoring station in addition to the routine ions and metals analysis conducted on these samples. A review of the results of this additional $PM_{2.5}$ composition data for 2015 (52 data points) indicates that, in general, organic carbon is the principal constituent of $PM_{2.5}$ in Fort McKay but that during colder months i.e., January-March and October-December, the fraction of ions increases. This 2015 dataset only had 2 sampling events when $PM_{2.5}$ levels were above 19 µg/m^3 (the orange management level trigger) and there were 6 sampling events with $PM_{2.5}$ levels in the 10 – 19 µg/m^3 range (the yellow management level). Figure 8 provides a summary of the percentage fraction of each $PM_{2.5}$ component for the entire 2015 datasets (Note: Figure 8 is a draft and was kindly provided by Dr. Yu-Mei Hsu from WBEA).

This data would indicate that organic carbon is, in general, the major component of $PM_{2.5}$ in Fort McKay, but that ions are also important particularly in cold/cooler weather periods. Ions would be associated with NOx and SO_2 emissions but, as noted above, the ion composition is dominated by sulphate ion, which is the result of SO_2 emissions, which are not associated with NPS. The organic carbon fraction of $PM_{2.5}$ is likely linked to NPS sources i.e., tailings ponds, fugitive plant emissions and oil sands mines, as well as biogenic organic carbon emissions. The relative significance of anthropogenic versus biogenic VOC sources in terms of secondary aerosol formation in the LAR is important in terms of determining whether or not improved anthropogenic VOC emissions management would result in significant reductions of ambient $PM_{2.5}$ levels. Recent information indicates that it would (see Section 5.6). How representative this data is of other locations in the region would need to be determined but the CNRL Horizon is relatively close to Fort McKay at ~18 km distance. The Fort McKay $PM_{2.5}$ carbon and organic composition data may therefore be relevant to the CNRL Horizon station. A much more detailed analysis of these datasets, linked to periods when regional $PM_{2.5}$ levels are high, would be required to determine if the data could provide insights into the emissions types that might be contributing to elevated regional $PM_{2.5}$ levels.

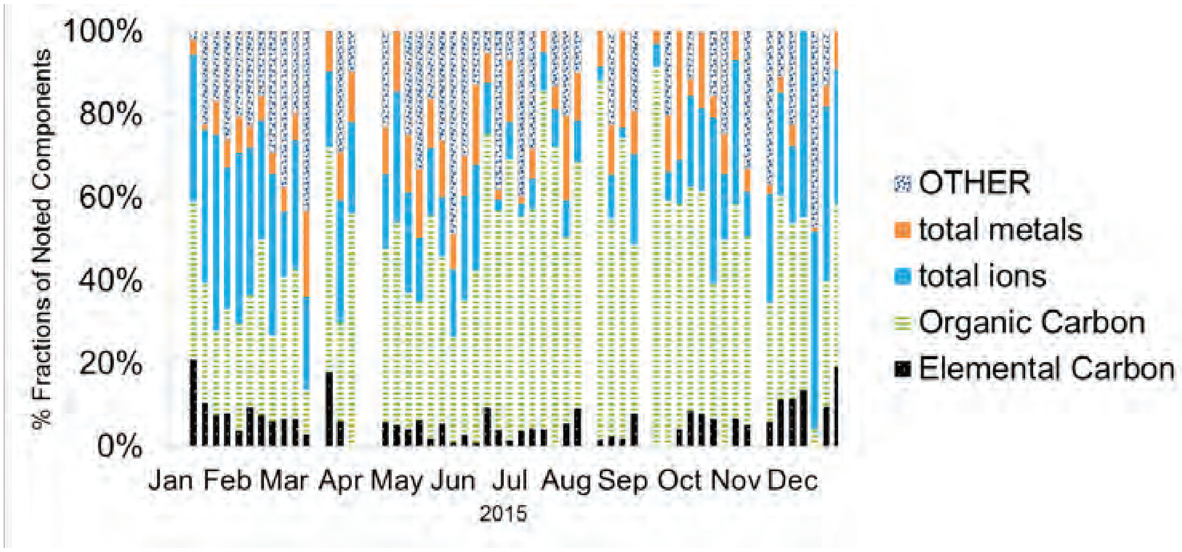


Figure 8: Summary (Draft) of Relative % Fractions of $PM_{2.5}$ Constituents as Measured in Fort McKay in 2015 (52 - 24 hour Integrated $PM_{2.5}$ Samples)

5.3 Ambient Ion and PM Precursor Gas Measurement in the Alberta Oil Sands Region (AOSR)

(Note: the AOSR can be considered to represent the LAR)

WBEA conducted studies in the May to July 2011 period (in Fort McKay) and April to December 2013 period (in Fort McMurray) using an ambient ion monitoring instrument that measured levels of cations and anions in $PM_{2.5}$ and also SO_2, HNO_3, and NH_3 gaseous levels on an hourly basis (Hsu & Clair, 2015). Key conclusions made by the study authors were:

1. "….emission and oxidation of SO_2 significantly influence particulate-phase SO_4^{2-} and NH_4^+ concentration in the AOSR and that this influence is independent of the time of year"
2. "In winter months, the NO_2 concentrations were usually higher in the AOSR due to low vertical mixing caused by a shallow planetary boundary layer (PBL). Elevated NO_2 concentration should favor HNO_3 formation, but this was not observed in the winter months in the AOSR. It is likely that the conditions (e.g., low OH concentration) did not favor HNO_3 formation."

The gaseous NH_3 levels measured during the studies would indicate that ambient ammonia levels in the region are not limiting ammonium nitrate or ammonium sulphate formation. The results from these studies are generally consistent with those from the routine and enhanced (in Fort McKay) $PM_{2.5}$ ion composition data. The results would therefore seem to confirm that regional industrial SO_2 and NOx emissions are not likely major contributors to periodic elevated $PM_{2.5}$ levels. As noted previously, a more detailed analysis of datasets would be required to confirm that this is indeed the case.

5.4 Particulate Black Carbon Measurement in the AOSR and Possible Sources

WBEA recently started monitoring black carbon (BC) levels in $PM_{2.5}$ at Fort McKay using an aethalometer. The results of this monitoring for 2015 indicate that it can be used to differentiate between BC associated with vehicle emissions versus biomass burning (Hsu, Martineau, & Edgerton, 2016). Data from this monitoring would indicate that at times the fraction of non-biomass burning related BC in $PM_{2.5}$ can be large i.e. > 4 $\mu g/m^3$. This type of monitoring could have application as a source identification tool at monitoring sites that have elevated $PM_{2.5}$ levels and where wildfires and/or biomass burning are potential contributors to these elevated $PM_{2.5}$ levels.

5.5 Sources of Particulate Matter in the LAR Air Zone Based on Metal Composition

Particulate matter trace element composition was measured using intermittent integrated sampling from December 2010 to December 2012 at 3 monitoring sites near oil sands upgrader projects and at 1 site in August 2013 using hourly $PM_{2.5}$ sampling (Phillips-Smith, et al., 2016). The results of this monitoring were analyzed using positive matrix factorization to attribute $PM_{2.5}$ trace element composition to different possible source types i.e., upgrader 1, upgrader 2, soil, haul road dust, biomass burning, and 2 mixed sources. This study concluded that: "Overall much of the $PM_{2.5}$ related metal was found to be anthropogenic, or at least to be aerosolized through anthropogenic activities." Biomass burning, upgrader emissions and haul road dust were the principal sources of trace metals with some seasonal variations in the relative contributions from each of these sources with haul road dust contribution highest in the summer. Of interest was that biomass burning was a contributing source year round. This study would indicate that NPS i.e,. biomass burning and haul road dust, are contributors to $PM_{2.5}$ metal levels in the area of mineable oil sands developments.

5.6 Primary Organic Aerosol Emissions and Secondary Organic Aerosols in the LAR Air Zone

In 2013, Environment Canada conducted airborne measurement of specific oil sands emission plumes, integrated facility emissions, and multiple facility downwind primary and secondary pollutant monitoring. Part of this monitoring focused on particulates and primary particulate emissions versus secondary particulate formation and the possible mechanisms involved in secondary PM formation. Two papers have been published on this monitoring work. The first paper by Howell et al. (2014) concluded that oil sands facilities do not emit much particulate organic matter directly but have very high aerosol numbers which can coagulate and form organic aerosols rapidly i.e., within hours, within facility emission plumes. The paper notes that precursors for this organic aerosol (OA) formation "…may be primary OA, due to condensation of vapors as the plume cools, but reactions between H_2SO_4 and either biogenic or plume-derived organic vapors may be important."

The second paper by Liggio et al. (2016) discusses the results of airborne measurements that followed two intermixed integrated multiple facility plumes and looked at changes in secondary organic aerosol levels and their possible precursors. The study found that vapours from mines and the mined bitumen were contributing to the production of very large amounts of secondary organic particulate matter e.g., 10-15 $\mu g/m^3$. The overall aerosol production rates levels were estimated to be 45–84 tonnes per day, which the authors note: *"*make the oil sands one of the largest sources of anthropogenic secondary organic aerosols in North America."

These studies would indicate that oil sands related NPS fugitive VOC emissions are, at least at times, a major contributor to $PM_{2.5}$ levels downwind of oil sands mining operations and may therefore be a contributing factor to elevated $PM_{2.5}$ levels affecting the status of the LAR in terms of the CAAQS.

6 LAR Ozone and/or $PM_{2.5}$ Modelling and Related Source Allocation

Modelling the potential for secondary O_3 and $PM_{2.5}$ formation associated with biogenic and/or anthropogenic precursors i.e., NOx, VOCs, NH_3, and SO_2, is challenging (USEPA, 2015). Photochemical grid models e.g., the Community Multi-Scale Air Quality (CMAQ) model, are specifically designed for $PM_{2.5}$ and O_3 formation modelling. Lagrangian modeling systems e.g., CALPUFF, have significant limitations in terms of modelling $PM_{2.5}$ and O_3 formation. In the LAR Air Zone, since approximately 2000, air dispersion modelling associated with project applications has been based on the use of the CALPUFF model. This modelling does not include ozone formation but does provide a simplified prediction of secondary $PM_{2.5}$ formation. CMAQ, and other photochemical models, have been used in the LAR for special or specific studies and were used in the 1990s as part of project applications.

The following is a summary of photochemical and CALPUFF modeling work that has been conducted in the Alberta Energy Regulator (AER) that is related to predicting O_3 and/or $PM_{2.5}$ formation and levels, and what this modelling indicates in terms of existing and possible future levels of $PM_{2.5}$ and O_3 in the LAR Air Zone. In some cases, the modelling has examined the relative significance of different source types to these predicted current and future $PM_{2.5}$ and O_3 levels.

6.1 Early Photochemical Regional Modelling

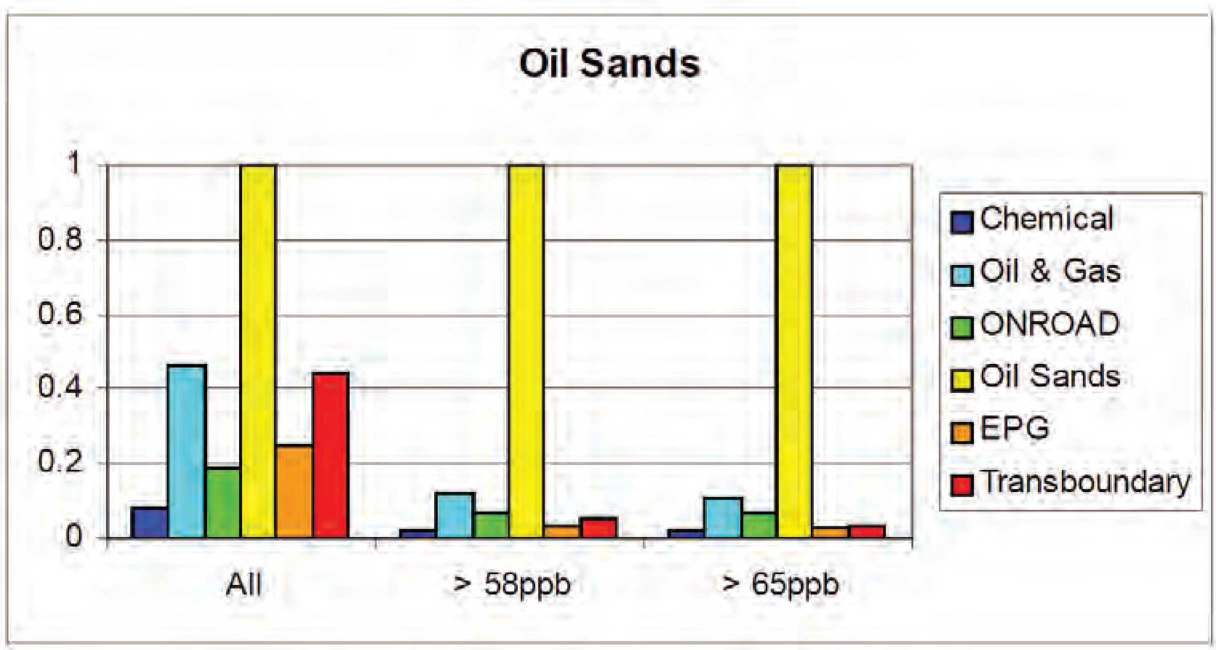
Davies and Fellin (1999) summarized the results of photochemical modelling associated with oil sands project assessments in 1993 using the SMOG model and in 1999 using the GALGRID model. These modelling studies looked at the potential for enhanced O_3 production associated with existing and possible future oil sands emissions. These studies identified the potential for large emission related increases in regional O_3 levels e.g., 25 to 44 ppb greater than background levels. Anthropogenic NOx emissions and biogenic VOC emissions were identified as the dominant emission sources contributing to these predictions. Davies and Fellin (1999) also discuss the O_3 titration effects of local point and NPS NOx sources and how these can influence the ozone levels at specific monitoring sites. They note that monitoring locations intended to measure maximum ambient levels of certain emission parameters e.g., NOx and THC, will not measure the maximum O_3 levels that may result from these emissions. They also note that biomass burning can result in photochemical O_3 production.

6.2 CEMA Ozone Management Framework Modelling

The Cumulative Environmental Management Association (CEMA) developed an Ozone Management Framework (OMF) for the RMWB (CEMA, 2006). This framework recommended that: *"initially modelling be done every 3 years and include both an "approved development" (including existing and approved projects) and a "full development" (including all existing and approved, plus all planned projects) emissions scenario."* Since 2006, 3 modelling studies have been conducted with 2 of these modelling studies also considering $PM_{2.5}$ formation. The following is a summary of the results from each of these modelling studies.

6.2.1 2007

- Environment Canada conducted provincial ozone monitoring using the CMAQ model, which considered sectoral contributions to ozone levels in the province (Fox & Kellerhals, 2007). This modelling, while provincial in scope, provided a focused analysis on four regions: Edmonton; Calgary; Red Deer; and the oil sands, and also modelled a future emission scenario. The sectorial emission scenarios consider were: electrical power generation; on road vehicles; chemicals and refineries; upstream oil and gas (excluding oil sands); transboundary (sources outside Alberta); and oil sands (which included all oil sands related point, mobile and fugitive emission sources). The study used 2002 meteorological data and 2000 emissions for the base case and a 2012-2015 emissions case for the future scenario. The modelling predicted exceedances of the CWS in the oil sands area under both the base case (2000) and future (2012-2015) emission scenarios with levels increasing in the future scenario. Oil sands emissions were a major contributor to these predicted elevated levels as demonstrated by comparison between predicted regional O_3 levels with and without oil sands emissions. The predicted contribution of oil sands emissions relative to the other sectoral sources is shown in Figure 9, which was extracted from the report.



Source: Fox, D., & Kellerhals, M. (2007)

Figure 9: A Sector Contribution Ranking of the Relative Contribution of Each Sector to Ozone Levels in the Oil Sands/Fort McMurray Region

Note: the rankings are relative and do not add to 1.

It should be noted that the modelling generally over-predicted O_3 levels in the oil sands region although the geographic area covered by ambient O_3 monitoring in this region is small, which limited the ability to fully assess the model's predictive capability. In addition, the grid size used in the modelling of Alberta was 12 km x 12 km, which increases uncertainties when comparing a grid cell prediction to a point measurement in that grid cell particularly when there are emission sources within the cell, or adjacent cells, that can have localized air quality impacts.

6.2.1.1 Conclusion

- This modelling identified a high potential for elevated O_3 levels in the oil sands region which to date have not been measured at the monitoring stations in the region. This was the first CMAQ modelling of the oil sands region and subsequent CMAQ modelling used smaller grid sizes and/or had better emission inventory data and as such are considered to better represent O_3 levels and O_3 formation potential in the region. This study did however provide a clear indication that oil sands emissions are the major anthropogenic contributor to regional O_3 levels.

6.2.2 2010

- CEMA contracted ENVIRON and Millennium EMS Solutions Limited in 2009 to undertake PM and O_3 modelling in the AOSR, which resulted in a report entitled PM and Ozone Chemistry Modelling in the Alberta Oil Sands Area Using the Community Multiscale Air Quality (CMAQ) Model. (Morris, et al., 2010). Year 2006 emission inventory data and meteorological data was used and for the Alberta portion of the modelling domain and a 12 km x 12 km grid size was used. Included in this study was an evaluation of the relative significance of two regional emission sources types and two out of region geographic area emissions i.e., medium range and long range transport, on predicted O_3 and $PM_{2.5}$ levels in the RMWB and Cold Lake (CL) areas. This was accomplished by excluding (zeroing) a different emission source from each of the four sensitivity runs. The four emission scenarios were:
  - Local Production from Stationary Point Sources in the RMWB/CL region;
  - Local Production from Area Sources (includes mobile sources) in the RMWB/CL region;
  - Medium Range Transport defined as all anthropogenic emissions in Alberta outside of the RMWB/CL region; and
  - Long Range Transport defined as all anthropogenic emissions in the 36/12 km domains outside of Alberta.

  These scenarios allow an assessment of the relative significance of regional point and NPS on regional O_3 and $PM_{2.5}$ levels and the significance of "out-of-region" sources.

- The following excerpts from the study report summarize some of the key finding and results:

  > "An evaluation of the CMAQ 2006 12 km base case simulation showed that USEPA's ozone performance goals for hourly ozone concentrations are achieved during most of the summer months (April, May, June and July), albeit with an underestimation bias."
  >
  > "The CMAQ $PM_{2.5}$ model performance across Alberta is characterized by a systematic overestimation bias in and near the Calgary and Edmonton areas. This was attributed to an overstatement of primary PM emissions from construction sources in the urban areas due to the spatial surrogate used to disaggregate the Alberta provincial level construction emissions to the 12 km grids." And "Away from the Calgary and Edmonton urban areas and the periods with the wildfire events, the CMAQ model did a respectable job in reproducing the magnitude of the observed PM2.5 concentrations."

"…the modeled 4th highest 8-hour ozone concentrations were used as a pseudo-CWS ozone metric for comparisons with the CWS threshold (65ppb). Within the RMWB region, the CMAQ-estimated 4th highest daily maximum 8-hour ozone concentrations are all below the 65 ppb CWS ozone threshold."

For $PM_{2.5}$ a pseudo-CWS metric defined as the 98^{th} percentile (i.e., 8th highest) 24-hour $PM_{2.5}$ concentration that occurred during 2006 was compared against the 30 µg/m3 CWS threshold. The results of this comparison were that: "the model estimates exceedances of the pseudo-CWS metric in Edmonton and Calgary and single 12 km grid cells in Red Deer, Fort McMurray and Fort Chipewyan, which are interpreted to be due to anthropogenic emissions."

"…local production emissions from stationary point and area sources have only minor impacts on predicted maximum 1-hour and 8-hour ozone concentration the RMWB/CL region. The largest reduction in the 4th highest daily maximum 8-hour ozone concentrations within the RMWB/CL region are due to the medium range transport of anthropogenic emission sources within Alberta (but outside of the RMWB/CL region), with contributions from long range transport from outside of Alberta also present."

"For the most part, the 24-hour daily maximum $PM_{2.5}$ concentrations within the RMWB/CL region showed the largest contributions from local point source emissions, as well as smaller contributions from local area sources. Medium range transport also was found to be relatively important, especially for sites within the southern portion of the RMWB region. Long range transport (i.e., sources from outside of Alberta) had less influence on $PM_{2.5}$ concentrations in the RMWB region, except for along the border with Saskatchewan."

- The predicted reductions in the 4th highest daily maximum 8-hour O_3 concentrations associated with the elimination of any of the 4 emission sources is shown in Figure 10 which was extracted from the report. The predicted relative contribution of each of the four emission sources to the 98^{th} percentile 24-hour $PM_{2.5}$ concentration is shown in Figure 11, which was also extracted from the report. In Figure 10 the increase in predicted ozone concentrations at some stations associated with the elimination of area sources is likely due to the loss of NOx emissions that in those grid cell result in ozone scavenging.

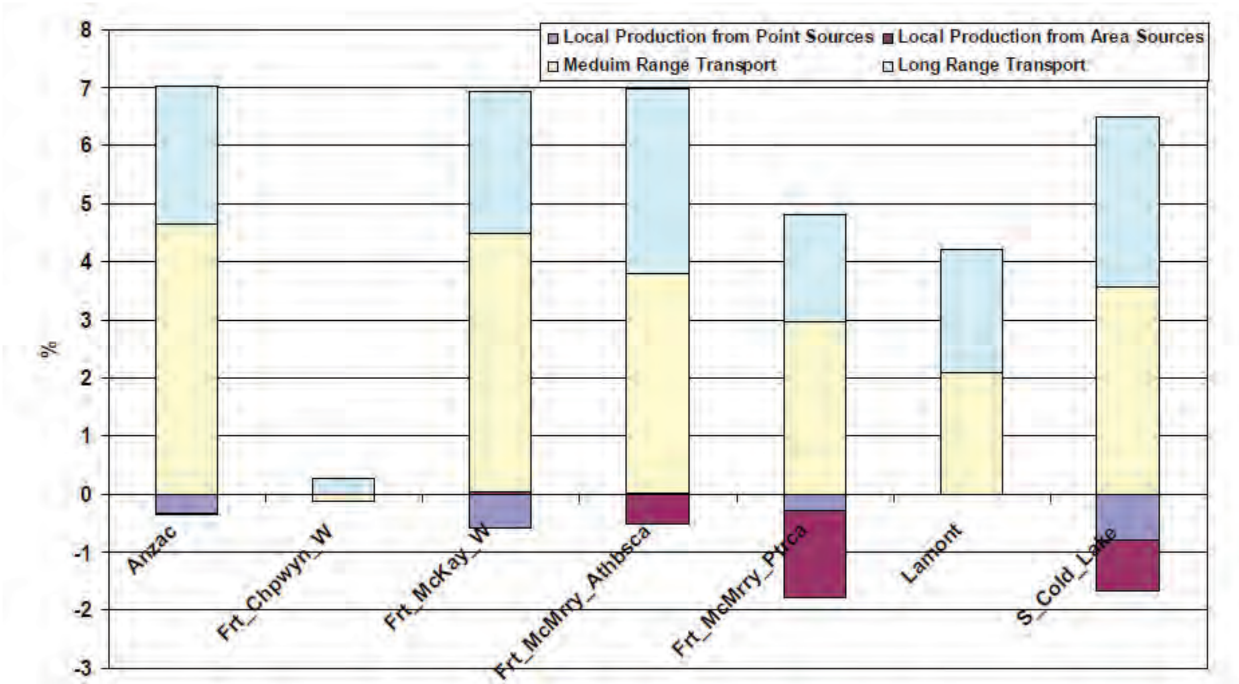


Figure 10: Reductions in Estimated 4th Highest Daily Maximum 8-hour Ozone Concentration at Selected Monitoring Sites within the NEAB Sub-region

Note: Reductions are due to removal of source sector emissions expressed as a percentage of the base case O_3 concentration.

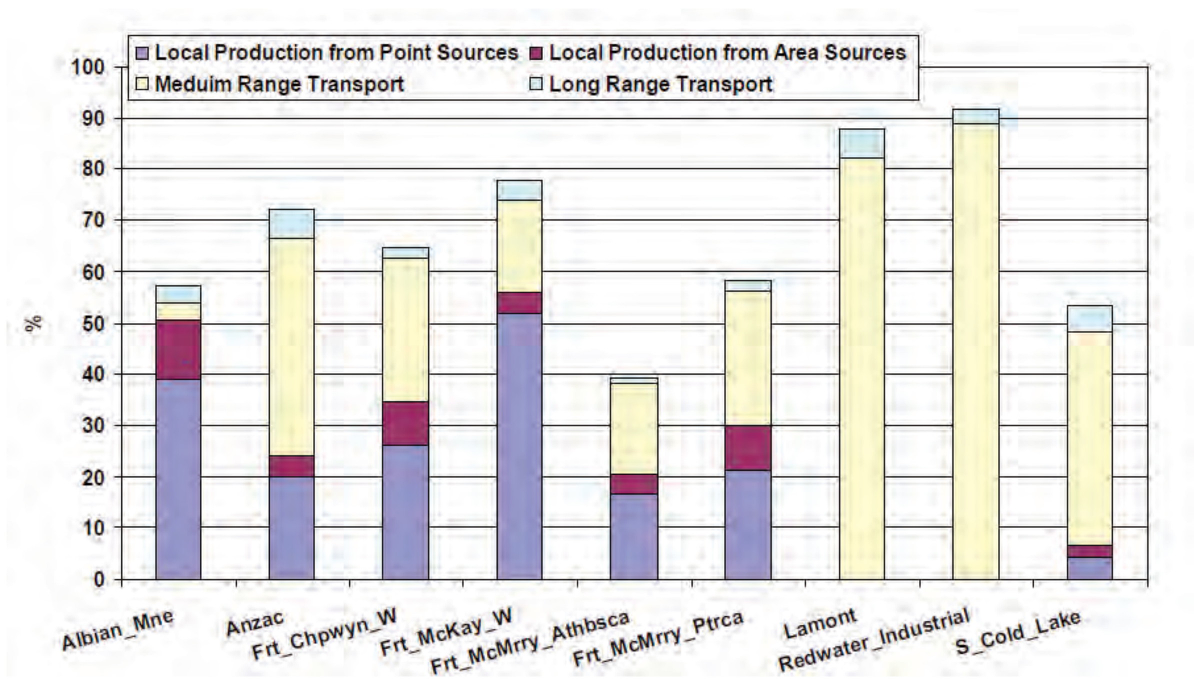


Figure 11: Sectoral Contributions to 98th Percentile 24-hour Average $PM_{2.5}$ Concentrations at Select Monitoring Sites within Northeast Alberta

6.2.2.1 Conclusion

- This modelling didn't predict 4th highest daily maximum 8-hour O_3 concentrations above 65 ppb in the AOSR based on 2006 emissions which was/is consistent with monitoring data and indicates that NPS are not a major contributor to O_3 levels. The model predictions for 98th percentile 24-hour $PM_{2.5}$ concentrations would indicate that NPS might be contributing to elevated regional $PM_{2.5}$ levels with the model predicting one grid cell in the AOSR being above 30 µg/m^3 and several grid cells being above 20 µg/m^3.

6.2.3 2014

- CEMA contracted ENVIRON and Stantec in 2012 to undertake modelling focused on the LAR Air Zone, which included PM and O_3 modelling and resulted in a report entitled: CMAQ Modelling for the CEMA Ozone Management Framework, Acid Deposition Management Framework and Interim Nitrogen Eutrophication Management Plan (Vijayaraghaven, et al., 2014). PM and O_3 modelling used 2010 meteorology and 3 emissions cases, which were:
  - an existing case (2010)
  - *Future Case 1* which was based on a nominal development scenario that is 15 years in the future, i.e., ~2025/2030 period and included existing and approved projects; and
  - *Future Case 2,* which is based on a nominal development scenario that is 30 years in the future, i.e., ~2040/2045 period and which included all existing, approved and planned projects.

- The Community Multiscale Air Quality (CMAQ) model was used with a 4km x 4km grid size in the northeast part of the province, a 12 km x 12 km grid size for the remainder of Alberta, and a 36 km x 36 km grid size for the remainder of the model domain i.e., western Canada and the northeastern USA. The emission inventories for the modelling were developed specifically for this modelling and related CALPUFF modelling (Davies, et al., 2012) and likely represent the most thorough and representative inventories that had ever been used in regional air quality modelling. A new approach for determining and using leaf area index in the model was also employed, which should result in more representative air quality and deposition predictions. The modelling also applied a dust emissions transport adjustment factor for Alberta based on dominant land-use category to try and better represent the likely impact of dust emission sources on ambient PM levels.

- The following summaries and excerpts outline the key finding and results from the study related to existing and future O_3 and $PM_{2.5}$ levels in relation to the CWS and CAAQS:

> For ozone the model performed reasonably well in terms of predicted versus monitored levels with a slight underestimation bias and future predictions were adjusted i.e., increased, based on this measured bias.
>
> "Modelled 4th highest daily maximum 8-hour average ozone concentrations in 2010 do not exceed the current Canada-wide standard (CWS) of 65 ppb or the Canadian Ambient Air Quality Standards (CAAQS) (which will be 63 ppb in 2015 and 62 ppb in 2020) in either future case. The 2010 pseudo design values do not exceed the CWS in the existing case and the projected pseudo design values do not

exceed the CWS or CAAQS in both future cases. However, they exceed the current Planning Trigger threshold of 58 ppb at the Anzac, Cold Lake South, Lamont and Lamont County stations and exceed the future Planning Trigger threshold of 56 ppb at these stations as well as Athabasca Valley and Patricia McInnes in both future cases. Modelled maximum 1-hour concentrations in the LAR are well below the Alberta Ambient Air Quality Objective (AAAQO) in all three emission cases."

For $PM_{2.5}$ the study found that: "…the modelled 98th percentile 24-hour average PM2.5 concentration in the three emission cases. Within the domain, there are exceedances of the CWS and CAAQS thresholds near Edmonton and within the RMWB along the border with Saskatchewan and north of Lake Athabasca." And that: "The modelled annual average PM2.5 concentrations in the RMWB (Figure 6-22) are slightly below the CAAQS". Figures 12 and 13 extracted from the study report show the predicted 98th percentile 24-hour average $PM_{2.5}$ and annual $PM_{2.5}$ concentrations.

NO_2 was modelled and the study found that: "The maximum estimated 1-hour NO_2 concentration within the RMWB is up to 19% higher than the AAAQO threshold (159 ppb) in the existing case and up to 3% higher in the future cases. The maximum estimated annual NO2 concentrations are 29% and 50% higher in the existing case and (both) future cases, respectively, than the corresponding AAAQO threshold (24 ppb)." Although there are currently no CAAQS for NO_2 these are under development and this modelling would indicate the potential for regional NO_2-CAAQS related issues.

6.2.3.1 Conclusion

This air quality modelling, which is likely the most comprehensive and representative photochemical modelling conducted on the LAR Air Zone to date, provides an indication that $PM_{2.5}$ and NO_2 (when CAAQS for NO_2 are finalized), are the parameters that in the LAR Air Zone are likely to require additional management with ozone possibly triggering an orange management level in some locations. The structure of the study was such that the contribution of different sources e.g., point versus NPS, to the predictions could not be assessed.

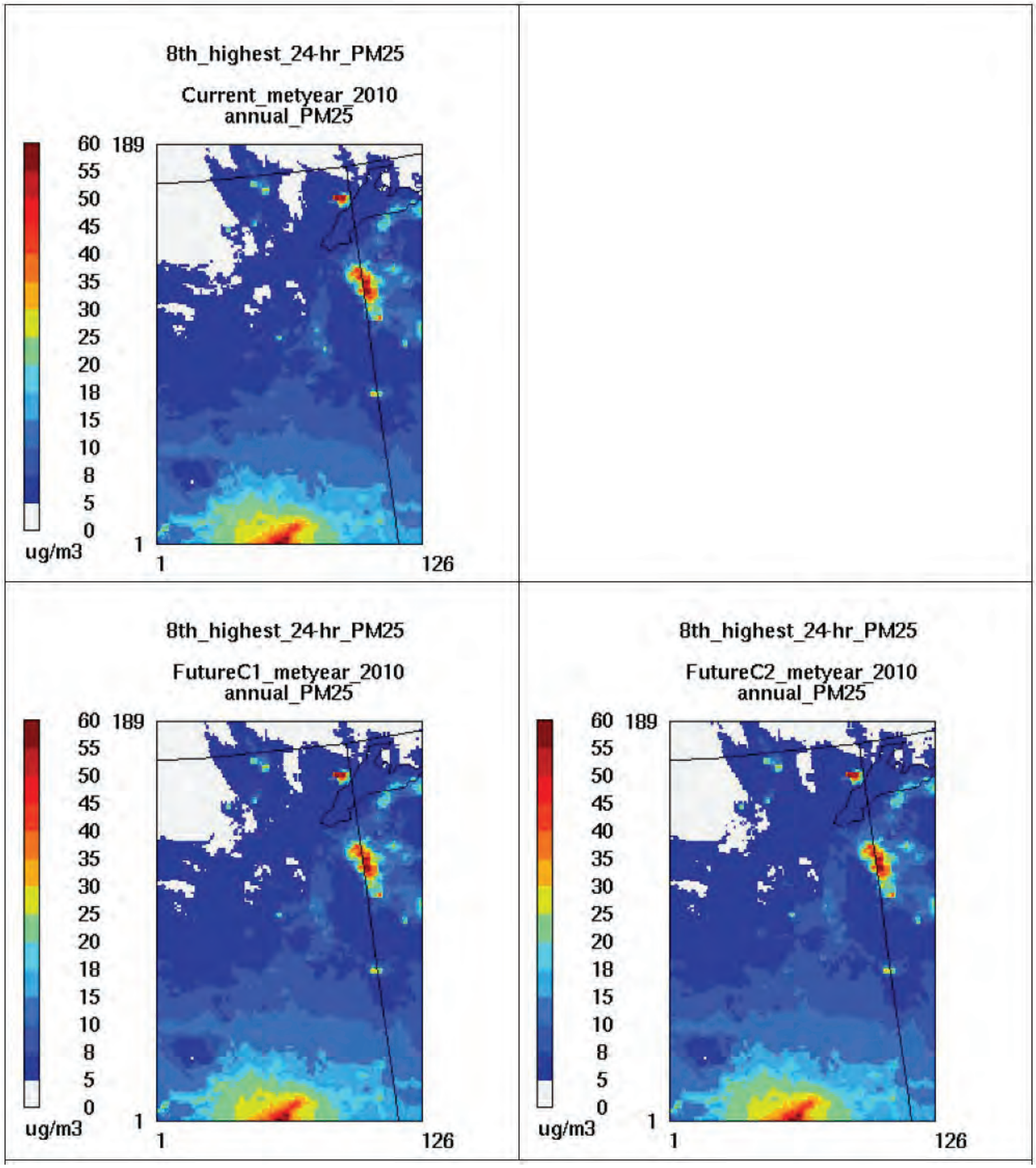


Figure 12: Predicted 98th Percentile 24-hour Average $PM_{2.5}$ Concentrations with 2010 Meteorology in the Existing case (top), Future Case 1 (bottom left) and Future Case 2 (bottom right)

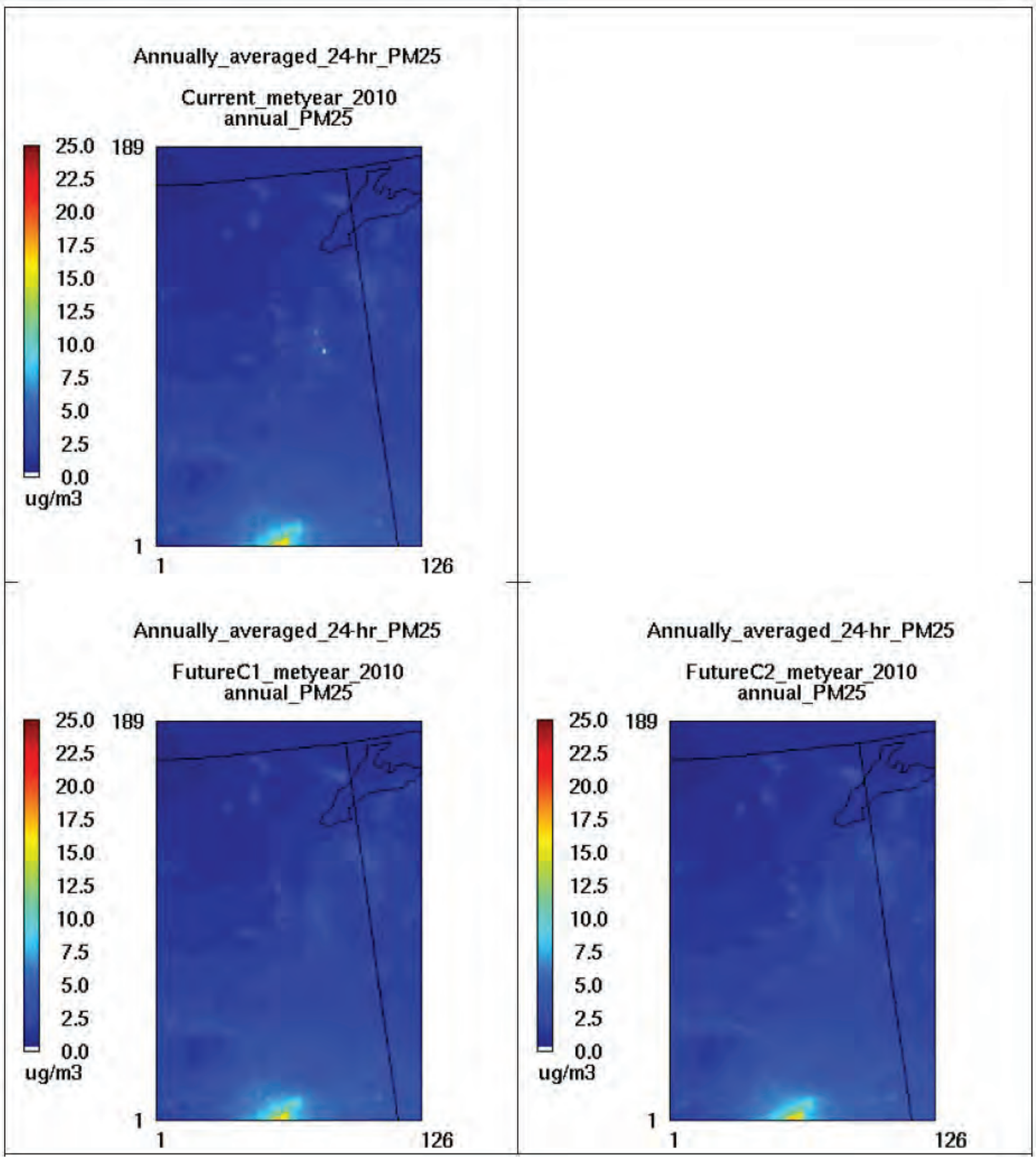


Figure 13: Predicted Annual Average $PM_{2.5}$ Concentrations with 2010 Meteorology in the Existing Case (top), Future Case 1 (bottom left) and Future Case 2 (bottom right)

6.3 Alberta Environment and Parks Photochemical Modelling Study

Alberta Environment and Parks conducted air quality modeling focused on north east Alberta using the Community Multiscale Air Quality (CMAQ) photochemical grid modelling system modeling system (Cho, et al., 2012a; Cho, et al., 2012b). The purpose of this modelling was to evaluate the capability of the model to predict $PM_{2.5}$ and O_3 and also to assess the impact of different regional emission sources, namely:

- all stationary (industrial) point source emissions within the AOSR;
- all area and mobile source emissions within the AOSR i.e. non-point sources both industrial and non-industrial; and
- all mobile emission sources (on-road mobile and non-road mobile) within Alberta, but outside the AOSR; and
- biogenic sources within Alberta, on PM2.5and O3 levels.

The impacts of these sources on $PM_{2.5}$ and O_3 levels were determined by comparing model predictions with all these sources included with model predictions that excluded that specific source. This modeling approach allows a general source apportionment in terms of each evaluated source type. The modelling was done using 2002 meteorological data, which was selected because it was a warmer year and therefore conducive to O_3 production. The emission inventory used was based on 2006 data, which was considered more reliable and representative than the 2002 inventory, and the actual change in emissions between 2002 and 2006 was not considered significant. The results of this modelling and sources apportionment indicated that:

- O_3 - Point sources emissions are generally the largest contributor to O_3 formation in the AOSR followed by area and mobile sources. Elimination of point sources were predicted to reduce base case i.e,. all sources, O_3 predictions North of Fort McMurray from 56-58 ppb to 52-54 ppb. Elimination of area and mobile sources reduced O_3 predictions North of Fort McMurray from 56-58 ppb to 54-56 ppb.
- $PM_{2.5}$ – There is an area of elevated model estimated 98th percentile 24-h daily maximum PM2.5 concentrations with a peak value of 24 µg/m3 North of Fort McMurray. The elimination of local point source emissions reduces the predicted 24-h daily maximum $PM_{2.5}$ concentration to 14 µg/m3 value. The elimination of area and mobile sources also results in major reductions in the predicted 24-h daily maximum $PM_{2.5}$ concentration North of Fort McMurray but not quite as large a reduction as associated with the elimination of point sources. The predicted relative contributions of the different sources types to $PM_{2.5}$ levels were presented in graphical form in the paper (Cho, et al., 2012b) and these figures are presented below in Figure 14.

6.3.1 Conclusion

This 2006 emission based modelling would indicate that in terms of the CAAQS, $PM_{2.5}$ levels are more likely to trigger CAAQS management action levels than O_3 levels, which is consistent with the CWS/CAAQS assessments since 2001 (Tables 4 & 5). The modelling also indicates that while point source emissions are likely the major contributor to both anthropogenic O_3 and $PM_{2.5}$ levels in the AOSR, and particularly in the area north of Fort McMurray, NPS are also major contributors particularly to $PM_{2.5}$ levels. Since it is $PM_{2.5}$ levels north of Fort McMurray that have put the LAR Air Zone into the orange management level, this modelling work would indicate that NPS need to be considered in the development of $PM_{2.5}$ management plans.

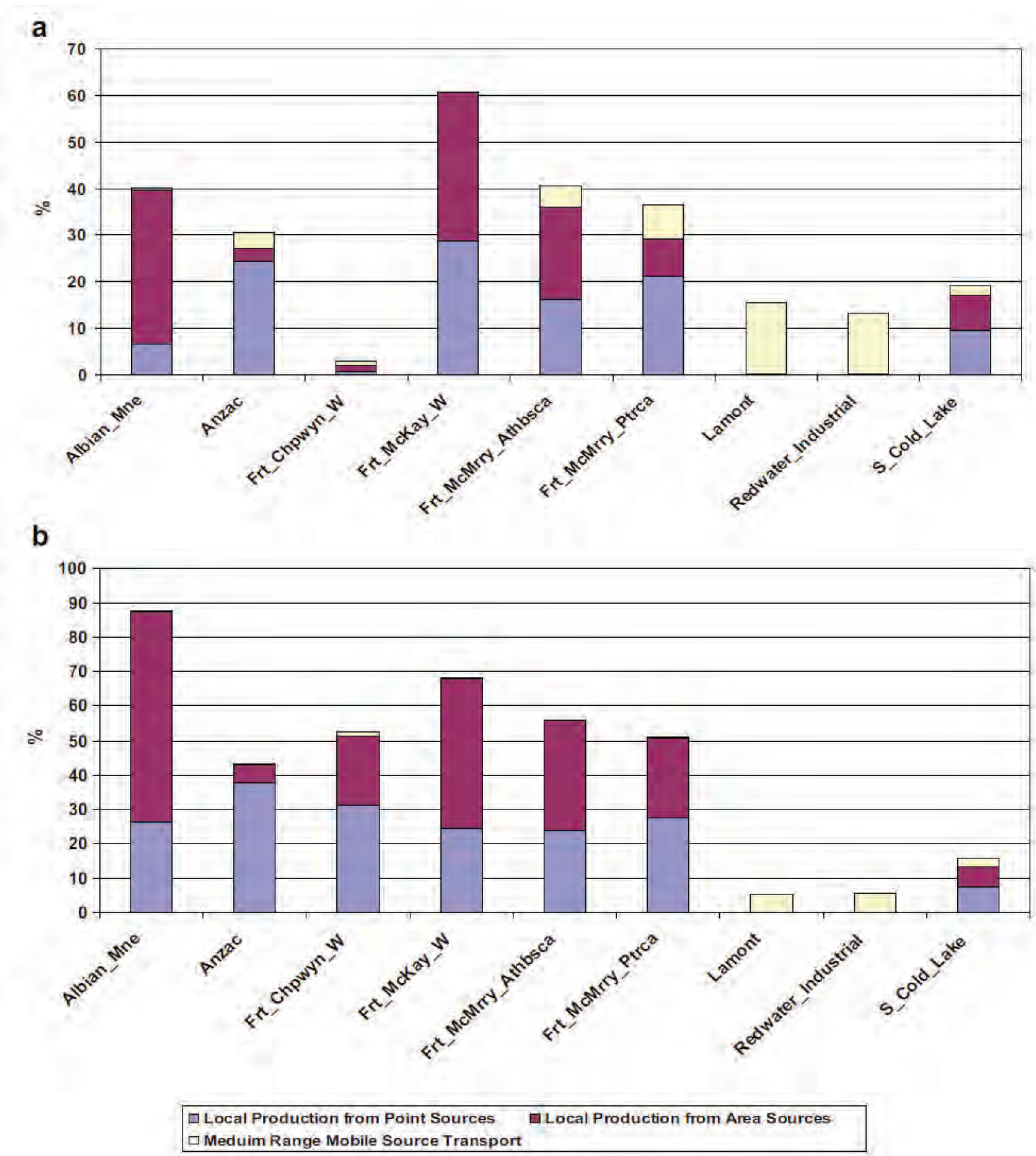


Figure 14. Sectoral Contributions to (a) 98th Percentile 24-hr Average and (b) Maximum 1-hr $PM_{2.5}$ Concentrations at Selected Monitoring Sites within the 4 km Modelling Domain Expressed as a Contribution to the Base Case Value

6.4 Review of Project Environmental Impact Assessment (EIA) CALPUFF Modeling Predictions for $PM_{2.5}$

Proposed oil sands mines and other oil sands projects producing more than 2000 cubic metres of crude bitumen or its derivatives per day are required to conduct an EIA. Potential air quality impacts associated with the project relative to already approved projects and planned projects are assessed using CALPUFF (dispersion and deposition) and CALMET (meteorology) models. CALPUFF has limitations in terms of modeling $PM_{2.5}$ and is not able to model O_3 formation. $PM_{2.5}$ predictions from CALPUFF modelling include primary $PM_{2.5}$ emissions plus secondary $PM_{2.5}$ formed by atmospheric reactions between ammonium and nitrate and sulphate species. CALPUFF EIA modelling includes all emission sources, i.e., point and non-point, within the modelling domain which is generally large i.e. > 200 km x 200 km around the proposed project. Therefore while this modelling approach does allow an assessment of the relative significance of different emission source types it does provide an indication of the potential for a region to trigger $PM_{2.5}$ management action requirements under the CWS/CAAQS.

Table 13 is a summary of predicted $PM_{2.5}$ levels in Fort McKay over time under the planned development assessment scenario (existing and approved projects plus the project being applied for plus planned projects) from a number of EIAs. Fort McKay was selected as the receptor location for the predictions because it is in the centre of the mineable oil sands area and is near the 3 largest oil sands operations that do bitumen upgrading.

Table 13: $PM_{2.5}$ Predictions at Fort McKay from Different Project EIAs and Time Periods for a Planned Development Scenario

Project EIA and Date	98^{th}%tile 24-hr $PM_{2.5}$ Prediction in Fort McKay (µg/m^3)	Annual Average $PM_{2.5}$ Prediction in Fort McKay (µg/m^3)
CNRL Horizon Project (2002)	20.7	8.0
Albian Sands Muskeg River Mine Expansion (2005)	24.9	9.25
Shell Jackpine Mine Expansion and Pierre River Mine (2007)	28.2	Not Given
Teck Frontier Mine Project (2011)	26.2-49.5*	6.9-13.3*
Teck Frontier Mine Project (2015)	21.7**	8.9**
* The range is based on either all off-road sources meeting Tier IV emission limits or a mix of Tier 0, I, II, III & IV limits		
** Assumes all mine fleet vehicles meet Tier IV emission limits		

6.5 Ozone and $PM_{2.5}$ Modelling of On- and Off-Road Diesel Emissions (2015)

Health Canada recently undertook at study that examined the human health risk associated with diesel exhaust in Canada (Health Canada, 2015). In the study Environment Canada's AURUMS (A Unified Regional Air Quality Modelling System) was used to estimate the impact of on- and off-road diesel emissions on NO_2, O_3, and $PM_{2.5}$ concentrations across Canada on a 22.5 km x 22.5 km grid spacing. Projected 2015 emissions were used in the modelling. The study notes that:

> The objective of the current analysis was to evaluate the impact that diesel emissions have on air quality in Canada. A sensitivity analysis technique was used wherein air quality was modelled under three scenarios: 1) with the full Canadian emission inventory, 2) with on-road diesel emissions removed from the Canadian inventory and 3) with on-road and off-road diesel emissions removed from the Canadian inventory.(page 21)
>
> and
>
> The air quality differences between the full emission inventory scenario and the scenarios with diesel emissions removed were assumed to represent the impact of diesel emissions in Canada. (page 21)

This modelling would indicate that in the LAR Air Zone, particularly near mining operations, on- and off-road diesel emissions are contributors to NO_2, O_3, and $PM_{2.5}$ concentrations. This is illustrated in Figures 15, 16, and 17, which are from the study, but were obtained directly from Environment Canada (Van Olst, 2016) in order to focus on the results for Alberta.

6.5.1 Conclusion

This study provides information that would indicate that on-road and off-road diesel emissions may not be major contributors to daily $PM_{2.5}$ levels but could be major contributors to annual NO_2 levels and may contribute a few ppb to maximum daily hourly O_3 levels.

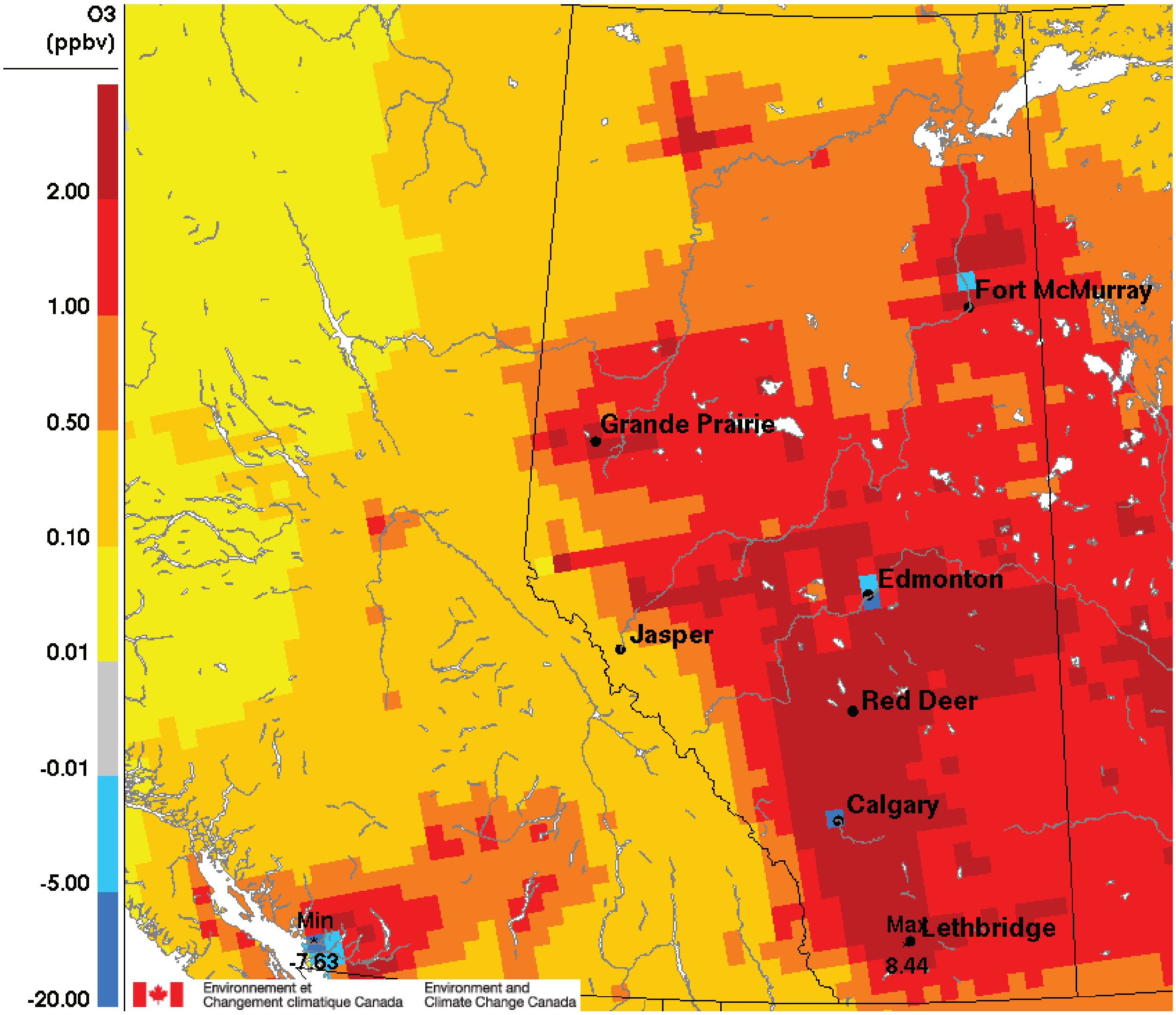


Figure 15. Absolute Contribution to Summer 1 hr Daily Maximum O_3 Concentrations Associated with On-road and Off-road Diesel Emissions in Canada in 2015

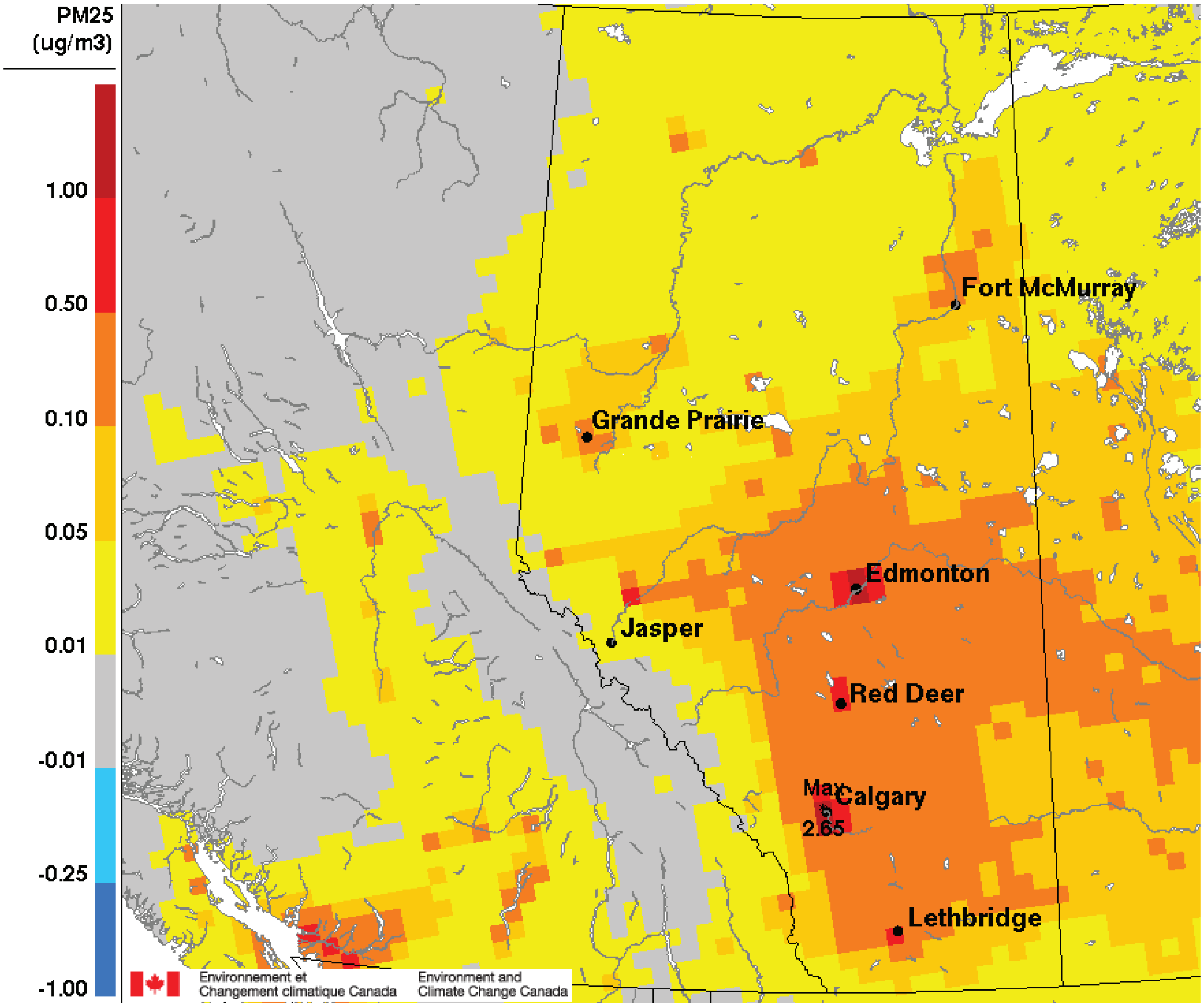


Figure 16. Absolute Contribution to Annual Daily Mean $PM_{2.5}$ Concentrations Associated with On-road and Off-road Diesel Emissions in Canada in 2015

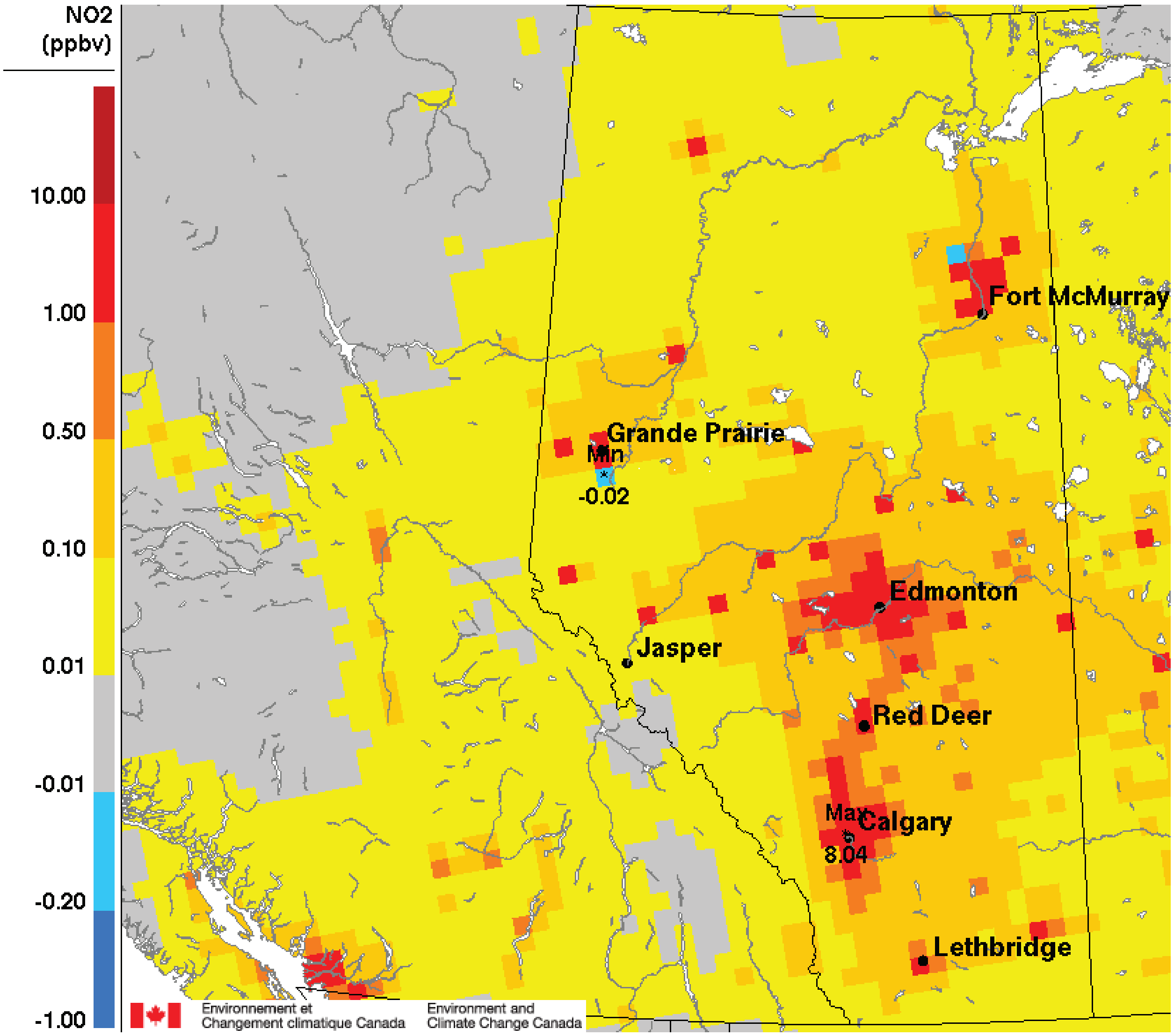


Figure 17. Absolute Contribution to Annual Daily Mean NO_2 Concentrations Associated with On-road and Off-road Diesel Emissions in Canada in 2015

7 Summary

The LAR Air Zone has been assigned the orange management level based on both the annual 24-hr 98th percentile $PM_{2.5}$ readings and the 3-year average annual $PM_{2.5}$ readings (2011-2013) at the CNRL Horizon air monitoring station. Preliminary data for the 2012-2014 assessment period indicates that this station remains in the orange management level. The CNRL Horizon station is located approximately 18 km north of Fort McKay and 70 km north of Fort McMurray and is within a few km of the CNRL Horizon oil sands mining and upgrading facility. This is the only station in the LAR that was in the orange management level for the CAAQS $PM_{2.5}$ metrics and O_3 metric. There are other stations in the LAR Air Zone that that are in the mid- to upper range of the yellow management level for $PM_{2.5}$ indicating that $PM_{2.5}$ levels are somewhat elevated throughout the LAR. Ozone levels in the LAR are in the green management level at all stations but one, Anzac, which is in the lower range of the yellow management level.

8 Information Sources and Key Findings

The LAR Air Zone is unique in that its air quality is heavily influenced by oil sands development related air emissions, which occur throughout the air zone but are concentrated in the area north of Fort McMurray. In addition, unlike in other provincial air zones, the air monitoring station that triggered the orange management level is distant from an urban centre.

In terms of primary $PM_{2.5}$ emissions, and emissions of O_3 and secondary $PM_{2.5}$ emissions precursors, oil sands NPS emissions are a major source.

The large amount of oil sands activity in the LAR Air Zone has resulted in numerous monitoring programs and many focused studies on emissions and their impact on air quality including air quality trending and forecasting. These monitoring programs and studies provide insights into the potential significance of various NPS on air quality in the LAR Air Zone and possible priorities in terms of managing air quality in the LAR Air Zone relative to the CAAQS.

The following is a summary of the types, and general sources, of information available to inform and guide decisions regarding NPS emissions management and air quality management priorities related to the CAAQS:

- information from the extensive WBEA airshed's continuous, passive, and intermittent air monitoring network within the RMWB;
- special studies that have been and/or are being conducted by, or for, the WBEA;
- information from the Lakeland Industrial & Community Association (LICA) airshed, which includes parts of the Counties of Lakeland, St. Paul, Two Hills, and Vermillion River and which operates a continuous, intermittent, and passive monitoring network;
- results from monitoring programs and special studies that have been and are being conducted under the 2012 Joint Canada/Alberta Implementation Plan for Oil Sands Monitoring (JOSM), which includes a comprehensive air quality monitoring plan;
- Cumulative Environmental Management Association (CEMA) modelling results associated with implementation of the CEMA Ozone Management Framework;
- project application modelling;
- federal and/or provincial emission inventory, monitoring and/or modelling programs that considered NPS in the LAR Air Zone; and
- academic papers that cover air quality trending in the LAR Air Zone.

Based on the review of the information from the above sources the following are the key findings.

1. While there is considerable emission and air quality information available for the LAR Air Zone, there are considerable gaps and/or uncertainties in much of the information that complicates relating emission sources to resultant air quality impacts.
2. Relative to the CAAQS' management levels, current regional $PM_{2.5}$ levels are higher than O_3 levels.

3. Air quality modelling indicates that regional $PM_{2.5}$ levels and O_3 levels are likely to increase under current planned development scenarios with $PM_{2.5}$ level increases more than O_3 level increases relative to the current CAAQS levels for $PM_{2.5}$ and O_3.
4. NPS associated with oil sands development have a major influence on regional $PM_{2.5}$ and O_3 levels.
5. Considerable air quality and emission monitoring work in the region is underway and/or planned which, with some enhancements or modifications, represents an opportunity to help inform and guide future CAAQS related air quality management.
6. There appear to be opportunities to reduce and/or enhance management of certain NPS that are relevant to improving air quality relative to the CAAQS.

9 Conclusions

The following is a summary of the conclusions from the review.

1. $PM_{2.5}$ levels in the LAR Air Zone are a much higher management priority than O_3 based on both monitoring and modelling of current and future development scenarios.
2. Based on the available emissions inventory information there are several major industrial non-point sources in the LAR Air Zone that may warrant consideration in relation to CAAQS $PM_{2.5}$ management actions. These industrial non-point sources are:
    a. mine fleets (NOx emissions);
    b. tailings ponds and mines (VOC emissions);
    c. plant fugitive emissions (VOC emissions);
    d. mining and tailings operations (primary $PM_{2.5}$ emissions i.e. dust);
    e. construction activities (primary $PM_{2.5}$ emissions i.e. dust); and
    f. oil sands related prescribed burning (primary $PM_{2.5}$ emissions i.e., smoke).
3. On-road transportation in terms of primary $PM_{2.5}$ emissions (dust) is a non-industrial NPS that that may warrant consideration in relation to CAAQS $PM_{2.5}$ management actions .
4. Of the anthropogenic NPS emissions, VOCs and primary $PM_{2.5}$ emissions (dust and smoke) appear to be the most significant contributors to $PM_{2.5}$ levels.
5. All of the anthropogenic NPS sources may contribute to ambient $PM_{2.5}$ and therefore warrant consideration for enhanced management.
6. In terms of regional O_3 formation, anthropogenic NPS of NOx are the most relevant although secondary to point NOx emission sources.
7. There is limited $PM_{2.5}$ composition data, which hinders developing a full understanding of the sources and factors contributing to the $PM_{2.5}$ levels being measured in the region. This information is essential to the development of $PM_{2.5}$ air quality management strategies.
8. There is considerable uncertainty regarding the magnitude and character of most anthropogenic NPS sources in the LAR Air Zone with emerging information indicating that NPS emissions are higher than previously estimated. Better emission information is necessary to help identify priority emission sources for enhanced management in relation to the CAAQS.
9. Air quality modelling indicates that point and NPS are significant contributors to regional $PM_{2.5}$ levels. This modelling provides insights into possible source management priorities and such modelling should be further developed and used as part of CAAQS related management plans.

10. There appear to be opportunities to improve or advance management and reduction of certain anthropogenic NPS /types such as dust, smoke, and mine fleet emissions, but for other sources such as VOC emissions from mines, management may be difficult and/or challenging.
11. Monitoring and modelling of NO_2 would indicate that NO_2 levels are increasing and will increase further under planned regional development scenarios. Since CAAQS for NO_2 are currently being developed, proactive management of regional NOx sources should be considered.

10 Advice and Recommendations

The following is a summary of the recommendations arising from this review.

10.1 Emission Quantification and Characterization

1. Integrated plant-wide NPS fugitive emission monitoring at oil sands central processing facilities would reduce the uncertainty associated with the current estimates of VOC and NH_3 emissions from these facilities, which are potentially a large source of these emissions.
2. Studies to quantify and characterize fugitive dust emissions from oil sands mining operations would help address the uncertainties regarding the potential significance of this source of primary $PM_{2.5}$ on air quality.
3. There should be a continued focus on improving fugitive air emissions estimates (VOCs, reduced sulphur compounds, PACs, and ammonia) from tailing ponds and mines.
4. Consideration should be given to formalizing tailings pond and mine fugitive emission monitoring requirements for VOCs, reduced sulphur compounds, PACs, and ammonia) similar to the formalized requirements for GHG emission monitoring for these operations.
5. Consider developing and maintaining a comprehensive and continuously updated emission inventory for the LAR Air Zone.
6. A review of prescribed burning practices and associated control requirements in the LAR Air Zone should be undertaken as this practice may be significantly influencing regional $PM_{2.5}$ levels at times and contributing to CAAQS determination levels.

10.2 NPS Management

1. Consider assessing and establishing best management practices for fugitive dust emissions associated with oil sands developments. Alternately, a provincial good practices dust management guide that covered all major dust generating activities, including oil sands mining, could be developed analogous the CASA's recent Good Practices Guide for Odour Management in Alberta document.
2. Consideration should be given to developing more stringent NOx limits for off-road diesel units >750hp in size and that for existing off-road diesel units >750 hp, consideration should be given to applying more stringent NOx limits based on practical retrofit NOx control options.
3. Consider assessing and establishing best management practices for prescribed burning in the LAR Air Zone in the context of minimizing air emissions and air quality impacts associated with this activity. Alternately, a provincial good practices prescribed burning management guide that covered all prescribed burning activities, including oil sands development related slash burning, could be developed analogous the CASA's recent Good Practices Guide for Odour Management in Alberta document.

10.3 Additional Air Quality Monitoring

1. A full $PM_{2.5}$ speciation monitoring program should be implemented at select monitoring sites in the LAR Air Zone to provide the information necessary to identify and assess the sources and/or source types contributing to $PM_{2.5}$ levels at sites that are in, or approaching, CAAQS orange or red management levels.
2. Install aethalometers at select monitoring sites in the LAR Air Zone to provide continuous information on elemental carbon levels in $PM_{2.5}$ and the sources of this elemental carbon.
3. Conduct semi-continuous ambient ion and VOC measurement at select monitoring sites in the LAR Air Zone to provide the information on the organic and inorganic compounds that are or may be contributing to measured $PM_{2.5}$ levels at these sites.
4. During elevated $PM_{2.5}$ events consideration should be given to deploying mobile air quality monitoring equipment to collect air quality and meteorological data on a temporal and spatial scale that would help to determine the sources and factors contributing to these elevated events.

10.4 Air Quality Modelling

1. Use photochemical modelling to inform air quality management plans related to the CAAQS and include NPS apportionment evaluations in this modelling.
2. Efforts should continue on developing and parameterizing air quality models to improve regional model predictions and their usefulness as planning and assessment tools.

10.5 Air Quality Studies

1. A focused and detailed evaluation of existing $PM_{2.5}$ composition data in relation to the elevated $PM_{2.5}$ days identified in the CWS/CAAQS compliance/management assessments should be undertaken. This evaluation should also assess meteorological and industrial emission locations to try to identify the factor(s) and source(s) possibly contributing to the elevated levels.
2. Approaches to air quality trending should be evaluated to try to address the dataset "noise" issues that complicate and compromise current trending approaches.
3. Current studies related to determining the sources and processes contributing to secondary organic aerosol (SOA) formation and ozone formation should continue, with a focus on identifying the relative significance of biogenic versus anthropogenic VOC sources to SOA formation and the identification of any anthropogenic VOC sources that may be significantly contributing to regional $PM_{2.5}$ levels.

10.6 Nitrogen Dioxide

1. The management of NO_2 should be a priority as CAAQS values for NO_2 are being developed and based on current NO_2 levels in the LAR Air Zone and modelled predicted future levels. It is likely that NO_2 will be a CAAQS management in the LAR Air Zone in the future.

11 References

Alberta Environmental Monitoring, Evaluation, and Reporting Agency (AEMERA). 2016. CASA PM_O3 CAAQS 2011 to 2015. *Unpublished material provided to the CASA NPS Technical Task Goup upon request*. Edmonton: Alberta Environmental Monitoring, Evaluation and Reporting Agency.

Alberta Environment and Parks (AEP). 2014, June. *Quantification of Fugitive Emissions at Oil sands Mines.* Retrieved from Alberta Environment and Parks: http://aep.alberta.ca/climate-change/guidelines-legislation/specified-gas-emitters-regulation/documents/AreaFugitiveEmissionsOilSandsMines-2014.pdf

______. 2015. Alberta: Air Zones Report 2011-2013. Edmonton, AB: Government of Alberta.

______. 2016a. Alberta Environment and Parks Regional Air Quality Management Update by Lisa Avis. *Presentation CASA March 24 Board Meeting*. Edmonton: Government of Alberta.

______.2016b. *Canadian Ambient Air Quality Standards.* Alberta Environment and Parks: http://aep.alberta.ca/air/management-frameworks/canadian-ambient-air-quality-standards-for-particulate-matter-and-ozone/default.aspx. accessed April 9, 2016

______. 2016c. *Draft Summary Report on Major Non-Point Air Emission Sources in Alberta* (March 2016). Edmonton: Government of Alberta.

Avis, L. 2016. *See* Alberta Environment and Parks

Bari, M. A., & Kindzierski, W. B. 2015. Fifteen-year trends in criteria air pollutants in oil sands communities of Alberta, Canada. *Environment International.* 74*:* 200–208.

______. 2016. Evaluation of air quality indicators in Alberta, Canada – An international perspective. *Environment International.* 93: 119-129.

Bari, M. A., Kindzierski, W. B., & Spink, D. R. 2016. Twelve-year trends in ambient concentrations of volatile organic compounds in a community of the Alberta Oil Sands Region, Canada. *Environment International*. May 2016: 40-50.

Chambers, A., & Strosher, M. 2006. *Refinery Demonstration of Optical Technology for Measurement of Fugitive Emissions and for Leak Detection.* Edmonton: Alberta Research Council.

Cho, S., McEachern, P., Morris, R., Shah, T., Johnson, J., & Nopmongcol, U. 2012a. Emission sources sensitivity study for ground-level ozone and PM2.5 due to oil sands development using air quality modeling system: Part I- model evaluation for current year base case simulation. *Atmospheric Environment*, 533-541.

______. 2012b. Emission sources sensitivity study for ground-level ozone and PM2.5 due to oil sands development using air quality modelling system: Part II e Source apportionment modelling. *Atmospheric Environment*, 542-556.

Cumulative Environmental Management Association. (n.d.). *Recommendations Acid Deposition Management Framework.* Retrieved October 11, 2015, from http://cemaonline.ca/index.php/cema-recommendations/acid-deposition

______. 2005. *CEMA/Recommendations/Acid Deposition Management Framework*. Retrieved from Cumualtive Environmental Management Association: http://cemaonline.ca/index.php/cema-recommendations/acid-deposition February 25)

______. 2006. *Recommendations: Ozone Management.* Retrieved from Cumualtive Environmental Management Association: http://cemaonline.ca/index.php/cema-recommendations/ozone-management

______. 2008a. *Cumulative Environmental Management Association.* Retrieved from Recommendations: Interim Nitrogen: http://cemaonline.ca/index.php/cema-recommendations/interim-nitrogen

______. 2008b. *Recommendations Interim Nitrogen Management Framework.* Retrieved October 11, 2015, from Cumualtive Environmental Management Association: http://cemaonline.ca/index.php/cema-recommendations/interim-nitrogen

______. 2012. *Development of a Modeling Emissions Inventory Database for the Implementation of Emissions Management Frameworks* . Retrieved from Cumulative Environmental Management Association: http://library.cemaonline.ca/ckan/dataset/2011-0038

______. 2015a. *Libraries/Tools* . Retrieved from Cumualtive Environmental Management Association: http://cemaonline.ca/

______. 2015b. *Lower Athabasca Region Source and Emission Inventory.* Retrieved from Cumualtive Environmental Management Association: http://library.cemaonline.ca/ckan/dataset/2011-0038/resource/fba8a3b0-72df-45ed-bf12-8ca254fdd5b1 January 28

______. 2016. *Assessment of Ozone Precursors.* Retrieved from Cumualtive Environment Management Association: http://library.cemaonline.ca/ckan/dataset/2014-0013. , March 2

Davies, M., & Fellin, P. (1999). The Potential for Ozone Formation in Alberta: A Discussion Paper. *Ozone Experts Form, June 10 & 11, 1999.* Calgary.

Davies, M., Person, R., Nopmongcol, U., Shah, T., Vijayaraghavan, K., Morris, R., & Picard, D. (2012). *Lower Athabasca Region Source and Emission Inventory. Stantec Consulting Ltd., ENVIRON International Corporation and Clearstone Engineering Ltd. Prepared for Cum.* Fort McMurray: Cumulative Environmental Management Association (CEMA).

Environment and Climate Change Canada. (2016, January 4). *National Pollutant Release inventory*. Retrieved from Environment and Climate Change Canada: https://www.ec.gc.ca/inrp-npri/

Fox, D., & Kellerhals, M. (2007). *Modelling Ozone Levels in Alberta: Base Case, Sectoral Contributions and a Future Scenario.* Edmonton: Environment Canada, Prairie and Northern Region.

Galarneau, E., Hollebone, B. P., Yang, Z., & Schuster, J. 2014. Preliminary measurement-based estimates of PAH emissions from oil sands ponds. *Atmospheric Environment*, 332-335.

Government of Alberta. (2014, June). *Quantification of Fugitive Emissions at Oil sands Mines.* Retrieved from Alberta Environment and Parks: http://aep.alberta.ca/climate-change/guidelines-legislation/specified-gas-emitters-regulation/documents/AreaFugitiveEmissionsOilSandsMines-2014.pdf

______. 2015a. Specified Gas Emitters Regulation Chapter/Regulation: 139/2007 Alberta Queen's Printer. Retrieved from Laws Online/Catelogue:http://www.qp.alberta.ca/documents/Regs/2007_139.pdf

______.2015b. Specified Gas Reporting Regulation Chapter/Regulation: 251/2004 : Alberta Queen's Printer . Retrieved from Laws Online/Catelogue;http://www.qp.alberta.ca/1266.cfm?page=2004_251.cfm&leg_type=Regs&isbncln=9780779787050

Government of Canada. 2015, December 16. *Current Regulation. Off-Road Compression-Ignition Engine Emission Regulations (SOR/2005-32). .* Retrieved from Environment and Climate Change Canada: http://www.ec.gc.ca/lcpe-cepa/eng/regulations/detailReg.cfm?intReg=88

______. 2015. *Human Health Risk Assessment for Diesel Exhaust.* Ottawa: Health Canada. Retrieved from http://healthycanadians.gc.ca/publications/healthy-living-vie-saine/exhaust-diesel-gaz-echappement/index-eng.php

Government of Canada and Alberta Government. 2012. Retrieved from Canada-Alberta Oil Sands Environmental Monitoring Information Portal: http://jointoilsandsmonitoring.ca/default.asp?n=5F73C7C9-1&lang=en

Howell, S. G., Clarke, A. D., Freitag, S., McNaughton, C. S., Kopustin, V., Brekovkikh, V., . . . Cubison, M. J. 2014. An airborne assessment of atmospheric particulate emissions from the processing of Athabasca oil sands. *Atmospheric Chemistry and Physics*, 5073-5087.

Hsu, Y.-M. 2013a. *2009-2011 Ambient Air Sample Collection and Analytical Program for Integrated PM2.5, PM10, VOCs, Semi-Volatile Organics, SO2, NO2, O3, Wet Precipitation Chemistry, HNO2, HNO3, and NH3 (Intermittent Data).* Fort McMurray: Wood Buffalo Environmental Association.

______. 2013b. Trends in Passively-Measured Ozone, Nitrogen Dioxide and Sulfur Dioxide Concentrations in the Athabasca Oil Sands Region of Alberta, Canada. *Aerosol and Air Quality Research*, 1448-1463.

Hsu, Y.-M., & Clair, T. A. 2015. Measurement of fine particulate matter water-soluble inorganic species and precursor gases in the Alberta Oil Sands Region using an improved semicontinuous monitor. *Journal of the Air and Waste Management Association*, 423-435.

Hsu, Y.-M., Harner, T., Li, H., & Fellin, P. 2015. PAH Measurements in Air in the Athabasca Oil Sands Region. *Environmental Science and Technology*, 5584-5592.

Hsu, Y.-M., Martineau, M., & Edgerton, E. 2016, January 17. New Approaches to Air Measurements in AOSR: -Preliminary Results-Black Carbon real time monitor: AE22 and AE33. Wood Buffalo Environmental Association.

Hsu, Y.-M., Wang, X., Chow, J. C., Watson, J. G., & Percy, K. E. 2016. Collocated comparisons of continuous and filter-based PM2.5 measurements at Fort McMurray, Alberta, Canada. *Journal of Air and Waste Management Association*, 0-12.

Kelly, E. N., Short, J. W., Shindler, D. W., Hodson, P. V., Mingsheng, M., Kwan, A. K., & Fortin, B. 2009. Oil sands development contributes polycyclic aromatic carbons to the Athabasca River and its Tributaries. *Proceedings of the National Acedemy of Sciences*, 22346-22351.

Kindzierski, W. B., Chelma-Ayala, P., & Gamel El-Din, M. 2009. *Wood Buffalo Environmental Association Ambient Air Quality Data Summary and Trend Analysis.* Edmonton: University of Alberta, School of Public Health.

Kurek, J., Kirk, J. L., Muir, D. C., Wang, X., Evans, M. S., & Smol, J. P. 2013. Legacy of a half century of Athabasca oil sands development recorded by lake ecosystems. *Proceedings of the National Academy of Science*, 1761-1766.

Landis, M. S., Pancras, J. P., Graney, J. R., Stevens, R. K., Percy, K. E., & Krupa, S. 2012. Receptor Modeeling of Epiphytic Lichens to Elucidate the Sources and Spatial Distribution of Inorganic Air Pollution in the Athabasca Oil Sands Region. In K. E. Percy, *Alberta Oil Sands Energy, Industry and the Environment* (pp. 427-465). Oxford: Elsevier Ltd.

Liggio, J., Li, S.-M., Hayden, K., Taha, Y. M., Stroud, C., Darlington, A., . . . Genter, D. R. 2016. Oil sands operations as a large source of secondary organic aerosols. *Nature*, 1-4.

M. J. Bradley and Associates. 2008. *Evaluation Of Vehicle Emissions Reduction Options For The Oil Sands Mining Fleet.* Ottawa: Environment Canada.

Marson, G. 2015. Better Estimates of Geography-Based Emissions from the Oil Sands. *AEMERA Oil Sands Monitoring Symposium.* Edmonton.

McLinden, C. A., Fioletov, V., Boersma, K. F., Krotov, N., Sioris, C. E., Veefkind, J. P., & Yang, K. (2012). Air quality over the Canadian oil sands: A first assessment using satellite observations. *Geophysical Research Letters, VOL. 39, L04804, , 2012*, L04804. doi:doi:10.1029/2011GL050273

McLinden, C. A., Fioletov, V., Krotkov, N. A., Li, C., Boersma, K. F., & Adams, C. 2016. A Decade of Change in NO2 and SO2 over the Canadian Oil Sands As Seen from Space. *Environmental Science and Technology*, 331-337. doi:DOI: 10.1021/acs.est.5b04985

Morris, R., Shah, T., Johnson, J., Jung, J., Piyachaturawat, P., Pollock, T., . . . Staniaszek, P. 2010. *PM and Ozone Chemistry Modelling in the Alberta Oil Sands Area Using the Community Multiscale Air Quality (CMAQ) Model.* Fort McMurray: Cumualtive Environmental Management Association.

Phillips-Smith, C., Jeong, C.-H., Healy, R. M., Dabek-Zlotorzynska, E., Celo, V., Brook, J. R., & Evans, G. 2016. Sources of Particulate Matter in the Athabasca Oil Sands Region: Investigation through a Comparison of Trace Element Measurement Methodologies. *Submitted for publication*.

Proemse, B. C., & Mayer, B. 2012. Tracing Industrial Nitrogen and Sulfur Emissions in the Athabasca Oil sands Region Using Stable Isotopes. In K. E. Percy, *Alberta Oil Sands Energy, Industry and the Environment* (pp. 243-266). Oxford: Elsevier Ltd.

Small, C. C., Cho, S., Hashisho, Z., & Ulrich, A. C. 2015. Emissions from oil sands tailings ponds: Review of tailings pond parameters and emission estimates. *Journal of Petroleum Science and Engineering*, 490-501.

Spink, D. 2016. Fort McKay Prescribed Burning Air Quality Concerns .

Stantec Consulting Ltd., Clearstone Engineering Ltd. and Intrinsik Environmental Sciences Inc. 2016. *Air Pollutant and GHG Emissions from Mine Faces and Tailings Ponds (DRAFT:V2).* Edmonton: AEMERA.

Stroud, C., Liggio, J., Taha, Y., Makar, P., Hayden, K., & Li, S.-M. 2015. Oil Sands Operations in Alberta, Canada: A Large Source of Secondary Organic Aerosol. *International Aerosol Modeling Algorithm Conference*. Davis.

Teck Resources Limited. 2015. *Frontier Oil Sands Mine Project Update Volume 3: Assessment Update. Appendix 4A: Source and Emission Inventory.* Calgary: Teck.

US Environmental Protection Agency (USEPA). 2004, June 29. Federal Register / Vol. 69, No. 124 / Tuesday, June 29, 2004 / Rules and Regulations. *Control of Emissions of Air Pollution from Nonroad Diesel Engines and Fuel.* . Retrieved from http://www.gpo.gov/fdsys/pkg/FR-2004-06-29/pdf/04-11293.pdf

______. 2015. *Guidance on the use of models for assessing the impacts of emissions from single sources on the secondarily formed pollutants ozone and PM2.5.* Research Triangle Park, NC.: United States Environmental Protection Agency. Retrieved from https://www3.epa.gov/ttn/scram/11thmodconf/Draft_Guidance_SingleSource_SecondarilyFormed-07152015.pdf

______. 2016, February 23. *United States Environmental Protection Agency.* Retrieved from Nonroad Engines, Equipment, and Vehicles: https://www3.epa.gov/otaq/nonroad-diesel.htm

Van Olst, M. (2016, April 26). Senior Analyst, Regional Analysis and Relationships, Environment Canada, Edmonton. (D. Spink, Interviewer)

Vijayaraghavan, K., Jung, J., Sakulyanonvittay, T., Shah, T., Hahn, R., Morris, R., . . . Person, R. 2014. *CMAQ Modelling for the CEMA Ozone Management Framework, Acid Deposition Management Framework and Interim Nitrogen Eutrophication Management Plan.* Fort McMurray, Alberta: Cumualtive Environmental Management Association.

Wang, X. L., Watson, J. G., Chow, J. C., Kohl, S. D., Chen, L. -W., Sodeman, D. A., . . . Percy, K. E. 2012. Measurement of Real-World Stack Emissions with a Dilution Sampling System. In K. E. Percy, *Alberta Oil Sands Energy, Industry and the Environment* (pp. 171-192). Oxford: Elsevier Ltd.

Wang, X., Chow, J. C., Kohl, S. D., Narasimha, L., Yatavelli, R., Percy, K. E., . . . Watson, J. G. 2015. Wind erosion potential for fugitive dust sources in the Athabasca Oil Sands Region. *Aeolian Research*, 121-134.

Wang, X., Chow, J. C., Kohl, S. D., Percy, K. E., Legge, A. H., & Watson, J. G. 2015. Characterization of PM2.5 and PM10 fugitive dust source profiles in the Athabasca Oil Sands Region. *Journal of Air and Waste Management Association*, 1421-1433.

Wang, X., Chow, J. C., Percy, K. E., Legge, A. H., Watson, J. G., & Kohl, S. D. 2015. Real-world emission factors for Caterpillar 797B heavy haulers duringmining operations. *Particuology*. doi:http://dx.doi.org/10.1016/j.partic.2015.07.001

Watmough, S. A., Whitfield, C. J., & Fenn, M. E. 2014. The importance of atmospheric base cation deposition for preventing soil acidification in the Athabasca Oil Sands Region of Canada. *Science of the Total Environment*, 1-11.

Watson, J. G., Chow, J. C., Wang, X., Lowenthal, D. H., Kohl, S. D., & Gronstal, S. (2011). *Real-World Emissions from Non-Road Mining Trucks.* Fort McMurray: Wood Buffalo Environmental Association.

Wood Buffalo Environmental Association (WBEA). 2012, 2013, 2014. *Annual Monitoring Reports.* Retrieved from Wood Buffalo Environmental Association : http://www.wbea.org/resources/ambient-air-monitoring-reports/ambient-annual-reports

Zhang, Y., Shotyk, W., Zaccone, C., Noernberg, T., Pelletier, R., Bicalho, B., . . . Martin, J. W. 2016. Airborne Petcoke Dust is a Major Source of Polycyclic Aromatic Hydrocarbons in the Athabasca Oil Sands Region. *Environmental Science & Technology*, 1711-1720.

2016

CASA Air Zone Reports

Upper Athabasca Air Zone

Summary of Information, Studies, Papers, and Reports of Possible Relevance to the Work of the CASA Non-Point Source (NPS) Technical Task Group Related to: Air Monitoring, Ambient Air Quality Trending, Air Dispersion Modelling, Source Characterization, and Air Emission Inventories for the Upper Athabasca Air Zone

Martin Van Olst
GOA

8/12/2016

Contents

List of Figures

List of Tables

1 Context

1.1 Purpose

This document has been prepared to summarize information pertaining to the Upper Athabasca (UA) Air Zone and the possible significance of non-point sources (NPS) on air quality as measured against the Canada Wide Standards (CWS) and Canadian Ambient Air Quality Standards (CAAQS).

The focus is on:

1. past and current UA air quality assessments against the CWS and CAAQS;
2. trends in UA air quality based on ambient monitoring data;
3. air emissions inventory data and emission trends for the UA; and
4. air modelling and source apportionment studies for the Upper Athabasca Region Air Zone.

This information can be used to assess and understand which, and how, non-point sources may be contributing to ambient concentrations of fine particulate matter ($PM_{2.5}$) and ozone (O_3) in the UA Air Zone relative to the CAAQS and where there are gaps in information and understanding. Table 1 summarizes the CAAQS for $PM_{2.5}$ and O_3.

Table 1: The CAAQS and Associated Management Levels

Management Level	Ozone (ppb)	$PM_{2.5}$ 24 hour (µg m^{-3})	$PM_{2.5}$ Annual (µg m^{-3})
Effective	**2015**	**2015**	**2015**
Red	**Actions for Achieving CAAQS**		
Threshold	63	28	10.0
Orange	**Actions for Preventing CAAQS Exceedances**		
Threshold	56	19	6.4
Yellow	Actions for Preventing Air Quality Deterioration		
Threshold	50	10	4.0
Green	**Actions for Keeping Clean Areas Clean**		

1.2 Ambient Monitoring in the Upper Athabasca Air Zone

The *Alberta: Air Zones Report 2011-2013* summarizes the Canadian Ambient Air Quality Standards (CAAQS) achievement status and management levels for Alberta's air zones for $PM_{2.5}$ and O_3 monitoring results. Five stations in the UA Air Zone were used in the 2011 to 2013 assessment. Figure 1 provides a map of the ambient monitoring stations in the UA Air Zone used in the 2011-2013 CAAQS assessment.

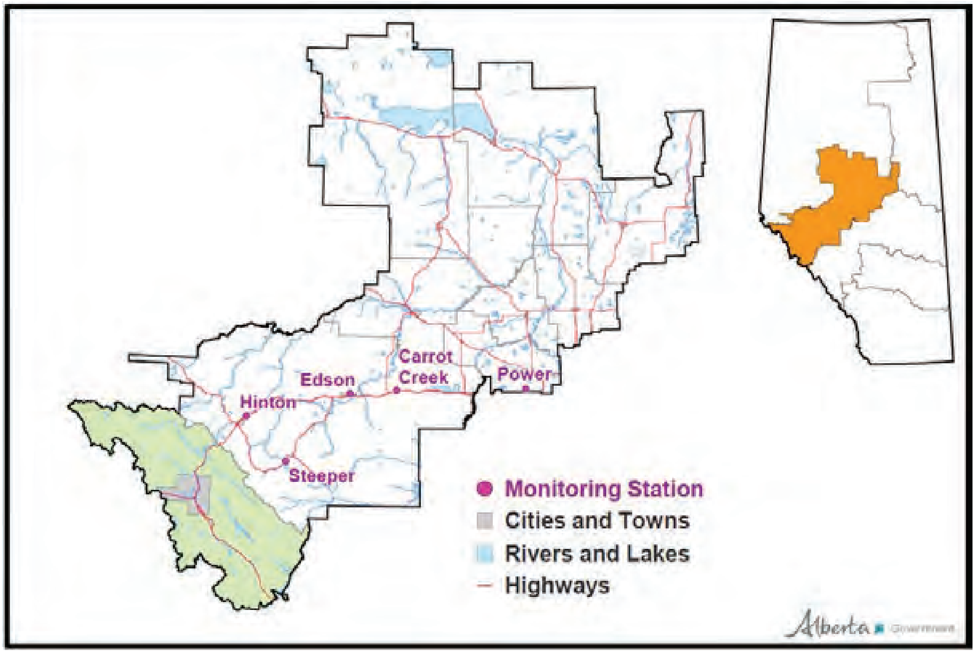


Figure 1: Ambient Monitoring Stations in the Upper Athabasca Region Air Zone used to Assess Air Zone Status relative to the CAAQS

1.3 CAAQS Assessments for the Upper Athabasca Air Zone

The Alberta: Air Zones Report 2011-2013 assigned Hinton station to the orange management level for $PM_{2.5}$, Actions for Preventing CAAQS Exceedance. The other stations in the zone were assigned to lower management levels. As such, the zone is assigned to the orange management level for $PM_{2.5}$. This management level indicates that $PM_{2.5}$ concentrations are approaching CAAQS and proactive action is needed to prevent exceedance.

All stations were assigned to the yellow management level for O_3; as such, the UA Air Zone is assigned to the yellow management level for ozone, Actions for Preventing Air Quality Deterioration. This management level calls for improvement to air quality using early and ongoing actions for continuous improvement.

Concentrations of criteria air contaminants at 5 ambient air monitoring stations were used for the assessment.

Table 2: CAAQS Concentration Determination and Assigned Level for Noted Stations

Station	$PM_{2.5}$ – 24 hr (µg/m3)				$PM_{2.5}$ – Annual (µg/m3)				O_3 Annual (ppb)			
	2011	2012	2013	**2011-13**	2011	2012	2013	**2011-13**	2011	2012	2013	**2011-13**
Carrot Creek	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	50.4	53.4	56.3	53
Edson	10.3	11.0	11.4	11	3.8	4.8	4.0	4.2	42.1	50.0	56.9	50
Hinton	13.7	16.8	17.6	16	7.6	7.8	7.7	7.7	n/a	n/a	n/a	
Power	11.3	14.7	9.3	12	3.6	4.5	3.5	3.9	n/a	n/a	n/a	
Steeper	7.8	10.6	9.1	9	2.0	2.5	2.5	2.3	50.3	56.8	52.1	53
Upper Athabasca Air Zone				16				7.7				53

2 Non-Point Emission Sources and Upper Athabasca Emissions Inventories in the Upper Athabasca Air Zone

2.1 Alberta Non-point Sources

Government of Alberta 2016b lists the following industrial and non-industrial sources as the major NPS types in Alberta.

Industrial Non-point Sources

- Plant fugitive leaks;
- Liquid tailings ponds;
- Mine fleets;
- Mine faces;
- Solid mine tailings;
- Materials storage and handling;
- Non-stationary equipment;
- Space heating; and
- Storage tanks.

Non-industrial, Non-point Sources

- Road dust (unpaved and paved roads);
- Construction (industrial, transportation, municipal, residential, and communications);
- Agriculture (agricultural animals, fertilizer application, harvesting, tilling, and wind erosion); and
- Transportation (on-road vehicles, off-road vehicles, and rail transportation).

Note: Dust sources were not specifically addressed in the CEMA inventory and it appears that sources like prescribed burning were also not considered.

2.2 Relative Significance of Different Sources to NPS Emissions in the Upper Athabasca Region Air Zone

Figure 2 (AEP 2016b) provides the relative fractional estimates of the contribution of different sources to primary $PM_{2.5}$, VOC, NOx, and SO_2 emissions in the UA Air Zone. In this figure, the "other sources" include all other source categories, each of which individually contributed to less than 5% of the region's emissions total of the particular pollutant.

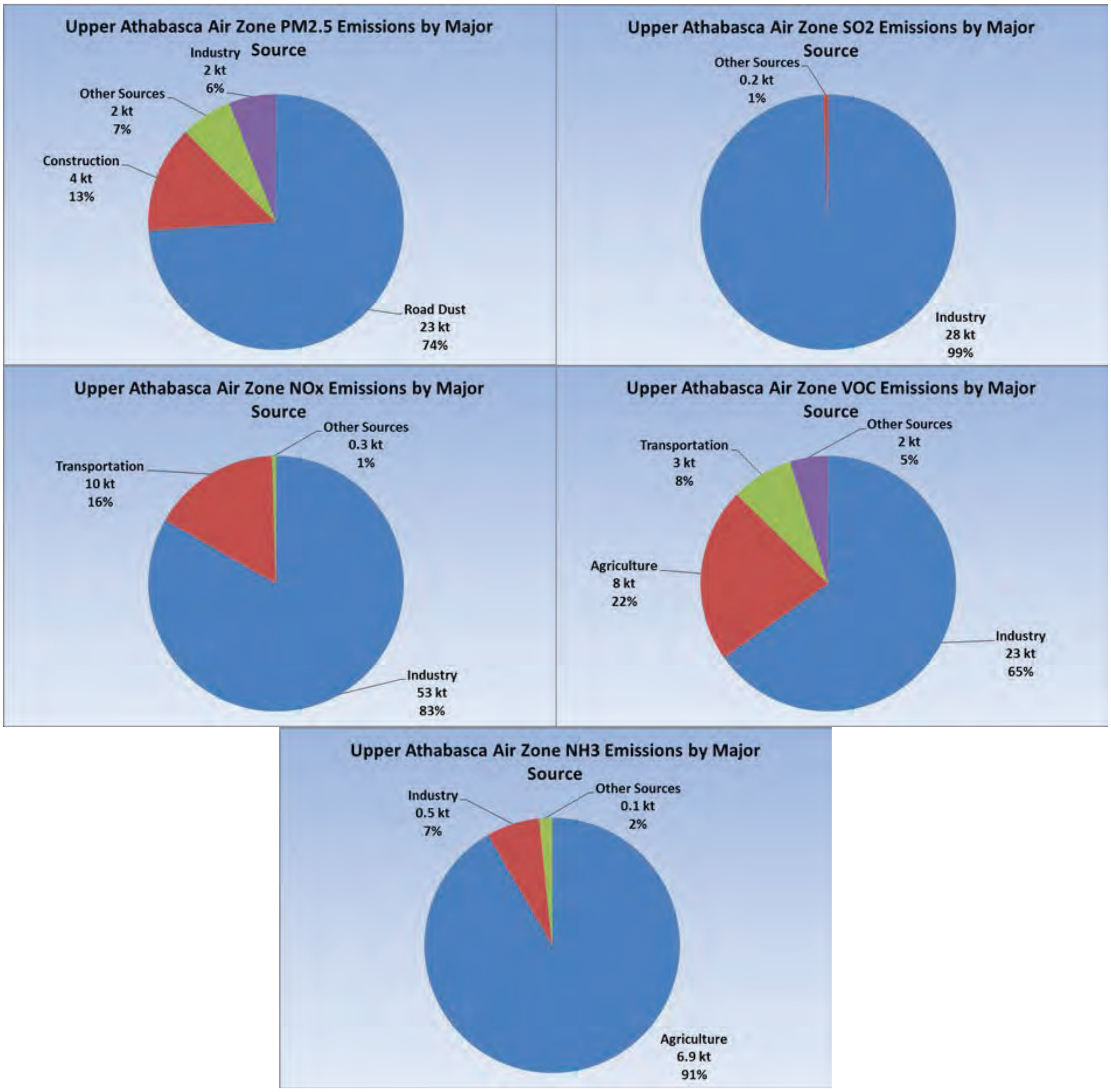


Figure 2: Relative Contribution of Different Emissions Source Types to Primary $PM_{2.5}$, VOC, NOx, and SO_2 Emissions in the Upper Athabasca Air Zone

3 Upper Athabasca Air Zone Non-Point Source Emissions

The *Alberta: Air Zone Report 2011-2013* (AEP 2016a), in addition to assessing the status of air zones relative to the CAAQS, also provided emission inventory data by sector and region for primary PM, NOx, SO_2, and NH_3. The inventory is based on the 2008 Alberta Air Emissions Inventory. Table 3 summarizes the emission inventory for the UA Air Zone from this report.

Table 3: Breakdown by Sector/Source of Emissions of Noted Parameters (AEP 2016a)

Sector/Source	Emissions of Noted Parameter in the Upper Athabasca Region by Sector (tonnes)									
	Primary PM2.5	% of total	SO2	% of total	NOx	% of total	VOCs	% of total	NH3	% of total
Agriculture	1,268	4%	0	0%	0	0%	7,771	2%	6,872	92%
Cement and Concrete	22	0%	0	0%	0	0%	0	0%	0	0%
Chemical	0	0%	0	0%	0	0%	0	0%	0	0%
Construction	4,198	14%	0	0%	10	0%	0	0%	0	0%
Conventional Oil and Gas	655	2%	25,135	89%	48,354	72%	19,078	4%	323	4%
Electrical Power Generation	22	0%	1	0%	1,589	2%	67	0%	3	0%
Fertilizer	0	0%	0	0%	0	0%	0	0%	0	0%
Oil Sands	0	0%	0	0%	0	0%	0	0%	0	0%
Pulp and Paper	431	1%	2,730	10%	2,004	3%	397	0%	131	2%
Road Dust	22,964	74%	0	0%	0	0%	0	0%	0	0%
Transportation	496	2%	117	0%	10,331	15%	2,764	1%	111	1%
Wood Products	212	1%	40	0%	839	1%	3,251	1%	48	1%
Other Sources	581	2%	198	1%	282	0%	1,660	0%	7	0%
Non-Industrial Sources	154	0%	57	0%	301	0%	172	0%	3	0%
Natural Sources	50	0%	0	0%	3,218	5%	457,927	93%	1	0%
Total	31,053	100%	28278	100%	66928	100%	493,087	100%	7,499	100%
*Conventional oil and gas includes both upstream and downstream oil and gas										

Note: Yellow and blue highlight denotes the highest and second highest emission source for each parameter, respectively.

4 Ambient Monitoring Trends in the Upper Athabasca Air Zone

The total emissions for the Upper Athabasca Region (PM2.5, SO2, NOx, VOCs and NH3) are comparable to that of the Peace Region and anywhere from a third to a half of that from the other more populated regions. The trend for the past 14 years has been insignificant for all NPS sources.

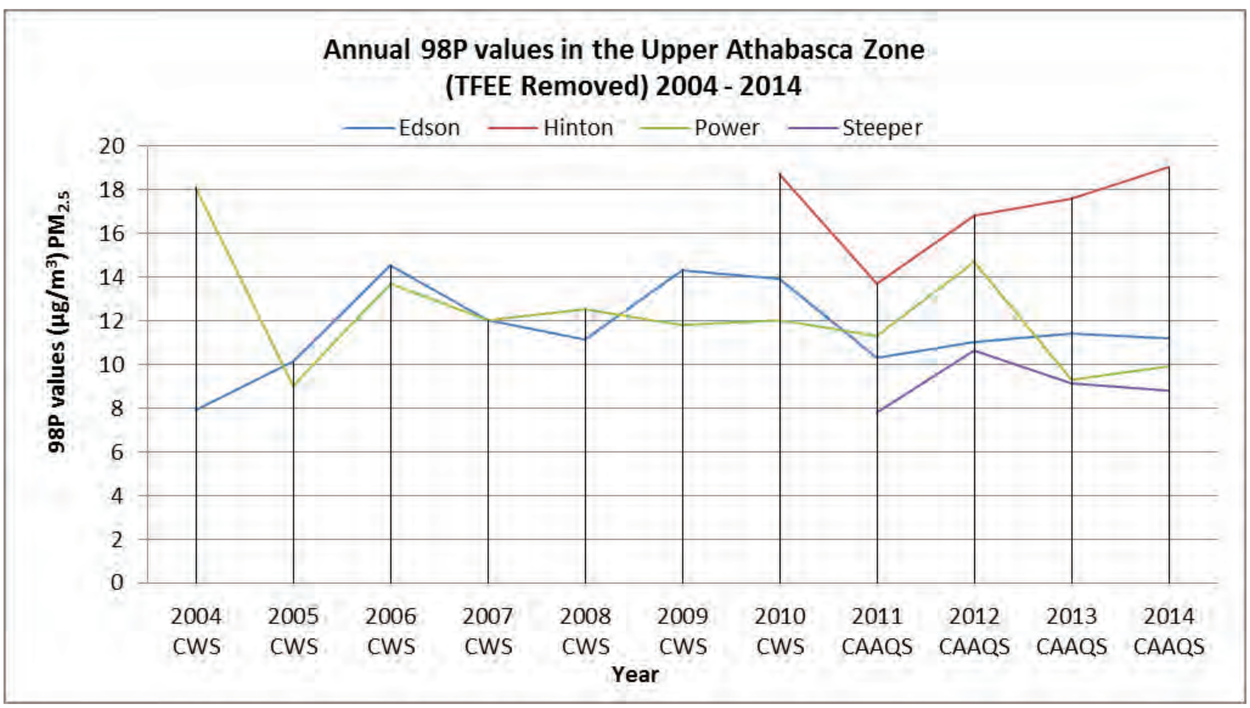


Figure 3: Annual 98th percentile $PM_{2.5}$ levels in the Upper Athabasca Zone from 2001 to 2014

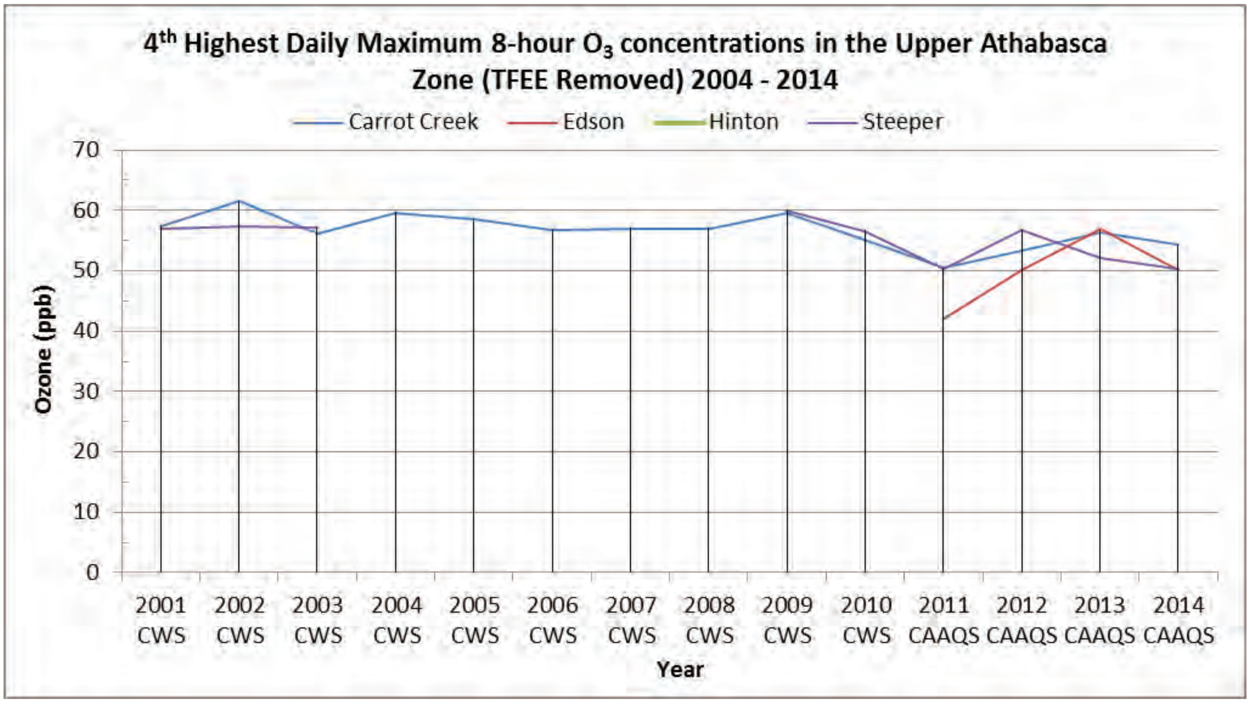


Figure 4: Annual 98th percentile $PM_{2.5}$ levels in the Upper Athabasca Zone from 2001 to 2014

Generally, the UA Air Zone is expected to remain in the green to yellow level for both $PM_{2.5}$ and O_3. Assuming the UA Air Zone follows the projected provincial trend in population and industrial growth, $PM_{2.5}$ (road dust), SO_2 (Conventional Oil and Gas) and NH_3 (Agriculture) are also projected to rise over the next 20 years and there may be more occurrences of CAAQS non-attainment at the orange level of both $PM_{2.5}$ and O_3.

5 Summary of Conditions of Dates Exceeding CAAQS Actions for Preventing CAAQS Exceedances for $PM_{2.5}$

5.1 Hinton Air Monitoring Station

The UA Air Zone achieved orange, Actions for Preventing CAAQS Exceedances, in the 2011-2013 CAAQS report for the annual $PM_{2.5}$ based on the Hinton station (Data is provided for the Hinton station).

Table 4: Annual Average Metric - before and after TF/EE Analysis at Hinton

Air Zone **Station**	**Upper Athabasca** **Hinton**		
Year	2011	2012	2013
Number of Valid Days	365	364	356
Sum of $PM_{2.5}$ Concentrations	2881.8	3108.7	2853.5
Average	7.9	8.5	8.0
3-Year Average	(7.9 + 8.5 + 8.0) /3 = **8.1** Exceeds actions for Preventing CAAQS Exceedances		
Number of Days removed for TFEE	25	53	25

Adjusted Number of Days	340	311	331
Adjusted Sum of $PM_{2.5}$ Concentrations	2603.4	2413.2	2541.6
Average	7.7	7.8	7.7
Adjusted 3-Year Average	(7.6 + 7.8 + 7.7) /3 = **7.7** Exceeds actions for Preventing CAAQS Exceedances		

Topography and meteorology are significant factors in elevated $PM_{2.5}$ levels in Hinton as the monitoring station is situated in town site, which resides in the Athabasca River valley. However, there are concerns that the station is not representative of the UA Air Zone. The monitoring station is located in an industrial area of Hinton near a settling pond, gravel road and other sources of particulate matter. The West Central Airshed Society will install a second monitoring station in Hinton by the end of 2016 and will compare the results of the two stations, once a requisite amount of data has been obtained.

6 Other Related Studies

There are no related studies in relation to the Upper Athabasca Air Zone.

7 Conclusions

Based on the available emissions inventory data, the largest anthropogenic sources of $PM_{2.5}$ and precursor emissions in the Upper Athabasca Air Zone are:

- Conventional oil and gas (SO_2, NOx, VOCs);
- Road dust ($PM_{2.5}$);
- Agriculture (VOCs, $PM_{2.5}$, NH_3);
- Transportation (NOx, VOCs); and
- Construction ($PM_{2.5}$).

These are the main contributors to anthropogenic NPS and are also the most likely sources to increase over the next two decades at the provincial level.

Based on the available information, there are a couple of non-industrial non-point sources in the Upper Athabasca Air Zone that may warrant consideration by the Project Team in relation to CAAQS management actions. These non-industrial sources include: transportation (on-road and off-road) and agriculture.

8 References

Alberta Environmental Monitoring, Evaluation, and Reporting Agency (AEMERA). unpublished 2016. CASA PM_O_3 CAAQS 2011 to 2015. Unpublished material provided to the CASA NPS Technical Task Goup upon request. Edmonton: AEMERA

Alberta Environment and Parks. 2015a. *Non-Point Sources Background Information*. Prepared for the CASA Non-Point Sources Team. Edmonton, AB: Government of Alberta.

______. 2015b. *2011-2013 CAAQS Reporting Upper Athabasca Air Zone* Published report. Edmonton, AB: Government of Alberta.

______. 2015c. *Air Zone Preliminary Historical Time Series in Response to CAAQS Assessments*. Prepared for the CASA Non-Point Sources Technical Task Group Edmonton, AB: Government of Alberta.

______. 2016a. *Alberta: Air Zones Report 2011-2013.* Edmonton: Government of Alberta.

______. 2016b. *Summary Report on Major Non-Point Air Emission Sources in Alberta*. Prepared for the CASA Non-Point Sources Task Group. Edmonton, AB: Government of Alberta.

North Saskatchewan Air Zone Information Summary for the CASA Non-Point Source Technical Task Group

Prepared by:
Alberta Environment and Parks
Version 1.2
August 2016

Executive Summary

The Canadian Ambient Air Quality Standards (CAAQS) are designed to protect human health and the environment and form the key driver for Canada's Air Quality Management System. Alberta Environment and Parks has completed an assessment of the CAAQS for fine particulate matter ($PM_{2.5}$) and ozone (O_3) for 2011-2013. Fourteen ambient air monitoring stations located in the North Saskatchewan Air Zone were used in the 2011-2013 CAAQS assessment. The assessment included assigning monitoring stations to various management levels.

The Edmonton Central, Edmonton East, and Edmonton South stations, as well as Bruderheim, Drayton Valley, Fort Saskatchewan, and Lamont County monitoring stations were assigned to the orange management level for $PM_{2.5}$. The Bruderheim, Lamont County, and Genesee stations were assigned to the orange management level for O_3. The orange management levels mean that $PM_{2.5}$ and/or O_3 concentrations are approaching the CAAQS and proactive action is needed to prevent exceedance of the standard. This document provides a summary of ambient air and emissions data and related studies in order to help assess and understand the point and non-point sources contributing to ambient concentrations of $PM_{2.5}$ and O_3 in the North Saskatchewan Air Zone.

In addition to looking at current ambient concentrations at monitoring stations in the North Saskatchewan Air Zone, it also important to understand how measured annual average concentrations at monitoring stations have been changing over the last several years. Examining the preliminary 2001 to 2015 annual mean concentrations for $PM_{2.5}$ and O_3 identified that there were no significant increasing or decreasing trends for annual mean $PM_{2.5}$ concentrations at monitoring stations within the North Saskatchewan Air Zone. However, the Edmonton Central monitoring station showed an increasing trend in annual mean O_3 concentrations, while the Breton, Genesee, Steeper, and Violet Grove monitoring stations showed decreasing trends in annual mean O_3 concentrations.

While there are many anthropogenic sources of $PM_{2.5}$ and precursor emissions in the North Saskatchewan Air Zone, many individually emit in small amounts and thus it can be useful to focus on the largest emitting sources. Road dust and construction sources were responsible for the largest portions of primary $PM_{2.5}$ emissions in the North Saskatchewan Air Zone. Transportation, electric power generation, and conventional oil & gas were the largest sources of NOx emissions. Electric power generation, conventional oil & gas, petroleum refining, and oil sands upgrading were the largest sources of SO_2 emissions. Conventional oil & gas, agriculture, transportation, petroleum refining, and bulk storage terminals were the largest sources of VOC emissions. Agricultural sources were the dominant emitting source of NH_3 in the North Saskatchewan Air Zone, followed by industrial sources.

Non-point sources were responsible for approximately 95% of industrial VOC emissions in the North Saskatchewan Air Zone. Point sources were the major source of industrial $PM_{2.5}$, NOx, SO_2, and NH_3 emissions in the North Saskatchewan Air Zone. The largest industrial non-point sources of VOC emissions in the North Saskatchewan Air Zone were plant fugitives, storage and handling, and spills and accidental releases. The largest industrial non-point sources of $PM_{2.5}$ emissions were fugitive dust sources and the storage & handling of on-site materials. The largest industrial non-point sources of NOx and SO_2 emissions were space heating and non-stationary equipment. The largest industrial non-point sources of NH_3 emissions were plant fugitive leaks and storage tanks.

Examining the preliminary 1985 to 2013 total annual anthropogenic emissions time series within the North Saskatchewan Air Zone identified that primary $PM_{2.5}$ emissions from combined major sources increased by 40% between 1985 and 2013, driven mainly by increases from road dust and construction sources. Emissions of many of the secondary $PM_{2.5}$ and O_3 precursors showed a mix of decreasing and increasing emissions. NOx emissions from combined major sources decreased by 18% between 1985 and 2013, led by decreases from transportation sources. SO_2 emissions from combined major sources decreased by 26% between 1985 and 2013, mainly due to decreases from conventional oil & gas sources. VOC emissions from combined major sources decreased by 32% between 1985 and 2013, as the result of large decreases from transportation sources. NH_3 emissions from combined major sources increased by 48% between 1985 and 2013, primarily due to increases from agricultural sources and to a lesser extent from increases from the chemical manufacturing sector.

A key relevant study carried out for a large portion of the North Saskatchewan Air Zone was the Capital Region Particulate Matter Air Modelling Assessment. This study utilized photochemical modelling and source apportionment analysis to elevate wintertime $PM_{2.5}$ concentrations and assess the effects of alternative emission control strategies. The Capital Region Assessment identified that $PM_{2.5}$ in the Capital Region appears to originate mainly from local sources within the region.

The first phase of the Capital Region Assessment found sulphate to be a key component of high wintertime $PM_{2.5}$ concentrations predicted in the Capital Region and that much of the sulphate was attributable to several different stationary point sources, including: petroleum refineries, bulk storage terminals, oil sands upgraders, and to a lesser extent electric power generation. Refinements made for the second phase of the Capital Region Assessment reduced the significance of sulphate and brought the speciation breakdown closer to monitoring station observations. Overall, the Capital Region Assessment identified sulphate, nitrate, and ammonium as the three key species of $PM_{2.5}$ in the Capital Region.

Other anthropogenic sources, specifically off-road transportation and agriculture, were identified as the dominate contributors to nitrate in the region, while agricultural sources contributed the most to ammonium. The contributions of on-road transportation sources to the average $PM_{2.5}$ concentrations were found to be small and the nitrate contributions from this source generally followed highway and road networks. Commercial and residential heating and off-road transportation were the dominant source of primary $PM_{2.5}$ in the Capital Region.

Based on the available emissions inventory information and the results of the Capital Region Assessment, the major non-industrial non-point sources in the North Saskatchewan Air Zone are: on-road transportation, off-road transportation, agriculture, and commercial/residential heating. The major industrial non-point sources in the North Saskatchewan Air Zone are: plant fugitives, storage and handling, and spills and accidental releases particularly from the petroleum refining, bulk storage terminals, and conventional oil & gas sectors.

Table of Contents

List of Figures

List of Tables

1.0 Context

1.1 Purpose of This Document

This document has been prepared to summarize the: (1) assessments against the Canadian Ambient Air Quality Standards (CAAQS); (2) relevant ambient air monitoring data; (3) air emissions inventory data; and (4) air modelling and source apportionment studies for the North Saskatchewan Air Zone in order to assess and understand the point and non-point sources contributing to ambient concentrations of fine particulate matter ($PM_{2.5}$) and ozone (O_3) in the region.

1.2 Ambient Air Monitoring in the North Saskatchewan Air Zone

The CAAQS are designed to protect human health and the environment and form the driver for Canada's Air Quality Management System. Alberta Environment and Parks has completed an assessment of the CAAQS for $PM_{2.5}$ and ozone for 2011-2013. This assessment included assigning ambient air monitoring stations to various management levels. The report *Alberta: Air Zones Report 2011-2013* (Alberta Environment and Parks, 2015b) summarizes the CAAQS achievement status and management levels for Alberta's Air Zones for the $PM_{2.5}$ and O_3 monitoring results. Sections 1.2 and 1.3 of this report provide a brief summary of the North Saskatchewan Air Zone information presented in the air zone report.

Ambient air monitoring stations are located throughout the North Saskatchewan Air Zone. Fourteen of the monitoring stations in the North Saskatchewan Air Zone were used in the 2011-2013 CAAQS assessment. These stations are located within communities or in areas accessed by members of the public. Figure 1 provides a map of the North Saskatchewan Air Zone showing the locations of the ambient air monitoring stations used in the 2011-2013 CAAQS assessment.

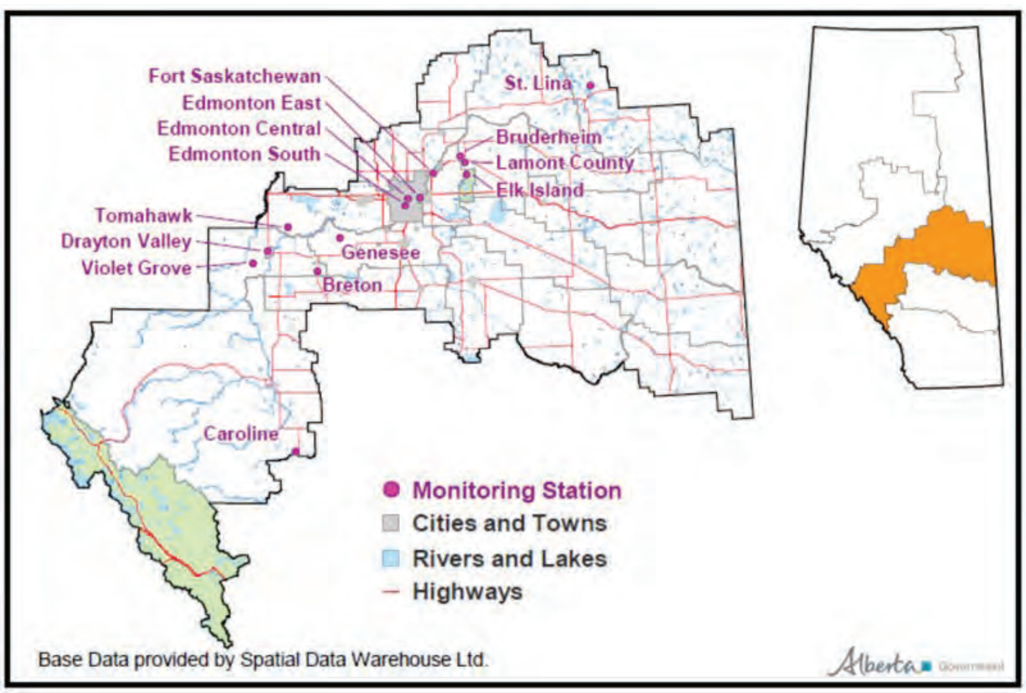


Figure 1: Ambient Air Monitoring Stations in the North Saskatchewan Air Zone.

1.3 CAAQS $PM_{2.5}$ and O_3 Assessments for the North Saskatchewan Air Zone

The 2015 $PM_{2.5}$ 24-hour standard is 28 µg m-3. The form of the standard is the 3-year average of the annual 98th percentile of the daily 24-hour average concentrations for each of three consecutive years. Table 1 shows the annual and three year averages of 24-hour 98th percentile $PM_{2.5}$ concentrations compared to CAAQS levels for the North Saskatchewan Air Zone. According to the findings of the 2011-2013 CAAQS assessment, the standard was achieved at the individual monitoring stations and for the overall North Saskatchewan Air Zone after removal of exceptional events.

The 2015 $PM_{2.5}$ annual standard is 10.0 µg m-3. The form of the standard is the 3-year-average of the annual 1-year average of the daily 24-hour average concentrations for each of three consecutive years. Table 1 shows the annual and three year averages of average $PM_{2.5}$ concentrations compared to CAAQS levels for the North Saskatchewan Air Zone. According to the findings of the 2011-2013 CAAQS assessment, the standard was achieved at the individual monitoring stations and for the overall North Saskatchewan Air Zone achieved the standard after the removal of exceptional events.

Based on the 2011-2013 CAAQS assessment, several stations were assigned to the orange management level for $PM_{2.5}$, Actions for Preventing CAAQS Exceedance. This included: the Edmonton Central, Edmonton East, and Edmonton South stations, as well as the Bruderheim, Drayton Valley, Fort Saskatchewan, and Lamont County stations. All other stations in the North Saskatchewan Air Zone were assigned to lower management levels. As there were stations in the orange management level, the entire North Saskatchewan Air Zone was assigned to the orange management level for $PM_{2.5}$. This management level indicates that $PM_{2.5}$ concentrations are approaching the CAAQS and proactive action is needed to prevent exceedance.

The 2015 8-hour ozone standard is 63 ppb. The form of the standard is the 3-year-average of the annual 4th highest of the daily maximum 8-hour average concentration for each of three consecutive years. Table 1 shows the annual and three year averages of 4th highest O_3 concentrations compared to CAAQS levels for the North Saskatchewan Air Zone. According to the findings of the 2011-2013 CAAQS assessment, all stations in the North Saskatchewan Air Zone achieved the ozone standard for 2011-2013. In some cases, individual years within the three year period exceeded the standard, but the three-year averages all achieved the standard.

Based on the 2011-2013 CAAQS assessment, several stations were assigned to the orange management level for O_3, as concentrations are approaching the CAAQS. This included: the Bruderheim, Lamont County, and Genesee stations. All other stations in the North Saskatchewan Air Zone were assigned to lower management levels. As there were stations in the orange management level, the entire North Saskatchewan Air Zone was assigned to the orange management level for O_3 and proactive action is needed to prevent exceedance of the standard.

Table 1: Annual 24-Hour 98th Percentile $PM_{2.5}$ Concentrations Compared to CAAQS Levels (Alberta Environment and Parks, 2016c).

Station	24-h $PM_{2.5}$ (Annual 98th Percentile & 3-Year Average)				Annual $PM_{2.5}$ (Annual Average & 3-Year Average)				8-h O_3 (Annual 4th Highest Daily Maximum & 3-Year Average)			
	2011	2012	2013	2011-13	2011	2012	2013	2011-13	2011	2012	2013	2011-13
Breton									55.1	54.8	57.8	56
Bruderheim	21.8	19.8	23.8	22	7.2	7.2	8.2	7.5	63.9	48.1	57.9	57
Caroline	10.7	13.6	14.9	13	3.6	3.6	4.0	3.7	49.7	53.4	58.6	54
Drayton Valley	12.5	12.3	12.7	13	6.9	6.9	7.1	7.0				
Edmon Central	24.3	18.9	26.5	23	9.4	7.6	8.5	8.5	51.3	50.1	50.3	51

Station	24-h $PM_{2.5}$ (Annual 98th Percentile & 3-Year Average)				Annual $PM_{2.5}$ (Annual Average & 3-Year Average)				8-h O_3 (Annual 4th Highest Daily Maximum & 3-Year Average)			
Edmon East	20.8	21.6	32.7	25	9.2	8.2	10.7	9.4	51.1	50.4	50.4	51
Edmon South	21.5		23.9	23	8.4		6.4	7.4	57.0	57.0	54.4	56
Elk Island	9.7	11.0	15.2	12	3.3	4.6	5.3	4.4	59.9	50.5	56.3	56
Fort Sask	19.4	16.7	24.1	20	6.0	6.0	6.7	6.2	57.8	54.6	50.1	54
Genesee	9.3	9.5	8.3	9	3.1	3.0	2.9	3.0	52.4	58.0	60.6	57
Lamont County		16.5	17.7	17		6.6	6.7	6.7	58.4	55.3	57.9	57
St. Lina	14.0	16.6		15	5.2	5.3		5.3	50.3	49.9	57.8	53
Tomahawk	9.1	9.1	8.2	9	2.9	2.9	2.9	2.9	51.0	57.8	55.3	55
Violet Grove									53.1	56.6	57.0	56

1.4 Ambient Trends in the North Saskatchewan Air Zone

In addition to examining the most recent monitoring years, it is also important to review the overall $PM_{2.5}$, O_3 and precursor concentration trends for the monitoring stations in the North Saskatchewan Air Zone. *AMERA Ambient Air Monitoring Assessments* (Alberta Environmental Monitoring, Evaluation and Reporting Agency, 2016) were provided to the CASA Non-Point Source Technical Task Group for each of the various Alberta air zones. These assessments are adapted and summarized in this section of the report. Figures 2 to 6 present preliminary annual mean concentrations from the AEMERA ambient assessments for $PM_{2.5}$, O_3, NO_2, SO_2, and THC (as a proxy for VOCs) for 2001 to 2015 at the continuous ambient air monitoring stations within the North Saskatchewan Air Zone.

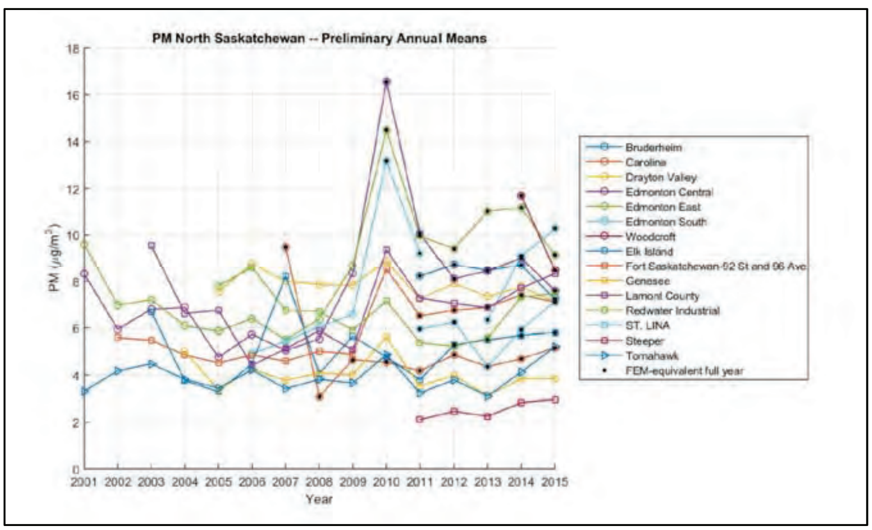


Figure 2: $PM_{2.5}$ North Saskatchewan Preliminary Annual Means (2001-2015).

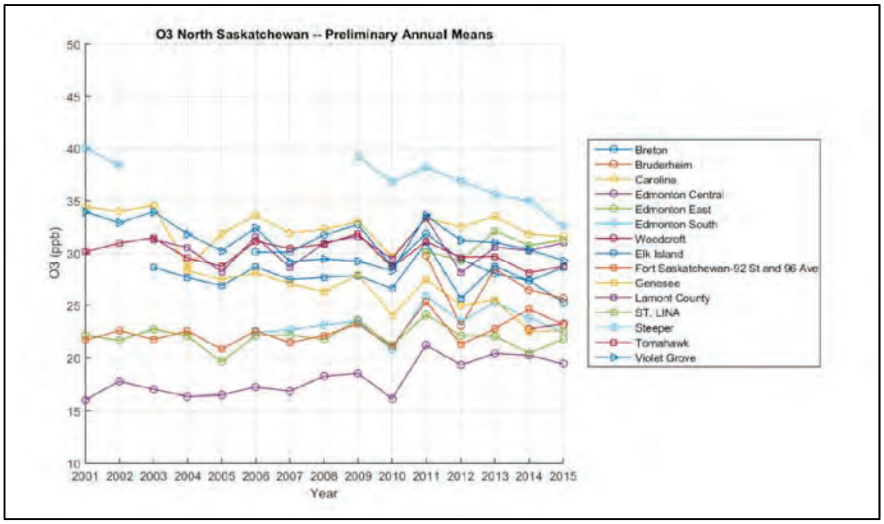


Figure 3: O_3 North Saskatchewan - Preliminary Annual Means (2001-2015).

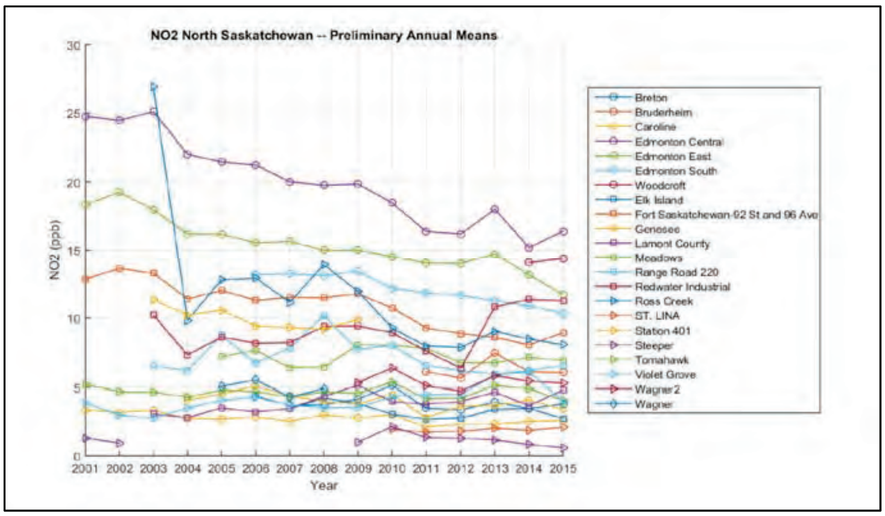


Figure 4: NO_2 North Saskatchewan - Preliminary Annual Means (2001-2015).

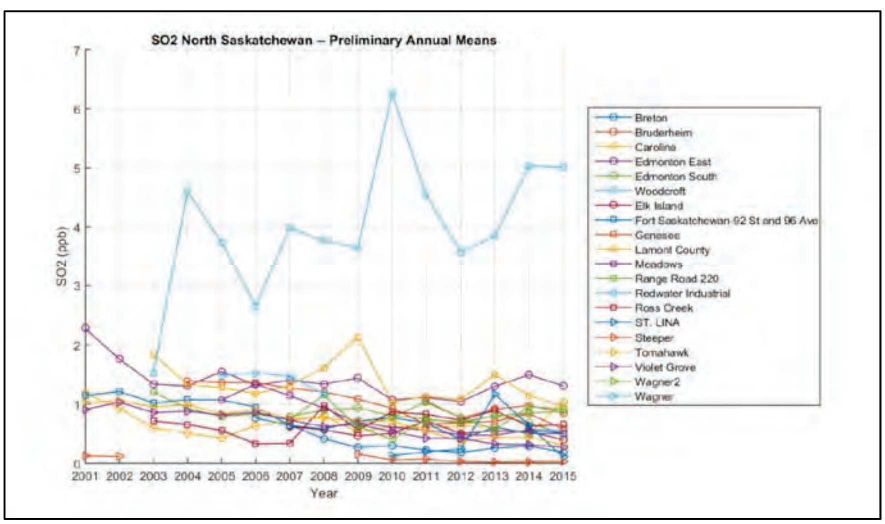


Figure 5: SO_2 North Saskatchewan - Preliminary Annual Means (2001-2015).

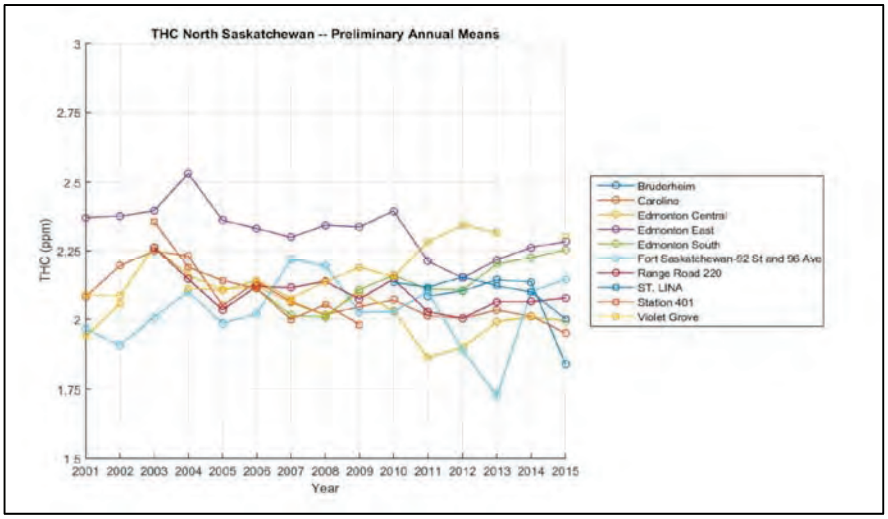


Figure 6: THC North Saskatchewan - Preliminary Annual Means (2001-2015).

Table 2 presents an assessment of the annual mean concentration trends for continuous ambient air monitoring stations in the North Saskatchewan Air Zone. According to the AEMERA ambient assessments, many monitoring stations, for several of the monitored substances, had insufficient data or showed no significant trends. There were no significant increasing or decreasing trends identified for annual mean $PM_{2.5}$ concentrations. During this period, there were notable changes to $PM_{2.5}$ monitoring technology (see Appendix B) that drastically improved capture of some $PM_{2.5}$ species. The Edmonton Central station showed an increasing trend in annual mean O_3 concentrations, while the Breton, Genesee, Steeper, and Violet Grove stations showed decreasing trends in annual mean O_3 concentrations.

The Lamont County and Violet Grove stations showed increasing trends in annual mean NO_2 concentrations, while the Caroline, Edmonton Central, Edmonton East, Edmonton South, Fort Saskatchewan, and Genesee stations showed decreasing trends in annual mean NO_2 concentrations. The Wagner 2 station showed an increasing trend in annual mean SO_2 concentrations, while the Breton, Edmonton East, Edmonton South, Fort Saskatchewan, Genesee, Meadows, Tomahawk, and Violet Grove stations showed decreasing trends in annual mean SO_2 concentrations. The Edmonton South station showed increasing trends in annual mean THC concentrations, while the Caroline, Edmonton Central, Edmonton East, and Range Road 220 stations showed decreasing trends in annual mean THC concentrations.

Table 2: Assessment of Trends for Continuous Ambient Air Monitoring Stations in the North Saskatchewan Air Zone.

Station Name	Trend $PM_{2.5}$	Trend O_3	Trend NO_2	Trend SO_2	Trend THC
Breton		Decreasing	Not Significant	Decreasing	
Bruderheim	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Caroline	Changed Instruments	Not Significant	Decreasing	Not Significant	Decreasing
Drayton Valley	Not Significant				
Edmonton Central	Changed Instruments	Increasing	Decreasing		Decreasing
Edmonton East	Changed Instruments	Not Significant	Decreasing	Decreasing	Decreasing
Edmonton South	Changed Instruments	Not Significant	Decreasing	Decreasing	Increasing
Woodcroft	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	
Elk Island	Changed Instruments	Not Significant	Not Significant	Not Significant	
Fort Saskatchewan	Changed Instruments	Not Significant	Decreasing	Decreasing	Not Significant

Station Name	Trend $PM_{2.5}$	Trend O_3	Trend NO_2	Trend SO_2	Trend THC
Genesee	Not Significant	Decreasing	Decreasing	Decreasing	
Lamont County	Not Significant	Not Significant	Increasing	Not Significant	
Meadows			Not Significant	Decreasing	
Range Road 220			Insufficient Data	Not Significant	Decreasing
Redwater Industrial	Not Significant		Insufficient Data	Not Significant	
Ross Creek			Insufficient Data	Insufficient Data	
ST. LINA	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data	Insufficient Data
Station 401			Insufficient Data		Insufficient Data
Steeper	Insufficient Data	Decreasing	Not Significant	Not Significant	
Tomahawk	Not Significant	Not Significant	Not Significant	Decreasing	
Violet Grove		Decreasing	Increasing	Decreasing	Insufficient Data
Wagner2			Not Significant	Increasing	
Wagner			Insufficient Data	Insufficient Data	

1.5 2001 to 2014 $PM_{2.5}$ and O_3 Concentrations After Removal of TF/EE

The CAAQS assessments allow for the removal of measured values significantly influenced by transboundary flows and exceptional events. The *AMERA Ambient Air Monitoring Assessments* (Alberta Environmental Monitoring, Evaluation and Reporting Agency, 2016) provided information on the results of removing transboundary flow and exceptional event influences. This section of the report summarizes that information for the North Saskatchewan Air Zone. Table 3 shows the annual 98th percentile 24-hour average $PM_{2.5}$ concentrations for the North Saskatchewan Air Zone ambient air monitoring stations, after the removal of the transboundary flow and exceptional events monitoring data. Figure 7 provides a graphical display of the 98th percentile 24-hour average $PM_{2.5}$ concentrations for the North Saskatchewan Air Zone ambient air monitoring stations, after the removal of the transboundary flow and exceptional events monitoring data.

Table 3: Annual 98th Percentile 24-hour Average $PM_{2.5}$ Concentrations After TF/EE Removal from 2001 to 2014.

Zone	Station	One-year 98th percentile 24-hour averages – After TFEE Removal													
		Yearly Values Calculated according to CWS										Yearly Values Calculated according to CAAQS			
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
North Saskatchewan	Bruderheim	No data									39.5	n/a*	19.8	23.8	22.7
	Caroline	No data					11.8	23.3	8.8	16.0	14.4	10.7	13.6	14.9	14.2
	Drayton Valley	No data				14.4	16.0	15.2	17.9	16.3	15.5	12.5	12.3	12.7	16.1
	Edm Central	18.0	16.8	18.4	15.8	12.9	15.4	13.4	16.0	22.1	46.2	24.3	18.9	26.5	20.8
	Edm East	20.4	20.3	18.8	15.6	15.2	18.0	15.5	21.2	21.7	43.8	20.8	21.6	32.7	27.5
	Edm NW	28.6	20.2	20.1	17.5	14.2	Station shut down								
	Edm South	No data				13.1	14.3	15.5	18.6	19.3	38.8	21.5	n/a*	23.9	20.6
	Woodcroft	No data													26.1
	Elk Island	No data		17.4	14.2	9.5	11.9	18.6	10.9	14.1	12.1	9.7	11.0	15.2	15.7
	FTSK	43.0	16.7	15.0	14.2	14.9	13.5	13.1	16.4	15.6	27.4	19.4	16.7	24.1	22.5
	Genesee	No data			16.7	8.3	13.4	11.5	13.7	14.6	13.7	9.3	9.5	8.3	9.3
	Lamont	No data		24.4	20.1	17.1	16.4	16.0	20.0	19.2	24.7	n/a*	16.5	17.7	18.5
	St. Lina	No data										14.0	16.6	n/a*	n/a*
	Tomahawk	15.2	13.8	14.5	12.9	8.9	13.3	11.9	11.8	11.5	11.3	n/a*	9.1	8.2	11.6

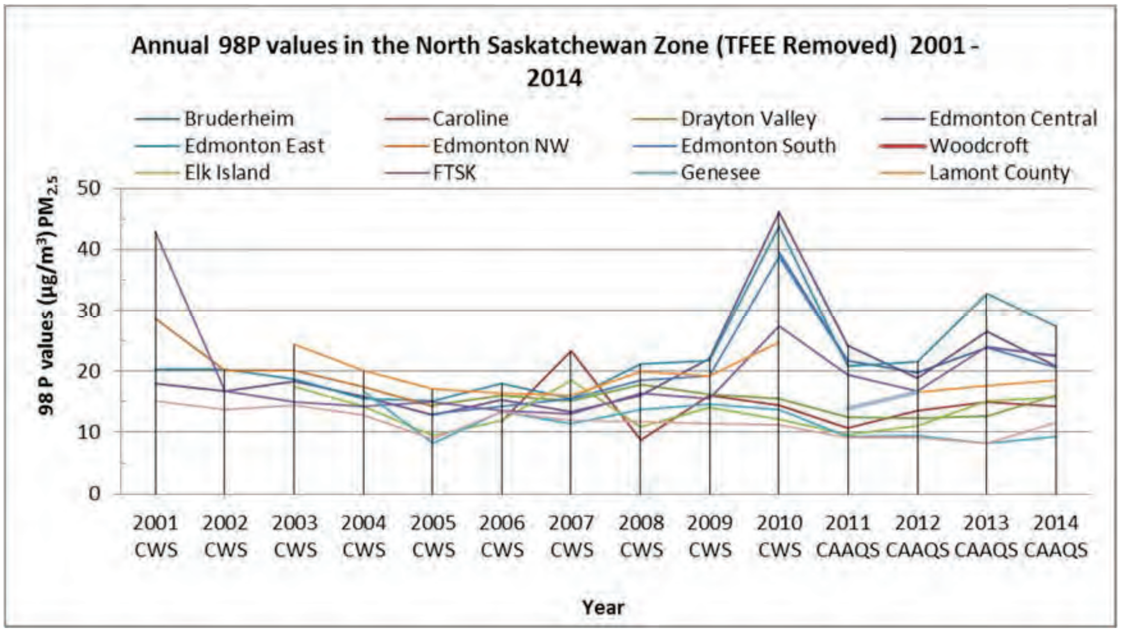


Figure 7: Annual 98th percentile $PM_{2.5}$ levels in the North Saskatchewan Zone from 2001 to 2014.

Table 4 shows the annual 4th highest maximum 8-hour ozone concentrations for the North Saskatchewan Air Zone ambient air monitoring stations, after the removal of the transboundary flow and exceptional events monitoring data. Figure 8 provides a graphical display of the annual 4th highest maximum 8-hour ozone concentrations for the North Saskatchewan Air Zone ambient air monitoring stations, after the removal of the transboundary flow and exceptional events monitoring data.

Table 4: Annual 4th Highest Maximum 8-hour Ozone Concentrations (ppb) After TF/EE Removal (2001 to 2014).

Zone	Station	Ozone Annual 4th Highest Maximum 8-hour concentrations (ppb) – After TFEE Removal													
		Yearly Values Calculated according to CWS										Yearly Values Calculated according to CAAQS			
		2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
North Saskatchewan	Breton	No data					56.5	57.6	64.6	65.0	56.9	55.1	54.8	57.8	55.0
	Bruderheim	No Data									56.6	63.9*	48.1	57.9	53.1
	Caroline	62.4	62.0	58.8	53.4	59.8	56.4	57.8	57.8	58.4	55.8	49.7	53.4	58.6	50.1
	Edm Central	49.5	62.5	52.0	51.9	50.8	50.6	52.8	54.0	51.9	51.1	51.3	50.1	50.3	49.6
	Edm East	59.9	69.5	57.4	60.9	50.9	57.0	57.0	57.8	57.0	56.0	51.1	50.4	50.4	47.0
	Edm NW	54.6	69.3	58.9	55.9	51.0	Station shut down								
	Edm South	No Data				n/a*	57.5	59.1	59.9	58.6	56.4	57.0	57.0	54.4	53.4
	Woodcroft	No Data													55.6
	Elk Island	No Data		55.3	59.0	55.3	57.3	55.3	57.8	58.4	56.6	59.9	50.5	56.3	51.3
	FTSK	57.6	69.8	55.8	56.6	53.5	56.6	56.9	61.0	56.8	57.8	57.8	54.6	50.1	51.1
	Genesee	No Data			62.5	57.4	60.4	60.1	59.4	67.0	56.3	52.4	58.0	60.6	53.9
	Lamont	No Data		56.1	59.4	56.1	58.5	55.9	65.0	59.9	57.1	58.4	55.3	57.9	51.6
	St. Lina	No Data									54.1	50.3	49.9	57.8	49.8
	Tomahawk	60.0	74.0	56.3	60.8	57.0	56.6	57.0	59.9	64.8	57.3	51.0	57.8	55.3	50.1
	Violet Grove	57.0	62.0	57.6	58.0	57.5	57.1	56.9	58.0	62.8	56.3	53.1	56.6	57.0	55.9

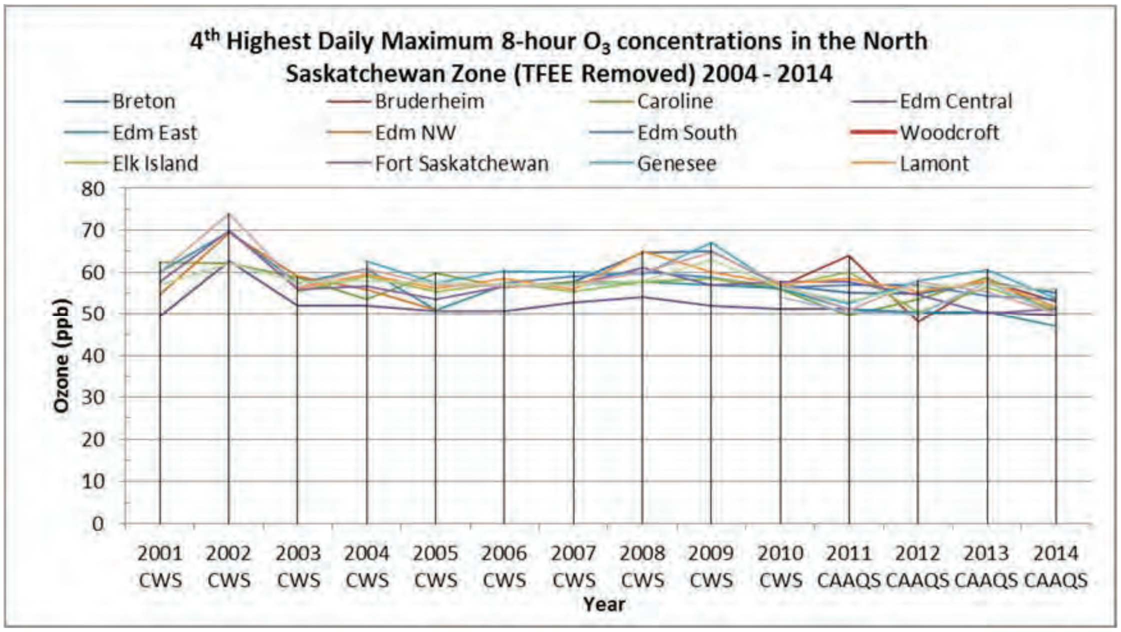


Figure 8: Highest Daily Maximum 8-hour Ozone concentrations Levels in the North Saskatchewan Air Zone from 2001 to 2014.

2.0 Major Emission Sources in the North Saskatchewan Air Zone

2.1 Alberta Non-Point Sources

The *Non-Point Sources Background Information* (Alberta Environment and Parks, 2015c) and *Summary Report on Major Non-Point Air Emission Sources in Alberta* (Alberta Environment and Parks, 2016b) documents provided by Alberta Environment and Parks identified several non-industrial and industrial sources as major non-point source types in Alberta. These sources include:

Non-industrial non-point sources:

- Road dust (unpaved and paved roads);
- Construction (industrial, transportation, municipal, residential, and communications);
- Agriculture (agricultural animals, fertilizer application, harvesting, tilling, and wind erosion); and
- Transportation (on-road vehicles, off-road vehicles, rail, and air transportation).

Industrial non-point sources:

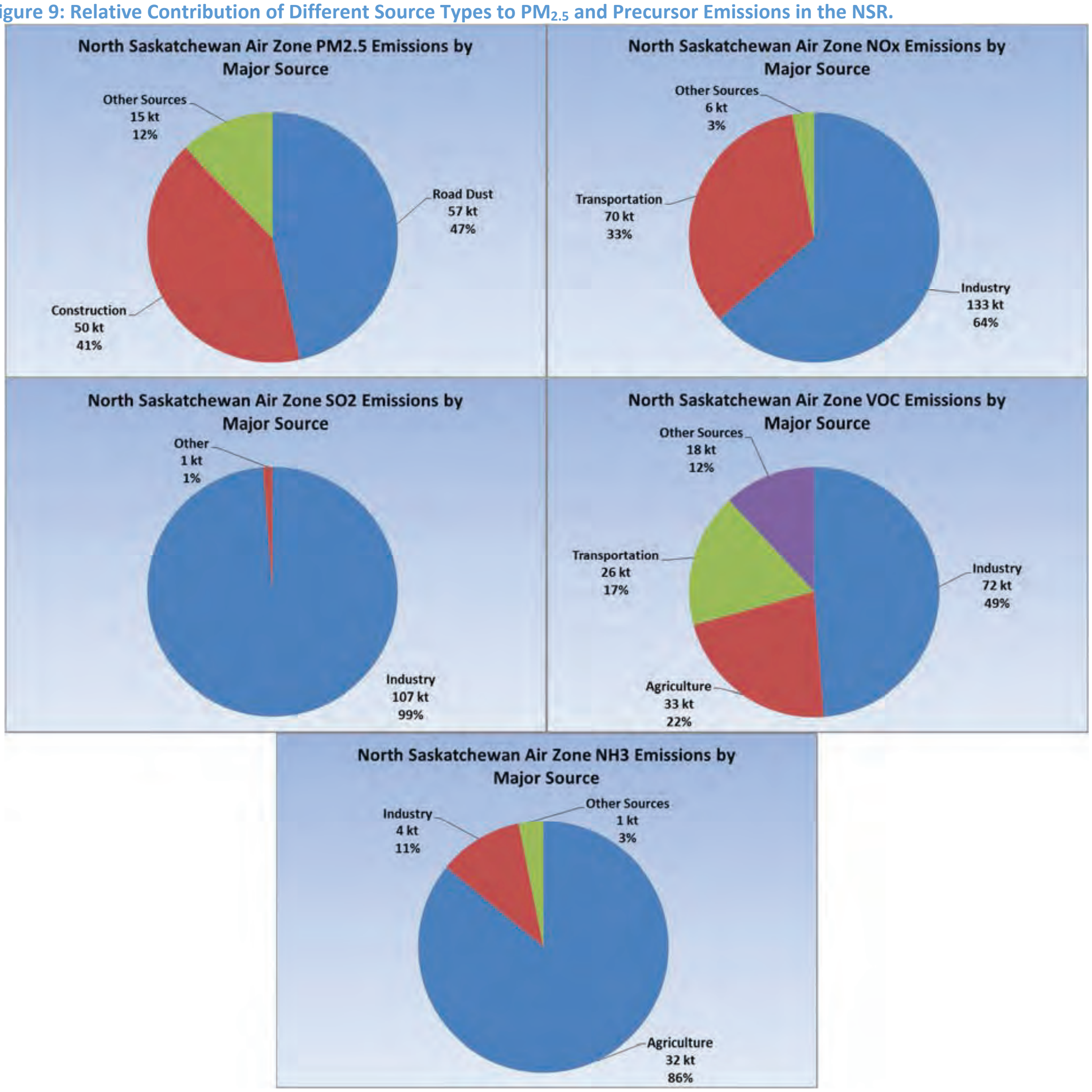
- Plant fugitive leaks;
- Liquid tailings ponds;
- Mine fleets;
- Mine faces;
- Solid mine tailings;
- Materials storage and handling;
- Non-stationary equipment;
- Space heating; and
- Storage tanks.

2.2 Major Emission Sources in the North Saskatchewan Air Zone

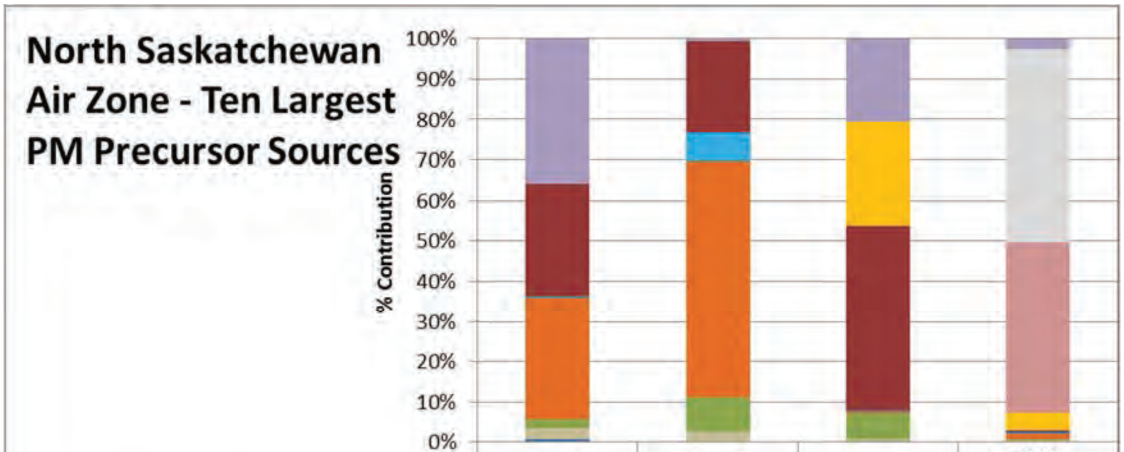
The *Summary Report on Major Non-Point Air Emission Sources in Alberta* (Alberta Environment and Parks, 2016b) utilizes the *2006-2008 Alberta Air Emissions Inventory* (Alberta Environment and Sustainable Resource Development, 2011a), *LUF Regional Air Emissions Analysis* (Alberta Environment and Sustainable Resource Development, 2011b) and *Results of the Alberta Air Emissions Inventory* (Alberta Environment and Sustainable Resource Development, 2011c) to analyze major emission sources for the various Alberta air zones. This section of the report summarizes that summary report's information specifically for the North Saskatchewan Air Zone. Figure 9 shows the relative contributions of different anthropogenic sources to $PM_{2.5}$ and precursor emissions in the North Saskatchewan Air Zone. In this Figure the "other sources" category includes all other source categories, each of which individually contributed to less than 5% of the region's emissions total of the particular pollutant.

Road dust was the source of nearly half of $PM_{2.5}$ emissions in the North Saskatchewan Air Zone, followed closely by construction sources with 41% of $PM_{2.5}$ emissions. Industrial sources were responsible for 64% of NOx emissions in the North Saskatchewan Air Zone, followed by transportation which accounted for 33% of NOx emissions. Industrial sources emitted 99% of all SO_2 in the North Saskatchewan Air Zone. Industrial sources accounted for 49% of VOC emissions in the North Saskatchewan Air Zone, while agricultural sources emitted 22% and transportation sources emitted about 17% of VOCs. Agricultural sources were the dominant emitting source of NH_3 in the North Saskatchewan Air Zone, with 86% of emissions. Industrial sources were responsible for 11% of NH_3 emissions in the North Saskatchewan Air Zone.

Figure 9: Relative Contribution of Different Source Types to $PM_{2.5}$ and Precursor Emissions in the NSR.



While there are many anthropogenic sources of $PM_{2.5}$ and precursor emissions in the North Saskatchewan Air Zone, many individually emit in small amounts and thus it can be useful to focus on the largest individually emitting sources. Figure 10 provides a breakdown of the relative contributions of the ten largest sources of $PM_{2.5}$ and precursor emissions. Road dust and construction sources were responsible for the largest portions of primary $PM_{2.5}$ emissions in the North Saskatchewan Air Zone. Transportation, electric power generation, and conventional oil & gas were the largest sources of NOx emissions. Electric power generation, conventional oil & gas, petroleum refining, and oil sands upgrading were the largest sources of SO_2 emissions. Conventional oil & gas, agriculture, transportation, petroleum refining, and bulk storage terminals were the largest sources of VOC emissions.



	NOx	SO2	VOC	PM2.5
Transportation	69,760	730	25,873	2,934
Road Dust	-	-	-	56,687
Construction	115	-	-	50,342
Agriculture	-	-	32,535	5,243
Conventional Oil and Gas	54,087	23,028	57,718	821
Oil Sands	680	7,218	263	12
Electric Power Generation	59,069	59,367	560	1,821
Petroleum Refining and Bulk Storage	4,459	8,546	7,961	405
Chemicals and Fertilizer	5,036	2,684	1,087	196
Cement and Concrete Industry	1,768	54	16	303
Top Ten Total Emissions	194,973	101,627	126,012	118,764
Total Air Zone Emissions	205,628	108,420	148,554	121,975

Figure 10: Breakdown by Sector/Source of PM Precursor Emissions in the North Saskatchewan Air Zone.

2.3 Industrial Emission Sources in the North Saskatchewan Air Zone

The *Summary Report on Analysis of the 2014 National Pollutant Release Inventory* (Alberta Environment and Parks, 2016a) utilizes the *2014 National Pollutant Emissions Inventory* (Environment Canada, 2015) to examine large industrial emission sources in Alberta. This section of the report summarizes that summary report's information specifically for the North Saskatchewan Air Zone.

The North Saskatchewan Air Zone is home to many large industrial, commercial, and institutional facilities that emit at large enough levels to report to the National Pollutant Release Inventory (NPRI). Figure 11 shows the locations of the NPRI reporting facilities in the North Saskatchewan Air Zone, classified by NPRI sector categories. The North Saskatchewan Air Zone contains what is known as Alberta's Industrial Heartland, which is Canada's largest hydrocarbon processing region. This region includes large chemical processing, fertilizer manufacturing, petroleum refining, and bitumen upgrading facilities. The North Saskatchewan Air Zone is also home to large coal-fired power plants, conventional oil and gas facilities, cement & concrete manufacturing plants, and numerous other manufacturing facilities.

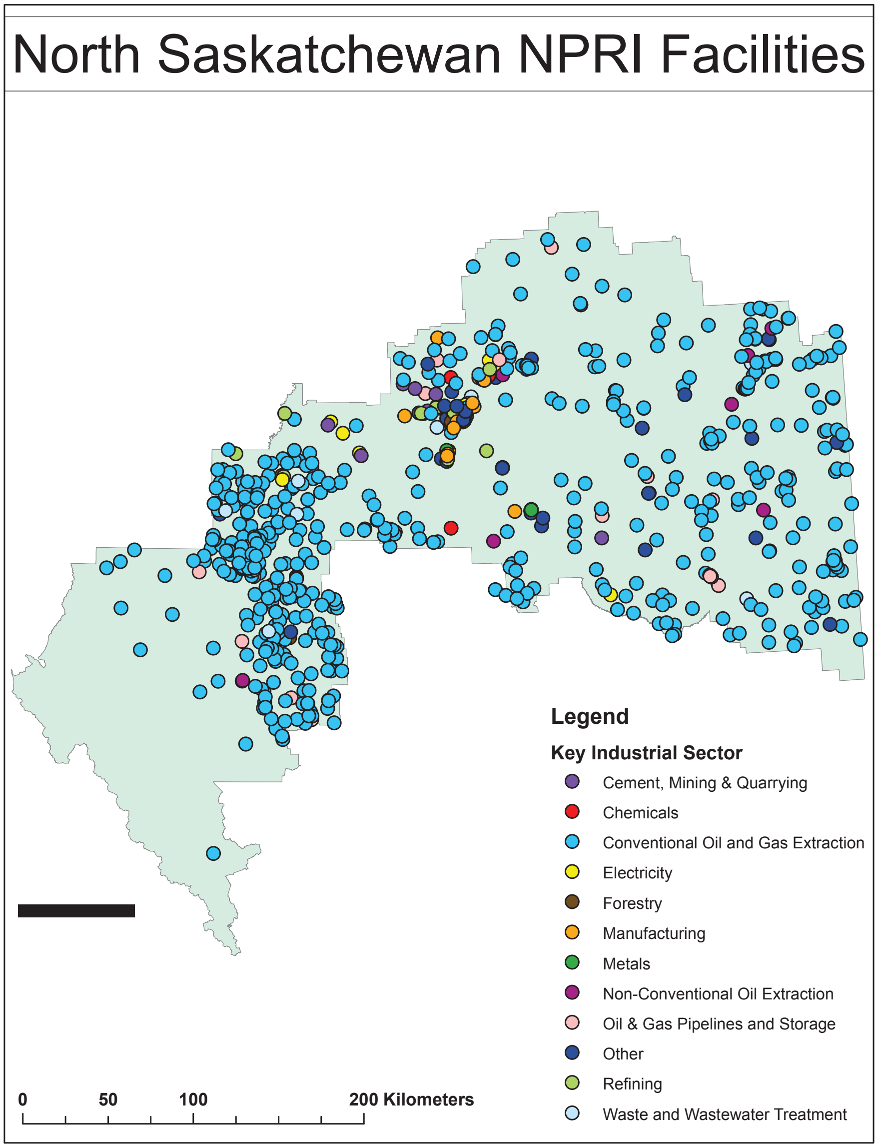


Figure 11: Spatial Distribution of 2014 Large Industrial Facilities in the North Saskatchewan Air Zone.

The electricity generating sector was the largest source of most of the reported industrial emissions in the North Saskatchewan Air Zone. Figure 12 shows the sector contributions to $PM_{2.5}$ and precursor emissions in the North Saskatchewan Air Zone, while Table 5 shows the reported emissions for all NPRI sectors in the region. The electricity generating sector accounted for the largest portions of reported industrial NOx, $PM_{2.5}$, and SO_2 emissions in the region. The chemical manufacturing sector was the largest source of reported industrial NH_3 emissions. The conventional oil & gas sector was the second largest source of industrial NOx and VOC emissions. The oil & gas pipeline and storage sector was the largest source of industrial VOC emissions. The petroleum refining sector was the second largest source of reported industrial SO_2 and $PM_{2.5}$ emissions.

Figure 12: Sector Contributions to $PM_{2.5}$ and Precursor Emissions in the North Saskatchewan Air Zone.

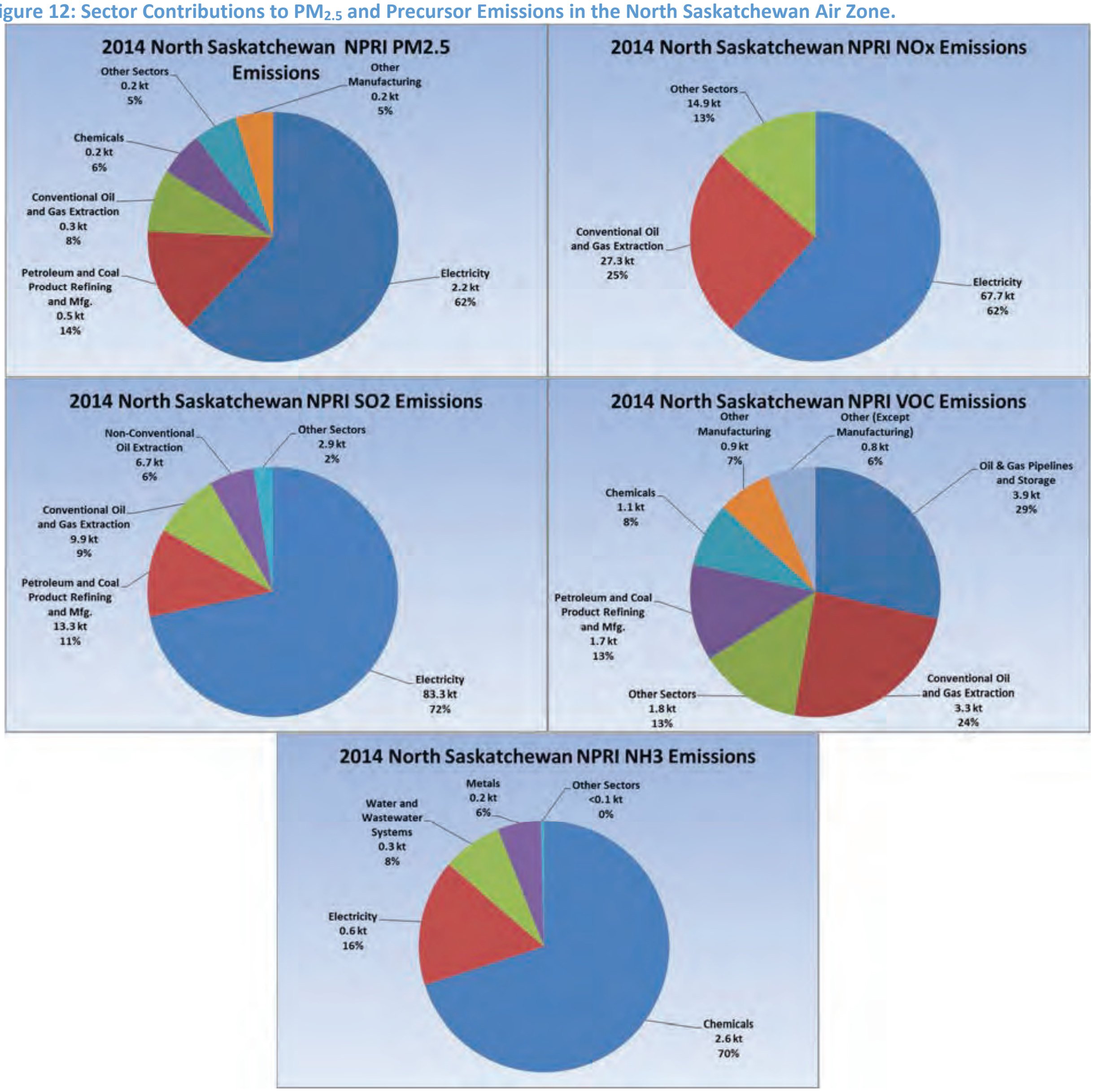


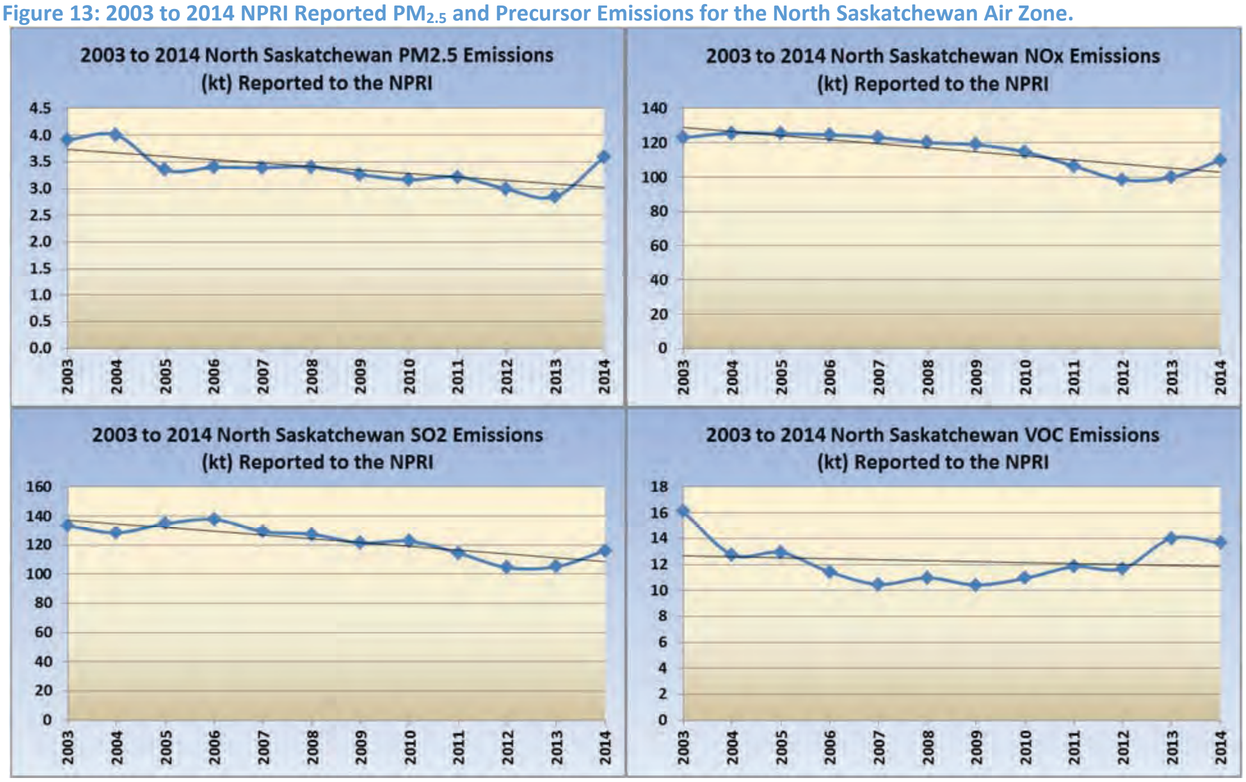
Table 5: Sector $PM_{2.5}$ and Precursor Emissions in the North Saskatchewan Air Zone.

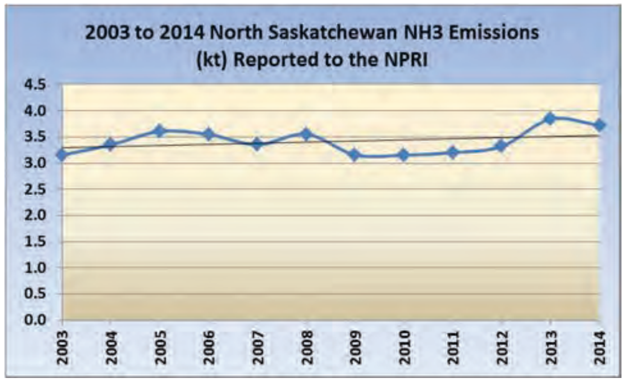
Sector	NH_3 Emissions (kt)	NOx Emissions (kt)	$PM_{2.5}$ Emissions (kt)	SO_2 Emissions (kt)	VOC Emissions (kt)
Cement, Lime and Other Non-Metallic Minerals	0.0	1.0	0.1	0.1	0.0
Chemicals	2.6	4.3	0.2	2.4	1.1
Conventional Oil and Gas Extraction	0.0	27.3	0.3	9.9	3.3
Electricity	0.6	67.7	2.2	83.3	0.4
Iron and Steel	0.0	0.1	0.0	0.1	0.0
Metals (Except Aluminum and Iron and Steel)	0.2	1.6	0.0	0.1	0.0
Mining and Quarrying	0.0	0.0	0.0	0.0	0.0
Non-Conventional Oil Extraction	0.0	1.9	0.0	6.7	0.5
Oil & Gas Pipelines and Storage	0.0	1.7	0.0	0.0	3.9
Other (Except Manufacturing)	0.0	0.3	0.0	0.0	0.9

Sector	NH_3 Emissions (kt)	NOx Emissions (kt)	$PM_{2.5}$ Emissions (kt)	SO_2 Emissions (kt)	VOC Emissions (kt)
Other Manufacturing	0.0	0.1	0.2	0.2	0.9
Petroleum and Coal Product Refining and Mfg.	0.0	3.9	0.5	13.3	1.7
Plastics and Rubber	0.0	0.0	0.0	0.0	0.3
Waste Treatment and Disposal	0.0	0.0	0.0	0.0	0.3
Water and Wastewater Systems	0.3	0.0	0.0	0.0	0.0
Wood Products	0.0	0.1	0.0	0.0	0.2
2014 NPRI North Saskatchewan Air Zone Total	**3.7**	**109.9**	**3.6**	**116.1**	**13.7**

In the North Saskatchewan Air Zone, reported industrial emissions of the $PM_{2.5}$ and precursor substances showed a mixture of increases and decreases between 2003 and 2014, varying by substance. Figure 13 shows the 2003 to 2014 NPRI reported $PM_{2.5}$ and precursor emissions for the North Saskatchewan Air Zone. Reported industrial $PM_{2.5}$ emissions in the region showed small percentage decreases between 2003 and 2014. Reported industrial NOx emissions also decreased, with 2014 NOx emission levels being 11% (13 kt) lower than 2003 levels. Reported industrial SO_2 emissions in the region decreased by 13% (17 kt) between 2003 and 2014, while reported industrial VOC emission levels decreased by 15% (2 kt). Reported industrial NH_3 emissions increased by 18% (0.6 kt) over the time period.

Figure 13: 2003 to 2014 NPRI Reported $PM_{2.5}$ and Precursor Emissions for the North Saskatchewan Air Zone.





2.4 Industrial Point and Non-Point Sources in the North Saskatchewan Air Zone

Alberta Environment and Parks' analysis of the 2014 NPRI, the *2011 Canadian Upstream Oil & Gas Inventory* (Clearstone Engineering, 2014) and the *Results of the Alberta Air Emissions Inventory (Alberta Environment and Sustainable Resource Development, 2011c)* provide breakdowns of industrial point vs. non-point source emissions in Alberta. This section of the report summarizes the Alberta Environment and Parks' analysis findings for the North Saskatchewan Air Zone.

Figure 14 shows the breakdown of industrial point source vs. non-point source emissions for $PM_{2.5}$ and the precursor substances. Non-point sources were responsible for approximately 95% of industrial VOC emissions in the North Saskatchewan Air Zone. Point sources were the major source of industrial NH_3, NOx, $PM_{2.5}$, and SO_2 emissions in the North Saskatchewan Air Zone. It should be noted that road dust from on-site industrial roads are excluded from the industrial $PM_{2.5}$ emissions, as they accounted for in the separate road dust source category (categorized as non-industrial). If on-site industrial roads were included as industrial, the contribution of non-point sources to primary $PM_{2.5}$ emissions would increase greatly.

The largest sources of industrial non-point $PM_{2.5}$ emissions in the North Saskatchewan Air Zone were fugitive dust sources and the storage & handling of on-site materials. The largest industrial non-point sources of NOx and SO_2 emissions were space heating and non-stationary equipment. The largest industrial non-point sources of NH_3 emissions were plant fugitive leaks and storage tanks. The largest industrial non-point sources of VOC emissions were plant fugitives, storage and handling, and spills and accidental releases.

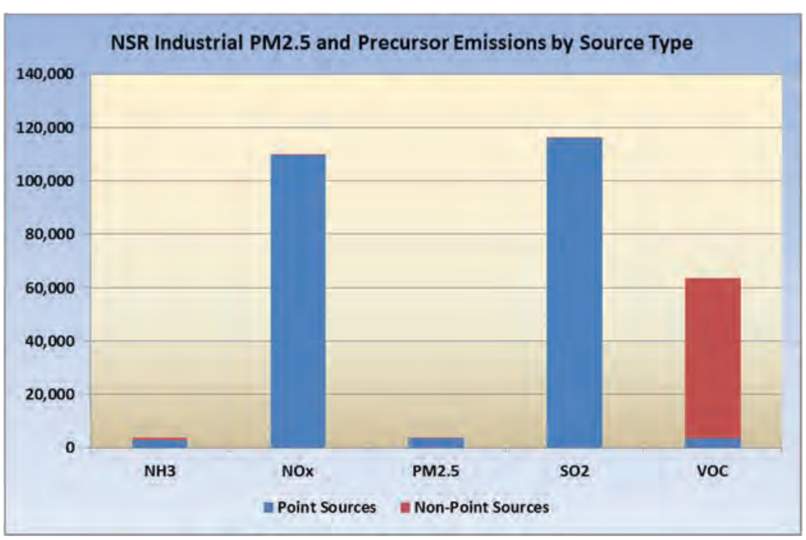


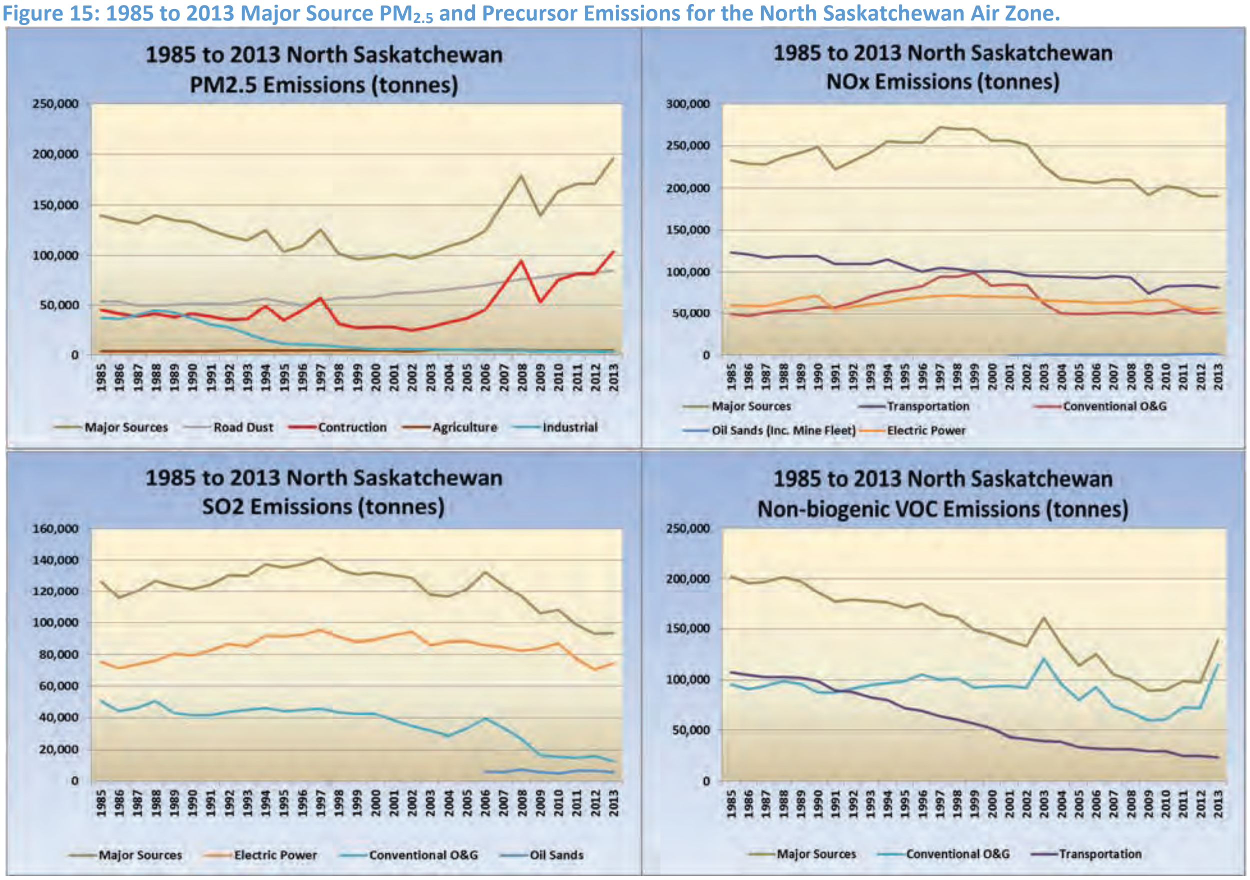
Figure 14: Contribution of Point and Non-Point Sources to 2014 NSR $PM_{2.5}$ and Precursor Emissions.

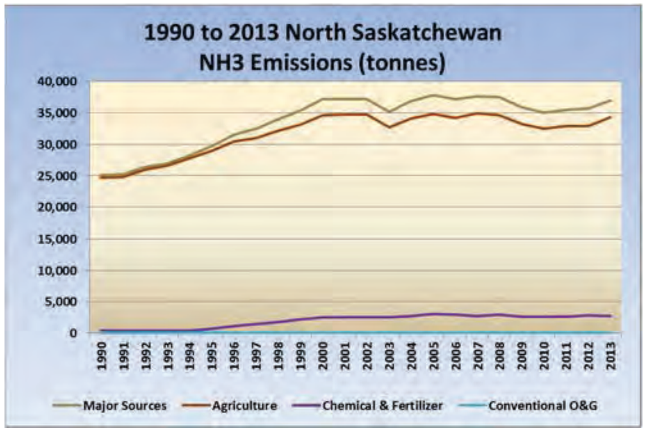
2.5 Preliminary Emissions Time Series for the North Saskatchewan Air Zone

As part of the scientific investigation in response to the 2011-2013 CAAQS assessment, Alberta Environment and Parks examined preliminary historical time series of $PM_{2.5}$ and precursor substances for each of the Alberta air zones. The preliminary findings were summarized in *Air Zone Preliminary Historical Time Series in Response to CAAQS Assessments* (Alberta Environment and Parks, 2015a) and this section of the report summarizes the preliminary results of that investigation specifically for the North Saskatchewan Air Zone. Figure 15 presents preliminary emissions time series for the major sources of $PM_{2.5}$ and the precursor substances for the North Saskatchewan Air Zone. In the North Saskatchewan Air Zone, anthropogenic emissions of the $PM_{2.5}$ and precursor substances showed a mixture of increases and decreases between 1985 and 2013, varying by substance.

$PM_{2.5}$ emissions in the North Saskatchewan Air Zone from combined major sources increased by 40% between 1985 and 2013, driven by increases from road dust and construction sources. NOx emissions from combined major sources decreased by 18% between 1985 and 2013, led by decreases from transportation sources. SO_2 emissions from combined major sources decreased by 26% between 1985 and 2013, mainly due to decreases from conventional oil & gas sources. VOC emissions from combined major sources decreased by 32% between 1985 and 2013, as a result of large decreases in VOC emissions from transportation sources. NH_3 emissions from combined major sources increased by 48% between 1985 and 2013, primarily due to increases from agricultural sources and to a lesser extent from increases from the chemical manufacturing sector.

Figure 15: 1985 to 2013 Major Source $PM_{2.5}$ and Precursor Emissions for the North Saskatchewan Air Zone.




1990 to 2013 North Saskatchewan
NH3 Emissions (tonnes)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
Major Sources
Agriculture
Chemical & Fertilizer
Conventional O&G

3.0 Capital Region Particulate Matter Air Modelling Assessment

3.1 About the Assessment

The Capital Region Particulate Matter Air Modelling Assessment (Environ and Novus Environmental, 2014) and (Environ International Corporation, 2015), hereafter referred to as the Capital Region Assessment, was a photochemical modelling and source apportionment study done to: 1. Reproduce observed winter elevated $PM_{2.5}$ concentrations in the Capital Region; 2. Provide a reliable tool for analyzing source contributions to elevated $PM_{2.5}$ concentrations; and 3. Evaluate the effects of alternative emission control strategies on the elevated $PM_{2.5}$ concentrations. Figure 16 shows a map of the Capital Region relative to entire North Saskatchewan Air Zone. Although the Capital Region does not cover the entire North Saskatchewan Air Zone, it does cover most of the zone. The Capital Region includes: the largest urban centre, the major emission sources, and many of the monitoring stations assigned to the CAAQS orange management level. Sections 3.1 to 3.5 of this report summarize the results of the Capital Region Assessment.

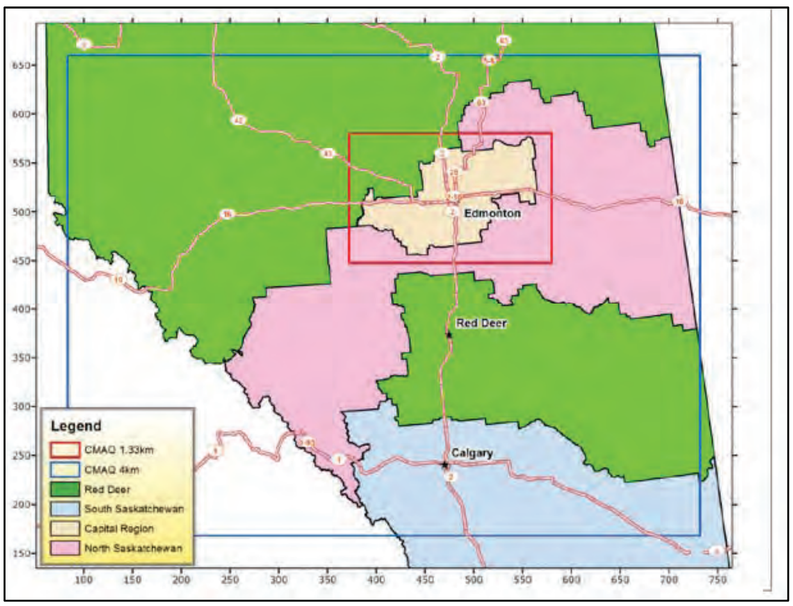


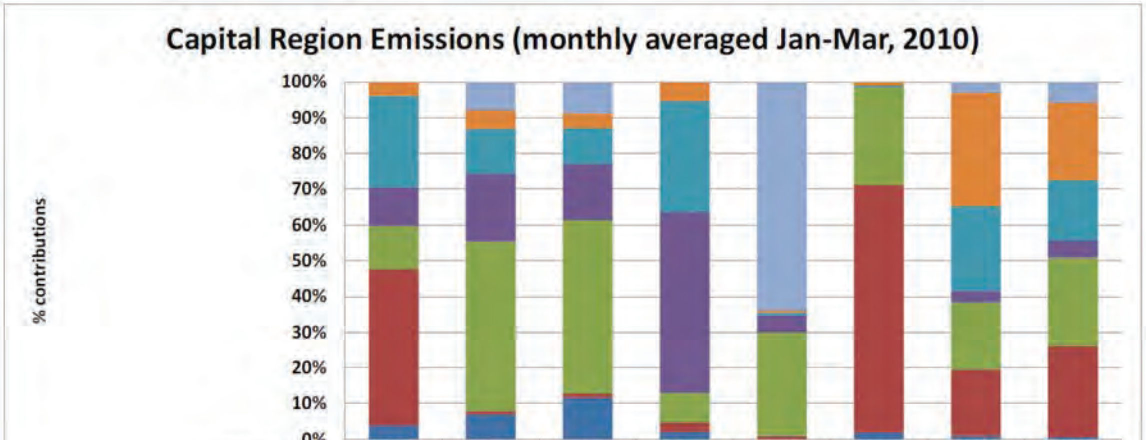
Figure 16: Map of the Capital Region Relative to the Entire North Saskatchewan Air Zone.

3.2 Capital Region Emission Sources

Sources of fine particulate matter and precursor gases in the Capital Region are many and varied. Industrial sources include petroleum refining, manufacturing, and fugitive emissions from hydrocarbon holding tanks and bulk petroleum storage terminals. The major industrial areas within the Capital Region include the Nisku Industrial Business Park in Leduc County, Acheson Industrial Area in Parkland County, Refinery Row in Strathcona County, and Alberta's Industrial Heartland. Other emission sources in the region include on and off-road transportation, space heating, electricity power generating plants located in the western portion of the region, and various other sources.

Figure 17 shows the relative source contribution of primary $PM_{2.5}$ and precursor emissions in the Capital Region. The major sources and their percent contributions to $PM_{2.5}$ and precursor emissions were often similar to those of the entire North Saskatchewan Air Zone. The electric power sector was the largest emitter of both SO_2 (69%) and NOx (44%) emissions in the Capital Region. Off-road transportation sources were the second largest NOx emitter in the region (25%). On-road transportation sources were major contributors of VOCs and NOx with emissions of 19% and 11%, respectively.

Agriculture was the dominate source of NH_3 emissions (64%) in the Capital Region. The upstream oil & gas sector was a relatively minor source within the region, contributing to less than 5% of NOx and SO_2 emissions. Residential and commercial heating were the largest source of primary $PM_{2.5}$ emissions in the region, followed by off-road transportation, other industrial sources, and the electric power generation sector. Other industrial sources (mainly petroleum refineries and bulk storage terminals) were the largest source of VOC emissions and the second largest source of SO_2 and NH_3 emissions in the region.



tonne/month	NOx	VOC	TOG	CO	NH3	SO2	PM25	PM10
Agriculture	0	437	673	8	555	0	26	72
Commercial and residential heating	482	291	321	1,534	6	82	271	274
Transportation: Offroad	3,083	689	775	8,970	6	16	201	210
Transportation: Onroad	1,315	1,051	1,212	14,608	43	18	28	61
Industrial – others	1,461	2,631	3,741	2,418	252	2,175	161	311
Industrial – electric power generation	5,303	46	91	744	8	5,522	158	319
Industrial – upstream oil and gas	472	390	899	607	0	154	8	8

Figure 17: Anthropogenic Emission Contributions for the Capital Region by Source Sector.

3.3 $PM_{2.5}$ Speciation for the Capital Region

The first phase of modelling in the Capital Region Assessment showed that sulphate (SO_4), nitrate (NO_3), and ammonium (NH_4) were the three largest species components of $PM_{2.5}$ in the Capital Region. Refinements made for the second phase of modelling reduced the significance of sulphate and brought the speciation breakdown closer to monitoring station observations. Overall, both the modelling and the measurements at the ambient air monitoring stations confirmed sulphate, nitrate, and ammonium as the three key species of $PM_{2.5}$ in the Capital Region. Figure 18 shows the speciation breakdown of $PM_{2.5}$ for the Capital Region Assessment.

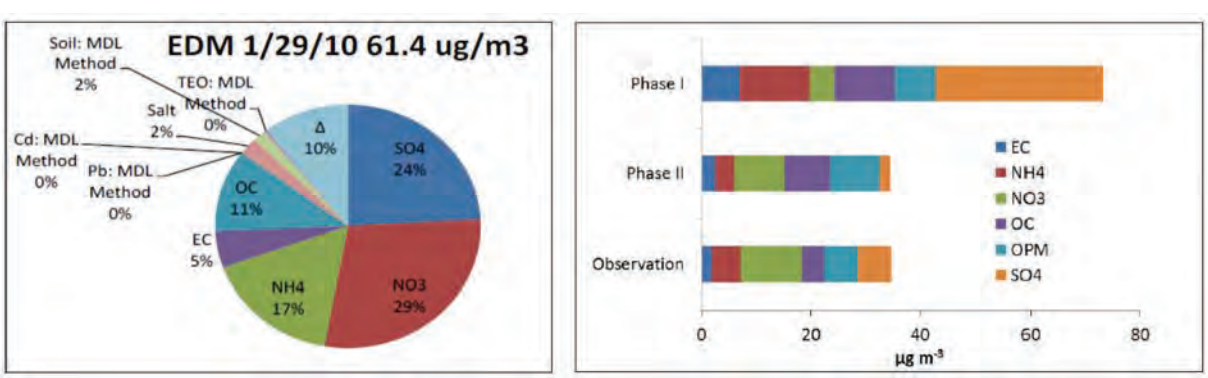


Figure 18: $PM_{2.5}$ Speciation for the Capital Region Assessment.

Figure 19 presents the Capital Region Assessment CMAQ-estimated two-month average $PM_{2.5}$, sulphate, and nitrate concentrations for the base case simulation from January through February 2010. Elevated average $PM_{2.5}$ concentrations occurred from the City of Edmonton extending to the Industrial Heartland to the northeast. The highest predicted average $PM_{2.5}$ concentration occurred near the City of Edmonton. Most of the elevated $PM_{2.5}$ concentrations were sulphate which peaked at roughly the same location. Sulphate was generally high near large SO_2 sources including the Strathcona Refinery east of Edmonton and Scotford Upgrader in the Industrial Heartland. Nitrate appeared low within the Capital Region with maximum concentrations predicted in the city core.

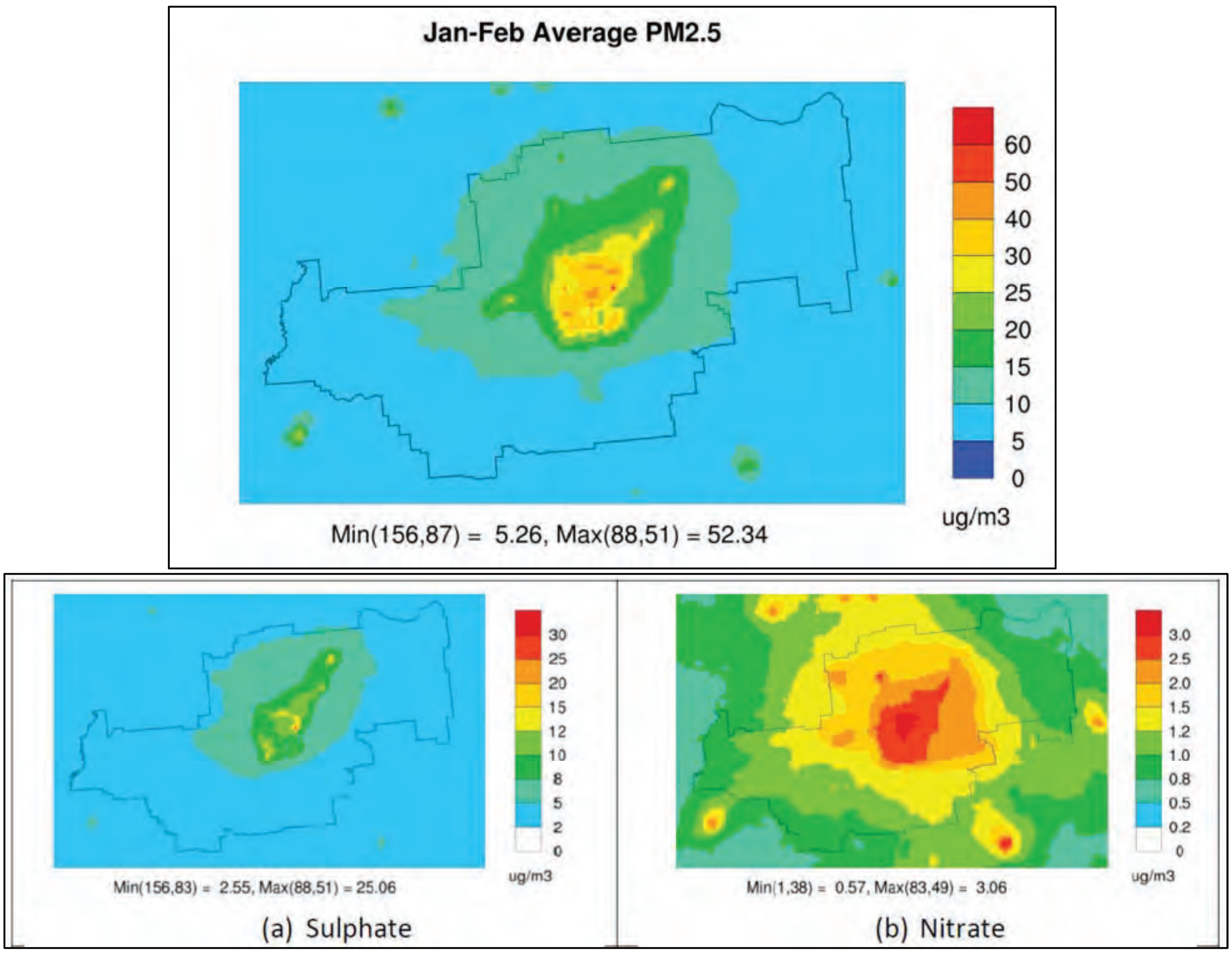


Figure 19: CMAQ-Estimated Average $PM_{2.5}$, Sulphate and Nitrate Concentrations (µg/m3) for Base Case.

3.4 Zero-Out Simulations for the Capital Region

In order to evaluate the contributions to wintertime fine particulate matter of the various emission sectors, four zero-out emission sensitivity simulations were performed as part of the Capital Region Assessment. This included examining the impact of removing (turning off) four sector categories in order to see the predicted changes in the formation of secondary particulate matter and overall concentrations of $PM_{2.5}$ and related species. The zero-out sectors used were: 1. On-road transportation sources; 2. Power Plants (EGU); 3. Other stationary point sources (sectors other than power plants and UOG); and 4. All anthropogenic sources (to assess the impact from sources outside of the Capital Region).

Figures 20 to 23 display the differences in CMAQ-estimated average $PM_{2.5}$, sulphate, nitrate, and ammonium concentrations during Jan-Feb for the four zero-out simulations. High particulate matter concentrations appear to originate from local sources within the Capital Region, with much of these contributions being attributable to sulphate. Other (non-power, non-UOG) point sources appear to be the major sulphate contributors; whereas other anthropogenic sources (e.g., agriculture and off-road) dominate contributions to all other PM species. Agriculture (included in the all anthropogenic source group) was the main contributor to ammonia emissions in the Capital Region. Eliminating emissions from the agricultural sector resulted in less available ammonia to form ammonium nitrate. Contributions of on-road transportation sources to the average $PM_{2.5}$ concentrations were found to be small.

Spatial distributions of nitrate contributions from on-road transportation sources generally followed highway networks. Contributions of electric power generation sources to $PM_{2.5}$ were generally less than 1 µg/m3, with the highest impact being seen near the Sundance coal-fired power plant. Outside of the Capital Region, sulphate contributions from EGU of about 1 µg/m3 were predicted close to large non-electric power generation ammonia sources. While sulphate was reduced with the elimination of electric power generation sources, nitrate was predicted to see small increases in most areas due to more ammonium becoming available. The other point source sector gave highest PM impacts with large PM contributions close to the City of Edmonton and Industrial Heartland. This sector dominated contributions to total $PM_{2.5}$ and several PM species including sulphate and ammonium in the Capital Region.

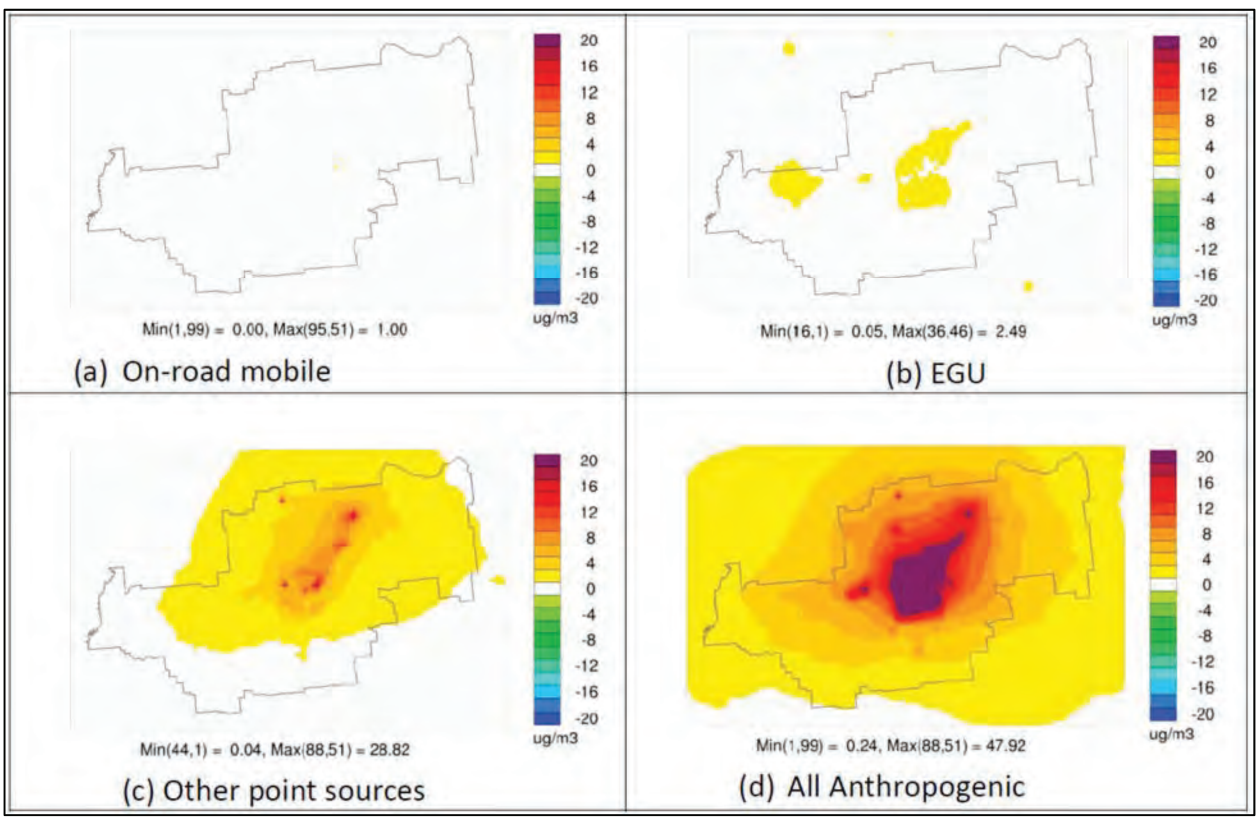


Figure 20: Differences in CMAQ-Estimated Average $PM_{2.5}$ Concentrations During Jan-Feb for the Four Zero-Out Simulations.

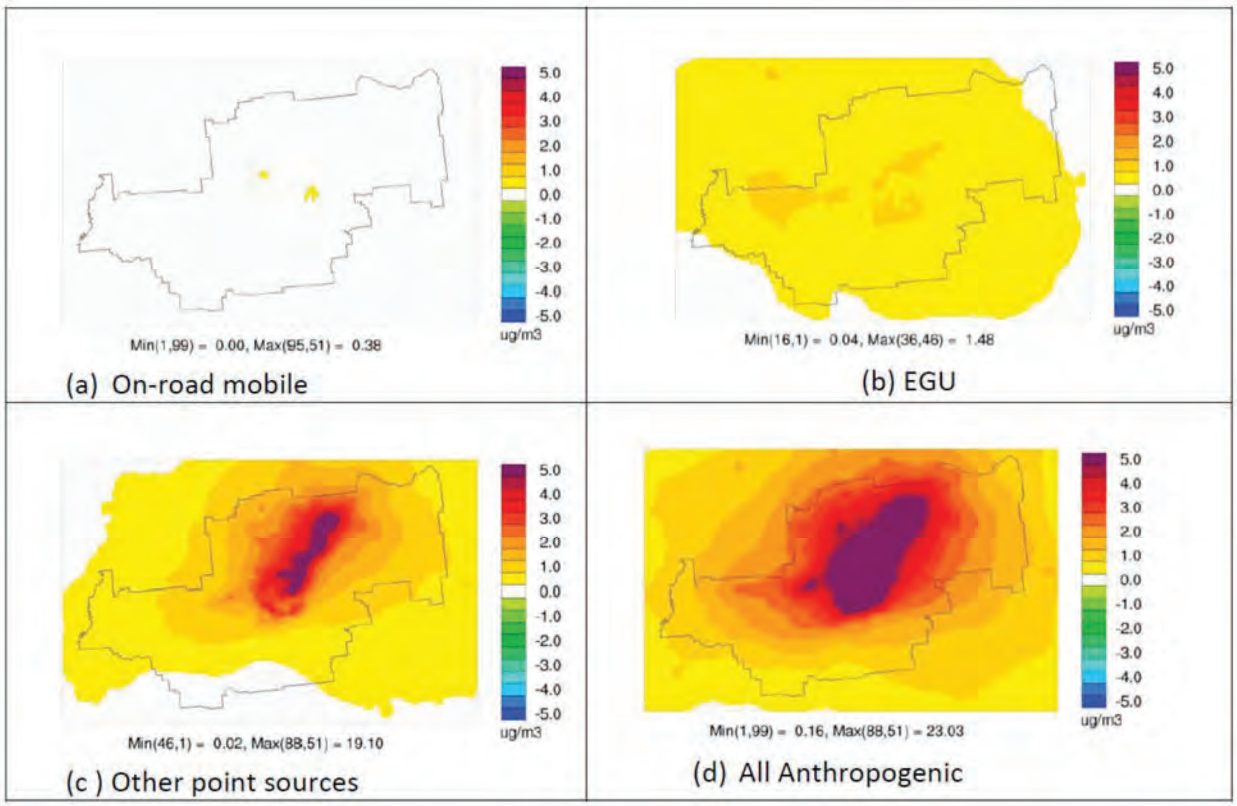


Figure 21: Difference in CMAQ-Estimated Average Sulphate Concentrations During Jan-Feb for the Four Zero-Out Scenarios.

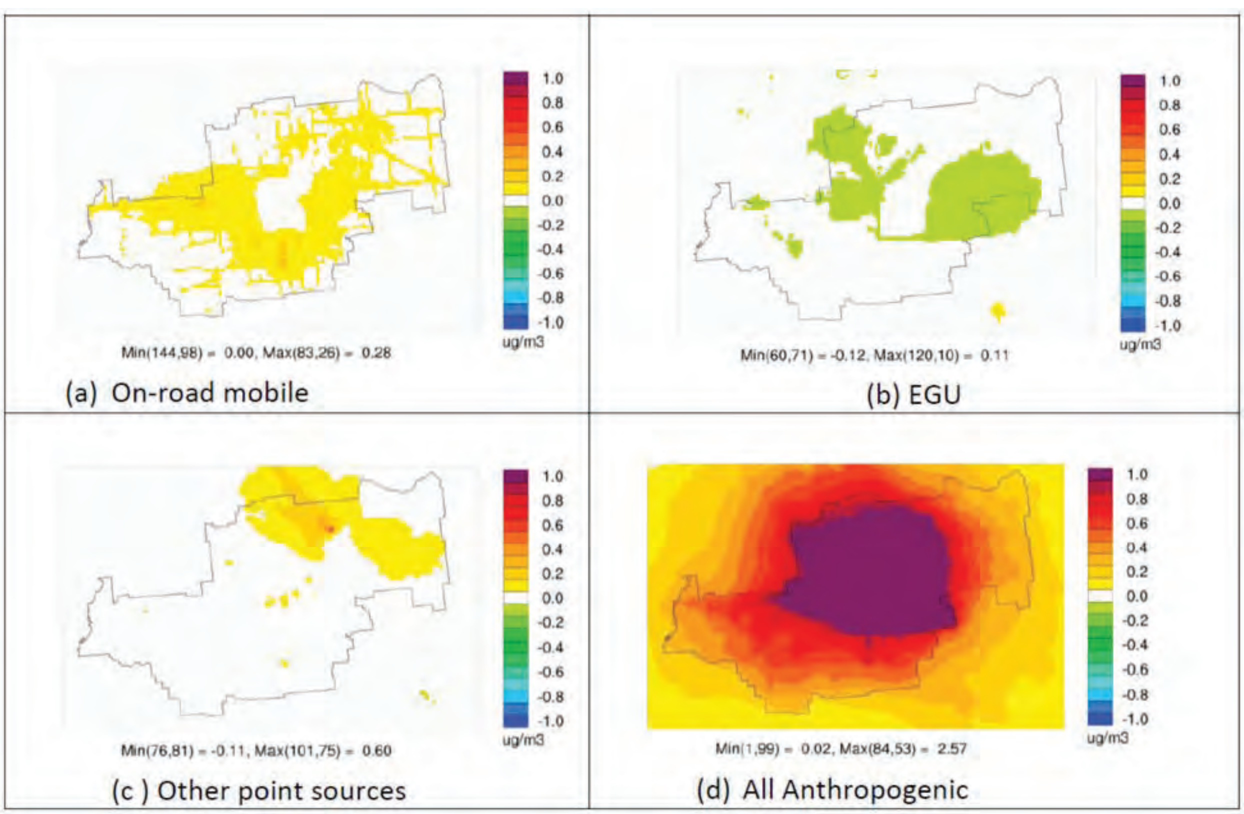


Figure 22: Difference in CMAQ-Estimated Average Nitrate Concentrations During Jan-Feb for the Four Zero-Out Scenarios.

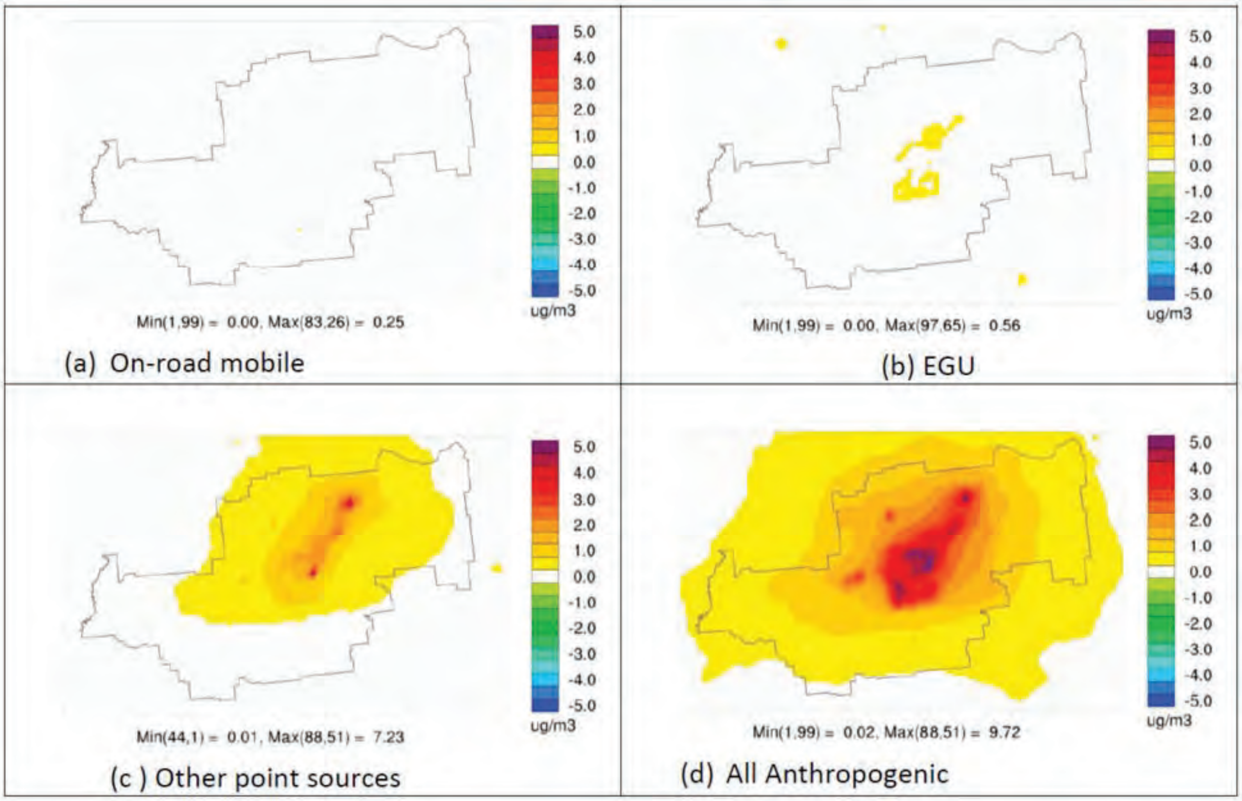


Figure 23: Difference in CMAQ-Estimated Average Ammonium Concentrations During Jan-Feb for the Zero-Out Scenarios.

3.5 Zero-Out Simulations for Monitoring Stations

Figures 24 to 27 show zero-out source contributions to average $PM_{2.5}$, sulphate, nitrate, and ammonium concentrations at monitoring stations within the Capital Region. The results of the source apportionment simulations again showed that high PM concentrations in the Capital Region were mostly from local sources. Contributions from electric power generation were low even at the western monitors located closer to power generation facilities. PM concentrations at both the Tomahawk and Genesee monitors were influenced mainly by sources outside of the Capital Region, likely due to upstream oil & gas sources. PM contributions from on-road transportation were also low with highest impacts seen at the industrial and Edmonton monitors. However, the on-road contributions at Edmonton monitors were likely understated due to lack of ammonia emissions from the CALMOB6 data. Edmonton and industrial monitors were mostly affected by other anthropogenic sources. Impacts from other point sources at monitoring stations varied depending on their downwind distance from sources. The highest contributions of other point sources to average $PM_{2.5}$ concentrations were seen at REDWIN.

Industrial sources in the Capital Region are large SO_2 emitters, thus the impacts of other point sources (mainly petroleum refineries) to average sulphate concentrations were seen at near-by monitors of these sources. However, sulphate concentrations at the western monitors were mainly influenced by sources outside of the Capital Region instead of near-by electric power generation sources. In contrast to sulphate, industrial sources had small impacts to nitrate. In fact, small nitrate increases occurred at most sites when eliminating local electric power generation sources. Other anthropogenic sources yielded highest impacts to nitrate at all monitors due mainly to agricultural ammonia sources. Eliminating emissions from the agriculture sector resulted in less available ammonia to form ammonium nitrate. Commercial and residential heating and off-road transportation dominated primary PM emissions in the Capital Region. Since these emissions were spatially allocated near the city centre, highest contributions were seen at the EDCEN site.

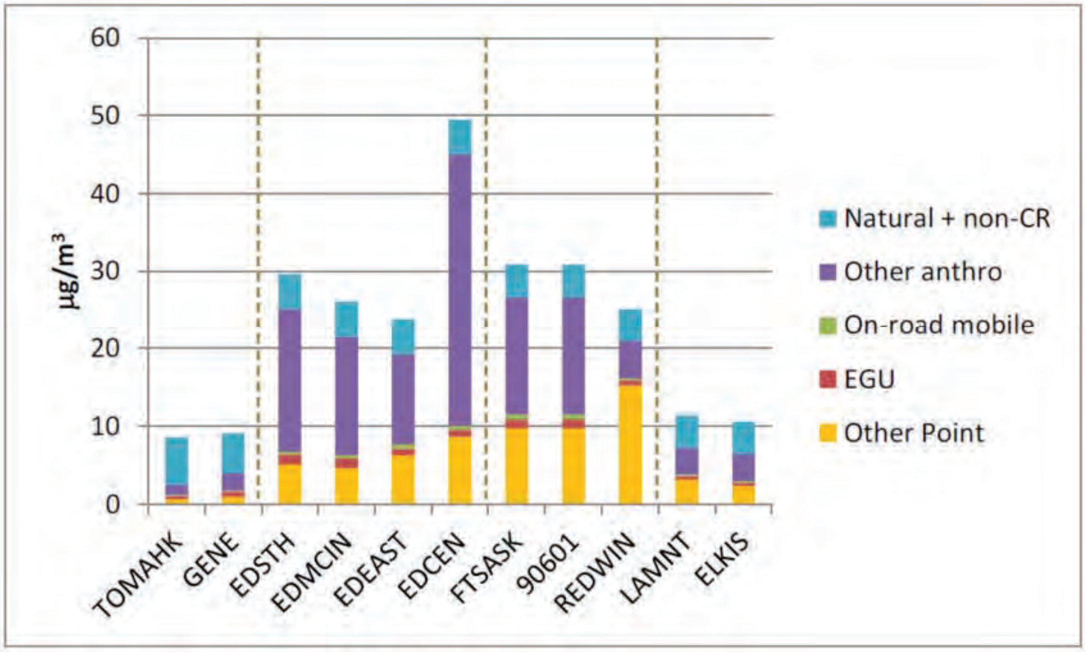


Figure 24: Source Contributions to Average $PM_{2.5}$ at Monitoring Stations Within the Capital Region.

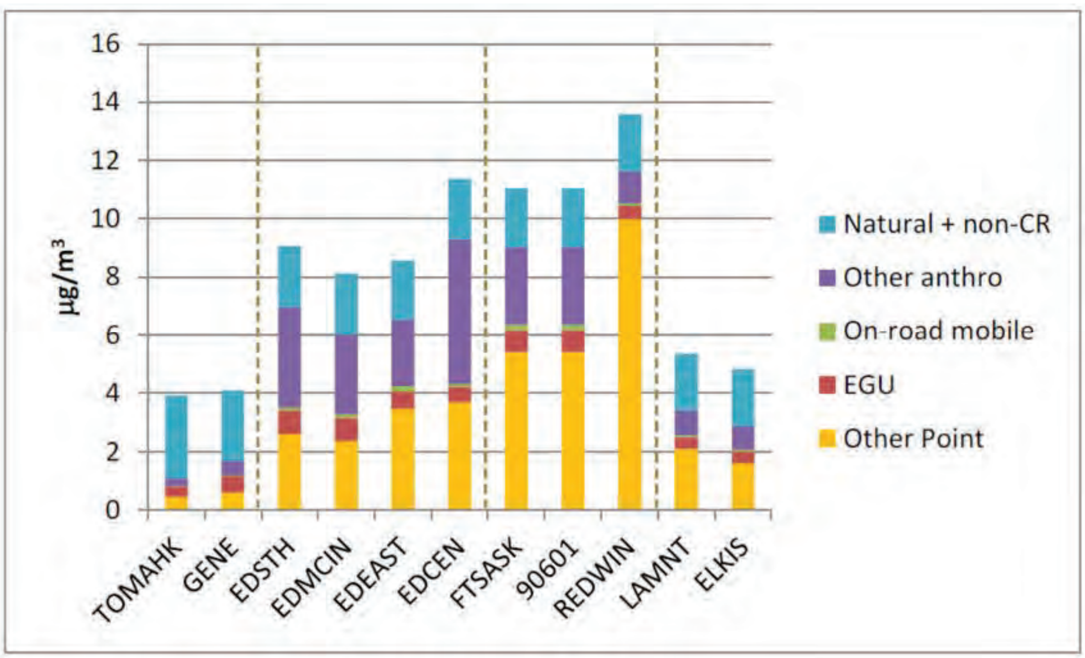


Figure 25: Source Contributions to Average Sulphate at Monitoring Stations Within the Capital Region.

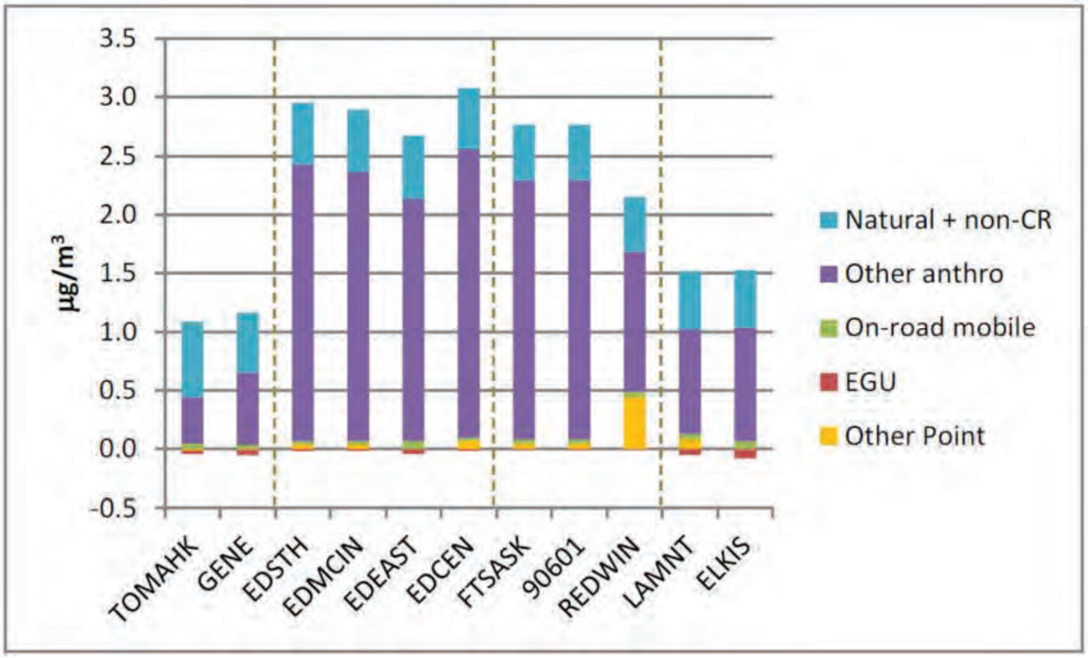


Figure 26: Source Contributions to Average Nitrate at Monitoring Stations Within the Capital Region.

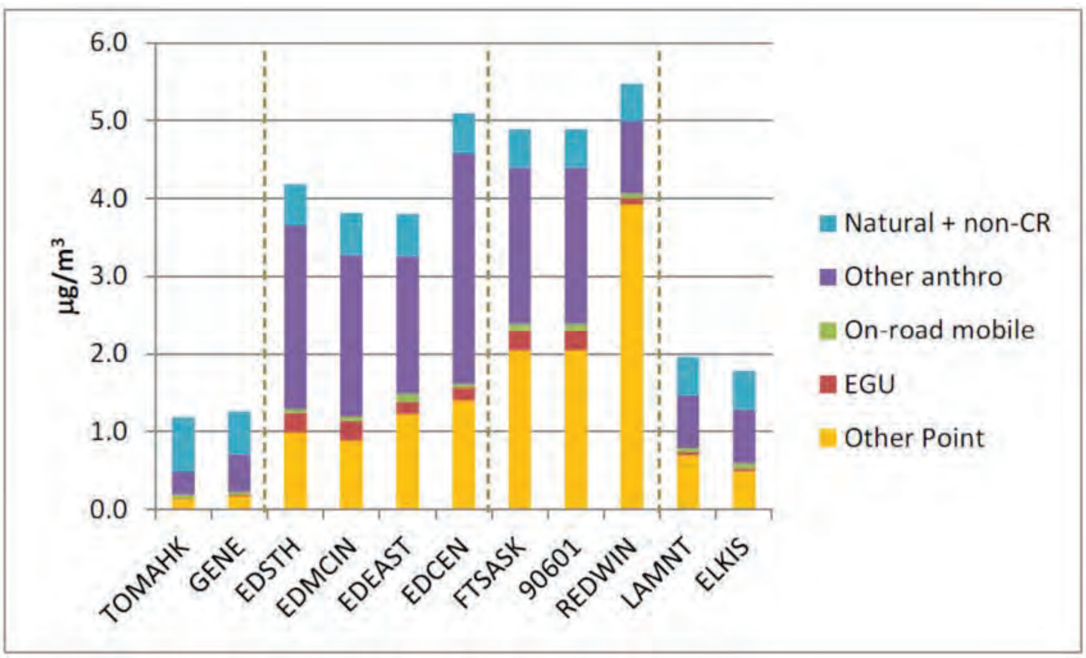


Figure 27: Source Contributions to Average Ammonium at Monitoring Stations Within the Capital Region.

4.0 Conclusions

Based on the available emissions inventory data, the largest anthropogenic sources of $PM_{2.5}$ and precursor emissions in the North Saskatchewan Air Zone are road dust, construction, industry (specifically the electricity generation, conventional oil & gas, chemical manufacturing, petroleum refining, and oil & gas pipeline and storage sectors), on-road transportation, off-road transportation, and agriculture.

The Capital Region Assessment identified that $PM_{2.5}$ in the Capital Region appears to originate mainly from local sources within the region. The three largest species of $PM_{2.5}$ in the Capital Region were sulphate, nitrate, and ammonium. Sulphate was found by the study to be a key component of high winter $PM_{2.5}$ predicted in the Capital Region and much of the sulphate was attributable to the other stationary point sources, including (petroleum refiners, bulk storage terminals, and oil sands upgrading), and to a lesser extent electric power generation. Other anthropogenic sources, specifically off-road transportation and agriculture, were identified as the dominate contributors to nitrate in the region, and agricultural sources contributed the most to ammonium. The contribution of on-road transportation sources to the average $PM_{2.5}$ concentrations was found to be small and this source's contribution to nitrate concentrations generally followed the highway and road networks. Commercial and residential heating and off-road transportation were the dominant source of primary $PM_{2.5}$ in the Capital Region.

Based on the available emissions inventory information and the results of the Capital Region Assessment, there are several major non-industrial non-point sources in the North Saskatchewan Air Zone that may warrant consideration in relation to CAAQS management actions. These non-industrial sources include: on-road transportation, off-road transportation, agriculture, and commercial/residential heating. There are also several major industrial non-point sources in the North Saskatchewan Air Zone that may warrant consideration in relation to CAAQS management actions, in particular for their large contribution to the region's VOC emissions. These industrial sources include: plant fugitives, storage and handling, and spills and accidental releases. These industrial sources are largest in the petroleum refining, bulk storage terminals, and conventional oil & gas sectors.

This summary report and the above conclusions on relevant non-point sources in the North Saskatchewan Air Zone were based on the assumptions that:

- The various available emissions inventory datasets (representing several calendar years) are adequately representative of current emission levels and rates in the North Saskatchewan Air Zone; and
- The photochemical modelling and source apportionments for the Capital Region Assessment are adequate to represent the larger North Saskatchewan Air Zone.

References

Alberta Environmental Monitoring, Evaluation and Reporting Agency. *AEMERA Ambient Air Monitoring Assessments*. Prepared for the CASA Non-Point Sources Technical Task Group. Alberta Environmental Monitoring, Evaluation and Reporting Agency.

Alberta Environment and Parks. 2016a. *Summary Report on Analysis of the 2014 National Pollutant Release Inventory*. Internal report. Alberta Environment and Parks, Government of Alberta.

Alberta Environment and Parks. 2016b. *Summary Report on Major Non-Point Air Emission Sources in Alberta*. Prepared for the CASA Non-Point Sources Task Group. Alberta Environment and Parks, Government of Alberta.

Alberta Environment and Parks. 2016c. *Summary Results of CAAQS Assessment*. From Communication with AEP Staff.

Alberta Environment and Parks. 2015a. *Air Zone Preliminary Historical Time Series in Response to CAAQS Assessments*. Internal report. Alberta Environment and Parks, Government of Alberta.

Alberta Environment and Parks. 2015b. *Alberta: Air Zones Report 2011-2013*. Published report. Alberta Environment and Parks, Government of Alberta.

Alberta Environment and Parks. 2015c. *Non-Point Sources Background Information*. Prepared for the CASA Non-Point Sources Team. Alberta Environment and Parks, Government of Alberta.

Alberta Environment and Sustainable Resource Development. 2011a. *2006-2008 Alberta Air Emissions Inventory*. Internal database. Alberta Environment and Sustainable Resource Development, Government of Alberta.

Alberta Environment and Sustainable Resource Development. 2011b. *LUF Regional Air Emissions Analysis*. Internal analysis results. Alberta Environment and Sustainable Resource Development, Government of Alberta.

Alberta Environment and Sustainable Resource Development. 2011c. *Results of the Alberta Air Emissions Inventory (2006-2008 emission years)*. Internal report. Alberta Environment and Sustainable Resource Development, Government of Alberta.

Clearstone Engineering. 2014. *2011 Canadian Upstream Oil & Gas Inventory*. Prepared for Environment Canada. Alberta dataset provided to Alberta Environment and Sustainable Resource Development by Environment Canada. Environment Canada, Government of Canada.

Environment Canada. 2015. *2014 National Pollutant Emissions Inventory*. Dataset provided to Alberta Environment and Parks by Environment Canada. Environment Canada, Government of Canada.

Environ International Corporation. 2015. *Formation of Secondary $PM_{2.5}$ in the Capital Region Study: Final Report*. Prepared for Alberta Environment and Sustainable Resource Development. Environmental International Corporation, Novato, California.

Environ and Novus Environmental. 2014. *Capital Region Particulate Matter Air Modelling Assessment: Final Report*. Prepared for Alberta Environment and Sustainable Resource Development. Environmental International Corporation, Novato, California.

2016

CASA Air Zone Region Reports

South Saskatchewan Air Zone

Summary of Information, Studies, Papers, and Reports of Possible Relevance to the Work of the CASA Non-Point Source (NPS) Technical Task Group Related to: Air Monitoring, Ambient Air Quality Trending, Air Dispersion Modelling, Source Characterization, and Air Emission Inventories for the South Saskatchewan Air Zone

CASA NPS Technical Task Group
8/31/2016

Contents

List of Figures

List of Tables

1 Context

1.1 Purpose

This document has been prepared to summarize information pertaining to the South Saskatchewan Region (SSR) Air Zone and the possible significance of non-point sources (NPS's) on fine particulate matter ($PM_{2.5}$) and ground-level ozone (O_3), as measured against the Canada Wide Standards (CWS) and Canadian Ambient Air Quality Standards (CAAQS).

The focus is on:

1. relevant ambient monitoring data;
2. air emissions inventory data; and
3. air modelling and source apportionment studies for the South Saskatchewan Air Zone.

This information can be used to assess and understand which, and how, NPS may be contributing to ambient concentrations of fine particulate matter ($PM_{2.5}$) and ozone (O_3) in the SSR Air Zone relative to the CAAQS and where there are gaps in information and understanding. Table 1 summarizes the CAAQS for $PM_{2.5}$ and O_3.

Table 1: The CAAQS and Associated Management Levels

Management Level	Ozone (ppb)	$PM_{2.5}$ 24 hour ($\mu g\ m^{-3}$)	$PM_{2.5}$ Annual ($\mu g\ m^{-3}$)
Effective	**2015**	**2015**	**2015**
Red	**Actions for Achieving CAAQS**		
Threshold	63	28	10.0
Orange	**Actions for Preventing CAAQS Exceedances**		
Threshold	56	19	6.4
Yellow	Actions for Preventing Air Quality Deterioration		
Threshold	50	10	4.0
Green	**Actions for Keeping Clean Areas Clean**		

1.2 Ambient Monitoring in the South Saskatchewan Air Zone

The *Alberta: Air Zones Report 2011-2013* summarizes the CAAQS achievement status and management levels for Alberta's air zones for $PM_{2.5}$ and O_3 monitoring results. Four stations in the SSR Air Zone were used in the 2011 to 2013 assessment. These stations are located within communities or in areas accessed by members of the public. Figure 1 provides a map of the ambient monitoring stations in the SSR Air Zone used in the 2011-2013 CAAQS assessment.

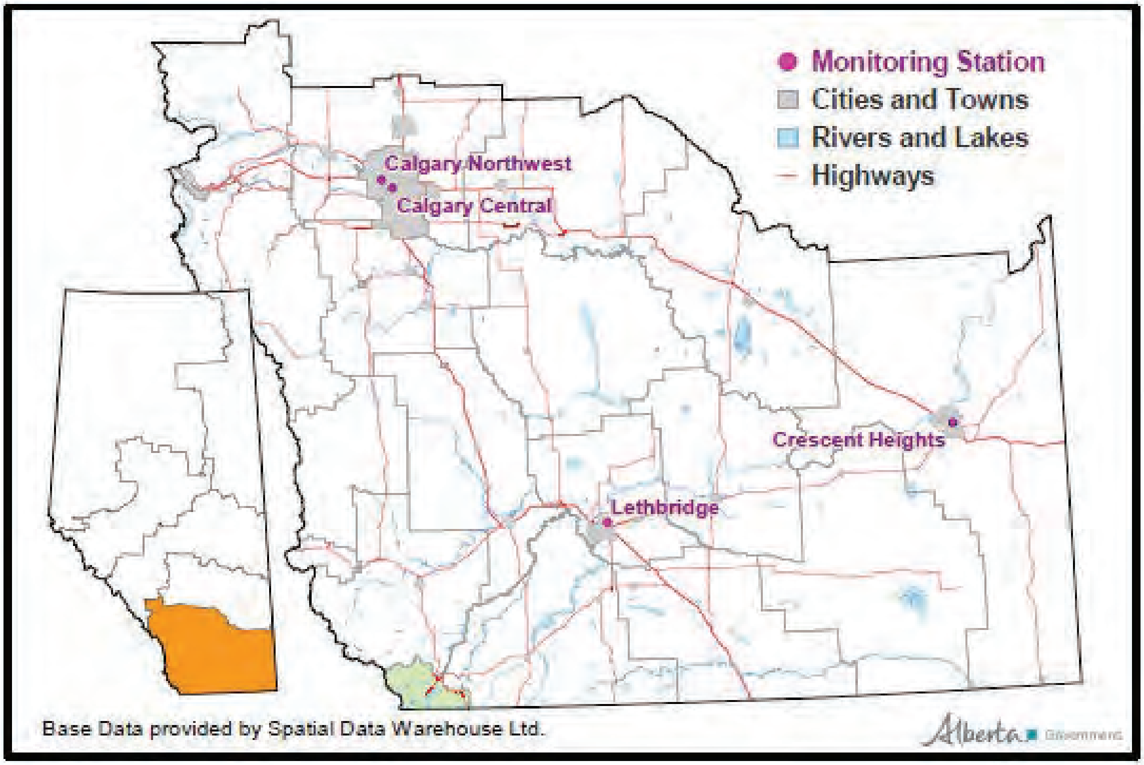


Figure 1: Ambient Air Monitoring Stations in the South Saskatchewan Region Air Zone used to Assess Air Zone Status relative to the CAAQS

1.3 CAAQS $PM_{2.5}$ and O_3 Assessments for the South Saskatchewan Air Zone

The Alberta: Air Zones Report 2011-2013 assigned the Calgary Northwest (24-hour and annual average), Crescent Heights (Medicine Hat), and Lethbridge monitoring stations (annual average) to the CAAQS orange management level for $PM_{2.5}$, Actions for Preventing CAAQS Exceedance. An orange management level for $PM_{2.5}$ was assigned to the SSR Air Zone. This management level indicates that $PM_{2.5}$ concentrations are approaching the highest level of CAAQS and proactive actions are needed to prevent exceedance.

The SSR Air Zone monitoring stations used to assess air quality relative to the CAAQS are listed in Table 2 along with their 2011-2013 levels for $PM_{2.5}$ (24-hour and annual) and O_3 (8-hour), and their assigned management level. If an air zone has more than one station, the highest metric value is used for comparison against the threshold values and the CAAQS to determine the management level for the entire air zone.

The CAAQS values in Table 2 indicate that while only Calgary Northwest was in the orange level for the 24-hour $PM_{2.5}$ metric, all the stations are in the orange $PM_{2.5}$ annual metric level of at or above 6.4 $\mu g/m^3$. This indicates that $PM_{2.5}$ may be an issue in all urban centres of the region. The air zone levels for O_3, unlike those for $PM_{2.5}$, are almost entirely within the green, Actions for Keeping Clean Areas Clean and yellow, Actions for Preventing Air Quality Deterioration levels.

O_3 triggered management actions under the former Canada Wide Standard (CWS) for the Calgary area, which are ongoing (CRAZ Particulate Matter and Ozone Management Plan). For $PM_{2.5}$, the CRAZ Plan focuses regional NPS management efforts on primary $PM_{2.5}$ and secondary $PM_{2.5}$ precursors.

Table 2: CAAQS Concentration Determination and Assigned Level for Noted Stations*

Station	PM2.5 - 24hr (µg/m3)				PM2.5 - Annual (µg/m3)				O3 8-hour (ppb)			
	2011	2012	2013	**2011-13**	2011	2012	2013	**2011-13**	2011	2012	2013	**2011-13**
Calgary Central	n/a*	n/a*	18.7	n/a**	n/a*	n/a*	7.5	n/a**	54.3	48.6	48.4	50.4
Calgary Northwest	23.7	19.5	22.9	22.0	8.1	7.7	8.4	8.1	51.6	55.9	57.6	55.0
Crescent Heights	15.4	15.9	n/a*	15.7	7.5	7.8	n/a*	7.7	53.9	55.5	50.4	53.3
Lethbridge	18.5	n/a*	16.8	17.7	6.6	n/a*	6.5	6.6	53.1	55.1	50.3	52.8
South Saskatchewan Air Zone				23				8.1				60

* Did not meet data completeness requirements
** 3 years of data required

*(Note: the Colour Coding in the Table for the 2011-2013 Period is the Management Level that the station falls into under the CAAQS – see Table 1. The Colour Coding for each individual year is not directly relevant to the CAAQS but is intended to depict on an annual basis where the station levels were relative to the CAAQS management levels.)

2 Non-point Emission Sources and Emissions Inventories

2.1 Alberta Non-point Sources

Government of Alberta 2016b lists the following industrial and non-industrial sources as the major NPS types in Alberta.

Industrial Non-point Sources

- Plant fugitive leaks;
- Liquid tailings ponds;
- Mine fleets;
- Mine faces;
- Solid mine tailings;
- Materials storage and handling;
- Non-stationary equipment;
- Space heating; and
- Storage tanks.

Non-industrial, Non-point Sources

- Road dust (unpaved and paved roads);
- Construction (industrial, transportation, municipal, residential, and communications);
- Agriculture (agricultural animals, fertilizer application, harvesting, tilling, and wind erosion); and
- Transportation (on-road vehicles, off-road vehicles, and rail transportation).

2.2 Relative Significance of Different Sources to Non-point Source Emissions in the South Saskatchewan Region Air Zone

Figure 2 (AEP 2016b) provides the relative fractional estimates of the contribution of different sources to primary $PM_{2.5}$ and precursor (VOC, NOx, and SO_2) emissions in the SSR Air Zone. In this figure, the "other sources" include all other source categories, each of which individually contributed to less than 5% of the region's emissions total of the particular pollutant.

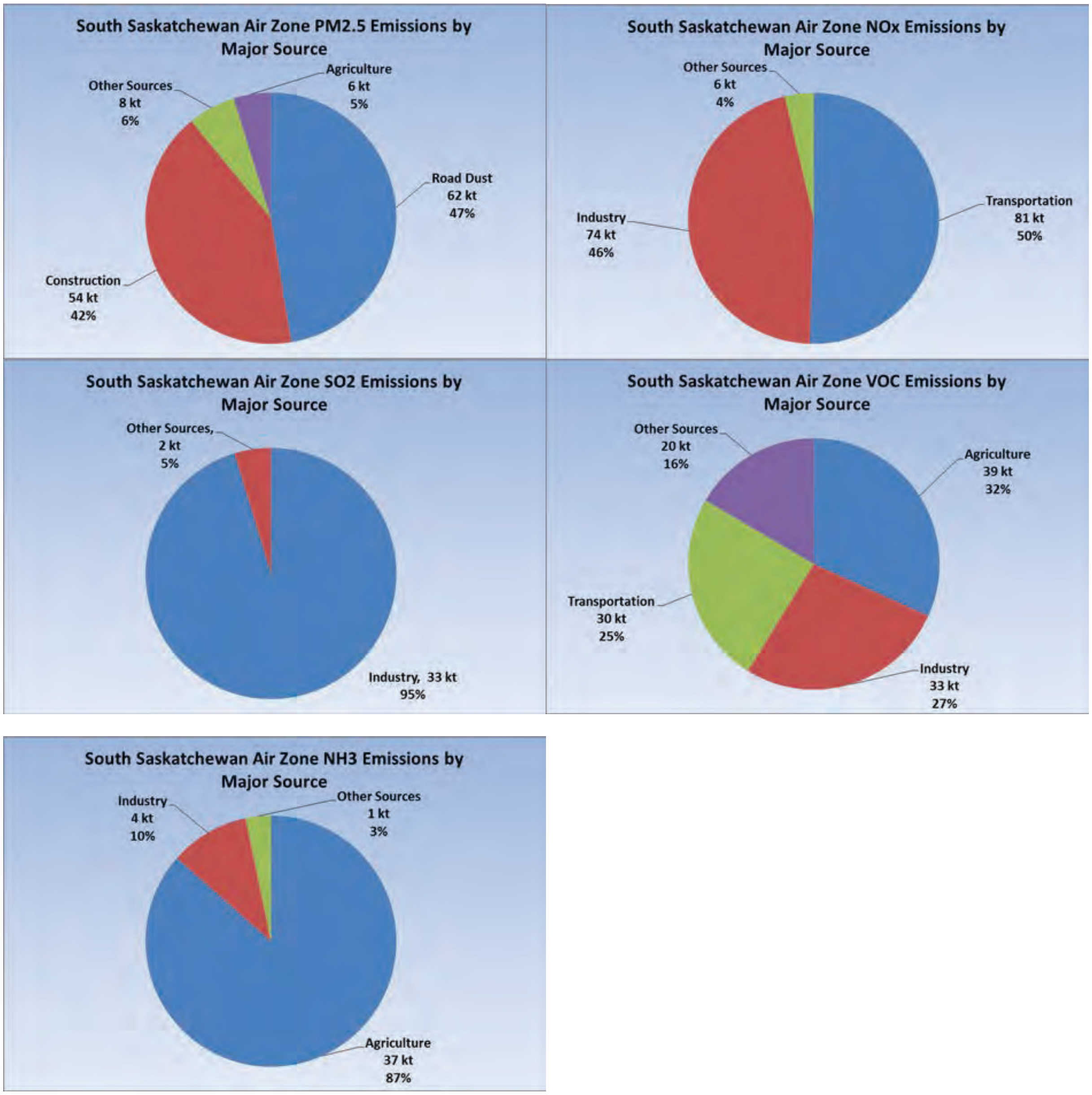


Figure 2: Relative Contribution of Different Emissions Source Types to Primary $PM_{2.5}$, VOC, NOx, and SO_2 Emissions in the SSR Air Zone

Road dust was the source of nearly half of $PM_{2.5}$ emissions in the SSR Air Zone, followed closely by construction sources, which contributed 42% of $PM_{2.5}$ emissions. Transportation emissions were responsible for 50% of NOx emissions in the SSR Air Zone, followed by industrial sources, which accounted for 46% of NOx emissions. Industrial sources emitted 95% of all SO_2 in the SSR Air Zone. Industrial sources accounted for 27% of VOC emissions in the SSR Air Zone, while agricultural sources emitted 32% and transportation sources emitted about 25% of VOCs. Agricultural sources were the dominant emitting source of NH_3 in the SSR Air Zone, with 87% of emissions. Industrial sources were responsible for 10% of NH_3 emissions in the SSR Air Zone.

Figures 3 through 5, inclusive, (AEP 2016b) provide the relative fractional estimates of the contribution of different sources to primary $PM_{2.5}$, VOC, NOx, and SO_2 emissions broken out for Calgary, Medicine

Hat, and Lethbridge, respectively. The data from the monitoring stations in these locations are those used for the CAAQS assessment.

Construction sectors, followed by road dust, dominate the primary $PM_{2.5}$ emissions while mobile sources are the highest contributor of NOx emissions in all three urban centres.

Dominant SO_2 sectors varied in each city. In Calgary, the mobile sources and non-industrial sources (commercial fuel combustion) sectors contributed ~50% and ~49% of total SO_2 emissions, respectively. In Lethbridge, the largest contributors to primary SO_2 emissions were the non-industrial sector (commercial fuel combustion) with 56% of total emissions followed by the mobile sources sector with 42% of total emissions. In Medicine Hat, the industrial sector contributes 19% of the total SO_2 emissions and the mobile and non-industrial sectors contribute 51% and 30%, respectively. Mobile and miscellaneous (general solvent use, refined petroleum products, and retail etc.) sources dominate the VOC emissions contribution in Calgary. The agriculture sector influences the VOC emissions in both Medicine Hat and Lethbridge, contributing 30% and 75 % of total VOC emissions, respectively, followed by the mobile source sector.

The largest sector contributions to primary $PM_{2.5}$ and NOx were similar for the urban centers as for the entire SSR Air Zone. NPS's of construction, road dust, and mobile sources were common large contributors of $PM_{2.5}$ and precursor substances.

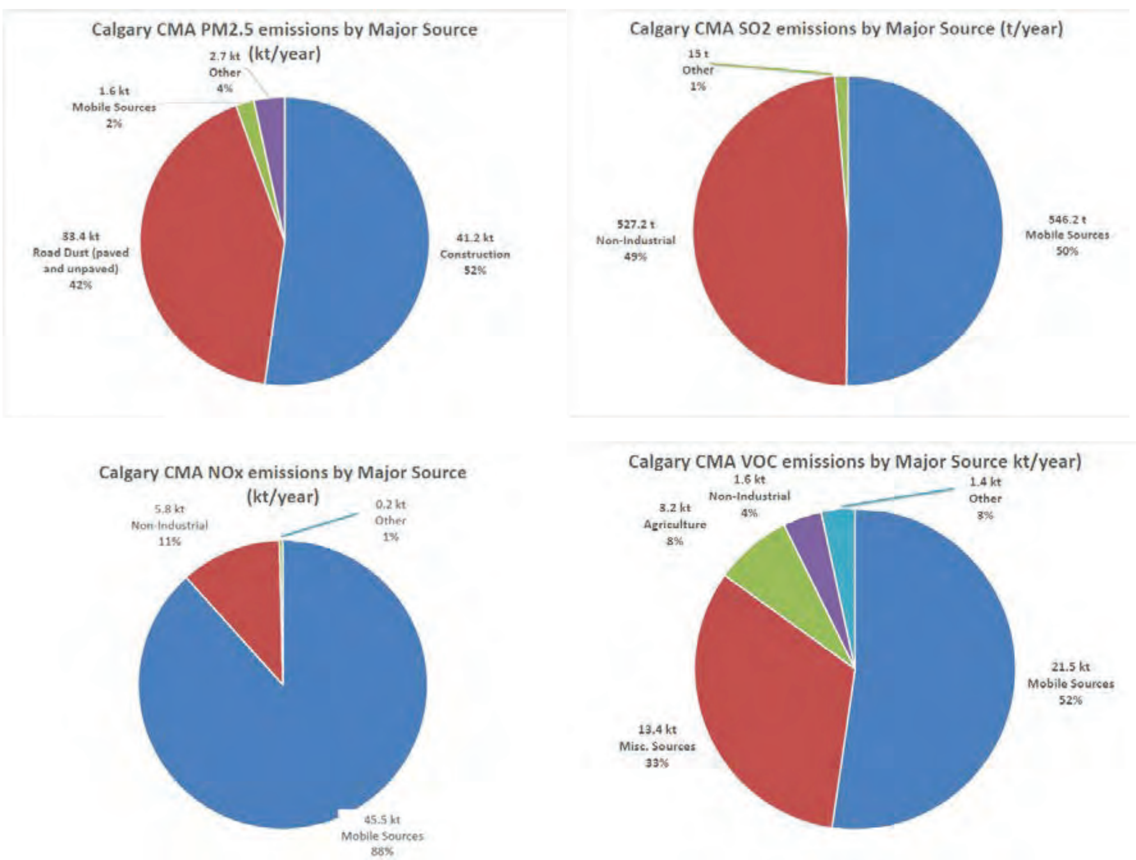


Figure 3: Relative Contribution of Different Emissions Source Types to Primary $PM_{2.5}$, VOC, NOx, and SO_2 Emissions in Calgary

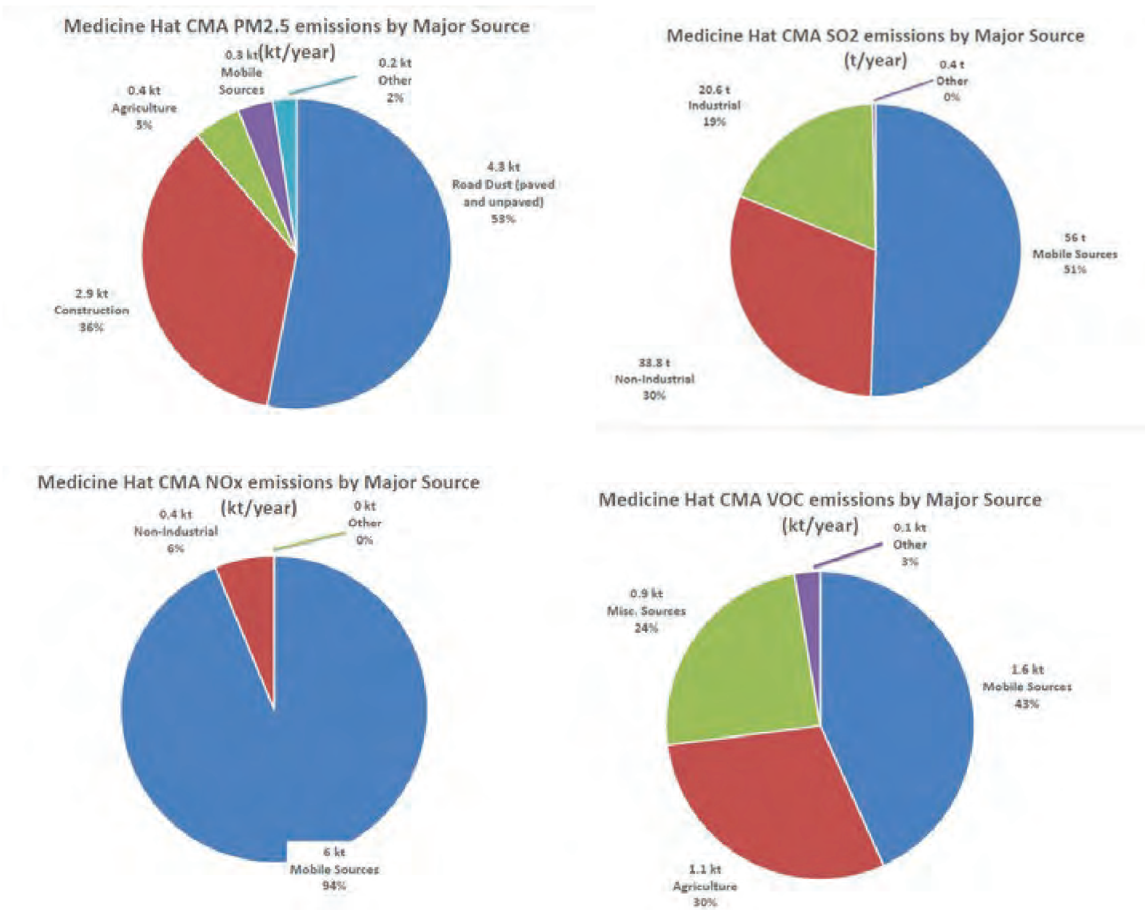
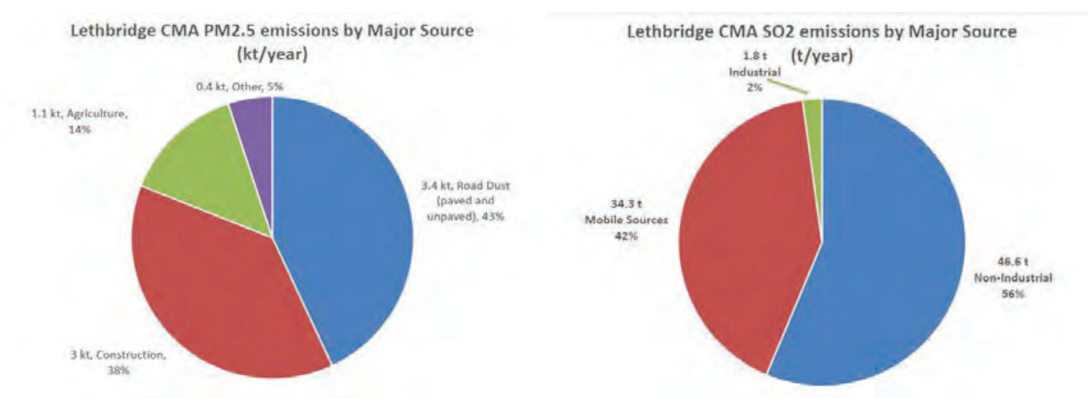


Figure 4: Relative Contribution of Different Emissions Source Types to Primary $PM_{2.5}$, VOC, NOx, and SO_2 Emissions in Medicine Hat



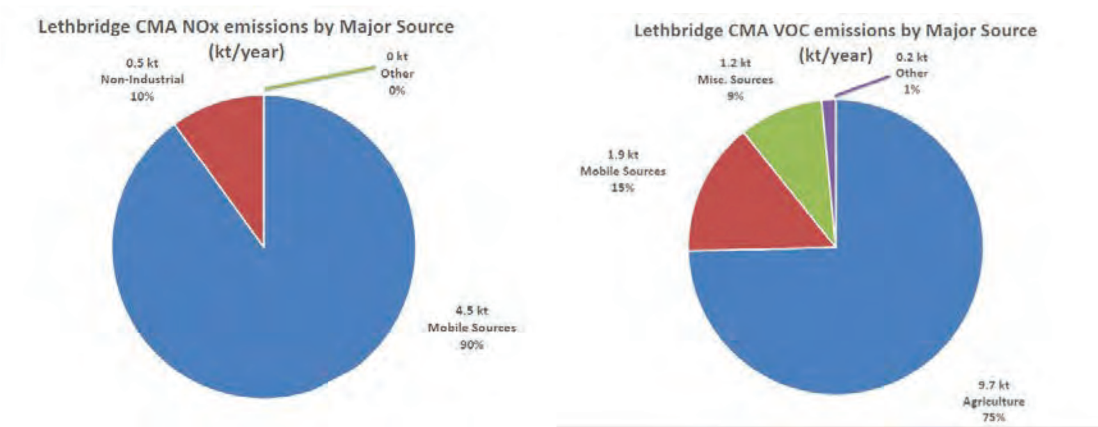


Figure 5: Relative Contribution of Different Emissions Source Types to Primary $PM_{2.5}$, VOC, NOx, and SO_2 Emissions in Lethbridge

Emission inventory data by sector and region for primary $PM_{2.5}$, NO_x, SO_2, and NH_3 is based on the 2008 Alberta Air Emissions Inventory found in the Alberta: Air Zones Report 2011-2013. Table 3 summarizes the emission inventory for the SSR Air Zone from this report.

Table 3: Breakdown by Sector/Source of Emissions of Noted Parameters in tonnes for the SSR Air Zone (AEP 2016a)

Sector/Source	Primary PM2.5	% of total	SO2	% of total	NOx	% of total	VOC	% of total	NH3	% of total
Agriculture	6,292	5	0	0	0	0	39,113	9	36,550	86
Cement and Concrete	642	0	1,615	5	3,967	2	16	0	0	0
Chemical	59	0	60	0	751	0	20	0	2	0
Construction	54,336	42	0	0	124	0	0	0	2	0
Conventional Oil and Gas	649	0	30,287	89	58,846	37	26,817	6	404	1
Electrical Power Generation	190	0	14	0	5,569	3	146	0	35	0
Fertilizer	73	0	0	0	3,535	2	476	0	3,439	8
Oil Sands	0	0	0	0	0	0	0	0	0	0
Pulp and Paper	0	0	0	0	0	0	0	0	0	0
Road Dust	61,836	47	0	0	0	0	0	0	0	0
Transportation	3,408	3	913	3	81,095	50	30,280	7	1,245	3
Wood Products	19	0	23	0	98	0	1,313	0	34	0
Other Sources	1,187	1	550	2	857	1	22,870	5	510	1
Non-Industrial Sources	1,753	1	693	2	3,431	2	1,957	0	36	0
Natural Sources	6	0	0	0	2,333	1	333,596	73	0	0
Total	130,450	100	34,155	100	160,606	100	456,604	100	42,257	100

This inventory breaks the industrial sector down further than the information shown in Figure 2. Table 3 indicates that for the SSR Air Zone, road dust and construction are the major primary $PM_{2.5}$ sources followed by agriculture and transportation. Conventional oil and gas, and cement and concrete contribute the most to the SO_2 emissions. Transportation followed by conventional oil and gas contribute to NOx emissions. Natural sources dominated the contributions to VOC emissions; however agriculture and transportation dominated the anthropogenic contributions. NH_3 contributions were dominated by the agriculture sector.

3 Summary of Conditions on Dates When Exceedances of Management Level Orange, Actions for Preventing CAAQS Exceedance for $PM_{2.5}$ Occurred

As discussed in Section 1.0, that while only the Calgary Northwest was in the orange level for the 24-hour $PM_{2.5}$ metric, all stations are in the orange $PM_{2.5}$ annual metric orange, Actions for Preventing CAAQS Exceedances level of at or above 6.4 µg/m³. The following is a summary of the dates when elevated concentrations were monitored, including meteorology associated with the event, where available. "Events" are defined as days where the 24-hour daily average was greater than 19 µg/m³ the trigger into the orange, Actions for Preventing CAAQS Exceedances level.

3.1 Calgary Northwest Station Event Summary

For 2011, there were 7 events during which the average 24-hour $PM_{2.5}$ values exceeded 19 µg/m³. Of these, 1 event occurred in March, 2 events occurred in August, 3 events occurred in September, and 1 event occurred in November. The August and September events were attributed to summertime smog and the March and November events to wintertime smog. Average winds speeds on the event days were between 3-10 km/hr. Five of the events had predominant winds occurring from the WNW and NW and the remaining two events were dominated by winds from the SSE and SE.

2012 also had 7 events during which the average 24-h $PM_{2.5}$ values exceeded the 19 µg/m³, all of which occurred in the winter months of November, December, January, and March. The events were attributed to anthropogenic wintertime smog with winds ranging from 4-9 km/hr from the SE and one day with winds from the N.

In 2013, 5 of 7 events occurred in March with winds ranging from 6-13 km/hr from the WNW, SE and NNE. Two events occurred in February with winds at 2 and 7 km/hr, from the WNW and SE, respectively. All the events in 2013 were attributed to wintertime smog.

3.2 Crescent Heights (Medicine Hat) and Lethbridge Station Event Summaries

Both the Crescent Heights and Lethbridge stations did not trigger the orange management level for the 24 hour average metric, thus AEMERA did not provide analysis of event days. However, annual levels of $PM_{2.5}$ were at or above the 6.4 µg/m³ orange, Actions for Preventing CAAQS Exceedances level. The annual average concentration is calculated from the total daily 24-hour $PM_{2.5}$ and the total number of valid daily 24-hour $PM_{2.5}$ in the year. The annual $PM_{2.5}$ metric value is calculated from the valid annual average concentrations for the first, second, and third years, thus being an average of an average. The annual values triggering the orange management level suggests that there are chronic issues in the smaller urban centres of the SSR Air Zone.

4 Other Related Studies

The following are a summary of the findings of studies that have investigated the possible effects or contributions of NPS's in the SSR, and other relevant topics.

4.1 Community Multi-scale Air Quality(CMAQ) Modelling of the South Saskatchewan Region Air Zone

Alberta Environment and Parks commissioned regional modelling in 2012 to understand the spatial distribution of predicted concentrations and to estimate contribution of local sources to air quality in the SSR. The modelling was performed using the CMAQ (Community Multi-scale Air Quality modelling system) for the 2006 emissions base year, 2020, and 2050 future years and included 6 zero-out simulations to evaluate impact and source contribution. For the zero-out simulations, selected emission sectors were turned off in the model to investigate whether there would be a reduction in concentrations if that source sector were eliminated.

The evaluation of source sector impacts on NO_2, O_3, and $PM_{2.5}$ concentrations attributed the biggest change in predicted concentrations when emissions from NPS's (transportation, construction, road dust sectors) were removed (Environ & Novus Environmental 2013). The modelling further demonstrated NPS's as the common largest contributor of primary indicator emissions and precursors in the SSR Air Zone.

4.2 Identifying Drivers for Local Anthropogenic Ozone in the Calgary Area

Novus Environmental conducted a study in 2011 in support of the CRAZ Particulate Matter and Ozone Management Plan, to identify drivers of local anthropogenic ozone in the Calgary area (CRAZ, 2011). Ozone is not directly emitted into atmosphere but caused by other pollutants interacting with sunlight in the atmosphere. Thus, ozone is complex to manage; this studied help inform where to focus management actions.

The HYSPLIT model was used to calculate air flow origin and ozone concentrations for the 3 preceding days associated with each high ozone day in order to determine, at least partially, whether the ozone was likely due to local sources, or had resulted from long-range transport from upwind sources and air masses. The monitoring data from the years 2001-2009 was analyzed for the Calgary Northwest, Central, and East stations.

A volatile organic compound (VOC)-limited regime was identified within the City of Calgary, likely extending to nearby suburban/rural communities that are immediately downwind. Ozone reduction measures should be focused on VOC emission reduction strategies within the city. A NOx-limited regime was identified for the rural areas of CRAZ, outside the influence of Calgary emissions, thus ozone reduction should be focused on measures to limit NOx emissions in the rural areas.

4.3 Source Apportionment of Volatile Organic Compounds Measured in Downtown Calgary

Through the Canadian National Air Pollution Surveillance (NAPS) program, 24-hour integrated whole air samples are collected and analyzed to determine ambient VOCs concentrations including at the Calgary Central monitoring station site. Alberta Environment and Parks conducted source apportionment analysis on the data from 2004-2011 (AEP 2014). The samples were analyzed for up to 160 individual VOCs. The receptor model, positive matrix factorization (PMF), was applied to ambient VOCs data collected.

The final source apportionment solution grouped the identified factors into the following categories: transportation, fugitive, biogenic, and aged/processed air mass. The transportation factors on average contributed the most to the reconstructed mass; however, a significant decrease over time was observed for this factor. Higher winter time concentration for the transportation factors is likely due to increased vehicle idling and lower mixing height during the cold months. The absence of significant seasonal variation for the diesel factor is likely the result of increased emissions from construction vehicles during the summer months.

The second highest on average contribution to the reconstructed mass were the carryover factors. These factors are likely associated with processed air mass based on the key species within the group. The global factor showed characteristics of a well-mixed atmosphere and contained key halocarbon species (freons). The highest global factor concentrations were observed during the spring and may be facilitated by springtime stratosphere-troposphere exchange. The dry cleaning and solvent use factors were likely associated with commercial activities near the monitoring sites and the biogenic factor contributes the least to the reconstructed mass contribution, but was readily identified by its key hydrocarbon isoprene and clear seasonal variability.

Preliminary comparison of these receptor modelling results with the local emission inventory suggests emissions in the region are heterogeneous; they vary by area. Emission management actions may need to be tailored to specific areas in the region.

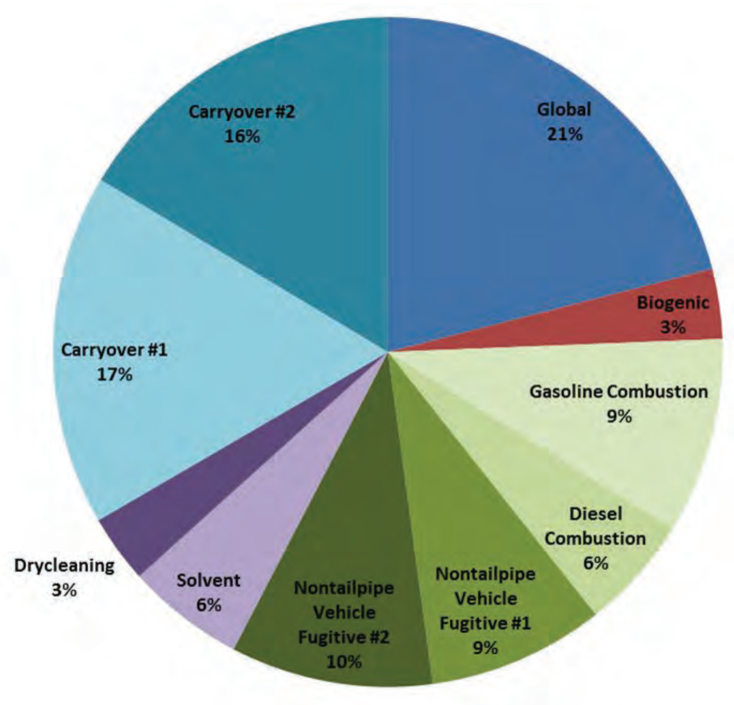


Figure 6: Five main categories of potential sources of measured VOCs: transportation (green), fugitive (purple), aged air mass (light blue), biogenic (red).

5 Conclusions

Based on the available emissions inventory data, the largest anthropogenic sources of $PM_{2.5}$ and precursor emissions in the SSR Air Zone are road dust, construction, industry (specifically the conventional oil and gas, fertilizer manufacturing, and cement and concrete sectors), transportation, and agriculture.

Modelling and source apportionment studies conducted in the SSR Air Zone also indicated that transportation, construction, and road dust sectors had the largest impact on modelling predictions or source contributions. NPS's were identified as the common largest contributor of primary indicator emissions and precursors in the study area.

Based on the available information, there are several major anthropogenic NPS's affecting ambient air quality in the SSR Air Zone that may warrant consideration when responding to CAAQS and other air quality issues. These include:

- Road dust ($PM_{2.5}$);
- Construction ($PM_{2.5}$);
- Transportation (NOx, VOCs);
- Industry (NOx, VOCs); and
- Agriculture (NH_3, VOCs, $PM_{2.5}$).

6 References

Aklilu,Yayne-abeba and Rabia Ladha. *See* Alberta Environment and Parks.

Alberta Environmental Monitoring, Evaluation, and Reporting Agency (AEMERA). unpublished 2016. CASA PM_O_3 CAAQS 2011 to 2015. Unpublished material provided to the CASA NPS Technical Task Goup upon request. Edmonton: AEMERA

Alberta Environment and Parks. 2014. Source Apportionment of Volatile Organic Compounds Measured in Downtown Calgary, by Aklilu,Yayne-abeba and Rabia Ladha. Poster presented at 2014 AWMA Annual Conference, Long Beach California. Edmonton: Alberta Environment and Parks.

______. 2016a. *Alberta: Air Zones Report 2011-2013.* Edmonton: Government of Alberta.

______. 2016b. Draft Summary Report on Major Non-point Air Emission Sources in Alberta (March 2016). Edmonton: Government of Alberta - Unpublished.

______. 2016c. Calgary, Medicine Hat and Lethbridge Emisions Inventories Spreadsheets Unpublished material provided to the CASA NPS Technical Task Goup upon request. Edmonton: Government of Alberta - Unpublished.

Calgary Region Airshed Zone (CRAZ). 2011. Identifying Drivers for Local Anthropogenic Ozone in the Calgary Region prepared by Novus Environmental for CRAZ. Calgary: Calgary Region Airshed Zone (CRAZ)

______. 2014. Calgary Region Airshed Zone (CRAZ) Particulate Matter and Ozone Management Plan. prepared by SNC-Lavalin Inc for CRAZ. Calgary: Calgary Region Airshed Zone.

Environ & Novus Environmental. 2013. Air Quality Modelling Exercise using Community Multiscale Air Quality (CMAQ) Model for South Saskatchewan Regional Plan Summary Report.

Novus Environmental. *See* Calgary Region Airshed Zone (CRAZ)

SNC-Lavalin Inc. *See* Calgary Region Airshed Zone (CRAZ)

A Summary Assessment of Air Quality in Red Deer Air Zone with Respect to CAAQS for Fine Particulate Matter and Ozone

Ambient Air Monitoring

According to AEP (2015) report, of the six air zones in Alberta, Red Deer air zone was determined to fall within the red management level with respect to the CAAQS for fine particulate matter ($PM_{2.5}$) and a yellow management level with respect to ozone (O_3). The CAAQS metric values for $PM_{2.5}$ and O_3 for the Red Deer air zone for 2011 to 2013 (adjusted after removing the influence of trans-boundary flows/exceptional events - TF/EE), and their averaged values and associated management levels over the three year period, are presented in Table 1 (AEMERA 2016a; AEMERA 2016b). The management levels for the air zone were ascertained based on the ambient air quality data obtained from a single air monitoring station (Red Deer-Riverside) located within the City of Red Deer (Fig. 1) between January 1, 2011 and December 31, 2013.

Table 1. 2011 to 2013 $PM_{2.5}$ and O_3 CAAQS for Red Deer Air Zone

Station	24-h $PM_{2.5}$ (Annual 98th Percentile & 3-Year Average in µg/m^3)				Annual $PM_{2.5}$ (Annual Average & 3-Year Average in µg/m^3)				8-h O_3 (Annual 4th Highest Daily Maximum & 3-Year Average in ppb)			
	2011	2012	2013	Avg.	2011	2012	2013	Avg.	2011	2012	2013	Avg.
Red Deer-Riverside	34.2	22.1	34.5	30	13.4	9.8	10.3	11.2	48.9	54.1	52.4	52

Red Deer-Riverside Air Monitoring Station

- **Ambient Air Data**

As of January 1, 2011, this station was (and is still) owned by Parkland Airshed Management Zone (AEMERA 2016c). Seventeen parameters were continuously monitored at the Red Deer-Riverside air station between January 2011 and December 2013 including (but not limited to), O_3, $PM_{2.5}$, NO_x (total oxides of nitrogen), SO_2 (sulphur dioxide), and the following corresponding meteorological parameters: outdoor air temperature - TEMP; relative humidity - RH; standard deviation of wind direction - STDWDIR; wind direction - WDR; and wind speed - WSP (AEMERA 2016c). NH_3 (ammonia) was not monitored at this station. Concentrations of CH_4 (methane) were continuously monitored, while other VOCs (volatile organic compounds) were continuously monitored in aggregate as NMHC (non-methane hydrocarbons) and THC (total hydrocarbons = CH_4 + NMHC). These aggregates represent the total concentrations of specific categories of VOCs in ambient air and are not specific to individual VOCs, i.e., other than CH_4.

A close review of the Red Deer-Riverside air monitoring station data over the three years (AEMERA 2016a), with highlights in Table 2 below, indicated that there were 15 days in 2011 when the 24-h $PM_{2.5}$ values exceeded the CAAQS. Of these, 11 of the 15 events occurred in March, and of those, 8 events were attributed to wintertime smog. No indication was provided for what might have led to the 4 events that did not occur in March (January - 1, February - 1, May - 1, June - 1) or the remaining 3 events that occurred in March. Similar data on the annual average $PM_{2.5}$ concentrations and the 4th highest daily maximum 8-h concentrations of O_3 were not requested from AEMERA.

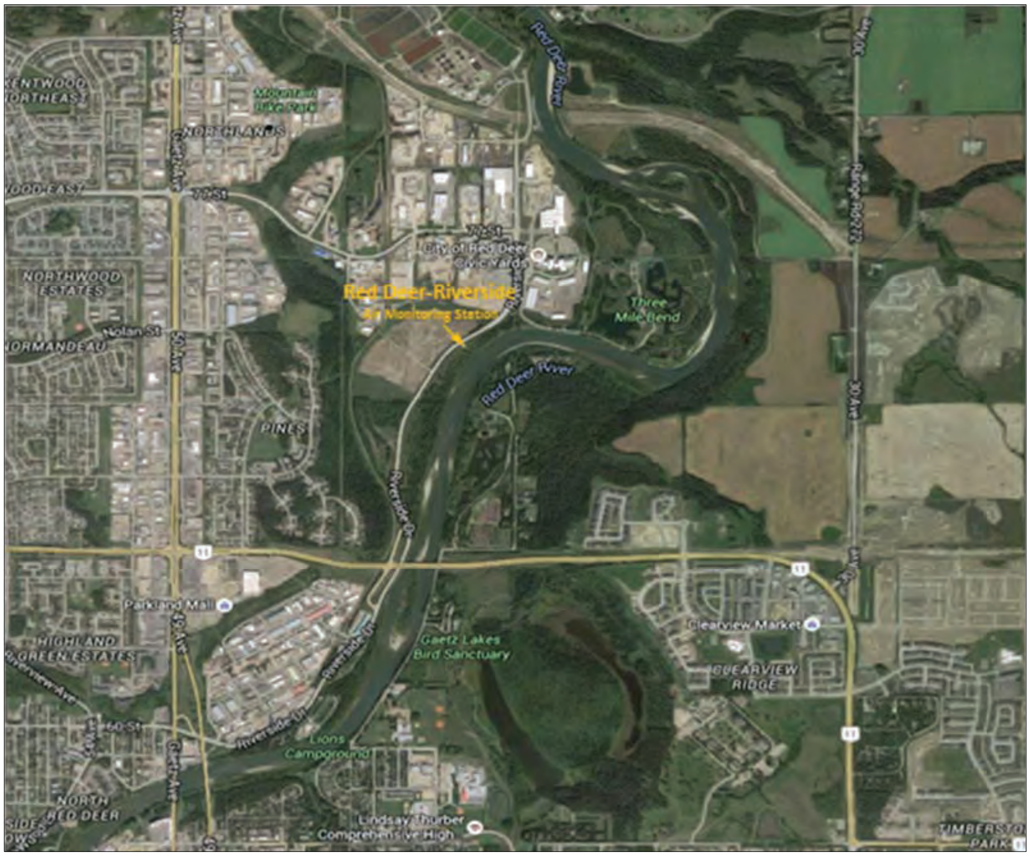


Fig. 1. Map showing location of Riverside Air Monitoring Station in the City of Red Deer.
Imagery ©2016 Google. Map data ©2016 Google.

Wind rose for all 8 wintertime smog events showed the wind was prevalently from the south (S) for 5 events with average daily wind speeds ranging between 3 km/h and 13 km/h; between the north (N) and north-northeast (NNE) for 2 events with average daily wind speeds of 8km/h and 11 km/h; and east (E) for 1 event with an average daily wind speed of 4 km/h (AEMERA 2016b). No indication was provided by AEMERA (2016a, 2016b) regarding potential non-point sources of emission that might have contributed to the wintertime smog.

As shown in Table 1, it appears that the annual $PM_{2.5}$ concentration in 2011 was prominent in triggering the red management level in the air zone with respect to CAAQS for the annual $PM_{2.5}$ concentrations, compared to the concentrations in 2012 and 2013. On the other hand, O_3 concentrations monitored in 2011 were not as influential in determining the yellow management level with respect to CAAQS, i.e., in comparison to the concentrations monitored in 2012 and 2013.

AEMERA (2016d) provided annual average concentrations for NO_2, SO_2 and THC. The reported annual average concentrations in 2011, 2012 and 2013, respectively, were: 11.6 ppm, 10.2 ppm and 11.7 ppm for NO_2, 0.4 ppm, 0.2 ppm and 0.1 ppm for SO_2, and 2.04 ppm, 1.99 ppm and 2.17 ppm for THC. Highlights associated with annual values of the various air quality parameters monitored at Red Deer - Riverside air monitoring station between 2011 and 2013 are presented in Table 2 (24-h $PM_{2.5}$), Fig. 2 (Annual $PM_{2.5}$, O_3 and NO_2) and Fig. 3 (SO_2 and THC).

In comparison, the annual average NO_2 concentrations over the three years followed a similar pattern as the reported 24-h $PM_{2.5}$ CAAQS values, with the lowest annual average NO_2 concentration associated with 2012 and only slight differences in concentrations in 2011 and 2013. The adjusted annual $PM_{2.5}$ concentration was also lowest in 2012. Furthermore, when compared to the annual average concentrations from other air monitoring stations across Alberta over the same 3-year time period, the NO_2 concentrations monitored at Red Deer - Riverside could be classified as being relatively high, but were not the highest in the province.

The same cannot be said for the annual average SO_2 concentrations that seemed to be in the low to mid-range at Red Deer - Riverside air monitoring station in comparison to other stations around the province. Similarly, the annual average concentrations of THC were close to the provincial average of 2.13 ppm for all monitoring stations over the three year period. There was no obvious relationship between THC annual average concentrations and the adjusted 8-h O_3 concentrations between 2011 and 2013.

In 2012, a single event in February exceeded the 24-h $PM_{2.5}$ CAAQS, with the cause reported as wintertime smog (AEMERA 2016a). The prevailing wind direction on that day was southerly with an average daily wind speed of 9 km/h. Presumably, and as indicated in Table 1, the 24-h $PM_{2.5}$ concentrations in 2012 had limited influence in triggering the red management level in the air zone with respect to CAAQS over the 3 year, 2011 to 2013 assessment period. Conversely, the annual $PM_{2.5}$ concentration in 2012 was more prominent in determining the red management level in the air zone with respect to CAAQS for the annual $PM_{2.5}$ concentrations.

In 2013, there were 9 events during which the 24-h $PM_{2.5}$ values exceeded the CAAQS (AEMERA 2016a). Of these, 6 events occurred in March of that year, with 5 of the events attributed to wintertime smog. Average daily wind speed associated with the 5 events were not reported by AEMERA (2016b). The other 3 events occurred in February, two of which were also attributed to wintertime smog with an average daily wind speed of 5 km/h on each day. No indication was provided for what might have triggered the other events in February (1) and March (1). Wind rose were only provided for the two wintertime smog events that occurred in February, indicating that the prevailing wind direction was from the S. No information was provided on the wind patterns that prevailed during the 5 wintertime smog events in March.

Table 2. Annual Highlights of the Air Monitoring Information for Red Deer - Riverside for 2011, 2012 and 2013

Parameter	2011	2012	2013
24-h $PM_{2.5}$	• Slightly lower than 2013 value by 0.3 µg/m^3 • CAAQS values exceeded in 15 events • 11 of the 15 events occurred in March • 8 of the 11 events identified as wintertime smog • Southerly wind in 4 of the 8 wintertime smog events	• Lowest value of the 3 years • CAAQS values exceeded in 1 event • Single event occurred in February • Single event identified as wintertime smog • Southerly wind	• Highest value of the 3 years • CAAQS values exceeded in 9 events • 6 of the 9 events occurred in March; 3 in February • 5 of the 6 March events and 2 of the 3 February events identified as wintertime smog • Southerly wind for 2 possible wintertime smog events in February

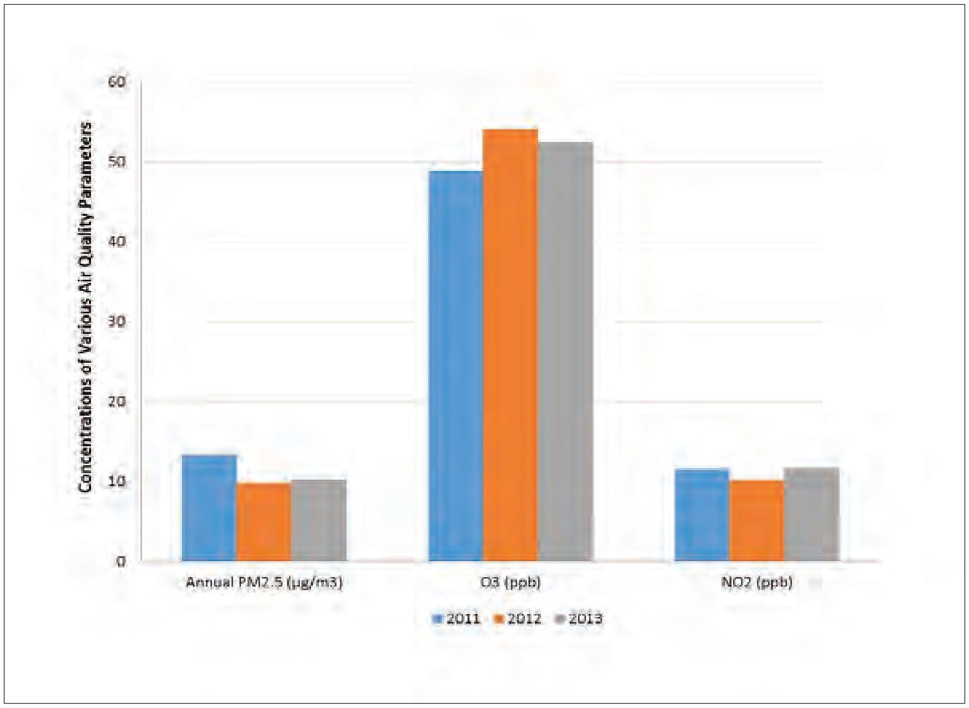


Fig. 2. Annual concentrations of $PM_{2.5}$, O_3 and NO_2 for comparison in 2011, 2012 and 2013.

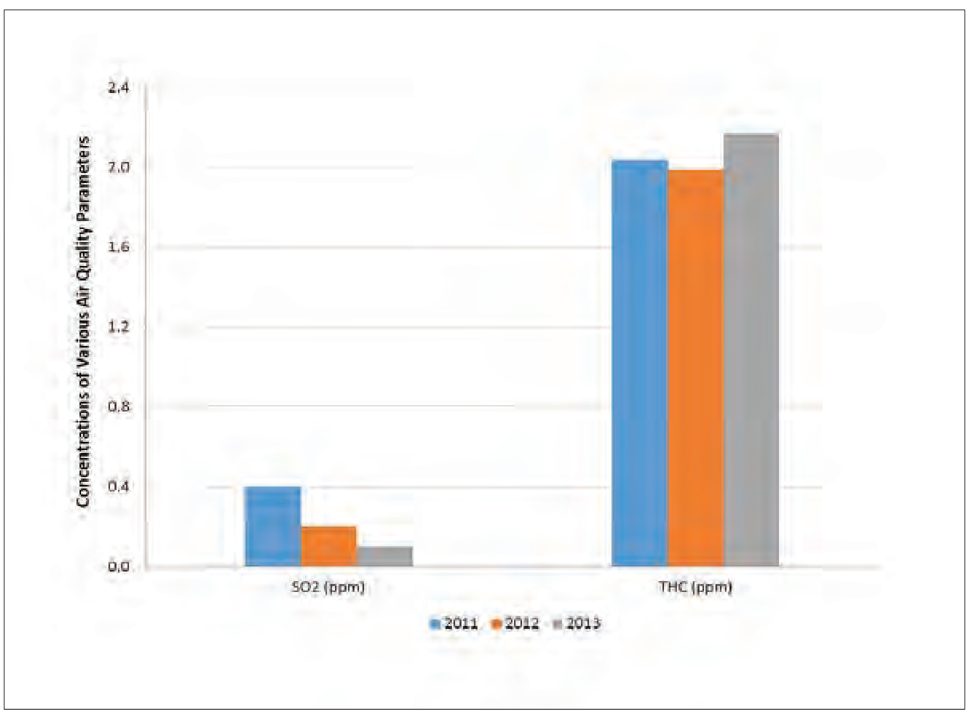


Fig. 3. Annual concentrations of SO_2 and THC for comparison in 2011, 2012 and 2013.

- **Time Series Analysis**

Figure 4 shows a time series analysis of the adjusted (TF/EE influences removed), annual averages of the 98th percentile metric values for the 24-h $PM_{2.5}$ from 2001 to 2014 (AEMERA 2016e). It indicates an increased concentration of $PM_{2.5}$ occurred as of 2009 followed by fluctuating levels in subsequent years, although they remained higher than the levels in 2008 and the years prior. It would appear the increased levels as of 2009 were associated with an upgrade to more accurate monitoring technology for particulate matter in May of that year (AEP 2016a). This suggests that higher concentrations, possibly approaching or exceeding the CAAQS for 24-h $PM_{2.5}$ may also have occurred in the years prior to the 2009 upgrade, but were under reported due to the less accurate monitoring technology.

The adjusted annual 4th Highest Daily Maximum 8-h O_3 levels between 2001 and 2014 are presented in Fig. 5 (AEMERA 2016e). Unlike the annual 24-h $PM_{2.5}$ 98th percentile levels, O_3 levels appear to be less variable, with a decrease in concentrations from 2011 to 2012 and another less prominent decrease from 2013 to 2014. Levels in 2014 appear to approach the historical 14 year low recorded in 2005.

- **Inferences**

1) AEP (2016a) conducted a scientific assessment with respect to the $PM_{2.5}$ events that triggered the CAAQS red management level associated with the Red Deer - Riverside air monitoring station, and prior events associated with CWS.

2) The highest number of $PM_{2.5}$ events recorded at the station tended to occur during the cooler time of the year, between October and March, and appeared to be influenced largely by meteorological factors.

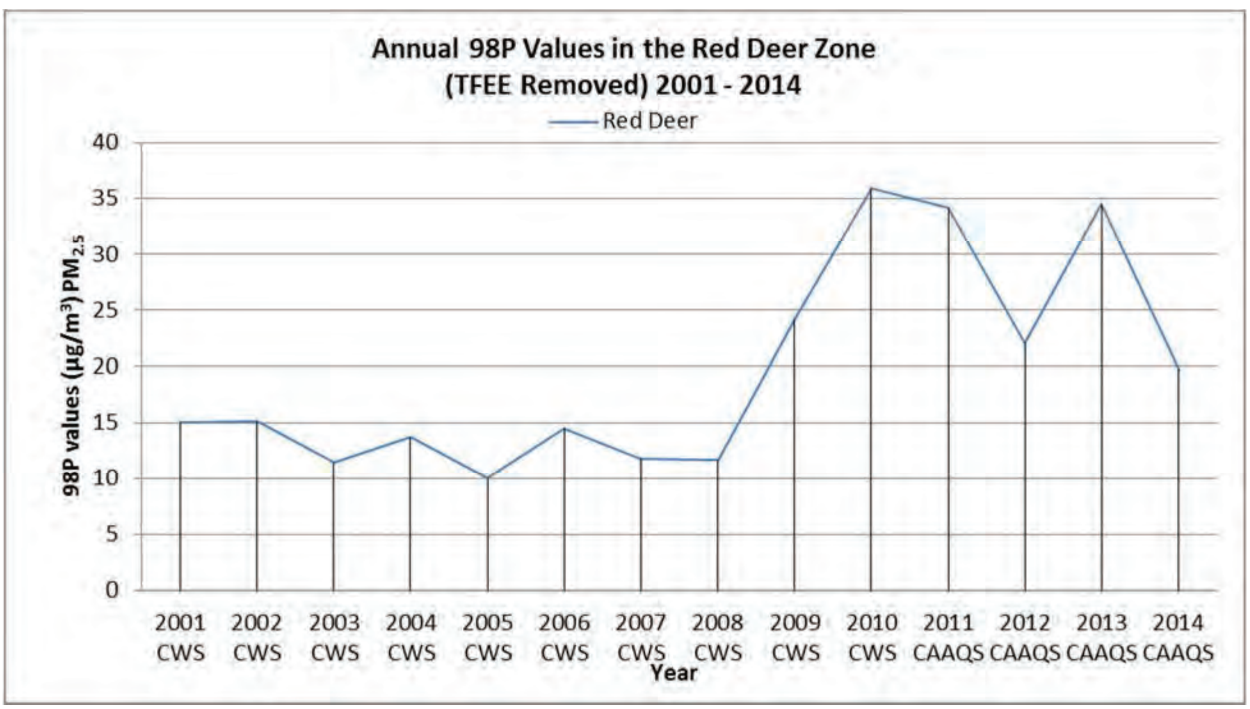


Fig. 4. Annual 98th Percentile of the 24-h $PM_{2.5}$ Levels Recorded at Red Deer-Riverside Air Monitoring Station. CWS - Canada Wide Standards were in effect prior to CAAQS. Courtesy AEMERA (2016e).

5

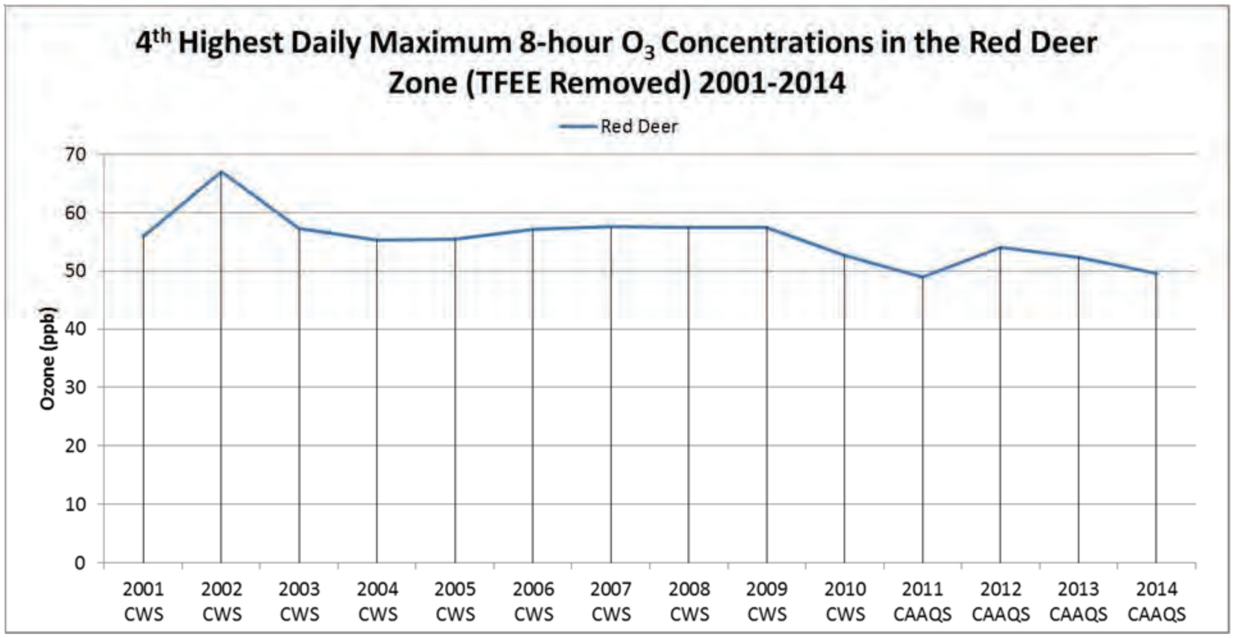


Fig. 5. Annual 4th Highest Daily Maximum 8-h O_3 Levels Recorded at Red Deer-Riverside Air Monitoring Station.

3) The meteorological factors included low wind speeds, the likelihood of temperature inversions associated with low wind speeds, and a predominantly southerly wind direction (over 100 event days) compared to the next most prominent south-southeast (SSE) wind direction associated with a little more than 20 event days (AEP 2016a). According to AEP (2016a), "event days" were assigned when the averaged 24-h $PM_{2.5}$ concentration was greater than 19 µg/m^3.

4) Topographically, the location of the air monitoring station in the Red Deer River valley, and the potential for winds to be channeled along the N-S portion (relatively speaking) of the valley towards the station, may have contributed to the high incidence of southerly winds recorded at the station during the 100 plus event days (AEP 2016a).

5) As shown in Fig. 1 above, the area immediately southeast (SE) to southwest (SW) of the air monitoring station is populated by residences, educational and recreational facilities, shopping centres, a secondary highway (David Thompson Hwy 11) and other roadways, including a roadway that runs right past the air monitoring station on its E side.

6) However, according to (AEP 2016a), no single, major contributor of primary $PM_{2.5}$ could be identified upwind of the Red Deer - Riverside station with respect to the significant number of the $PM_{2.5}$ event days associated with southerly winds.

7) Conversely, there was a strong suspicion that a prevalence of $PM_{2.5}$ event days were likely as a result of secondary $PM_{2.5}$ rather than primary $PM_{2.5}$, citing the presence of a predominance of sources capable of contributing to precursors (NO_2) of secondary $PM_{2.5}$ in the vicinity of the Red Deer - Riverside air monitoring station.

8) A similar assessment of the O_3 events recorded at the Red Deer - Riverside air monitoring station was not available.

Red Deer-Lancaster Air Monitoring Station

The Red Deer-Lancaster station, also located within the City of Red Deer and owned by Parkland Airshed Management Zone (AEMERA 2016c), is a continuous monitoring site for O_3, $PM_{2.5}$, SO_2, NOx, and the following meteorological parameters: TEMP; RH; STDWDIR; WDR; and WSP. The Lancaster station started reporting some parameters as of November 29, 2012, and as such there was insufficient data to determine the management levels with respect to the CAAQS for $PM_{2.5}$ and O_3 for the 2011 to 2013 time period (AEMERA 2016f). The Lancaster air monitoring station was used temporarily (for a few months at a time) in 2012 and 2013 and became a permanent station in late 2014.

Esther Air Monitoring Station

A third station in the air zone located in Esther (AEMERA 2016g) approximately 300 km east-southeast (ESE) of the City of Red Deer, and owned by Environment Canada (now Environment and Climate Change Canada), has been suspended and stopped reporting data as of January 1, 2007. Ozone was one of the parameters monitored at the Esther station.

Caroline Air Monitoring Station

Although the air monitoring station near Caroline is located in the North Saskatchewan Air Zone, (ESRD 2014a) and not within Red Deer Air Zone, it is the closest, rural-based station to the City of Red Deer (approximately 73 km southwest (SW) of the Red Deer - Riverside station) capable of providing a background (baseline) reference for the state of the air in a rural environment (AEP 2016a). Between January 2011 and December 2013 the associated air quality and meteorological parameters monitored at this station included: O_3, $PM_{2.5}$, NOx, SO_2, RH, TEMP, STDWDIR, WDR, and WSP, among several other parameters (AEMERA 2016c).

According to AEP (2016a), $PM_{2.5}$ concentrations measured at the Caroline air monitoring station were typically low over winter in comparison to the high concentrations recorded at Red Deer - Riverside station in the same timeframe. No report was found regarding the O_3 concentrations monitored at the Caroline station over the inaugural CAAQS assessment period (2011 to 2013).

Non-Point Emission Sources and Emission Inventories for Red Deer Air Zone

The estimated annual emissions of NH_3, NOx, $PM_{2.5}$, SO_2 and VOCs from the different NPS in Red Deer Air Zone are presented in Table 3 below. Estimates for Census Division 8 and the City of Red Deer are also presented in Tables 4 and 5, respectively.

- **Emission Inventories for $PM_{2.5}$**

According to AEP (2016c), non-point sources in Red Deer Air Zone are estimated to contribute to over 91% (37 kilotonnes) of the emissions of primary $PM_{2.5}$ in the air zone, annually. Among these sources, road dust is estimated to emit 23 kilotonnes annually, followed by construction at 10 kilotonnes and agriculture at 4 kilotonnes.

Non-point sources located within Statistics Canada's Census Division 8 (comprised of Lacombe County, Ponoka County and Red Deer County in Red Deer Air Zone) were reported to be responsible for 97% of the emissions of primary $PM_{2.5}$ in the census division annually, i.e., approximately 23,000 tonnes (23 kilotonnes) per year (AEP 2016a). The emissions were reported to be largely from unpaved road dust, with smaller contributions from construction operations and agriculture. AEP (2016c) attributed 56% (13 kilotonnes) of the $PM_{2.5}$ emissions from the Census Division 8 to road dust, 32% (≈ 7 kilotonnes) to construction operations and 7% (≈ 2 kilotonnes) to agriculture.

Within the City of Red Deer, motor vehicle traffic and the operation of the city's civic yards, both in close proximity to Red Deer - Riverside Air Monitoring station may have influenced some of the high concentration $PM_{2.5}$ events observed at the station (AEP 2016a). Among non-point sources, AEP (2016c) estimated $PM_{2.5}$ emissions from road dust to be approximately 0.11 kilotonnes, construction operations approximately 4 kilotonnes and about 0.12 kilotonnes from transportation sources.

Estimates of agricultural livestock confined feeding operation (CFO) contributions to $PM_{2.5}$ from the 3 counties totaled 30 tonnes in 2011, while the estimated total contribution in Red Deer Air Zone totaled 61 tonnes (ARD 2013). An estimate of the contribution of the primary source or sources of $PM_{2.5}$ emissions within the agricultural sector in the air zone was not available.

- **Emission Inventories for Precursors of $PM_{2.5}$**

Preliminary modelling and monitoring in Red Deer Air Zone indicated that $PM_{2.5}$ in the air zone constitutes primarily of secondary particulate (AEP 2016b). Precursors of inorganic, secondary $PM_{2.5}$ include, NH_3, NOx (in particular nitrogen dioxide - NO_2), SO_2 and VOCs (AEP 2016a). Among all non-point sources, agricultural sources were reported to contribute 97% (26 kilotonnes) of the NH_3 emissions in Red Deer Air Zone annually, with agricultural sources in Census Division 8 estimated to emit about 12 kilotonnes annually, representing about 46% of total agricultural emissions in the air zone annually (AEP 2016c). Agricultural sources within the City of Red Deer were reported to emit 52 tonnes of NH_3 annually, representing 30% of the NH_3 emissions from within the city, while transportation sources were estimated to be responsible for 40% (68 tonnes) of the NH_3 emissions (AEP 2016c), representing the highest amount of emissions among all point and non-point sources in the city.

ARD (2013) estimated CFO emissions of NH_3 in the air zone in 2011 to be approximately 7 kilotonnes, representing about 27% of the annual estimate of agricultural NH_3 emissions in the air zone estimated by AEP (2016c). Estimates of the contributions of other agricultural sources of NH_3 emissions within the agricultural sector in the air zone were not available.

The primary non-point source contributor of NOx emissions in the air zone was reported to be transportation, emitting 27 kilotonnes annually, with approximately 10 kilotonnes (37%) from Census Division 8 contributed by transportation sources (AEP 2016c). Within the City of Red Deer, transportation sources were estimated to emit the highest amount of NOx (≈ 3 kilotonnes) compared to all other point and non-point sources of emission. Similarly, AEP (2016a) reported transportation sources to contribute the highest amount of NO_2 emissions from Census Division 8 and the City of Red Deer, among all other non-point sources of emission. The emissions from transportation sources were also reported to be approximately equal (≈50%) from off-road and on-road sources.

With respect to non-point sources of emission of SO_2 in Red Deer Air Zone and Census Division 8, contributions by non-point sources compared to point sources seemed negligible, and no specific non-point sources of emissions were mentioned. However, within the City of Red Deer, 37 tonnes of SO_2 emissions were attributed to commercial fuel combustion and 19 tonnes to transportation sources (AEP 2016c). Similarly, AEP (2016a) stated that the primary non-point sources of SO_2 in the City of Red Deer and Red Deer County were residential and commercial heating sources, and off-road transportation sources, with the predominance of SO_2 emissions in Census Division 8 coming from point sources located in close proximity to population centres.

- **Emission Inventories for Precursors of O_3**

There are no emission inventories for O_3. However, since it is formed via a series of chemical reactions involving NOx and VOCs in the atmosphere (AEP 2014b), emission inventories have been developed for the latter two parameters. Agriculture was estimated to emit the highest amount of VOCs annually (27 kilotonnes) among all non-point sources in Red Deer Air Zone, followed by transportation sources at 6 kilotonnes annually (AEP 2016c). It is uncertain what specific agricultural sources are responsible for the VOC emissions in Red Deer Air Zone. However, agricultural sources within Census Division 8 were estimated to emit about 13 kilotonnes annually and transportation sources in the census division, approximately 4 kilotonnes annually. Finally, AEP (2016c) estimated the annual emissions of VOCs from non-point sources within the City of Red Deer to be approximately 2 kilotonnes from transportation, 0.6 kilotonnes from general solvent use, 0.3 kilotonnes from retail of refined petroleum products and 0.2 kilotonnes from surface coatings.

Table 3. Estimated Annual Emissions from Non-Point Sources* in Red Deer Air Zone

Source	NH_3 (kilotonnes)	NOx (kilotonnes)	$PM_{2.5}$ (kilotonnes)	SO_2 (kilotonnes)	VOCs (kilotonnes)
Agriculture	26		4		27
Construction Operations			10		
Road Dust			23		
Transportation		27			6
Sub-Total	**26**	**27**	**37**	**negligible**	**33**

** excluding Industrial Non-Point Sources*

Table 4. Estimated Annual Emissions from Non-Point Sources* in Census Division 8

Source	NH_3 (kilotonnes)	NOx (kilotonnes)	$PM_{2.5}$ (kilotonnes)	SO_2 (kilotonnes)	VOCs (kilotonnes)
Agriculture	12		2		13
Construction Operations			7		
Road Dust			13		
Transportation		10			4
Sub-Total	**12**	**10**	**22**	**negligible**	**17**

** excluding Industrial Non-Point Sources*

Table 5. Estimated Annual Emissions from Non-Point Sources in the City of Red Deer

Source	NH_3 (kilotonnes)	NOx (kilotonnes)	$PM_{2.5}$ (kilotonnes)	SO_2 (kilotonnes)	VOCs (kilotonnes)
Agriculture	0.05				
Construction Operations			4		
Commercial Fuel Combustion				0.04	
General Solvent Use					0.6
Refined Petroleum Products					0.3
Road Dust			0.11		
Surface Coatings					0.2
Transportation	0.07	3	0.14	0.02	2
Sub-Total	**0.12**	**3**	**4.25**	**0.06**	**3.1**

Dispersion Modeling for Red Deer Air Zone

AEP (2016a) cited a 2012 report on the use of a dispersion model (CALPUFF) to estimate the effects of localized non-point sources (roadway traffic and the City of Red Deer civic yards) on $PM_{2.5}$ readings measured at Red Deer - Riverside Air Monitoring station in 2009. According to AEP (2016a), the results suggest that in addition to increased emissions from traffic along Riverside Drive, 77 Street and emissions from the City of Red Deer civic yard, there were emissions from other sources that contributed to high $PM_{2.5}$ events at the Red Deer - Riverside Air Station location. There were no specifics provided relative to the composition of the estimated $PM_{2.5}$ emissions (e.g., proportion of primary versus secondary fine particulate, speciation of the secondary fine particulate, etc.), nor the nature or orientation of the other sources relative to the spatial coordinates of the air station. Rather, the modelling was very simplistic. Only a couple of sources (two road segments, a few area sources and point sources) were actually modeled and all inferences about other sources were derived from comparisons to the monitored $PM_{2.5}$ concentrations.

Receptor Modeling for Red Deer Air Zone

Apparently, there are no reports on receptor modeling, and the associated speciation profiling for secondary $PM_{2.5}$ and O_3, for Red Deer Air Zone for the 2011 to 2013 timeframe.

Conclusions

- Elevated 24-h $PM_{2.5}$ concentrations at Red Deer - Riverside air monitoring station, after removing the influence of TF/EE, are observed to occur more frequently in the cold season (October to March) and to be associated predominantly with wintertime smog.
- The source(s) of the wintertime smog was not evident, but the wintertime smog was associated mostly with southerly wind directions.
- The apparent correlation between annual average NO_2 levels and the annual 98th percentile of the 24-h $PM_{2.5}$ levels over the 3-year period, suggests that sources of NO_2 emissions may have contributed to secondary particulate formation. However as these are not congruent metrics, further, in-depth investigation is warranted to identify specific sources of NO_2 emissions or occurrences of high NO_2 concentrations that may be contributing to elevated 24-h $PM_{2.5}$ levels at the Red Deer - Riverside station.
- A similar, apparent relationship between annual average SO_2 levels and the annual 98th percentile of the 24-h $PM_{2.5}$ levels was not observed. Therefore, unlike NO_2, there does not appear to be the same degree of importance to investigate the potential contribution of SO_2 to elevated 24-h $PM_{2.5}$ levels at this time.
- Although NH_3 was not monitored at Red Deer - Riverside air station (nor at the Caroline station), the potential contribution of NH_3 from agricultural or other NPS sources to elevated 24-h $PM_{2.5}$ levels during the cold season is uncertain and warrants further exploration and explanation.
- A potential relationship between the annual 4th highest daily maximum 8-h O_3 concentration and annual average THC could not be established. Information on CH_4 or NMHC concentrations monitored at Red Deer - Riverside air station were not available, i.e., to help highlight the possibility of one or more sources of VOC emissions contributing to O_3 formation.
- Although Red Deer air zone was assigned a yellow management level for O_3 with respect to CAAQS, the potential relationship between NO_x (as a precursor of O_3) and O_3 formation, as well as potential NPS of NO_x, is worthwhile investigating in conjunction with investigations into its ties with secondary $PM_{2.5}$ formation as stated earlier.

References

AEMERA. 2016a. CASA PM_O3 CAAQS 2011 to 2015.docx. Unpublished material provided to CASA NPS project technical task group upon request. Edmonton, AB: Alberta Environmental Monitoring, Evaluation and Reporting Agency.

AEMERA. 2016b. CASA NPS Data Request_May17 AEMERA.docx. Unpublished material provided to CASA NPS project technical task group upon request. Edmonton, AB: Alberta Environmental Monitoring, Evaluation and Reporting Agency.

AEMERA. 2016c. Station Information Report: Red Deer - Riverside (1142). Edmonton, AB: Alberta Environmental Monitoring, Evaluation and Reporting Agency. http://airdata.alberta.ca/aepContent/Reports/StationInformationMain.aspx (Accessed: 2016/07/07).

AEMERA. 2016d. AnnualAvg_2001_2015_(Data and Stn Loc).xlsx. Unpublished material provided to CASA NPS project technical task group upon request. Edmonton, AB: Alberta Environmental Monitoring, Evaluation and Reporting Agency.

AEMERA. 2016e. CAAQS Trends from 2001 to 2014 (PM_O3).docx. Unpublished material provided to CASA NPS project technical task group upon request. Edmonton, AB: Alberta Environmental Monitoring, Evaluation and Reporting Agency.

AEMERA. 2016f. Summary Information Report for One Station and Multiple Parameter(s): Lancaster data summary from 01-Jan-2011 to 31-Dec-2013 for all parameters. Edmonton, AB: Alberta Environmental Monitoring, Evaluation and Reporting Agency. http://airdata.alberta.ca/aepContent/Reports/DataSummaryMultiParams.aspx?stnid=1476&sdt=01-Jan-2011&edt=31-Dec-2013 (Accessed: 2016/07/07).

AEMERA. 2016g. Station Information Report: Esther (1041). Edmonton, AB: Alberta Environmental Monitoring, Evaluation and Reporting Agency. http://airdata.alberta.ca/aepContent/Reports/StationInformationMain.aspx (Accessed: 2016/07/07).

AEP. 2015. Alberta: Air Zones Report 2011-2013. Edmonton, AB: Ministry of Environment and Parks, Alberta Government.

AEP. 2016a. Red Deer Fine Particulate Matter Response: Science report. Edmonton, AB: Ministry of Environment and Parks, Alberta Government.

AEP. 2016b. Red Deer Air Zone Fine Particulate Matter Response: Government of Alberta action plan. Edmonton, AB: Ministry of Environment and Parks, Alberta Government.

AEP. 2016c. Alberta Non-Point Source Summary (April 2016).docx. Unpublished material provided to CASA NPS project technical task group upon request. Edmonton, AB Ministry of Environment and Parks, Alberta Government.

ARD. 2013. Managing Air Emissions from Confined Feeding Operations in Alberta: Ammonia and particulate matter emissions inventory for Confined Feeding Operations in Alberta. 2nd Edition. Edmonton, AB: Ministry of Agriculture and Rural Development (now Agriculture and Forestry), Alberta Government.

ESRD. 2014a. Profile of the North Saskatchewan Region. Edmonton, AB: Ministry of Environment and Sustainable Resource Development (now Environment and Parks), Alberta Government.

ESRD. 2014b. Air: Particulate matter and ozone management factsheet (2010 - 2012). Edmonton, AB: Ministry of Environment and Sustainable Resource Development (now Environment and Parks), Alberta Government.

2016

Air Zone Region Reports

Peace Air Zone

Summary of Information, Studies, Papers, and Reports of Possible Relevance to the Work of the CASA Non-Point Source (NPS) Technical Task Group Related to: Air Monitoring, Ambient Air Quality Trending, Air Dispersion Modelling, Source Characterization, and Air Emission Inventories for the Peace Air Zone

Victoria Pianarosa
Parkland Fuels Corporation
8/12/2016

Contents

List of Figures

List of Tables

1 Context

1.1 Purpose

This document has been prepared to summarize information pertaining to the Peace Air Zone and the possible significance of non-point sources (NPS) on fine particulate matter ($PM_{2.5}$) and ground-level ozone (O_3) as measured against the Canada Wide Standards (CWS) and Canadian Ambient Air Quality Standards (CAAQS).

The focus is on:

1 past and current Peace air quality assessments against the CWS and CAAQS;
2 trends in Peace air quality based on ambient monitoring data;
3 air emissions inventory data and emission trends for the Peace; and
4 air modelling and source apportionment studies for the Peace Air Zone.

This information can be used to assess and understand which, and how, non-point sources may be contributing to ambient concentrations of fine particulate matter ($PM_{2.5}$) and ozone (O_3) in the Peace Air Zone relative to the CAAQS and where there are gaps in information and understanding. Table 1 summarizes the CAAQS for $PM_{2.5}$ and O_3.

Table 1: The CAAQS and Associated Management Levels

Management Level	Ozone (ppb)	$PM_{2.5}$ 24 hour ($\mu g\ m^{-3}$)	$PM_{2.5}$ Annual ($\mu g\ m^{-3}$)
Effective	**2015**	**2015**	**2015**
Red	**Actions for Achieving CAAQS**		
Threshold	63	28	10.0
Orange	**Actions for Preventing CAAQS Exceedances**		
Threshold	56	19	6.4
Yellow	Actions for Preventing Air Quality Deterioration		
Threshold	50	10	4.0
Green	**Actions for Keeping Clean Areas Clean**		

1.2 Ambient Monitoring in the Peace Air Zone

The *Alberta: Air Zones Report 2011-2013* summarizes the CAAQS achievement status and management levels for Alberta's air zones for $PM_{2.5}$ and O_3 monitoring results. Four (4) stations in the Peace air zone were used in the 2011 to 2013 assessment. These stations are located within communities or in areas accessed by members of the public. Ambient air quality monitoring is conducted by PAZA (Peace Airshed Zone Association), a non-profit, multi-stakeholder organization. Figure 1 provides a map of the ambient monitoring stations in the Peace Air Zone used in the 2011-2013 CAAQS assessment.

Peace Air Zone was assigned to yellow management level for $PM_{2.5}$ (24-hour and annual), which is below the applicable CAAQS. Management actions for yellow are Actions for Preventing Air Quality Deterioration.

Peace Air Zone was assigned to green, Actions for Keeping Clean Areas Clean for O_3, below the applicable CAAQS.

The concentrations by station are provided in Table 1.

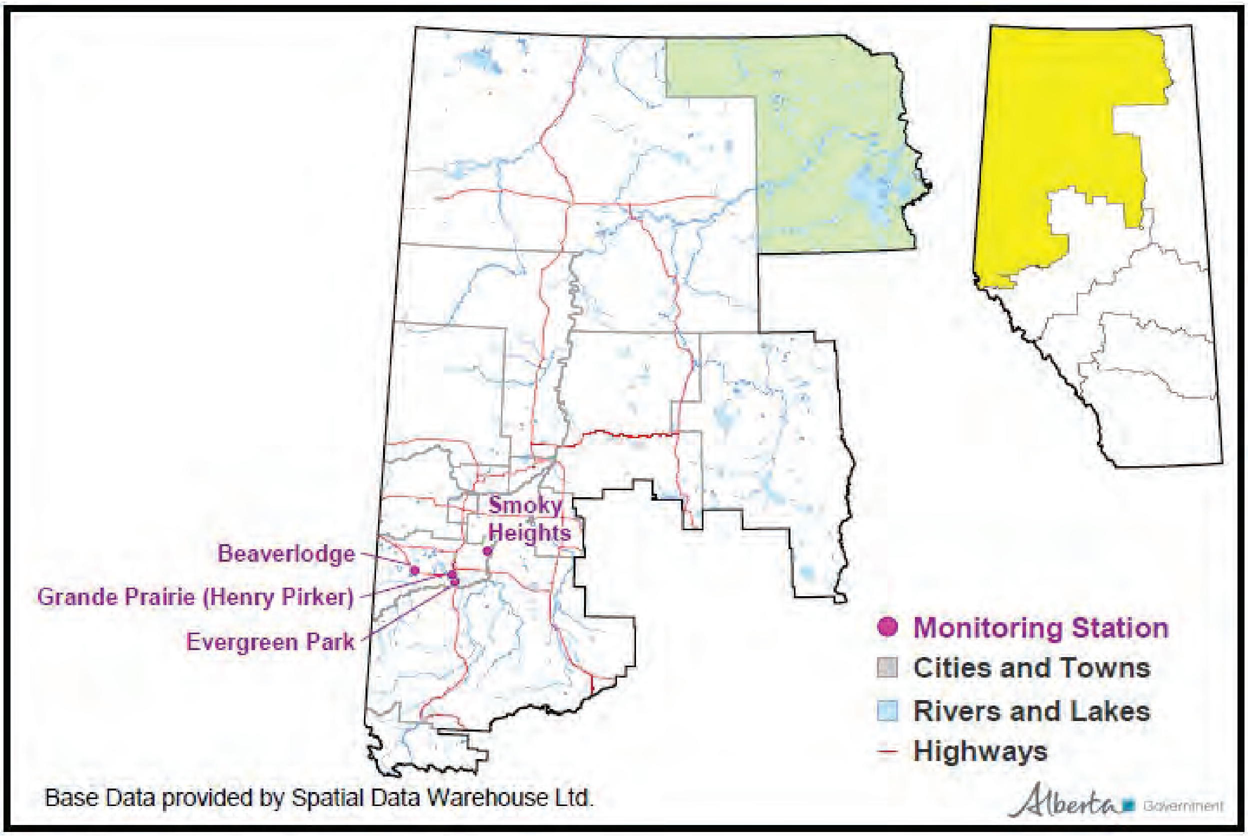


Figure 1: Ambient Monitoring Stations in the Peace Air Zone used to Assess Air Zone Status relative to the CAAQS

Table 2. CAAQS Concentration Determination and Assigned Level for Noted Stations in the Peace Air Zone

Station	Annual 98th percentile 24-hour average PM2.5 concentrations after TF/EE removal (ug/m3)				Annual average PM2.5 after TF/EE removal (ug/m3)				Annual 4th highest Maximum 8-hour ozone concentrations after TF/EE removal (ppb)			
	2011	2012	2013	2011-13	2011	2012	2013	2011-13	2011	2012	2013	2011-13
Beaverlodge	15.8	17.6	n/a	insufficient data	5.8	7.0		insufficient data	50	50.4	49.8	50.0
EVGN Park	15.2	13.5	9.4	13.0	4.8	3.8	3.8	4.1				
Gr Prairie HP	19.5	13.8	17.3	17.0	7.5	5.3	5.9	6.2	49.9	50.0	49.8	50.0
Smoky Hts	16.2	14.1	11.2	14.0	4.0	3.6	4.1	3.9				
AVERAGE FOR ZONE				14.7				4.8				50.0

TF/EE - transboundary flows or exceptional events

n/a - the year is not available as it did not meet the completeness criteria

blank data indicates station not equipped to collect data or data was not available

2 Alberta Non-Point Source Emissions

Government of Alberta 2016b lists the following industrial and non-industrial sources as the major NPS types in Alberta.

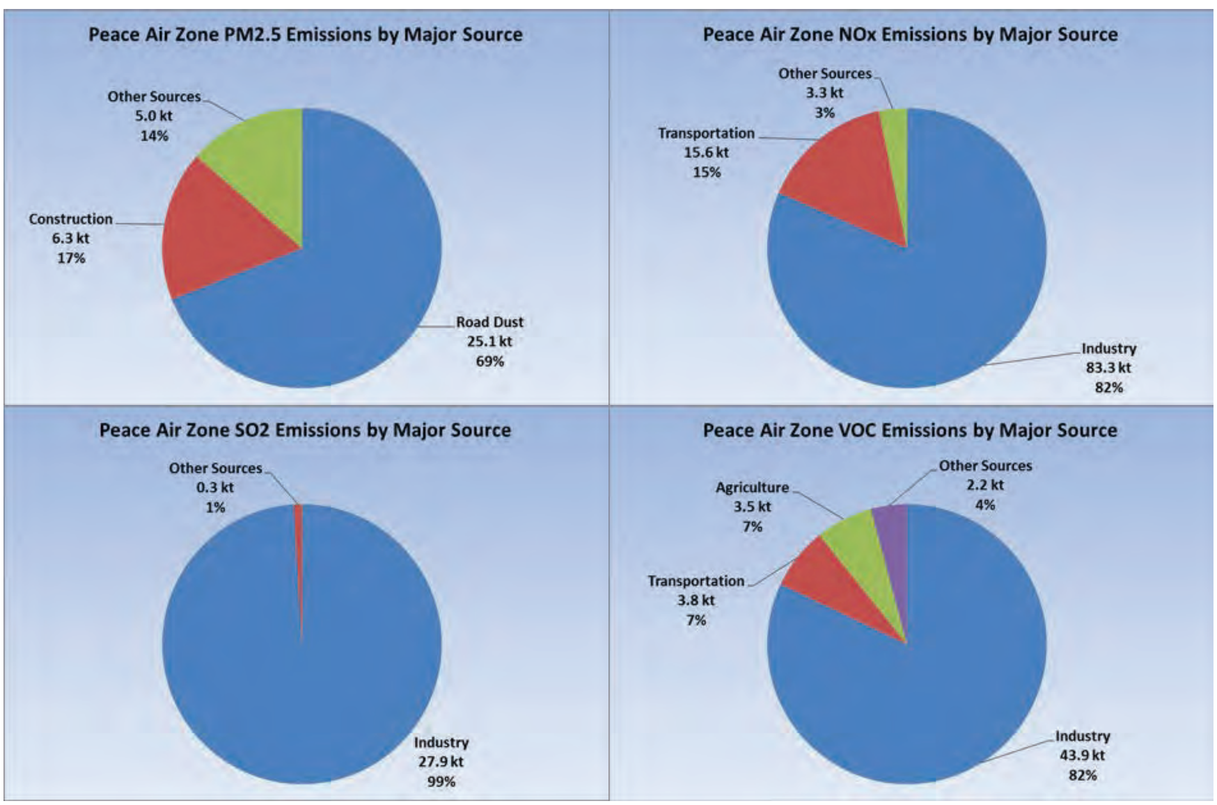
Industrial Non-point Sources

- Plant fugitive leaks;
- Liquid tailings ponds;
- Mine fleets;
- Mine faces;
- Solid mine tailings;
- Materials storage and handling;
- Non-stationary equipment;
- Space heating; and
- Storage tanks.

Non-industrial, Non-point Sources

- Road dust (unpaved and paved roads);
- Construction (industrial, transportation, municipal, residential, and communications);
- Agriculture (agricultural animals, fertilizer application, harvesting, tilling, and wind erosion); and
- Transportation (on-road vehicles, off-road vehicles, and rail transportation).

The Alberta: Air Zones Report 2011-2013 (Alberta Government, 2015), in addition to assessing the status of air zones relative to the CAAQS, also provided emission inventory data by air zone for primary PM2.5, SO2, NOx, VOCs and NH3. The data points are from the 2008 Alberta Air Emissions Inventory.



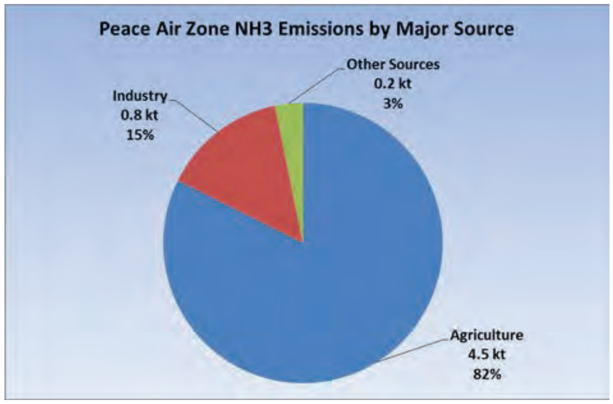


Figure 2. Major sources of $PM_{2.5}$ and Precursor Emissions in the Peace Air Zone

2.1 Peace Air Zone Non-Point Source Emissions

Emission inventory data by sector and region for primary PM, NOx, SO_2 and NH_3 is based on the 2008 Alberta Air Emissions Inventory found in the Alberta: Air Zones Report 2011-2013. Tables 3 and 4 summarize the emission inventory for the Peace Air Zone from this report.

Table 3. Major Sources of Air Contaminant Emissions in the Peace Air Zone

Emission Source	Primary $PM_{2.5}$	SO_2	NO_x	VOCs	NH_3
Agriculture	3				1
Cement and Concrete					
Chemical					
Construction	2				
Conventional Oil and Gas		1	1	2	2
Electrical Power Generation					
Fertilizer					
Oil Sands		3			
Pulp and Paper		2			3
Road Dust	1				
Transportation			2	3	
Wood Products					
Other Sources					
Non-industrial Sources					
Natural Sources			3	1	

Table 4. Total Criteria Air Contaminants Emitted Annually (in tonnes) from Major NPS in the Peace Air Zone

Emission Source	Primary $PM^{2.5}$	SO_2	NO_x	VOCs	NH_3
Natural Sources	469	0	10,697	1,506,529	12
Road Dust	25,159	0	0	0	0
Transportation	782	196	15,650	3,841	150

Conventional Oil and Gas	1,122	18,146	76,607	39550[1]	518
Agriculture	1,275	0	0	3,536	4,525
Construction	6,326	0	14	0	0
Oil Sands[2]	15	3,439	172	991	0
Pulp and Paper[3]	183	4,418	1,981	401	165

Units are tonnes.
[1] 41% of VOC emissions from industrial sources are fugitives, assumed non-point sources (Alberta Air Emissions Trends and projections June 2008).
[2] The majority of oil sands operations in Peace Air Zone employ insitu processes; therefore, the emissions would primarily be point source.
[3] The majority of pulp and paper emissions would be point source (Alberta Air Emissions Trends and projections June 2008).

3 Conclusions and Recommendations

Based on the available information, the larger anthropogenic NPS potentially affecting ambient air quality in the Peace Air Zone should be considered for further study. These are:

- Road dust;
- Transportation;
- Conventional Oil and Gas;
- Agriculture;
- Construction; and
- Oil Sands.

4 Assumptions

To identify the larger NPS potentially affecting ambient air in the Peace Air Zone, certain assumptions were made, as follows.

- The 2008 Peace Air Zone emissions inventory includes all sources.
- Emission rate estimation methods used for the 2008 inventory are still valid.
- More recent emission inventory data is not available for Peace Air Zone, or is not compiled in a readily available format.

Proportions of criteria air contaminants emitted annually from the different NPS have remained constant since the 2008 inventory and will remain constant in the future.

5 References

Alberta Air Emissions Trends and projections June 2008

Alberta: Air Zones Report 2011-2013 (Alberta Government, 2015

Government of Alberta 2016b (unpublished)

APPENDIX 3

CASA NON-POINT SOURCE PROJECT CHARTER

Non-Point Source Draft Project Charter

Contents

Introduction

Non-point source (NPS) air emissions are a key element in the Government of Alberta's (GoA) *Clearing the Air: Alberta's Renewed Clean Air Strategy (CAS)*, and a significant issue to CASA stakeholders. NPS emissions must be addressed if we are to maintain and improve air quality in Alberta. A project to address NPS emissions aligns with the CASA goals of providing strategic advice, and of contributing to the development and implementation of effective air quality management in Alberta. It would also contribute to management of air quality in the Capital region, Red Deer, and Calgary, by informing potential actions that could be taken as a part of regional management response plans under Alberta's Land Use Framework, or identifying cross-cutting actions benefitting all areas. On a provincial scale, an NPS project complements CAS.

A complex issue, NPS emissions involves a broad range of stakeholders with a wide variety of perspectives and degrees of understanding; many interests will need to be considered. For individual agencies this would pose a challenge, due to the potentially sensitive nature of possible related management recommendations. However, CASA has a unique ability to build relationships and provide a neutral forum in which this type of multi-stakeholder and multi-interest work can be done.

Background

The issue of NPS emissions initially came to CASA through its work on Vehicle Emissions Project Teams (VET), which were active from 1998 to 2007. They had a mandate to implement initiatives to protect human health and the environment from vehicle emissions produced in Alberta. In 2010, the CASA Board of Directors accepted the VET Final Report.

After the disbandment of VET, the CASA Secretariat asked stakeholders to identify priority air quality issues. Transportation continued to be an important issue, however the Secretariat noted that conversations regarding vehicle emissions frequently led to discussions of NPS emissions. Vehicle emissions were seen by stakeholders as only one piece of the greater NPS issue. With clear direction from the Board in 2012, the development of a Statement of Opportunity was focused on NPS emissions. Also in 2012, the GoA released the CAS and the associated Action Plan, which outline four strategic directions and key categories of actions for implementation. Many of the actions identified address NPS emissions.

An NPS Statement of Opportunity was developed collaboratively with interested stakeholders, and presented to the Board in June 2013. The document began to contextualize the issue, including a general description of NPS emissions, current regulations and incentives, and a summary of past CASA work on mobile sources. It also identified options for potential areas of work.

Though each of the areas of work identified had the potential to be the focus for a project team, no corresponding prioritization was provided. Presented with of such varied options of scale, jurisdiction, and audience, the Board was unable to agree on how best to proceed. To explore how CASA could add value to the management of NPS emissions in Alberta, the Board agreed to convene a targeted one-day workshop.

NPS Workshop

In October 2013, CASA hosted representatives from a broad cross-section of stakeholder organizations at an NPS Workshop in order to begin developing a common understanding of NPS emissions in Alberta, and to discuss needs, gaps, and opportunities for CASA to add value.

Three priority areas of work were identified. Although considered to be equal in importance, it was suggested that they be addressed in the following order:

- ***Understanding the NPS issue***, through: development of an NPS emissions inventory; exploring data management provisions; identification of information/data gaps; and modelling. These activities would be directed at building confidence in available information.
- ***Assessing options for action***, by developing templates and tools that equip organizations and individuals to address important NPS air quality issues, and by providing guidance regarding management options. This work may be complementary to implementation of the Clean Air Strategy and Regional Land Use Plans.
- ***Engaging the public and stakeholder groups*** to build awareness of NPS air quality issues and support for related actions.

NPS Working Group

At the December 2013 Board meeting, in response to the outcomes of the workshop, the GoA offered to champion the preparation of a new NPS Statement of Opportunity, in consultation with other interested parties. At the March 2014 Board meeting, Alberta Environment and Sustainable Resource Development (ESRD) provided an update on GoA's progress. The CASA Board indicated that there was limited interest in continuing with this issue at a Board level until the scope and prioritization of work could be further refined. The Board directed the Secretariat to establish a working group to create an NPS project charter, which would be presented at the September 2014 Board meeting. A group of 10 interested stakeholders convened in June 2014 to form the NPS Working Group. Membership of the working group is provided in Appendix A.

The Working Group noted the recent and historical exceedances of the Canada-Wide Standards for Particulate Matter 2.5 ($PM_{2.5}$) and ozone (O_3), respectively, that have occurred in the Capital, Red Deer, and Calgary regions. Under the new more stringent Canadian Ambient Air Quality Standards (CAAQS), which Alberta will be reporting against in 2015, additional areas may have non-achievement of the $PM_{2.5}$ standard and require management response plans to be developed.

In all three urban areas, NPS as well as point source emissions are thought to be a contributing factor to ambient concentrations of $PM_{2.5}$, but some stakeholders feel that there are significant gaps in information and have a lack of confidence in existing data. Currently the management focus in Alberta rests primarily on point-source emitters, and NPS must be addressed to adequately respond to current air quality pressures in the urban centres.

The NPS project will be based on the following description of NPS provided by the Government of Alberta[1]. A list of examples of NPS can be found in Appendix B:

Definition:
Point source pollution is a term used to describe emissions from a single discharge source that can be easily identified. Non-point source pollution is subtle and gradual, caused by the release of pollutants from many different and diffuse sources (aggregated sources of emissions). This aggregation is done because the emission sources are either too small and numerous, too geographically dispersed, or too geographically large to be estimated or represented by a single point.

There are four types of non-point sources:

> **Area:** Area sources are spatially diffuse and/or numerous sources that can only be measured or estimated using the accumulation of numerous point sources or as estimation of an entire area (e.g. forest fires, tailings ponds).
>
> **Volume:** A volume source is a three-dimensional source of air emissions. Essentially, it is an area source with a third dimension. Examples include: particulate emissions from the wind erosion of uncovered piles of materials, fugitive gaseous emissions from various sources within industrial facilities, etc.
>
> **Line:** A line source is a source of air pollution that emanates from a linear (one-dimensional) geometric shape, usually a line. Examples include dust from roadways, emissions from aircraft along flight paths, etc. There can be several different segments in a line source (e.g. road network).
>
> **Mobile:** Mobile sources are broad area sources that are the accumulation of non-stationary operations. These include transportation sources such as: cars, trucks, boats and non-stationary construction equipment. Mobile sources can include both on-road and non-road sources. On-road refers to pollutants emitted by on-road engines and on-road vehicles. For example: cars, trucks, motorcycles, etc. Non-road emissions refer to pollutants emitted by non-road engines and non-road vehicles. For example: mine fleets, farm and construction equipment, gasoline-powered lawn and garden equipment, etc.

Scope

The work of the project team will be limited to NPS emissions of primary $PM_{2.5}$, and precursors of secondary $PM_{2.5}$ and O_3 (SOx, NOx, VOCs, and ammonia). While work to reduce these substances is likely to have the co-benefit of reducing other emissions, recommendations of the project team should address only these substances. Limiting the scope in this manner creates a manageable piece of work, with the potential to complement existing initiatives.

[1] Clean Air Strategic Alliance NPS Workshop October 23, 2013. Background Information. Prepared by: Government of Alberta.

The primary focus of the project team will be on the six major categories of sources of NPS emissions in Alberta, which are (in no order): agriculture, transportation, construction, biogenic, road dust, and forest fires[2]. A more detailed description of each of these categories can be found in Appendix C.

Project Goal

To help address non-point source air emissions contributing to ambient $PM_{2.5}$ and O_3 standard non-achievement in Alberta.

What it means

The team will focus on $PM_{2.5}$ and O_3 non-achievement in the orange[3] or red[4] management levels of the Canadian Ambient Air Quality Standards (CAAQS)[5].

Project Objectives and Strategies

The working group anticipates that the process outlined below will result in the work of the team having an increasingly narrow focus as the project progresses.

The 'Potential Outcomes/Deliverables' under each objective are not meant to be prescriptive or limit the creativity of the project team, rather to provide additional texture around the intent of the objectives. They are meant to help inform discussions of the project team by providing an understanding of Working Group conversations. The project team members will create more detailed work plans which will outline how each strategy is to be executed. As they do so, specific outcomes and deliverables will be identified based on what is most appropriate and useful to achieving each objective.

1. Objective 1

Compile and review information and agree on a common understanding of non-point sources in Alberta.

---

[2] Clean Air Strategic Alliance NPS Workshop October 23, 2013. Background Information. Prepared by: Government of Alberta.

[3] Under CAAQS, "orange" management level signifies: actions for preventing CAAQS non-achievement. This corresponds to Level 3 in the South Saskatchewan Regional Plan.

[4] Under CAAQs, "red" management level signifies: actions for achieving zone air CAAQS in case of non-achievement. This corresponds to Level 4 in the South Saskatchewan Regional Plan.

5 Canadian Ambient Air Quality Standards (CAAQS) replace the Canada-wide air standards and the CASA PM and Ozone Management Framework (this was Alberta's commitment to achieve Canada-wide Standards). CAAQS for fine particulate matter and ground-level ozone have been developed and were published to Canada Gazette in May 2013. http://www.ccme.ca/en/current_priorities/air/caaqs.html

Strategies

1.1. Review ambient $PM_{2.5}$ and O_3 standard achievement to identify what regions of Alberta are in orange or red management levels according to the Canadian Ambient Air Quality Standards (CAAQS) Management Guidance Document on Air Zone Management.

1.2. For regions of Alberta that are in orange or red management levels, review and compile existing inventories; ambient monitoring data; and modeling[6] of non-point sources and their total and relative contributions to primary $PM_{2.5}$ and precursors of secondary $PM_{2.5}$ and O_3.

1.3. Identify gaps in the available inventories; ambient monitoring data; and modeling and 1) where feasible, obtain data to address the gaps and/or 2) make recommendations for addressing the gaps.

1.4. Refine list of non-point sources based on their total and relative contribution of primary $PM_{2.5}$, and precursors of secondary $PM_{2.5}$ and O_3, as well as potential mechanisms and ability to influence these sources.

Potential Outcomes/Deliverables

- Technical document: Inventory of non-point sources in Alberta, their total and relative contributions of primary $PM_{2.5}$ and precursors of secondary $PM_{2.5}$ and O_3, and gap analysis (where feasible, based on available resources and time).
- Refined list of sources and their total and relative contributions in areas of Alberta where there is non-achievement.

2. Objective 2

Identify non-point source opportunities in Alberta, where CASA's multi-stakeholder approach could add the most value.

Strategies

2.1. Review existing work on NPS emissions management in other jurisdictions and identify best management practices and actions.

Inputs could include:

- Other available jurisdictional scans on areas under pressure to reduce NPS.
- Air Quality Management Policy Tools Leading Practice Research, prepared for the purpose of addressing high levels of $PM_{2.5}$ and O_3[7].
- Canadian Council of Ministers of the Environment Mobile Sources Working Group action plan work under the national Air Quality Management System.

[6] The modeling information is only available for ozone at this time.
[7] http://esrd.alberta.ca/air/management-frameworks/canadian-ambient-air-quality-standards-for-particulate-matter-and-ozone/documents/AirQualityManagementTools-Dec2007.pdf

2.2. Review what is currently being done in Alberta to address the list of NPS identified in objective 1.4 and identify gaps.
2.3. Based on foregoing work, further refine the list of NPS candidates for consideration of potential management actions in Alberta.
2.4. Identify the non-point sources where CASA could add the most value (from objective 2.3). Considerations could include the criteria for determining whether an issue is suitable for a collaborative process identified in CASA's *Guide to Managing Collaborative Processes.*
2.5. Review team membership to determine if a change in membership is required for next steps.

Potential Outcomes/Deliverables

- Understanding of work being done in Alberta and elsewhere to address the refined list of NPS identified for consideration of management options.
- List of NPS for consideration of potential management actions that are also good candidates for CASA to add value.
- Regardless of the outcome of the screening, information on any NPS will be documented for potential follow-up by other stakeholders.

3. Objective 3

Identify and recommend management actions, which could include recommending policy change, to address the highest value non-point source air emissions opportunities in Alberta (from Objective 2).

Strategies

3.1. Develop a list of potential management actions for implementers (i.e. Governments, airsheds, etc.).

Inputs could include:

- Existing work on NPS management in other jurisdictions
- Particulate Matter and Ozone Management Response Plans
- Management responses for Land-use Framework regional air quality management frameworks
- GoA Transportation Strategy for Alberta

3.2. Test and refine the management actions with interested parties.
3.3. Evaluate management actions. Some considerations may include:

- Ecological and human health benefit
- Cost effectiveness
- Achievability (ease of implementation, acceptability)
- Environmental costs/benefit

- Cross-regional benefits and efficiencies (i.e. whether an action would have benefits in one area or across multiple jurisdictions)
- Compatibility with existing provincial and national strategies in Alberta.

3.4. Develop related advice on implementation for parties responsible for implementing the management actions that may be required (e.g. measures to educate the public and build acceptance for applicable new actions).

Potential Outcomes/Deliverables

- The evaluated list of management actions and advice (cross-cutting and regional) that has the potential to be used as a practitioner's guide.
- Advice for those managing $PM_{2.5}$ and O_3 in areas that are in or approaching standard non-achievement.
- Identification of cross-cutting management actions or policy recommendations that would benefit more than one area or region.

4. Objective 4

Develop and implement a strategy and action plan for communicating the work of the project team and engaging stakeholders and the public.

Note: Objective 4 will need to be considered at the outset and on an ongoing basis to determine what stakeholder and public engagement will be necessary and/or appropriate at each stage of implementation.

Strategies

4.1. Determine relevant information to be communicated, the appropriate audience, and timing.

4.2. Engage stakeholders as required throughout the project.

4.3. Provide advice on stakeholder and public engagement to the implementers of management actions, where applicable.

4.4. Develop messaging on the outcomes of each objective for project team members to communicate relevant information to their constituents.

Potential Outcomes/Deliverables

- Recommendation for a future phase of work, potentially focused on informing the general public.
- Effective sharing of information and, where required, engagement with project stakeholders as the project proceeds.

Project Deliverables

The project team will develop a final report providing recommendations and key findings, and documenting the methodology and outcomes of each strategy.

As outlined in the strategies of each objective, the following sub-deliverables will also be produced during the course of the project team's work:

- An evaluated list of recommended management actions and advice for implementation (Objective 3.3 and 3.4). Depending on outcomes of each objective, this has the potential to be used as a practitioner's guide.
- Communication tools developed in support of Objective 4. (e.g. Fact sheets)

It should be noted that *CASA's Performance Measures Strategy: A "how-to" guide to performance measurement at CASA* indicates that each project team is required to generate one specific metric that will allow the success of the team to be evaluated 5 years in the future. More guidance on how this can be achieved can be found in the strategy.

Project Structure and Schedule

After a 2-month convening period, project work should begin in November 2015. The working group anticipates that the project will take approximately 24 months, with a completion date of September 2017.

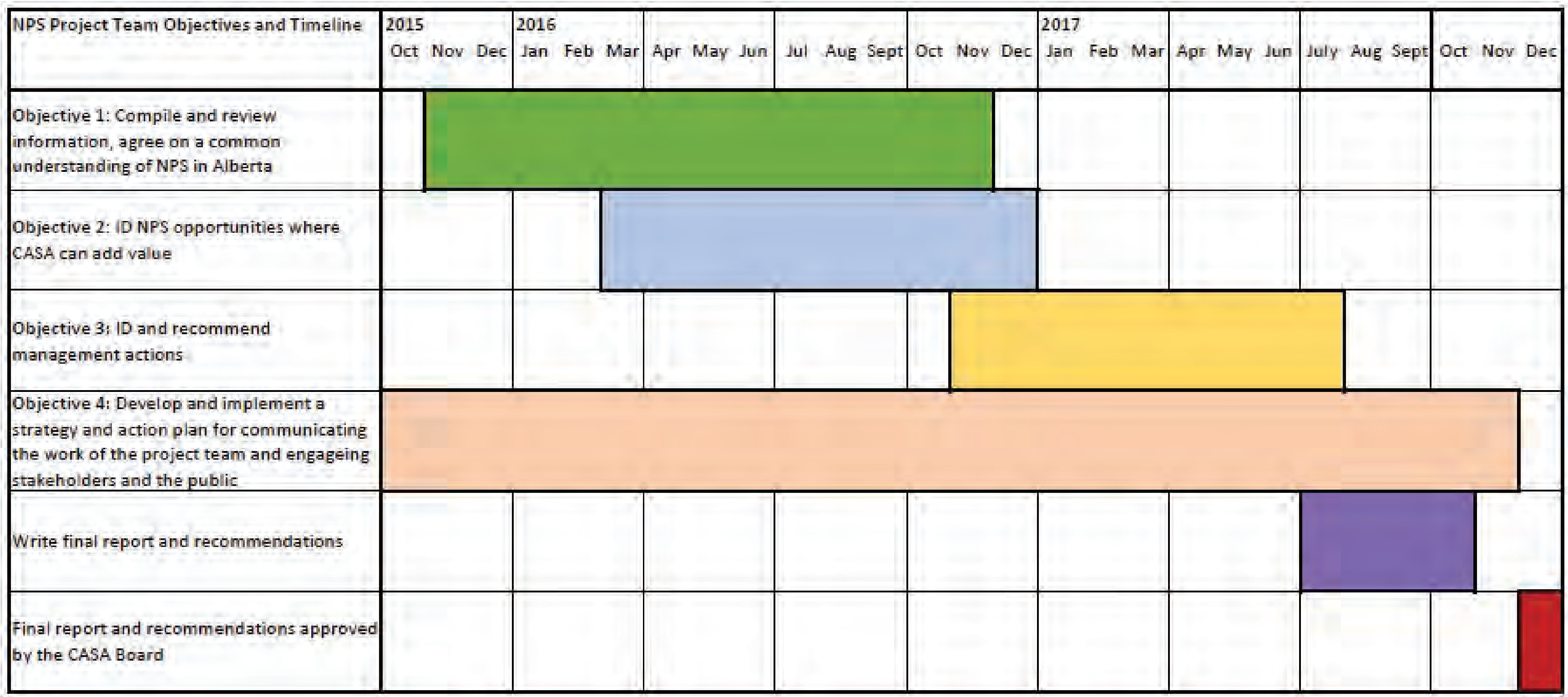
The bulk of the work is sequential, meaning that the outcomes of Objective 1 are the inputs of Objective 2, and the outcomes of Objective 2 are the inputs of Objective 3. The project team should also assess the entire process to identify opportunities for work to be done concurrently.

A series of filters will be applied in the following order. The end result of the filtering process is a list of management actions directed at specific NPS – the process filters the broad list to one or a few specific NPS.

1. Regions in Alberta where ambient concentrations of $PM_{2.5}$ and O_3 are in orange or red management levels. (Objective 1.1)
2. NPS of interest within the regions identified based on relative and total contribution. (Objective 1.2 and 1.3)
3. The potential mechanism and ability to influence each NPS of interest. (Objective 1.4)
4. What work is already being done to address each NPS of interest, and corresponding gaps. (Objective 2.2)
5. Which of the NPS of interest identified are opportunities where CASA could add the most value. (Objective 2.4)

Refer to "Table 1: Non-point Source Project Timeline" for a high level illustration of the process.

Table 1: Non-point Source Project Timeline



Projected Resources and Costs

The working group anticipates the following potential external costs over the life of the project. These figures are estimates only. As the work of the project team progresses, detailed work plans and associated budgets will need to be created. The funds to complete this work will need to be assured prior to the commencement of the project. Note that the bulk of the funding will likely be required in implementation of Objectives 1 and 4, which occur at the beginning of the project.

Item	**Estimated Cost**
Consultant fees to undertake objectives 1.2 and 1.3 as follows: • Review and compile existing inventories; ambient monitoring data; and modeling. • Identify gaps in available inventories and 1) where feasible, obtain data to address the gaps and/or 2) make recommendations for addressing the gaps.	$100,000*
Communications expert to develop a plan for Objective 4.	$15,000
Implementation of plan developed by the communications expert.	$45,000
Contract fee to assist with compiling information in Objective 2.2 • The working group suggests that individuals who have an understanding of the current work being done in Alberta be invited to present to the team. A contractor could be hired to compile the information presented.	$1,500
Two workshops to implement, test, and refine management actions for the highest value CASA work with interested parties (Objective 3.2).	$50,000
Final Report Writing	$1,500
Total Estimated External Costs	**$ 213,000**

*In-depth discussion of the Project Team is needed to confirm the scope of the Request for Proposal.

Risk Analysis

Identifying, analyzing and mitigating project risks is a key component to executing a successful project. The project team should incorporate proactive risk management into the project in order to mitigate risks that could undermine its success. The working group identified risks as well as possible mitigation strategies that the project team should consider as they undertake their work.

Risks	**Possible Mitigation Strategies**
Timely funding not available	• Identify who the "customers" of this work are. Who will find this valuable – seek funding there.

	• Develop a strong value-proposition that includes: examples of sectors that may be involved or affected. • Project Team members discuss the work and associated need for funding with their constituents early in the process.
Lack of / limited data (accessibility)	• Ensure Project Team membership enables the team access to data. • Use judgement to fill gaps where data is imperfect. • Seek advice from modelers on how to determine whether the data is sufficient. • Reference existing guidelines provided for ambient air modeling to determine adequacy and quality of data. •
Lack of 3rd party/subject matter expertise	• Team members connect with their respective networks to find out who might be able to do the work (rather than being limited to the expertise around the table).Rather than postpone, include funds for an expert advisory team or consultant, rather than postponing work in the event that expertise is not present. •
Can't reach agreement on: • Identification of gaps (1.3) • Highest value NPS (2.4) • Management actions (3.3)	• Determine in advance which pieces of work do and do not require consensus. • Outline a clear decision-making process that includes what happens if the team can't agree – who will make the decision? • Have an explicit discussion around Interest-Based Negotiation, and get all the interests of the team members on the table.
CASA's 3 year review impacts the project	While the project team does not have control over this risk, it does provide incentive for the value proposition to be well described in order to increase likelihood of Board buy-in.
Project Team doesn't understand or follow the Project Charter	• Working group to create a project charter that is clear, especially with respect to the intent for sequencing of objectives. • Board receives regular updates to ensure progress is monitored.
CASA Board doesn't agree with: • NPS priorities identified in Objective 2	• Project Team members liaise with their constituents and Board members on an ongoing basis. • Project Team provides regular status reports for Board meetings

• Management actions identified in Objective 3	
During testing, “interested parties” don’t agree with the list of management actions provided in Objective 3.2	• Make an effort to develop the potential management actions collaboratively. • If stakeholders disagree, seek to understand stakeholder reasons for disagreement.
Recommended management actions are too broad or not specific to the project goal.	• Seek a balance between regional needs and provincial applicability in management actions chosen. • Consider prioritizing cross-cutting actions that provide regional benefit and also have the potential to be broadly applicable. • Consider ways to align this work with existing management frameworks and plans (e.g. Capital Region Air Management Framework; CRAZ PMO3 Management Plan).
Lack of engagement/ownership on Project Team (incl. Human resources)	• Identify and communicate with potential stakeholders early in the process. • Create a clear value proposition. • Be clear about what is being asked of stakeholders.
Testing and refining management actions with interested parties (Objective 3.2) takes longer than expected, or causes scope creep.	• Set specific parameters for this piece of work: o Purpose of soliciting feedback. o Scope of influence outcomes will have on overall process. o Time available.
Insufficient time scheduled for Objectives 1 and 2.	• Prior to finalizing workplans, test how much time the outlined tasks might take with people who know (e.g. subject matter experts, consultants). • Have clear parameters in RFPs: o Timeframe o Scope o Specific deliverables • Practice strong oversight and communication with consultants. • Consider the needs for outside resources (i.e. consultants) early in the process, and plan accordingly to avoid delays when project team is ready to implement.
Recommendations of the project team are not	This risk is outside the scope of the project team to mitigate, however this risk will be reduced if i) the parties potentially

implemented. Specifically, advice given on implementing management actions in Objective 4.3.	involved in implementation are engaged, and ii) reference to implementation (who and how) is included in the report's recommendations.
Work isn't linked to $PM_{2.5}$ management response plans.	• Ensure the project team includes members from the airsheds and other stakeholders who are involved in developing PM regional management response plans to: o Understand work they are doing, and o Avoid duplication of effort. • Regularly consider how the outcomes of the project team work can contribute to their work.

Operating Terms of Reference

An Operating Terms of Reference describes how the project team agrees to work together. The project team should discuss and reach consensus on the following items:

- Requirements for quorum
- Governance
- Meeting protocols
- Roles and expectations of project team members
- How decisions will be made
- Ground Rules
- Frequency of project team meetings
- Frequency of updates and reports to the CASA Board
- Protocols for handling media requests
- Protocols for providing updates to interested parties
- Any other considerations for working together

Stakeholder Analysis and Engagement Plan

NPS is a very broad issue, which would benefit from engaging different stakeholders at different levels. Different stakeholders could be engaged in a variety of capacities and at different times throughout the project.

The working group identified the following categories of stakeholders that may be involved:

- Project Team: Stakeholders who are required at the table to reach consensus agreement.
- Corresponding members: Stakeholders who receive all correspondence, but are not required at the table to reach consensus agreement.
- Task Groups or Technical Experts: Stakeholders who have a specific interest or expertise and can be engaged in a more focused way.

- Other:
    - Stakeholders with whom management actions are to be tested (Objective 3.2)
    - Members of the public who may be consulted

The Working Group drafted a list of stakeholders for potential inclusion in the Project Team.

Agriculture:

- Government of Alberta: Agriculture and Rural Development
- Intensive Livestock Working Group
- Agriculture Equipment Suppliers
- Fertilizer manufacturers
- Crop Sector Working Group
- Agri-Environmental Partnership Association
- Alberta Milk
- Alberta Canola Producers Commission
- Alberta Barley Commission
- Potato Growers of Alberta
- Food processors
- Alberta Federation of Agriculture

Construction:

- Industry Associations:
    - Alberta Road Builders and Heavy Construction Association
    - Alberta Sand and Gravel Association
    - Construction Owners Association of Alberta
- Government of Alberta: Infrastructure, Transportation, Municipal Affairs

Road Dust:

- Alberta Association of Municipal Districts &Counties
- Alberta Urban Municipalities Association

Home Heating:

- Government of Alberta: Alberta Environment and Sustainable Resource Development; Alberta Energy

Transportation:

- Alberta Association of Municipal Districts &Counties
- Alberta Urban Municipalities Association
- Alberta Motor Association

- Government of Alberta: Transportation, Alberta Environment and Sustainable Resource Development
- Alberta Motor Vehicle Industry Council
- Alberta Motor Transport Association
- Commercial operators, road builders, fleet operators, transportation business.

NGOs:

- Alberta Environmental Network: Clean Air and Energy Caucus
- CASA Environment Caucus
- Urban
- Health (ex. The Lung Association/ Alberta and Northwest Territories)

Airsheds:

- Calgary Region Airshed Zone
- Parkland Airshed Management Zone
- 1 of the following Edmonton area groups: Fort Air Partnership, Alberta Capital Airshed, West Central Airshed Society

Major Municipalities:

- City of Edmonton
- City of Red Deer
- City of Calgary

Other:

- Alberta Chamber of Resources
- Chemical Industry Association of Canada
- Aboriginal and Metis groups

Given the filtration process outlined for this work, it is likely that new stakeholders will become apparent as the work progresses and the scope of work becomes more refined. The project team will need to regularly evaluate whether the appropriate representation is present based on findings and prioritizations of the group.

For information only:

Organizations identified through the work of the CCME Mobile Sources Working Group:

- Canadian Vehicle Manufacturing Association (CVMA)
- Association of International Automobile Manufacturers of Canada (AIAMC)

- Canadian Trucking Alliance (CTA)
- Truck and Engine Manufacturers Association (EMA)
- Natural Resources Canada – SmartWay Transport Partnership
- Canadian Transportation Equipment Association
- Association of Equipment Manufacturers Canada
- Canadian Fuels Association
- Canadian Natural Gas Vehicle Association
- Automotive Industries Association Canada
- Railway Association of Canada
- Canadian Hydrogen Fuel Cell Association
- Transportation Association of Canada
- Association of Commuter Transportation
- Canadian Urban Transit Association
- Pembina Institute
- Victoria Transport Policy Institute
- Summerhill Impact
- Pollution Probe
- World Wildlife Fund
- Electric Mobility Canada (EV)
- Clean Air Partnership (CAP) – Toronto Centre for Active Transportation (TCAT)
- Better Environmentally Sound Transportation (BEST)
- Richmond Sustainability Initiative
- Fraser Basin Council – E3 Fleets

Appendix A: Working Group Membership

	Role	Organization
Members		
Bill Calder	Co-member with Chris Severson-Baker	Prairie Acid Rain Coalition
Chris Severson-Baker	Co-member with Bill Calder	Pembina Institute
Scott Wilson	Member	Alberta Motor Association
Peter Noble	Member	Imperial Oil
Rich Smith	Member	Alberta Beef
Dan Thillman	Co-member w Rob Beleutz	Lehigh Cement
Rob Beleutz	Co-member w Dan Thillman	Graymont Western Canada
Ann Laing	Member	Jobs, Skill, Training, and Labour
Rhonda-Lee Curran	Member	Environment and Sustainable Resource Development
Mike Mellross	Member	City of Edmonton
Mandeep Dhaliwal	Member	Calgary Region Airshed Zone
Corresponding Members		
Brian Gilliland	Corresponding member	Weyerhaeuser Company
David Lawlor	Corresponding member	Enmax
Martina Krieger	Corresponding member	Environment and Sustainable Resource Development
Sharon Willanen	Corresponding member	Environment and Sustainable Resource Development
Project Managers		
Michelle Riopel	Project Manager	Project Manager
Robyn Jacobsen	Project Manager	Senior Project Manager

Appendix B: Examples of Non-point Sources in Alberta[8]

This information was prepared by the GoA and is not a consensus product of the NPS Working Group

Activities associated with Non-Point Source emissions include industry, transportation, urbanization, and agriculture, to name a few. However, Non-Point Source emissions are also caused naturally as a result of forest (wild) fires and emissions from live and decaying vegetation, soil, etc. Cumulatively, these Non-Point Sources contribute substantially to certain types of emissions.
The following non-exhaustive list depicts the predominant Non-Point Sources as well as the major contributors to these emissions:

- Residential Fuel Combustion (e.g. home heating) – **Public**;
- Commercial Fuel Combustion (e.g. space and water heating) – **Commercial**;
- Residential Fuel Wood Combustion (e.g. fire places, wood burning stoves) – **Public**;
- Transportation (e.g. on-road and off-road vehicles, air, rail, etc) – **Public, Commercial, Industry (construction, road-building and use, mine fleet, mine faces), Airlines, Rail lines**;
- Incineration (e.g. cremation) – **Commercial, Industrial**;
- Cigarette Smoking – **Public**;
- Dry Cleaning – **Commercial**;
- General Solvent Use – **Commercial**;
- Meat Cooking (e.g., BBQ, etc.) – **Public, Commercial**;
- Refined Petroleum Products Retail (gas stations) – **Commercial**;
- Printing – **Commercial**;
- Structural Fires – **Commercial, Public**;
- Surface Coatings – **Commercial**;
- Agriculture (e.g. animals, tilling & wind erosion, fertilizer application) – **Public**;
- Construction Operations – **Commercial, Industrial**;
- Road Dust (paved and unpaved roads) – **Public, Commercial, Industrial**;
- Waste – **Public, Commercial, Industrial**;
- Mine Tailings – **Industrial**;
- Prescribed Burning – Forest Fire and Pest Management, **Industrial**;
- Biogenics (soils and plants) – Natural Processes;
- Forest Fires – Natural Processes, **Public-induced**;
- Etc.

[8] Clean Air Strategic Alliance NPS Workshop October 23, 2013. Background Information. Prepared by: Government of Alberta.

Appendix C: Summary of the Six Major Non-Point Sources and their Emissions Contributions[9]

This information was prepared by the GoA and is not a consensus product of the NPS Working Group

The following information summarizes the sources that contribute the majority of the six major Criteria Air Contaminants. Those with an asterisk contribute substantially more than any other source.

Significant Sources of Non-Point Source Emissions
PM (Total PM): 1) *Road Dust; 2) Construction; 3) Agriculture
PM10: 1) *Road Dust; 2) Construction; 3) Agriculture
PM2.5: 1) *Road Dust; 2) Construction
VOCs: 1) *Biogenic; 2) Agriculture; 3) Transportation
CO: 1) *Transportation; 2) Forest Fires
NH3: Agriculture
NOx: Transportation

Agriculture
Components of Agricultural emission sources are: i) Animals; ii) Tillage and Wind Erosion; iii) Fertilizer Application; and iv) Agriculture Fuel Combustion
Agriculture is a source of:
1. Particulate Matter
a. Total PM: 481 kilotonnes (6% of total TPM)
b. PM10: 252 kilotonnes (11% of total PM10)
c. PM2.5: 15 kilotonnes (4% of total PM2.5)
2. NH3: 118 kilotonnes (90% of total)
3. VOC: 99 kilotonnes (17% of total if excludes biogenics)

Transportation
Components of Transportation emission sources are: i) on-road; ii) off-road vehicles & equipment; iii) air and rail transportation
Transportation is a source of:
1. CO: 938 kilotonnes (62% of total)
2. NOx: 237 kilotonnes (31% of total)
3. VOC: 69 kilotonnes (~2% of total)
4. Particulate Matter:
a. Total PM: 122 kilotonnes (0.16% of total TPM)
b. PM10: 122 kilotonnes (0.51% of total PM10)
c. PM2.5: 110 kilotonnes (2.7% of total PM2.5)
GoA Non-Point Submission #1 19 Final

[9] Clean Air Strategic Alliance NPS Workshop October 23, 2013. Background Information. Prepared by: Government of Alberta.

5. SO_2: Included with 'other sources' as 3 kilotonnes (0.36% of total)

Construction

Components of Construction emission sources are: i) heavy machinery operations including excavation, levelling, loading, unloading and compaction, and all vehicular movement; ii) Residential; iii) commercial, iv) institutional, and v) engineering construction operations. Emissions from construction equipment fuel combustion by off-road vehicles and engines are inventoried as part of off-road use of diesel and gasoline.

Construction is a source of:

1. Particulate Matter:
a. Total PM: 2,182 kilotonnes (29% of total TPM)
b. PM10: 653 kilotonnes (27% of total PM10)
c. PM2.5: 130 kilotonnes (32% of total PM2.5)
2. NOx – fuel combustion
3. CO – fuel combustion
4. NH_3 – fuel combustion

Biogenic

Components of biogenic emission sources are: i) Plants; ii) Soil

Sources of biogenics are:

1. VOC: 3,242 kilotonnes (85% of total VOC)
2. NOx: 24 kilotonnes (3.1% of total NOx)

Road Dust

Components of Road Dust are the result of vehicles travelling on paved and unpaved roads (silt, dust, other particles). Particulate matter emissions due to tire and brake lining wear are considered in a separate category in the transportation sector.

Road Dust is a source of:

1. Particulate Matter
a. Total PM: 4,886 kilotonnes (64% of total TPM)
b. PM10: 1,449 kilotonnes (60% of total PM10)
c. PM2.5: 223 kilotonnes (55% of total PM2.5)

Forest Fires

Components of forest (wild) fires covers the emissions of criteria air pollutants from the combustion of forest material (vegetation, soil)

Forest Fires are a source of:

1. Particulate Matter
a. Total PM: 10 kilotonnes (0.13% of total TPM)
b. PM10: 9 kilotonnes (0.35% of total PM10)
c. PM2.5: 7 kilotonnes (1.69% of total PM2.5)
2. CO: 81 kilotonnes (5.35% of total)
3. VOC: 11 kilotonnes (1.90% of total)
4. NOx: 3 kilotonnes (0.34% of total)
5. SO_2: 0.006 kilotonne (0.002% of total)
6. NH_3: 0.17 kilotonne (0.13% of total)

APPENDIX 4

CASA NON-POINT SOURCE TEAM COMMUNICATIONS PLAN

CASA Non-Point Source Team Communications Plan

Introduction

The Canadian Ambient Air Quality Standards (CAAQS) are the driver for air quality management across the country under the national Air Quality Management System and are becoming increasingly stringent. The 2011-2013 Air Zones Report for Alberta indicates 5 of the 6 air zones in Alberta are either approaching non-achievement or are not achieving the CAAQS for fine particulate matter and the North Saskatchewan air zone is approaching the CAAQS for ozone. The Clean Air Strategic Alliance (CASA) Project on Non-Point Sources, composed of government, non-government, airshed, and industry members, began in November 2015 to help address non-point air emissions contributing to these ambient air quality levels in Alberta. Non-point source emissions are the smaller but numerous air emissions from many different, aggregated and diffused sources. While individual emissions from non-point sources may be relatively small, these sources can have notable cumulative effect.

Limited understanding exists regarding the impacts of non-point sources emissions contributions to air quality. While there are some gaps in monitoring coverage in the province, the information available indicates urban areas are facing challenges related to air quality. There is an opportunity to increase **understanding** amongst CASA Stakeholders, including all levels of Government, of this issue utilizing a two phase communications strategy.

The goal of Phase One is to create understanding among CASA Stakeholders of: (i) why it is important to manage non-point source emissions; (ii) the role of CASA and the CASA process in drafting and recommending management actions; (iii) the impact of non-point source emissions on the state of air quality in Alberta, and; (iv) the findings and priorities of the Non-Point Source Team to address non-point source emissions in Alberta. Phase One is currently in draft.

Phase Two is currently under development.

Target Audience: Non-Point Source Team members, including Government, Industry and ENGO partners. These messages are for the stakeholders and their constituents who may not understand who CASA is and what CASA does.

Objective 1: Raise awareness of CASA, the CASA process and the Non-Point Source Project Team as a foundation for future dissemination of information.

Key Messages	Tactics/Activities/Tools	Timelines	Who	Performance Measures
CASA is a multi-stakeholder alliance composed of representatives selected by industry, government and non-government organizations to provide strategies to assess and improve air quality for Albertans, using a collaborative consensus process.	Presentations, briefing notes, facts sheets, and key messages provided for use within team members' caucus.	Materials complete January 2017; Feedback from the CASA Board at the March Board Meeting	Team members, their caucus, CASA Board, CASA Executive	Number of times these materials have been shared.
The CASA Non-Point Source Team is working to address non-point source air emissions contributing to ambient $PM_{2.5}$ and O_3 standard non-achievement in Alberta.	Presentations, briefing notes, and communication within team members' caucuses.	Materials complete January 2017; Feedback from the CASA Board at the March Board Meeting	Team members, CASA Board, CASA Executive	Number of times these materials have been shared.
CASA facilitates multi-stakeholder consensus based negotiation to provide strategies to assess and improve air quality for all Albertans. All CASA groups and teams, including the Board of Directors, make decisions and recommendations by consensus.	Presentations, briefing notes, fact sheets, and key messages provided for use within team members' caucus.	Materials complete January 2017; Feedback from the CASA Board at the March Board Meeting	Team members, CASA Board, CASA Executive	Number of times these materials have been shared.

Objective 2: Communicate the impact of non-point source emissions on the state of air quality in Alberta.

Key Messages	Tactics/Activities/Tools	Timelines	Who	Performance Measures
Non-point source emissions negatively impact Alberta's air quality leading to poorer health and ecological outcomes.	Presentations, briefing notes, and communication within team members' caucuses.	Complete materials April 2017; Feedback from the CASA Board during the June 2017 Board meeting	Team members, CASA Board, CASA Executive	Number of times these materials have been shared.
Non-point source emissions are not recognized to have a single point of origin. They are area[1], volume[2], line[3], or mobile sources[4] responsible for the release of a substance to the atmosphere.	Presentations, briefing notes, and communication within team members' caucuses.	Complete materials April 2017; Feedback from the CASA Board during the June 2017 Board meeting	Team members, CASA Board, CASA Executive	Number of times these materials have been shared.
Canadian Ambient Air Quality Standards are health-based air quality objectives for pollutant concentrations in outdoor air. Alberta Environment and Parks, air zones, Environment Canada, and industry operate a network of about 110 air quality monitoring stations across Alberta that measure the ambient air quality. These stations are used to determine the achievement status of the standards and management levels in air zones.	Presentations, briefing notes, and communication within team members' caucus.	Complete materials April 2017; Feedback from the CASA Board during the June 2017 Board meeting	Team members, CASA Board, CASA Executive	Number of times these materials have been shared.
The CASA Non-Point Source Team is working to help address non-point source air emissions (CAAQS exceedances) contributing to ambient $PM_{2.5}$ and O_3 standard non-achievement in Alberta.	Presentations, briefing notes, and communication within team members' caucus.	Complete materials April 2017; Feedback from the CASA Board during the June 2017 Board meeting	Team members, CASA Board, CASA Executive	Number of times these materials have been shared.

[1] Area sources are spatially diffuse and/or numerous sources that can only be measured or estimated using the accumulation of numerous point sources or as an estimation of an entire area (e.g. forest fires, tailings ponds).
[2] Volume sources are three-dimensional sources of air emissions. An area source with a third dimension (e.g. particulate emissions from the wind erosion of uncovered piles of materials).
[3] Line sources are sources of air pollution that emanate from linear (one-dimensional) geometric shapes, usually a line (e.g. dust from roadways, emissions from aircraft along flight paths, etc.)
[4] Mobile sources are broad area sources that are the accumulation of non-stationary operations. These include transportation sources such as cars, trucks, boats, and non-stationary construction equipment. Mobile sources can include both on-road and non-road sources.

Objective 3: Communicate findings and priorities to address non-point source emissions in Alberta.

Key Messages	Tactics/Activities/Tools	Timelines	Who	Performance Measures
Air quality experts have investigated non-point source emissions throughout Alberta and are identifying priority areas for improving Alberta's air.	Presentations, briefing notes, and communication within team members' caucus.	Complete materials by September 2017	Team members, CASA Board, CASA Executive	Number of times these materials have been shared.
When available from the project team, develop key messages pertaining to findings, priorities and recommendations.	Presentations, briefing notes, and communication within team members' caucus.	Complete materials by September 2017	Team members, CASA Board, CASA Executive	Number of times these materials have been shared.

APPENDIX 5

NON-POINT SOURCE PROJECT: PROJECT AND COMMUNICATIONS PLAN BACKGROUNDER

CASA Non-Point Source Project:

Project & Communications Plan Backgrounder

Introduction

In 2012, federal and provincial governments agreed to new Canadian Ambient Air Quality Standards (CAAQS) for fine particulate matter ($PM_{2.5}$) and ozone (O_3) to better protect human health and the environment. They are the driver for air quality management across the country under the national Air Quality Management System and are becoming increasingly stringent. The 2011-2013 Air Zones Report for Alberta indicates 5 of the 6 air zones in Alberta are either approaching or not achieving the CAAQS for $PM_{2.5}$and the North Saskatchewan air zone is approaching the CAAQS for O_3.

Non-point source emissions are the smaller but numerous air emissions from many different, aggregated and diffused sources. While individual emissions from non-point sources may be relatively small, these sources can have notable cumulative effect.

While there are limitations to our current understanding of non-point sources and their impact, the information available indicates that the challenges facing air quality in Alberta's urban areas, for example, stem from both point and non-point sources. There is an opportunity among CASA Stakeholders, including all levels of government, to increase understanding of non-point sources and CASA's work to help address them.

The Clean Air Strategic Alliance (CASA) Project on Non-Point Sources, composed of government, non-government, airshed, and industry members, began in November 2015 to help address non-point source air emissions contributing to these ambient air quality levels in Alberta.

Project Goals & Timeline

To help address non-point source air emissions contributing to non-achievement of ambient fine particulate matter and ozone standards in Alberta.

Objective 1
Compile and review information and agree on a common understanding of non-point source air emissions in Alberta.

Objective 2
Identify non-point source air emissions reduction opportunities in Alberta, where CASA's multi-stakeholder approach could add the most value.

Objective 3
Identify and recommend management actions, which could include recommending policy change, to address the highest value non-point source air emissions reduction opportunities in Alberta (from Objective 2).

Objective 4
Develop and implement a strategy and action plan for communicating with and engaging stakeholders and the public on the work of the project.

This project is scheduled to be complete in September 2017.

Non-Point Sources for CASA Recommendation Development

The Non-Point Source Project Team has identified the following potential areas for development of management action recommendations:

1. Mobile sources (on-road light and heavy duty vehicles)
2. Residential wood burning
3. Open-air (prescribed) burning
4. Gasoline distribution (retail stations and terminals)
5. Construction and road dust
6. Urban planning
7. Knowledge of non-point sources
8. Energy efficiency action and climate change co-benefits

Communications Plan

The goal of Phase One is to create an understanding among CASA Stakeholders of: (i) why it is important to manage non-point source air emissions; (ii) the role of CASA and the CASA process in drafting and recommending management actions; and (iii) communicate the potential contribution of non-point source air emissions on the state of air quality in Alberta. Phase One is in its initial stages.

The objective of Phase Two is to develop a plan for communication of the final non-point source recommendations following the completion of the project. It is currently in progress and will be implemented in September 2017.

Additional CASA Resources

Consensus process:

http://www.casahome.org/consensus-process/

Non-point source project:

http://www.casahome.org/current-initiatives/non-point-source-project-team-37/

2015 annual report and strategic plan:

http://www.casahome.org/about-casa/annual-reports-strategic-plans/

Message maps:

http://www.casahome.org/uploads/source/Communications/Message%20Map%20CASA.pdf

[Non-point source message map under development]

APPENDIX 6

CASA NON-POINT SOURCE PROJECT MESSAGE MAP

Non-Point Source Project – Message Map

CASA is a non-profit organization that facilitates multi-stakeholder consensus-based negotiations to provide strategies to assess and improve air quality for all Albertans.

The CASA NPSPT was a multi-stakeholder group of representatives from government, industry, NGOs and airshed organizations working collaboratively, through consensus, to help address non-point sources contributing to ambient air quality levels in

Air quality affects us all, no matter who we are, where we live, or the state of our health.

CAAQS are new Canadian Ambient Air Quality Standards to better protect human health and the environment.

$PM_{2.5}$ consists of airborne particles in solid or liquid form and may be emitted in particle form, or result from a series of chemical and physical reactions.

NO_x includes the gases of nitrogen oxide and nitrogen dioxide and is formed during combustion processes.

Ground-level ozone is a colorless and highly irritating gas that forms just above the earth's surface.

Alberta's urban centers are approaching or have not achieved CAAQS for $PM_{2.5}$ and ozone.

Vehicle emissions contribute to air quality concerns in Alberta, particularly in large urban centers.

How we design our cities and buildings affects air quality.

No single source of air pollution is responsible for the ambient air quality to which you are exposed.

Everyone contributes to air quality, and choices have impacts. Clean air depends on all of us.

$PM_{2.5}$ is monitored at 58 locations throughout the province (52 of these are operated by airsheds). $PM_{2.5}$ is an important factor in the calculation of the Air Quality Health Index (AQHI).

The AQHI is a tool to help people understand what local outside air quality means to their health. It is reported in 32 communities throughout the province and current ratings can be found on your local Airshed Organization website.

Long term exposure to $PM_{2.5}$ has significant health effects. There is no safe level of $PM_{2.5}$, but reducing your exposure can reduce your health risks.

Good air quality protects the health of Albertans and the environment.

We are always learning about how air pollution affects health, and research is driving necessary improvements to air quality management.

The NPSPT focused on helping to reduce larger non-point sources where there are opportunities for management actions.

The NPSPT gave priority to management actions that help lower ambient $PM_{2.5}$ levels and also help reduce other pollutants of concern (e.g. NO_2).

This project was to help Alberta manage cumulative impacts of a wide variety of air emission sources, including non-industrial sources.

The NPSPT completed its project within approximately 2 years, ending late 2017. Opportunities for additional work are expected.

The NPSPT made 19 recommendations across a variety of non-point sources and themes.

Nine of the recommendations address transportation non-point sources, including personal vehicles, commercial vehicles, and freight strategies.

Recommendations for residential heating focus on retrofitting or replacing wood burning appliances and using air quality notifications to let people know when they should minimize wood burning.

Other recommendations target non-point sources including construction operations and road dust, open-air burning, and gasoline vapours from fuel terminals.

The NPSPT also recommended the impact of land-use planning and climate change initiatives on air quality be considered.

CASA = Clean Air Strategic Alliance

NGOs = Non-governmental organizations

NPSPT = Non-point Source Project Team

For additional information:

- **Clean Air Strategic Alliance:**
  - Homepage: http://www.casahome.org/
  - Non-point source project: http://www.casahome.org/current-initiatives/non-point-source-project-team-37/
- **Environment and Climate Change Canada:**
  - Air quality: https://www.ec.gc.ca/Air/default.asp?lang=En&n=04104DB7-1
  - Air pollution sources: https://www.ec.gc.ca/Air/default.asp?lang=En&n=F963E49C-1
  - Air pollutants: https://www.ec.gc.ca/Air/default.asp?lang=En&n=BCC0B44A-1
  - AQHI: https://www.ec.gc.ca/cas-aqhi/default.asp?Lang=En
- **Alberta Environment and Parks**
  - Air quality management: http://aep.alberta.ca/air/air-quality-management/default.aspx
  - Canadian Ambient Air Quality Standards: http://aep.alberta.ca/air/management-frameworks/canadian-ambient-air-quality-standards/default.aspx
  - AQHI: http://aep.alberta.ca/air/air-quality-health-index/default.aspx
  - AQHI map: http://maps.srd.alberta.ca/AQHI/
- **Alberta Airsheds Council:**
  - Homepage: https://www.albertaairshedscouncil.ca/

CASA = Clean Air Strategic Alliance
NGOs = Non-governmental organizations
NPSPT = Non-point Source Project Team

APPENDIX 7

AGRICULTURAL PRACTICES

Appendix 7: Agriculture Best Management Practices for Managing Air Quality Issues (Provided by Alberta Agriculture and Forestry)

Types of Air Emissions from Agricultural Practices

Air emissions from confined feeding operations (CFOs) depend on many factors such as temperature, humidity, wind speed, housing and manure management systems, and animal characteristics (species, size, and density). Emissions of particulate matter (PM) from tillage operations are affected by soil moisture conditions (degree of wetness or dryness) and type of tillage operation (disking, shaping, chiseling, and leveling), while PM emissions from harvesting crops are dependent on the crop type, soil conditions, weather, and types of equipment used for harvesting. Factors affecting PM emissions from agricultural residue include burning types (spread or pile) and moisture content of residues being burned. The majority of farmers in Alberta utilize zero or minimum tillage, which minimizes the generation of $PM_{2.5}$ significantly. Most of the rural municipalities in Alberta require permits to burn agricultural residues.

Managing Air Quality Issues with Precision Agriculture

Many agricultural commodity groups and organizations in Alberta are working to promote practices that enable the industry to become environmentally sustainable, globally competitive, and publicly acceptable.

Agriculture production utilizes a number of management practices to increase production while decreasing the amount of energy and increasing efficiency of inputs. The two foundations to making this change has been 1) to soil test, which allows farmers to use the precise amounts of fertilizer the crops require and 2) to plant the best variety for their farms for each crop they plant. A number of tools have also been critical in allowing this change to occur. This includes global positioning (GPS) and geographic information systems (GIS) applications for farming for precision agriculture, which is an approach to tailoring site-specific practices of agricultural technology that results in better yield as well as reduced or mitigated environmental damage.

Some of the tools of precision agriculture allow for variable rate application of fertilizer, herbicides, and pesticides. Other tools provide means for geo-referenced field scouting of insects, pests, disease, and weeds, which enables precise application of controls rather than total field applications. GPS enabled precision sprayers can now allow sprayer sections to shut off when not above crop sections. This automatic section control reduces input use and provides for accurate input placement. It also enables reduction of application in environmentally sensitive areas.

Using satellites to steer equipment allows for fewer field passes and maximizes the efficiency of crop inputs, further reducing fuel use, providing less carbon release and protecting water from nutrient run-off. This, coupled with the minimal tillage practices, has substantially decreased the number of field passes required in modern agriculture.

An example of the benefits of these practices is that energy use in production of spring wheat has decreased by 6% between 1981 and 2011, on a per hectare basis (***Source:*** *Canadian Field Print Initiative)*. As energy use per hectare is going down, production per hectare is going up. During that same time period, the energy use per tonne produced was reduced by 39% and the yield of spring wheat increased by 59% (***Source:*** *Canadian Field Print Initiative)*. These trends suggest that further improvements can be expected.

Developing Policies and Strategies for Managing Air Quality

The Environmental Stewardship Branch (ESB) developed an Odour and Air Quality Strategy spanning five years (2012 to 2017). The strategic plan aimed at facilitating the management of odour and other agricultural industry air emissions in the province. The strategy identified agricultural contributors to these emissions, and defined a vision that stated AAF would guide and support the agricultural industry in managing odour and other air emissions, keeping in mind the need to maintain healthy ecosystems and at the same time a sustainable agricultural industry in managing odour and other air emissions, keeping in mind the need to maintain healthy ecosystem and at the same time a sustainable agricultural industry. Four strategic outcomes and associated actions were defined within the plan as follows:

- Promote the adoption of BMPs via research and extension activities;
- Support the measurement, evaluation, and reporting of agricultural odour and other air emissions;
- Develop policies to help manage concerns pertaining to agricultural odour and other air emissions; and
- Enhance public knowledge and awareness regarding agricultural odour and other air emissions.

Implementing Components of the Odour and Air Quality Strategy

Four of the associated accomplishments following the implementation of the plan include 1) a CFO Strategic Plan, 2) research projects, 3) an extension plan for CFO air quality management, and 4) a survey called the Environmentally Sustainable Agriculture Tracking Survey. These four components are described below.

1) CASA CFO Strategic Plan Implementation

In 2008, the CASA Confined Feeding Operations (CFOs) Project team released a strategic plan that focused on managing air quality around CFOs. The plan outlined ten recommendations to help the CFO industry manage six emissions of concern (NH_3, H_2S, PM, pathogens and bio-aerosols, VOCs, and odour).

AAF implemented the following recommendations and provided support to others:

- Development of a New Emission Inventory for NH_3 and PM

The inventory was first developed based on 2006 activity data, obtained from Statistics Canada and AAF, and later on was updated using 2011 Statistics Canada and AAF activity data. Compared to the *2006 Ammonia and Particulate Matter Emissions Inventory for Confined Feeding Operations in Alberta* (APMEICA 2006), CFOs in Alberta were estimated to emit 39,870 tonnes of NH_3 in 2011. This represented a 6.7% decline in CFO NH_3 emissions from 2006 to 2011. Despite increases in emissions from beef cattle and dairy cattle, 1,167 tonnes and 1,936 tonnes, respectively, decreases in emissions from poultry, sheep and especially swine, 216 tonnes, 31 tonnes and 5,736 tonnes, respectively, resulted in a net decrease in the overall emissions from CFOs in 2011. Estimated emissions of coarse particulate matter ($PM_{10}$and $PM_{2.5}$) from all CFOs in Alberta decreased by approximately 13% between 2006 and 2011. Except for swine CFOs, estimated PM_{10} and $PM_{2.5}$ emissions in 2011 did not appear to vary considerably among the other livestock categories and subcategories compared to emissions in 2006. AAF is planning to update the inventory using 2016 Statistics Canada and AAF activity data.

- Monitoring for NH_3, H_2S, PM, and VOCs

Ambient air concentrations of NH_3, H_2S, PM, and VOCs were measured upwind and downwind of four CFOs (beef cattle feedlot, dairy, poultry, and swine) in Alberta over a 14-month period, at the category one minimum distance of separation (MDS-1), as defined by the *Agricultural Operation Practices Act* (*AOPA*). The results indicated that NH_3 emissions were significantly higher at the downwind versus upwind locations of all four CFOs. It is important to note however, that the results obtained are considered specific to the four CFOs, and are not statistically representative of the entire CFO industry in Alberta.

- Management Mechanisms Research Plan

BMPs with the potential to reduce emissions of NH_3 from CFOs were evaluated and shortlisted. Three options with the potential to reduce NH_3 emissions from beef cattle feedlot pens were considered, namely, frequent manure removal, application of a urease enzyme inhibitor, and pen floor amendment with fly ash. Another three options with the potential to reduce NH_3 emissions following land application of liquid manure (pigs or dairy cattle) were also considered, namely, broadcasting with rapid incorporation, manure injection, and band spreading (trail hose application).

2) CURRENT RESEARCH PROJECTS

From 1998 to date, AAF's role in research broadened beyond policy-based research. Over this time period, AAF has engaged directly and indirectly, in a leadership or supportive role, in more than 22 different air quality research projects of varying length and resource requirement, and often in a collaborative fashion with partnership from the agricultural sector, various governments departments and agencies, public institutions, and at times, members of the general public.

A spectrum of suppressive, inhibitive, capture and control technologies and BMPs, proven to work efficiently, are needed to reduce ammonia emissions from agricultural operations in Alberta. Strategies for reducing NH_3 emission should be directed towards reducing (1) NH_3 formation (inhibition methods), (2) NH_3 losses immediately after it has been formed (suppressive methods), or (3) the NH_3 loss potential (Arogo et al. 2001)[1]. To date, there is no technology or BMP that emerges as a clear choice for the industry due, in part, to the associated cost of implementation of available technologies and their associated long-term operational costs and issues. Currently AAF is conducting research to evaluate BMPs with the potential to mitigate ammonia and other air emissions from agricultural operations in Alberta.

The following is the list of these projects:

Air Quality (Ammonia) Management: **Assessing the impact of amended feedlot pen surface on cattle health and welfare, environmental, and economic sustainability (Funded by the former Alberta Livestock and Meat Agency (ALMA))**
This project is investigating the integrated social, environmental (including NH_3 emissions), and economic impacts of using Roller Compacted Concrete (RCC), amended with fly ash, in a commercial feedlot pen compared to traditional, clay-based floor surfaces. The long-term objective of this study is to widely disseminate the results of this project to feedlot cattle producers in Alberta. This project is intended to support producers and stakeholders through the assessment of technologies and development of innovative tools for air quality (ammonia) management, among other potential benefits.

Managing Greenhouse Gases (GHGs) and Ammonia: Using an integrated multi-disciplinary approach to reduce GHG emissions from cattle and manure and soil and losses when feeding BioChar to cattle (Funded by Agri-Agri Food Canada, Agricultural Greenhouse Gases Program (AGGP))
One of the objectives of this project is to quantify the losses of GHGs and ammonia from cattle manure following the addition of biochar as a feed supplement to backgrounding and finishing cattle rations.

Reducing NH_3 emissions: Managing Agronomic Nitrogen: Assessing agronomic nitrogen management to mitigate environmental and economic losses in Alberta (Funded Research Opportunities and Innovation-Growing Forward 2)
Some objectives of this project are to evaluate the effectiveness and economic benefits of **4R** plant nutrient stewardship (**R**ight source - **R**ight rate - **R**ight time - **R**ight place), and provide information for policy analysts to prioritize aspects of crop production that could be targeted with incentives to reduce environmental impacts.

Targeting Nitrous Oxide (N_2O) Emissions: (Initiated by the Canadian Fertilizer Institute (Fertilizer Canada), the University of Alberta and Alberta Agriculture and Forestry)
The purpose of the study is to determine the effect of stabilized and enhanced efficiency fertilizer on GHG - nitrous oxide (N_2O) emissions, nitrogen leaching, Nitrogen Use Efficiency (NUE) and crop yield response in cereal crops, using **4R** Nutrient Stewardship.

---

[1] Arogo, J., P.W. Westerman, A.J. Heber, W.P. Robarge, and J.J. Classen. 2001. Ammonia in animal production—A review. ASAE paper 014089. St. Joseph, Mich.: ASAE

3) CFO AIR QUALITY BMP EXTENSION PLAN

AAF will continue to plan, develop, and coordinate programs and activities to raise awareness regarding the sustainable management of agriculture's potential impacts on ambient air quality. In 2012, AAF developed an extension plan which was intended to identify, promote, and extend key BMPs that Alberta agricultural producers might adopt and implement in order to manage the potential impacts of their production activities on air quality. The extension activities outlined by this plan provide producers with knowledge, information, and education related to agricultural air quality and encourages them to adopt select BMPs that have been proven to be effective, practical, and economically feasible.

The following is a list of some extension activities related to agricultural air quality that have been initiated by AAF in the last few years.

Factsheets and Workbooks

- Shelterbelts for Livestock Farms in Alberta - Overview, Agdex 400/092-1
- Shelterbelts for Livestock Farms in Alberta-Planning, Planting and Maintenance, Agdex 400/092-2
- Shelterbelts for Livestock Farms in Alberta - Shelterbelt Planning Workbook Agdex, 400/092-3
- Ammonia Emissions from Confined Feeding Operations (CFOs) - Control and Mitigation
- Ammonia Volatilization from Manure Application
- Odour Management Plan for Alberta Livestock Producers, Agdex 092-1
- Dust Control for Livestock Buildings

Workshops

- Agricultural Ammonia Emissions and Policy Implications - Where are We Today and What Lies Beyond the Horizon?
    - Hosted by AAF in Lethbridge in March 2013
    - Participants (including guest speakers) from Europe, the U.S. and across Canada discussed issues, concerns, and effects of agricultural NH_3 emissions and to a broader extent nitrogen, on the environment.

On-line Source Emission Calculators (AAF website):

- Ammonia Losses from Liquid Manure Applications Calculator
- Ammonia Emissions Estimator – for livestock housing and manure storage facilities.

Web links (AAF website)

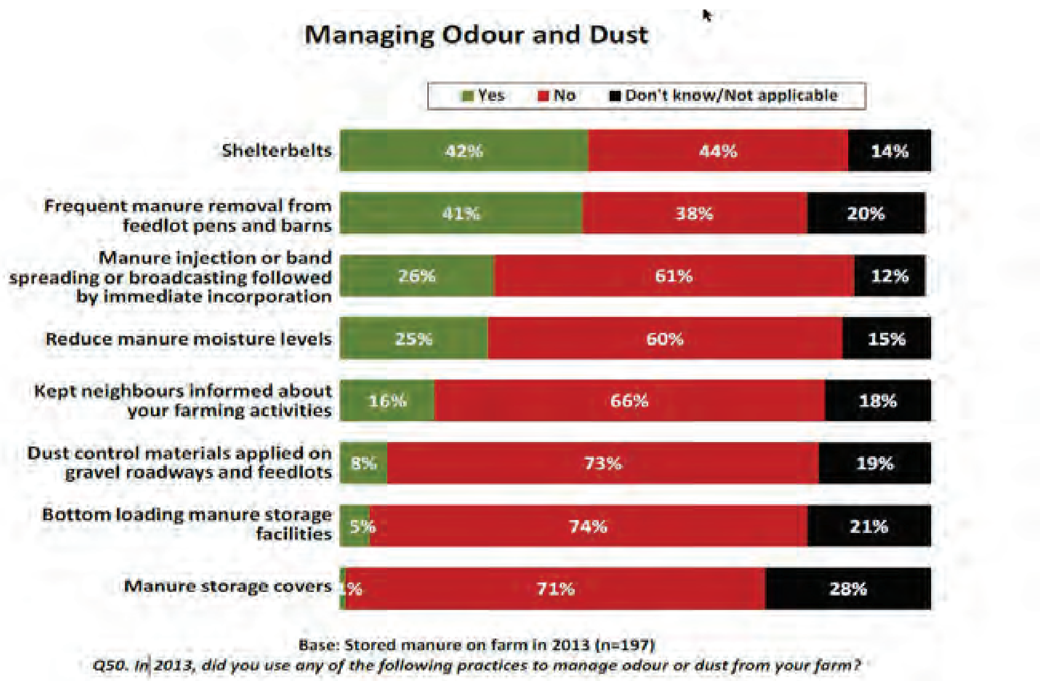
- Air Quality Resources for Alberta Livestock Producers

Manuals

- Beneficial Management Practices: Environmental Manual for Livestock producers in Alberta.
- Beneficial Management Practices: Environmental Manual for Alberta Farmsteads
- Beneficial Management Practices: Environmental Manual for Crop Producers in Alberta

4) THE ENVIRONMENTALLY SUSTAINABLE AGRICULTURAL TRACKING SURVEY (ESATS)

ESATs is conducted by AAF every two years to measures producers' awareness, attitude toward and adoption of key BMPs. See Figure 1 for 2014 survey results for producer's adoption of BMPs that mitigate emissions of odour and dust from agricultural operations in Alberta. The survey shows that there is a low adoption rates of some of BMPs. AAF will continue to investigate the effectiveness and barriers to adoption of these BMPs.



(Alberta Agriculture 2014 ESATs)

Figure 1: Results of Alberta Agriculture and Forestry survey of BMP adoption.

Challenges and Opportunities for Managing Agricultural Non-Point Sources of Emissions

Challenges: Air emissions from agricultural operations are very complex and highly variable in nature (spatially, temporally, and scale). Geographical differences and variations can influence the type and magnitude of agricultural emissions in the province. All sources of agricultural emissions are affected by seasonal cycles. Finally, agricultural operations vary in type, business size, sales, production practices, management practices, etc. Agricultural air emissions measurement, characterization, modelling, and mitigation are very challenging and require extensive resources and experience. Sufficient data and information are required to enable the verification and adoption of BMPs.

Since air emissions from agricultural operations are variable, any BMP utilized to mitigate emissions must be viable (effective and efficient) and feasible (practical, customizable, flexible, and affordable) in order to account for spatial, temporal, and scalar variation.

Opportunities: AAF is willing to support the agricultural sector in achieving BMP research and development objectives towards the reduction of NH_3 and other emissions of concern. AAF has the technical capacity, limited resources, and the expertise to conduct sound, scientific research aimed at reducing the impact of air emissions from agricultural operations in Alberta. AAF will develop performance metrics to assess the effectiveness of adopted BMPs designed to reduce NH_3. ANH_3AAF will develop and utilize programs to support, both financially and via extension activities, the adoption of BMPs aimed at reducing NH_3AAF will continue to engage with other stakeholders who may be directly or indirectly affected by agricultural air emissions.
There is a great opportunity for collaboration with other stakeholders (e.g., the Alberta Airsheds Council) to promote agriculture's ongoing efforts towards sustainable ambient air quality stewardship.

Agricultural Operation and Practices Act and Regulations (AOPA)

The Agricultural Operation and Practices Act and Regulations (AOPA) came into force on January 1, 2002. It contains legislation intended to mitigate odour issues associated with CFOs. Although AAF is responsible for creating and revising AOPA, the Natural Resources Conservation Board (NRCB), a quasi-judicial government agency, is responsible for issuing licenses and regulating CFOs in Alberta in compliance with AOPA. AOPA consists of main 3 parts namely Nuisance, Livestock and Manure and Regulation

1- Nuisance

- **ALL** agricultural producers that follow Generally Accepted Practices (GAPs) are protected from Nuisance lawsuits
- Administered by the Farmer Advocate Office (FAO)
- A Practice Review Committee (PRC) recommends the GAPs.
- Complaints received by FAO
    - Facilitation and mediation
- Minister must appoint a PRC to address a complaint against a producer
    - 3 members - 2 similar producers and 1 public
- PRC recommends GAPs for the operation
- If the producer is not following GAPs, the door is open for complainant to sue

2- Livestock and Manure

- Applies to **livestock producers** and **people** handling manure
- New and expanding Confined Feeding Operations (CFOs) require a permit from the NRCB
- NRCB also enforces Part 3 - regulations and issues permits

3- Regulations

- NRCB can issue orders or prosecute for:
    - non-compliance with regulations or permits
    - risk to the environment
    - inappropriate disturbance (nuisance)
- NRCB investigates complaints
- Process of escalating consequences
    - Education, verbal directive, written directive, order/prosecute
- Involve affected parties in permit decisions
- Minimum Distance Separation (MDS) applied to new and expanding livestock operations
- Manure Incorporation requirements
- Setbacks for manure storage and application

#1400, 9915 - 108 STREET
EDMONTON, AB T5K 2G8

PHONE: 780-427-9793
TWITTER (@CleanAirSA)

CASA