

# Recurrent Human Health Complaints Technical Information Synthesis

## Fort McKay Area

**September 2016**

Prepared by the Alberta Energy Regulator and Alberta Health

Alberta Energy Regulator

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Prepared for residents of Fort McKay and oil sands industry stakeholders.

*The information contained herein was prepared by the AER for the AER, the residents and industry referred to in the document, and Alberta Health and Alberta Health Services, and is intended to address concerns raised by Fort McKay. The AER's analysis and conclusions are based on information that is specific to Fort McKay's recurring complaints. Readers of this report are therefore cautioned against assuming that this report or its findings apply to other individuals, communities, areas or circumstances, regardless of any apparent similarity.*

**Alberta Energy Regulator**

Recurrent Human Health Complaints Technical Information Synthesis: Fort McKay Area

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## Executive Summary

This report provides an assessment of recurrent complaints received by the Alberta Energy Regulator (AER) from Fort McKay residents related to air quality and odour from local oil sands mining operations. The assessment, based on complaints received over a five-year period (2010–2014), focuses on emergency response, inspections and investigations, industry performance monitoring, and ambient air quality monitoring.

Between January 2010 and December 2014, the AER received 172 complaints from Fort McKay residents, 165 of which were related to odours. The AER, in partnership with Alberta Health, initiated a review as part of the AER's recurrent human health complaints process.

This initial and screening level review found that some substances were present in the air in concentrations that exceeded odour and health thresholds, and that there is a potential that ongoing exposure to certain substances may impact human health. However, it is not clear what the implications are to human health, and further assessment is necessary.

While there is a link between air quality and odours in Fort McKay and nearby oil sands mining operations, it is not clear what emission sources from industry operations are contributing to higher concentrations of substances in the air. In addition, improvements in AER's odour complaint response protocols are needed with respect to communications between the AER, Fort McKay, Alberta Health, and industry, in order to better correlate an odour complaint to specific industry operations and to ambient air quality and associated thresholds.

The review also found that while the risk of acute air quality exceedances requiring emergency response in the Fort McKay community is extremely low, it is critical for the community to understand when air quality poses an immediate and acute health concern.

The review identified some gaps related to air quality and odour management that need to be addressed. As such, the AER and Alberta Health have made 17 recommendations that include conducting consistent and integrated air quality monitoring, assessing emission sources from the oil sands industry, improving emergency response related to air quality, improving the AER's odour complaint response protocols, and conducting a human health assessment to assess in more detail links between some air quality parameters and human health.

It is also recommended that a Fort McKay Odour and Air Quality Task Force be established to help implement the recommendations outlined in this report. The results from implementing these recommendations will help the AER to improve regulatory requirements for oil sands operators related to air quality and odours in Fort McKay and will support the Government of Alberta in providing policy guidance to the AER.

Recommendations can be found in Appendix 6.



## Abbreviations

AAAQOs	Alberta's ambient air quality objectives	CNRL	Canadian Natural Resources Limited
AAL	ambient air limits	COP	code of practice
AEMERA	Alberta Environmental Monitoring, Evaluation and Reporting Agency	COSIA	Canada's Oil Sands Innovation Alliance
AER	Alberta Energy Regulator	EC	Environment Canada
AIHA	American Industrial Hygiene Association	EMS	Environmental Management System
AMCV	air monitoring comparison values	EP	Environment and Parks
AMD	Air Monitoring Directive	EPC	exposure point concentration
AMS	air monitoring stations	EPEA	Environmental Protection and Enhancement Act
AMU	air monitoring unit	EPO	environmental protection order
AQHI	air quality health index	ERCB	Energy Resources Conservation Board
AQI	air quality index	ERP	emergency response plan
AQMF	Air Quality Management Framework	ESL	effect screening levels
AQMS	air quality management system	ESRD	Environment and Sustainable Resource Development
CAAQS	Canadian ambient air quality standards	FC	fluorocarbons
CAPP	Canadian Association of Petroleum Producers	FGD	flue-gas desulphurization
CASA	Clean Air Strategic Alliance	FIRST	Field Incident Response Support Team
CCME	Canadian Council of Ministers of the Environment	FIS	Field Inspection System
CEMA	Cumulative Environmental Management Association	FMAQI	Fort McKay's air quality index
CEMS	continuous emissions monitoring system	GHG	greenhouse gas
CFC	chlorofluorocarbons	GLC	ground-level concentration
CIC	Coordination and Information Centre	GoA	Government of Alberta
		HCFC	hydrochlorofluorocarbons
		HEMP	Human Exposure Monitoring Program

HRSG	heat recovery steam generation	OT	odour thresholds
IQR	interquartile range	PAC	polycyclic aromatic compounds
IRIS	Integrated Risk Information System	PAH	polycyclic aromatic hydrocarbons
IRMS	Integrated Resource Management System	PLA	Public Lands Act
JOSM	Joint Oil Sands Monitoring	REDA	Responsible Energy Development Act
LARP	Lower Athabasca Regional Plan	RSC	reduced sulphur compounds
LDAR	leak detection and repair	SCD	sulphur chemiluminescence detector
LOAEL	lowest observable adverse effect level	SCO	synthetic crude oil
LP	low pressure	SCOT	Shell Claus Offgas Treating
LPSG	low-pressure sour gas	SER	sulphur emission reduction
MDL	minimum detection level	SERP	sulphur emission reduction project
MLUEP	Mildred Lake upgrader expansion project	SGER	Specified Gas Emitters Regulation
MMA	Mines and Minerals Act	SRU	sulphur recovery unit
NAAQS	national ambient air quality standard	THC	total hydrocarbon concentration
NAPS	National Air Pollutant Surveillance Program	TRS	total reduced sulphur
NPRI	National Pollutant Release Inventory	VOC	volatile organic compounds
OGCA	Oil and Gas Conservation Act	VRU	vapour recovery unit
OMOE	Ontario Ministry of Environment	WD	wind direction
OSCA	Oil Sands Conservation Act	WHO	World Health Organization

# 1 Introduction

## 1.1 Purpose

On June 17, 2013, the Alberta Energy Regulator (AER) was formed under the *Responsible Energy Development Act (REDA)* (Province of Alberta, 2012). Later that year (November 30, 2013) powers, duties, and functions under the *Public Lands Act (PLA)* and Part 8 of the *Mines and Minerals Act (MMA)* were assumed by the AER, and on March 29, 2014, the AER took on powers, duties, and functions under the *Environmental Protection and Enhancement Act (EPEA)* (Province of Alberta, 2014) and the *Water Act*.

Thus, over the past two years, the AER has been transitioning into its expanded environmental mandate, assuming a number of functions previously held by government departments and agencies. This transition has included a review of the AER's environmental mandate, its role in human health assessments relative to other government departments, development of an expanded environmental program, and migration of key processes and data to the AER to enable it to perform its expanded role.

The AER's mandate is to ensure the safe, efficient, orderly, and environmentally responsible development of Alberta's hydrocarbon resources over their entire life cycle. Its environmental protection mandate extends to those elements of the environment that have the potential to affect human health. The AER has serious regard for human health concerns that relate to resource development. However, the AER does not regulate human health directly or have primary responsibility for identifying health concerns in Alberta. Alberta Health and Alberta Health Services are the agencies responsible for health and health concerns. The AER supports these organizations when questions arise about the impact of energy resource development on the health of individuals.

When stakeholders are concerned about energy resource activity in their area, one mechanism to register that concern is a complaint that is directed to AER offices for investigation. Often complaints can recur if a complainant believes the original complaint was not resolved. Recurrent complaints involve multiple complaints from multiple individuals over multiple years. They are often complex, involving multiple government agencies. When recurrent complaints involve human health, this can be particularly concerning for all stakeholders, industry, and government agencies.

The AER is not a human health regulator, but as the regulator of energy resource activity in Alberta, the AER does have a responsibility to assess recurrent human health complaints associated with energy resource activities. This is done by gathering industry, regulatory, and environmental information to support further assessment of human health concerns by the human health regulators.

To achieve this, and as part of its expanded environmental mandate, the AER developed the recurrent human health complaint process. Based on a history of interaction and requests from the Fort McKay First Nation, the recurrent human health complaint process has been initiated with the Fort McKay First Nation

to assess recurrent human health complaints from the First Nation associated with air quality, odours and oil sands mining in the area.

This report is the technical synthesis from the recurrent human health complaint process implemented in Fort McKay to

- assess recurring complaints involving human health, air quality, and odours associated with oil sands development in the area and
- determine if there are technical gaps in our understanding of the issue and if further assessment is required to resolve concerns.

This document is intended primarily for residents who have expressed concerns about air quality, odours, and oil sands development near Fort McKay and for other stakeholders such as industry, monitoring agencies, and government departments that may be involved in such concerns. The report is also intended to inform Alberta Health, which have primary responsibility for health care in Alberta.

## 1.2 Process

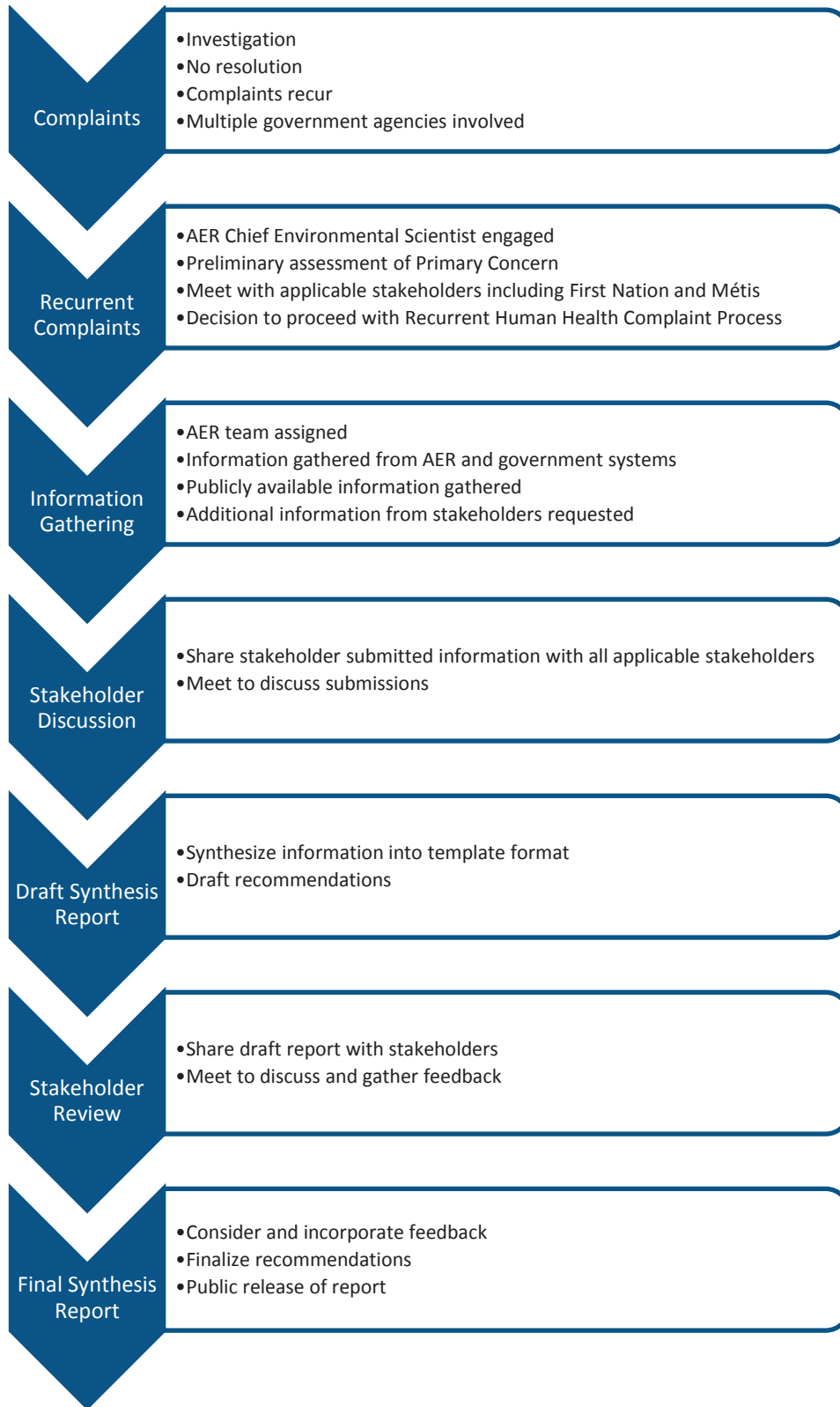
The recurrent human health complaint process was developed by the AER and is a technical process where recurrent complaints involving human health are assessed, any gaps identified, and recommendations towards resolution made. The process is focused on inclusive information gathering, transparency, and stakeholder participation. The intent of this report is not to provide the solution to any gaps identified. Identification of solutions, if required, is the next step in this process, with accountability for any actions directed by recommendations in this report. The process is captured in Figure 1.

## 2 Primary Concern

### 2.1 Background

Odours and air quality have been an ongoing concern for Fort McKay residents. Residents have made multiple complaints about odours that they attribute to the oil sands mines in the vicinity of Fort McKay. Since January 2010, 172 calls to the AER's Fort McMurray Regional Office have been recorded, capturing a variety of concerns. Of those calls, 165 are related to odours.

On October 17, 2014, the Fort McKay Sustainability Department (FMSD) communicated their expectations of industry, requesting that industry identify major odour sources at each operation, identify types of technologies to reduce odours, conduct internal reviews and mitigation for odours during normal operations, produce site maps of odour sources, and initiate on-site odour monitoring groups to report internally on odour sources and odour events. The FMSD recognized this was a long-term plan but progress was required.



**Figure 1. Recurrent human health complaint process**

Industry responded to these expectations by requesting further dialogue and stating that monitoring technology and coverage may not be sufficient to understand odour sources; initiation of programs required validation of their effectiveness in specific applications/locations across sites, and government should be part of the process at senior levels.

During 2014 and 2015, the FMSD reached out to the AER and the Government of Alberta in an attempt to bring more attention to this matter. Fort McKay had also been working with oil sands mining companies to discuss the odour issue during this period.

Early in 2015, industry representatives (Suncor) and the FMSD contacted the AER requesting attendance at a March meeting between the FMSD, industry (Suncor, Syncrude, Imperial, Shell, CNRL), and other government organizations (Environment Canada, Alberta Health) to discuss air quality and odours.

A meeting was held on March 5, 2015. Key points of the discussion included the following:

- The FMSD identified emergency response for odour as a priority with a need for clarification of roles and responsibilities between the community, industry, and government. The FMSD considered the government response to their complaints to be inadequate and sought clarity around the role of Alberta Environment and Parks (EP) (previously Environment and Sustainable Resource Development [ESRD]) relative to the AER (ESRD was not at the meeting).<sup>1</sup>
- A physician practising in Fort McKay expressed little confidence in government. He stated that he instructed fifteen pregnant mothers to leave the community of Fort McKay and not deliver their babies in the community.
- All parties expressed the need for clarity on the science around air quality, who was the regulating agency with respect to air quality given the transition of mandates, and which agency was responsible for monitoring.

Two key issues were identified:

- 1) the odours themselves are experienced on a very frequent basis even with industry operating “normally” and
- 2) a plan was needed for emergency events and possible evacuation of the community of Fort McKay with respect to odours and air quality.

Although these discussions were extensive, next steps could not be agreed on. Some representatives from industry left the meeting. The CEO of the AER was notified by AER staff that further attention to the matter was required.

In May 2015, the AER’s chief environmental scientist was assigned to the file. Soon thereafter, the AER’s recurrent human health complaint process was developed and initiated with the Fort McKay First Nation.

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<sup>1</sup> Throughout this report, you will see references to both ESRD and EP. We have tried to use the name appropriate for the timeframe being discussed, but regardless, the two organizations are one and the same. ESRD became EP on May 24, 2015.



## 2.2 Jurisdiction

The following is a list of groups engaged as a result of the recurrent human health complaint process initiated with Fort McKay First Nation:

- Fort McKay First Nation
- industry (Syncrude, Suncor, Shell, CNRL, Imperial)
- Alberta Health and Alberta Health Services
- Alberta Environment and Parks
- The Alberta Environmental Monitoring, Evaluation and Reporting Agency (AEMERA<sup>2</sup>)
- Environment Canada (including under the Joint Oil Sands Monitoring Program)
- Wood Buffalo Environmental Association (WBEA)
- Canadian Association of Petroleum Producers (CAPP)
- Canada's Oil Sands Innovation Alliance (COSIA)

Understanding the role of each stakeholder requires an understanding of how regulation of the energy sector, including environmental responsibilities and environmental monitoring, has changed over the past three years:

**March 18, 2013:** Ministerial Order 25/2013 established the Joint Oil Sands Monitoring Program (JOSM) between ESRD and Environment Canada (JOSM , 2012). JOSM resulted in changes to environmental monitoring, including in the community of Fort McKay. Regional ambient environmental monitoring transitioned from that conducted by multistakeholder organizations, including industry under regulatory approvals, to that coordinated by government, namely ESRD and Environment Canada through contracts with WBEA.

**June 17, 2013:** *REDA* was proclaimed, except for the powers, duties, and functions of the AER under the specified enactments (*EPEA*, *PLA*, *Water Act*, and Part 8 of the *MMA*). This resulted in the creation of the AER as the regulatory successor to the Energy Resources Conservation Board (ERCB).

**November 30, 2013:** Further *REDA* sections proclaimed, giving the AER powers, duties, and functions under the *PLA* and Part 8 of the *MMA*.

**December 5, 2013:** The *Oil Sands Environmental Monitoring Program Regulation* (AR 226/2013) came into force, establishing the Oil Sands Monitoring Program, which included JOSM. This replaced the ministerial order issued on March 18, 2013, and established the new regional ambient monitoring program. This required oil sands operators to pay the Government of Alberta for regional ambient environmental monitoring that was previously conducted by ESRD but was then conducted by AEMERA.

2 On April 5, 2016, AEMERA transitioned to the Monitoring and Science Division of Alberta Environment and Parks.

**March 29, 2014:** Remaining *REDA* sections proclaimed, giving the AER powers, duties, and functions under *EPEA* and the *Water Act*. This is when environmental oversight under those enactments transferred from ESRD to the AER in relation to energy resource activities.

**April 28, 2014:** The *Protecting Alberta's Environment Act* was proclaimed, which established AEMERA. AEMERA was the new independent monitoring agency for regional ambient monitoring, including for the energy resource sector. AEMERA did not hold regulatory or enforcement functions but implemented the regional ambient environmental monitoring program as specified in operating approvals issued by the AER. Previous regional ambient environmental monitoring organizations (e.g., WBEA, RAMP), as appropriate, worked collaboratively through AEMERA.

**April 5, 2016:** AEMERA transitioned to the Monitoring and Science Division of Alberta Environment and Parks.

Of particular relevance to this report is the fact that all public policy-making authority for provincial resource development activities, including energy resources, resides with the Government of Alberta. EP (through its environmental protection mandate) shares regulatory authority for the protection of human health in the province with the Ministry of Health. The AER is not directly involved in human health regulation, but it may implement health policy when it performs its regulatory functions.

Regulation of the energy resource sector, including environmental protection, now largely resides with the AER. The AER is also responsible for implementing Government of Alberta policy with respect to energy resource activity. This is done for oil sands operators primarily through regulatory approvals under the specified enactments (including *EPEA*, the *Water Act*, and the *PLA*) and under the energy resource enactments such as the *Oil Sands Conservation Act*. AER regulatory approvals require oil sands mining operators to function within specified parameters that are designed to ensure that policy outcomes are achieved. These may include requiring operators to conduct or participate in monitoring and reporting on emissions and ambient air quality.

The AER works with the Monitoring and Science Division of EP to ensure that regional ambient monitoring is aligned with policy outcomes and regulatory approvals for industry, and that information is gathered, collected, and reported to agencies and stakeholders in a manner that ensures the safe, efficient, orderly, and environmentally responsible development of energy resources.

Environment Canada works with the AER and the Monitoring and Science Division of EP to ensure that regional monitoring addresses federal policy goals, regulatory requirements, and scientific needs. Establishing clarity of these roles and responsibilities within and between governments and their respective agencies, and with external stakeholders, is a priority for the AER.

### 3 Description of Area

Fort McKay is located 58 km north of Fort McMurray, Alberta. This document focuses on the area within a 30 km radius from the centre of the community of Fort McKay and encompasses six oil sands mining projects and one in situ project approved by the AER. Figure 2 shows the locations of these projects in relation to Fort McKay.

A radius of 30 km was selected because it includes the significant emitters for air quality and odour in Fort McKay from oil sands development. This area includes oil sands mines, upgraders, and in situ facilities. One facility within this area, the Williams Energy (Canada) Inc. Hydrocarbon Liquids Conservation Project, was not considered because it was not thought to be a significant contributor to odour issues in the area. This facility essentially handles sweet gas ( $<100\text{ppm H}_2\text{S}$ ) and removes liquids from fuel gas received from Suncor. Facilities with tailings ponds, upgraders, amine systems, or sulphur plants were considered as part of this study. The 30 km radius did not consider the Imperial Kearn facilities (partially within the area). Imperial was asked to provide information to this assessment because it has a facility close to the 30 km radius and are a key operator in the oil sands. Two other facilities that are shown on Figure 2 but not included in our analysis were Joslyn North (approved but deferred by the owners, including Total) and Fort Hills (under construction).

Air emissions and odours from the facilities that were considered may originate from the mines, process areas, tank farms, and tailings ponds. Emissions can be from fixed-point sources, from area sources, and from tanks, or mobile sources. For the purposes of this report, fixed-point sources include stacks, and area sources include ponds and mine faces, while mobile sources will be associated only with vehicles. Fugitive emissions are air contaminant emissions released to the atmosphere from a plant source other than a flue, vent, or stack. It does not include emissions that may occur due to breaks or ruptures in process equipment. In this report, fugitive emissions include those from area sources (mines and ponds) and equipment leaks.

This report considered five years of data, from 2010 to 2014. The study period was selected because it reflects the last full five years of data available and the current condition. Note that the AER assumed its environmental duties and functions under *REDA* in March of 2014. This transition resulted, in some cases, in processing datasets and reports across government jurisdictions that previously held this mandate.

A brief description of the facilities considered is in Table 1. This information includes the start-up date of the facility, the area of the tailings pond, and the bitumen production for 2014.





**Table 1. Description of oil sands facilities considered**

Mine name	Start-up Date	2014 Tailings Pond Area (ha)*	2014 Bitumen Production (m <sup>3</sup> /year)**
Syncrude Mildred Lake	1978	4 763	7 596 665
Syncrude Aurora	2000	2 060	10 184 847
Shell Muskeg River	2002	495	7 670 321
Shell Jackpine	2010	620	6 457 410
CNRL Horizon	2008	1 902	7 532 364
Suncor MacKay River	2002	—	1 550 681
Suncor Base Plant and Millennium	1967	2 613	15 925 985

\* Information from industry received by AER's Fort McMurray Office in 2014 as part of oil sands mining liquid impoundment inventory. Other inventories exist (e.g., 2014 Fugitive VOC and RSC Emissions from the Syncrude Mildred Lake and Aurora Oil Sands Facilities, May 21, 2015) but were not verified and available in time for this assessment.

\*\* From Petrinex.

## 4 Emergency Response, Complaints, Inspections, and Investigations

### 4.1 Emergency Response

The FMSD identified emergency response related to air quality, including odours, and oil sands operators as a priority. It was beyond the scope of this assessment to conduct a detailed assessment of emergency response procedures of industry or the community of Fort McKay. However, clarification of the current state, regulatory requirements, and the state of air quality monitoring for the purposes of emergency response in the community were considered.

#### 4.1.1 Emergency Response Planning for Industry

The AER is committed to ensuring effective emergency response through the Field Incident Response Support Team (FIRST) working collaboratively with the Alberta Emergency Management Agency. The AER (through FIRST) and the Alberta Emergency Management Agency support operators and local municipal authorities in protecting the public and the environment and bringing incidents safely under control as quickly as possible. The Government of Alberta also has a provincial operations centre, which provides a provincial-level emergency response coordination facility shared by all public safety stakeholders. The operations centre is organized to provide response support, coordination, and communication.

With respect to regulatory requirements, *Directive 071: Emergency Preparedness and Response Requirements of the Petroleum Industry* sets out requirements for some industry in regards to emergency preparedness and response. *Directive 071* derives its authority from the *Oil and Gas Conservation Act (OGCA)*, so it only pertains to conventional energy facilities such as wells, pipelines, and conventional processing facilities (AER, 2009). Under the *OSCA*, operators of mines and process facilities are required to have an emergency response plan (ERP) on file to present to the AER upon request, and *Directive 071*

may be used as guidance, but it is not a requirement (AER, 2009). For facilities required to comply with *Directive 071*, it ensures that

- appropriate ERPs are in place to respond to incidents that present significant hazards to the public and the environment,
- there is an effective level of preparedness to implement ERPs, and
- there is the capability in terms of trained personnel and equipment to carry out an effective emergency response to incidents.

Under *Directive 071*, it is primarily the operator's responsibility to identify an emergency and ensure a quick and effective response to protect the health, safety, and welfare of people and limit damage to property and the environment (AER, 2009). Emergency response planning must address roles and responsibilities of responders, procedures for how and when public notification will take place, and how evacuation will be accomplished during an incident. Although each ERP is slightly different, there are common requirements, described in section 5 of *Directive 071* (AER, 2009). ERPs must include the following:

- public protection measures such as evacuation,
- notification requirements,
- air quality monitoring,
- maps showing the emergency planning zone (geographical area surrounding a facility that requires specific emergency response),
- responsibilities of personnel during an emergency,
- mutual aid agreements, and
- a summary of discussions that operators have had with local authorities regarding notification and evacuation.

Should an operator be inadequately prepared for or incapable of handling an incident, the AER has staff trained in emergency response who will assume control of the response. During incidents where there is an immediate need for action and protection, and where the source of the release is clearly identified, the AER response typically involves the following steps:

- The AER receives information about the emergency through consultation with the operator.
- The AER dispatches a representative to the emergency site and confirms that local resources such as police, fire, emergency medical services, or spill response have been notified.
- The AER confirms, plans, or implements public safety actions to ensure the safety of the public and the environment.



- A regional emergency operation centre is established to coordinate response activities, including deployment of other Government of Alberta staff as appropriate.
- The AER acts as the lead agency and provides coordination and updates to stakeholders regarding the emergency situation.
- When the emergency has concluded and there is no longer a hazard, affected stakeholders are notified.

In addition, the *Approvals and Registrations Procedure Regulation* under *EPEA* sets out the requirements for an *EPEA* application:

3(1) An application must be made to the Director and must be accompanied by the following information relative to the activity, the change to the activity or the proposed amendment, addition or deletion of the term or condition: ... (n) confirmation that any emergency response plans that are required to be filed with the local authority of the municipality in which the activity is or is to be carried on or with Alberta Public Safety Services have been so filed; (o) confirmation that there are contingency plans in place to deal with any unforeseen sudden or gradual releases of substances to the environment.

Oil sands operators are required to have ERPs that will be followed in the event of an uncontrolled emission of contaminants to the air, water, or land. The AER has two air monitoring units (AMUs) that are stationed in Drayton Valley (for northern Alberta) and Calgary (for southern Alberta). These mobile AMUs are deployed in response to incidents to monitor for H<sub>2</sub>S and SO<sub>2</sub> in the air near the incident site. The AMU helps to track the emissions plume, determine whether evacuation air quality levels have been met, and determines concentrations in areas to ensure safe evacuation.

#### 4.1.2 Emergency Response Planning in the Community of Fort McKay

Emergency response planning for the Fort McKay First Nation is the responsibility of the Fort McKay First Nation. The Fort McKay First Nation's ERP is in the process of being updated. Emergency response and evacuation related to air quality and odours does not exist in the Fort McKay First Nation's ERP. There are also no established links between ambient environmental monitoring and emergency response described in the Fort McKay First Nation ERP.

Development of an ERP for the Fort McKay First Nation would be informed by each of the operator's ERPs. Currently, there is no consistency around whether operators must provide their ERPs (or relevant sections of their ERPs) to the Fort McKay First Nation. Clarity is required to ensure seamless planning related to emergency response for both industry and the community of Fort McKay.

#### 4.1.3 Acute Air Quality Monitoring and Emergency Response

The community of Fort McKay is not within the lease of any one of the operators but is effectively surrounded by operations and cumulative air emissions. Ambient air quality is measured at air monitoring stations in the community by both WBEA (under EP) and Environment Canada. The monitoring stations are funded by industry through the Government of Alberta and the JOSM program.

Regional ambient air monitoring is designed to measure parameters for averaging periods consistent with Alberta's ambient air quality objectives (AAAQOs; Government of Alberta, 2013) and other standards, for example on a one-hour basis. The detection limits, instrumentation, and data from the WBEA monitoring network has two limitations:

- Odour events can occur on a subhourly timescale; therefore, the averaging period of the current reported information in some cases might not be high enough resolution to capture short-term odour events. That said, odiferous plumes have been tracked from fenceline to community stations most recently with this level of resolution.
- Acute levels of parameters which would require emergency management in the community and trigger emergency responses (notification or evacuation) cannot be measured because currently the maximum measurement level of the instrumentation is well below the emergency management thresholds for SO<sub>2</sub> and H<sub>2</sub>S as indicated in *Directive 071* (AER, 2009), for example.

Emergency response requirements for important air quality parameters such as H<sub>2</sub>S and SO<sub>2</sub> are known and are typically specified for on-site operations. Appendix 6 of *Directive 071* (for conventional oil and gas operations) specifies evacuation thresholds for H<sub>2</sub>S and SO<sub>2</sub> (AER, 2009). This includes evacuation when above 10 ppm in rural areas and 1 ppm in urban areas for H<sub>2</sub>S (3 minute average) and 5 ppm for SO<sub>2</sub> (15 minute average) (AER, 2009). Continuous monitoring instruments throughout the ambient monitoring network do not have alarm systems with predetermined emergency evacuation triggers for chemicals which may present an acute risk to human health.

The potential or risk of acute air quality issues requiring emergency response in the community of Fort McKay is extremely low based on controls placed into *EPEA* approvals and modelling conducted during environmental impact assessments prior to project approval. However, it is critical that the community of Fort McKay understand when air quality poses an immediate and acute health concern. Given that acute evacuation concentrations are known for important air quality parameters, monitoring technology exists for this purpose in other areas, and considering the potential for cumulative air emissions to affect this community, acute air quality monitoring in the community for selected parameters should be considered.

The community of Fort McKay is in a unique situation related to this issue due to

- proximity of the cumulative oil sands development to the community;
- single entry and exit point into the community;



- the type of development and diversity of emissions relative to other communities;
- the uniqueness of the meteorology, wind patterns, and landscape, including the river valley that, under the right conditions, can serve as a conduit of emission to the community; and
- the uniqueness of upgraders.

The suggestion to consider monitoring of acute air quality for select parameters in the community of Fort McKay for the purposes of emergency response is based on the unique criteria specified above for this community.

There are no established odour levels in policy or regulation that trigger an immediate acute health concern and emergency response. Even if monitoring for acute odour levels were conducted in the community of Fort McKay, no emergency response procedures would be triggered in the absence of this policy direction. Guidance is required from Alberta Health for acute odour thresholds.

#### 4.1.4 Recommendations

**Recommendation 1:** Ambient air quality monitoring for acute concentrations of H<sub>2</sub>S and SO<sub>2</sub> should be instituted for the purposes of emergency response (including potential evacuation) in the community of Fort McKay within one year. Monitoring should be conducted by EP, funded by industry, and acute thresholds for H<sub>2</sub>S and SO<sub>2</sub> concentrations approved by Alberta Health in discussion with Fort McKay. Review of this monitoring program, including the need for additional parameters, should be conducted annually. Lead for monitoring: EP supported by the AER.

**Recommendation 2:** Policy guidance is needed on the appropriateness of odour thresholds for emergency response purposes in the community of Fort McKay. Lead: Government of Alberta supported by Alberta Health.

**Recommendation 3:** Oil sands industry ERPs (or relevant sections) should be shared with the community of Fort McKay through a regulatory mechanism or instrument to be determined. Lead: AER.

## 4.2 Complaints, Inspections and Investigations

This section reviews the complaints, inspections, and investigations that have occurred over the five-year study period (2010–2014). To understand the odour issues, it is important to understand the complaints received. It is also important to understand how the AER carries out the day-to-day work of ensuring compliance with regulatory requirements through inspections and investigations.

### 4.3 Process

A formal complaint is an expression of concern from a stakeholder regarding an operation, site, or facility under the jurisdiction of the AER that the stakeholder believes is causing, has caused, or may cause an adverse impact to public safety, the environment, or personal property. The complaint data used in this report is drawn from the phone calls received from the Coordination and Information Centre (CIC). This report only includes complaints in the AER's databases from the CIC. Before April 2014, these complaints were tracked by the Environmental Management System (EMS), which was under the jurisdiction of ESRD. The Field Inspection System (FIS) was used after April 2014 and is under the jurisdiction of the AER.

All complaints received by the AER are triaged and prioritized according to the nature of the complaint. If a human health symptom is reported, the complainant is directed to call the local health authority or Alberta Health to log the complaint and seek medical attention as necessary. A complaint may be linked to an incident or an inspection, as defined below. Not every complaint is linked to an incident nor is an inspection or investigation initiated for each complaint received.

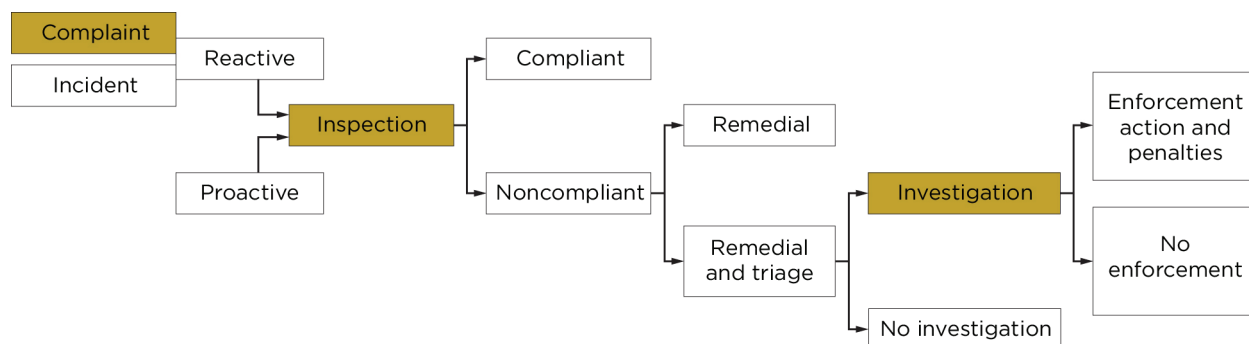
When an industry stakeholder contravenes legislation or their approval or licence under the AER's jurisdiction, it may be termed an incident and includes releases, exceedances of approval limits, failures, and emergencies. This may also include fires, well blowouts, injuries, and fatalities.

Response to both incidents and complaints are based on an assessment using criteria such as risk to public safety, impact on the environment, resource loss, and severity of the equipment damage. For AER-regulated facilities, an incident response, which may include an inspection, is conducted based on these criteria. Priority may be given in situations where AER staff believes additional attention is warranted.

An inspection is any field activity undertaken to verify compliance with regulatory requirements. They are both reactive and proactive (based on the risk-informed planning process), can be operation specific or sector based, and, wherever possible, are coordinated with audit activities. Reactive inspections may occur in response to information such as audits, incident notifications, or complaints that come to the attention of the AER. Inspections can also be announced or unannounced, meaning that the facility may or may not know in advance that an inspection will take place.

After a facility inspection has been conducted, the facility is found to be either compliant or noncompliant with the regulatory requirements. If the inspection finds noncompliances, remedial action will be required, and a triage process can be initiated to determine if there should be an investigation. During an investigation, the noncompliance is reviewed in considerable detail and additional evidence may be gathered. The investigation may result in enforcement actions that may include warnings, suspensions, orders, and administrative penalties or prosecutorial actions.

Figure 3 illustrates the AER's complaint response process showing how a complaint may result in an inspection or investigation. The three areas analyzed in this section of the report are highlighted in yellow.



**Figure 3. AER process describing the relationship between complaints, inspections, and investigations**

An odour complaint does not represent a noncompliance because odours are not a specific regulatory requirement within *EPEA* approvals and may be difficult to link with specific industrial operations, especially in a cumulative context. If an odour complaint can be linked with a contravention at an approved facility and ambient air quality impacts (i.e., releases of substances resulting in exceedances of Alberta's and Canada's ambient air quality objectives), then appropriate enforcement action can take place. There are, however, no specifically defined odour limits in *EPEA* approvals, which constrains the use of odour complaint data for inspection and compliance purposes. There are more general or indirect provisions in *EPEA* approvals through which odour might be addressed, but the subjectivity of the assessment in the absence of policy is a constraint for assessment of compliance. For example:

- With respect to fugitive emissions, the approval holder shall not release a substance or cause to be released a substance that causes or may cause any of the following;
- (a) impairment, degradation or alteration of the quality of natural resources; or
  - (b) material discomfort, harm or adverse effect to the well-being or health of a person; or
  - (c) harm to property or to plant or animal.

In some cases, odour complaints may trigger an inspection that identifies a noncompliance, but the odour itself would not typically be the noncompliance. Limits for select chemicals associated with air emissions are specified in approvals. The contaminants  $\text{SO}_2$ ,  $\text{NO}_x$ , and  $\text{NH}_3$  are typically specified in stack emission monitoring clauses of oil sands approvals and may be used to link odour complaints to noncompliances. Thresholds around opacity and particulates are also found in some existing approvals. On-site monitoring for fugitive emissions of volatile organic compounds (VOCs) and other specialty monitoring may also be required as per the approval. Industrial and ambient monitoring may also be included as part of the operating approval and is typically implemented through the WBEA air monitoring network under EP. This also includes biomonitoring and the Human Exposure Monitoring Program (HEMP). Specialty studies as part of an *EPEA* operating approval may include ground-level ozone monitoring and off-road vehicle emission studies.

There is a provision in *EPEA* that can address offensive odours through an environmental protection order (EPO; RSA 2000 cE-12 s116;2001 c16 s6) (Province of Alberta, 2014):

116(1) Where the Director is of the opinion that a substance or thing is causing or has caused an offensive odour, the Director may issue an environmental protection order to the person responsible for the substance or thing.

(2) Subsection (1) does not apply in respect of an offensive odour that results from an agricultural operation that is carried out in accordance with generally accepted practices for such an operation or in respect of which recommendations under Part 1 of the Agricultural Operation Practices Act indicate that the agricultural operation follows a generally accepted agricultural practice.

(3) An environmental protection order under this section may order the person to whom it is directed to take any or all of the following measures:

- (a) investigate the situation;
- (b) take any action specified by the Director to prevent the offensive odour;
- (c) minimize or remedy the effects of the offensive odour;
- (d) monitor, measure, contain, remove, store, destroy or otherwise dispose of the substance or thing causing the offensive odour or lessen or prevent the offensive odour;
- (e) install, replace or alter any equipment or thing in order to control or eliminate the offensive odour;
- (f) construct, improve, extend or enlarge a plant, structure or thing if that is necessary to control or eliminate the offensive odour;
- (g) take any other action the Director considers to be necessary;
- (h) report on any matter ordered to be done in accordance with directions set out in the order.

Environmental protection orders for odours are not commonly issued during inspections due to the subjectivity around odours, especially given that odour thresholds have not been defined in Alberta.

When an odour complaint comes into the AER, the field inspector calls the complainant to determine the location of the complaint, when it occurred, how strong the odour is, and any other relevant information. This information is gathered using a standardized form.

The inspector then reviews the ambient air quality monitoring data and wind data at the nearest WBEA air monitoring stations relative to the location of the complaint. Data that is monitored at different time intervals (e.g., 5 minute, hourly) is examined. These data are available from the WBEA website (WBEA, 2016).

The parameters reviewed are dependent on the type of complaint received. Parameters such as H<sub>2</sub>S, THC, SO<sub>2</sub>, and NO<sub>x</sub> are commonly reviewed to identify variations over time (before and after the complaint was received.) Data are examined for 4 to 6 hours before the start of the reported incident and 4 to 6 hours after the end of the incident. Ground-level concentration (GLC) exceedances, where concentrations are greater than AAAQOs, are assessed. In addition, any general increase of parameters over background concentrations is also examined. All data are saved and attached to the incident report. Depending on the wind direction found at the first station checked, additional stations upwind and crosswind of the incident location will also be examined.

If elevated parameters are identified, the inspector will call any relevant facilities to determine if any scheduled maintenance or shut-downs have occurred or any unintentional, temporary problems with normal operation of the facility (upsets) were reported during the time of the odour complaint or at the time an increase in parameters were observed at the WBEA station nearest to the operation.

The inspector will also look for reported upsets or planned events in the 12 to 24 hours before the reported incident from facilities that are upwind of the odour incident that may be contributing to the odour. If any facilities upwind of the odour incident have recently reported anything that may be contributing to the odour, they are expected to submit a report with details of the release and any remediation that took place.

If there is evidence of a substantial contaminant plume moving through the area (i.e., GLC exceedances of AAAQOs observed at multiple WBEA stations that appear to be travelling with the wind over time), FIRST is notified and may initiate emergency management of the event. Alberta Health is also notified.

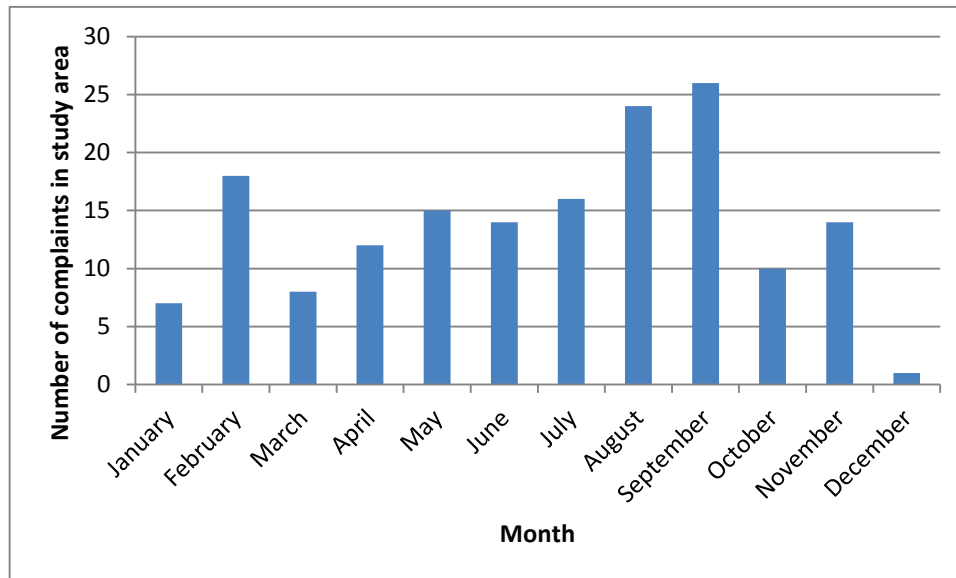
The inspector may request continuous emissions monitoring system (CEMS) data from a facility's stack to see if anything may have caused an off-site odour. If discrepancies are identified between what the company has provided and what information has been collected, an inspection may be initiated to determine if a noncompliance has occurred. If no variations have been identified in the data received, and no company has identified operations that could have caused the off-site odour, the complaint will be closed because a noncompliance cannot be determined unless a source has been confirmed and approval requirements have not been met.

#### 4.4 Complaints

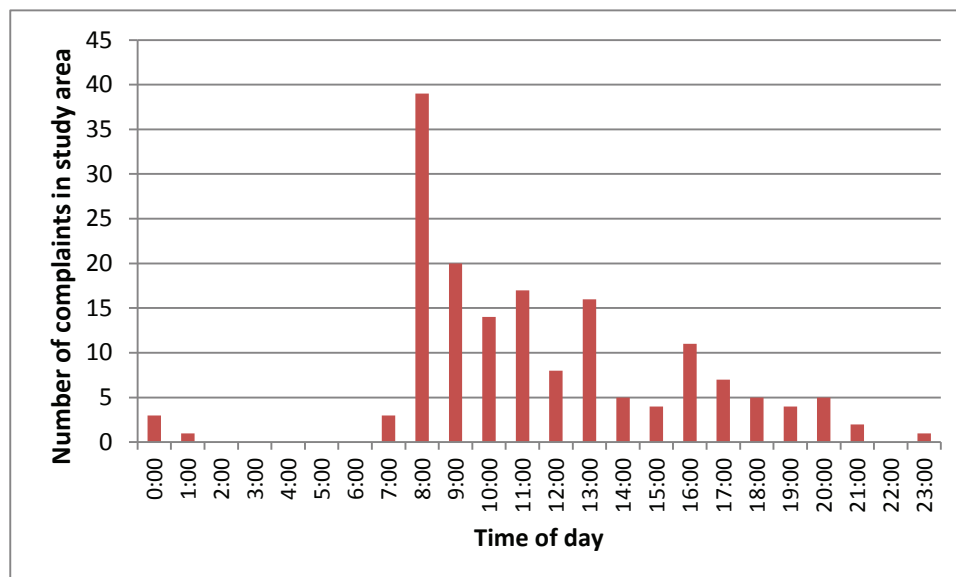
Only complaints received through the CIC and that are from the community of Fort McKay are presented here. There were 172 complaints of all types received from the community of Fort McKay, of which 165 were odour related. Table 2 summarizes the number of odour complaints by year and the number of days with one or more odour complaint. In total, there were 113 days in which there was at least one odour complaint. Due to the large number of complaints over the five-year study period, the details of each complaint are not provided in this report. However, in the analysis section of this report, some complaints that occurred on selected dates are reviewed in detail.

**Table 2. Odour complaints by year from Fort McKay**

Year	Number of odour complaints	Number of days with odour complaints
2010	42	26
2011	25	22
2012	16	13
2013	17	13
2014	65	39
<b>Total</b>	<b>165</b>	<b>113</b>



**Figure 4. Odour complaints by month during the study period in the community of Fort McKay**



**Figure 5. Odour complaints by time of day during the study period in the community of Fort McKay**

The total number of odour complaints, broken down by the month of year and hour of day, are presented in Figure 4 and Figure 5 and show that odour complaints tend to occur during warmer temperatures in the year (July, August, and September with the exception of February). It is important to note that the data presented in Figure 4 and Figure 5 are not based on a single year but for the five years in aggregate. Annual trends from year to year have not been analyzed.

Figure 5 illustrates that complaints were the highest in the morning until about 13:00. This could be due to a combination of different factors, including ambient conditions or typical times that odours are encountered by complainants.

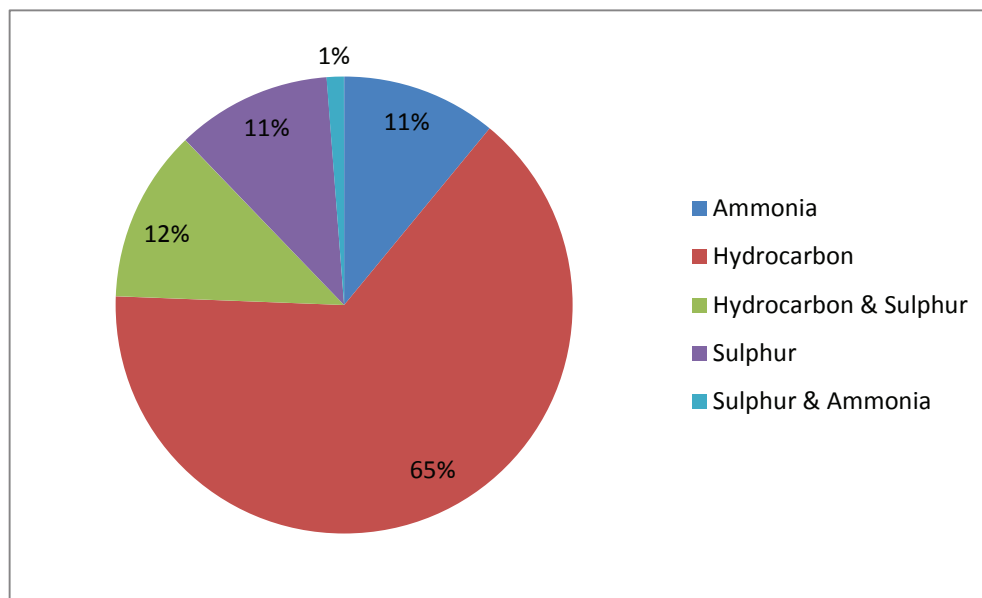
In 82 of the 165 complaints, the odours were described as either hydrocarbon, sulphur, ammonia, or any combination of the three. These descriptions are solely based on the complainant's perception of the odour at the time of the complaint. Figure 6 shows a breakdown of the identified odours as described by the complainant.

#### 4.5 Inspections

During the study period, 523 inspections were conducted at the facilities in the Fort McKay area.

Table 3 summarizes the number of yearly inspections and noncompliances found. The data below includes all types of inspections—not just those related to odours.

Of the 523 inspections, 342 were proactive and 181 were reactive. The 181 reactive inspections were conducted in response to a complaint or incident.



**Figure 6. Complaints by odour type in the community of Fort McKay**

**Table 3. Number of inspections and identified noncompliances in the study area**

Year	Total inspections	Number of noncompliances
2010	114	8
2011	105	15
2012	82	7
2013	139	2
2014	83	3
<b>Total</b>	<b>523</b>	<b>35</b>

There were 35 noncompliances found across 523 total inspections, a 93 per cent compliance rate. Most facilities were operating within the requirements (including their *EPEA* approval and *OSCA* legislation) at the time of the inspection. A summary of the 35 noncompliances by the type of noncompliance is presented in Figure 7.

Based on the AER's review of noncompliances in the study area, it is expected that unreported leaks, spills, or releases may be the most likely noncompliances that affect emissions and contribute to odour issues. However, this only makes up approximately 18 per cent of the total number of noncompliances.

#### 4.6 Investigations

Investigations can be described as the next level of the AER's compliance assurance process, in which there is more scrutiny on why a noncompliance occurred to determine what actions can be taken to ensure compliance. The data in Table 4 includes all types of investigations and are not specific to odours.

Some of the investigations resulted in penalties being assessed and some investigations are still ongoing, so the detailed information remains confidential. In total, five out of the twelve investigations were related to emissions (e.g., H<sub>2</sub>S releases or a CEMS unit not operating properly).

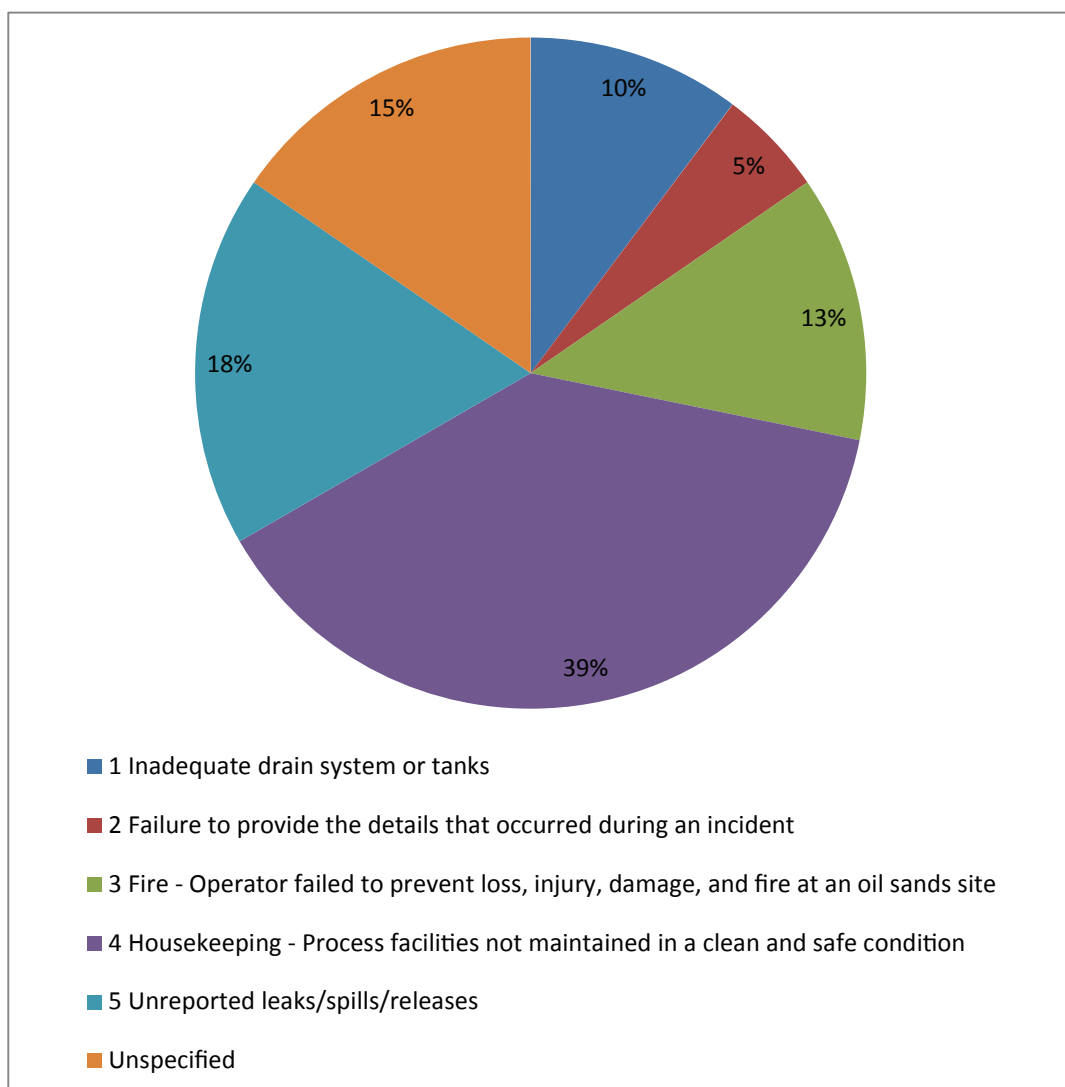
#### 4.7 Results and Analysis

Figure 8 shows the odour complaints, inspections (including available EP inspection data<sup>3</sup>), and noncompliant inspections over the five-year study period. The number of noncompliances is low in most years compared to the total number of inspections conducted.

The number of complaints received by the CIC has decreased by more than half between 2010 and 2013, which could indicate that odours were less of a concern over this timeframe. The community of Fort McKay stated that their motivation to file a complaint decreased over many years due to the perceived lack of action by government to resolve the complaints.

<sup>3</sup> Note that some information regarding ESRD inspections could not be retrieved and those results have not been included in this figure.

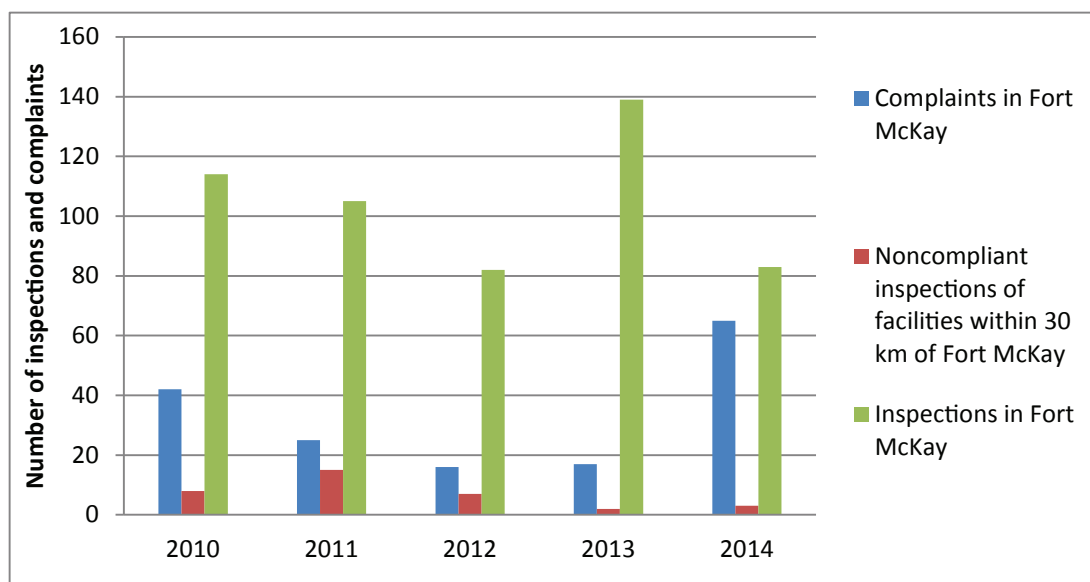




**Figure 7. Percent of noncompliances by type (out of thirty five) recorded in the study area from 2010 to 2014**

**Table 4. Number of investigations of AER-regulated operations in the study area from 2010 to 2014**

Year	Number of investigations of AER-regulated operations
2010	4
2011	0
2012	2
2013	2
2014	2
<b>Total</b>	<b>10</b>



**Figure 8. Summary of odour complaints, inspections (all types), and noncompliances (all types) in the study area for the study period**

Before 2010, a number of improvements were made by industry following the EPOs issued to Syncrude in 2006 and 2007 and Suncor in 2007, which have improved air quality and may have influenced the number of odour complaints. Odour complaints were highest in 2014.

The following events during the study period may also have affected the number of odour complaints:

- 1) A hydrotreater was installed at Suncor in 2012 to remove sulphur compounds from its solvent, which has reduced the odour from unrecovered solvent that is discharged to the tailings pond.
- 2) A flue-gas desulphurization (FGD) unit was commissioned by Syncrude in 2013 and was able to reduce emissions of compounds containing sulphur, which can be odorous.
- 3) In March 2014 the AER released a report about emissions and odours from heavy oil operations in the Peace River area. Members of the public stated that interest in the Peace River report may have increased the public interest in odours from oil sands operations and have contributed to the increased number of odour complaints received in 2014.

#### 4.8 Recommendations

Five recommendations have been made for gaps identified in this section of the report.

Several odour complaint response protocols as well as odour management guidance documents have or are being developed in the province, including those developed by the Clean Air Strategic Alliance (CASA 2015a,b), the Cumulative Environmental Management Association (CEMA), the AER (Peace River proceeding [AER, 2013] and section 8.23 of *Directive 060* [AER, 2016a]), and the Air & Climate Change Policy Branch of EP (Odour Management Team). A consistent approach is required for application by the AER.

Lines of communication between the AER, industry, and the community must be explicitly clear when information pertaining to an air quality or odour is provided through a complaint. Several gaps in lines of communication have been identified, including the following:

- The community of Fort McKay has reported fewer odour complaints to the AER because they believe that nothing can or will be done about them.
- At times, complaints are not reported to the AER but to individual operators, which complicates the ability to link odour complaints to industry operations. It is difficult for the AER to act on an odour complaint it does not receive.
- There is inconsistent communication by industry and the AER to the community for significant upsets or events that could potentially cause odours in the community.
- It is unclear to the FMSD when and why the AER has closed or resolved an odour complaint.
- Operators stated that on many days when complaints were noted by the AER, the companies were not informed of the complaint.

**Recommendation 4:** An AER odour complaint response protocol specific to the community of Fort McKay and consistent with odour management policy of the Government of Alberta is required. The protocol must consider the outcomes of this report, be transparent, establish lines of communication between the AER, industry, and the community of Fort McKay, and improve current complaint closure and resolution rates. The protocol must also consider use of the most appropriate ambient monitoring datasets. Lead: AER.

There is not sufficient information to correlate an odour complaint to a specific emission, emission source, facility, or operation. This correlation would be helpful to move towards mitigating odours through operational changes and technology improvements and to ensure that the occurrence of an odour is placed into the appropriate context of an emission. Correlating an odour complaint and an air quality emission from an oil sands facility is currently challenging due to several factors:

- There is a lack of on-site monitoring for odorants from potential sources.
- There is a lack of on-site odour monitoring consistent with ambient monitoring in the community for odours.
- Monitoring conducted by Environment Canada in the community of Fort McKay is shared with the community of Fort McKay in real time. These same data are not shared with industry, WBEA, the AER, or the public in real time. Wider sharing of these data in real time (flagged as “preliminary” if necessary) would help correlate odour complaints with operations.

- The definition of an “upset or significant event” will vary from company to company. When an odour complaint is received and an operator is contacted by the AER to inquire regarding industry operations, some companies interpret an “upset or significant event” to mean outside of approval conditions even though it could be significant from an emission or odour perspective.
- Given the nature of the operation, approvals have consideration for upset conditions. Cumulative emissions from multiple operations combined with meteorological (i.e., inversions) and terrain conditions (i.e., river valleys) can affect plume dispersion.

**Recommendation 5:** A standardized checklist for operating conditions must be developed and used as a best practice by industry when an odour complaint is received by the AER and industry is contacted by the AER. The checklist should be developed collaboratively with the AER, industry, and Fort McKay First Nation, be filed by the AER with the complaint, and be included in the odour response protocol described in recommendation 4. Transparency and access to this checklist as part of complaint closure should be considered in protocol development. Lead: AER.

Odour thresholds exist in other jurisdictions but have not been specifically identified in Government of Alberta policy and thus are not a regulatory requirement in *EPEA* approvals for operators. Therefore, odours cannot be treated as noncompliances as there is not an established threshold to use to evaluate compliance or to compare monitoring data to.

**Recommendation 6:** Policy guidance is needed on the use and application of odour thresholds in the community of Fort McKay and to clarify the use of environmental protection orders (EPOs) under *EPEA* by the AER to address offensive odours.  
Lead: Government of Alberta supported by Alberta Health and the AER, with technical participation of Fort McKay.

EP and Environment Canada monitor in the community of Fort McKay but do not have a confirmed role in complaint response or notification related to GLC exceedances. Previously, WBEA would assess ambient monitoring data in real time and notify the CIC of exceedances of some air quality parameters over AAQOs. The CIC would then notify the AER and EP. WBEA is now funded and supported under a contractual agreement with EP (previously with AEMERA). This role in complaint response or notification related to GLC exceedances is not captured in that agreement. WBEA however continues to perform the role. This accountability is important to clarify given that any complaint received by the AER is assessed by evaluating ambient monitoring datasets and GLC exceedances. It has also not been articulated through the regional monitoring program under JOSM how the Environment Canada ambient data is used relative to the WBEA ambient monitoring data for complaint response related to odours (Government of Alberta, 2012).

**Recommendation 7:** All parties should have access to real-time monitoring data collected by Environment Canada in the community of Fort McKay. Lead: Environment Canada supported by EP and the AER.

**Recommendation 8:** Accountability for supporting complaint response and notification of ground-level concentration exceedances through ambient monitoring should be clarified and included in the odour response protocol described in recommendation 4. Lead: EP supported by the AER.

## 5 Industry Performance Monitoring

### 5.1 Introduction

Approvals limit the release of selected emissions from major sources and specify monitoring requirements. The focus of the approvals is on SO<sub>2</sub>, NO<sub>x</sub>, and particulates associated with combustion equipment. In this report, information has been supplemented with VOC and total reduced sulphur (TRS) emission data from the National Pollutant Release Inventory (NPRI) and methane (CH<sub>4</sub>) emission data from the *Specified Gas Emitters Regulation (SGER)* (Province of Alberta, 2015). VOCs, TRS, and CH<sub>4</sub> can be associated with incomplete combustion, but they are also emitted from vents, process areas, ponds, and mine faces. These compounds were the focus in this section of the report because they may be odorous or used as potential indicators of odorous emissions. A detailed review of *EPEA* approval applications and environmental impact assessments was not conducted as part of this report.

### 5.2 Emission Sources in Approvals

Each *EPEA* approval identifies the air emission sources at the facility. Facilities in the study area (Table 5) are significant in size, produce significant emissions, and produce most of the mineable bitumen in Alberta. A brief description of the facilities in this area is given below. The study area includes six mines (three with upgraders) and one in situ facility. Site plans for each of these facilities are shown in Appendix 2. The site plans provide an indication of the size of these facilities and their associated footprint.

**Table 5. Facilities in the study area**

Mine name	Distance to Fort McKay (km)	Type	Upgrader	Production	Solvent type
Syncrude Mildred Lake	16	mine	yes	SCO, bitumen	naphtha
Syncrude Aurora	18	mine	no	bitumen froth	n/a
Shell Muskeg River	6	mine	no	bitumen	paraffinic
Shell Jackpine	18	mine	no	bitumen froth	n/a
CNRL Horizon	19	mine	yes	SCO, bitumen	naphtha
Suncor MacKay River	21	in situ	no	bitumen	n/a
Suncor Base Plant and Millennium	27	mine	yes	SCO, bitumen	naphtha

Each *EPEA* approval provides emission limits for particular sources located at each facility. Emission limits for facilities are set to minimize the amount of pollutants released to the environment. This helps ensure that when facilities are built, they are built to meet applicable emission standards (both provincial and federal), which consider what pollution control technologies are available at the time of project approval.

Modelling of source emissions is also typically required by *EPEA* approvals. The Government of Alberta sets out accepted models and modelling parameters in the *Air Quality Model Guideline* (Government of Alberta, 2013). Source emissions are modelled to verify that AAAQOs will be met. There are only three compounds that have AAAQOs that are based on odour. These are hydrogen sulphide ( $\text{H}_2\text{S}$ ), ammonia ( $\text{NH}_3$ ), and carbon disulphide ( $\text{CS}_2$ ).

Source emissions limits are primarily set for  $\text{SO}_2$  and  $\text{NO}_x$ . Fixed-source monitoring for other compounds, including potentially odorous compounds, is limited. Sources can include equipment such as boilers, heaters, dryers, gas turbines, incinerators, central processing facilities, steam generators, flare and other stacks, and diesel power units. *EPEA* approvals may also set performance targets for selected equipment.

Approval limits may involve different averaging periods (e.g., hourly, calendar day, 90 day rolling, 365 day rolling) for different facilities. Approvals include both individual stack limits and site-wide limits.

Combustion by incinerators, thermal oxidizers, or flare stacks can be used as a way to reduce odorous compounds found in various gas streams. Temperature is also an important factor in dispersing compounds to the environment, and minimum temperature limits help ensure that combustion efficiency is high. Minimum stack-top temperatures are set for incinerators and thermal oxidizers, but not for stacks with wet scrubbing. Upstream of wet scrubbing stacks, higher temperatures in boilers help ensure that combustion efficiency is high. Wet scrubbing in stacks is used to remove additional pollutants from the emissions and occurs at a lower temperature. There are no minimum temperatures specified for these stacks, but temperatures are monitored. Given the nature of the process, there is no easy way to control temperature of wet stacks, which is dependent on upstream operation.

There are sources listed in some *EPEA* approvals that do not have monitoring or reporting requirements, where emissions are generally expected to be small. This is because the AER assumes that the emissions from these sources are consistent with conditions described in the original project application, including the original modelling scenarios.

There is also gas released to the environment with minimal to no odour controls at the source of release (e.g., ponds and mine faces). Releases from sources such as tailings ponds can be minimized by controlling upstream operations such as improved solvent recovery.

There are no regulatory requirements for operators to determine the odour potential of the various emission sources at their sites or to consider odour as part of their air dispersion modelling.

Approvals have requirements for both monthly and annual reporting to the AER. Based on our review of a sample of monthly and annual industry reports examined for the three facilities with upgraders, quality control could be improved. Problems include differences between the monthly and annual reports, errors in units, and totals that have been truncated. The type of information provided in the reports also appears to vary across different *EPEA* approvals. *EPEA* approvals are issued on a facility-by-facility basis and are specific to the individual operations. They take into account feedback from companies and other stakeholders.

There are other standards cited in the *EPEA* approvals which too must be met. These include Canadian Council of Ministers of the Environment (CCME) standards for tanks and fugitive emissions from equipment leaks (CCME, 1993).

Approvals for each operator are available to the public through the approval viewer on EP's website (<http://aep.alberta.ca/lands-forests/land-industrial/programs-and-services/authorization-viewer.aspx>).

## 5.2.1 Stack Limits

### 5.2.1.1 SO<sub>2</sub> Limits

Sources of SO<sub>2</sub> emissions on sites with upgraders can include stacks where sour fuel gas is used, flare stacks, FGD units, diverter stacks, and incinerator stacks. Mine fleets can also contribute to SO<sub>2</sub> emissions but should be mitigated through the use of low-sulphur diesel. SO<sub>2</sub> emissions will occur with other sulphur compounds as well; for example, acid gas flared will primarily result in SO<sub>2</sub> emissions, but H<sub>2</sub>S and TRS will also be present in much smaller quantities due to combustion inefficiency. SO<sub>2</sub>, H<sub>2</sub>S, and TRS compounds can all be odorous.

Approved SO<sub>2</sub> emission limits for the facilities with upgraders are among some of the largest approved sources of SO<sub>2</sub> in the province. These limits are listed in Table 6. The table also illustrates the wide range of limits. These limits are set for specific fixed-point and site-wide sources and have various averaging periods and different limits for different facilities. This makes monitoring approval conditions more complicated.

Generally, approval limits allow some room for upsets and emergencies, and modelling is done at the application stage to ensure that AAAQOs are met during these periods. In addition, limits may vary across different operators but should generally reflect emissions standards of the date they were written.

For comparison purposes, limits in Table 6 have a column in which limits are standardized to tonnes per day for instances where the approvals express the limits in different units. This allows for a comparison of the various rates that have been approved and shows that generally for shorter periods of time, a higher rate of emissions is allowed.

**Table 6. Sulphur dioxide approval limits for upgraders in the study area**

SO <sub>2</sub> source	SO <sub>2</sub> limit	Averaging period	SO <sub>2</sub> limit standardized to t/d	Date of approval
<b>Suncor</b>				<b>December 17, 2014</b>
Old Main powerhouse stack	14.2 t/h	1 hour	340.8	
	259 t/d	1 day	259	
	4700 ppm	1 hour	n/a	
Thermal oxidation unit 1 exhaust stack (During time periods when the Tail Gas Treatment Unit 1 is in operation)	1.2 t/h	1 hour	28.8	
	51 t/d	1 day	51	
	9000 ppm	1 hour	n/a	
Thermal oxidation unit 1 exhaust stack (During time periods of sulphur recovery plant at U1 or U2 start-up, shutdown, upset and heat soaking of catalyst beds or when the Tail Gas Treatment Unit 1 is bypassed)	3 t/h	1 hour	72	
	20 000 ppm	1 hour	n/a	
Thermal oxidation unit 2 exhaust stack (During time periods when the Tail Gas Treatment Unit 2 is in operation)	1.7 t/h	1 hour	40.8	
	28.3 t/d	1 day	28.3	
Thermal oxidation unit 2 exhaust stack (During time periods of sulphur recovery plant at U1 or U2 start-up, shutdown, upset and heat soaking of catalyst beds or when the Tail Gas Treatment Unit 2 is bypassed)	4.4 t/h	1 hour	105.6	
Thermal oxidation unit 4 exhaust stack (During time periods when the Tail Gas Treatment Unit 4 is in operation)	0.7 t/h	1 hour	16.8	
	14.2 t/d	1 day	14.2	
All Sources	360 t/d	24 hour rolling average	360	August 13, 2007
All Sources (when starting up two or more upgraders to prevent freeze-up)	500 t/d	24 hour rolling average	500	
All Sources (commencing 550 days after start of the Millennium Coker Unit)	79 t/d	365 day rolling average	79	
<b>Synchrude</b>				<b>April 14, 2015</b>
Main stack	16.4 t/h	1 hour	393.6	
	292 t/d	per calendar day	292	
	245 t/d	90 day rolling average	245	
Combined emissions from main stack, the MLUEP desulphurization stack, the five flare stacks, the three CO Boiler diverter stacks, and the 92 MW cogeneration unit	150 t/d	365 day rolling average	150	Effective one year after the start-up of the Mildred Lake Plant SER Project SDA/Baghouse System
	100 t/d	365 day rolling average	100	Effective three years or after commencement of operations of the Mildred Lake Plant SER Project SDA/Baghouse System



<b>SO<sub>2</sub> source</b>	<b>SO<sub>2</sub> limit</b>	<b>Averaging period</b>	<b>SO<sub>2</sub> limit standardized to t/d</b>	<b>Date of approval</b>
<b>CNRL</b>	<b>930 kg/h</b>	<b>1 hour</b>	<b>22.32</b>	<b>August 5, 2015</b>
Sulphur recovery incinerator exhaust stack	7100 kg/h	1 hour	170.4	
Sulphur recovery incinerator exhaust stack (when the tail gas clean-up unit is bypassed)	360 t/d	24 hour rolling average	360	
Combined emissions from all sources at the plant	16 t/d	365 day rolling average	16	

### 5.2.1.2 NO<sub>x</sub> Limits

The NO<sub>x</sub> emission limits are set for major fixed-point sources at each of these facilities are shown in Table 7.

NO<sub>x</sub> limits are set to minimize emissions from combustion equipment and generally reflect standards of the day. In the Fort McKay area, NO<sub>x</sub> emissions from facilities are primarily due to the mine fleet vehicles, which are not included in the emission limits in the approval but are included in the NO<sub>x</sub> emissions reported in Section 5.3.1 of this report. Mine fleets are regulated federally through off-road vehicle diesel requirements. Odours may be present when NO<sub>2</sub> concentrations approach AAAQO thresholds.

### 5.2.2 Contraventions of Emission Limits

The approval holder must immediately report to the AER incidents resulting from any contraventions of the terms and conditions of their approval. A written report must also be submitted within 7 days. Contraventions are handled through the process described in Section 4.3 of this report.

Contraventions of *EPEA* approval requirements and limits are listed yearly in operators' annual reports. Table 8 provides a summary of the contraventions reported over the study period (2010–2014). Multiple-hour events are represented as a single event.

In 2014, 68 per cent of the noncompliances were related to NO<sub>x</sub> emissions, 16 per cent were SO<sub>2</sub>, and 16 per cent were stack temperature (Figure 9). Contraventions of temperature and SO<sub>2</sub> emission limits are more likely to be associated with odours.

## 5.3 Reported Emissions

### 5.3.1 NO<sub>x</sub> Sources

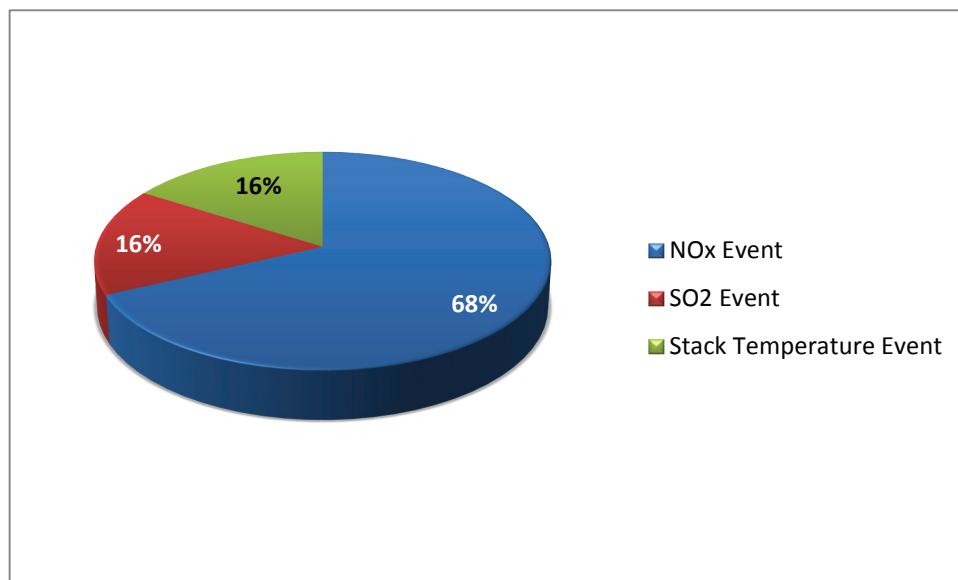
Figure 10 compares NO<sub>x</sub> emissions for 2014 (shown as circles) and emission trends for each facility over the study period (shown as bar charts.) As seen in Figure 10, the largest NO<sub>x</sub> emissions in 2014 were from Syncrude Mildred Lake and the Suncor Base Mine / Millennium operations. The only consistent temporal

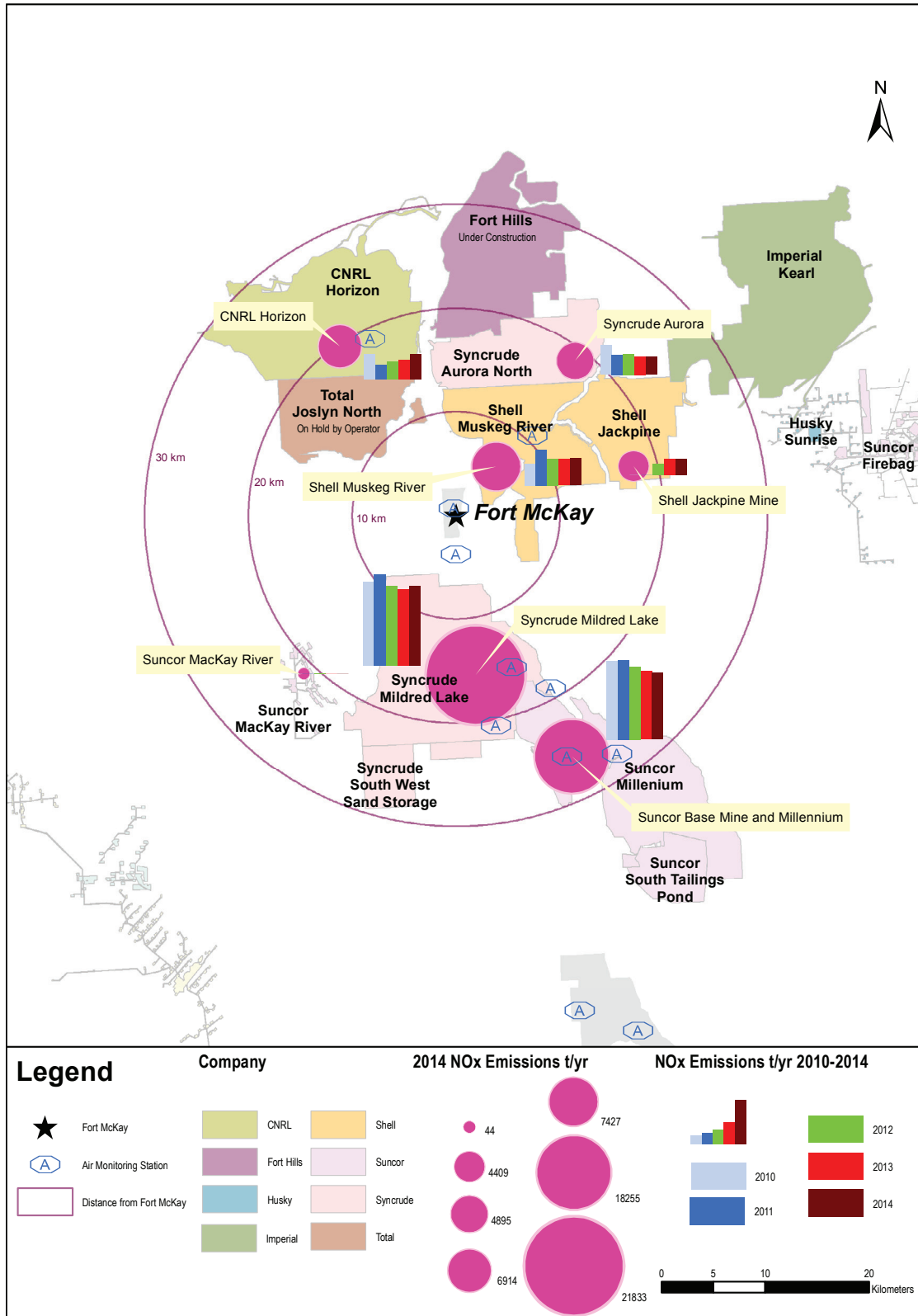
**Table 7. Nitrogen oxides approval limits for upgraders in the study area**

<b>NO<sub>x</sub> source (expressed as NO<sub>2</sub>)</b>	<b>NO<sub>x</sub> limit</b>	<b>Averaging period</b>	<b>NO<sub>x</sub> limit standardized to t/d</b>
<b>Suncor (approved December 17, 2014)</b>			
New main powerhouse stack	1.8 t/h	1 hour	43.2
Gas turbine GTG-5 main stack	94 kg/h	1 hour	2.256
Gas turbine GTG-6 main stack	94 kg/h	1 hour	2.256
Millennium coker charger heater stack (52F-302) (Capacity 504 GJ <sub>input</sub> /hr)	20.2 kg/h	1 month	0.4848
Each of two Millennium coker charger heaters stacks (52F-0300 and 52F-0301) (Capacity 456 GJ <sub>input</sub> /hr)	18.2 kg/h	1 hour	0.8736
Millennium hydrogen reformer furnace stack (54F-102) (Capacity 957 GJ <sub>input</sub> /hr)	38.3 kg/h	1 hour	0.9192
Each of two Millennium solvent heaters stacks (52F101A/B) (Capacity 168 GJ <sub>input</sub> /hr)	6.7 kg/h	1 hour	0.3216
Each of two Millennium solvent heaters stacks (57F-1 A/B) (Capacity 175 GJ <sub>input</sub> /hr)	7.0 kg/h	1 hour	0.336
Each of two Millennium vacuum heaters stacks (57F-2 A/B) (Capacity 222 GJ <sub>input</sub> /hr)	8.9 kg/h	1 hour	0.4272
Hydrogen Reformer Furnace stack 66F-101 (Capacity 408 GJ <sub>input</sub> /hr)	10.6 kg/h	1 hour	0.2544
<b>Syncrude (approved April 14, 2015)</b>			
Main stack	1.5 t/h	1 hour	36.0
The 92 MW cogeneration unit with associated steam generation unit (Input rating turbine 1147 GJ/hr; heat recovery steam generation [HRSG] 461 GJ/hr) exhaust stack	17.5 kg/h	1 hour	0.42
	105.9 kg/h during temporary steam injection supply failure	1 hour	2.5416
Each of the G-3 and G-5 cogeneration units with associated steam generation unit exhaust stacks (Input rating 364 GJ/hr and associated HRSG facilities 430 GJ/ hr)	28.4 kg/h	1 hour	0.6816
	14.2 kg/h performance target	1 hour	0.3408
<b>CNRL (approved August 5, 2015)</b>			
Cogeneration unit (Input rating turbine 1088 GJ/hr, HRSG 429 GJ/hr) exhaust stack	90.0 kg/h	1 hour	2.16
Cogeneration unit (Input rating turbine 1056 GJ/hr, HRSG 452 GJ/hr) exhaust stack	85.7 kg/h	1 hour	2.1048
Each of the four utility boiler (Input rating 410 GJ/hr) exhaust stack	18.5 kg/h	1 hour	1.776
Hydrogen plant furnace (Input rating 1143 GJ/hr) exhaust stack	45.7 kg/h	1 hour	1.0968
Hydrogen plant furnace (Input rating 1633 GJ/hr) exhaust stack	65.3 kg/h	1 hour	1.5672

**Table 8. Number of noncompliances for stack temperature and emissions of NO<sub>x</sub> and SO<sub>2</sub>**

Source	2010	2011	2012	2013	2014
Synchrude Canada Ltd. (Mildred Lake & Aurora)	2 (2 SO <sub>2</sub> )	0	1 (1 SO <sub>2</sub> )	1 (1 SO <sub>2</sub> )	0
Shell Canada Ltd. (Muskeg River & Jackpine)	0	0	0	2 (2 NO <sub>x</sub> )	0
Canadian Natural Resources Ltd. (Horizon)	39 (37 NO <sub>x</sub> , 2 Temp)	16 (16 NO <sub>x</sub> )	13 (12 NO <sub>x</sub> , 1 SO <sub>2</sub> )	23 (18 NO <sub>x</sub> , 5 SO <sub>2</sub> )	19 (17 NO <sub>x</sub> , 2 SO <sub>2</sub> )
Suncor Energy Inc. (MacKay River)	0	0	0	0	0
Suncor Energy Inc. (Base Mine & Millennium)	10 (10 Temp)	10 (2 SO <sub>2</sub> , 8 Temp)	8 (4 SO <sub>2</sub> , 4 Temp)	4 (3 SO <sub>2</sub> , 1 Temp)	6 (2 SO <sub>2</sub> , 4 Temp)
<b>Total</b>	<b>51</b>	<b>26</b>	<b>22</b>	<b>30</b>	<b>25</b>

**Figure 9. Contraventions of approved limits for SO<sub>2</sub>, NO<sub>x</sub>, or temperature in 2014**



The AER does not warrant the accuracy or completeness of the information contained in this map and is not responsible for any errors or omissions in its content and accepts no liability for the use of this information.

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Figure 10. NO<sub>x</sub> emissions in the study area from 2010 to 2014

trend across operators is Suncor Millennium and Syncrude Aurora reporting decreasing NO<sub>x</sub> emissions over the study period. Mobile sources (e.g., mine fleet) make up approximately half of the NO<sub>x</sub> emissions in this area based on industry annual reports. Note that NO<sub>x</sub> emissions were recorded for Suncor MacKay River; the levels were low and hence the small bar graph in the figure for this facility.

### 5.3.2 SO<sub>2</sub> Sources

Figure 11 compares SO<sub>2</sub> emissions for 2014 (shown as circles) and emission trends for each facility over the study period (shown as bar charts.) The largest emission source in this area is Syncrude, which has substantially reduced emissions from 2013 to 2014 due to SO<sub>2</sub> scrubbing as part of Syncrude's sulphur emission reduction project commissioned in 2013. SO<sub>2</sub> emissions in the study area have dropped by approximately 50 per cent from 2013 to 2014. Although Syncrude has been a large part of emission reduction, it still accounted for half of the SO<sub>2</sub> emissions in 2014. SO<sub>2</sub> emissions were recorded for Suncor MacKay River, but the levels were low.

### 5.3.3 NO<sub>x</sub> and SO<sub>2</sub> Trends

NO<sub>x</sub> emissions have remained relatively constant over the last five years. SO<sub>2</sub> emissions have decreased substantially since 2012, due in large part to Syncrude's sulphur emission reduction program (Figure 12).

## 5.4 Fugitive Emissions

Fugitive emissions are defined in *EPEA* approvals as air contaminant emissions to the atmosphere, other than ozone depleting substances, originating from a plant source other than a flue, vent, or stack but does not include sources which may occur due to breaks or ruptures in process equipment. As specified in the approval, operators may not emit fugitive emissions or an air contaminant from any source not specified in the approval that causes or may cause any of the following unless they receive approval in writing from a director at the AER:

- the impairment, degradation, or alteration of the quality of natural resources;
- material discomfort, harm, or adverse effect to the well-being or health of a person; or
- harm to property or to plant or animal life.

Fugitive emissions originate from process areas, ponds, and mine faces. Leak rates from process areas were estimated using leak detection and repair (LDAR) surveys. For the purposes of this report, fugitive VOC and TRS emission estimates were obtained from the NPRI and methane values were taken from the AEMERA website <http://aemeris.aemera.org/library/Dataset/Details/263>. Further information is also provided on solvent losses to tailings ponds which will result in VOC and TRS emissions from these ponds.

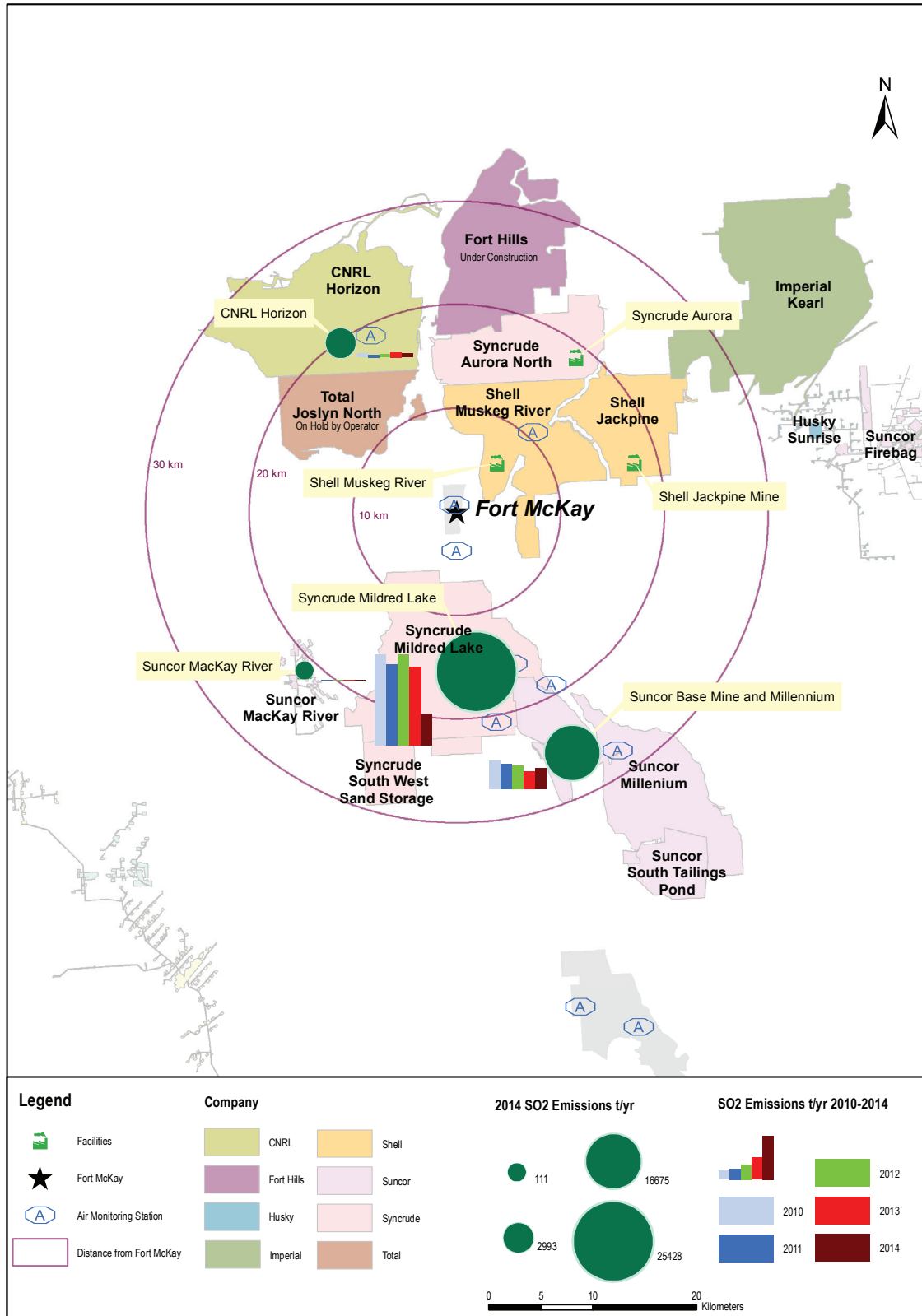
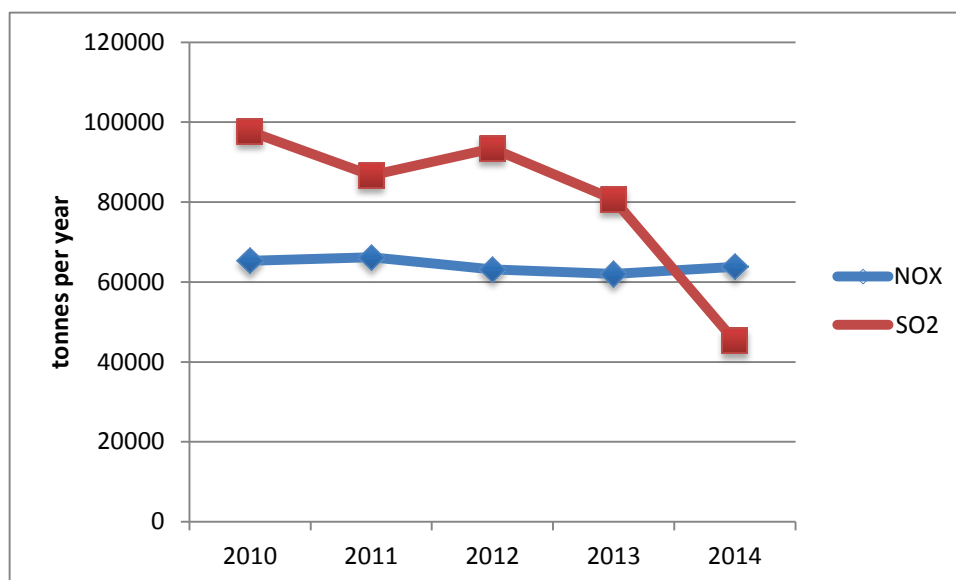


Figure 11. SO<sub>2</sub> emissions in the study area from 2010 to 2014



**Figure 12. Five-year trends in SO<sub>2</sub> and NO<sub>x</sub> emissions in the study area from 2010 to 2014**

#### 5.4.1 Leak Detection and Repair (LDAR) Survey Frequencies and Fugitive Emissions

LDAR surveys are an important part of minimizing fugitive emissions from equipment used in process areas. To control fugitive emissions, operators are required to monitor and repair leaks. *EPEA* approvals cite the CCME's *Environmental Code of Practice for the Measurement and Control of Fugitive VOC Emission from Equipment Leaks* (CCME, 1993). A leak is defined in the code as the detection of a VOC concentration of 10 000 parts per million by volume (ppmv) or more at the emissions source using a hydrocarbon analyzer. VOCs in the code are defined as any organic compound that participates in atmospheric photochemical reactions except for methane; ethane; 1,1,1-trichloroethane; methylene chloride; chlorofluorocarbons (CFCs); fluorocarbons (FCs); and hydrochlorofluorocarbons (HCFCs), which are excluded by the code because of their negligible photochemical reactivity.

The code requires LDAR surveys (CCME, 1993)

- quarterly for compressor seals and annually for all other components,
- immediately after repair for any component that was found to be leaking, and
- within 24 hours for a pressure relief valve that has been vented to the atmosphere.

The code does not cover area sources, stacks, vents, combustion systems, storage tanks, open storage piles, ponds, sludge drying beds, cooling tower sumps, and wastewater separators. Some of these sources, though absent from the code, may still be contributing to odour emissions at these sites (CCME, 1993).

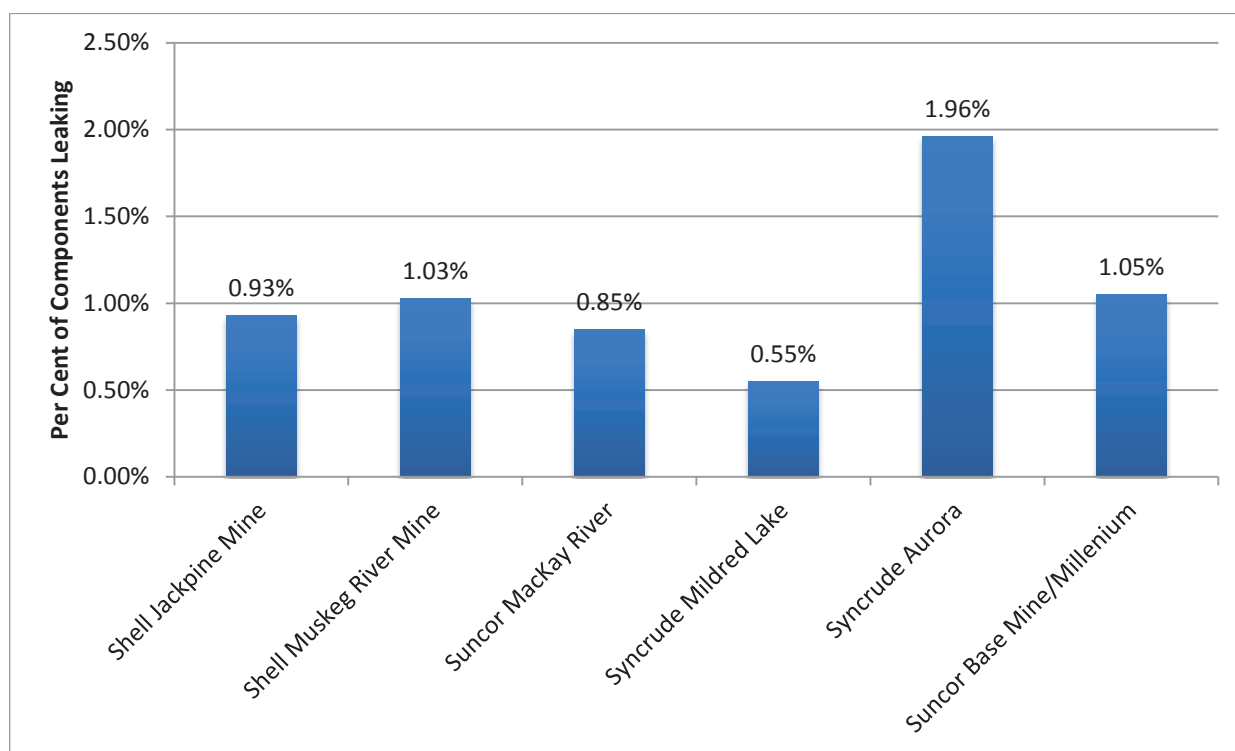
Repair times are not typically reported in annual reports, and it is not clear based on reporting if the first attempt at repairs is being made within five working days from time of detection (as required by the code).

Leak volumes are typically estimated using a variety of methods and not actually measured, although new technology has made it easier to measure most leaks.

The code defines a leak as 10 000 ppmv (CCME, 1993). More stringent leak definitions (e.g., 500 ppmv or more), which are defined as the detection of a VOC concentration at the emission source using a hydrocarbon analyzer, are being implemented by other regulatory agencies such as the United States Environmental Protection Agency, Colorado, and Texas for select facilities (e.g., gas processing plants, well sites, compressor stations) and are being considered for the Peace River area (draft directive).

The code of practice sets a maximum leak frequency of two per cent of the number of components surveyed showing leaks (except for pumps and compressors, which is set at ten per cent or three pumps or compressors, whichever is greater) (CCME, 1993). The code also allows for operators to apply for reduced monitoring in the event that they operate below this limit for two or more consecutive surveys (CCME, 1993). As shown in Figure 13, all operators reported leak frequencies of less than two per cent in 2014.

Figure 13 also shows that approximately one per cent of the components are found leaking under operators' current programs. The Syncrude Aurora site leak rate represents 20 leaking components out of 1022 components monitored, and the Syncrude Mildred Lake site leak rate represents 382 leaking components out of 69 488 components monitored. The Suncor Base Mine/Millennium leak rate represents 310 leaking components out of 29 591 components. CNRL Horizon is not presented in the figure, but the



**Figure 13. Leak rate of components surveyed at facilities in the study area for 2014**



number of leaking components reported ranges from 63 (in 2014) to a maximum of 153 (in 2011). The total number of potential components monitored for leak rates was not reported by CNRL, therefore the frequency of leak rates could not be calculated as presented for the other facilities

#### 5.4.2 National Pollutant Release Inventory (NPRI) Data

Operators are required to report emissions to the NPRI when certain thresholds or conditions are met (Environment Canada, 2016). In many cases, NPRI reporting includes a wider range of compounds than required through *EPEA* approvals. Reporting under Alberta's new *Air Monitoring Directive (AMD)* is under review and may change to include a broader annual emissions inventory. The *AMD* sets out requirements for monitoring and reporting air quality in Alberta (Government of Alberta, 2015a). The NPRI tracks both VOC and TRS emissions by industry on an annual basis.

##### 5.4.2.1 VOC Emissions

Measuring emissions from area sources (ponds and mine areas) is difficult and this has affected the quality of VOC data gathered by industry. A committee has been formed by EP and COSIA to rectify these methodological and analytical problems.

The NPRI data for 2014 was used for this report and was flagged on the NPRI website as "preliminary." There are significant differences observed between the NPRI data and some operator reports because of ongoing amendments to these data.

Increases in VOC emissions have occurred at some sites between 2013 and 2014 (Figure 14). These larger changes are likely due in part to the difficulty in measuring emissions from tailings ponds and mine faces and the low frequency of measurements, both of which may introduce errors. The data in Figure 14 was taken from NPRI on September 30, 2015. Subsequent changes to NPRI VOC data for 2012 and 2013 are not included in this report. VOC emissions for Suncor MacKay River were low.

##### 5.4.2.2 TRS Emissions

TRS emissions have dropped significantly at the Suncor site since 2010 following Suncor's response to an EPO. This order was removed in November 2010 after Suncor had satisfied all conditions of the EPO. Actions included changing the make-up solvent and improving the performance of the vapour recovery unit and naphtha recovery unit, among others. In 2012, Suncor moved to a hydrotreated solvent to further reduce TRS levels. A hydrotreated solvent removes TRS compounds from the solvent before the extraction process. A small amount of solvent is not recovered and is lost to the tailings pond. This solvent, if not hydrotreated, would have a higher sulphur content, and could be more odorous. Syncrude reports the majority of TRS emissions in the study area as shown in Figure 15. TRS emissions for Suncor MacKay River were low.

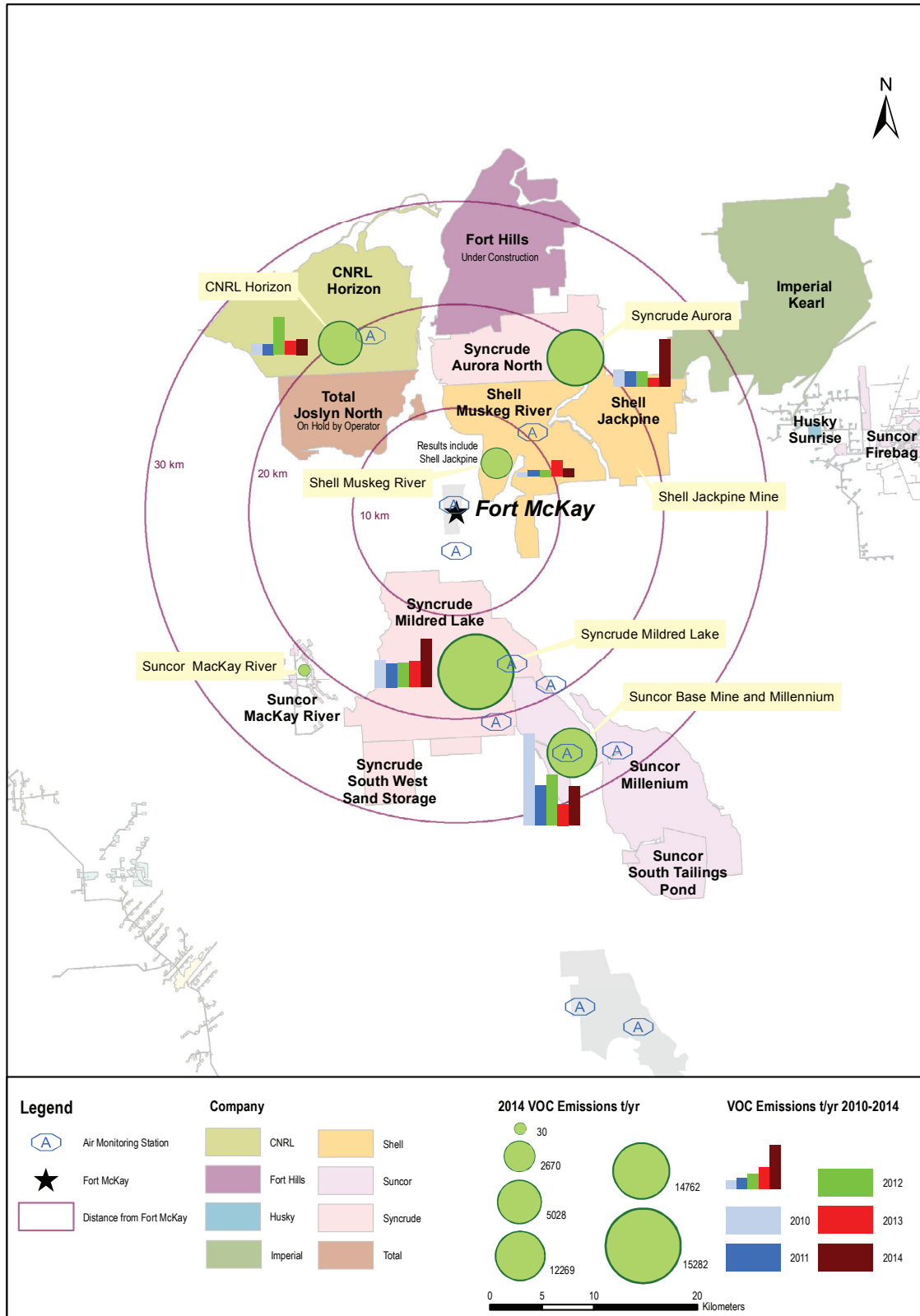


Figure 14. VOC emissions reported to the NPRI by operations within the study area from 2010 to 2014

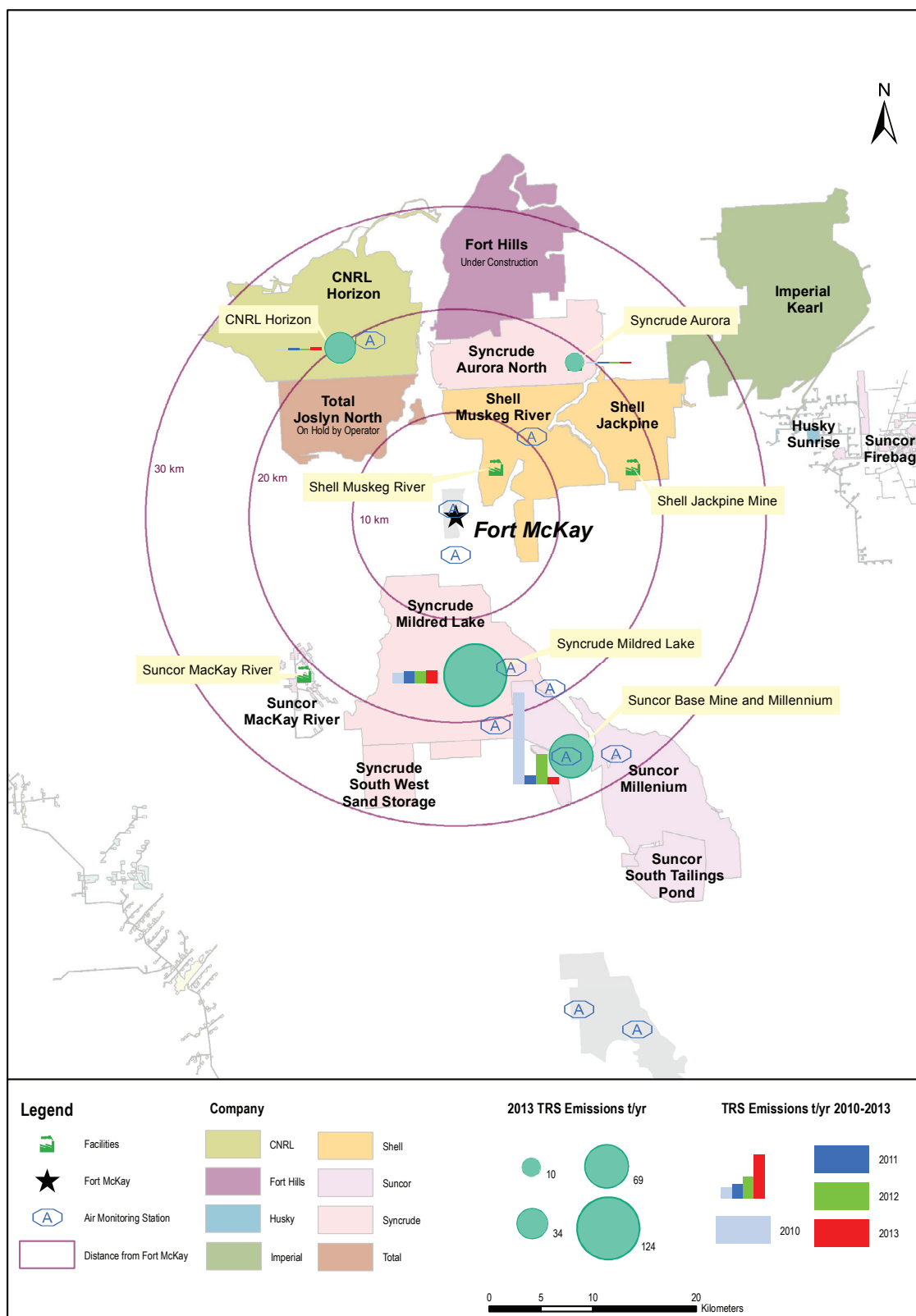


Figure 15. TRS emissions reported to the NPRI by operations within the study area from 2010 to 2013

#### 5.4.2.3 Solvent Losses

Despite minimizing TRS emissions by hydrotreating solvent, the loss of solvent to the tailings pond can be a source of odours. Solvent is used to help separate the bitumen from the sand and water in the extraction process. Syncrude, Suncor, and CNRL use naphtha-based solvent, and Shell uses a paraffinic solvent. Solvent losses are regulated by setting out the maximum solvent loss as a function of bitumen production. An annual average limit of four cubic metres of solvent loss per thousand cubic metres of bitumen production exists, but short-term daily limits on solvent losses do not. In addition to setting a maximum acceptable solvent loss threshold, most *OSCA* approvals have a clause that states that no untreated froth treatment tailings should be released to the tailings ponds. This means that if the solvent recovery unit is not operational, the extraction process must shut down. If the solvent recovery unit is not operational, solvent losses to the tailing pond would be significant.

Figure 16 shows solvent losses per thousand cubic metres of bitumen for the study period. These ratios were calculated from data published in the AER's *ST39: Alberta Mineable Oil Sands Plant Statistics Monthly Supplement* (AER, 2016b). Figure 17 shows the volume of solvent losses in 2014.

Improvement in performance of any operator's solvent recovery unit will result in less solvent loss to the tailing ponds and result in reduced emissions. Solvent losses reported by operators have decreased overall over the study period. The largest solvent losses in 2014 originated from Syncrude's Mildred Lake and Aurora operations.

#### 5.4.2.4 Specified Gas Emitters Regulation (SGER)

Alberta's *SGER* requires companies to report on facilities that emit more than 100 000 tonnes of GHGs. Operators provide estimates of methane and carbon dioxide released from ponds, mines, and process areas under this regulation. More than 90 per cent of methane emissions are from the tailings ponds, as shown in Figure 18. While methane itself is not odorous, it may be associated with other components that are.

The largest methane emissions are from Syncrude sites (both Aurora and Mildred Lake; Figure 19). Methane emissions from tailings ponds fluctuate significantly in magnitude from year to year. The cause of these fluctuations requires further investigation. As noted earlier, measuring emissions from area sources (ponds and mine areas) is difficult. A committee has been formed by EP (previously AEMERA) and COSIA to try to rectify these methodological and analytical challenges.

### 5.5 Industry Engagement Regarding Upgraders

To better understand plant operations, meetings were held with each of the operators. This section focuses on engagement with operators with upgraders at their facilities and includes CNRL Horizon, Suncor Base Mine, and Syncrude Mildred Lake. Discussion focused on potential odour sources including flaring, stack emissions, venting, and fugitive emissions. In addition, we examined the three highest SO<sub>2</sub> emission months in 2014 for each of the upgraders.

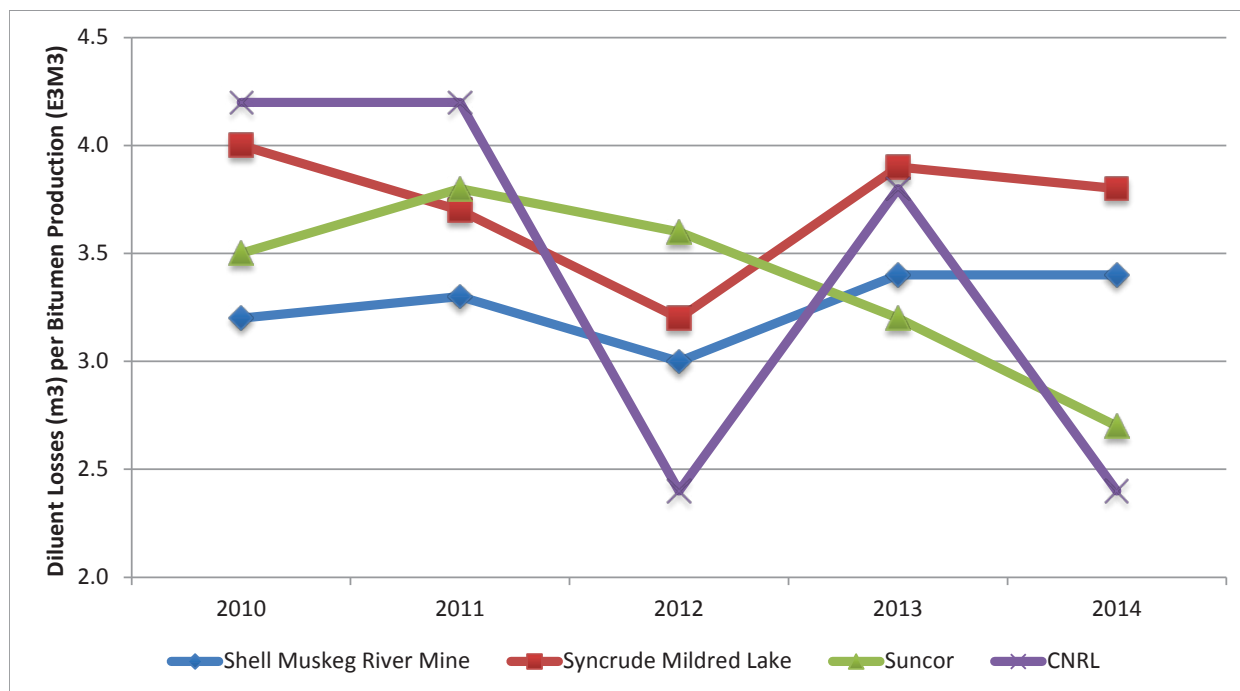


Figure 16. Solvent losses per thousand cubic metres of bitumen production for operations in the study area

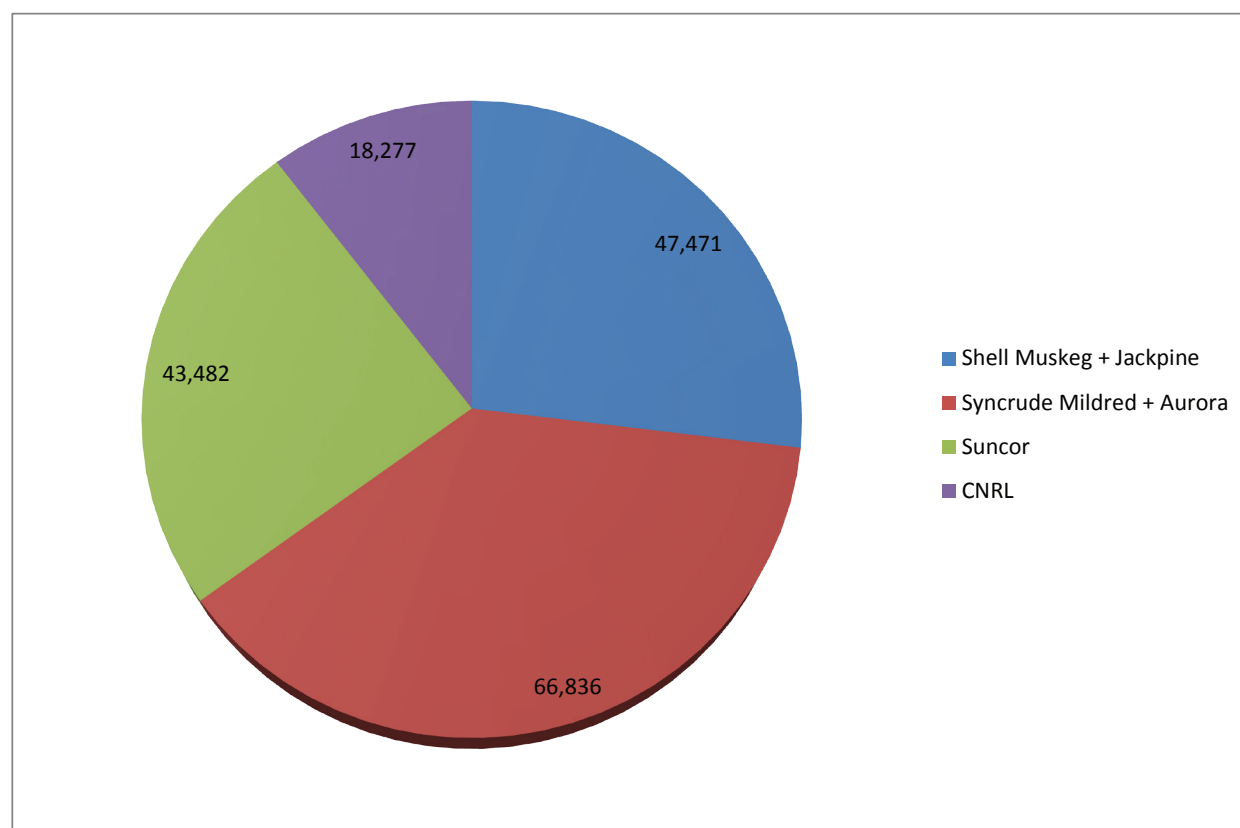
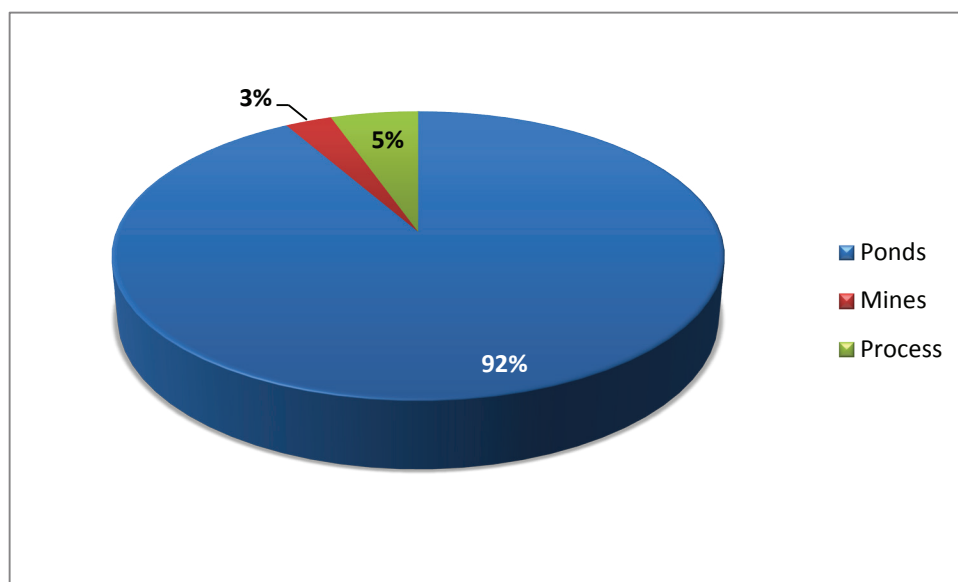


Figure 17. Total volume (m³) of solvent losses from operations in the study area in 2014



**Figure 18. Methane emissions by source for operations in the study area in 2014**

When plants flare, it is generally due to operational problems. Furthermore when flaring occurs due to plant upsets, there may be other sources of emissions that could cause odours. Increases in stack emissions can be due to increased throughput or plant problems. Data reviewed came from annual and monthly reports for the facilities. The analysis was not as simple as expected as the approval requirements for monthly and annual reporting differ across the three facilities with upgraders. Some operators are required to report on all intermittent flare events while others operators report totals on a monthly basis.

These reports showed that intermittent flaring appears to occur often or for extended durations at the sites examined. Some flare events also appear to be recurring. We note that all approvals require a minimum lower heating value of 12 MJ/m<sup>3</sup> for gases sent to flare. Where combustion efficiency is an issue, *Directive 060* requires upstream facilities to meet a minimum lower heating value of 20 MJ/m<sup>3</sup>. Adding fuel gas to sour streams flared also improves dispersion. When operators were questioned on flare stack operation, the responses received ranged from ensuring a conservative amount of excess fuel gas was added to conducting a visual observation of the flare to prevent smoky flares and ensure the correct ratio of steam to flared gas. For most streams flared, heating values are expected to be high. For low heating-value streams containing acid gas, ammonia, or nitrogen, additional fuel gas may be required to promote better combustion efficiency or improved dispersion. If odours from flare stacks are an issue, then this can be lessened by increasing minimum heating values. There are no flare limits on these facilities other than a site-wide SO<sub>2</sub> emission limit, which could restrict flaring in rare cases. SO<sub>2</sub> emissions from flaring varied significantly from month to month, sometimes by orders of magnitude as reported at one facility.

Monthly SO<sub>2</sub> emissions from stacks had wide fluctuations from month to month and in some cases accounted for significant portions of annual SO<sub>2</sub> site emissions. These cases were generally due to equipment outages on the sulphur recovery unit or FGD unit. In some cases, monthly stack emissions

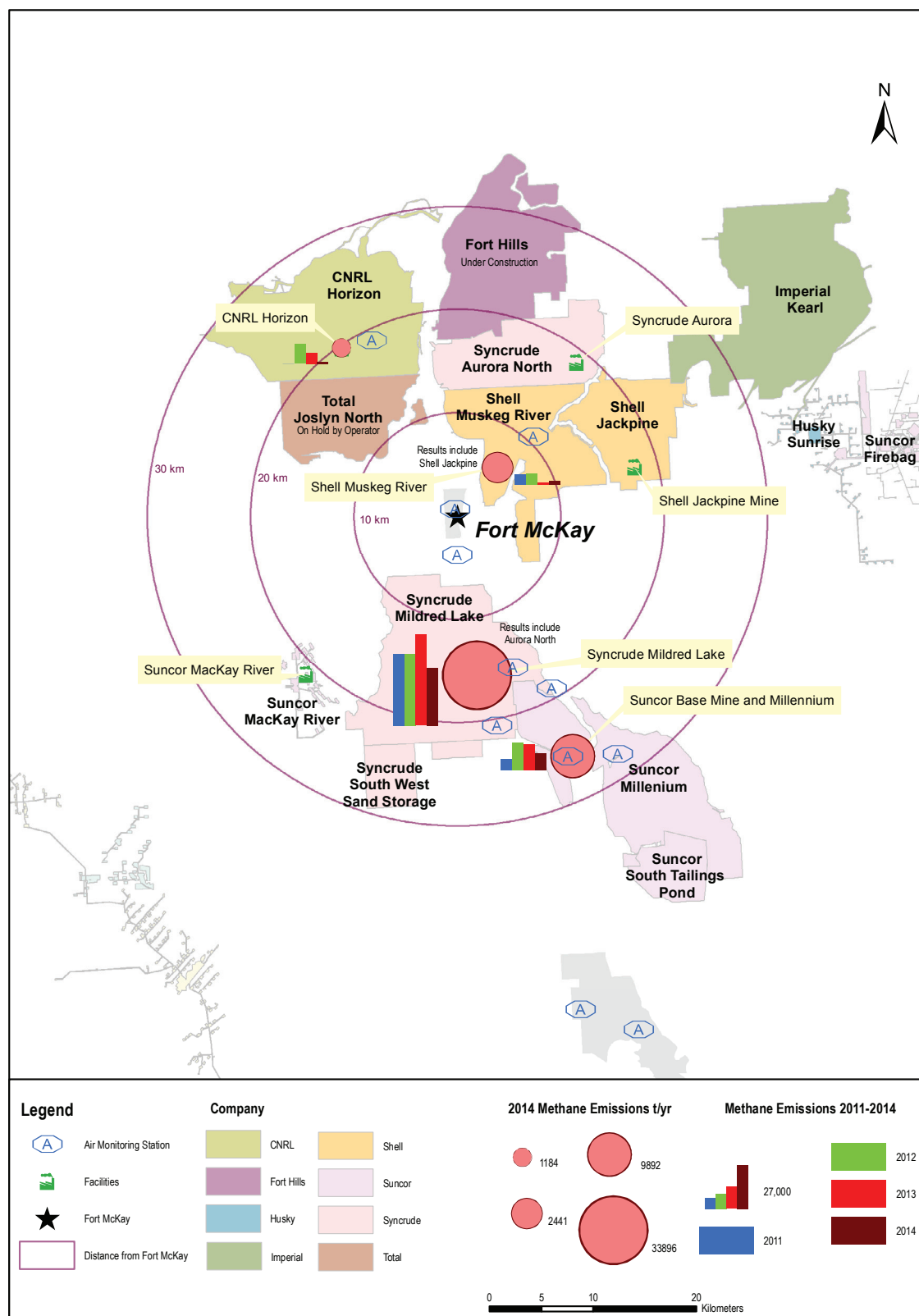


Figure 19. Methane emissions in the study area from 2011 to 2014



could be up to many times higher than normal due to equipment outages. These events are due to a number of reasons, including power outages and gas supply disruptions.

In discussions with operators, none believed odours from flare stacks were an issue. TRS and VOC emissions from flares were estimated assuming high conversion efficiencies.

While thermal oxidizers have minimum stack-top temperatures, a number of stacks with wet scrubbing, which have a temperature monitoring requirement, are not subject to minimum stack-top temperatures. While temperatures are an important factor in dispersion, controlling minimum temperatures may be challenging at the main and wet scrubbing stacks at Syncrude and Suncor as temperatures are a function of the process streams that feed the stack.

Venting from the plant sites will vary. In some cases, vents will be directed to a flare should the VRU fail. In other cases venting could occur if the VRU goes down. In discussions with operators, it would appear that all sour tanks were tied into a VRU or had floating roofs and systems in place to observe whether tanks had a problem with a seal. On the monthly air report, companies vary in how they report venting.

All operators stated that they notified the Fort McKay First Nation when larger events were occurring. Generally these only occurred for quite significant events (e.g., a power outage bringing down a plant, an event where a diverter stack was used to release coker gas, or a sulphur recovery unit outage occurred). Generally, flare events did not result in a notification. From discussions with the companies, they said that for most days when complaints were noted by the AER, the companies were not informed of the complaint.

Companies had a varied response when asked to identify larger odour sources:

- Suncor stated that tailings may be a contributor to odours but that it had not been able to correlate it with complaints. Suncor indicated that the source of the odours from the tailings pond would be from the diluent. Suncor's process is to ensure that any make-up diluent is hydrotreated and that the minimum target for hydrotreated diluent in circulation is 75 per cent which is accomplished by purging diluent in circulation and making up with hydrotreated diluent.
- Syncrude indicated that it was using hydrotreated diluent and pointed to other potential sources of emissions (e.g., when the diverter stack was used, off-spec stripped sour water discharged to tailings [Syncrude said this is no longer an issue], and tank venting when the VRU was down).
- CNRL suggested that over the last three years it had one complaint attributed to the upgrader. On larger events such as flaring over a hundred tonnes of SO<sub>2</sub>, CNRL did not believe there was an issue based on past history.

Companies generally operate within their approval. Generally companies all suggested they have no plans to implement further odour reduction measures due to a lack of understanding of the cause. Companies commented on the improvement in air quality that has been made in this area. One company suggested

that to take further action, the odour sources must be identified. All companies suggested that improved communication between the time when the complaint first comes in and notification to the company is important in helping track down the source of the odours.

## 5.6 Recommendations

### 5.6.1 Approval Conditions and Reporting

There are no requirements for operators to determine the odour potential of emission sources at sites. There is one instance where an operator did a detailed examination of ground-level exceedances of  $\text{H}_2\text{S}$  of its site, but provincial guidance and requirements around how these studies are to be conducted is not available.

There are emissions sources listed in the *EPEA* approval that do not have monitoring or reporting requirements. Follow-up assessment has not been conducted on these approved sources to determine if emissions remain consistent with conditions anticipated by the initial project application or by the modelling scenarios. Modelling of source emissions is typically required through the *EPEA* approval application process. Source emissions are modelled to verify that AAAQOs will be met (Government of Alberta, 2013b).

There are no requirements for operators to consider odour as part of air dispersion modelling (Government of Alberta, 2013b). There are only three parameters that have AAAQO thresholds that are based on odour. These are hydrogen sulphide ( $\text{H}_2\text{S}$ ), ammonia ( $\text{NH}_3$ ), and carbon disulphide ( $\text{CS}_2$ ) (Government of Alberta, 2013).

Approval limits for point-source monitoring generally focus on  $\text{SO}_2$  and  $\text{NO}_x$ . NPRI reporting includes a wider range of compounds than required through *EPEA* approval requirements (Government of Canada, 2016). Reporting under the Government of Alberta's *AMD* may also change to include a broader emissions inventory (expected September 2018).

Approval conditions, including reporting requirements, are developed for individual project applications and consider site-specific needs. Therefore, the type of information provided in the monthly and annual reports varies across the different operators. In addition, approvals may have different averaging periods for emission limits. This has resulted in challenges when analysis across operators is required, as was the case in this report.

As noted earlier, there were unit errors and truncations in annual reports. Quality assurance and quality control on monthly reporting is required to reduce reporting errors.

### 5.6.2 Fixed-Source Emissions

A better understanding of point sources causing odours is required. Contraventions of SO<sub>2</sub>, NO<sub>x</sub>, and stack temperature limits were reported over the study period and could be associated with odours. Significant improvements have been made by some operators in reducing emissions such as SO<sub>2</sub>. However, contraventions of temperature and SO<sub>2</sub> emission limits could be associated with odours.

A better understanding of significant events and upsets that cause odours but still remain within approval limits is required. Intermittent flaring occurred often and for extended durations at some of the sites examined. Some flare events also appear to be reoccurring on a repetitive basis. Equipment outages may result in flaring for long periods of time while repairs are made. Reporting requirements across operators vary, with some operators reporting on flare events daily while others operators on a monthly basis.

Improvement in understanding combustion efficiency is also required. TRS and VOC emissions from stacks are estimated based on older, single-point-in-time surveys or in some cases on emission factors such as 99.5 per cent efficiency. Some operators indicated that they use visual observation of the flare to determine if the appropriate amount of fuel or steam is being added. In addition, there are no minimum temperatures specified for a number of stacks with larger SO<sub>2</sub> emissions.

### 5.6.3 Fugitive Emissions

A better understanding of fugitive sources causing odours, specifically from the larger area sources such as tailings ponds and the mine faces, is required.

Our assessment of LDAR surveys was affected by variability in reporting requirements across operators (e.g., different units of measurement used to report emission volumes, different parameters reported, emission values reported as VOC, methane, or CO<sub>2</sub> equivalents). Estimation methodologies varied across the facilities, and it was not always clear which areas of the facilities were included in the estimates of fugitive emissions volumes.

*EPEA* reporting for fugitive emissions as required in approvals is focused on leak reporting from the process area and does not require reporting for mines and ponds.

Improved methodology for estimating VOC and TRS emissions from ponds is required.

Solvent losses could be a significant contributor of odour from ponds. An annual average limit exists, but short-term daily limits on solvent losses do not.

There are four recommendations from the industry performance monitoring section of this report.

**Recommendation 9:** Assessment of fixed and fugitive emission sources focused on the parameters in the Air Quality Focal Parameter List (Section 6.6.4) is required based on the findings of this report. Polycyclic aromatic hydrocarbons must also be considered.

The intent is to develop a roadmap outlining a systematic process for examination of the dominant emission sources for the parameters in the Air Quality Focal Parameter List for further consideration and refinement. Further work related to odours may be required pending direction from the Government of Alberta. Lead: Industry as required by the AER, supported by the AER.

**Recommendation 10:** A targeted examination of emissions control through best management practices should be conducted on the basis of findings from recommendation 9. A multiyear continuous-improvement program for implementation is required. Lead: AER supported by industry.

**Recommendation 11:** Air dispersion modelling conducted in *EPEA* approval applications and environmental impact assessments should consider odours generated during project activities. Additional guidance or review of the Air Quality Model Guideline to improve consistency across operators and applications for air dispersion modelling for odours is needed. Lead: Government of Alberta supported by AER.

**Recommendation 12:** Based on the findings of this report, reporting requirements for oil sands *EPEA* approvals with respect to air emissions should be reviewed to improve consistency across operators for monthly and annual reporting, units of measure, quality assurance and quality control to reduce reporting errors, and inclusion of additional parameters with AAAQOs. Consideration should also be given to transparency and public access to monthly and annual industry reports. Lead: AER.

## 6 Ambient Air Quality Monitoring

### 6.1 Introduction

The purpose of this section is to link odour complaints received from residents in Fort McKay to parameters in ambient air that are greater than odour thresholds and, where possible, identify potentially odorous compounds responsible for the complaint. During the scoping of this process it was identified that there has been significant ambient air monitoring for a large volume of parameters by various agencies in the Regional Municipality of Wood Buffalo in northeastern Alberta, which includes the communities of Fort McKay, Fort McMurray, and the Athabasca oil sands.

This report was a preliminary screening assessment initiated to determine if further assessment was required. Some parameters may be affecting human health in the area by decreasing air quality through offensive odours (i.e.,  $\text{H}_2\text{S}$ ) and/or direct adverse health effects (i.e., respiratory symptoms). It is important to compare data to a suite of different air quality benchmarks to identify which compounds should be further assessed in the Fort McKay area.

Ambient air concentration data collected in the study area was compared to AAAQOs, Alberta regional air monitoring frameworks, international air quality guidelines, odour thresholds, and other health-effect screening thresholds.

Analytical data and guidance documents from the following agencies were reviewed to determine available guidelines and thresholds in Alberta and other regulatory jurisdictions, air quality assessment tools, and historical and current ambient air sampling locations, frequency and duration of air sampling programs (historical and current), parameters characterized in ambient air samples, and quantification methods for field and laboratory analysis of ambient air monitoring in the Wood Buffalo region. Details relating to data collection methods are available from each of the sources listed below.

- Alberta Energy Regulator
  - Peace River Proceeding (No. 1769924) (AER, 2013)
    - A Screening Level Assessment of Potential Health and Odour-Related Impacts Associated with Heavy Oil Operations Emissions in the Peace River Area (Intrinsik, 2013)
- Alberta Environmental Monitoring, Evaluation and Reporting Agency (now under EP)
  - Current Ambient Air Monitoring Program (WBEA, 2016)
  - Current JOSM Programs (JOSM, 2015)
- Clean Air Strategic Alliance (CASA)
  - Final Report of the Odour Management Team to the CASA Board (CASA, 2015a)
  - Review of Odour Assessment Tools and Practices for Alberta (Millennium EMS Solutions Ltd. and Environmental Odour Consulting, 2015)
  - Good Practices Guide for Odour Management (CASA, 2015b)
- Environment Canada (EC)
  - Historical Environment Canada Aircraft Data (JOSM, 2015)
  - Environment Canada Fort McKay's Oski-ôtin Continuous Monitoring Data (Nov 2013 to Oct 2014) (JOSM, 2015; accessed July 2015)
- National Air Pollutant Surveillance Program Annual Databases (Environment Canada, 2016; Accessed August 2015)
- Alberta Environment and Parks (EP)
  - Air Monitoring Directive (Government of Alberta, 2015a)
  - Air Quality Health Index (Government of Alberta, 2016)

- Alberta Ambient Air Quality Objectives and Guidelines Summary (Government of Alberta, 2013a updated 2016)
- Air Quality Model Guide (August, 2013b)
- Woodland Buffalo Environmental Association
  - Human Effects Monitoring Program (HEMP) (Dann, 2013, 2014, 2015)
  - Hourly data from Air Monitoring Stations (AMS) (WBEA 2015; accessed July 2015)
  - Canister Sampling Data 2009–2013 (not publicly available)
  - Review of the WBEA Air Monitoring Network (Dan and Edgerton, 2011)
- Lower Athabasca Region Air Quality Management Framework
  - Lower Athabasca Regional Plan 2012–2022 (Government of Alberta, 2012a)
  - Lower Athabasca Region Air Quality Management Framework for NO<sub>2</sub> and SO<sub>2</sub> (Government of Alberta, 2012b)
  - Lower Athabasca Region “Status of Ambient Environmental Condition 2012” (Government of Alberta, 2014a)
  - Lower Athabasca Region “Status of Management Response for Environmental Management Frameworks” (Government of Alberta, 2014b)
- Fort McKay Sustainability Department (FMSD)
  - Fort McKay’s Air Quality Index (FMAQI) (Spink, 2013)
  - Odour Event Air Quality Monitoring in the Community of Fort McKay (FMSD, 2010)
  - Odour Impact Assessment Guidance Document (FMSD, 2013)
  - Odour Event 10 minute Canister Data 2010–2013 (FMSD, 2013)

During meetings held in November 2015, the AER became aware of additional data that had been collected but was not available in time to be included in this report. In the future, the following data should be integrated into the database developed for this assessment and compared to the same odour and health thresholds used in this report.

- Fort McKay Sustainability Department historical canister data from odour-event-triggered canister sampling program (odours greater than odour thresholds were presented in the current report whereas parameters greater than health thresholds were not assessed in this report).
- WBEA research program data characterizing stack emissions from three unnamed stacks from oil sands plant sites (WBEA internal data not publicly available).

- Environment Canada Level 2 data collected from Oski-ôtin from 2013 to present (Level 1 2013–2014 data available on portal at present).
- Environment Canada Aircraft Measurements in the vicinity of oil sands plant sites and tailings facilities (summer 2013).

This section of the report has been broken out into five main areas:

#### 1) Background

- Describes the regional setting and historical ambient air monitoring network.
- Identifies the ambient air monitoring stations operated by different agencies.
- Summarizes the current provincial and regional air quality assessments and health indices.
- Summarizes the historical ambient air datasets that were available from multiple monitoring agencies (a description of parameters that were monitored for is available in Appendix 3).

#### 2) Exposure Concentration Calculations

- Describes the methodology for calculating the exposure point concentration (EPC) for each parameter. The EPC for each parameter within each dataset was calculated so that comparisons to the available ten-minute, hourly, 24 hour, annual, and chronic benchmarks, identified in the toxicity assessment section, could be completed.

#### 3) Toxicity Assessment

- Identifies the odour detection and short- and long-term health-effect thresholds that were used for screening the ambient air data. A description of the source of the benchmarks and their development (in terms of how they were intended to be used) was not conducted but can be determined by the reader by referencing the source of the benchmark.

#### 4) Analysis

- Screens the EPCs from each dataset (WBEA, EC, and FMSSD) against benchmarks to identify potential odorants as well as other air quality parameters which are greater than various thresholds,
  - Regional Scale AAAQO Exceedance Identification: Assessment of the total number of AAAQO exceedances at WBEA AMS locations within a 30 km radius of Fort McKay over the study period (2010–2014), including dates during which complaints were and were not received by ESRD and AER.
  - AAAQO Exceedances on Dates When Complaints were Received: Assessment of AAAQO exceedances at WBEA AMS locations on dates during which 175 odour complaints were received from residents of Fort McKay to determine if AAAQO exceedances correlated with odour event complaints over the study period.



- Historical Ambient Air Monitoring Data for Broader Benchmark Comparison (Odour and Health Thresholds): Comparison of average and upper bound EPCs for hourly, daily, and annual time periods for each parameter of the WBEA (2010–2014 dataset), EC (2013–2014 dataset), and FMSD Odour Complaint Canister datasets against a suite of odour and health thresholds.

## 5) Discussion

- Review of the results, uncertainties, and limitations of the data. Final recommendations based on interpretation of the comparison of ambient air quality data to benchmarks.

## 6.2 Background Air Monitoring and Assessment in Wood Buffalo Region

### 6.2.1 Ambient Air Monitoring Data in Wood Buffalo Region

This report assesses four primary sources of ambient air monitoring data described below and summarized in Table 9.

- WBEA continuous hourly level 2 ambient air monitoring data from 2010 to 2014 (WBEA, 2015; accessed July 2015). Level 2 means the data have been checked for quality assurance and quality control;
- WBEA 24 hour canister sample data from AMS01 (in the community of Fort McKay) (not publicly available), collected as part of the NAPS program;
- Environment Canada/JOSM continuous data collected at Oski-ôtin (in the community of Fort McKay) from August 2013 to November 2014 (JOSM 2015; accessed July 2015); and
- FMSD 10 minute canister sample data which was collected during odour-related events where complaints were received by the FMSD between April 2010 and June 2013 on twenty-one dates (not publicly available).

**Table 9. Summary of primary sources of air monitoring data and estimates of concentrations for various averaging periods**

Dataset	Sampling time	3 min	Hourly	Daily	Annual
FMSD Canister	10 Minutes	Peak from 10 minute data*	n/a	n/a	n/a
WBEA Canister	24 hour	n/a	n/a	Direct	n/a
WBEA Hourly	1 to 5 minute intervals	n/a	Average of 5 min data	Average and upper bound of available data*	Average and upper bound of available data*
Environment Canada Hourly	1 to 60 min intervals	n/a	Average and upper bound of available data*	Average and upper bound of available data*	Average and upper bound of available data*

\* Indicates peak, average, or upper bound EPC was estimated from original minute or hourly dataset

n/a – calculation could not be applied to available dataset or averaging period was directly reported in dataset provided by monitoring agency

Historically, WBEA has conducted regional monitoring in the Wood Buffalo region. A monitoring network assessment (Dan and Edgerton, 2011) identified deficiencies regarding individual parameters monitored for and the data's value in identifying potential odorants. To address the findings of the WBEA, and AEMERA (now EP) reports as well as the community of Fort McKay's concerns, a new community monitoring station (in addition to the existing WBEA AMS01), funded in part by the JOSM and Environment Canada, became operational in 2013. This new station (named Oski-ôtin) is monitored in real time by the FMSD. Data is available to the community in real time and to other stakeholders through the JOSM portal with a time lag (JOSM, 2015). The Oski-ôtin station monitors for a larger number of individual parameters than the WBEA stations. A comparison of each continuous station and available dataset is provided in subsequent sections.

As stated by the FMSD, the 10 minute odour event canister sampling data "is intended to be used in the analysis of data from Fort McKay's odour-event-related canister sampling program. This sampling program is focused on characterizing air quality during odour events; however, in some cases canister sampling was done for other reasons. The reason for the canister sampling and some related air quality and meteorological measurements from the WBEA Fort McKay air monitoring station are provided at the top of each table for each sampling event" (FMSD data supplied to the AER in November 2015).

As of August 2013, there are forty-nine individual compounds that have AAAQO thresholds for various averaging periods (i.e., some parameters may have hourly, daily, or annual objectives). Three of the AAAQOs are based on odour perception (Government of Alberta, 2013a). Thirty-five such compounds are monitored for within the WBEA network; four parameters within the continuous network ( $H_2S$ ,  $SO_2$ ,  $NO_2$ ,  $NH_3$ ) and thirty-five parameters from the six-day 24 hour canister samples were collected for the NAPS (National Air Pollutant Surveillance Program) inventory (WBEA, 2016; data portal). The Oski-ôtin station monitors a hundred individual parameters on a continuous basis, thirty-one of which have available AAAQOs (JOSM, 2015; data portal).

Table 10 illustrates WBEA AMS locations in the study area in relation to oil sands operations. The WBEA AMS network currently collects continuous data at the following stations for the following parameters (Dann, 2014). Note that other parameters are monitored for but are not reported here. This may include ammonia, nonmethane hydrocarbons, and ozone, as indicated by the "Other" column in Table 10.

For this report, stations within a 30 km radius of the community of Fort McKay were included for analysis. The following stations were outside the 30 km study area and therefore excluded: AMS06 Patricia McInnes, AMS07 Athabasca Valley, AMS14 Anzac, AMS17 Wapasu, AMS19 Firebag, and Fort Chipewyan (historically used as baseline ambient air conditions).

Table 27 in Appendix 3 indicates data from each agency that were reviewed and assessed for potential linkages to odour complaints from residents of Fort McKay. It is important to understand the differences and similarities between each dataset, specifically the parameters measured and the time interval for sample collection so that trends and data gaps can be identified.

**Table 10. WBEA air monitoring station (AMS) locations in the Fort McKay area and associated air quality parameters continuously measured**

WBEA ID	Purpose	Station name	TRS	H <sub>2</sub> S	SO <sub>2</sub>	NO/NO <sub>2</sub>	THC	Methane	Other	Canister VOC/RSC
1	Community	Fort McKay Bertha Ganter	✓		✓	✓	✓	✓	✓	✓
2	Industrial	Mildred Lake		✓	✓		✓			
3	Meteorology	Lower Camp Met Tower								
4	Industrial	Buffalo Viewpoint		✓	✓		✓			
5	Industrial	Mannix		✓	✓		✓			
6	Community	Fort McMurray Patricia McInnes	✓		✓	✓	✓	✓	✓	✓
7	Community	Fort McMurray Athabasca Valley	✓		✓	✓	✓	✓		✓
9	Industrial	Barge Landing	✓				✓			✓
11	Industrial	Lower Camp		✓	✓		✓			
12	Industrial	Millennium	✓		✓	✓	✓			✓
13	Industrial	Fort McKay South	✓		✓	✓	✓			✓
14	Community	Anzac	✓		✓	✓	✓	✓		✓
15	Industrial	CNRL Horizon	✓		✓	✓	✓			✓
16	Industrial	Shell Muskeg River			✓	✓	✓			
17	Industrial	Wapasu		✓	✓	✓	✓			
104	Special Study	AMS104	✓					✓	✓	

It is also important to note that Table 9, describing the continuous ambient air data in the WBEA monitoring network, does not include polycyclic aromatic hydrocarbons (PAHs) (WBEA, 2016; data portal). Environment Canada has been monitoring ambient air for PAHs, polycyclic aromatic compounds (PACs), and selected trace elements since November 2010 under an enhanced deposition study (JOSM, 2015; data portal). The presence of PACs in air is reported for 17 sites across the oil sands region for the first year of sampling. The results show that concentrations of PACs vary considerably across the region. Higher concentrations of PACs (including benzo[a]pyrene) are measured at sites that are closer to oil sands mining and upgrading facilities compared to sites that are farther away. On average, the PACs concentrations in air at the closer sites are twice as high as the concentrations at farther sites (as reported on the Canada-Alberta Oil Sands Environmental Monitoring Information Portal: [http://www.jointoilsandsmonitoring.ca/pages/air\\_latestdata.aspx](http://www.jointoilsandsmonitoring.ca/pages/air_latestdata.aspx)).

The lack of systematic air monitoring data for individual PAHs with AAAQOs (Benzo[a]pyrene) (Government of Alberta, 2013a) and analysis of particulate matter for adsorbed PAHs is a gap in the data for this region.

## 6.2.2 Historical Ambient Air Quality Assessments in Alberta and the Wood Buffalo Region

Ambient air quality data collected throughout Alberta is assessed against AAAQOs, regional management triggers and limits, and air quality health indices on a regional and provincial scale, as described below. These various assessment tools provide a broad spectrum of conservatism and used in conjunction can provide insight into ongoing as well as emerging air quality changes in Alberta. Historical air quality indices published by the Government of Alberta were not included in the analysis of ambient air quality in Fort McKay. The current system in Alberta and the Wood Buffalo region is presented below to highlight the management systems currently implemented for assessing air quality within Alberta.

### 6.2.2.1 Provincial Air Quality Health Index System

In Alberta, ambient air data from the regional monitoring network is used to calculate the air quality health index (AQHI). The AQHI is a number from 1 to 10 that indicates the level of relative health risk associated with local air quality (Government of Alberta, 2016). Just as various air monitoring networks coexist in the Fort McKay area, there have been various AQHI methods proposed, which are discussed in subsequent sections.

The official AQHI is reported through EP and is calculated based on guidance provided by Health Canada using health and air quality data collected in major cities across Canada, including Calgary and Edmonton. The index does not measure the effects of pollen, heat, or humidity on health (Health Canada, 2016).

The AQHI calculation as provided by Health Canada represents the relative risk of a mixture of common air pollutants that are known to harm human health (Health Canada, 2016; Government of Alberta, 2016):

- ground-level ozone ( $O_3$ )
- fine particulate matter ( $PM_{2.5}$ )
- nitrogen dioxide ( $NO_2$ )

The AQHI calculation conducted by EP is calculated from monitoring data collected at WBEA stations and is based on the Health Canada guidance as described above but has been modified by EP to better account for changing air quality in Alberta and considers the following additional components (Government of Alberta, 2016):

- hourly comparisons of individual pollutant concentrations to AAAQOs and
- presence of sulphur dioxide, hydrogen sulphide, TRS compounds, and carbon monoxide.

The AQHI may therefore identify reduced visibility or special community-based odour events when concentrations of fine particulate matter, sulphur dioxide, hydrogen sulphide, or TRS compounds are greater than specific thresholds. Real-time AQHI reporting is available on the EP website, with WBEA as the data provider. Historical AQHI ratings were not considered in this report.

#### 6.2.2.2 Proposed Fort McKay Specific Air Quality Health Index

The FMSD has proposed a tailored AQHI for the community of Fort McKay to reflect health and general air quality considerations (Spink, 2013a). We will refer to this as the Fort McKay AQI (FMAQI).

In developing the FMAQI, the provincial AQHI is used as one measure of air quality and its potential health impacts on the community.

Parameters addressed in the calculation of the FMAQI are SO<sub>2</sub>, NO<sub>2</sub>, PM<sub>2.5</sub>, O<sub>3</sub>, THC, and TRS. Carbon monoxide (CO) is not included in the FMAQI.

The FMSD states that “the FMAQI is based on short-term air quality and possible related health implications and the AQI does not address possible long-term health and air quality issues. Also, as noted under the TRS write-up above, the index does not fully address odours and even though the FMAQI indicates a ‘good’ AQI, odours may be present. This is an issue the Fort McKay Sustainability Department and its scientists are attempting to address.” (Spink, 2013a, page 2).

WBEA now calculates and reports in real time on its web portal the FMAQI for Fort McKay as well as the AQHI as published by EP for all community stations.

#### 6.2.2.3 Provincial Air Zone Management Framework

Alberta Environment and Parks implements the *Canadian Air Quality Standards through the Air Zone Management Framework for Fine Particulate Matter and Ozone* (Government of Alberta, 2015c). In October 2012, the CCME agreed to new Canadian ambient air quality standards (CAAQS) for PM<sub>2.5</sub> and ozone. The CAAQS are part of a collaborative national air quality management system (AQMS) to better protect human health and the environment published in the *Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone* (CCME, 2012).

Within the AQMS there are four management levels (green, yellow, orange, and red) associated with increasing concentrations of ozone (8 hr: 50–63 ppb) and PM<sub>2.5</sub> (annual: 4.0–10.0 µg/m<sup>3</sup>; 24 hr: 10–28 µg/m<sup>3</sup>) (Government of Alberta, 2015c). Alberta’s six air zones are assessed for achievement against these values. The first assessment, based on 2011–2013 monitoring data, has been completed. The Lower Athabasca air zone (encompassing Ft. McKay within the Wood Buffalo Area) stated the following (Government of Alberta, 2015c):

Eight stations in the Lower Athabasca 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. One station, the CNRL Horizon station, was assigned to the orange management level for PM<sub>2.5</sub>. This management level indicates that PM<sub>2.5</sub> concentrations are approaching CAAQS and proactive action is needed to prevent exceedance. All other stations in the zone were assigned to lower management levels.

The Anzac station was assigned to the yellow management level for ozone. This management level calls for improvement to air quality using early and ongoing actions for continuous improvement.

The management level that an air zone is assigned to is a long-term indicator designed to derive policy action, and does not reflect the day-to-day changes in air quality. As such it should not be used for current conditions reporting or daily activity planning. Rather it is indicative of chronic long-term exposure of people and indicates whether or not a management strategy should be initiated.

As described above, an air quality management strategy is required for both ozone and PM<sub>2.5</sub> in the air zone within which Fort McKay is located.

#### 6.2.2.4 Lower Athabasca Region Air Quality Management Framework

In addition to the provincial AQHI and AQMS air management systems described above, EP has developed the *Lower Athabasca Regional Plan (LARP) 2012–2022* (Government of Alberta, 2012a) and management frameworks with input from different stakeholders within the Lower Athabasca region including industry, First Nations and Métis, and nongovernmental organizations.

These frameworks are designed to manage cumulative effects to air quality, surface water quality and groundwater quality and quantity within the Lower Athabasca region. The frameworks provide context for development and related regulatory processes and facilitate sustainable resource management. They are intended to add to and complement, not replace, existing policies, legislation, regulations, and management tools.

The *LARP Air Quality Management Framework* (Government of Alberta, 2012b) provides an additional component to supplement the current regulation of air quality through the application of guidelines, objectives, and standards including the AAAQOs which are developed and implemented under *EPEA*. Hourly and annual AAAQOs are thresholds that have been set to prevent adverse human and ecological health effects and nuisance odours (Government of Alberta, 2013a).

The framework includes setting ambient air quality triggers and limits for nitrogen dioxide (NO<sub>2</sub>) and sulphur dioxide (SO<sub>2</sub>) with guidance for decision-making and management. Exceedances of the

LARP triggers provide an early warning that hourly and annual AAAQOs for SO<sub>2</sub> and NO<sub>2</sub> may be exceeded. The LARP triggers for NO<sub>2</sub> and SO<sub>2</sub> are set at one-third (management level 2) and two-thirds (management level 3) of the annual AAAQO.

Typically, ambient air data is compared to AAAQOs using average annual concentrations of the dataset as an estimate of the exposure concentration. In applying the framework, not only are annual average values used as a basis for comparison, but a more conservative approach of comparing the 99th percentile of the annual hourly dataset is also used. The 99th percentile exposure concentration indicates the trend in the upper range of the hourly data as well as the frequency of peaks in the data, as opposed to the analysis of the annual average which “smoothes out” the data.

The framework states that NO<sub>2</sub> and SO<sub>2</sub> trends vary in the Lower Athabasca region depending on the location of the air monitoring station. Historical analysis indicates that annual average and 99th percentile of hourly data for NO<sub>2</sub> concentrations have increased at some air monitoring stations in the Lower Athabasca region, while annual average SO<sub>2</sub> concentrations have remained consistent in the Lower Athabasca region at industrial, community, and background stations and remain well below the annual AAAQO (Government of Alberta, 2012b).

The LARP framework specifies that (Government of Alberta, 2012b)

If any station in the planning region exceeds a LARP ambient air quality trigger or limit a management response will be initiated. The degree of investigation, analysis and action associated with the management response is tailored to:

- the type and location of air monitoring station
- the averaging time (hourly or annual)
- the ambient air quality trigger or limit
- trend analysis (rate of increase or variability of the parameter)
- the substance being detected.

Exceedance of data relative to the respective LARP triggers determines the level of management intent required ranging from level 4 (highest concern, mitigation and immediate management actions required) to level 1 (lowest concern, monitoring sufficient). If the hourly AAAQO is exceeded, the existing regulatory compliance mechanism will come into play as described above, but one hourly exceedance will not put an air monitoring station into level 4 (Government of Alberta, 2012b).

Table 11 compares the current provincial annual and hourly AAAQOs for NO<sub>2</sub> and SO<sub>2</sub> to the provincial-government-defined LARP triggers and limit threshold values (Government of Alberta, 2012b). In general, chemicals that exhibit threshold effects (dose-response relationships) in exposed populations allow for higher exposures to chemicals over short time periods (protection against acute effects) and lower exposures to chemicals over longer time periods (protection against chronic adverse effects).



Notably, the endpoint for protection for the hourly NO<sub>2</sub> AAAQO is defined in LARP as odour perception, but the AAAQO states it is for protection against adverse respiratory effects; Table 11 has defaulted to the AAAQO endpoint for protection against adverse respiratory effects (Government of Alberta 2012b; Government of Alberta, 2013b).

**Table 11. Comparison of AAAQOs to LARP triggers and limits**

<b>Alberta Ambient Air Quality Objectives</b>			
<b>Parameter</b>	<b>Averaging period (value)</b>	<b>Value (ppb)</b>	<b>Protection endpoint</b>
SO <sub>2</sub>	1 hour (average)	172	Pulmonary function
	Annual (average)	8	Vegetation effects
	30 day (average)	11	Adopted from European Union for ecosystem protection
	Annual (average)	8	
NO <sub>2</sub>	1 hour (average)	159	Respiratory effects
	Annual (average)	24	Vegetation effects
<b>LARP SO<sub>2</sub> Ambient Air Quality Triggers and Limits</b>			
<b>Level</b>	<b>Averaging period</b>	<b>Value (ppb)</b>	<b>Management Intent</b>
Limit for Level 4	1 Hour (99th percentile)	36	AAAQO Exceeded – ambient air quality exceeding air quality limits. Action is to improve ambient air quality to below AAAQO.
	Annual (Average)	8	
Trigger for Level 3	1 Hour (99th percentile)	24	Ambient air quality below but approaching air quality limits. Action is to proactively maintain air quality below limits.
	Annual (Average)	5	
Trigger for Level 2	1 Hour (99th percentile)	12	Ambient air quality below air quality limits. Action is to improve knowledge and understanding, and plan.
	Annual (Average)	3	
Trigger for Level 1	Not defined		Ambient air quality well below air quality limits. Action is to apply standard regulatory and nonregulatory approaches.
<b>LARP NO<sub>2</sub> Ambient Air Quality Triggers and Limits</b>			
<b>Level</b>	<b>Averaging period</b>	<b>Value (ppb)</b>	<b>Management Intent</b>
Level 4	1 Hour (99th percentile)	92	See the descriptions above
	Annual (Average)	24	
Level 3	1 Hour (99th percentile)	62	
	Annual (Average)	16	
Level 2	1 Hour (99th percentile)	30	
	Annual (Average)	8	
Level 1	Not defined		

### 6.3 Exposure Concentration Calculations

To identify exceedances of AAAQOs, provincial air quality management triggers, and odour and health thresholds, it was necessary to collate existing ambient air quality data from the previously identified sources and, in some instances, calculate various exposure point concentrations (EPC) for individual parameters. The EPC is the number calculated for a parameter from statistical analysis of the data for that parameter. It is calculated as a number to represent the data. Once the EPCs are calculated, they are compared to objectives and toxicological benchmarks taken from different agencies in Canada, the USA, and internationally.

#### 6.3.1 Continuous Data Exposure Point Concentration Calculations

Continuous datasets available from WBEA and EC were summarized, and EPCs for each parameter were calculated.

The average or mean value may be used to represent a dataset of chemical parameter concentrations in any given media, but the average value contains no information about the range of distribution of the concentrations in the dataset. For this reason, using an arithmetic mean may not provide a conservative estimate of exposure. Many environmental datasets are skewed (i.e., the numbers tend to fall more to one side than the other in a distribution of the data) with a long “tail” of high values at one end of the distribution. The other end may be truncated due to limit of detection.

Typically, ambient air data in Alberta is compared to AAAQOs, using average hourly, daily, and annual concentrations of the dataset as an estimate of the exposure concentration. For example, a one-hour average refers to averaging of instrument readings over a one-hour period (Government of Alberta, 2013b). This may be appropriate when assessing ambient air data for exceedances or for compliance against operating approval clauses for emissions. Considering the complexity of odour and air quality issues with respect to human health, alternative approaches to EPC calculations are warranted.

What the LARP framework adds to the evaluation of hourly data is the use of the 99th percentile as a statistical measure that indicates the upper range or peak of the data. The framework analyzes the upper range of the hourly data to identify actions that can be taken to reduce the likelihood of reaching the hourly AAAQOs (Government of Alberta, 2012b).

In this report, methods were adopted as described in the *LARP Air Quality Management Framework* (Government of Alberta, 2012b). Aligned with this methodology, two EPCs were calculated for comparison: one based on the average concentration, and one based on the 98th percentile concentration to represent an upper bound estimate. A percentile indicates the value below which a given percentage of observations in a group of observations fall. Thus, the 98th percentile value is the one below which 98 per cent of the data fall. It represents the possibility that a portion of the population may experience exposure that is above average. The 98th percentile approach is certainly more conservative and represents a

reasonable representation of peak concentrations of the data and thus is a conservative tool to provide insight on potential risk.

Where guidelines or benchmarks have a specified metric (i.e., the data statistic to use against the guideline is specified), it should be followed, but not all the benchmarks in this report have a metric. Also, the implications of exceeding a short-term benchmark multiple times over the course of a lifetime are not entirely clear just by relying on the short-term benchmark. Therefore, a weight-of-evidence approach was used that considered the data distribution relative to the selected exposure thresholds as well as the number of times the average or upper-bound values exceeded a given benchmark.

In a few cases, the benchmark prescribed a specific method for calculating the EPC. In these instances we used the prescribed method:

- The LARP comparisons were calculated as either the average or 99th percentile of the annual hourly dataset.
- The CAAQS threshold (as calculated for the *Alberta Implementation of the Air Zone Management Framework for Fine Particulate Matter and Ozone* [Government of Alberta, 2015]) for ozone specifies that the EPC be calculated as the three-year average of the annual fourth-highest daily maximum eight-hour average (CCME, 2012).
- The United States NAAQS defines the EPC for one-hour SO<sub>2</sub> as the 99th percentile of one-hour daily maximum concentrations averaged over three years, the one-hour NO<sub>2</sub> value to be calculated as the 98th percentile of one-hour daily maximum concentrations averaged over three years, and the annual NO<sub>2</sub> value was calculated from the annual mean (US EPA, 2011).

The LARP framework adopts the 99th percentile exposure concentration as an indication of the trend in the upper range of the hourly data as well as the frequency of peaks in the data, as opposed to the analysis of the annual average which “smoothes out” the data. This report adopted the 98th percentile in an attempt to eliminate outliers from a skewed dataset. Either the 98th or 99th percentile concentrations are estimates of the upper bound of the dataset.

The use of both average and upper bound percentile EPCs allows for decision-makers to evaluate the inherent uncertainty and variability in the dataset and what this variability may mean in term of estimating human exposure.

### 6.3.2 Canister Data Exposure Point Concentration Calculations

Concentrations greater than odour thresholds were identified by comparing the concentrations of each parameter from

- the three-minute peak concentrations of potential odorants calculated from the FMSD ten-minute canister data,

The ten-minute canister data was used to calculate a three-minute concentration which may be more relevant in ascertaining the concentration of specific chemicals with respect to odour perception. The three-minute average value is representative of the near-peak concentration that a person might be exposed to. The following equation was used (AER, 2013; Intrinsik, 2013):

$$C_{3\text{-min}} = C_{10\text{-min}} \times 3\text{-minute multiplier} = C_{10\text{-min}} \times (10 \text{ minutes}/3 \text{ minutes})^{0.2}$$

where

$C_{3\text{-min}}$  = predicted 3-minute “peak” concentration

$C_{10\text{-min}}$  = measured 10-minute concentration

0.2 = exponent for the 3-minute multiplier based on neutral atmospheric conditions (as cited in Intrinsik, 2013).

- directly comparing the concentrations reported from the 24 hour NAPS canister samples, and
- comparing the average and upper bound concentrations from the hourly, daily, and annual continuous EC and WBEA data.

Concentrations calculated as described above were then compared to odour thresholds defined or available from the following agencies (see Appendix 3 for tables of odour thresholds from each source listed below):

- FMSD-proposed odour thresholds (not publicly available)
- Intrinsik Human Health and Odour Impact Risk Assessment for the Peace River Proceedings (AER, 2013; Intrinsik, 2013)
- AER-identified odour thresholds (described in Appendix 3)

In summary, the following EPC derivation methods were adopted for continuous and canister ambient air data:

- EPC adopted directly from the data
  - WBEA 24 hour canister (not publicly available)
  - WBEA hourly data (WBEA, 2015; accessed July 2015)
- EPC calculated from the data
  - three-minute peak concentration from FMSD ten-minute canister data (not publicly available)
  - hourly average and 98th percentile calculated from Environment Canada minute data to derive hourly EPC (JOSM 2015; accessed July 2015)
  - hourly average and 98th percentile calculated from Environment Canada (JOSM 2015; accessed July 2015) and WBEA hourly data (WBEA, 2015; accessed July 2015) to derive daily EPC

- hourly average and 98th percentile calculated from Environment Canada and WBEA daily data to derive annual EPC

## 6.4 Toxicity Assessment

Odour and health effects exposure thresholds were identified from multiple provincial, federal, and international regulatory agencies in order to assess if ambient air monitoring data

- were of sufficient quality and quantity to identify potential odorants,
- were exceeding odour thresholds for individual and classes of chemicals at monitoring stations,
- could be used to identify additional chemical-specific AAAQOs that are being exceeded in ambient air when the comprehensive regional ambient air monitoring datasets (more than WBEA datasets alone) are evaluated, and
- whether ambient air data in Fort McKay over a five-year time period is correlated with elevated odorant concentrations and are greater than health thresholds.

Thresholds from a variety of sources and jurisdictions were used in this technical assessment of individual parameters to be thorough and representative. If a threshold was available from multiple agencies, the EPC was compared to each of the thresholds.

### 6.4.1 Odour Thresholds

Odour thresholds identified in this report are defined as the concentration in air at which 50 per cent of the population would detect the odour but not recognize the odour as a specific compound. Exceedance of an odour threshold does not necessarily indicate a direct health impact but rather that an odour has been detected and, depending on the characteristics of that odour, is perceived as offensive or noxious. Exceedances of odour thresholds in some instances may also be correlated with direct health effects, highlighting the importance of evaluating individual parameters for both odour and health impacts.

Experiencing offensive odours can cause negative health outcomes, depending on the frequency and intensity of the odour. Detection of odours does not necessarily correlate with other negative health effects that are caused by chemicals in ambient air, such as irritating sensitive tissue like eye, nose, or lung tissue, or by absorption of the chemicals into the body and damage to internal organs or tissues. For example, the odour detection threshold for acetaldehyde is 1.5 ppb, which is lower than the 50 ppb threshold at which human health is adversely impacted. In contrast, health effects following exposure to benzene have been noted above hourly exposures of 9 ppb, which is below the odour detection threshold of 2700 ppb. Thus, odour thresholds and health-based benchmarks are separated to the extent possible.

Odour thresholds for this analysis were adopted from the following sources (see Appendix 3 for individual odour thresholds which were applied):

- *Measurement of Odor Threshold by Triangle Odor Bag Method* (Nagata, 2003).

This was selected because the results of the triangle odour bag method, an olfactory test used for environmental regulation in Japan, is considered one of the most reliable sources of odour thresholds and was previously adopted by ESRD for the ambient air quality assessment in Three Creeks (ESRD, 2010).

- *Odor Threshold Determinations of 53 Odorant Chemicals* (Leonardos et al., 2012).

This source presents more current data which is peer reviewed and identifies lower odour thresholds for various chemicals than Nagata. This is important since historical ESRD odour reports have adopted the most conservative thresholds at that time.

- *A Screening-Level Impact Assessment of Potential Health and Odour Related Impacts Associated with Heavy Oil Operations Emissions in the Peace River Area. Final Report (as available in Peace River Proceeding No. 1769924. November 25, 2013- Phase II Submissions Volume 5)* (AER, 2013; Intrinsik, 2013).

This source presents the odour thresholds used in previous air quality assessments conducted by the AER using third-party consultants for comparison to three-minute peak concentrations.

- *Guidance for Odour Impact Assessments and Odour Management for Proposed Oil Sands Projects on Fort McKay's Traditional Territories* (FMSD, 2013).

The odour thresholds proposed by the FMSD reflect the community's understanding of odour issues. If the proposed odour thresholds deviated from the odour thresholds reported in the literature, the literature-based odour threshold was adopted, but the difference was noted.

#### 6.4.2 Health-Based Thresholds

Health-based short- and long-term thresholds were identified from the sources listed in Appendix 3. Each source was included as the thresholds reported are peer reviewed and are currently adopted for use in a jurisdiction or are the only source to define a threshold for a specific parameter.

Air quality objectives are generally established for one-hour, 24 hour, and annual averaging periods. Occasionally, the underlying information or ambient monitoring method requires that other averaging periods be used. For example, a three-day objective was set for ethylene as experimental evidence indicated that this was a more appropriate averaging period than 24 hours.

As per the guidance on CAAQS, most air quality thresholds can be thought of as having a time averaging period as well as a metric (CCME, 2012). Time averaging is a complex concept when it comes to associating air quality and correlated health effects. Exposure to low levels of an air contaminant may, over the course of a lifetime, cause poor health outcomes. These are referred to as chronic effects. Repeated intermittent exposure, even if it is not occurring on a daily basis, can have chronic effects, when

and if the contaminants in question have a long residence time in the body or if the damage they cause takes a long time for the body to repair. Also, air quality can vary dramatically in a short period of time, and short-term exposure to high levels of some pollutants in air can have immediate health impacts. This is usually referred to as acute or subchronic effects. The treatment of averaging time and the definition of what constitutes a chronic, subchronic, or acute effect are not consistently applied across different government agencies.

Notably, some of the thresholds identified below take odours into account, though often at the “physical response” level, not the perception level. AAAQOs do attempt to take all endpoints into account and use the most sensitive one as the guideline. For these reasons, an “odour-based AAAQO” should not be taken to mean that the exposure to the compound only has implications for odours.

- CAAQS – *Canadian Ambient Air Quality Standards* (CCME, 2012)
  - CAAQS drive air quality management across the country as part of the AQMS. Standards exist for fine particulate matter (24 hour ) and ozone (8 hour), and work has begun to develop standards for nitrogen dioxide (NO<sub>2</sub>) and sulphur dioxide (SO<sub>2</sub>).
- AAAQO – *Alberta Ambient Air Quality Objectives* (Government of Alberta, 2013b)
  - Alberta has developed or adopted objectives from other jurisdictions where there are no national objectives or Canada-wide standards. Air quality objectives are generally established for one-hour, 24 hour, and annual averaging periods.
- *The Department of Environmental Protection (MassDEP) Ambient Air Limits (AALs)* (MassDEP, 2015)
  - These values are developed using chronic toxicity benchmarks for cancer and threshold endpoints taken from agencies in the United States that evaluate chemical toxicity based on available literature. The AALs are used in permitting programs and to assess the health implications of ambient and indoor air concentration. No metric is specified. The averaging period is one year.
- TCEQ AMCVs – *Texas Commission on Environmental Quality Air Monitoring Comparison Values* (TCEQ, 2015)
  - There are short-term and long-term AMCVs, each representing the lowest concentration to be protective of relevant effects to human health and welfare (including odour) or vegetation. Guidance on using the AMCVs for air monitoring recommends using instantaneous to one-hour samples for comparison to short-term benchmarks and using annual average data for comparison to long-term benchmarks.



- US EPA NAAQS – *United States Environmental Protection Agency National Ambient Air Quality Standards* (US EPA, 2011)
  - US EPA sets guidelines for six criteria air parameters based on health impacts and technical considerations. The averaging time is specific to the parameter, as is the metric. The six parameters are the following:
    - particulate matter (PM)
    - ozone (O<sub>3</sub>)
    - nitrogen dioxide (NO<sub>2</sub>)
    - sulphur dioxide (SO<sub>2</sub>)
    - lead (Pb)
    - carbon monoxide (CO)
- WHO AQS – *World Health Organization Air Quality Standards* (WHO, 2005)
  - WHO has guidelines for four air parameters based on health impacts. Some parameters have more than one averaging time, and averaging times are specific to the parameter. The four parameters are the following:
    - particulate matter (PM)
    - ozone (O<sub>3</sub>)
    - nitrogen dioxide (NO<sub>2</sub>)
    - sulphur dioxide (SO<sub>2</sub>)
- US EPA Integrated Risk Information System (IRIS) (Database accessed July 2015; US EPA, 2003a [benzene]; US EPA, 2003b [hydrogen sulphide])
  - US EPA IRIS develops toxicity benchmarks for carcinogenic and threshold contaminants, including reference concentration and benchmark concentration, most typically for organic hydrocarbons and chlorinated hydrocarbons, but also for metals. These values are intended to estimate health risk based on a lifetime of exposure. No specific averaging time or metric is given.
- OMOE AAQC – *Ontario Ministry of the Environment Ambient Air Quality Criteria* (OMOE, 2012)
  - The Ontario Ministry of the Environment and Climate Change has ambient air quality criteria for a suite of VOCs as well as for oxides. The majority of these are based on 24 hour averaging time, with some one-hour and annual values as well.

- BC MOE – *British Columbia Ambient Air Quality Objectives* (BCMOE, 2015, updated 2016)
  - The province of B.C. uses a suite of ambient air quality criteria that have been developed provincially and nationally to inform decisions on the management of air contaminants. The majority of these are based on 24 hour averaging time, with some one-hour and annual values as well.

Health thresholds are derived from lab studies or epidemiological data that have correlated the exposure to negligible (LOAEL –lowest observable adverse effect levels or NOAEL – no observable adverse effect level) effects which are then decreased by 10 to 300 times by the addition of safety and uncertainty factors to account for uncertainties in the data and to protect sensitive individuals. This is to ensure a very conservative approach for health-effect assessment.

In this report, we evaluated ambient air quality parameters from WBEA (2015) and Environment Canada (JOSM, 2015) by comparing to short-term and long-term (or chronic) health toxicity benchmarks from the various agencies listed above. The ten-minute FMSD canister sample data were not compared to health thresholds due to limitations of averaging time comparisons (i.e., applicability of comparing ten-minute data to hourly thresholds) and Section 4 of this report addresses the need for emergency response (i.e., acute monitoring and appropriate thresholds).

Acute health risks from impacted air quality are often assessed through comparison to acute minimal risk levels (AER 2013; Intrinsik, 2013). This report does not include an analysis of potential acute health effects as the single acute dataset that exists (FMSD ten-minute odour event canister samples) in the community of Fort McKay was received after the primary assessment period. Assessment of this dataset should be considered in the future.

Short-term exposure thresholds are those below which humans can be exposed to hourly with minimal or negligible health effects. Short-term thresholds are different than acute exposure thresholds as acute thresholds are protective of adverse irreversible health effects associated with emergency upset scenarios and are protective of immediate acute risks to health. There is currently no government policy that identifies an acceptable (or unacceptable) number of exceedances of short-term exposure thresholds.

Long-term, or chronic, exposure thresholds are those below which humans can be exposed to daily or annually for the duration of their lives with minimal or negligible adverse health effects. Exceedance of an annual threshold indicates that the population is at risk of adverse chronic health effects. There is currently no government policy that identifies an acceptable (or unacceptable) number of exceedances of long-term exposure thresholds.

The health significance of intermittent exceedance of a lifetime or chronic threshold is determined not only by the magnitude and periodicity of the exceedance, but also by the toxic profile of the parameter in question. If a parameter has a long residence time in the body, or if the damage it does takes a long time for the body to repair, then recurring intermittent exposure through the course of a lifetime can have

consequences for health similar to continuous daily exposure. Similarly, for carcinogens, depending on the mode of action, may have long-term cancer risks to individuals similar to what would be seen with continuous exposure, even though the actual exposure may be intermittent.

Long-term exposure thresholds were identified for both noncarcinogenic and carcinogenic effects. These thresholds are used for the purpose of identifying air parameters that may pose a concern for human health. The AAAQOs do not represent a complete inventory of the compounds that may be related to industrial activity in the area and may be of concern for human health. Often in screening compounds of potential concern, the most conservative value is used. In this case all of the thresholds were presented for transparency and to assure that potential risks were not overlooked or overestimated.

Concentrations of various parameters in ambient air samples for short- (one-hour) and long-term (daily and annual) averaging periods were compared to odour and health thresholds. This assessment only identifies individual parameter exceedances and does not assess cumulative effects of exposure to multiple parameters in ambient air. Comparing single chronic exposure concentrations (i.e., average annual EPCs) to short-term odour thresholds is not appropriate because amalgamating the air quality data over a year will essentially “smooth out” the short-term spikes in parameter concentration that are responsible for the perception of odours. In the case of having short-term data, such as the canister samples, these were compared to short-term thresholds (hourly and daily) as a screening measure to identify whether assessment of long-term health impacts might be advisable.

Many of the complex compounds related to sulphur and hydrocarbons (such as thiophenes, mercaptans, sulphides, pentanes, butanes, and heptanes) do not have chemical-specific odour or health-exposure thresholds for comparison. Exposure thresholds for other compounds can be used as surrogates for both mixtures and individual compounds. This is a gap in the assessment of odour and air quality, including in the mineable oil sands region.

There is no single odour threshold for TRS compounds because the term includes a mixture of many different compounds. Each compound has an odour threshold that can differ from another by orders of magnitude. Depending on the ratio of mercaptans to thiophenes to sulphides, the odour threshold may be higher or lower than the 0.41 ppb odour threshold (Nagata, 2003) adopted for this assessment. Notably AMS01 in the community of Fort McKay monitors for only TRS, while each of the industrial monitoring stations monitor for only H<sub>2</sub>S.

Alberta Health commonly applies H<sub>2</sub>S as a surrogate for assessment of potential impact of TRS, in absence of more specific guidelines for TRS. Therefore this approach was taken in this report. Surrogates were also adopted for additional parameters (i.e., individual thiophenes and mercaptans based on a single congener) in an attempt to identify potential odour and health threshold exceedances.

In addition, a number of compounds that do have odour and health thresholds are not continuously monitored within the WBEA or Environment Canada networks, and potential air quality impacts from

these parameters could not be assessed. For example, 1,3 butadiene and acrolein have been characterized and quantified in ambient air samples in the mineable oil sands area, and AAAQOs, odour, and health thresholds exist, but it is not monitored continuously in the monitoring network. This report did not evaluate the analytical limitations of the current monitoring network, rather the purpose was to present the available data and compare them to available thresholds. Any technical limitations that may affect monitoring capabilities within the network for specific parameters in ambient air will need to be addressed in future work aligned with the recommendations of this report.

The tables in Appendix 3 list the multiagency thresholds available and thresholds used in this report for assessment of ambient air.

## 6.5 Analysis

The following sections relate to the direct comparison of provincially reported exceedances of AAAQOs from air quality data collected within the WBEA network as published in the CASA data warehouse, exceedances of AAAQOs at WBEA monitoring stations on dates which AER received an odour complaint, and comparison of odour and health thresholds to ambient air quality data collected at WBEA and EC continuous monitoring stations and the FMSD odour event triggered canister sampling program.

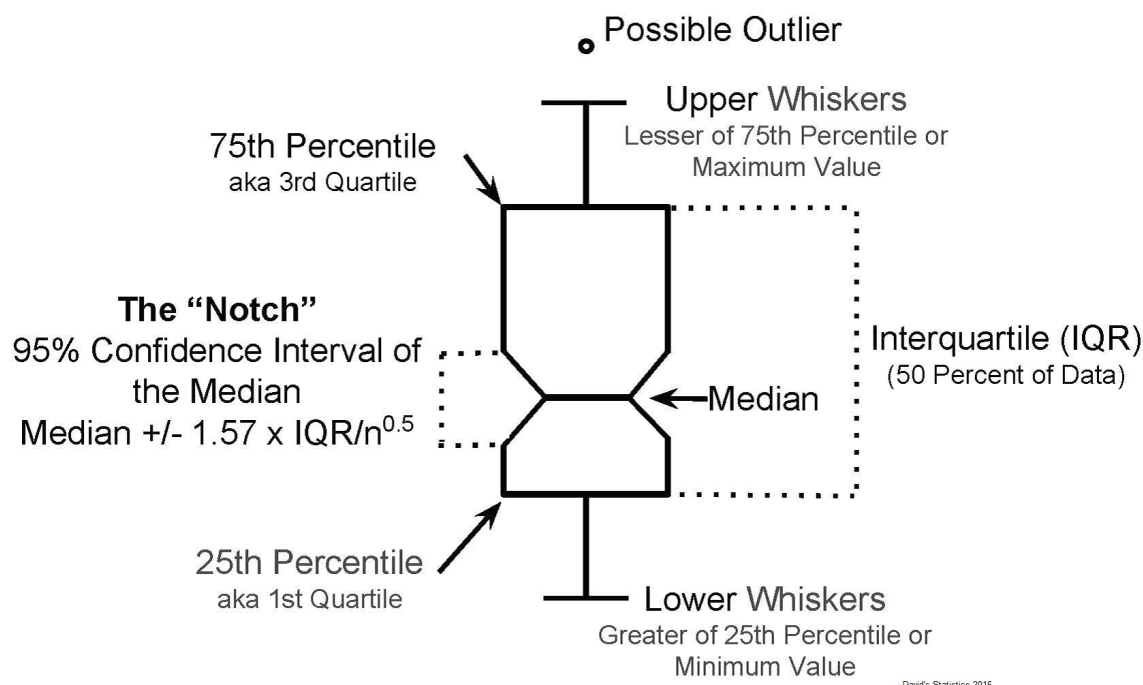
The objective of this section was to compare multiple air quality datasets in the community of Fort McKay to a suite of odour thresholds and health-effect thresholds that currently exist to determine if exceedances occur (or not), the frequency of those exceedances, and the concurrence of exceedances for a particular parameter.

After each section, a comparison of the dataset to appropriate thresholds and a statistical representation of the analysis is presented. The box plots presented in each section were generated using US EPA proUCL version 5.0 software. These representations of the data are important for full transparency to illustrate the distribution of the data compared with the thresholds selected. In statistical literature, one can find several ways to generate box plots. All box plot methods, including the ones presented in the analysis section, convey the same information about the dataset: potential outliers, mean, median, symmetry, and skewness.

The box plots presented in each statistical analysis section should be interpreted using Figure 20 and the US EPA ProUCL guidance documents (US EPA, 2013).

Guidance to interpret box plot statistical representation of datasets as compared to thresholds (Chambers et al., 1983; US EPA 2013).

- The box shows the interquartile range (IQR). The IQR is the 25th to 75th percentile, also known as Q1 and Q3. The IQR is where the centre 50 per cent of data points fall.



**Figure 20. Box plot diagram (Chambers et al., 1983)**

- The whiskers add 1.5 times the IQR to the 75th percentile (Q3) and subtract 1.5 times the IQR from the 25th percentile (Q1). The whiskers should include 99.3 per cent of the data if the data are from a normal distribution.
- The horizontal line indicates the median of the data.
- The notch displays the confidence interval around the median which is normally based on the median  $\pm 1.57 \times \text{IQR}/\text{square root of } n$ . According to *Graphical Methods for Data Analysis* (Chambers, 1983), although not a formal test, if two boxes' notches do not overlap there is "strong evidence" (95 per cent confidence) their medians differ.

### 6.5.1 Regional Scale AAAQO Assessment (2010–2014)

The following sections summarize exceedances of AAAQOs for the study period at WBEA monitoring stations in the study area as identified and extracted from the CASA data warehouse published by the provincial government.

#### 6.5.1.1 Ammonia

Ammonia ( $\text{NH}_3$ ) is used for scrubbing  $\text{SO}_2$  from production streams before releasing through stacks. This technology is associated with the FGD plant at Syncrude, which produces a wet emission plume. Ammonia reacts with acidic substances and  $\text{SO}_2$  to form ammonium salts (as monitored at the Oski-ôtin station) that occur predominantly in fine particulate matter ( $\text{PM}_{2.5}$ ) (Dann, 2013). Ammonia is monitored

at a single continuous AMS location within the WBEA network: Fort McKay (AMS01). There were no exceedances of the hourly average AAAQO of 2.0 ppm for the study period.

#### 6.5.1.2 Carbon Monoxide

Carbon monoxide (CO) is a colourless and odourless gas emitted from combustion processes. Carbon monoxide is formed from the incomplete combustion of carbon in fossil fuels. The AAAQOs for one-hour averages (13 ppm) and eight-hour averages (5 ppm) were not exceeded for the study period.

#### 6.5.1.3 Nitrogen Dioxide

Nitrogen dioxide (NO<sub>2</sub>) is a reddish-brown gas with a pungent, irritating odour. Oxides of nitrogen, mostly in the form of nitrogen monoxide (NO) and nitrogen dioxide (NO<sub>2</sub>), are produced by the combustion of fossil fuels. NO<sub>2</sub> plays a major role in atmospheric photochemical reactions and the formation and destruction of ground-level ozone (Dann, 2013). NO<sub>2</sub> is a precursor to ground-level ozone formation.

NO<sub>2</sub> is a health concern due to its respiratory effects. The odour threshold of NO<sub>2</sub> is 120 ppb (Nagata, 2003), the hourly average AAAQO is 159 ppb. Therefore odours may be detected when the AAAQO is not exceeded. There have been no exceedances of the hourly AAAQO (159 ppb) in the study area for the study period.

#### 6.5.1.4 Sulphur Dioxide

Sulphur dioxide (SO<sub>2</sub>) is a colourless, nonflammable gas with a sharp, pungent odour. Since coal and petroleum often contain sulphur compounds, their combustion generates SO<sub>2</sub> unless the sulphur compounds are removed before burning the fuel. SO<sub>2</sub> reacts in the atmosphere to form sulphuric acid and acidic aerosols, which contribute to acid deposition. SO<sub>2</sub> combines with other atmospheric gases to produce fine particles, which may reduce visibility and contribute to potential health impacts (Dann, 2013). SO<sub>2</sub> is a health concern as it affects pulmonary function.

There have been no exceedances of the 172 ppb hourly average, 48 ppb 24 hour average, or 8 ppb annual average AAAQOs in the community of Fort McKay. There were three hourly average and one 24 hour average exceedance noted in the 30 km study area for the study period.

#### 6.5.1.5 Hydrogen Sulphide and Total Reduced Sulphur

Hydrogen sulphide (H<sub>2</sub>S) is a colourless gas with a characteristic rotten egg odour. To clarify, H<sub>2</sub>S is a single gaseous chemical which is a component of TRS. The term TRS is used to collectively describe a group of compounds, including H<sub>2</sub>S, dimethyl sulphide, dimethyl disulphide, carbon disulphide, carbonyl sulphide, thiophenes, methyl mercaptan and other mercaptans. These individual compounds are assessed below. Note that individual WBEA monitoring stations monitor for either H<sub>2</sub>S or TRS but not both.

Natural sources of TRS in air include volcanoes and sulphur springs, oceans and estuaries, and exposed faces of sulphur-containing oil and coal deposits. In the absence of oxygen, decomposition of organic matter by bacteria results in the release of TRS. This produces the characteristic odour commonly associated with sewers, sewage lagoons, and swamps. Industrial sources are primarily petroleum refining, petrochemical complexes, and pulp and paper mills. In this study area, most TRS and H<sub>2</sub>S emissions are attributed to upgraders (stack and fugitive emissions), tailings ponds, and mine faces. There is a natural background ambient air concentration of the reduced sulphur compound carbonyl sulphide of approximately 0.5 ppb (Dann, 2013).

CASA does not adopt H<sub>2</sub>S as a surrogate for TRS when reporting exceedances of the H<sub>2</sub>S AAAQOs, whereas WBEA, the FMSD, and the remainder of data comparisons conducted in this report do report TRS concentrations greater than H<sub>2</sub>S thresholds. This is necessary because AAAQOs have not been developed for TRS, and monitoring stations within the WBEA network monitor for either H<sub>2</sub>S or TRS but not both at various locations.

For this section of the report, exceedances of TRS were identified through manual computation and incorporated with the CASA-identified H<sub>2</sub>S exceedances.

Figure 21 compares H<sub>2</sub>S and TRS one-hour exceedances of the H<sub>2</sub>S AAAQO in 2014 (10 ppb) and temporal trends in exceedances at each station. Exceedances generally occur near facilities. In 2010, there were 612 exceedances in the study area; that number decreased to 166 in 2011, 168 in 2012, and 12 in 2013 before increasing to 31 in 2014. There were no exceedances at the Fort McKay Bertha Ganter community station in 2014, 2013, and 2011, but there were 5 in 2010 and 2 in 2012.

The 24 hour average AAAQO for H<sub>2</sub>S is 3 ppb. In 2010 there were 118 exceedances in the study area, which decreased to 30 in 2011 and 2012, then to 2 in 2013 and 2014. There were no exceedances at the Fort McKay Bertha Ganter community station in 2014, 2013, or 2011, but there were 3 in 2010 and 1 in 2012.

#### 6.5.1.6 Ozone

Ozone (O<sub>3</sub>) can affect human pulmonary function. O<sub>3</sub> is a reactive, unstable form of oxygen. It is not emitted directly but it is formed in the air from oxygen and is influenced by NO<sub>x</sub> and VOCs and may act as an indicator of elevated NO<sub>x</sub>, THC, and VOC concentrations in ambient air. Ozone concentrations are also influenced by strong sunlight and warmer temperatures. Ozone is a natural component of the atmosphere, with concentrations increasing at higher altitudes (Dann, 2013). Ozone concentrations fluctuate daily and seasonally, with background levels in rural areas ranging from 20 to 50 ppb and about 10 ppb lower in urban areas.

WBEA (Dann, 2013) states that in concentrations found in outdoor air, even in the most severe pollution episodes, ozone is both colourless and odourless. Others note that ozone's odour is sharp, reminiscent of



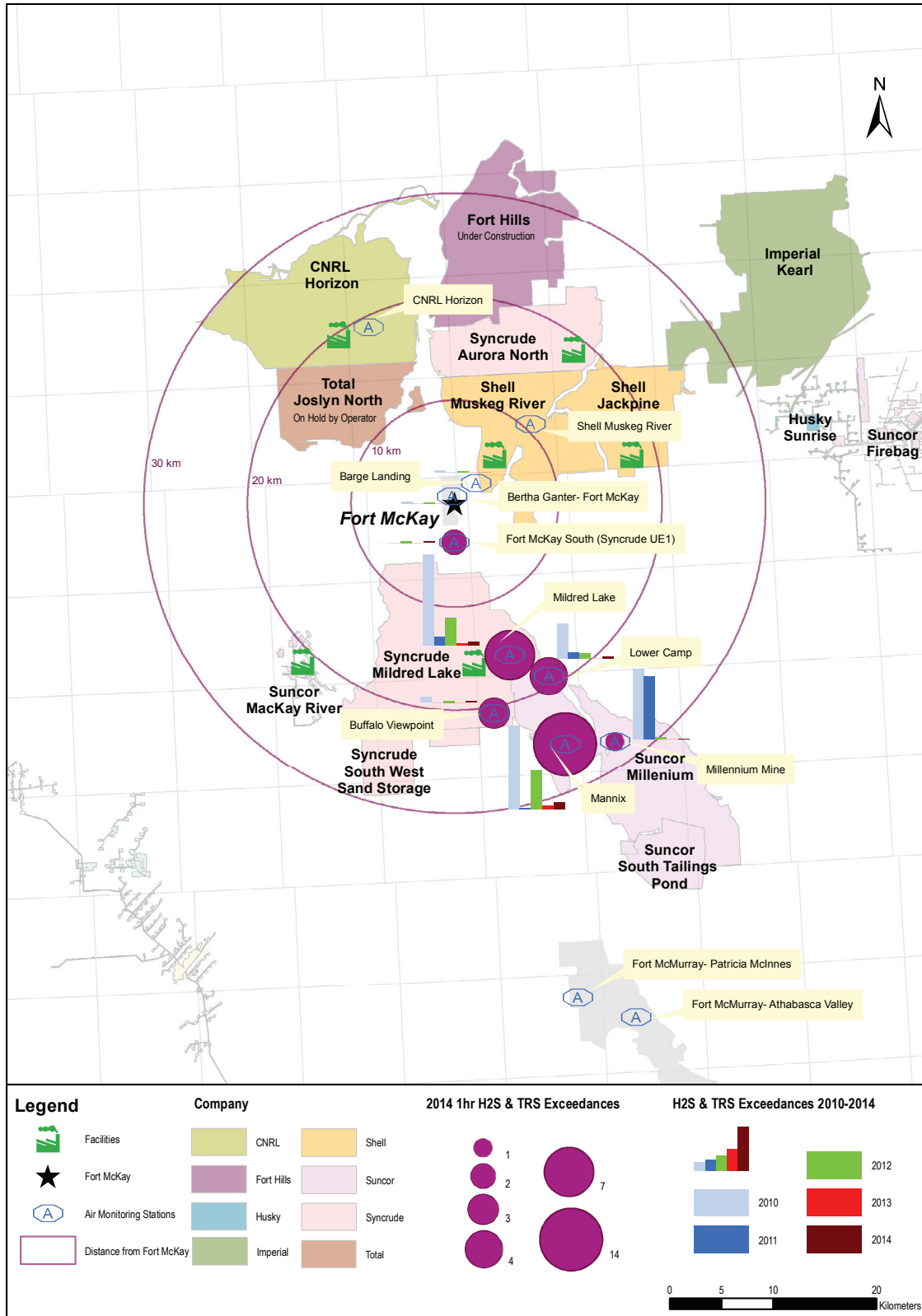


Figure 21. One-hour concentrations of H<sub>2</sub>S and TRS in ambient air greater than H<sub>2</sub>S AAAQO collected by the WBEA stations for the study period

chlorine, and detectable by the general population at concentrations as low as 10 ppb in air. Nagata (2003) lists the odour threshold for ozone as 3.2 ppb. This apparent contradiction in odour perception may be due to the testing methods, which require the addition of ozone to ultra-pure air in controlled amounts, which may allow for the notable detection of odours when compared to real-world situations where the general population has become accustomed or desensitized to the smell of ozone in outdoor air.

Figure 22 shows ozone exceedances in the study area. Fort McKay Bertha Ganter detected eleven exceedances of the 82 ppb one-hour AAAQO for the study period, eight in 2011 and three in 2014. Fort McKay South (Syncrude) had six exceedances in 2011, one in 2012 and two in 2014. The 2014 exceedances occurred in August.

#### 6.5.2 AAAQO Exceedances on Dates When Complaints Were Received (WBEA Data 2010–2014)

The data collected at WBEA monitoring stations were refined to reflect AAAQO exceedances at individual monitoring stations within the study area on dates during which complaints were received from residents of Fort McKay for the study period.

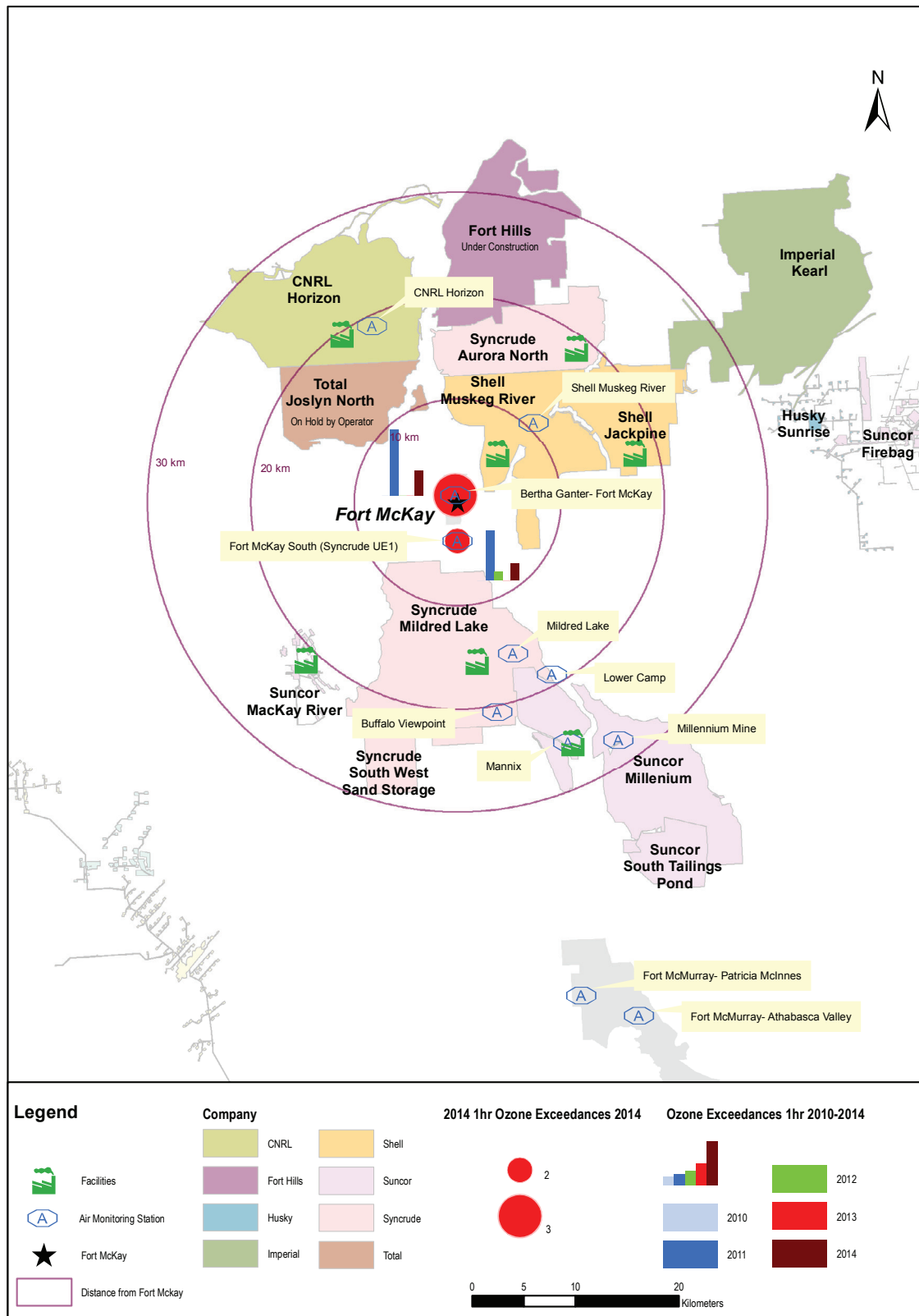
Data were compiled for 172 complaint dates for stations within the study area, excluding  $PM_{2.5}$ . Particulate matter is important in understanding overall air quality for the assessment of human health and should be included in an ambient air quality assessment, but for the purposes of this report, it was excluded because its detection in ambient air samples is often correlated to nonindustrial events (i.e., forest fires) and the relationship between  $PM_{2.5}$  and odours has not been well studied. It should be noted that  $PM_{2.5}$  did exceed AAAQOs on some dates odour complaints were received.

$H_2S$  is not monitored for in the community of Fort McKay and therefore the analysis below does not include any data collected within the community.

As shown in Figure 23, the majority of  $H_2S$  AAAQO exceedances for the study period, on dates which complaints were received, occurred primarily at three monitoring stations: Mildred Lake (29 per cent), Mannix (12 per cent), and Lower Camp (11 per cent). AAAQO exceedances were not observed for 47 per cent of the dates complaints were received for the study period.

As stated earlier,  $PM_{2.5}$  was excluded from this assessment; therefore, Table 12 only reflects  $H_2S$  exceedances of 1 and 24 hour AAAQOs.

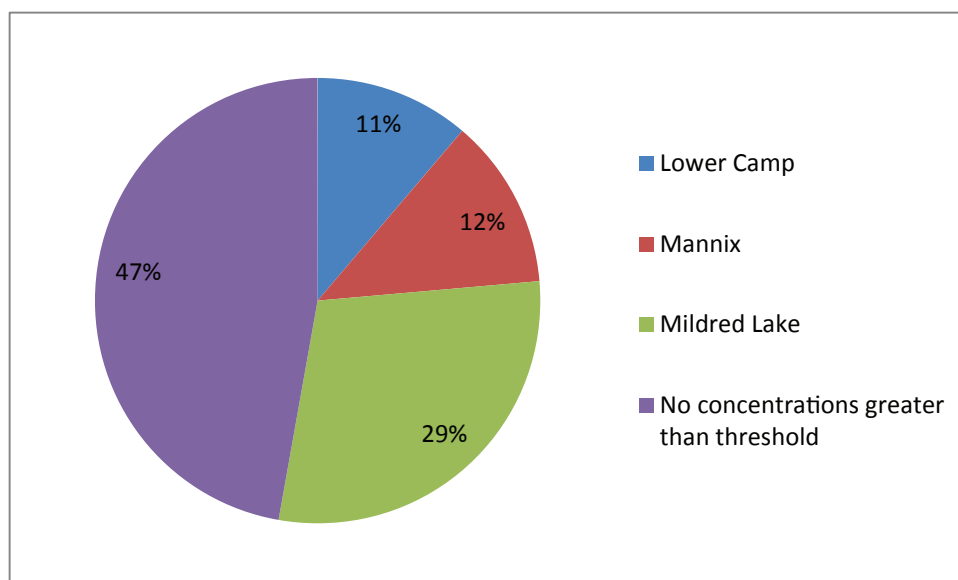
On average over the five-year study period, roughly half of the days on which odour complaints were received could be attributed to concentrations greater than AAAQOs in the study area. Annually, the percentage was highly variable: in 2010, 84 per cent of complaint days could be correlated; in 2011, 18 per cent; in 2012, 48 per cent; and in 2013 and 2014 less than 1 per cent of instances greater than AAAQO were correlated with odour complaints.



The AER does not warrant the accuracy or completeness of the information contained in this map and is not responsible for any errors or omissions in its content and accepts no liability for the use of this information.

Base data contains information licensed under the Open Government Licence – Alberta

**Figure 22. One-hour concentrations of ozone in ambient air greater than the AAAQO collected by the WBEA stations for the study period**



**Figure 23.** Per cent of H<sub>2</sub>S concentrations greater than AAAQO collected by the WBEA stations for the study period on dates when complaints were received by the AER from residents of Fort McKay

**Table 12.** H<sub>2</sub>S measurements compared to AAAQOs on complaint dates for the study period and the study area

Monitoring station and parameter	Number
<b>Lower Camp (AMS11) measurements greater than AAAQO</b>	<b>20</b>
H <sub>2</sub> S 1 hour	17
H <sub>2</sub> S 24 hour	3
<b>Mannix (AMS05) measurements greater than AAAQO</b>	<b>22</b>
H <sub>2</sub> S 1 hour	20
H <sub>2</sub> S 24 hour	2
<b>Mildred Lake (AMS02) measurements greater than AAAQO</b>	<b>52</b>
H <sub>2</sub> S 1 hour	43
H <sub>2</sub> S 24 hour	9
<b>Total number of concentrations less than AAAQO at time of complaint</b>	<b>84</b>
<b>Total number of measurements at time of complaint</b>	<b>178</b>

When comparing the entire WBEA AMS network to AAAQOs, there were 21 concentrations greater than ozone thresholds within the study area for the study period; however, none of these were correlated with dates and times odour complaints were received.

Due to the relatively small number of parameters continuously monitored by the WBEA network, additional data sources were reviewed to characterize ambient air conditions in the community of Fort McKay. These included WBEA canister data and Environment Canada continuous monitoring data from the Fort McKay station as presented below.

### 6.5.3 Historical Ambient Air Monitoring Data for Broader Benchmark Comparison

This section describes EPCs calculated from ambient air data for various parameters monitored by Environment Canada, WBEA, and the FMSD in the community of Fort McKay and determines whether the EPCs were greater than AAAQOs, regional management triggers, and/or greater than odour and health based thresholds available from other international regulatory jurisdictions.

Although the terms below may be inadvertently used interchangeably, for the purposes of this report, the following guidance is provided:

- An exceedance applies only when the calculated or provided EPC is greater than an Alberta or Canadian threshold prescribed by the regulatory agency (i.e., AAAQOs, LARP triggers, AQMS triggers, CAAQS).
- If an EPC is greater than non-Alberta or Canada-wide prescribed thresholds listed above, then it is considered as such, greater than (i.e., odour thresholds from published literature, US EPA, WHO, TCEQ AMCVs [not adopted as AAAQOs]).

In the discussion below, Section 6.5.3.1 and Section 6.5.4 describe noncontinuous canister data collected by WBEA and FMSD respectively. The latter sections describe continuous data collected by WBEA and Environment Canada.

#### 6.5.3.1 WBEA Canister Samples in Fort McKay (AMS01)

WBEA uses canister sampling methods for measurement of VOCs and reduced sulphur compounds over a 24 hour period. Canisters are analyzed for 60 VOCs and 20 reduced sulphur compounds (Percy et al., 2011). Sampling methodology is described in Percy et al. (2011), reporting that canister samples are collected from eight continuous monitoring stations over a 24 hour period with measurement of parameters in ambient air in the 0.01 to 20 ppb range. The sampling and analytical methods adhere to the *AMD* (Alberta Environment, 1989, updates released for review 2014).

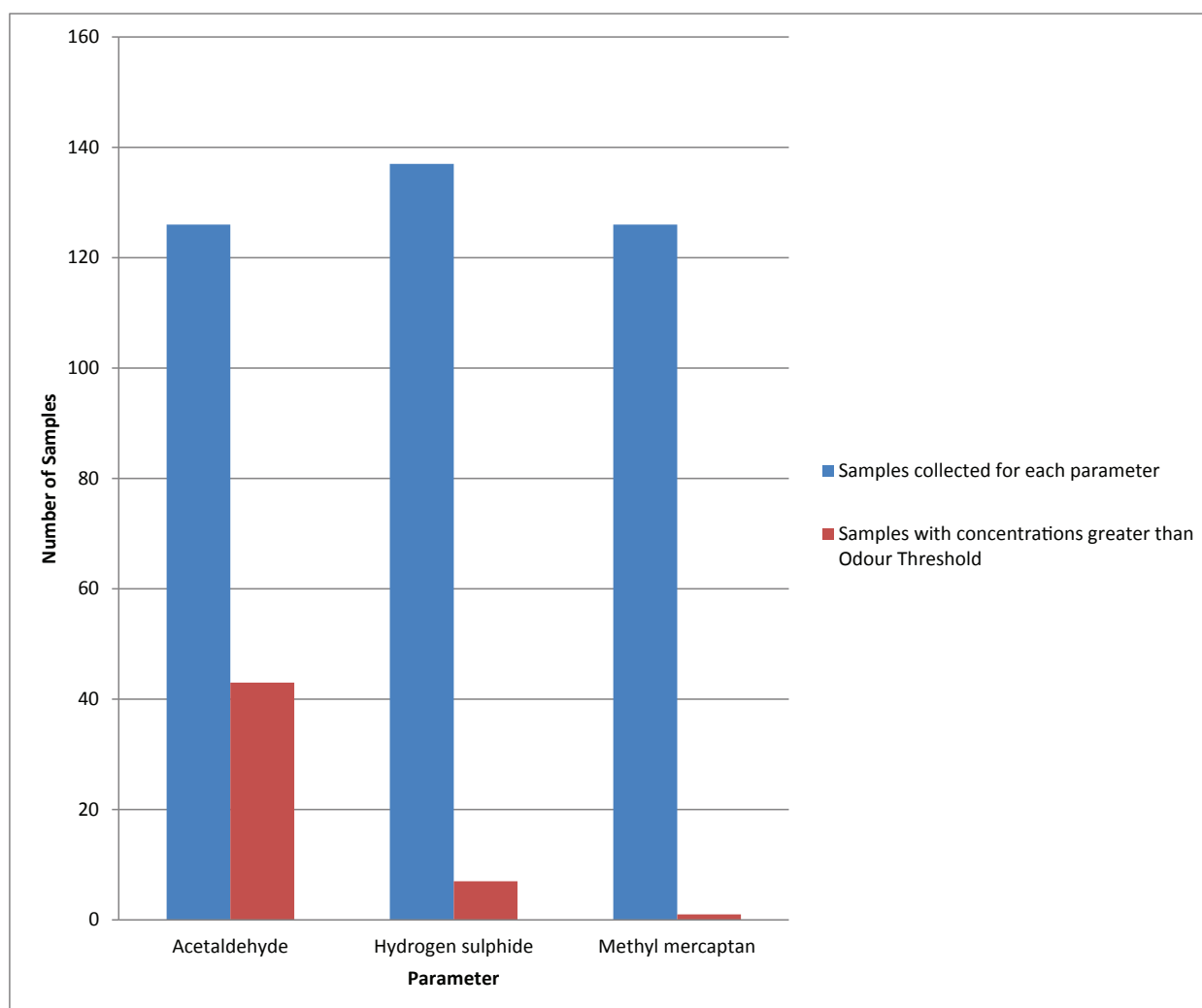
Data for parameters from WBEA canister samples were compared directly to available daily or 24 hour exposure thresholds. You cannot derive hourly concentrations from these samples because 24 hour canister samples do not capture fluctuations throughout the day. Canister samples are shipped every two

weeks, which may result in transformation or degradation of a number of volatile compounds, reduced sulphur compounds in particular.

The detailed comparison of the WBEA canister data to the daily (24 hour) odour and health-effect thresholds at AMS01 in the community of Fort McKay from 2010 to 2014 can be found in Table 29 of Appendix 3. Summaries are shown in Figure 24 and Figure 25.

Policy guidance in Alberta for the number of exceedances of a threshold for a given parameter does not currently exist. In addition to information about the dose, the mechanism of action would ultimately determine the health significance of exceeding a given guideline, therefore a frequency of exceedance was not defined.

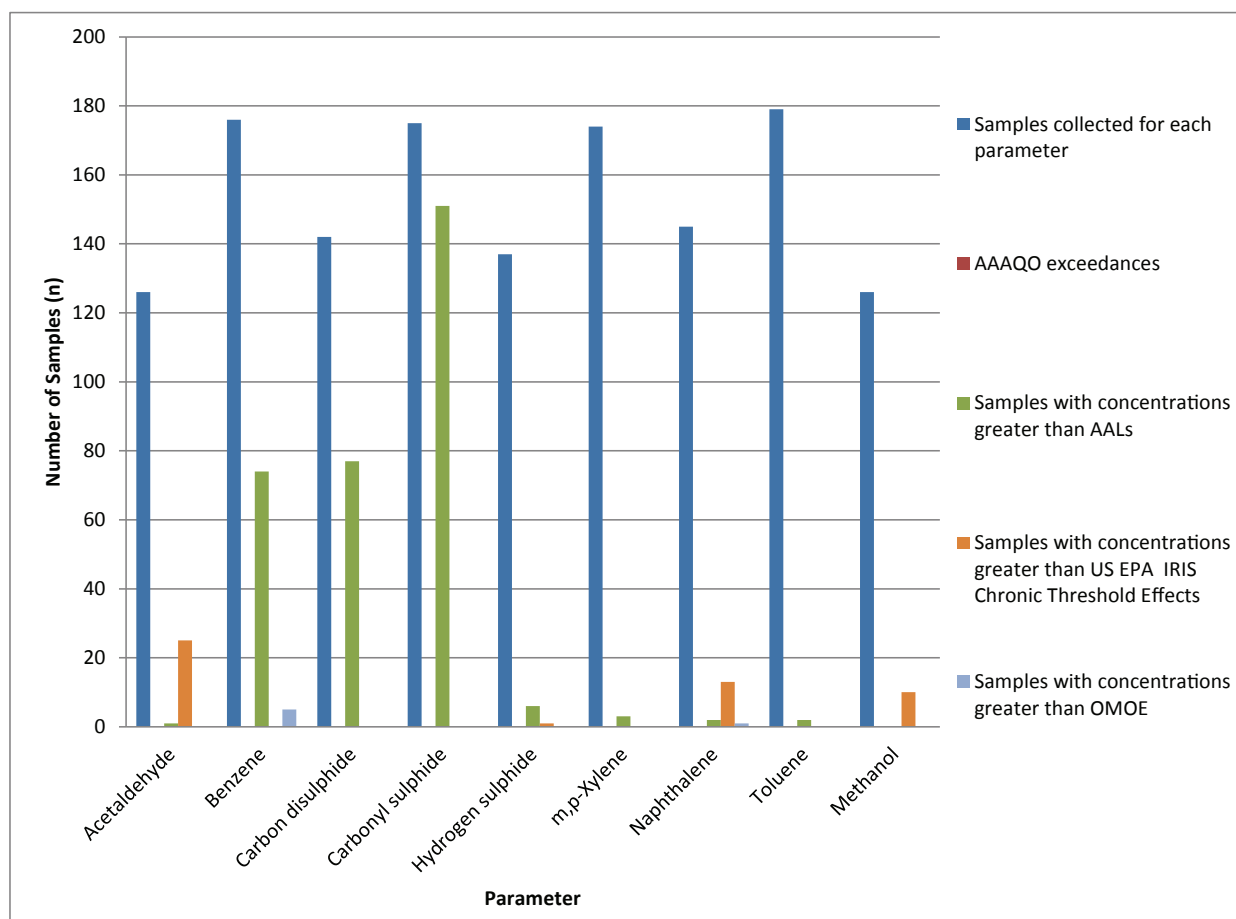
The WBEA canister data showed that the following chemicals were greater than specific odour and health thresholds (Figure 24, Figure 25, Figure 26):



**Figure 24. Number of samples with concentrations greater than the odour thresholds collected during WBEA ambient air canister sampling program at AMS01 in Fort McKay for the study period**

- acetaldehyde (greater than both odour and short-term thresholds, US EPA IRIS, 2016)
- carbon disulphide (greater than short-term thresholds, MassDep AAL, 2015)
- carbonyl sulphide (greater than short-term thresholds, MassDep AAL, 2015)
- methanol (greater than short-term thresholds, US EPA)
- naphthalene (greater than short-term thresholds, US EPA)
- benzene (greater than short-term thresholds, MassDep AAL, 2015; OMOE, 2012)
- mixed xylenes (greater than short-term thresholds, MassDep AAL, 2015)
- hydrogen sulphide (greater than odour thresholds and MassDep AAL, 2015; US EPA IRIS, 2016, short-term thresholds)
- methyl mercaptan (greater than odour thresholds, no health thresholds available)
- toluene (greater than short-term threshold, MassDep AAL, 2015)

Figure 26 indicates the magnitude and frequency of concentrations greater than odour and short- and long-term health thresholds for acetaldehyde. There is not a 24 hour AAAQO for acetaldehyde



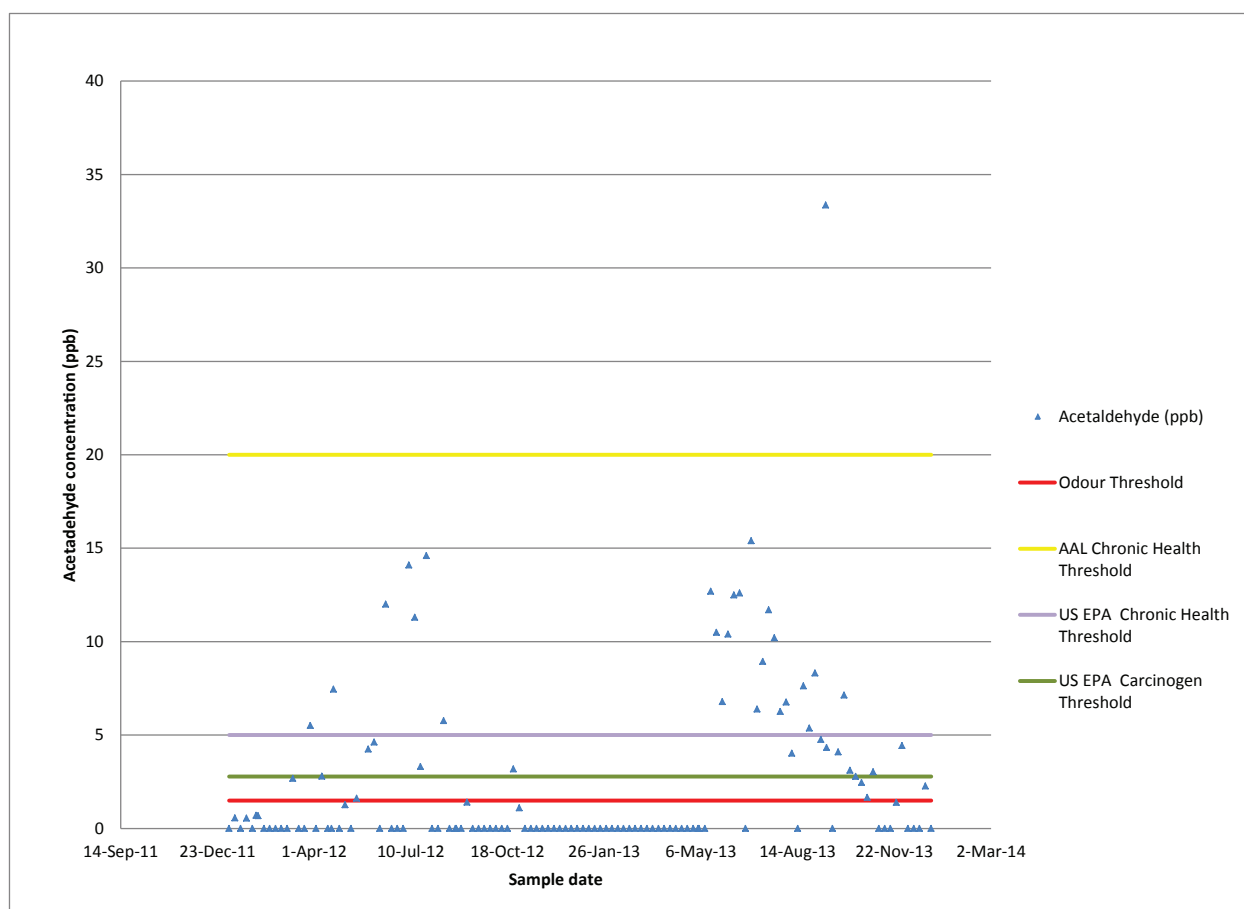
**Figure 25. Number of samples with concentrations greater than health thresholds collected during WBEA ambient air canister sampling program at AMS01 in Fort McKay for the study period**



(Government of Alberta, 2013a). This figure illustrates that certain chemicals are being characterized in ambient air and are greater than Alberta and non-Alberta health thresholds. There is a gap in the analysis of certain parameters in ambient air as there currently is either no applicable time-averaged AAAQO or no AAAQO at all.

The WBEA canister data is limited by the following considerations:

- Samples are collected over 24 hours and are therefore only comparable to daily or 24 hour thresholds (not hourly) and thus are difficult to correlate to concentrations of chemicals in ambient air during odour events.
- Hold times prior to shipping and analysis have exceeded two days for most samples, which may decrease concentrations of sulphur parameters due to degradation or transformation processes.
- Concentrations of a number of chemicals in ambient air are at or near instrument detection and method detection limits. The low concentrations of parameters that are odorants and potentially impacting human health makes the sensitivity of analytical instruments with respect to low minimum detection limits a necessity for monitoring ambient air in this region.



**Figure 26. WBEA 24 hour canister acetaldehyde concentration measurements for the study period compared to various exposure and odour thresholds**

#### 6.5.4 FMSD Ten-Minute Odour Event Samples Collected in Fort McKay from 2010 to 2013

As stated by the FMSD (2003), “the data are intended to be used in the analysis of data from Fort McKay’s odour-event-related canister sampling program. This sampling program is focused on characterizing air quality during odour events however in some cases canister sampling was done for other reasons.” Each of the twenty-one samples was collected during odour-related events related to complaints received from the FMSD.

The AER has completed a preliminary assessment to identify chemicals with concentrations greater than odour thresholds defined by the FMSD (FMSD, 2013), Intrinsik for the Peace River Proceedings (AER, 2013; Intrinsik, 2013), and the AER assessment for this report (Table 13). The three-minute peak concentration calculated from the ten-minute canister data showed that the following parameters were greater than one or more of the available odour thresholds (Figure 27).

The FMSD ten-minute odour event canister peak three-minute average or hourly concentration data showed the following instances with concentrations greater than the chemical-specific odour threshold (various odour thresholds as listed in Table 13 are available in Appendix 3). Footnoted parameters indicate chemicals that were greater than odour thresholds in both the WBEA and FMSD datasets.

Table 13 indicates all parameters that were greater than at least one threshold in any of the three odour threshold suites used for comparison. Figure 27 describes parameters that were greater than any odour threshold more than once (i.e., indicating an increased frequency of detection in the ambient air rather than potential laboratory error) and used to identify the focal parameter list for potential odorants.

The FMSD ten-minute canister data identified a number of chemicals that may be contributing to the perception of odours in the community of Fort McKay. These data need to be further assessed, and the data are limited by

- quality validation of FMSD ten-minute dataset,
- identification of complaints received by AER on sampling dates, and
- assessment of meteorological conditions on sampling dates and times.

Note that not all compounds have available odour or health-exposure thresholds for comparison, and further research to identify thresholds is required.

#### 6.5.5 WBEA Continuous Sampling in the Community of Fort McKay (AMS01)

Data from WBEA AMS01 were assessed to determine if parameters were detected in the community of Fort McKay that were greater than odour thresholds and hourly, daily, or annual health thresholds. Average and 98th percentile were calculated from hourly and daily data for each parameter to represent an exposure concentration for each parameter on a daily and annual basis for comparison to odour and health-based thresholds. Hourly concentrations for each parameter as published by WBEA (WBEA, 2015;

**Table 13. Number of peak three-minute concentrations calculated from FMSD ten-minute canister data greater than odour-based exposure thresholds (n=21; 2010 to 2013)**

Parameter	Number of samples with concentrations greater than the threshold		
	FMSD-defined odour thresholds (FMSD, 2013)	AER-identified odour thresholds for recurrent Ft. McKay odour complaint assessment	Peace River Odour Impact Assessment (Intrinsik, 2013) odour thresholds
Ethane	1	0	0
Ethylene	1	0	0
Hydrogen sulphide*	4	8	11
Carbonyl sulphide	1	0	0
Dimethyl sulphide	1	0	1
Carbon disulphide*	3	0	0
Thiophene	1	1	0
Dimethyl disulphide	3	1	5
2-methyl Thiophene	3	2	0
3-methyl Thiophene	2	3	0
Allyl sulphide	1	0	0
2,5-dimethyl Thiophene	1	0	0
Butane	1	0	0
Acrolein	2	0	1
Isoprene	13	0	0
Methyl ethyl ketone	6	0	0
Toluene*	1	0	1
n-Propylbenzene	2	0	0
p-Ethyltoluene	2	0	0
Naphthalene*	2	0	0
3-Butene-2-amine	1	0	0
Benzaldehyde	2	0	2
Benzene ethanamine,.alpha.,3,4-trimethyl	1	0	0
2 ethyl hexanol	2	0	0
Phenol, 4-methyl-	1	0	0
Benzenethiol	1	0	0
1-Octene	1	0	0
Heptanal	1	0	1
Decanal	1	0	1
Dodecanal	1	0	0
Ethanone, 1-(4-methylphenyl	1	0	0
Hexanal, 2-ethyl-	3	0	0
Nonanal	3	0	3
BENZENETHIOL-S-D	1	0	0
2-Pentenal, (E)-	1	0	0
2-Butenal, (Z)-	1	0	0
4-Nonyne	1	0	0
Methyl ethyl disulphide	1	0	0
Disulfide, methyl propyl	1	0	0
2-Octenal, (E)-	1	0	0
Acetic acid, [o-(trimethylsiloxy)phenyl]	1	0	1
1-hepten-3-one	1	0	0
Ethyl n-propyl disulfide	1	0	0

Parameter	Number of samples with concentrations greater than the threshold		
	FMSD-defined odour thresholds (FMSD, 2013)	AER-identified odour thresholds for recurrent Ft. McKay odour complaint assessment	Peace River Odour Impact Assessment (Intrinsik, 2013) odour thresholds
Trisulfide, dimethyl	1	0	1
Glycocyanidine	1	0	0
Benzene, 1-methyl-2-(1-meth	1	0	0
Benzaldehyde, 2-methyl-	1	0	0
Cyclobutanone, 2,3,3,4-tetramethyl-	1	0	0
2H-Pyrrole, 3,4-dihydro-5-[2-(methylthio	1	0	0
Propanal, 2-methyl-3-phenyl	1	0	0
Thiophene, 2-methyl-	1	0	0
Thiocyanic acid, methyl est	1	0	0
17-Octadecenal	1	0	0
Dimethyl tetrasulphide	1	0	0
Ethanone, 1-(2-methylphenyl	1	0	0
Thiophene, 3-methyl-	2	0	0
Benzene, 1-ethyl-4-methyl-	2	0	0
Dimethyl disulphide	1	0	0
2,4-Nonadiyne	1	0	0
Hexanal	1	0	1
Sulphur dioxide	2	0	0
Acetaldehyde*	3	0	0
Carbon disulfide*	1	0	0
alpha Pinene	2	0	0
2-Cyclopenten-1-one	1	0	0
<b>Total Number of Samples</b>			<b>21</b>

Note: FMSD ten-minute canister dataset was not compared to health-based thresholds

Yellow highlighting indicates number greater than the threshold used for comparison.

\*Parameters greater than odour thresholds in both WBEA 24 hour and FMSD ten-minute canister datasets

accessed July 2015) (as hourly average of five-minute data) were directly compared to thresholds rather than accessing raw data and calculating the upper bound as was completed for daily and annual comparisons.

#### 6.5.5.1 WBEA Hourly Data

Comparison of the WBEA hourly data collected in the community of Fort McKay over the study period to thresholds (Table 14 and Table 15) showed that

- TRS was greater than odour thresholds for H<sub>2</sub>S (0.41 ppb) ~50 per cent of the time over the five years and ~30 per cent of the time over the past two years;
- TRS was greater than H<sub>2</sub>S AAAQOs ~0.02 per cent of the first two years of the study period but not in the last two years, highlighting the discrepancy between the 0.41 ppb odour threshold reported in Nagata (2003) and the odour-based AAAQO (10 ppb);

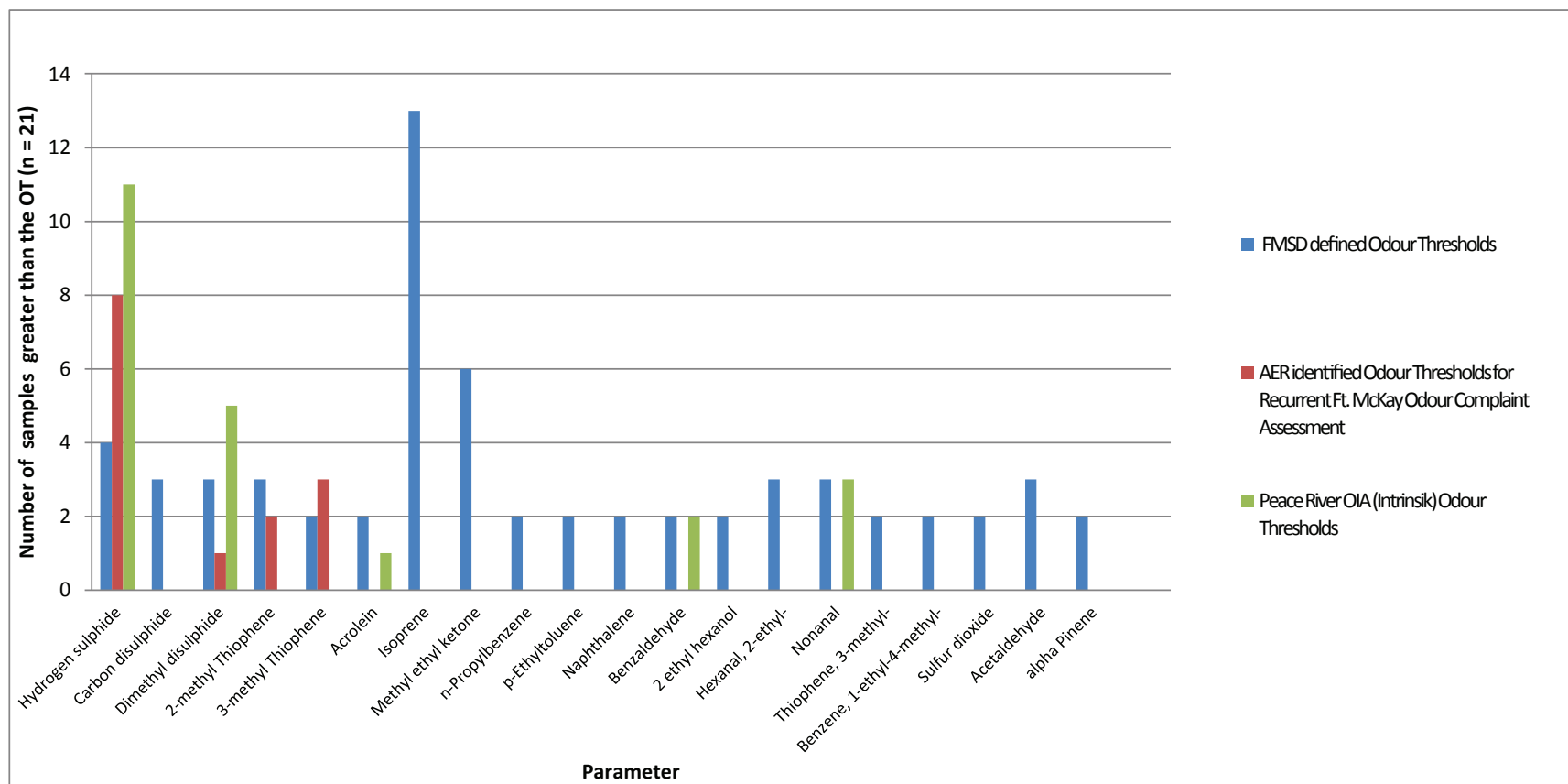


Figure 27. FMSD ten-minute odour event canister data with concentrations greater than odour thresholds corrected to three-minute average (n=21)

- ozone was greater than the Nagata (2003) odour threshold of 3.2 ppb in the community of Fort McKay ~90 per cent of the time over the five years, and ozone exceeded the 50 ppb Canadian Ambient Air Quality Management level (yellow) used as a trigger for the protection of deterioration of air quality as published by the Government of Alberta within the AQMS.

The WBEA hourly data collected over the study period in the study area indicates that TRS compounds, including H<sub>2</sub>S, thiophenes, mercaptans, and other sulphur-based compounds, are likely contributing to odour complaints received from residents of Fort McKay.

**Table 14. Number of samples with concentrations greater than the hourly thresholds from continuous average hourly WBEA AMS01 data for the study period**

		SO <sub>2</sub>	TRS based on H <sub>2</sub> S	NO <sub>2</sub>	THC	O <sub>3</sub>
Odour Threshold	Threshold (ppb)	470	0.41	120	—	3.2
	2010–2014 Average EPC greater than threshold	0	19 510	0	—	35 964
	% Average EPC greater than threshold	—	48.2	—	—	88.9
	2013–2014 Average EPC greater than threshold	0	5 415	0	—	14 871
	% Average EPC greater than threshold	—	32.7	—	—	90.1
AAAQO	Threshold (ppb)	172	10	159	—	82
	2010–2014 Average EPC greater than threshold	0	7	0	—	12
	% Average EPC greater than threshold	—	0.02	0	—	0.03
	2013–2014 Average EPC greater than threshold	0	0	0	—	3
	% Average EPC greater than threshold	—	—	—	—	0.0002
WHO AQG	Threshold (ppb)	—	—	106.29	—	—
	2010–2014 Average EPC greater than threshold	—	—	0	—	—
	2013–2014 Average EPC greater than threshold	—	—	0	—	—
<b>Total number of data collection hours 2010–2014</b>		<b>40 387</b>	<b>40 446</b>	<b>40 148</b>	<b>39 702</b>	<b>40 455</b>
<b>Total number of data collection hours 2013–2014*</b>		<b>16 552</b>	<b>16 556</b>	<b>16 517</b>	<b>16 431</b>	<b>16 506</b>

Yellow highlighting indicates number greater than the threshold used for comparison

\*EC data only available for 2013–2014

**Table 15. Comparison of data to NAAQOs, CAAQS, and AQMS management trigger thresholds from continuous WBEA AMS01 data for the study period**

		<b>NO<sub>2</sub></b>	<b>SO<sub>2</sub></b>	<b>O<sub>3</sub></b>
NAAQS	Threshold (ppb)	100	75	75
	2010–2012 greater than threshold (Y) or not (N)	N	N	N
	2012–2014 greater than threshold (Y) or not (N)	N	N	N
CAAQS	Threshold (ppb)			65
	2010–2012 greater than threshold (Y) or not (N)	—	—	N
	2012–2014 greater than threshold (Y) or not (N)	—	—	N
<b>Canadian Ambient Ozone Air Quality Management Levels at WBEA AMS01 data for the study period</b>				
<b>Canadian Ambient Air Quality Management Levels</b>	<b>Green (&lt;50 ppb)</b>	<b>Yellow (50–56 ppb)</b>	<b>Orange (56–63 ppb)</b>	<b>Red (&gt;63 ppb)</b>
2010–2012 greater than threshold (Y) or not (N)*	N	Y	N	N
2012–2014 greater than threshold (Y) or not (N)*	N	Y	N	N

Yellow highlighting indicates samples greater than the threshold used for comparison

"N" – no exceedance of a management trigger

"Y" – a management trigger was exceeded

Dash – no threshold for comparison was available

\*As per CAAQS calculation methods, a three-year dataset is required; therefore, two three-year dataset estimates are presented.



#### 6.5.5.2 WBEA Hourly Data Descriptive Statistics

Figures 28–31 indicate the spread of each dataset analyzed for each parameter and the thresholds used for comparison. For guidance on interpretation, refer to Section 6.5.

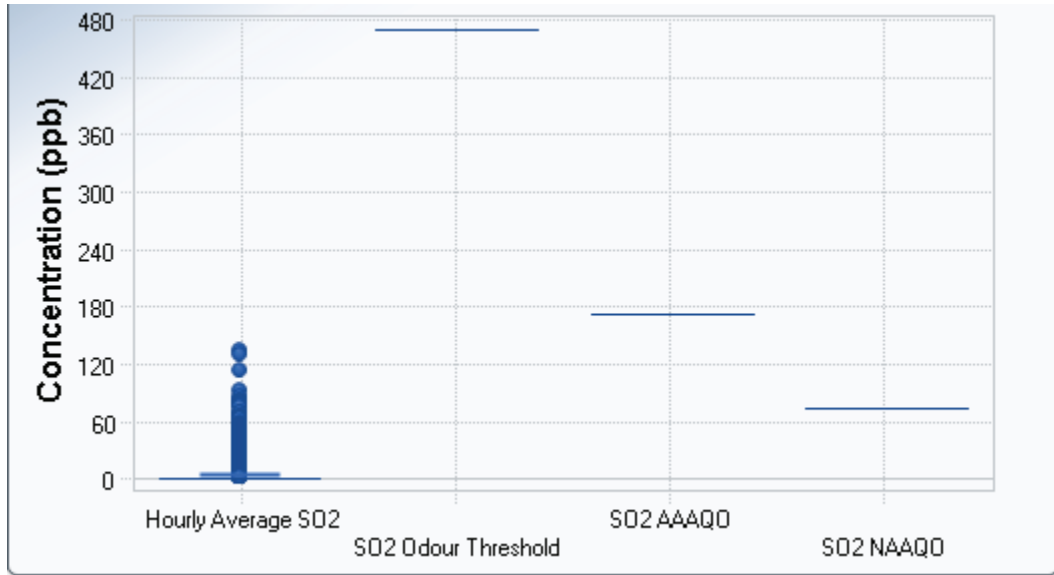


Figure 28. Statistical representation of average WBEA hourly SO<sub>2</sub> concentrations as compared to odour and health thresholds

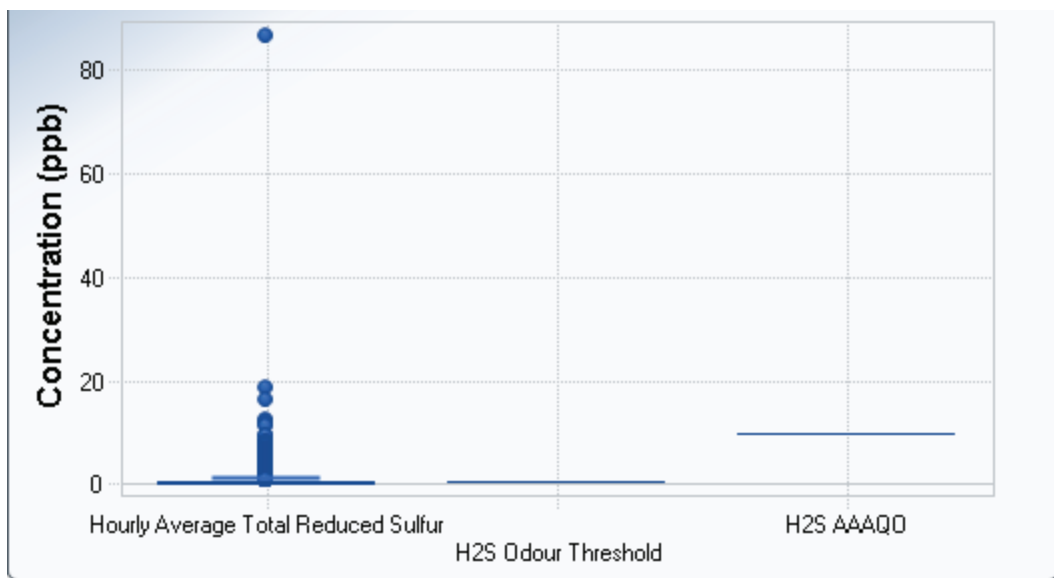


Figure 29. Statistical representation of average WBEA hourly TRS concentrations as compared to odour and health thresholds

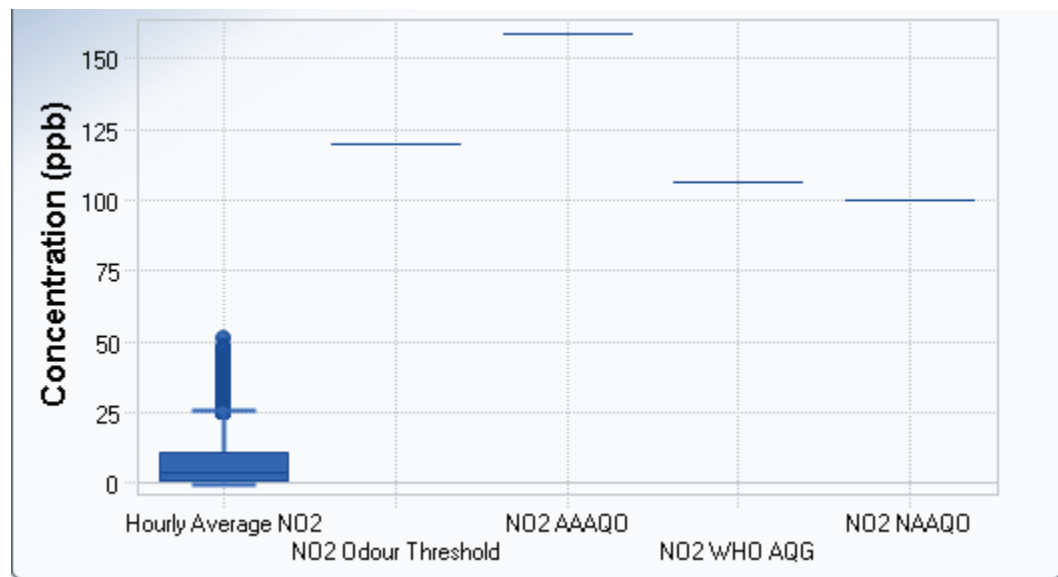


Figure 30. Statistical representation of average WBEA hourly NO<sub>2</sub> concentrations as compared to odour and health thresholds

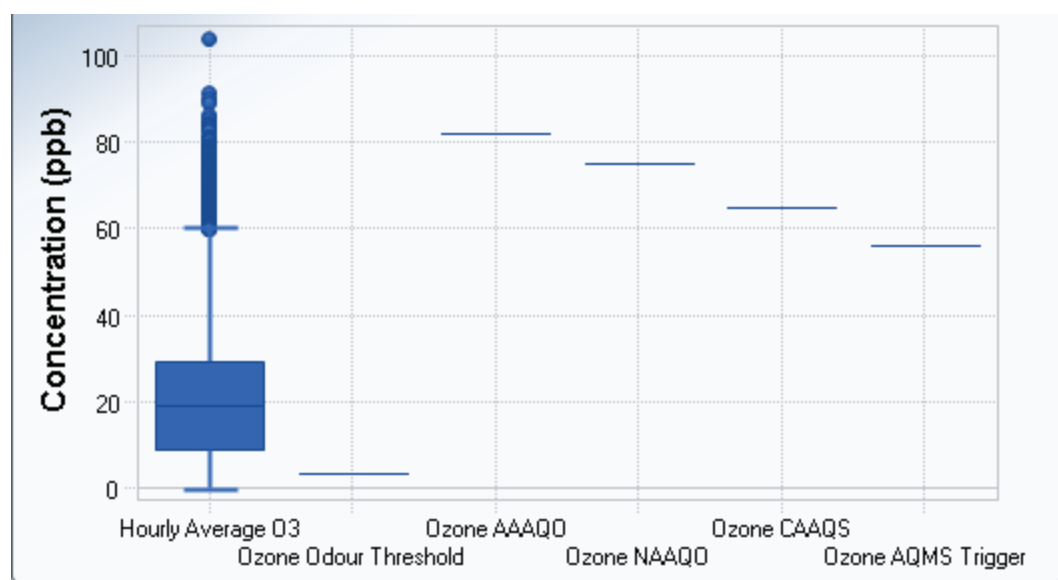


Figure 31. Statistical representation of average WBEA hourly O<sub>3</sub> concentrations as compared to odour and health thresholds

## 6.5.5.3 WBEA Daily EPC from Continuous Data

Daily average and 98th percentile concentrations for various parameters were calculated from the WBEA hourly dataset from AMS01. A minimum of 75 per cent of hourly readings per day were required to calculate a daily EPC for an individual parameter, as per the *Alberta Air Quality Model Guideline* (Government of Alberta, 2013b).

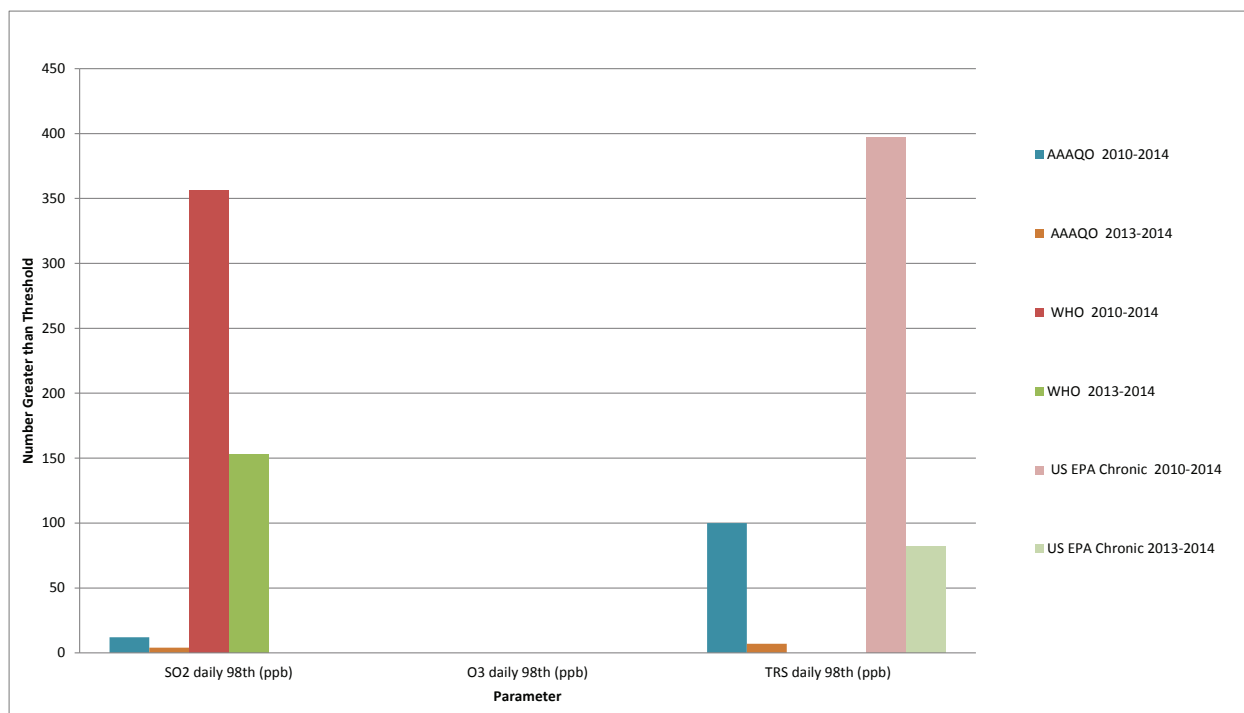
The detailed comparison of the WBEA daily average and 98th percentile to 24 hour health thresholds at AMS01 from 2010 to 2014 can be found in Table 16. Summaries are shown in Figure 32 and Figure 33, and descriptive statistics of the dataset are available in Section 6.5.5.4.

**Table 16. Number of samples with concentrations greater than daily health-exposure thresholds from continuous WBEA AMS01 data collected in Fort McKay in the study period**

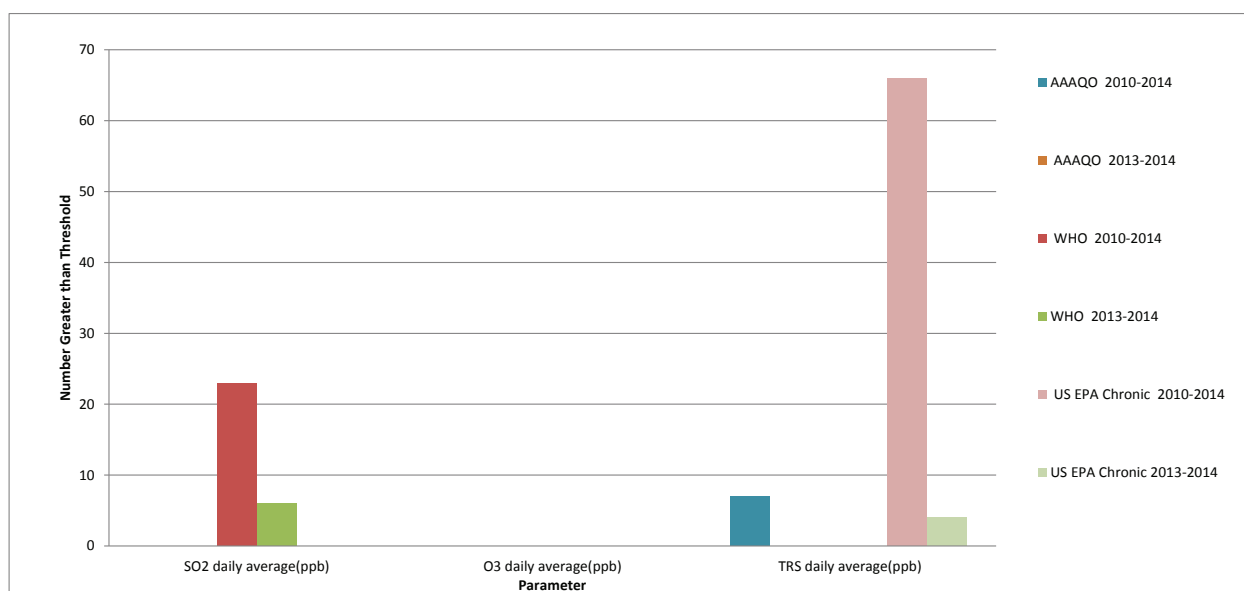
	98th percentile concentration comparison				Average concentration comparison			
	SO <sub>2</sub> daily 98th	NO <sub>2</sub> daily 98th	O <sub>3</sub> daily 98th	TRS daily 98th	SO <sub>2</sub> daily average	NO <sub>2</sub> daily average	O <sub>3</sub> daily average	TRS daily average
AAAQO	48	–	–	3	48	–	–	3
AAAQO 2010–2014	12	0	–	100	0	0	–	7
% Greater than threshold	0.66	–	–	5.77	0	–	–	0.39
AAAQO 2013–2014	4	–	–	7	0	–	–	0
% Greater than threshold	0.55	–	–	0.98	0	–	–	0
WHO AQG	7.63	–	–	–	7.63	–	–	–
WHO 2010–2014	356	–	–	–	23	0	–	–
% Greater than threshold	19.51	–	–	–	1.26	–	–	–
WHO 2013–2014	153	–	–	–	6	–	–	–
% Greater than threshold	20.99	–	–	–	0.82	–	–	–
US EPA IRIS chronic (ppb)	–	–	–	1.43	–	–	–	1.43
US EPA chronic 2010–2014	–	–	–	397	–	–	–	66
% Greater than threshold	–	–	–	22.92	–	–	–	3.69
US EPA chronic 2013–2014	–	–	–	82	–	–	–	4
% Greater than threshold	–	–	–	11.52	–	–	–	0.55
Number of daily data points (2010–2014)	1 825	1 683	1 731	1 732	1 825	1 788	1 731	1 788
Number of daily data points (2013–2014)*	729	697	711	712	729	730	711	730

Highlighting indicates concentrations greater than the threshold

\*Data available for 2013–2014 only



**Figure 32. Number of samples with daily 98th percentile concentrations (ppb) greater than health-effect thresholds for SO<sub>2</sub>, O<sub>3</sub>, and TRS measured at WBEA AMS01 in Fort McKay for the study period**



**Figure 33. Number of samples with daily average EPC (ppb) greater than health-effect thresholds for SO<sub>2</sub>, O<sub>3</sub>, and TRS measured at WBEA AMS01 in Fort McKay for the study period**

Comparison of the WBEA daily EPCs to thresholds showed that

- SO<sub>2</sub> was greater than the daily AAAQO less than 1 per cent of the study period,
- SO<sub>2</sub> was greater than the more stringent regulations for health effects adopted by the WHO ~20 per cent of days over the study period using 98th percentile comparisons and ~1 per cent of the sampling period using average values, and
- TRS was greater than the US EPA chronic health threshold for H<sub>2</sub>S (US EPA, 2003b) using both the 98th percentile and average values on at least 25 per cent of days when samples were collected. TRS was greater than the AAAQO on 5 per cent of sampling days using the upper bound for comparison and on less than 1 per cent of sampling days using the average daily concentration.

#### 6.5.5.4 WBEA Daily EPC from Continuous Data Descriptive Statistics

Figures 34–37 indicate the spread of each dataset analyzed for each parameter and the thresholds used for comparison.

#### 6.5.5.5 WBEA Annual EPC from Continuous Data

Annual average and 98th percentile were calculated from the WBEA continuous monitoring data for the study period and compared to annual health thresholds. The total number of annual comparisons was five: one for each year (2010, 2011, 2012, 2013, and 2014). Using the annual average versus the 98th percentile as a comparison point makes a significant difference between concentrations greater than a threshold.

Figure 38 illustrates the variability when calculating annual values using a 98th percentile versus an average. This is shown below for SO<sub>2</sub> to illustrate the differences in concentrations observed when summarizing data for a parameter using two different statistics (average versus 98th percentile). This similar pattern was observed for all parameters, as shown in Table 25.

Hourly odour thresholds were not compared to the annual average and 98th percentile concentrations of the parameter for the entire year as hourly odour threshold for identification of annual odour perception is not appropriate as odour perception typically occurs on a minute to hourly scale.

Table 17 shows samples greater than thresholds and the difference between comparing average values and 98th percentiles.

In addition, hourly annual data were used to calculate the average and 99th percentile concentrations for comparison to annual LARP management triggers. Table 18 shows average and upper bound exceedances of SO<sub>2</sub> and NO<sub>2</sub> LARP management triggers (Government of Alberta, 2012b).

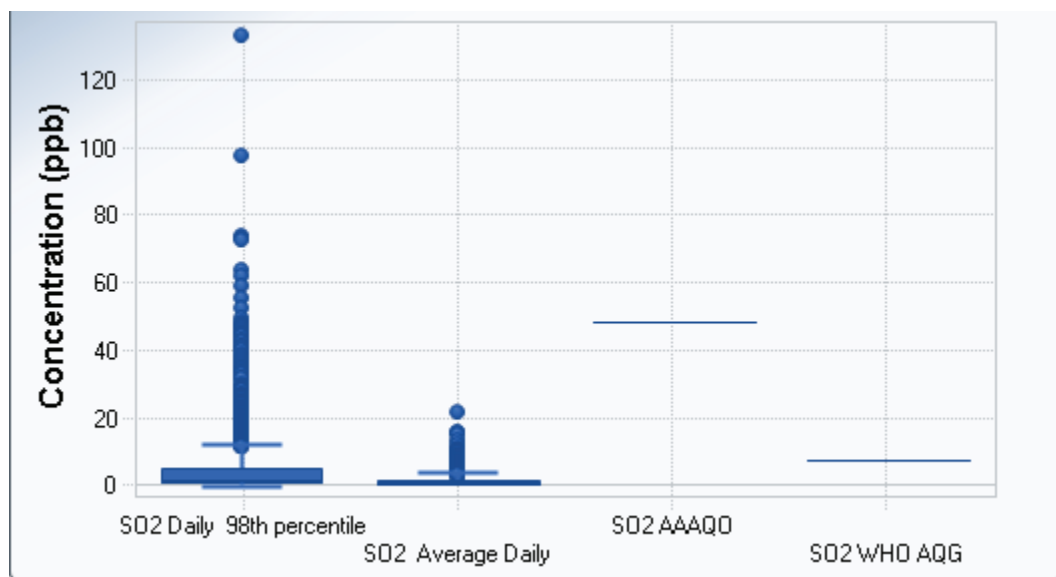


Figure 34. Statistical representation of average and upper bound WBEA daily SO<sub>2</sub> concentrations as compared to health thresholds

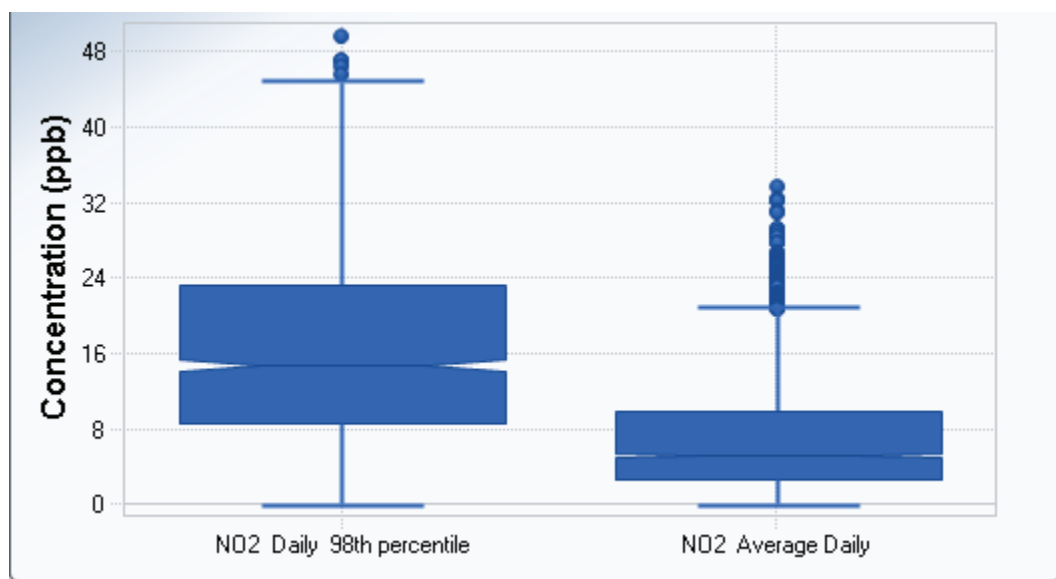


Figure 35. Statistical representation of average and upper bound WBEA daily NO<sub>2</sub> concentrations, no thresholds for comparison

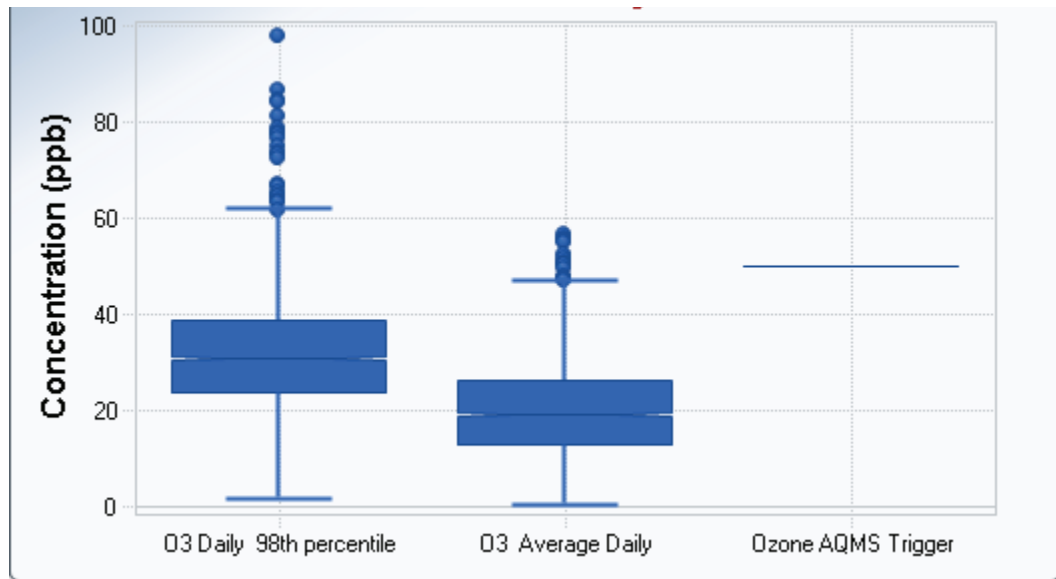


Figure 36. Statistical representation of average and upper bound WBEA daily O<sub>3</sub> concentrations as compared to health thresholds

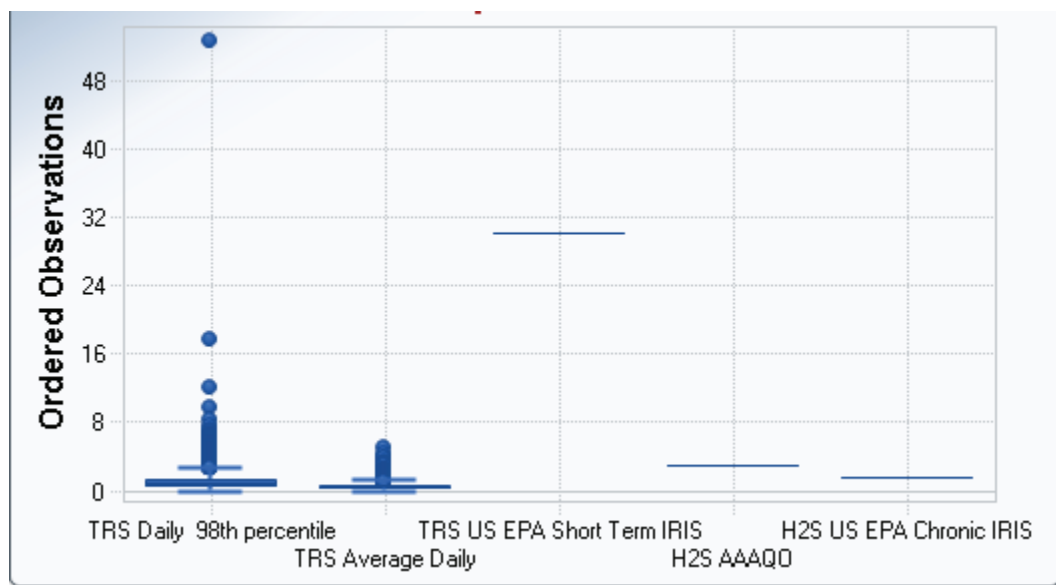


Figure 37. Statistical representation of average and upper bound WBEA daily TRS concentrations as compared to health thresholds



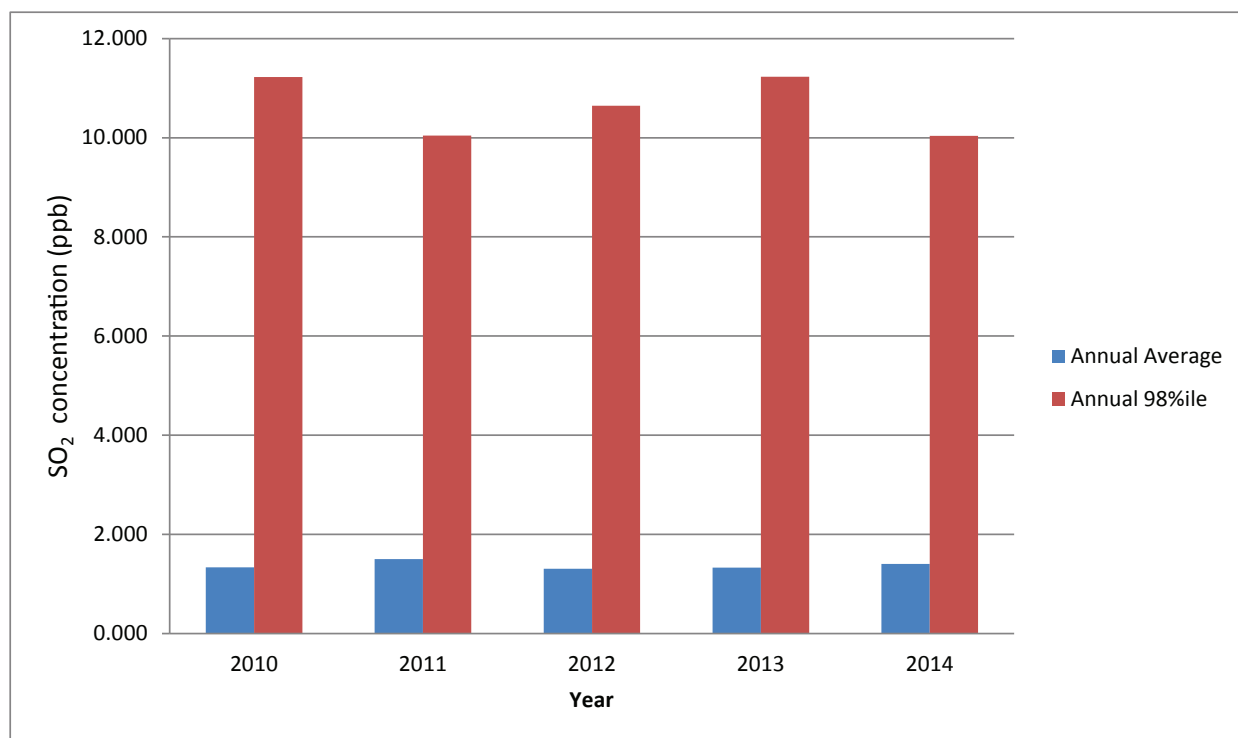


Figure 38. Variability in estimating annual concentrations of SO<sub>2</sub> from AMS01 using the annual average and 98th percentile

Table 17. Annual samples greater than thresholds based on annual average (mean) and 98th percentile calculations to derive annual concentrations from hourly data at WBEA continuous data at AMS01 for the study period (n=5)

		SO <sub>2</sub>	TRS	NO <sub>2</sub>	O <sub>3</sub>
CAAQS	Threshold (ppb)	—	—	—	—
	Average EPC greater than threshold	—	—	—	—
	98th percentile EPC greater than threshold	—	—	—	—
AAAO	Threshold (ppb)	8	—	24	—
	Average EPC greater than threshold	0	—	0	—
	98th percentile EPC greater than threshold	5	—	5	—
US EPA IRIS chronic	Threshold (ppb)	—	1.43	—	—
	Average EPC greater than threshold	—	0	—	—
	98th percentile EPC greater than threshold	—	3	—	—
US EPA NAAQS	Threshold (ppb)	—	—	53	—
	Average EPC greater than threshold	—	—	0	—
	98th percentile EPC greater than threshold	—	—	0	—
WHO AQG	Threshold (ppb)	—	—	21.26	—
	Average EPC greater than threshold	—	—	0	—
	98th percentile EPC greater than threshold	—	—	5	—

Yellow highlighting indicates number of exceedances of the threshold used for comparison

Dash – no threshold for comparison was available

**Table 18. Comparison of the annual average and 99th percentile hourly (upper range) ambient air quality data from AMS01 to the LARP management triggers (n=5)**

<b>99th Percentile Hourly (Upper Range)</b>				
<b>Year</b>	<b>NO<sub>2</sub> (ppb)</b>	<b>NO<sub>2</sub> LARP Trigger</b>	<b>SO<sub>2</sub> (ppb)</b>	<b>SO<sub>2</sub> LARP Trigger</b>
2010	31.1	Level 2 (30 ppb)	17.4	Level 2 (12 ppb)
2011	32.6	Level 2 (30 ppb)	16.0	Level 2 (12 ppb)
2012	33.5	Level 2 (30 ppb)	16.5	Level 2 (12 ppb)
2013	34.6	Level 2 (30 ppb)	16.3	Level 2 (12 ppb)
2014	33.0	Level 2 (30 ppb)	15.3	Level 2 (12 ppb)
2015	30.3	Level 2 (30 ppb)	14.0	Level 2 (12 ppb)
<b>Annual Average Hourly</b>				
<b>Year</b>	<b>NO<sub>2</sub> (ppb)</b>	<b>NO<sub>2</sub> LARP Trigger</b>	<b>SO<sub>2</sub> (ppb)</b>	<b>SO<sub>2</sub> LARP Trigger</b>
2010	7.1	Level 1 (<8 ppb)	1.3	Level 1 (<3 ppb)
2011	6.4	Level 1 (<8 ppb)	1.5	Level 1 (<3 ppb)
2012	7.2	Level 1 (<8 ppb)	1.3	Level 1 (<3 ppb)
2013	7.7	Level 1 (<8 ppb)	1.3	Level 1 (<3 ppb)
2014	7.6	Level 1 (<8 ppb)	1.3	Level 1 (<3 ppb)
2015	6.5	Level 1 (<8 ppb)	1.0	Level 1 (<3 ppb)

Yellow highlighting indicates concentrations greater than the threshold used for comparison

The following parameters were greater than health thresholds on a yearly basis for the study period:

- SO<sub>2</sub> – 98th percentile annual EPC was greater than annual AAAQO for each of the five years analyzed. The annual average was less than the annual AAAQO for all five years.
- SO<sub>2</sub> and NO<sub>2</sub> – Upper bound (99th percentile) concentrations triggered level 2 management responses in the LARP framework every year, consistent with Government of Alberta reporting.
- NO<sub>2</sub> – 98th percentile annual value was greater than the annual AAAQO and WHO AQG thresholds for each of the five years. The annual average was less than the annual AAAQO and WHO AQG thresholds for all five years.
- TRS – 98th percentile EPC was greater than the US EPA IRIS H<sub>2</sub>S threshold for chronic effects (US EPA, 2003b) for three of the five sampling years. The annual average EPC was less than the US EPA IRIS H<sub>2</sub>S threshold for all five years.

#### 6.5.5.6 WBEA Annual Data Descriptive Statistics

Figures 39–42 indicate the spread of each dataset analyzed for each parameter and the thresholds used for comparison.

#### 6.5.6 Environment Canada Continuous Sampling

Environment Canada, as part of the JOSM program, collected continuous data from an air monitoring station within the community of Fort McKay from August 2013 to November 2014 (JOSM, 2015; accessed July 2015). The Environment Canada dataset had not been reviewed by Environment Canada for quality assurance and was provided as level 1 data (has not undergone quality control review) at the time

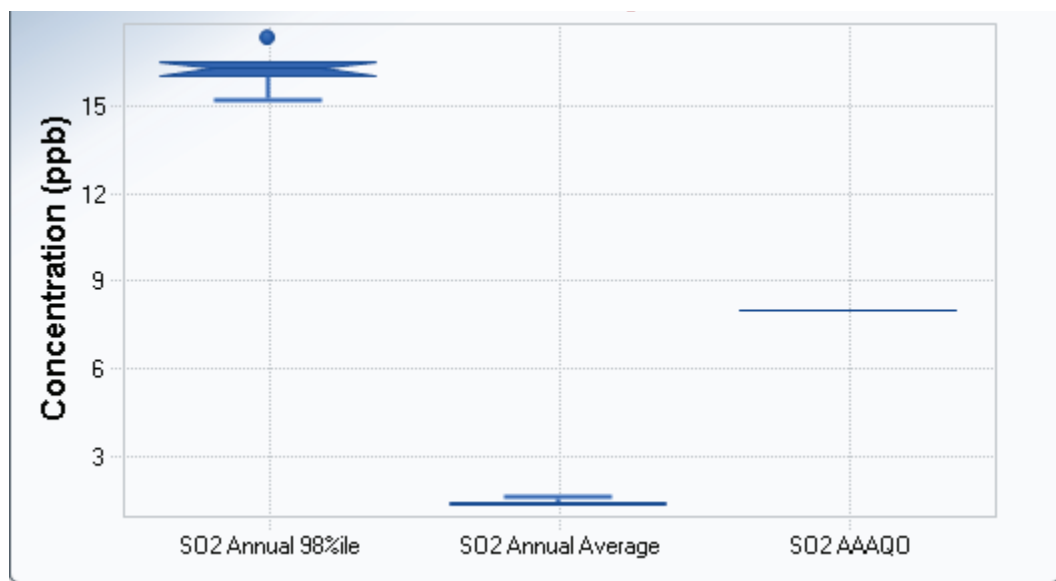


Figure 39. Statistical representation of average and upper bound WBEA annual SO<sub>2</sub> concentrations as compared to health thresholds

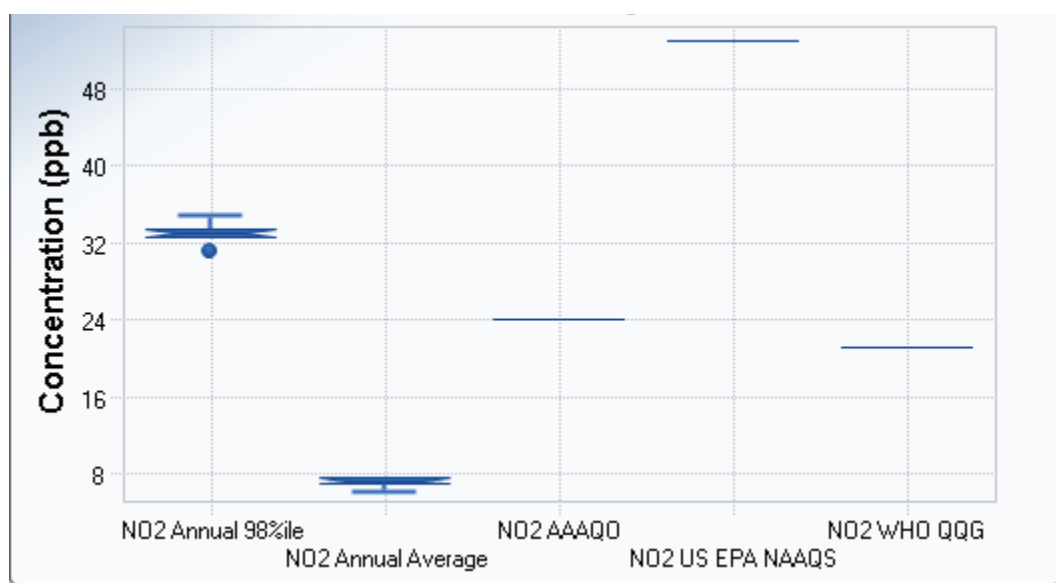


Figure 40. Statistical representation of average and upper bound WBEA annual NO<sub>2</sub> concentrations as compared to health thresholds

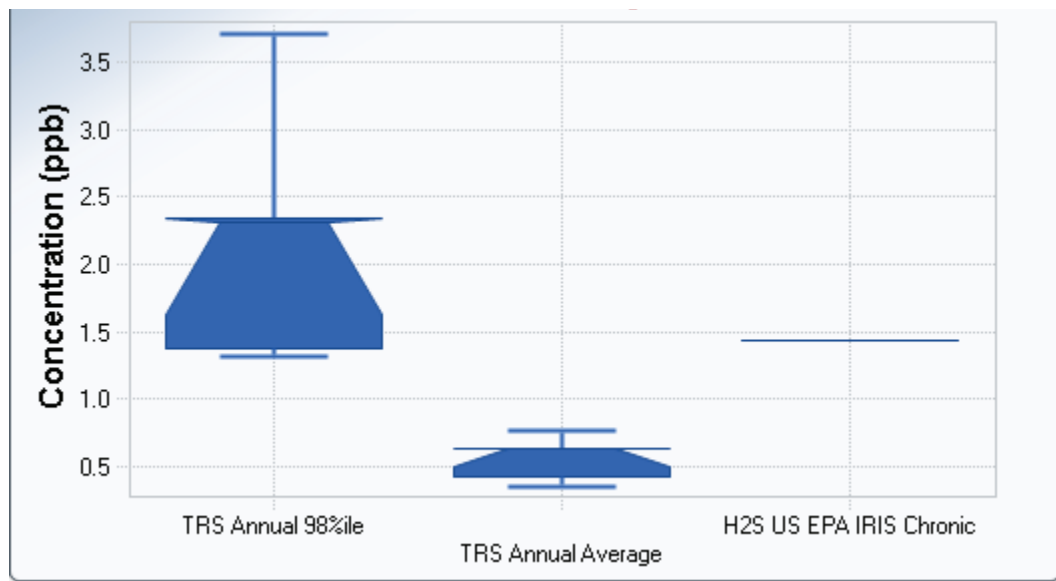


Figure 41. Statistical representation of average and upper bound WBEA annual TRS concentrations as compared to health thresholds

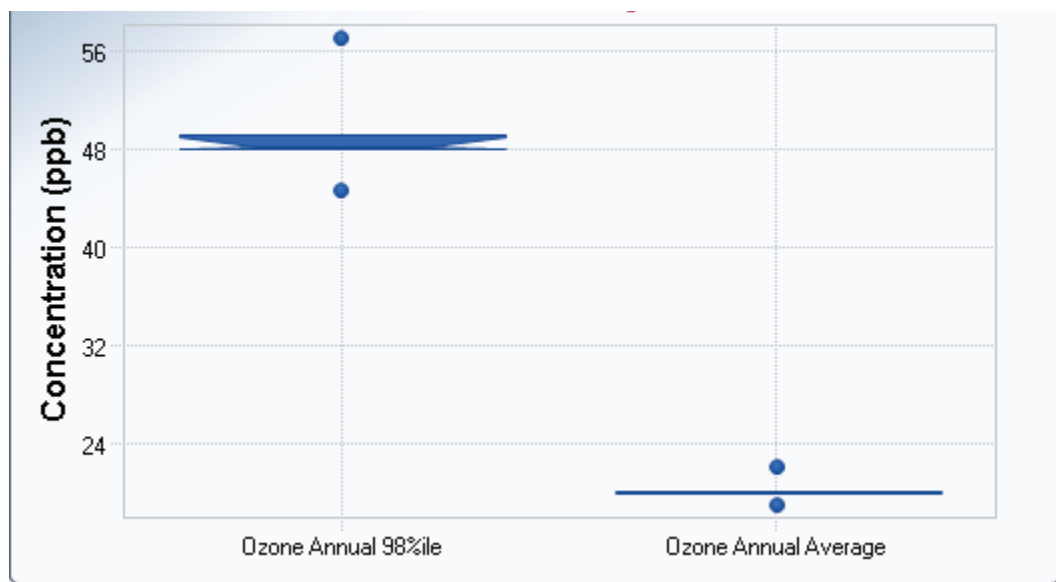


Figure 42. Statistical representation of average and upper bound WBEA annual O<sub>3</sub> concentrations as compared to health thresholds

of report compilation, so interpretations of results are preliminary. Level 2 data (has undergone quality control review) has recently become publicly available and should be used for follow-up air quality assessments. The sampling period ranges from 1 minute to 29 minutes depending on the parameter.

Hourly and daily concentrations of each compound were calculated as 98th percentile values from the raw data for each parameter. A minimum of 75 per cent of the minute and hourly data were required to calculate the 98th percentile hourly and daily values as per the *Alberta Air Quality Model Guideline* (Government of Alberta, 2013b). The available data after application of the minimum 75 per cent data requirement were then compared to hourly and daily odour and exposure thresholds.

#### 6.5.6.1 Environment Canada Hourly Data 2013–2014

The Environment Canada Oski-ôtin monitoring station analyzed for individual VOCs (JOSM, 2015; accessed July 2015). There were no hourly concentrations greater than any short-term odour or health-related thresholds for VOCs monitored at the EC continuous station in the community of Fort McKay (Table 19).

However, there were a number of hourly readings that were greater than the minimum and maximum carcinogenic screening thresholds, available from US EPA IRIS, for cancer formation in 1 in 100 000 individuals (US EPA, 2003a) (Table 19). Screening is done in this way to identify where there is a potential for a human health risk that requires further evaluation. The comparison of a single hourly data point to a chronic carcinogenic threshold is not appropriate; however, the comparison of hourly measurements over a five-year time period indicates that there is ongoing intermittent exposure over a number of years. There exists a potential health risk that cannot be eliminated or quantified through a simple screening. Evaluation of compounds that repeatedly exceed chronic and/or carcinogenic benchmarks will depend on available information about frequency of exposure, toxicokinetics, and mechanism of action of the chemicals in question.

The benzene concentration was greater than the maximum carcinogen threshold for 1 in 100 000 individuals less than 1 per cent of the time (average and upper bound comparisons) while 3 and 6 per cent of the average and upper bound benzene hourly EPCs were greater than the minimum threshold.

As shown in Figure 43 and Table 20, the Environment Canada hourly data showed concentrations greater than thresholds for H<sub>2</sub>S, TRS, and O<sub>3</sub>.

- Hourly H<sub>2</sub>S and TRS concentrations in the community of Fort McKay were greater than the odour threshold and hourly AAAQOs using both the hourly average and 98th percentile values. Variations between the average and 98th percentile values are clearly evident. The potential for odour perception of sulphur compounds is occurring with high frequency in the community of Fort McKay.
- Ozone was greater than odour thresholds in the community of Fort McKay ~90 per cent of the sampling period, which is consistent with the WBEA dataset.

**Table 19. Hourly odour and exposure thresholds comparison to continuous volatile organic compound parameters from Environment Canada data collected in Fort McKay for the study period**

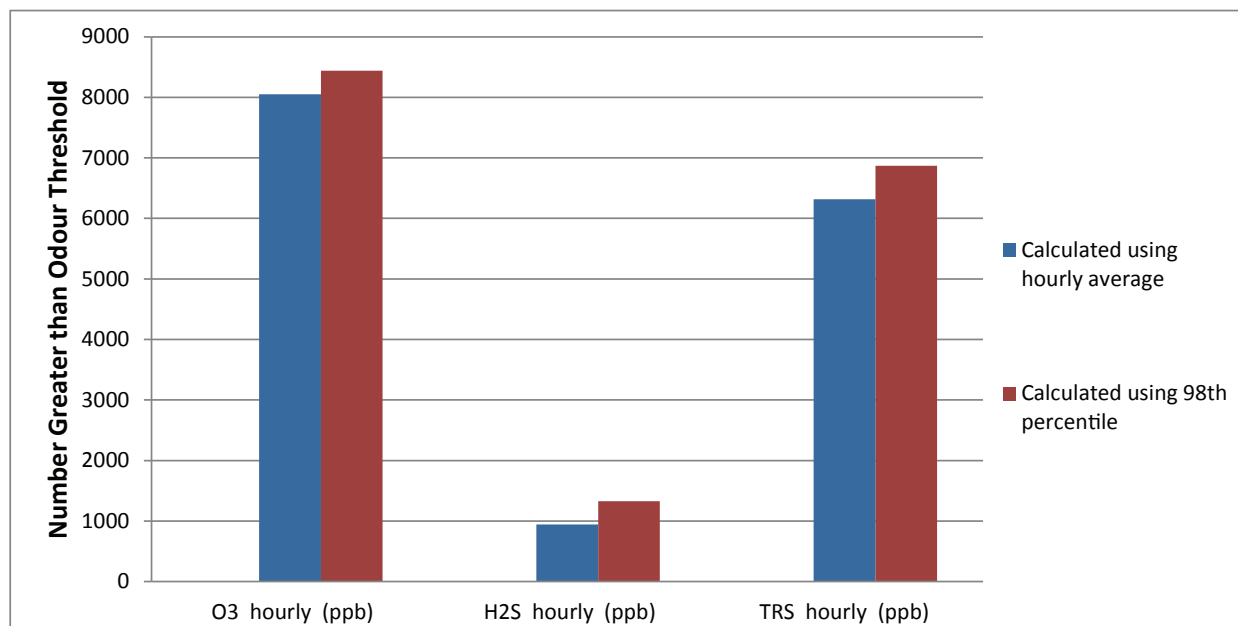
		Mixed- xylenes	Ethylbenzene	Octane	Toluene	Heptane	Benzene	Hexane
<b>Odour Threshold</b>	Threshold (ppb)	58	170	1 700	330	670	2 700	1 500
	Average EPC greater than threshold	0	0	0	0	0	0	0
	98th percentile EPC greater than threshold	0	0	0	0	0	0	0
<b>AAAQO</b>	Threshold (ppb)	530	460	—	499	—	9	5 960
	Average EPC greater than threshold	0	0	—	0	—	0	0
	98th percentile EPC greater than threshold	0	0	—	0	—	0	0
<b>US EPA IRIS Chronic</b>	Threshold (ppb)	23.03	230.31	—	1 326.93	—	9.39	198.62
	Average EPC greater than threshold	0	0	—	0	—	0	0
	98th percentile EPC greater than threshold	0	0	—	0	—	0	0
<b>TCEQ Short term</b>	Threshold (ppb)	1 700	20 000	750	4 000	850	180	1 500
	Average EPC greater than threshold	0	0	0	0	0	0	0
	98th percentile EPC greater than threshold	0	0	0	0	0	0	0
<b>US EPA IRIS Chronic Carcinogen min range 1 in 100 000</b>	Threshold (ppb)	—	—	—	—	—	0.406	—
	Average EPC greater than threshold	—	—	—	—	—	232	—
	98th percentile EPC greater than threshold	—	—	—	—	—	406	—
<b>US EPA IRIS Chronic Carcinogen max range 1 in 100 000</b>	Threshold (ppb)	—	—	—	—	—	1.41	—
	Average EPC greater than threshold	—	—	—	—	—	46	—
	98th percentile EPC greater than threshold	—	—	—	—	—	54	—
<b>Total Number of Hourly data points*</b>		<b>6 958</b>	<b>6 958</b>	<b>6 958</b>	<b>6 958</b>	<b>6 958</b>	<b>6 958</b>	<b>6 958</b>

Environment Canada dataset had not been reviewed by Environment Canada for quality assurance

Yellow highlighting indicates number of exceedances of the threshold used for comparison

Dash – no threshold for comparison was available

\* Indicates the available number of data points after minimum 75% validation criteria were met. Does not indicate total number of data points collected over the study period.



**Figure 43. Number of samples with concentrations greater than odour thresholds (hourly average and 98th percentile) of O<sub>3</sub>, H<sub>2</sub>S, and TRS measured at Environment Canada continuous monitoring station Oski-ôtin from 2013 to 2014**

**Table 20. Number of samples with concentrations greater than hourly odour and health-exposure thresholds from continuous Environment Canada data collected in Fort McKay from 2013 to 2014**

		NO <sub>2</sub>	SO <sub>2</sub>	O <sub>3</sub>	H <sub>2</sub> S	TRS
<b>Odour Threshold</b>	Threshold (ppb)	120	470	3.2	0.41	0.41
	Average EPC greater than threshold	0	0	8 050	943	6 315
	98th percentile EPC greater than threshold	1	0	8 442	1 329	6 869
<b>AAAQO</b>	Threshold (ppb)	159	172	82	10	10
	Average EPC greater than threshold	0	0	4	21	268
	98th percentile EPC greater than threshold	0	0	9	25	460
<b>WHO AQG</b>	Threshold (ppb)	106.29	—	—	—	—
	Average EPC greater than threshold	0	—	—	—	—
	98th percentile EPC greater than threshold	1	—	—	—	—
<b>Total Number of Hourly data points*</b>		<b>7 053</b>	<b>3 257</b>	<b>9 572</b>	<b>1 329</b>	<b>7 960</b>

Environment Canada dataset had not been reviewed by Environment Canada for quality assurance

Yellow highlighting indicates number of exceedances of the threshold used for comparison

Dash – no threshold for comparison was available

\* Indicates the available number of data points after minimum 75% validation criteria were met. Does not indicate total number of data points collected over the study period.



- Ozone was greater than the AAAQO less than 1 per cent of the sampling time.
- Ozone could not be compared to the NAAQS and CAAQS management limits as a full three-year dataset was not available.

NO<sub>2</sub> samples greater than the thresholds were negligible, and although continuously detected, this parameter appears to be low risk as an odorant or health risk. Only 1 of the 7053 hourly 98th percentile concentrations calculated exceeded the odour perception threshold and the WHO AQG.

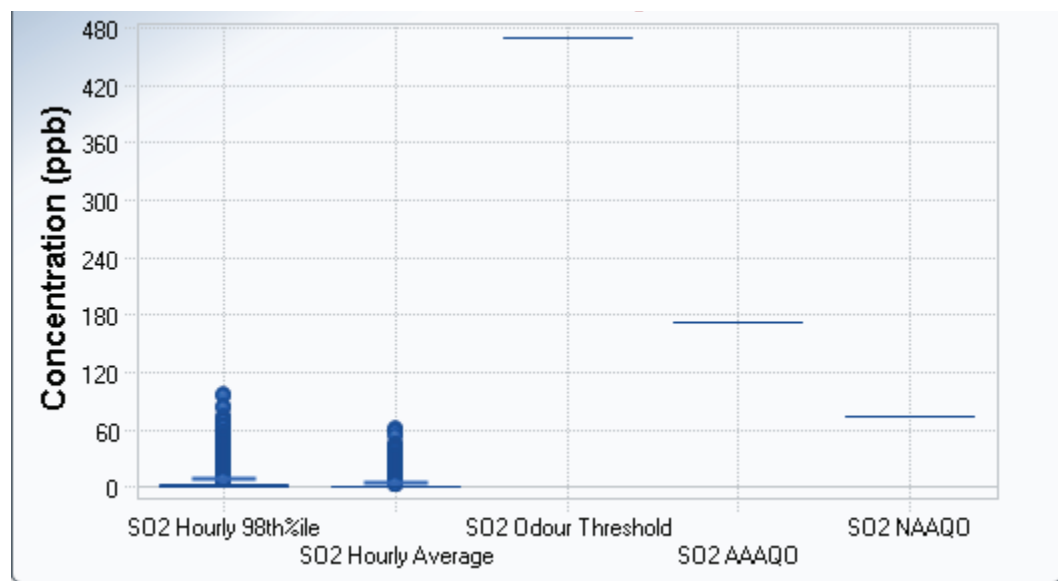
#### 6.5.6.2 EC Hourly Data Descriptive Statistics

Figures 44–48 indicate the spread of each dataset analyzed for each parameter and the thresholds used for comparison.

#### 6.5.6.3 Environment Canada Daily Data 2013–2014

There were no daily exceedances of individual VOCs measured in Environment Canada continuous data as compared to short-term (daily) thresholds (Table 21). This is inconsistent with the WBEA canister data.

However, there were a number of daily concentrations that were greater than the minimum and maximum thresholds for cancer formation in 1 in 100 000 individuals (Table 21) (US EPA, 2005a). The comparison of a single data point for a day to a chronic carcinogenic threshold is not appropriate; however, the comparison of daily data over a five-year time period indicates that there is ongoing intermittent exposure over a number of years. There exists a potential health risk that cannot be eliminated or quantified through a simple screening. Evaluation of compounds that repeatedly exceed chronic and/or carcinogenic benchmarks will depend on available information about frequency of exposure, toxicokinetics, and mechanism of action of the chemicals in question.



**Figure 44. Statistical representation of average and upper bound EC hourly SO<sub>2</sub> concentrations as compared to health thresholds**

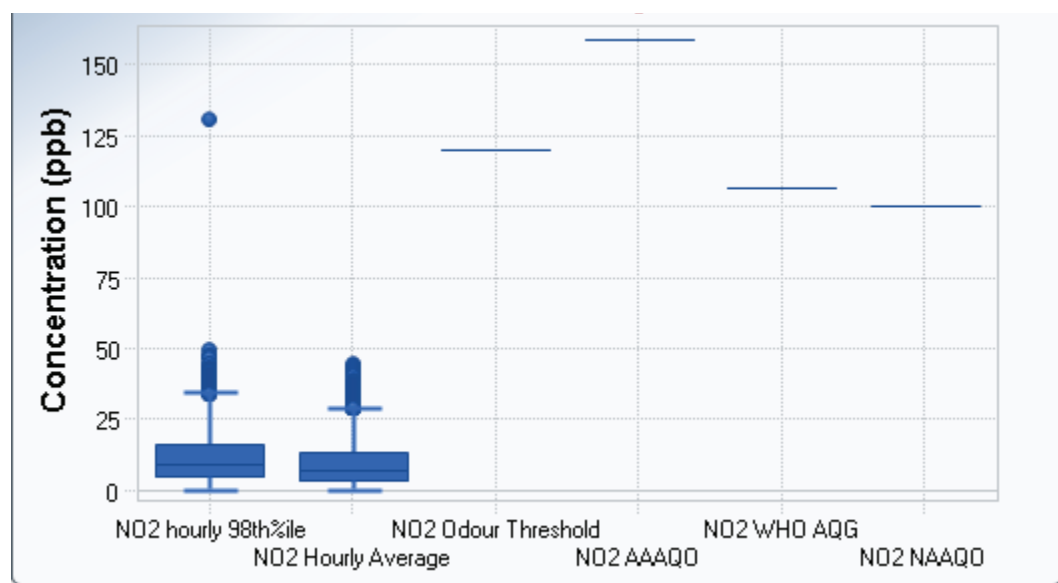


Figure 45. Statistical representation of average and upper bound EC hourly NO<sub>2</sub> concentrations as compared to health thresholds

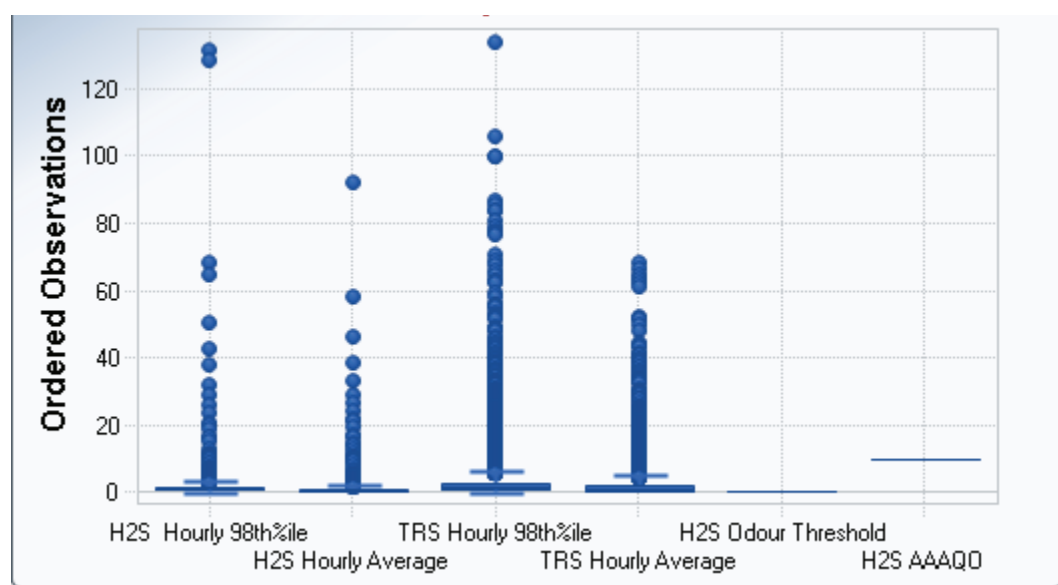


Figure 46. Statistical representation of average and upper bound EC hourly TRS and H<sub>2</sub>S concentrations as compared to odour and health thresholds

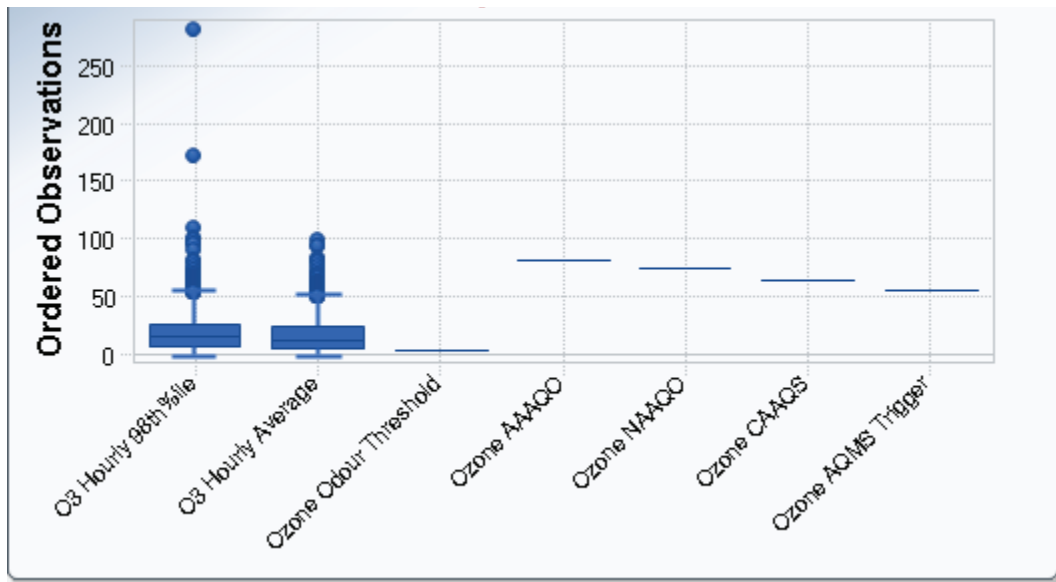


Figure 47. Statistical representation of average and upper bound EC hourly O<sub>3</sub> concentrations as compared to odour and health thresholds

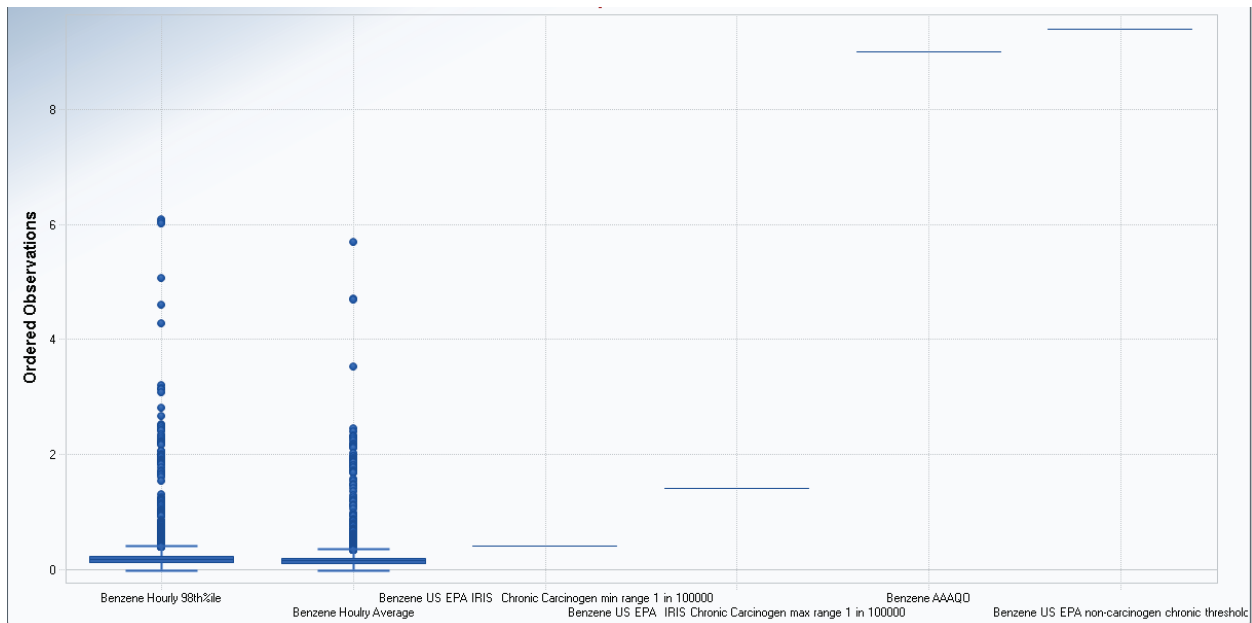


Figure 48. Statistical representation of average and upper bound EC hourly benzene concentrations as compared to short- and long-term health thresholds

**Table 21. Number of individual VOC concentrations greater than daily health thresholds from continuous Environment Canada data collected in Fort McKay from 2013 to 2014**

		Hexane	Benzene	Heptane	Toluene	Octane	Mixed xylene	Ethylbenzene
<b>AAAQO</b>	Threshold (ppb)	1 990	—	—	106	—	161	—
	Average EPC greater than threshold	0	—	—	0	—	0	—
	98th percentile EPC greater than threshold	0	—	—	0	—	0	—
<b>US EPA IRIS Chronic Carcinogen min range 1 in 100 000</b>	Threshold (ppb)	—	0.406	—	—	—	—	—
	Average EPC greater than threshold	—	6	—	—	—	—	—
	98th percentile EPC greater than threshold	—	68	—	—	—	—	—
<b>US EPA IRIS Chronic Carcinogen max range 1 in 100 000</b>	Threshold (ppb)	—	1.41	—	—	—	—	—
	Average EPC greater than threshold	0	1	0	0	—	0	0
	98th percentile EPC greater than threshold	0	8	0	0	—	0	0
<b>US EPA IRIS Chronic</b>	Threshold (ppb)	198.62	9.39	—	1 326.93	—	23.03	230.31
	Average EPC greater than threshold	0	0	0	0	0	0	0
	98th percentile EPC greater than threshold	0	0	0	0	0	0	0
<b>Total number of daily data points*</b>		<b>320</b>	<b>320</b>	<b>320</b>	<b>320</b>	<b>320</b>	<b>320</b>	<b>320</b>

Environment Canada dataset had not been reviewed by Environment Canada for quality assurance

Yellow highlighting indicates number of exceedances of the threshold used for comparison

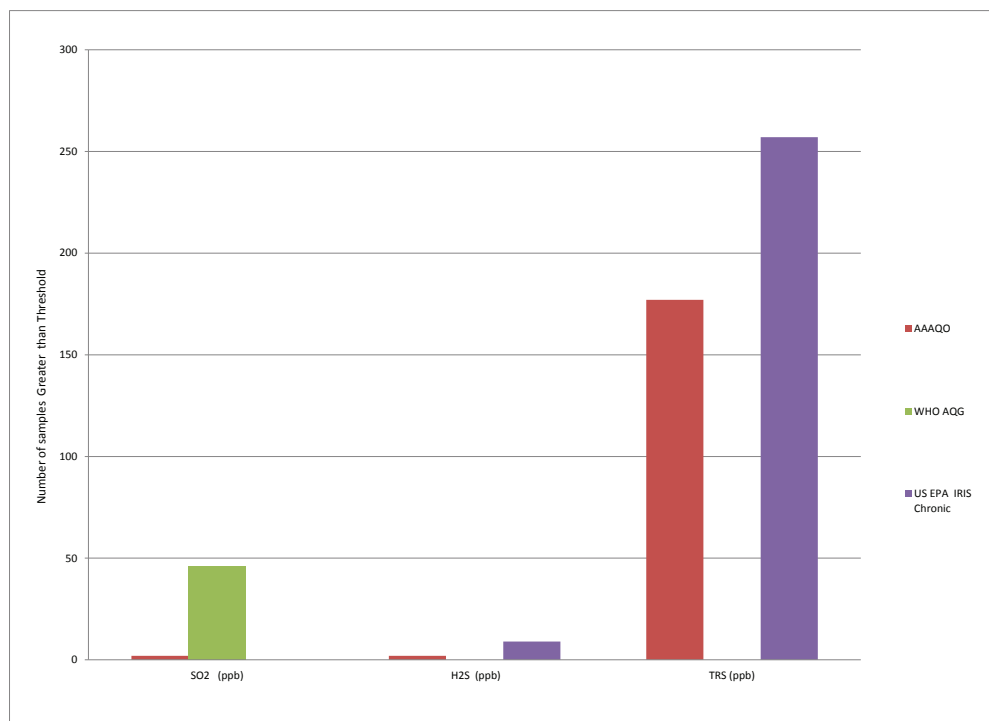
Dash – no threshold for comparison was available

\* Indicates the available number of data points after minimum 75% validation criteria were met. Does not indicate total number of data points collected over the study period

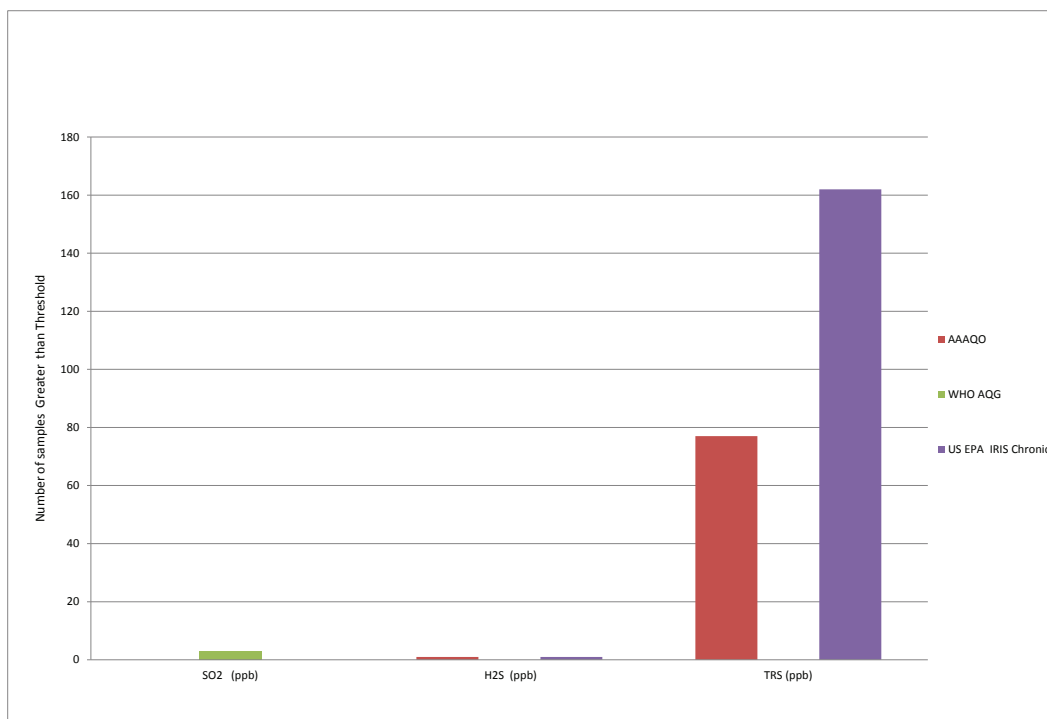
The benzene concentration was greater than the maximum carcinogen threshold for 1 in 100 000 individuals less than 1 per cent of the time (average EPC comparisons) and ~2.5 per cent of days throughout the study period when comparing the upper bound EPC. The average and upper bound benzene concentrations were greater than the minimum threshold for approximately 2 and 21 per cent of days (n=320) over the study period, respectively.

Analysis of the Environment Canada continuous data for daily measurements of NO<sub>x</sub>, SO<sub>2</sub>, O<sub>3</sub>, H<sub>2</sub>S, and TRS showed concentrations greater than the AAAQOs, WHO AQS, and US EPA IRIS chronic-effect thresholds (Figure 49 and Figure 50) over the 15 month sampling period. This is consistent with what was observed in the WBEA daily data.

- NO<sub>2</sub> did not exceed thresholds, which is consistent with the WBEA data. Further evaluation is needed as NO<sub>2</sub> is integral to understanding ground-level ozone formation.



**Figure 49. Number of samples with daily 98th percentile concentration (ppb) greater than health-effect thresholds for SO<sub>2</sub>, H<sub>2</sub>S, and TRS measured at Environment Canada continuous monitoring station Oski-ôtin from Aug 2013 to Oct 2014**



**Figure 50. Number of samples with daily average concentration (ppb) greater than health-effect thresholds for SO<sub>2</sub>, H<sub>2</sub>S, and TRS measured at Environment Canada continuous monitoring station Oski-ôtin from Aug 2013 to Oct 2014**

- SO<sub>2</sub> was greater than the more stringent regulations for health effects adopted by the WHO, comparing both the average and 98th percentile values.
- The upper bound H<sub>2</sub>S EPC was greater than the H<sub>2</sub>S AAAQOs (odour based) on 14 per cent of the 14 sample days, and the US EPA H<sub>2</sub>S health thresholds (US EPA, 2003b) for assessing potential chronic risks on ~64 per cent of days sampled. Note that very few H<sub>2</sub>S data points met the minimum requirements for inclusion, and conclusions from these comparisons are of low certainty.
- TRS was greater than the H<sub>2</sub>S AAAQO and the US EPA H<sub>2</sub>S health thresholds for assessing potential chronic risks using both average and upper bound comparisons. See Table 22 for individual threshold exceedances.
- In summary, H<sub>2</sub>S and TRS were greater than the AAAQOs, Alberta Health, and the US EPA IRIS thresholds on at least 5 per cent of sampling days using both the 98th percentile and average values.

Figure 49, Figure 50, and Table 22 emphasize the need to monitor TRS and H<sub>2</sub>S when assessing potential human health effects with respect to sulphur compounds released to ambient air from industrial operations. Comparison of TRS and H<sub>2</sub>S concentrations in ambient air to the various thresholds for H<sub>2</sub>S show a high frequency of concentrations greater than the thresholds. The magnitude of exceedances varies between the two parameters, but the trend is consistent.

**Table 22. Number of individual parameter concentrations greater than daily health thresholds from continuous Environment Canada data collected in Fort McKay from 2013 to 2014**

		NO <sub>2</sub>	SO <sub>2</sub>	O <sub>3</sub>	H <sub>2</sub> S	TRS
<b>AAAQO</b>	Threshold (ppb)	—	48	—	3	3
	Average EPC greater than threshold	—	0	—	1	77
	98th percentile EPC greater than threshold	—	2	—	2	177
<b>WHO AQG</b>	Threshold (ppb)	—	7.63	—	—	—
	Average EPC greater than threshold	—	3	—	—	—
	98th percentile EPC greater than threshold	—	46	—	—	—
<b>US EPA IRIS Chronic</b>	Threshold (ppb)	—	—	—	1.43	1.43
	Average EPC greater than threshold	—	—	—	1	162
	98th percentile EPC greater than threshold	—	—	—	9	257
<b>Total number of hourly data points*</b>		<b>438</b>	<b>109</b>	<b>416</b>	<b>14</b>	<b>325</b>

Yellow highlighting indicates number of exceedances of the threshold used for comparison

Dash – no threshold for comparison was available

\* Indicates the available number of data points after minimum 75% validation criteria were met. Does not indicate total number of data points collected over the study period

#### 6.5.6.4 EC Daily Data Descriptive Statistics

Figures 51–55 indicate the spread of each dataset analyzed for each parameter and the thresholds used for comparison.

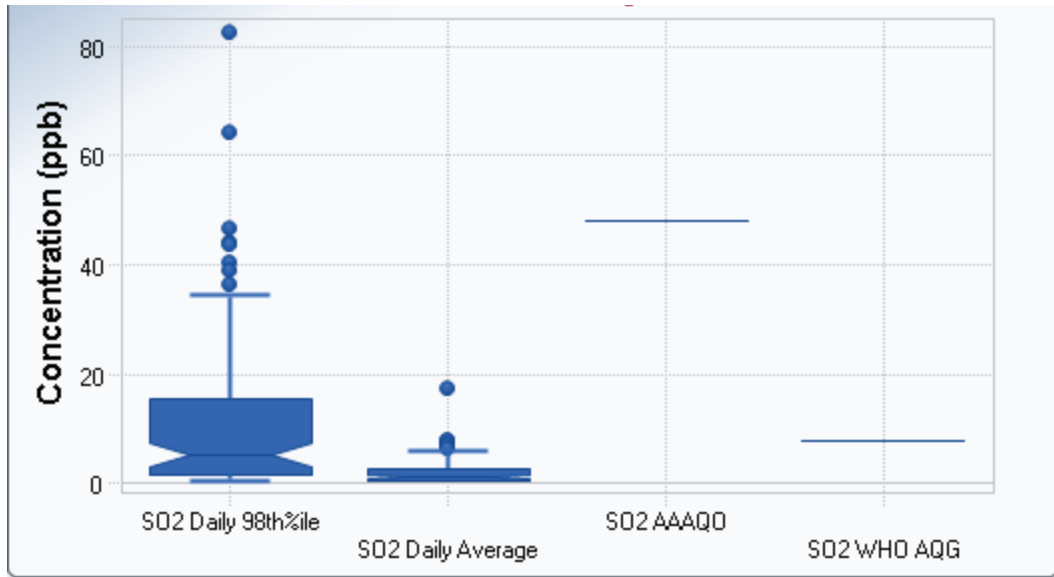


Figure 51. Statistical representation of average and upper bound EC daily SO<sub>2</sub> concentrations as compared to health thresholds

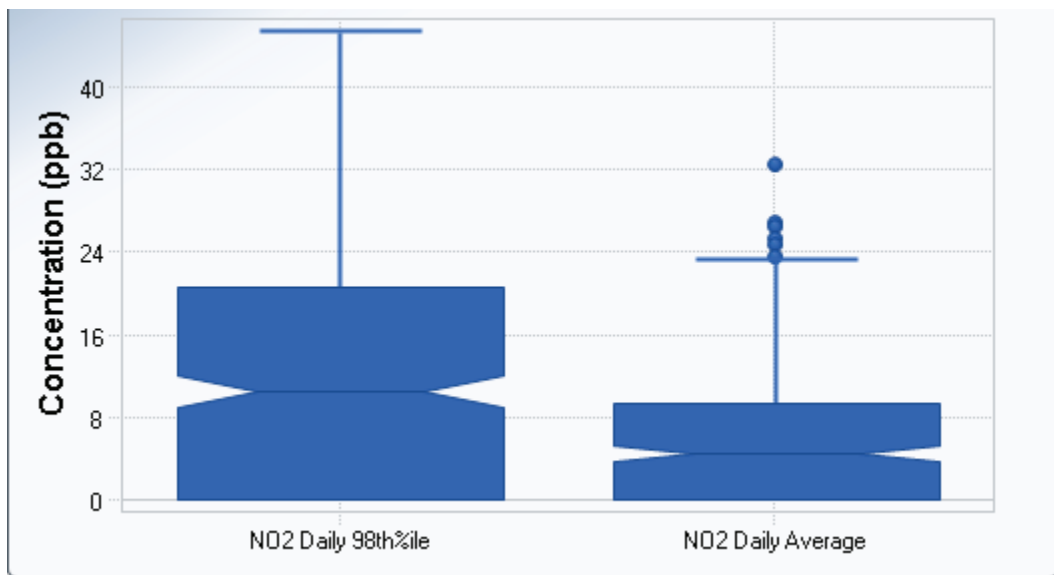


Figure 52. Statistical representation of average and upper bound EC daily NO<sub>2</sub> concentrations, no thresholds for comparisons



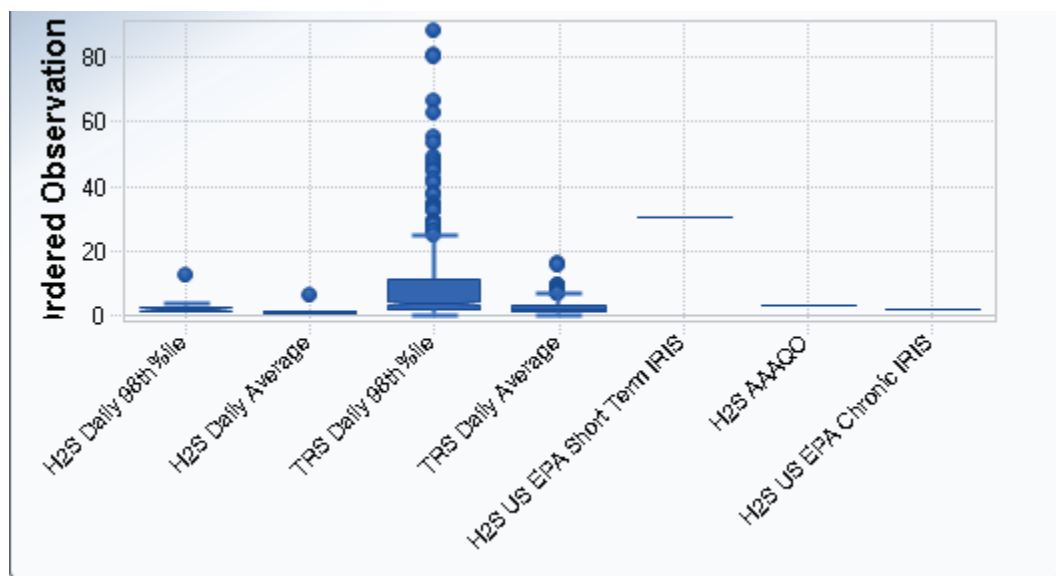


Figure 53. Statistical representation of average and upper bound EC daily TRS and H<sub>2</sub>S concentrations as compared to health thresholds

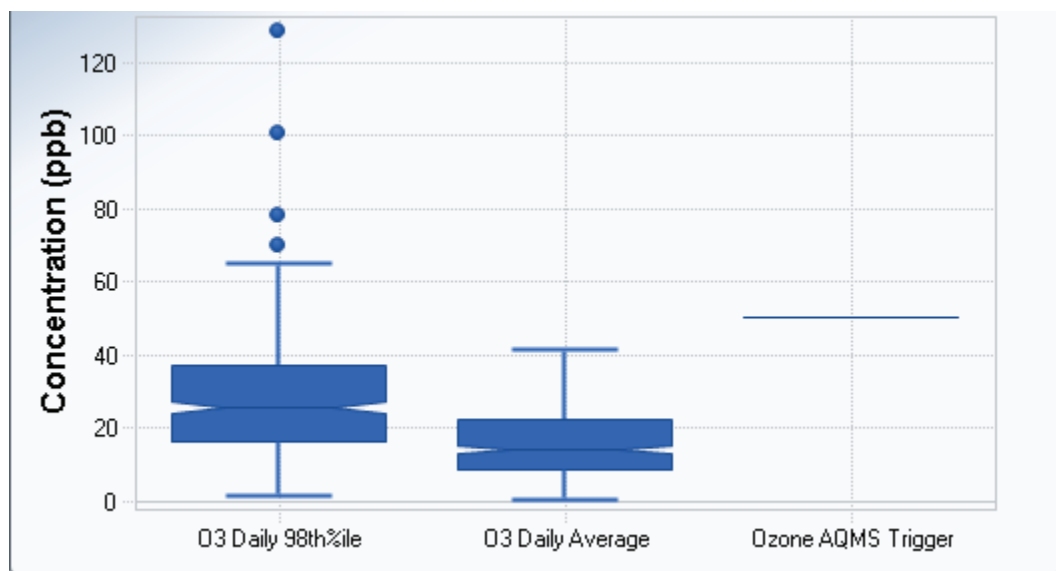
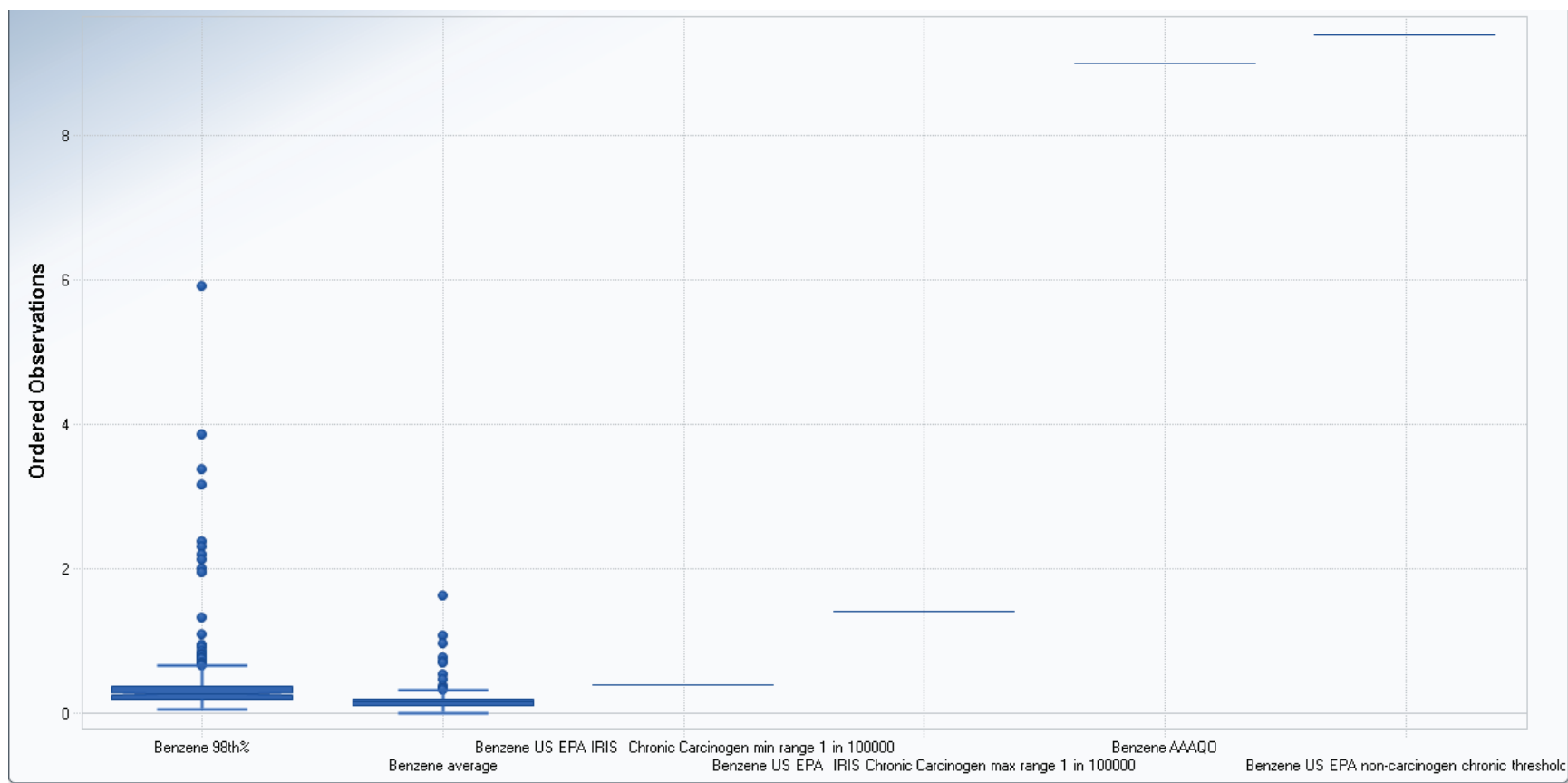


Figure 54. Statistical representation of average and upper bound EC daily O<sub>3</sub> concentrations as compared to health thresholds



**Figure 55. Statistical representation of average and upper bound EC daily benzene concentrations as compared to short- and long-term health thresholds**

## 6.5.6.5 Environment Canada Annual Data 2013–2014

Annual values for concentrations of individual parameters were only available for a single year. Annual values were calculated from October 2013 to October 2014. Data are presented to indicate whether the annual value was greater than (Y) or not (N) the thresholds. The annual average and 98th percentile values were used for comparison to thresholds, and there were differences in the magnitude of exceedances as a result (as expected). The Environment Canada annual data could not be compared to NAAQS or CAAQS for certain parameters as there was not a minimum three-year dataset available as required to calculate the appropriate percentile (US EPA, 2011; CCME, 2012).

No descriptive statistics are presented for annual Environment Canada data as only a single year of data (2013–2014) was available.

The following annual thresholds were exceeded in the period from October 2013 to October 2014 (Table 23 and Table 24):

- Both average and 98th percentile TRS concentrations were greater than the US EPA chronic-effect threshold (US EPA, 2003b). 98th percentile concentrations of H<sub>2</sub>S were greater than the US EPA chronic-effect threshold, but annual averages were less than this threshold.

**Table 23. Annual number of samples with concentrations greater than health thresholds based on annual average and 98th percentile parameter concentrations from Environment Canada continuous data at Oski-ôtin from 2013 to 2014 (n=1)**

		NO <sub>2</sub>	SO <sub>2</sub>	O <sub>3</sub>	H <sub>2</sub> S	TRS
<b>AAAQO</b>	Threshold (ppb)	24	8	—	—	—
	If average is greater than threshold	N	N	—	—	—
	If 98th percentile is greater than threshold	Y	Y	—	—	—
<b>Health Canada</b>	Threshold (ppb)	—	—	—	—	—
	If average is greater than threshold	—	—	—	—	—
	If 98th percentile is greater than threshold	—	—	—	—	—
<b>US EPA IRIS chronic</b>	Threshold (ppb)	—	—	—	1.43	1.43
	If average is greater than threshold	—	—	—	N	Y
	If 98th percentile is greater than threshold	—	—	—	Y	Y
<b>US EPA NAAQS</b>	Threshold (ppb)	53	—	—	—	—
	If average is greater than threshold	N	—	—	—	—
	If 98th percentile is greater than threshold	N	—	—	—	—
<b>WHO AQG</b>	Threshold (ppb)	21.26	—	—	—	—
	If average is greater than threshold	N	—	—	—	—
	If 98th percentile is greater than threshold	Y	—	—	—	—

Environment Canada dataset had not been reviewed by Environment Canada for quality assurance

Yellow highlighting indicates exceedances of the threshold used for comparison

“N” - concentrations less than threshold

“Y” – concentrations greater than thresholds

Dash indicates no threshold for comparison was available

**Table 24. Annual number of samples with VOC concentrations greater than health thresholds based on average and 98th percentile parameter concentrations from EC continuous data at Oski-ôtin from 2013 to 2014 (n=1)**

		Hexane	Benzene	Heptane	Toluene	Octane	Ethylbenzene	Mixed xylenes
<b>AAAQO</b>	Threshold (ppb)	—	0.9	—	—	—	—	—
	If average is greater than threshold	—	N	—	—	—	—	—
	If 98th percentile is greater than threshold	—	N	—	—	—	—	—
<b>Health Canada</b>	Threshold (ppb)	198.6	—	—	—	—	—	41.5
	If average is greater than threshold	N	—	—	—	—	—	N
	If 98th percentile is greater than threshold	N	—	—	—	—	—	N
<b>TCEQ long term</b>	Threshold (ppb)	190	1.4	85	1 100	75	450	140
	If average is greater than threshold	N	N	N	N	N	N	N
	If 98th percentile is greater than threshold	N	N	N	N	N	N	N
<b>US EPA IRIS chronic</b>	Threshold (ppb)	198.62	9.39	—	1 326.93	—	230.31	23.03
	If average is greater than threshold	N	N	—	N	—	N	N
	If 98th percentile is greater than threshold	N	N	—	N	—	N	N
<b>US EPA IRIS chronic carcinogen min range 1 in 100 000</b>	Threshold (ppb)	—	0.4	—	—	—	—	—
	If average is greater than threshold	—	N	—	—	—	—	—
	If 98th percentile is greater than threshold	—	Y	—	—	—	—	—
<b>US EPA IRIS chronic carcinogen max range 1 in 100 000</b>	Threshold (ppb)	—	1.41	—	—	—	—	—
	If average is greater than threshold	—	N	—	—	—	—	—
	If 98th percentile is greater than threshold	—	N	—	—	—	—	—
<b>US EPA NAAQS</b>	Threshold (ppb)	—	—	—	—	—	—	—
	If average is greater than threshold	—	—	—	—	—	—	—
	If 98th percentile is greater than threshold	—	—	—	—	—	—	—
<b>WHO AQG</b>	Threshold (ppb)	—	—	—	—	—	—	—
	If average is greater than threshold	—	—	—	—	—	—	—
	If 98th percentile is greater than threshold	—	—	—	—	—	—	—

Environment Canada dataset had not been reviewed by Environment Canada for quality assurance

Yellow highlighting indicates exceedances of the threshold used for comparison

“Y” – concentrations greater than thresholds

“N” – concentrations less than thresholds

Dash – no threshold for comparison was available

- 98th percentile concentrations for NO<sub>2</sub> and SO<sub>2</sub> were greater than AAAQOs and the WHO AQG for NO<sub>2</sub>.
- The annual 98 percentile concentration of benzene was greater than the minimum US EPA carcinogenic threshold for cancer formation in 1 in 100 000 individuals (US EPA, 2003a).

## 6.6 Discussion and Recommendations

### 6.6.1 Approval Conditions

The compounds monitored at WBEA continuous monitoring stations do not represent the extent of the AAAQOs and are not a full representation of the complex mixture of gases and particulates that are released from industrial emissions related to oil sands mining operations. Historically NH<sub>3</sub>, CO<sub>2</sub>, CO, H<sub>2</sub>S, O<sub>3</sub>, NO<sub>2</sub>, and SO<sub>2</sub> have been the focal parameters in industrial development areas as reflected in *EPEA* approval clauses. Based on the results of this report and subsequent health assessment, additional parameters could be considered for monitoring as directed in *EPEA* approvals for improved assessment related to human health and odour perception. Petroleum hydrocarbons that are known to have health implications include benzene, toluene, ethylbenzene, and mixed xylenes (BTEX), and PAHs. Review and alignment of monitoring is important to ensure that industry source, fence line, and ambient monitoring are aligned in purpose and methodology and comparable (i.e., parameters, frequency, appropriateness of locations, suitability of monitoring to address odour issues and human health risk). This is a gap affecting correlation of odour complaints and air quality to industry operations as well as allowing for a scientifically defensible assessment for the potential effects to human health in the community of Fort McKay.

### 6.6.2 Thresholds

The AER does not establish thresholds for air quality or odours for environment or human health protection. The AER implements the policy direction provided by the Government of Alberta and the human health regulators including Alberta Health. Based on the results of this report, monitoring programs based exclusively on a selection of parameters with an AAAQO requires further policy guidance from the Government of Alberta and Alberta Health. Specifically, guidance is required regarding inclusion of additional parameters with AAAQOs as well as use or application of additional thresholds. Toxicity benchmarks cannot be used for regulatory enforcement in the same manner as AAAQOs, but they do provide an important indication of when the concentration of a compound may present a human health concern that warrants further assessment.

Further policy guidance is required on the number or frequency of exceedances for both individual parameters as well as for multiple parameters in the case of cumulative exposure.

A suite of different thresholds were used in this section of the report as were specific statistical methods for representing a dataset for comparison to thresholds (average versus 98th percentile versus

95th percentile, etc.). Compounds that exceed benchmarks are recommended for further assessment. Guidance is required from the Government of Alberta and Alberta Health on the thresholds to be used as well as the analytical methods to apply.

Additional considerations surrounding thresholds that require policy guidance from the Government of Alberta and Alberta Health include uncertainties around the application of the H<sub>2</sub>S odour and health thresholds to the assessment of TRS, and the applicability of the ozone odour threshold.

### 6.6.3 Ambient Air Monitoring

Review of the data reports available from each agency identified the following:

- A large volume of ambient air quality data has been collected by a number of government and nongovernment agencies, working groups, and companies. These data require rigorous quality control and statistical evaluation as a consolidated dataset.
- The WBEA continuous monitoring network analyzes for total hydrocarbons (THC), which is a complex mixture of VOCs, but cannot be compared to AAAQOs or be related to odour and health thresholds. The Canada-wide Standards for Petroleum Hydrocarbons (CCME, 2008) do specify inhalation-based toxicity benchmarks for volatile petroleum hydrocarbons, and there are AAAQOs for some petroleum hydrocarbons.
- There is a lack of consistency in monitoring of TRS and H<sub>2</sub>S, which is affecting the state of knowledge about the potential for sulphur-based compounds to act as odorants in the community of Fort McKay. Monitoring data did not provide detail on individual TRS components, specifically for individual parameters within the mercaptan, sulphide, and thiophene chemical classes, to allow for identification of specific odorants which may be related to odour complaints. Concentrations were greater than odour thresholds but the only class of chemicals that is consistently greater than thresholds is TRS compounds. This warrants further speciation at the monitoring location so mitigation efforts can be targeted. A mixture of odorous chemicals may increase the intensity of the experience. Assessing health impacts of odours is a developing field. Assessing health impacts of any type of cumulative exposure is also complex, and both are beyond the scope of this report.
- The permanency of the Environment Canada monitoring station in the JOSM program design is unknown. This station monitors a very different suite and frequency of parameters than the WBEA monitoring network and was an excellent resource to support the WBEA monitoring. In addition, a comprehensive suite of potential odorants is not captured in the current WBEA or Environment Canada continuous monitoring, and the current canister data (WBEA) is limited to 24 hour measurements with sampling varying by location. Greater alignment of purpose and intent between the monitoring organizations is needed to better assess odours and human health risk in the community of Fort McKay.

- Concentrations of a number of chemicals in ambient air are low and near instrument detection limits. This is indicative of an ongoing chronic exposure scenario rather than an acute exposure risk. The low concentrations of parameters that are odorants and potentially impacting human health makes the sensitive analytical instruments with low minimum detection limits a necessity for monitoring ambient air in this region.

Figure 56 and Figure 57 compare the results of concentrations greater than the threshold for the Environment Canada and WBEA datasets. Trend lines for the monitored parameters are comparable, but concentrations of parameters measured at each station differ in magnitude. In general, concentrations at the WBEA AM01 station appear to be lower than the concentrations reported at the Environment Canada station. This may be a function of physical location of each station as the Environment Canada station is at a lower elevation in the river valley than the WBEA AMS01 station. Another possible reason for the higher concentrations reported at the Environment Canada station is that the data has not undergone data validation procedures (QA/QC validation).

Ozone measurements at each station were comparable over the sampling period and did not show seasonal fluctuations, as would be expected. Seasonal and diurnal variations may be masked by the increased ozone concentrations attributed to a local source, artifact of sampling or analysis, ground-level formation from continuous  $\text{NO}_x/\text{NO}_2$  emissions reaching Fort McKay, or another reason not related to actual ambient air concentrations of ozone. Verification of these findings is required.

#### 6.6.4 Concentrations Greater than Odour and Human Health Thresholds

Concentrations greater than odour and health thresholds between the WBEA and EC datasets are comparable and identify the need for further investigation related to odour perception and short and long-term health effects in the community of Fort McKay.

**Air Quality Focal Parameter List:** Parameters identified from this analysis for more targeted evaluation based on average and upper bound concentration estimates in ambient air that are greater than odour and health-based thresholds:

- acetaldehyde (comparison to thresholds displayed in Figure 24, Figure 25, Figure 26, Figure 27)
- carbon disulphide (comparison to thresholds displayed in Figure 25 and Figure 27)
- carbonyl sulphide (comparison to thresholds displayed in Figure 25)
- methanol (comparison to thresholds displayed in Figure 25)
- naphthalene (comparison to thresholds displayed in Figure 25 and Figure 27)
- ozone (frequently greater than odour thresholds, occasionally greater than health-based effect thresholds, provincially exceeding management triggers, potential risks are unknown which warrants

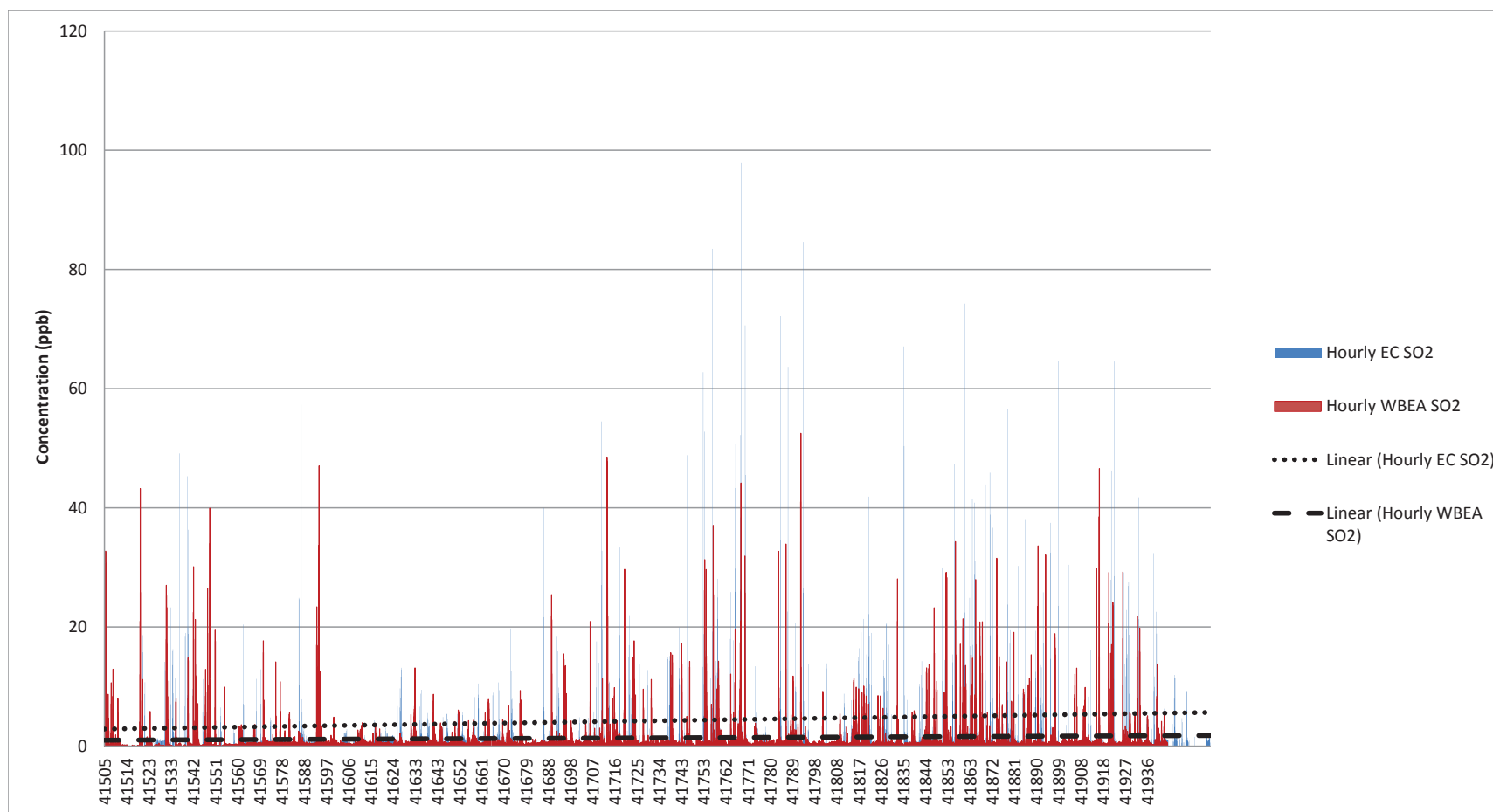


further evaluation) (comparison to thresholds displayed in Table 14, Table 15, Figure 31, Figure 32, Figure 36, and Figure 54)

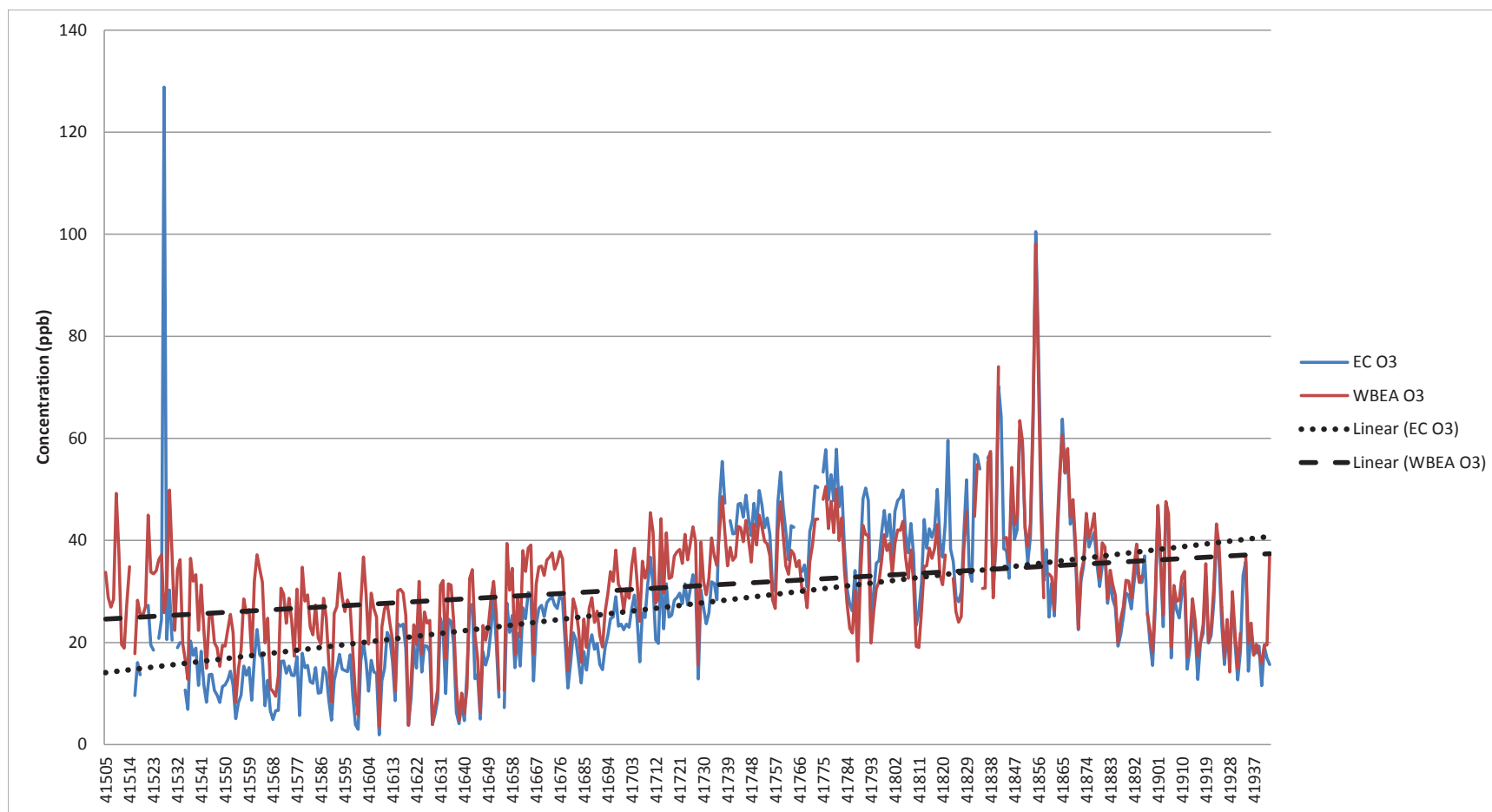
- sulphur dioxide (frequently greater than long-term health thresholds but no concentrations greater than odour thresholds) (comparison to thresholds displayed in Figure 32, Figure 33, Figure 34, Table 17, Table 18, Figure 39, Table 22, Figure 49, Figure 51, and Table 23)
- nitrogen dioxide (potential long-term health risks associated with exposure and source of ground-level ozone formation) (comparison to thresholds displayed in Table 17, Table 18, Figure 40, Table 20, Figure 45, and Table 23)
- hydrogen sulphide (frequently greater than odour thresholds and short-term and long-term thresholds) (comparison to thresholds displayed in Table 12, Figure 24, Figure 25, Table 13, Figure 27, Table 20, Figure 43, Figure 46, Table 22, Figure 49, Figure 50, Figure 53, and Table 23)
- total reduced sulphur (frequently greater than surrogate odour thresholds and short-term and long-term thresholds) (comparison to thresholds displayed in Figure 24, Figure 25, Table 13, Figure 27, Table 14, Figure 29, Figure 32, Figure 33, Figure 37, Table 17, Figure 41, Figure 43, Table 20, Figure 46, Table 22, Figure 49, Figure 50, Figure 53, and Table 23)
- benzene (comparison to thresholds displayed in Figure 25, Table 19, Figure 48, Table 21, Figure 55)
- mixed (m,p) xylenes (comparison to thresholds displayed in Figure 25)
- toluene (comparison to thresholds displayed in Figure 25)

**Odorant Focal Parameter List:** Potential odorants which were frequently greater than odour thresholds, as displayed in Figure 24, Table 13, and Figure 27, during odour events include the following. The list below identifies parameters in canister samples that exceeded an odour threshold from multiple samples (increased frequency) and does not reflect every parameter which exceeded an odour threshold in a single sample (as indicated in Table 12):

- |                       |                       |                            |
|-----------------------|-----------------------|----------------------------|
| • hydrogen sulphide   | • acetaldehyde        | • 2-ethyl hexanol          |
| • carbon disulphide   | • naphthalene         | • 2-ethyl hexanal          |
| • dimethyl disulphide | • benzaldehyde        | • nonanal                  |
| • 2-methyl thiophene  | • isoprene            | • 1-ethyl-4-methyl-benzene |
| • 3-methyl thiophene  | • methyl ethyl ketone | • alpha pinene             |
| • methyl mercaptan    | • n-propylbenzene     |                            |
| • acrolein            | • p-ethyltoluene      |                            |



**Figure 56. Comparison of hourly SO<sub>2</sub> concentrations recorded at WBEA and EC datasets to identify the linear trends and potential differences between monitoring stations**



**Figure 57. Comparison of hourly O<sub>3</sub> concentrations recorded at WBEA and EC datasets to identify linear trends and potential differences between monitoring stations and diurnal fluctuations**

Table 25 summarizes results as well as limitations of ambient air data collected in the community of Fort McKay and compared to odour and human health thresholds. Exposure point concentrations that are greater than the threshold for comparison are indicated by a Y (Yes) or less than threshold as N (No); N/A indicates no threshold was available for comparison or data for that specific parameter were not collected. The EPC that was greater than the threshold is indicated as average or upper bound (98th percentile).

Parameters that were greater than short-term thresholds from canister and continuous data or had a single dataset for comparison (i.e., individual VOC parameters) are identified above and are not presented in the Table 25.

These results have not been contextualized against background air quality data or relative to other communities or cities in the province of Alberta or in Canada. Contextualization is also a critical component for further valuation of these results.

#### 6.6.5 Recommendations

Based on the limited contextualization and preliminary review by AER and Alberta Health, the following recommendations have been made:

**Recommendation 13:** Assessment of the health implications of the ambient monitoring results in this report to the community of Fort McKay. This assessment should consider the results of this report, specifically the Air Quality and Odorant Focal Parameter Lists (Section 6.6.4) where concentrations greater than standards, limits, objectives, and thresholds have been demonstrated. The assessment must consider data limitations and distributions, applicability of thresholds, and the context of parameters exceeding thresholds in relation to background concentrations and other areas of Alberta. Lead: Alberta Health supported by the Government of Alberta, Government of Canada, and the AER.

**Recommendation 14:** Establish an integrated, consistent approach to air quality monitoring from source (industry emissions), to fenceline (Mildred Lake [AMS02], Mannix [AMS05], and Lower Camp [AMS11]) to ambient monitoring stations (AMS 01 and Oski-ôtin). Changes to monitoring should initially consider contaminants on the Air Quality Focal Parameter List (Section 6.6.4). Polycyclic aromatic hydrocarbons should also be considered in future monitoring plans. Lead: EP and the AER, supported by Environment Canada.

**Recommendation 15:** Using the best available knowledge, improve consistency of H<sub>2</sub>S and total reduced sulphur monitoring, including examination of individual sulphur compounds in the ambient air monitoring network in the oil sands. Lead: EP supported by Environment Canada and the AER.

**Recommendation 16:** Development and application of ambient air quality policy for parameters that do not have AAAQOs in areas of odour, ecological and human health.

Lead: Alberta Environment and Parks supported by Alberta Health and the AER.

**Table 25. Comparison of continuous ambient air data collected in the community of Fort McKay to odour and health threshold between EC and WBEA datasets to identify trends for target parameters**

	WBEA AMS01 2010–2014 Data and Threshold Comparison Result			Environment Canada 2013–2104 Data and Threshold Comparison Result		
	Hourly	Daily	Annual	Hourly	Daily	Annual
<b>SO<sub>2</sub></b>						
Odour threshold	No	n/a	n/a	No	n/a	n/a
Health threshold	No	Yes, average and upper bound	Yes, upper bound	No	Yes, average and upper bound	Yes, upper bound
<b>NO<sub>2</sub></b>						
Odour threshold	No	n/a	n/a	No	n/a	n/a
Health threshold	No	n/a	Yes, upper bound	Yes, upper bound	n/a	Yes, upper bound
<b>H<sub>2</sub>S</b>						
Odour threshold	n/a	n/a	n/a	Yes, average and upper bound	n/a	n/a
Health threshold	n/a	n/a	n/a	n/a	Yes, average and upper bound	Yes, upper bound
<b>TRS based on H<sub>2</sub>S as a surrogate</b>						
Odour threshold	Yes, average	n/a	n/a	Yes, average and upper bound	n/a	n/a
Health threshold	n/a	Yes, average and upper bound	Yes, upper bound	n/a	Yes, average and upper bound	Yes, average and upper bound
<b>O<sub>3</sub></b>						
Odour threshold	Yes, average	n/a	n/a	Yes, average and upper bound	n/a	n/a
Health threshold	Yes, average	n/a	n/a	Yes, average and upper bound	n/a	n/a
<b>Benzene</b>						
Odour threshold	n/a			No	n/a	n/a
Health threshold				Yes, average and upper bound (chronic carcinogen threshold)	Yes, average and upper bound (chronic carcinogen threshold)	Yes, upper bound (chronic carcinogen threshold)
				No (short term)		

## 7 Analysis of Odour Complaints, Ambient Conditions, and Industry Plant Operations

### 7.1 Purpose and Methodology

This section examines whether plant operations can be correlated with odour complaints using ambient conditions and plant information on dates when there were large numbers of complaints.

Information for each of the nine selected complaint dates was analyzed to determine the following:

- complaint details;
- ambient conditions including air quality, wind direction, and the presence of inversions at the time of the complaint;
- reported plant performance issues, with a focus on upset events; and
- whether routine plant emissions or upset events were qualitatively correlated with the odour complaint from the residents of Fort McKay.

Table 26 summarizes the complaints, ambient conditions, plant performance, and the analysis findings for the nine selected dates. A discussion of each section and the rationale for choosing each date is included after the table. More detailed information is provided in Appendix 4.

### 7.2 Complaint Details

Over the study period, there were 165 odour complaints received from residents of Fort McKay. The nine dates selected accounted for 32 complaints (or 19 per cent). These dates were selected because of complaints from the community of Fort McKay. The time of the complaints was generally in the morning with a few in the afternoon. The description of the odour from the complainants varies considerably. Sulphur odours are the most common description, followed by hydrocarbon and ammonia (cat urine).

### 7.3 Ambient Conditions

Ambient conditions include the concentrations of compounds in the air and meteorological conditions that are monitored. The meteorological conditions considered are the wind direction and temperature inversion. To correlate odour complaints with ambient air conditions with the time of a complaint, the following method was employed:

- Continuous ambient air data for H<sub>2</sub>S, TRS, SO<sub>2</sub>, THC, O<sub>3</sub>, and NO<sub>x</sub> were compared for trends in time at two community and four industrial air monitoring stations:
  - Community stations
    - AMS01 – Bertha Ganter (Fort McKay)
    - Oski-ôtin/ EC CAM 1 (Fort McKay)

- Industrial air monitoring stations
  - AMS02 – Mildred Lake (Syncrude)
  - AMS05 – Mannix (Suncor)
  - AMS11 – Lower Camp (Suncor)
  - AMS15 – CNRL
- Ambient air concentrations of  $\text{H}_2\text{S}$ , TRS,  $\text{SO}_2$ , THC,  $\text{O}_3$ , and  $\text{NO}_x$  at each monitoring location were examined graphically before, after, and at the time of a complaint to identify potential correlations between locations over a 24 hour time period.
- Qualitative correlations between potential emission sources and odour complaints were made by comparing the chemical signature or trend at each industrial monitoring station with the trend at the community station over the 24 hour time period.

The following example illustrates odour complaints and plume dispersion during an inversion.

On February 25, 2010, nine complaints were received between 12:00 and 13:00. Ambient data for each of the previously identified stations were compiled into a single figure to compare chemical signatures and trends from continuous data, as shown in Figure 58.

For  $\text{SO}_2$ ,  $\text{O}_3$ , and  $\text{NO}_x$  there are clear trends of increased concentrations in the community of Fort McKay at AMS01 and Oski-ôtin occurring mid- to late afternoon, which are not correlated to any single industrial monitoring station and rarely linked to elevated TRS or THC concentrations. This is indicative of an inversion event where the air near the ground is colder than the air above it. Inversions trap emissions from plant sites south of the community of Fort McKay (Syncrude and Suncor) within the mixing layer near the earth's surface rather than allowing dispersion to the atmosphere and upper air. Once the cloud cover breaks and the sun heats the air near the surface, the inversion breaks up as the warmer air near the ground rises and is replaced by colder air above it sinking to the ground.

The accumulated emissions in the upper air near the mixing layer and the plume are driven down further towards the earth's surface. This process, known as inversion breakup fumigation, occurs often in the Fort McKay area.

The wind was from the south on this particular day, and because of the topography of the region, the surface winds with the emissions flowed down the river valley towards the community of Fort McKay and then further along the river valley.

Later in the day there were clear sources detected at industrial monitoring stations, such as  $\text{H}_2\text{S}$  at AMS02 near Syncrude and AMS11 near Suncor. However, they were not linked to the odour complaint. Rather, elevated TRS was evident in the community of Fort McKay at the same time as elevated  $\text{SO}_2$ ,  $\text{O}_3$ , and  $\text{NO}_x$  concentrations, which indicated TRS compounds (mercaptans, sulphides, and thiophenes) are likely associated with various emissions from the plants and inversion events.

Table 26. Summary of complaints, ambient conditions, plant performance, and analysis

Date		February 25, 2010	June 1, 2010	September 21, 2011	October 13, 2012	August 24, 2013	November 6, 2013	March 2, 2014	July 28, 2014	September 22, 2014
Complaints	Time	12:00–14:00	9:30	8:00–8:30	16:30	10:00	11:00	11:00–11:30	8:30	10:00–12:00
	Number of odour complaints	9	1	2	1	1	3	5	2	8
	Description of odour	onion, body odour, propane, chlorine, causing headaches	plant smell, burning sensation to eyes	hydrocarbon	cat pee, stinging sensation to eyes	sulphur, hydrocarbon	sulphur, chemical smell	bitumen, diesel, oil & gas, causing headaches and tears in eyes	ammonia, industrial	sewage, tailings ponds, ammonia, sulphur, hydrocarbon, causing headache, watery eyes and sore throat
Ambient Monitoring	TRS elevated at complaint time at AMS01 and is greater than OT (>0.41 ppb)?	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	THC elevated at complaint time at AMS01 (>2 ppm)?	No	Yes	Yes	Yes	Yes	Yes	Yes	No	No
	SO <sub>2</sub> elevated at complaint time at AMS01?	No	No	No	Yes	No	No	No	No	No
	Inversion time during day	0:00–9:00	0:00–6:00	0:00–7:00	Unlikely	0:00–7:00	Unlikely	0:00–12:00	Unlikely	0:00–7:00
	SO <sub>2</sub> elevated after odour complaint and after inversion at AMS01?	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes
	Wind direction at complaint time at AMS01	S, SSE	SE, SSE	S, SSE	SE, SSE, SSW	S, SSE	S, SSE	SE, SSE	SSE, S	S
Plant Performance	Facilities upwind of Fort McKay at time of complaint	Suncor and/or Syncrude	Suncor and/or Syncrude	Suncor and/or Syncrude	Suncor and/or Syncrude	Suncor and/or Syncrude	Suncor and/or Syncrude	Suncor and/or Syncrude	Suncor and/or Syncrude	Suncor and/or Syncrude
	Operational upsets at Suncor that could cause odours?	Possibly	Yes	No	Possibly	Yes	No	Possibly	Yes	Yes
	Operational upsets at Syncrude that could cause odours?	Possibly	Possibly	No	No	Yes	Possibly	Yes	Yes*	Yes
	Operational upsets at CNRL that could cause odours?	No	No	No	No	Possibly	No	No	No	Yes
	Industry incident reported to AER?	No	Syncrude (2)	CNRL	No	No	Syncrude	No	Syncrude	Syncrude
Analysis	7 day letter?	No	Syncrude	No	Syncrude	No	No	No	No	Suncor
	Complaints, Ambient Monitoring, Wind Direction, and Plant Performance qualitatively correlated?	Yes	Yes	No	Possibly	Yes	Possibly	Possibly	Yes	Yes

\*July 28, 2014: During a meeting Syncrude indicated that this shutdown occurred after the complaint was received (18:40–20:50).





In this particular example, AMS15 (located at CNRL) is downwind of emission sources, and lower concentrations with comparable chemical signatures to those in the community of Fort McKay are seen in a time lag fashion, indicating CNRL is not a potential source in this example.

TRS concentrations were elevated during the complaint time and were greater than the odour threshold. THC was not elevated during the complaint.  $\text{SO}_2$  was elevated and was increasing during the complaint. There was also elevated  $\text{SO}_2$  after the complaint and after the temperature inversion indicating inversion breakup fumigation. The wind direction at the time of the complaint was from the south and south-southeast, which is from Suncor and Syncrude.

This second example illustrates odour complaints and plume dispersion from a point or area source release.

Ambient data for each of the previously identified stations were compiled into a single figure to compare chemical signatures and trends from continuous data, as shown in Figure 59.

The parameter profiles indicate a release from an area source such as the tailings ponds or flaring or venting from a point source. This is indicated by the differential  $\text{H}_2\text{S}$ /TRS and  $\text{SO}_2$  signatures at the monitoring stations.

The TRS and  $\text{H}_2\text{S}$  signatures detected during the time of complaint in the community of Fort McKay correlates with the  $\text{H}_2\text{S}$  concentrations detected at AMS02 fenceline. The source is unknown but appears to be independent of stack emissions as  $\text{SO}_2$  is not detected at fenceline and in very low concentrations in the community at the time of the complaint. It appears this signature is characteristic of emissions from a single point source at a plant site or area emissions from the tailings ponds moving at ground level along the river valley towards the community of Fort McKay when the wind is coming from the south.

Concentration profiles and time for each complaint date are provided in Appendix 4. The following summarizes chemical trends on the nine complaint dates:

- TRS was elevated during each complaint day and was greater than the  $\text{H}_2\text{S}$  odour threshold (0.41ppb) at the time of each complaint.
- THC was elevated on six of the nine complaint days.
- $\text{SO}_2$  was elevated on two of the nine complaint days.
- $\text{SO}_2$  was elevated in the community after the complaint on eight of the nine complaint days.
- The wind direction was from Suncor and Syncrude (S, SW, SE) direction on all nine complaint days.

## 7.4 Plant Issues

For the examination of plant operation and performance issues, three upgraders were included in the analysis: Suncor Base, Syncrude Mildred Lake, and CNRL Horizon. It was assumed that the emissions footprint from these upgraders would have the most significant impact in the community of Fort McKay given the complex nature of their operations and the potential for emissions from the upgraders. Furthermore this is consistent with the submission from the FMSD and discussions with companies on potential sources of emissions and past history of impact that their facilities have had. Monthly and annual reports were reviewed for upsets, and monitoring results were examined with respect to the nine dates that were selected. In reviewing plant operation, consideration was given to sour gas flared, sour gas vented, larger FGD emissions, diverter stack events, sulphur recovery operations (including tail gas outages), and other events that appeared outside of normal operation and could cause odours. We note that for CNRL's Horizon operation, daily flare volumes and other events are not part of monthly reporting unless approved limits are exceeded and thus could not be examined as part of this analysis.

The plant performance portions of Table 26 provides an indication if there were reported upsets that could result in odorous emissions (Yes), may result in odorous emissions (Possibly), and would not result in odorous emissions (No). Details on reported plant issues are provided in Appendix 4.

Suncor and Syncrude had operational issues that could cause odours on four complaint days, possibly had operational issues that could cause odours on three additional complaint days, and did not have operational issues on two of the nine complaint days. CNRL had operational issues that could cause odours on one complaint day, possibly had operational issues that could cause odours on one complaint day, and did not have operational issues that could cause odours on seven of the nine complaint days (data not included).

In examining incidents reported to the AER that may be related to these nine days, it was noted that for four of the sixteen events, an incident was reported to the AER.

## 7.5 Correlations Between Plant Performance, Odour Complaints, and Ambient Air Data

Analysis of the data show clear trends of SO<sub>2</sub>, NO<sub>x</sub>, O<sub>3</sub>, H<sub>2</sub>S, TRS, and THC detection at various industrial and community monitoring stations (AMS02, 05, 11, and 15) and the Fort McKay community monitoring station (AMS01 and Oski-ôtin). Analysis of the data collected on dates with complaints received show two clear and distinctive patterns:

- Releases may be detected at the industrial monitoring stations AMS02, 05, and 11, which can attribute the source of the release to Syncrude or Suncor. Chemicals released during these events are then detected north along the river valley in the community of Fort McKay first and then at AMS15 at CNRL.



Figure 58. Profiles of concentrations of H<sub>2</sub>S, TRS, SO<sub>2</sub>, THC, O<sub>3</sub>, and NO<sub>x</sub> at monitoring stations with time of day on February 25, 2010

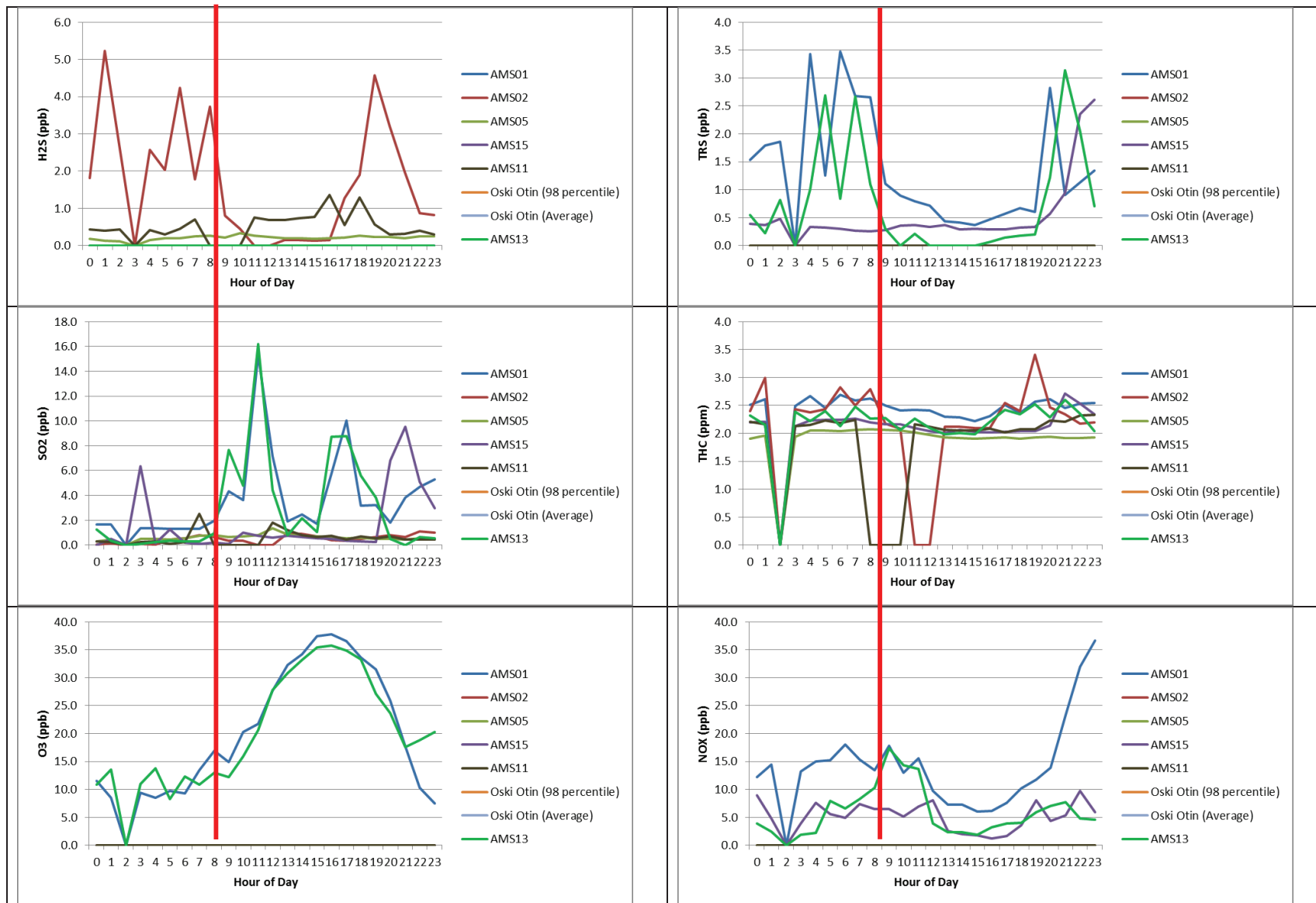


Figure 59. Profiles of concentrations of H<sub>2</sub>S, TRS, SO<sub>2</sub>, THC, O<sub>3</sub>, and NO<sub>x</sub> at monitoring stations with time of day on September 21, 2011

- During inversion breakup fumigation events when winds are out of the south and southwest, higher concentrations of SO<sub>2</sub>, NO<sub>x</sub>, O<sub>3</sub>, H<sub>2</sub>S, TRS, and THC are detected in the community of Fort McKay at AMS01 than at the industrial monitoring stations, and therefore only the community AMS data correlates with odour complaints. The increased concentrations and odour complaints cannot be attributed to a single source but rather appear to be a cumulative effect of air emissions from operators to the south of the community of Fort McKay (i.e., Suncor and Syncrude). On one of the nine days, an inversion was likely present at the time of the complaint; for five other days, an inversion was present earlier in the day.

Complaint data were correlated with ambient monitoring data in the community of Fort McKay to see whether odour thresholds were exceeded in the community of Fort McKay. As can be seen in Table 26, TRS was greater than H<sub>2</sub>S odour thresholds in all cases.

Table 26 shows a simple analysis confirming days when events could cause odours, plants were upwind of Fort McKay, complaints were present and ambient numbers were elevated. During plant events, emissions may increase from a number of sources in addition to the ones that have been noted. While Table 26 suggests a correlation of plant problems with odour events, it should be noted that these events represent a small portion of the total emissions of the plants. The cumulative contribution from sources during normal operations and relative to meteorological conditions is also a key factor.

The nine selected dates were significant because of complaints or air quality parameters in the community of Fort McKay. Table 26 (and Appendix 4) shows that for eight of these nine selected dates there were plant events with the potential to cause odours at plants upwind of Fort McKay.

When examining these plant events, specific times were not available and were not specifically requested of industry. This limitation in the data limits the correlation to the day of the complaint and the day of the event. Furthermore we did not look at the frequency of these types of plant events for other days of the year. To improve this work a more detailed examination of days when plant events occur over the year, wind direction, and air quality monitoring should be conducted.

While ambient air data for these days were examined, there were no conclusions reached as to the extent that plant events versus ambient conditions contributed to complaints occurring on the nine selected days. In any event the information provided in this section and Appendix 4 may be a useful starting point for further work that would be necessary to correlate plant operations to odour complaints.

## **8 Stakeholder Feedback**

Several meetings were held with stakeholders as part of this assessment.

In addition, stakeholders were asked to provide input into this report. Submissions from each of the parties are provided in Appendix 5.

A brief summary of the content of these submissions is provided below.

### **8.1 Common Messages**

All saw a need for improved communication and sharing of information, including complaint information and operational information at the time of complaint.

All acknowledged that TRS and VOCs resulted in odours.

All agreed that changes to the regional monitoring network would add value.

Both industry and the FMSD saw value in meeting to share information on air quality and odour events and work on these issues.

### **8.2 Complaint Response**

The FMSD saw difficulty in getting information from companies for on-site issues or activities that could contribute to odour events. Lack of odour-related characterization of emissions sources (chemical or sensory) makes it impossible (in their opinion) to link plant operations to odour complaints.

Industry stated that a focus on enhanced reporting and complaint response protocols is the best approach to better determine odour sources. A review of the process for handling odour complaints should be undertaken to help ensure a responsive, timely, and consistently executed response to odour complaints. It is helpful to industry to be made aware of odour complaints when they occur to enable a company to track down sources of odours when they are occurring.

WBEA stated that it would be helpful to have data on source and control equipment during complaint periods to link to operations. This is necessary if we want to improve our understanding of why odours occur and potentially reduce the number of complaints.

EP (previously AEMERA) was interested in better understanding the role of WBEA in complaint response and how to address that in the regional monitoring program going forward, including implications to funding and capacity.

### **8.3 Industry Performance**

The FMSD stated that the major odour sources affecting the community of Fort McKay are Suncor and Syncrude, followed by CNRL Horizon and Shell Muskeg River, which are relatively minor sources of

odours except during certain events. In addition to tailings ponds, upgrading and flaring are also thought to be sources of odours.

Industry stated that odour events are not caused by a single compound, and an odour event will likely be due to multiple compounds, multiple sources, and particular meteorological conditions. In an industry submission, a tabulation of routine and event-based sources was provided for each facility. Generally routine VOC emissions were attributed to ponds and mines, while VOC events were attributed to ponds and smaller amounts due to venting. Generally, TRS emissions were attributed to ponds, flare stacks, and other stacks.

Environment Canada stated that it has not been able to rule out any of the suspected hydrocarbon-related sources as potential contributors to odour issues in the community of Fort McKay.

WBEA stated that measurements at AMS01 indicated that odours may have been associated with fugitive emissions from tailings ponds. It noted that beginning in 2014, there has been a coincidence of increased ambient SO<sub>2</sub> concentrations along with increased TRS concentrations and suggest it may now be a mixture of tailings ponds and combustion sources.

EP (previously AEMERA) stated that better alignment between industry emissions and ambient monitoring is necessary to improve understanding of cause and effect relationships between sources of emissions and ambient air quality and odour monitoring results.

## 8.4 Emergency Response

Emergency response was noted by the FMSD as an important priority. The FMSD noted in their submission frequent reports of headaches and nausea from their community members during odour events. They stated that the perception that their health is being threatened leads to a decreased sense of personal safety and security.

## 8.5 Ambient Monitoring

The FMSD stated that thiophenes, sulphides, and disulphides are considered to be the largest contributors to TRS odours, while aldehydes were the VOCs with the most odour relevance. The FMSD stated that there is difficulty distinguishing between odours from Suncor and Syncrude and that there is a lack of any meaningful fenceline odour monitoring. To help with the identification of on-lease odour sources, they stated there is a strong need for species characterization and identification of on-lease odour sources. They recommended that ambient monitoring for odours be enhanced by improving monitoring during complaint response and by improving regional area monitoring. This included the use of trained odour observers, field olfactory measurement, sampling with panel olfactory analysis, and use of E-nose at key locations.



Industry stated that TRS ( $\text{CS}_2$ ,  $\text{H}_2\text{S}$ ,  $\text{COS}$ ),  $\text{SO}_2$ ,  $\text{NH}_3$ , and VOCs are the primary contributors to odours. It does not believe that chemical speciation and enhanced monitoring should be the primary focus. It believes that the regional monitoring network should consider the findings of local odour response and investigations.

WBEA stated that concentrations of some RSCs (substituted thiophenes) and TRS were often increased when odours occurred. It stated that peak concentrations of  $\text{H}_2\text{S}$  and TRS were much greater in the 2008–2010 period, which made the use of the S detector (SCD) technology in subsequent years more challenging given the detection limit. It suggested it would be beneficial to carry out source emission characterization for a list of candidate odorous compounds.

Environment Canada suggested that real-time monitoring at or very near the points of emissions that targets the likely odour-causing pollutants is needed to advance their understanding of emissions.

As above, EP (previously AEMERA) stated that better alignment between industry emissions and ambient monitoring is necessary to improve understanding of cause and effect relationships between sources of emissions and ambient air quality and odour monitoring results.

## 8.6 Future Engagement

The FMSD suggested that a CEMA-like association develop a strategy or framework for addressing odour issues in the region. In the absence of a CEMA-type group, they suggested an AER-led initiative with a clear intent of significantly reducing odour events in the community of Fort McKay be established.

Industry suggested that a collaborative community-focused odour forum be established that included industry, the Fort McKay First Nation, and the AER to regularly review the current state of odours in the community. This committee could share information on odour events, discuss odour mitigation, and discuss nonroutine operations.

WBEA recommended that the AER lead a process to advance the assessment of odours. A workshop could be a first step in the process with emissions experts from industry, WBEA, Fort McKay, the AER, and EP.

## 8.7 Recommendations

**Recommendation 17:** A Fort McKay Odour and Air Quality Task Force is required to oversee implementation of the recommendations in this report. The task force would be chaired by the AER; include the Government of Alberta, Alberta Health, and EP; and involve participation of industry, Fort McKay, WBEA, Environment Canada, and other parties as required. Lead: AER supported by Integrated Resource Management System (IRMS) partners.

## 9 Conclusion

The intent of this report was to conduct an initial gap analysis related to recurrent human health complaints in the community of Fort McKay related to odours and oil sands mining activities. Given the complexity of the task, the number of datasets, the numerous stakeholders involved, and the nature of the health complaints, Alberta Health coauthored this report with the AER, with specific attention to Section 6. Significant effort was expended to examine the study area, review the complaint and investigation history (which transcended the transition of regulatory responsibility from ESRD to the AER), compile industry performance monitoring data and regulatory requirements, and to compile and analyze ambient air quality monitoring from multiple monitoring sources and relative to a suite of benchmarks.

Acquisition of information and transparency in the process with stakeholders was a priority from the onset. Stakeholder participation was complete and engaged from the onset including industry, IRMS government partners, Alberta health, and the community of Fort McKay.

Seventeen recommendations have been tabled based on gaps identified and prioritized as high or medium. Ten high-priority recommendations were identified. Accountabilities for each recommendation (lead and support) are also identified. Prioritization should not be interpreted as a particular recommendation not being considered important but more to ensure the medium-level priorities can benefit from the results of addressing the higher-priority recommendations.

Ranking of recommendations was based on the conclusion that air quality in Fort McKay is a higher priority than odours in the immediate short term. Given that odours are obviously driven by air quality, improvement in the latter should also improve odour management and assessment. Emergency response for air quality assessment in Fort McKay is also by its nature a high priority. The other three areas of high priority are

- human health assessment in Fort McKay related to air quality,
- alignment of air quality monitoring from emissions to ambient to consider human health and odours in Fort McKay, and
- improvement in human health complaint odour response protocols through improved alignment of monitoring, sharing, and communication among the AER, industry, monitoring agencies, and Fort McKay, and improved and more routine systematic analysis linking complaints to industry operations, events, and to ambient air monitoring.

The results of improved monitoring, complaint response processes, and a human health assessment will be important to support the Government of Alberta and Alberta Health in providing policy guidance to the AER. These results will also be important for the AER to improve regulatory requirements for oil sands operators related to air quality and odours in Fort McKay.

## 10 References

- Alberta Energy Regulator (AER), 2009. Directive 071: Emergency Preparedness and Response Requirements for the Petroleum Industry. <https://www.aer.ca/rules-and-regulations/directives/directive-072>
- Alberta Energy Regulator (AER), 2013. Peace River Proceeding No. 1769924. November 25, 2013-Phase II Submissions Volume 5. Peace River Proceeding (No. 1769924).. <http://aer.ca/documents/applications/hearings/1769924-SUBMISSIONVOLV-20131125.pdf>
- Alberta Energy Regulator (AER), 2016a. Directive 060: Upstream Petroleum Industry Flaring, Incinerating, and Venting <https://www.aer.ca/rules-and-regulations/directives/directive-060>
- Alberta Energy Regulator (AER), 2016b. Products and Services Catalogue. ST39: Alberta Mineable Oil Sands Plant Statistics Monthly Supplement. <http://www1.aer.ca/ProductCatalogue/12.html>
- British Columbia Minister of the Environment (BCMOE), 2015 (updated 2016). British Columbia Ambient Air Quality Objectives. <http://www.bcairquality.ca/reports/pdfs/aqotable.pdf>.
- Canadian Council of Ministers of the Environment (CCME), 1993. Environmental Code of Practice (COP) for the Measurement and Control of Fugitive VOC Emission from Equipment Leaks. ISBN 1-895925-12-6. [http://www.ccme.ca/files/Resources/air/emissions/pn\\_1106\\_e.pdf](http://www.ccme.ca/files/Resources/air/emissions/pn_1106_e.pdf).
- Canadian Council of Ministers of the Environment (CCME), 2008. Canada-wide Standards for Petroleum Hydrocarbons (PHCs) in Soil. [http://www.ccme.ca/files/Resources/csm/phc\\_cws/phc\\_standard\\_1.0\\_e.pdf](http://www.ccme.ca/files/Resources/csm/phc_cws/phc_standard_1.0_e.pdf)
- Canadian Council of Ministers of the Environment (CCME), 2012. Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone. PN 1483. ISBN 978-1-896997-91-9 PDF.
- Chambers, John M., William S. Cleveland, Beat Kleiner, and Paul A. Tukey. “Comparing Data Distributions.” In *Graphical Methods for Data Analysis*, 62. Belmont, California: Wadsworth International Group, 1983. ISBN 0-87150-413-8 International ISBN 0-534-98052-X. As cited by David’s Statistics
- Clean Air Strategic Alliance (CASA), 2015a. Final Report of the Odour Management Team to the CASA Board. [http://casahome.org/Portals/0/DMX/OMT%20GPG/OMT%20Final%20Report%20to%20CASA%20Board%20Final\\_09SEP2015.pdf?timestamp=1445441170172](http://casahome.org/Portals/0/DMX/OMT%20GPG/OMT%20Final%20Report%20to%20CASA%20Board%20Final_09SEP2015.pdf?timestamp=1445441170172)
- Clean Air Strategic Alliance (CASA), 2015b. Good Practices Guide for Odour Management in Alberta. From Prevention and Mitigation to Assessment and Complaints. ISBN 978-1-896250-81-6.

- Dann, T., 2013. Integration of 2012 Odour Data for the Human Exposure Monitoring Program (HEMP). R.S. Environmental Report to WBEA, September 27, 2013. 78 p.
- Dann, T., 2014. Integration of 2013 Odour Data for the Human Exposure Monitoring Program (HEMP). R.S. Environmental Report to WBEA, October 21, 2014. 127 p.
- Dann, T., Edgerton, E. 2011. Review of the WBEA Air Monitoring Network. Report to WBEA AATC. 78 p.
- Dann., T., 2015. Integration of 2014 Odour Data for the Human Exposure Monitoring Program (HEMP). R.S. Environmental Report to WBEA, October 25, 2015. 156 p.
- Environment Canada, 2016. National Pollutant Release Inventory. Online Database. <https://www.ec.gc.ca/inrp-npri/>
- Fort McKay Sustainability Department (FMSD), 2003. Odour Event Air Quality Monitoring in the Community of Fort McKay. Submission of Fort McKay First Nation.
- Fort McKay Sustainability Department (FMSD), 2013. Guidance for Odour Impact Assessments and Odour Management for Proposed Oil Sands Projects on Fort McKay's Traditional Territories. Submission of Fort McKay First Nation.
- Government of Alberta, 2013a. Alberta Ambient Air Quality Objectives and Guidelines Summary (updated June 2016). Air Policy Branch. ISBN 978-1-4601-2861-9 (PDF).
- Government of Alberta, 2013b. Alberta Air Quality Model Guideline. Air Policy Section. ISBN No. 978-1-4601-0599-3 (On-line Edition).
- Government of Alberta, 2015a. Air Monitoring Directive. Air and Climate Change Policy Branch. ISBN No. 978-1-4601-1060-7 (On-line Edition).
- Government of Alberta, 2015b. 2011-2013 Canadian Ambient Air Quality Standards Reporting Lower Athabasca Air Zone. Air and Climate Change Policy Branch.
- Government of Alberta, 2015c. Alberta Implementation of the Air Zone Management Framework for Fine Particulate Matter and Ozone. Air and Climate Change Policy Branch. ISBN No. 978-1-4601-2058-3 (PDF)
- Government of Alberta, 2016. Air Quality Health Index Frequently Asked Questions. <http://aep.alberta.ca/air/air-quality-health-index/AQHI-FAQs.aspx>
- Government of Alberta, 2014a. Lower Athabasca Region. Status of Ambient Environmental Condition - 2012. LUF Regional Planning Branch, Integrated Resource Management Planning Division. . ISBN No. 978-1-4601-1536-7 (On-line Edition).

- Government of Alberta, 2014b. Lower Athabasca Region. Status of Management Response for Environmental Management Frameworks - March 2014. LUF Regional Planning Branch, Integrated Resource Management Planning Division. ISBN No. 978-1-4601-1538-1 (On-line Edition).
- Government of Alberta, 2012a. Lower Athabasca Regional Plan. <https://landuse.alberta.ca/LandUse%20Documents/Lower%20Athabasca%20Regional%20Plan%202012-2022%20Approved%202012-08.pdf>.
- Government of Alberta. 2012b. Lower Athabasca Region Air Quality Management Framework for NO<sub>2</sub> and SO<sub>2</sub>. ISBN 978-1-4601-0532-0 (On-line Version).
- Health Canada, 2016. About the Air Quality Health Index. <https://www.ec.gc.ca/cas-aqhi/default.asp?Lang=En&n=065BE995-1>
- Intrinsik, 2013. A Screening-Level Impact Assessment of Potential Health and Odour Related Impacts Associated with Heavy Oil Operations Emissions in the Peace River Area. Final Report. <http://aer.ca/documents/applications/hearings/1769924-SUBMISSIONVOLV-20131125.pdf>
- Joint Canada-Alberta Oil Sands (JOSM), 2012. Implementation Plan for Oil Sands Monitoring. <http://www.ec.gc.ca/pollution/EACB8951-1ED0-4CBB-A6C9-84EE3467B211/Final%20OS%20Plan.pdf>
- Joint Canada-Alberta Oil Sands Environmental Monitoring Portal (JOSM), 2015. Air Data. <http://jointoilsandsmonitoring.ca/default.asp?lang=En&n=A743E65D-2>
- Leonardos, Gregory, David Kendall, and Nancy Barnard. 1969. Odor threshold determinations of 53 odorant chemicals.” Journal of the Air Pollution Control Association 19, no. 2 (1969): 91–95.
- Massachusetts Department of Environmental Protection (MassDEP), 2015. Ambient Air Limits (AALs) and Threshold Effect Exposure Limits (TELs). <http://www.mass.gov/eea/agencies/massdep/toxics/sources/air-guideline-values.html>
- Millennium EMS Solutions Ltd. and Environmental Odour Consulting, 2015. Prepared for the Clean Air Strategic Alliance. Review of Odour Assessment Tools and Practices for Alberta. <http://casahome.org/LinkClick.aspx?fileticket=P-9teU5NWU4%3D&portalid=0>.
- Nagata, Yoshio, and N. Takeuchi, 2003. Measurement of odor threshold by triangle odor bag method. Odor measurement review 118: 127.
- Ontario Ministry of the Environment (OMOE), 2012. Ontario’s Ambient Air Quality Criteria. Standards Development Branch. PIBS # 6570e01.
- Province of Alberta, 2012. Responsible Energy Development Act. Comes with Proclamations and changes from SA 2014 c13 - effective December 17, 2014. Chapter R-17.3 2012. Alberta Queen’s Printer. [http://www.qp.alberta.ca/570.cfm?frm\\_isbn=9780779776368&search\\_by=link](http://www.qp.alberta.ca/570.cfm?frm_isbn=9780779776368&search_by=link)

- Province of Alberta, 2014. Alberta Environmental Protection and Enhancement Act. Revised Statutes of Alberta 2000. Chapter E-12. Alberta Queen's Printer. [http://www.qp.alberta.ca/1266.cfm?page=E12.cfm&leg\\_type=Acts&isbncln=9780779735495](http://www.qp.alberta.ca/1266.cfm?page=E12.cfm&leg_type=Acts&isbncln=9780779735495)
- Province of Alberta, 2015. Climate Change and Emissions Management Act. Specified Gas Emitters Regulation. Alberta Regulation 139/2007. Alberta Queen's Printer. [http://www.qp.alberta.ca/1266.cfm?page=2007\\_139.cfm&leg\\_type=Regs&isbncln=9780779738151](http://www.qp.alberta.ca/1266.cfm?page=2007_139.cfm&leg_type=Regs&isbncln=9780779738151)
- Spink, David, 2013a. Considerations in Attributing an Air Quality and/or Odour Event in Fort McKay to a Specific Industrial Operation and/or Source(s). Submission of Fort McKay First Nation.
- Spink, David, 2013b. Fort McKay's Air Quality Index (FMAQI). Submission of Fort McKay First Nation.
- Texas Commission on Environmental Quality (TCEQ), 2015. Air Monitoring Comparison Values. <http://www.tceq.state.tx.us/toxicology/AirToxics.html/#list>.
- United States Environmental Protection Agency (US EPA), 2003a. Integrated Risk Information System (IRIS). Chemical Assessment Summary for Benzene. CASRN 71-43-2. [https://cfpub.epa.gov/ncea/iris/iris\\_documents/documents/subst/0276\\_summary.pdf](https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0276_summary.pdf).
- United States Environmental Protection Agency (US EPA), 2003b. Integrated Risk Information System (IRIS). Chemical Assessment Summary for Hydrogen sulfide. CASRN 7783-064. [https://cfpub.epa.gov/ncea/iris/iris\\_documents/documents/subst/0061\\_summary.pdf](https://cfpub.epa.gov/ncea/iris/iris_documents/documents/subst/0061_summary.pdf).
- United States Environmental Protection Agency (US EPA), 2011. National Ambient Air Quality Standards. <https://www.epa.gov/criteria-air-pollutants/naaqs-table>.
- United States Environmental Protection Agency (US EPA), 2013. ProUCL Version 5.0.00 User Guide, Statistical Software for Environmental Applications for Data Sets with and without Nondetect Observations. [https://www.epa.gov/sites/production/files/2015-03/documents/proucl\\_v5.0\\_user.pdf](https://www.epa.gov/sites/production/files/2015-03/documents/proucl_v5.0_user.pdf)
- United States Environmental Protection Agency (US EPA), updated 2016. Integrated Risk Information System (IRIS). Various Chemical Assessment Summaries. <https://www.epa.gov/iris>.
- Wood Buffalo Environmental Association (WBEA). Historical Monitoring Data (accessed July, 2015). <http://www.wbea.org/monitoring-stations-and-data/historical-monitoring-data>.
- Wood Buffalo Environmental Association (WBEA), 2016; online. Current Ambient Air Quality Data. <http://www.wbea.org/monitoring-stations-and-data/monitoring-stations>.
- World Health Organization (WHO), 2005. WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide - Global update 2005 - Summary of risk assessment. WHO/SDE/PHE/OEH/06.02.



## Appendix 1 Glossary

<b>acetaldehyde (C<sub>2</sub>H<sub>4</sub>O)</b>	A naturally occurring, colourless, flammable liquid used in manufacture of acetic acid, perfumes, and flavors.
<b>acid gas</b>	A mixture of hydrogen sulphide (H <sub>2</sub> S) and carbon dioxide (CO <sub>2</sub> ), with minor traces of hydrocarbons, which is the by-product of “sweetening” sour hydrocarbons.
<b>acidic aerosols</b>	A colloidal suspension of acidic particles that form the “summer haze” generated by SO <sub>2</sub> and NO <sub>2</sub> emissions.
<b>Alberta ambient air quality objectives (AAAQOs)</b>	Ambient air quality objectives and guidelines that were developed under Alberta’s <i>Environmental Protection and Enhancement Act (EPEA)</i> for all or part of the province to protect Alberta’s air quality.
<b>ammonia (NH<sub>3</sub>)</b>	A colourless gas with a pungent urine-like odour.
<b>benzene (C<sub>6</sub>H<sub>6</sub>)</b>	A colourless, highly flammable, volatile, liquid aromatic hydrocarbon with a gasoline-like odour. It is found in crude oils and as a by-product of oil-refining processes.
<b>biomonitoring</b>	Monitoring of ambient air quality environmental effects.
<b>bitumen</b>	A sticky black and highly viscous liquid or semisolid form of petroleum.
<b>BTEX</b>	Benzene, toluene, ethylbenzene, and xylenes. These are volatile organic compounds found in petroleum and its products.
<b>carbon disulphide (CS<sub>2</sub>)</b>	A colourless, flammable, poisonous gas, which can be used as a solvent in liquid form. It can be poisonous to humans and animals.
<b>carbonyl sulphide (COS)</b>	A colourless, poisonous, flammable gas with a distinct rotten egg odour.
<b>diverter stack</b>	A stack which allows emergency release of gases and particulate in the event of a carbon monoxide boiler failure or coker upset.



<b>e-nose</b>	A device that identifies the specific components of an odour and analyzes its chemical make-up to identify it.
<b>fine particulate matter</b>	Microscopic solid or liquid matter suspended in the atmosphere.
<b>Field Inspection System (FIS)</b>	An inspection and safety compliance management system used by the AER.
<b>flaring</b>	The controlled burning of natural gas in the course of oil and gas production operations.
<b>flash gas</b>	Gas released from a liquid when the pressure drops.
<b>flue-gas desulphurization</b>	A technology used to remove sulphur dioxide (SO <sub>2</sub> ) from flue gases resulting from the burning of coke or tail gas from a sulphur plant.
<b>froth</b>	A substance that floats to the top of the slurry when bitumen is separated from sand.
<b>fugitive emissions</b>	Unintentional releases of gas resulting from production, processing, transmission, storage, and delivery.
<b>gas turbine</b>	A combustion engine that converts natural gas or other liquid fuels to mechanical energy.
<b>hydrogen sulphide (H<sub>2</sub>S)</b>	A colourless gas with the characteristic foul odour of rotten eggs; it is heavier than air, very poisonous, corrosive, flammable, and explosive.
<b>H<sub>2</sub>S analyzers</b>	Instruments based on a scientific measurement principle (fluorescence after thermal oxidation) specified by Alberta Environment in the <i>AMD</i> . The H <sub>2</sub> S analyzers also oxidize other sulphur compounds that are fluoresced and read as H <sub>2</sub> S. The analyzer can therefore over report actual H <sub>2</sub> S concentrations. Within the WBEA network, H <sub>2</sub> S is measured at some stations and TRS is measured at others. TRS analyzers use the same measurement principle (fluorescence after thermal oxidation) as H <sub>2</sub> S analyzers, but operate at a different oxidizing temperature. The choice of analyzer for each station is mandated by Alberta Environment Reporting Requirements in operating approvals, and by the <i>AMD</i> .

<b>hydrotreating</b>	A process to remove sulphur, aromatics and other compounds from hydrocarbon liquids.
<b>in situ</b>	Oil sands facilities that recover bitumen that is too deep to mine.
<b>methane (CH<sub>4</sub>)</b>	A chemical compound with the formula CH <sub>4</sub> . It is the simplest alkane and the main part of natural gas.
<b>methanol (CH<sub>3</sub>OH)</b>	A volatile, colourless, flammable, toxic liquid with a distinctive odour very similar to that of ethanol (drinking alcohol). It is a common industrial solvent.
<b>methyl mercaptan (CH<sub>3</sub>SH)</b>	A colourless flammable gas with unpleasant odour that can be described as rotten cabbage.
<b>naphtha</b>	A liquid hydrocarbon mixture often used as fuel, solvent, diluent or cleaning fluid.
<b>naphthalene (C<sub>10</sub>H<sub>8</sub>)</b>	A white, volatile, solid polycyclic hydrocarbon with a strong mothball odour. Naphthalene is obtained from either coal tar or petroleum distillation.
<b>NO</b>	nitrogen monoxide
<b>NO<sub>2</sub> (nitrogen dioxide)</b>	A reddish-brown toxic gas that has a characteristic sharp, biting odour and is a prominent air pollutant.
<b>NO<sub>x</sub> (nitrogen oxides)</b>	A generic term for the mononitrogen oxides NO and NO <sub>2</sub> (nitric oxide and nitrogen dioxide).
<b>noncompliance event</b>	A noncompliance event is when a company or licensee does not follow AER requirements. Education, prevention, and enforcement activities are used to ensure compliance with AER requirements. Education, prevention and enforcement aspects of compliance assurance and applies to all AER requirements and processes. The AER uses a risk assessment process to predetermine the level of inherent risk associated with a noncompliance with each AER requirement. Each noncompliant event has an associated low or high risk rating based on the results of the risk assessment process for each AER requirement.

<b>NPRI</b>	National Pollutant Release Inventory
<b>O<sub>3</sub> (ozone)</b>	A pale blue gas with a distinctively pungent smell.
<b>PAHs (polycyclic aromatic hydrocarbons)</b>	Neutral, nonpolar molecules; they are found in fossil fuels (oil and coal) and in oil sands deposits, and are formed from incomplete combustion of organic compounds. PAHs have been identified as carcinogenic and mutagenic (as well as teratogenic), and are considered pollutants.
<b>paraffins</b>	Saturated hydrocarbons with the formula C <sub>n</sub> H <sub>2n+2</sub>
<b>photochemical reaction</b>	A chemical reaction initiated by absorption of energy in the form of sunlight.
<b>PM<sub>2.5</sub></b>	Fine particulate matter, less than 2.5 µm
<b>PM<sub>10</sub></b>	Larger particulate matter, up to 10 µm
<b>steam-assisted gravity drainage (SAGD)</b>	An enhanced oil recovery technology for producing heavy crude oil and bitumen.
<b>SO<sub>2</sub> (sulphur dioxide)</b>	A toxic gas with a pungent, irritating, and rotten smell.
<b>sour gas</b>	Natural gas that contains measurable amounts of hydrogen sulphide (H <sub>2</sub> S). It is a colourless, flammable gas that smells like rotten eggs and can be poisonous to humans and animals.
<b>tailings</b>	A by-product of the process used to extract bitumen from mined oil sands and consists of water, silt, sand, clay, condensate or solvent, and residual bitumen.
<b>temperature inversion</b>	A condition in the atmosphere in which a layer of cool air at the surface is overlain by a layer of warmer air.
<b>thermal oxidizer</b>	A combustion device that controls total reduced sulphur compounds, volatile organic compounds (VOC), carbon monoxide (CO), and other hazardous air pollutant emissions by combusting them to sulphur dioxide (SO <sub>2</sub> ), carbon dioxide (CO <sub>2</sub> ), and water.

<b>toluene (C<sub>7</sub>H<sub>8</sub>)</b>	A colourless, volatile liquid with a sweet smell used as an industrial solvent. Also known as methylbenzene.
<b>TRS (total reduced sulphur)</b>	A group of sulphur compounds that includes hydrogen sulphide, mercaptans, dimethyl sulphide, dimethyl disulphide, and other sulphur compounds, but not sulphur dioxide.
<b>upset</b>	An incident which causes unintentional, temporary problems with normal operation of the facility.
<b>venting</b>	The intentional controlled release of gases into the atmosphere in the course of oil and gas production operations. These gases might be natural gas or other hydrocarbon vapours, water vapour, and other gases, such as carbon dioxide, separated in the processing of oil or natural gas.
<b>VOC</b>	Volatile organic compounds are organic chemicals that have a high vapour pressure at ordinary room temperature. They can be toxic to humans and animals.
<b>wet scrubbing</b>	An air pollution control process for removing particles and gases from industrial exhaust streams by introducing the gas stream with a scrubbing liquid (typically water).



## **Appendix 2    Industry Performance Monitoring**





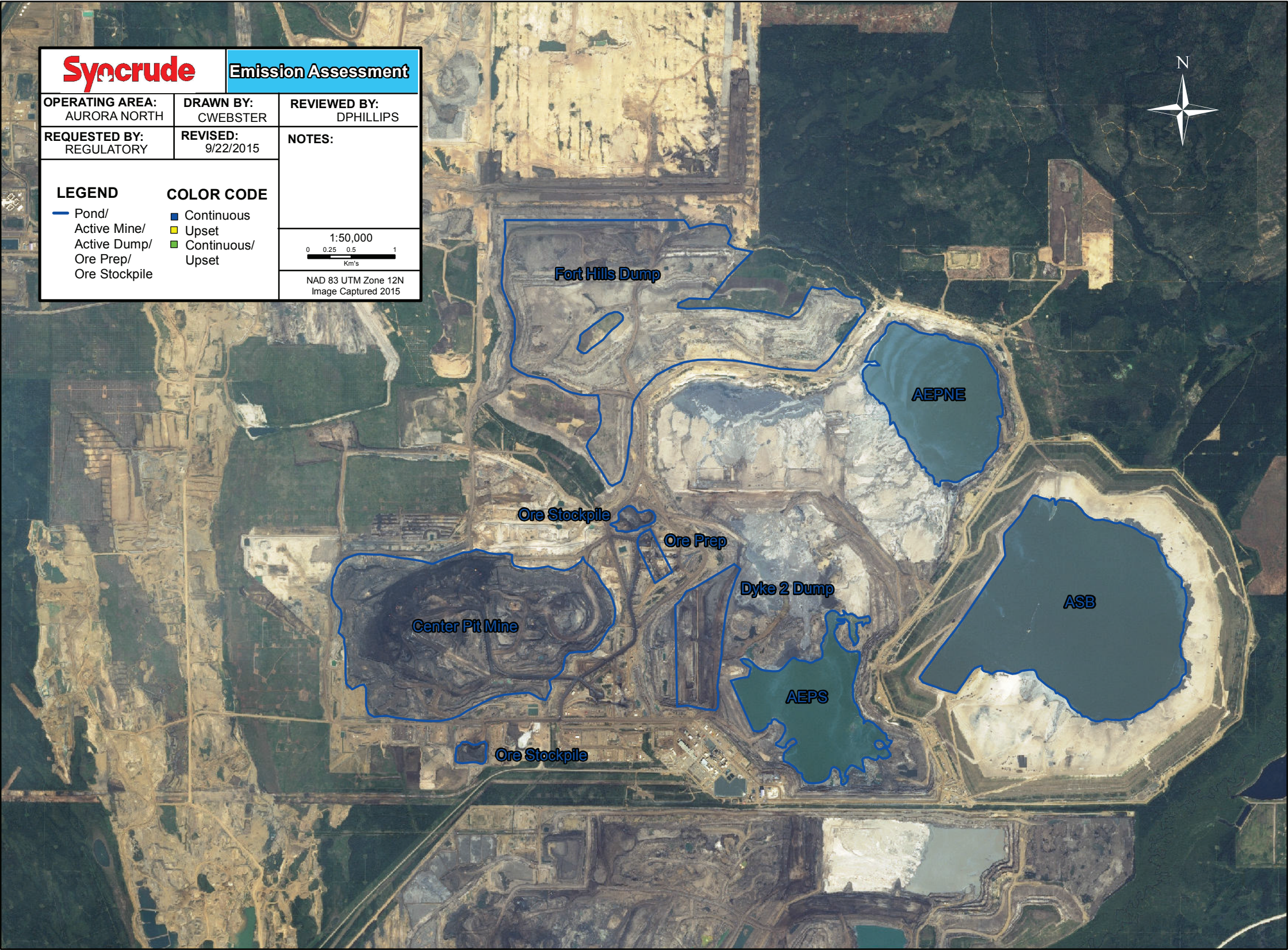


Figure 60. Site plan: Syncrude Aurora



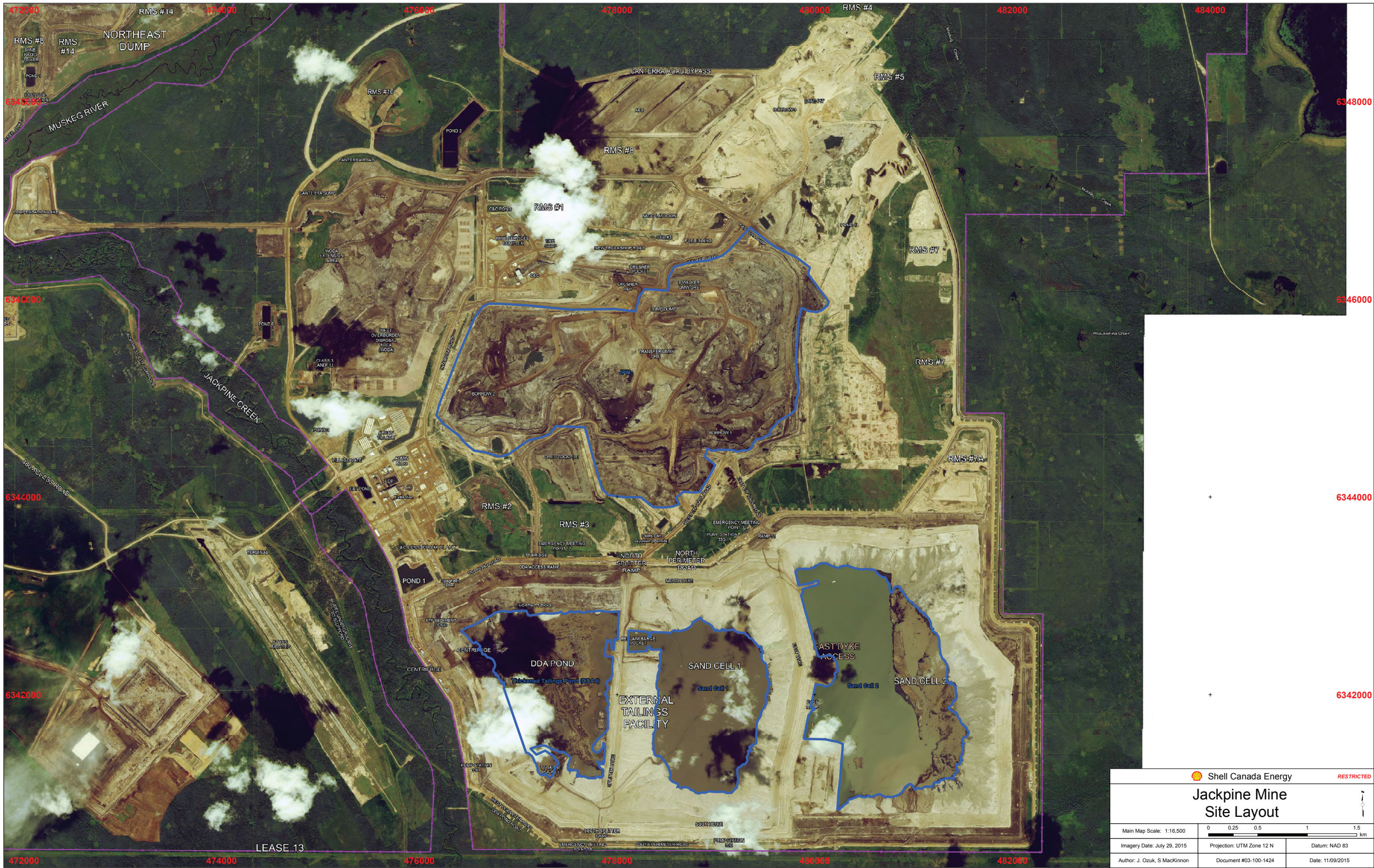


Figure 61. Site plan: Shell Jackpine





Figure 62. Site plan: Shell Muskeg River



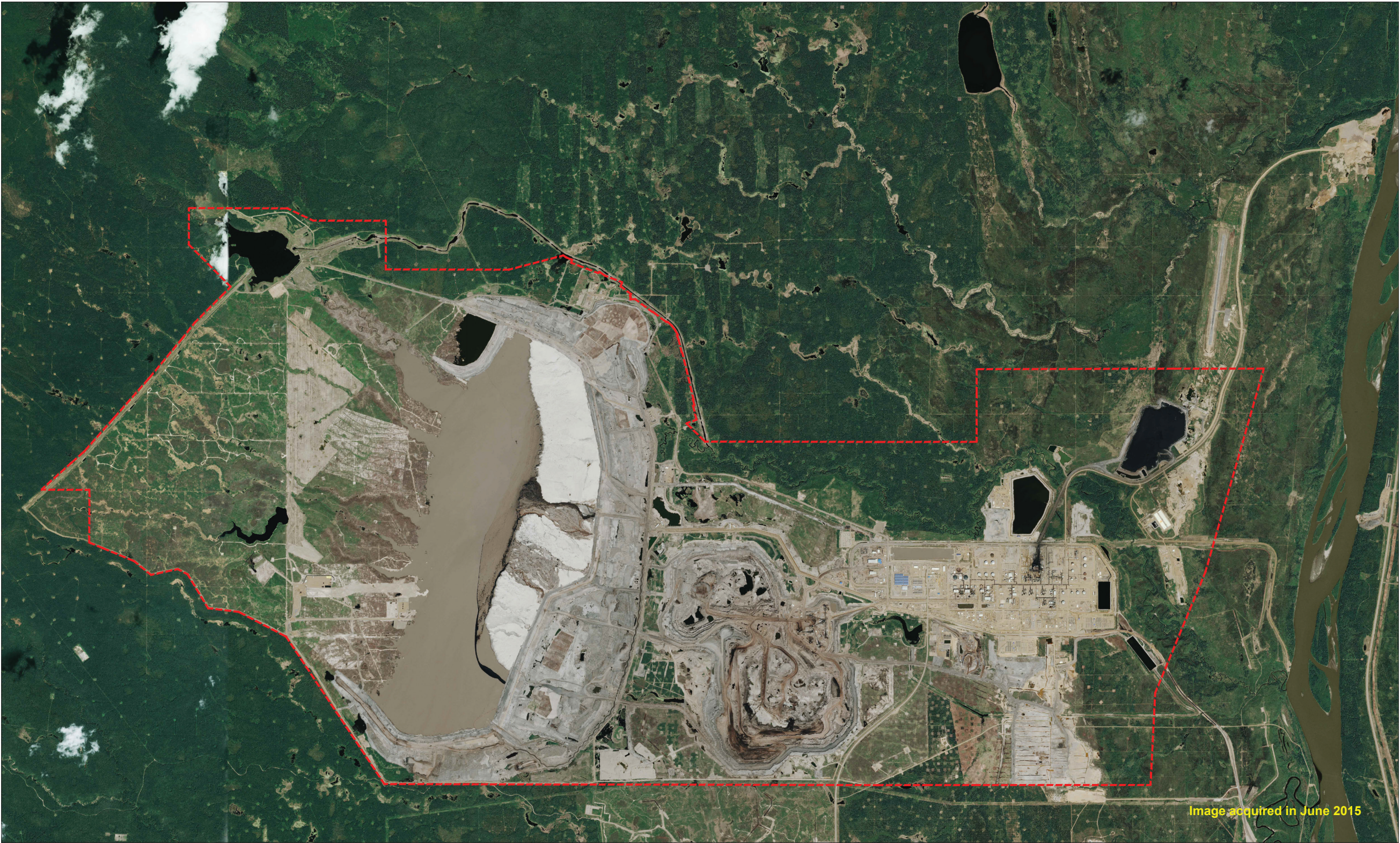


Figure 63. Site plan: CNRL Horizon



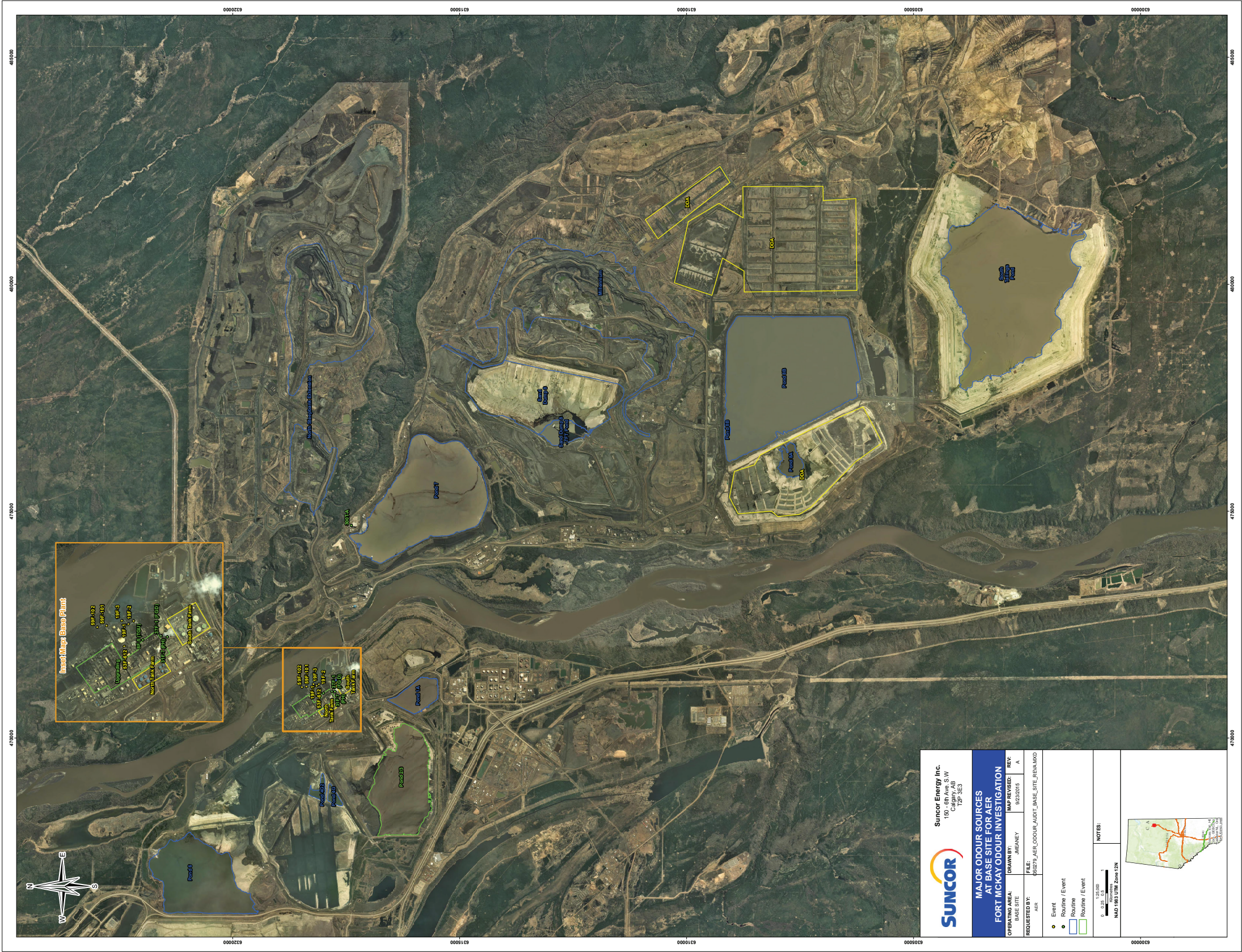


Figure 64. Site plan: Suncor Base Plant



**150** Recurrent Human Health Complaints Technical Information Synthesis: Fort McKay Area (September 2016)



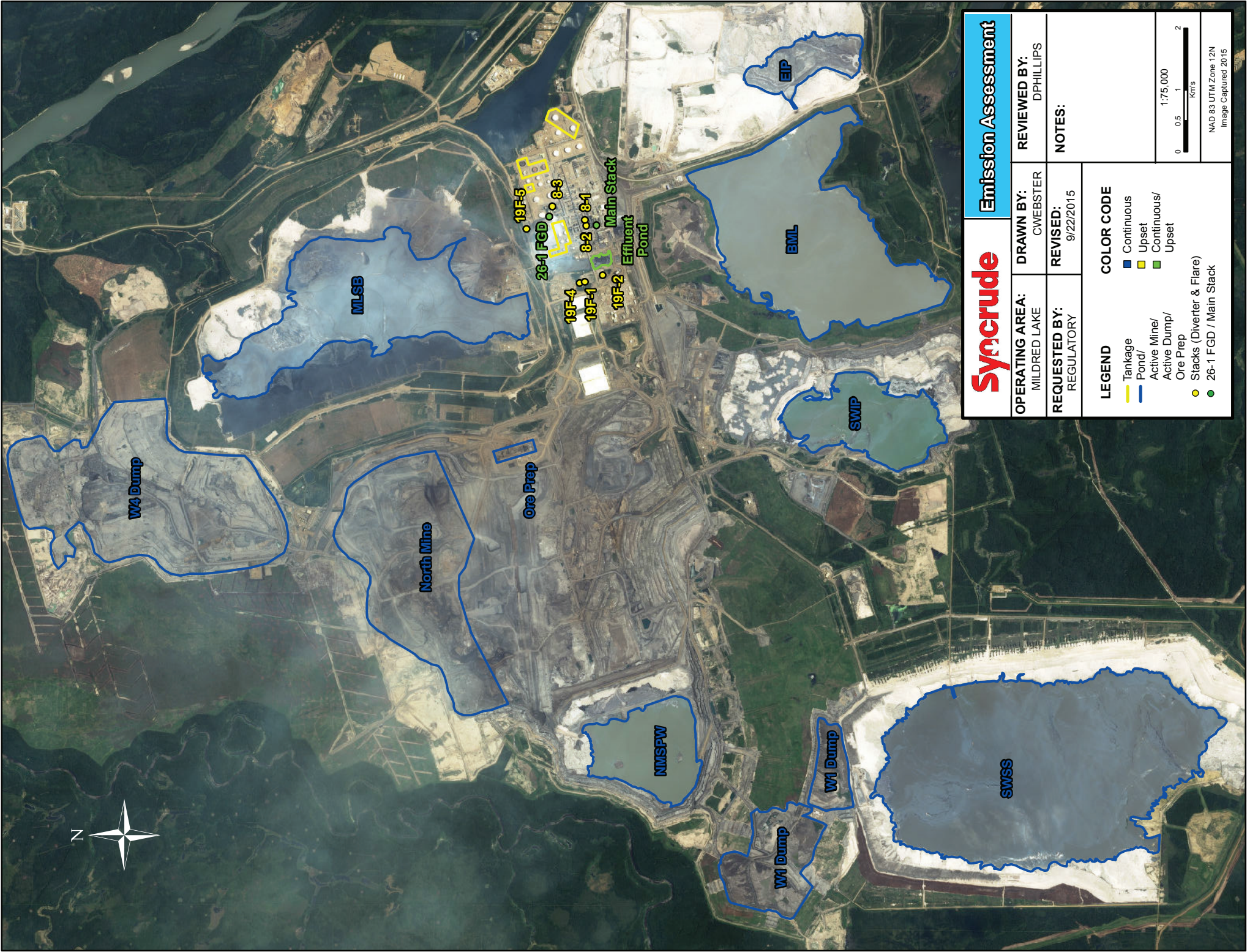


Figure 66. Site plan: Syncrude Mildred Lake





## Appendix 3 Ambient Environmental Monitoring

**Table 27. Comparison of the ambient air monitoring data available to the AER in the vicinity of Fort McKay from 2010 to 2014**

	<b>WBEA continuous data</b>	<b>WBEA canister data</b>	<b>Environment Canada continuous data</b>	<b>FMSD odour event canister samples</b>
<b>Total no. of monitoring stations</b>	16 (AMS01–07, 09, 11–17)	16 (AMS01–07, 09, 11–17)	1 (Oski-ôtin [Fort McKay])	Various locations in Fort McKay
<b>Monitoring locations reviewed in report</b>	AMS01 (Fort McKay), AMS02 (Mildred Lake), AMS03/11 (Lower Camp), AMS05 (Mannix), AMS15 (CNRL)	AMS01 (Fort McKay)	Oski-ôtin (Fort McKay)	Various locations in Fort McKay
<b>Available sampling period (direct reporting averaging time)</b>	5 min, 1 hour	24 hour	Range from 1 min to 29 min	10 min
<b>Calculated values from reported sampling period</b>	Adopted hourly data. Calculated average and 98 percentile values from hourly data to derive 24 hour value.	Adopted directly. Calculated average and 98 percentile values from 24 hour data to derive annual value.	No values directly adopted. Calculated average and 98 percentile values from minutes data to derive hourly value. Calculated average and 98th percentile values from hourly data to derive 24 hour value. Calculated average and 98th percentile values from hourly data to derive annual value.	3 min peak concentrations
<b>Parameters</b>	TRS, H <sub>2</sub> S, SO <sub>2</sub> , NO, O <sub>3</sub> , NO <sub>2</sub> , Total Hydrocarbons (THC), NH <sub>3</sub> , Methane, NMHC	See WBEA odour thresholds for individual parameters (Table 29)	CO, NO <sub>x</sub> , SO <sub>2</sub> , O <sub>3</sub> , H <sub>2</sub> S, TRS, Hexane, Benzene, Heptane, Toluene, Octane, m,p-xylene, o-xylene, ethylbenzene	See Fort McKay odour thresholds for individual parameters (Table 31, Table 32, Table 33, Table 34)



**Table 28. AER-applied odour thresholds of various parameters collected in ambient air samples**

Pollutants	Unit	Odour threshold	Source
1,2,4-Trimethylbenzene*	ppb	120	Nagata, 2003
1,3,5-Trimethylbenzene*	ppb	170	Nagata, 2003
1-Butene	ppb	360	Nagata, 2003
1-Pentene	ppb	100	TCEQ
2,2,4-Trimethylpentane	ppb	670	Nagata, 2003
2,2-Dimethylbutane	ppb	20 000	Nagata, 2003
2,3,4-Trimethylpentane*	ppb	670	thiophene surrogate, Nagata, 2003
2,3-Dimethylbutane	ppb	420	Nagata, 2003
2,3-Dimethylpentane	ppb	4 500	Nagata, 2003
2,4-Dimethylpentane	ppb	940	Nagata, 2003
2,5-dimethyl Thiophene*	ppb	0.56	thiophene surrogate, Nagata, 2003
2-ethyl Thiophene*	ppb	0.56	thiophene surrogate, Nagata, 2003
2-methyl Thiophene*	ppb	0.56	thiophene surrogate, Nagata, 2003
2-Methyl-1-pentene	ppb	—	Nagata, 2003
2-Methyl-2-butene	ppb	—	Nagata, 2003
2-Methylheptane	ppb	110	Nagata, 2003
2-Methylhexane	ppb	420	Nagata, 2003
2-Methylpentane	ppb	7 000	Nagata, 2003
3-methyl Thiophene*	ppb	0.56	thiophene surrogate, Nagata, 2003
3-Methyl-1-butene	ppb	—	Nagata, 2003
3-Methylheptane	ppb	1 500	Nagata, 2003
3-Methylhexane	ppb	840	Nagata, 2003
3-Methylpentane	ppb	8 900	Nagata, 2003
4-Methyl-1-pentene	ppb	—	—
Acetaldehyde	ppb	1.5	Nagata, 2003
Acetone	ppb	42 000	FMSD 42 ppb
Allyl sulphide	ppb	0.22	Nagata, 2003
alpha Pinene	ppb	18	Nagata, 2003
Benzene	ppb	2 700	Nagata, 2003
beta Pinene	ppb	33	Nagata, 2003
Butane	ppb	1 200 000	Nagata, 2003
Butyl mercaptan	ppb	0.0028	Nagata, 2003
Carbon disulphide	ppb	210	10 proposed by ESRD and FMSD, adopted Nagata, 2003
Carbonyl sulphide	ppb	55	Nagata, 2003
cis-2-Butene	ppb	360	butene as surrogate, Nagata 2003
cis-2-Hexene	ppb	140	hexene as surrogate, Nagata, 2003
cis-2-Pentene	ppb	100	pentene as surrogate Nagata 2003
Cyclohexane	ppb	2 500	Nagata, 2003
Cyclopentane	ppb	1 700	methylcyclopentane as surrogate, Nagata 2003
Cyclopentene	ppb	—	Nagata, 2003
Decane	ppb	620	Nagata, 2003
Dimethyl disulphide	ppb	2.2	Note: FMSD proposed 0.2 incorrect units?
Dimethyl sulphide	ppb	1	UK 2007; FMSD proposed 3, based on Nagata, 2003
Dodecane	ppb	110	Nagata, 2003
Ethyl benzene	ppb	170	Nagata, 2003
Ethyl mercaptan	ppb	0.0087	Note: Nagata 100–1000× lower than other sources
Ethyl sulphide*	ppb	0.033	diethyl sulphide as surrogate
Formaldehyde	ppb	500	Nagata, 2003

<b>Pollutants</b>	<b>Unit</b>	<b>Odour threshold</b>	<b>Source</b>
Heptane	ppb	670	Nagata, 2003
Hexane	ppb	1 500	Nagata, 2003
Hydrogen sulphide	ppb	0.41	Nagata, 2003
Isobutane*	ppb	10 000	Isobutene as surrogate
Isobutyl mercaptan	ppb	0.0068	Nagata, 2003
Isopentane	ppb	1 300	Nagata, 2003
Isoprene	ppb	48	Nagata, 2003
Isopropyl mercaptan	ppb	0.006	Nagata, 2003
Isopropylbenzene	ppb	8.4	Nagata, 2003
m,p-Xylene	ppb	58	Nagata, 2003
Methanol	ppb	33 000	Nagata, 2003
Methyl ethyl ketone	ppb	440	Nagata, 2003
Methyl isobutyl ketone	ppb	170	Nagata, 2003
Methyl mercaptan	ppb	0.07	Nagata, 2003
Methylcyclohexane	ppb	150	Nagata, 2003
Methylcyclopentane	ppb	1 700	Nagata, 2003
Naphthalene	ppb	38	FMSD, no source reported
Nonane	ppb	2 200	Nagata, 2003
n-Propylbenzene	ppb	3.8	Nagata, 2003
Octane	ppb	1 700	Nagata, 2003
o-Xylene	ppb	380	Nagata, 2003
Pentane	ppb	1 400	Nagata, 2003
Pentyl mercaptan	ppb	0.0078	FMSD proposed based on Nagata but source not verified
Propyl mercaptan	ppb	0.013	Nagata, 2003
sec-Butyl mercaptan	ppb	0.03	Nagata, 2003
Styrene	ppb	35	Nagata, 2003
tert-Butyl mercaptan	ppb	0.029	Nagata, 2003
tert-Pentyl mercaptan*	ppb	0.029	tert-Butyl mercaptan as surrogate
Thiophene	ppb	0.56	Nagata, 2003
Toluene	ppb	330	Nagata, 2003
trans-2-Butene*	ppb	360	1-butene as surrogate
trans-2-Hexene*	ppb	140	1-hexene as surrogate
trans-2-Pentene*	ppb	100	1-pentene as surrogate
Undecane	ppb	870	Nagata, 2003

**Table 29. WEBA 24 hour canister samples as compared to odour and health thresholds**

Parameters	Number of Samples Collected	Number of Odour Threshold Exceedances	AAAQO Exceedances	Greater than MassDEP AAL Threshold	Greater than US EPA IRIS Chronic Threshold	Greater than OMOE Threshold
1,2,4-Trimethylbenzene*	155	0	—	—	—	0
1,3,5-Trimethylbenzene*	135	0	—	—	—	0
1-Butene	160	0	—	—	—	—
1-Pentene	128	0	—	—	—	—
2,2,4-Trimethylpentane	134	0	—	—	—	—
2,2-Dimethylbutane	151	0	—	—	—	—
2,3,4-Trimethylpentane*	128	0	—	—	—	—
2,3-Dimethylbutane	157	0	—	—	—	—
2,3-Dimethylpentane	141	0	—	—	—	—
2,4-Dimethylpentane	130	0	—	—	—	—
2,5-dimethyl Thiophene*	126	ND	—	—	—	—
2-ethyl Thiophene*	126	ND	—	—	—	—
2-methyl Thiophene*	126	ND	—	—	—	—
2-Methyl-1-pentene	134	—	—	—	—	—
2-Methyl-2-butene	127	0	—	—	—	—
2-Methylheptane	149	0	—	—	—	—
2-Methylhexane	148	0	—	—	—	—
2-Methylpentane	168	0	—	—	—	—
3-methyl Thiophene*	126	0	—	—	—	—
3-Methyl-1-butene	127	—	—	—	—	—
3-Methylheptane	144	0	—	—	—	—
3-Methylhexane	147	0	—	—	—	—
3-Methylpentane	167	0	—	—	—	—
4-Methyl-1-pentene	126	0	—	—	—	—
Acetaldehyde	126	43	—	1	25	0
Acetone	175	0	—	0	—	0
Allyl sulphide	126	0	—	—	—	—
alpha Pinene	166	0	—	—	—	—
Benzene	176	0	—	74	0	5
beta Pinene	145	0	—	—	—	—
Butane	174	0	—	—	—	—
Butyl mercaptan	126	0	—	—	—	—
Carbon disulphide	142	0	—	77	0	0
Carbonyl sulphide	175	0	—	151	—	—
cis-2-Butene	127	0	—	—	—	—
cis-2-Hexene	126	0	—	—	—	—
cis-2-Pentene	127	0	—	—	—	—
Cyclohexane	152	0	—	—	—	0
Cyclopentane	143	0	—	—	—	—
Cyclopentene	129	—	—	—	—	—
Decane	153	0	—	—	—	—

Parameters	Number of Samples Collected	Number of Odour Threshold Exceedances	AAAQO Exceedances	Greater than MassDEP AAL Threshold	Greater than US EPA IRIS Chronic Threshold	Greater than OMOE Threshold
Dimethyl disulphide	129	0	—	—	—	—
Dimethyl sulphide	126	0	—	—	—	—
Dodecane	137	0	—	—	—	—
Ethyl benzene	161	0	—	—	0	0
Ethyl mercaptan	126	0	—	—	—	—
Ethyl sulphide*	126	0	—	—	—	—
Formaldehyde	127	0	—	0	—	0
Heptane	163	0	—	—	—	0
Hexane	165	0	0	—	—	0
Hydrogen sulphide	137	7	0	6	1	0
Isobutane*	173	0	—	—	—	—
Isobutyl mercaptan	126	0	—	—	—	—
Isopentane	174	0	—	—	—	—
Isoprene	141	0	—	—	—	—
Isopropyl mercaptan	126	0	—	—	—	—
Isopropylbenzene	129	0	—	—	—	—
m,p-Xylene	174	0	0	3	0	0
Methanol	126	0	—	—	10	—
Methyl ethyl ketone	162	0	—	0	—	0
Methyl isobutyl ketone	126	0	—	0	0	0
Methyl mercaptan	126	1	—	—	—	—
Methylcyclohexane	165	0	—	—	—	—
Methylcyclopentane	155	0	—	—	—	—
Naphthalene	145	0	—	2	13	1
Nonane	155	0	—	—	—	—
n-Propylbenzene	134	0	—	—	—	—
Octane	161	0	—	—	—	—
o-Xylene	163	0	0	0	0	0
Pentane	167	0	—	—	—	—
Pentyl mercaptan	126	0	—	—	—	—
Propyl mercaptan	126	0	—	—	—	—
sec-Butyl mercaptan	126	0	—	—	—	—
Styrene	131	0	—	0	—	0
tert-Butyl mercaptan	126	0	—	—	—	—
tert-Pentyl mercaptan*	126	0	—	—	—	—
Thiophene	126	0	—	—	—	—
Toluene	179	0	0	2	—	0
trans-2-Butene*	127	0	—	—	—	—
trans-2-Hexene*	126	0	—	—	—	—
trans-2-Pentene*	126	0	—	—	—	—
Undecane	145	0	—	—	—	—

**Table 30. References consulted to develop odour threshold screening levels for the Fort McKay Sustainability Department canister sampling program and cited (supplied by the FMDS in December 2015)**

	Reference
1	3M. "2009 Respirator Selection Guide." <i>3M Occupational Health and Environmental Safety Division</i> . 2009. <a href="http://www.internationalsafety.com/PDF/3M-2009-respirator-selection.pdf">http://www.internationalsafety.com/PDF/3M-2009-respirator-selection.pdf</a> (accessed May 21, 2010).
2	AENV. (2010). Three Creeks Odour Issue: A Report on Air Quality Monitoring Conducted between February and May 2010. Alberta Environment, June 29, 2010. < <a href="http://www.environment.alberta.ca/03042.html">http://www.environment.alberta.ca/03042.html</a> >(last visited August 23, 2010).
3	AIHA. (1989). <i>Odor Thresholds for Chemicals with Established Occupational Health Standards</i> . Fairfax, Virginia: American Industrial Hygiene Association. AEAR89-108, 1989.
4	Amoore, J.E., and E. Hautala. "Odor as an Aid to Chemical Safety: Odor Thresholds Compared with Threshold Limit Values and Volatilities for 214 Industrial Chemicals in Air and Water Dilutions." <i>Journal of Applied Toxicology</i> , Vol. 3, No. 6, 1983.
5	Hellman, T.M., and F.H. Small. "Characterization of the Odor Properties of 101 Petrochemicals Using Sensory Methods." <i>Journal of the Air Pollution Control Association</i> . Vol. 24, No. 10, 1974: 979–982.
6	Nagata, Y. "Measurement of odor threshold by triangle odor bag method." <i>Odor Measurement Review</i> , Japan Ministry of the Environment. 2003. <a href="http://www.env.go.jp/en/air/odor/olfactory_mm/04ref_2.pdf">www.env.go.jp/en/air/odor/olfactory_mm/04ref_2.pdf</a> .
7	Peng, C-Y, Lan, C-H and Wu, T-J. (2009). Investigation of indoor chemical pollutants and perceived odor in an area with complaints of unpleasant odors. <i>Building and Environment</i> 44 (2009) 2106–2113.
8	Ruth, J.H. "Odor Thresholds and Irritation Levels of Several Chemical Substances: A Review." <i>Am. Ind. Hyg. Assoc. J.</i> (47), 1986.
9	Shell Canada Limited. (2010). Jackpine Mine Expansion Supplemental Information Round 2: <i>AENV SIR Response 49a</i> . Section 13.1. June 2010. CR030.
10	Total E&P Canada Ltd. (2007). <i>Human Health and Odour Assessment: TOTAL Upgrader Project</i> . Volume 2: Environmental Impact Assessment, Section 14: Human Health and Odour assessment. Dec. 2007.
11	United States Environmental Protection Association. 2009. "Tab C." <i>Consumer Product Safety Commission</i> . <a href="http://www.cpsc.gov/info/drywall/TabC.pdf">http://www.cpsc.gov/info/drywall/TabC.pdf</a> (accessed May 21, 2010). Also see – <a href="http://www.doh.state.fl.us/environment/community/indoor-air/drywall.html#cpSC">http://www.doh.state.fl.us/environment/community/indoor-air/drywall.html#cpSC</a> .
12	TCEQ. (2010a). <i>Uses of Effects Screening Levels (ESLs) and Air Monitoring Comparison Values (AMCVs)</i> . Texas Commission on Environmental Quality. May, 2010. <a href="http://www.tceq.state.tx.us/assets/public/implementation/tox/monitoring/amcv/document.doc">http://www.tceq.state.tx.us/assets/public/implementation/tox/monitoring/amcv/document.doc</a>
13	TCEQ. (2010b). Interim Guidelines for Setting Odor-Based Effects Screening Levels. Texas Commission on Environmental Quality. May 28, 2010. <a href="http://www.tceq.state.tx.us/assets/public/implementation/tox/esl/guidelines/odor.pdf">http://www.tceq.state.tx.us/assets/public/implementation/tox/esl/guidelines/odor.pdf</a>
14	TCEQ. (2012a). March 2012 Effects Screening Levels. <a href="http://www.tceq.texas.gov/toxicology/esl/list_main.html/">http://www.tceq.texas.gov/toxicology/esl/list_main.html/</a> (last visited July 31, 2012) and TCEQ (2015). Sept. 2015 Effects Screening Levels. <a href="https://www.tceq.texas.gov/toxicology/esl/list_main.html/#esl_1">https://www.tceq.texas.gov/toxicology/esl/list_main.html/#esl_1</a> (last visited November 15, 2015).
15	TCEQ. (2012b). March 2012 Air Monitoring Comparison Values. <a href="http://www.tceq.texas.gov/toxicology/AirToxics.html">http://www.tceq.texas.gov/toxicology/AirToxics.html</a> (last visited July 31, 2012).



**Table 31. FMSD-supplied odour thresholds (OTs) and short-term health-effect screening levels (ESLs) for target C1 to C4 hydrocarbons used to identify potential air contaminants of interest from the FMSD air canister sampling program and the basis for these OTs and ESLs**

Compound	Chemical Abstract Service number (CAS)	Molecular Formula	Conc. Units	Method Detection Limit	Odour Threshold	Basis for Odour Thresholds	Texas Commission for Environmental Quality (TCEQ) Short-Term Exposure Criteria	
							Health Effects Criteria	Basis for Criteria: ESL, AMCV or NV
Methane	74-82-8	CH <sub>4</sub>	ppmv	50 ppbv	n/a	simple asphyxiant	simple asphyxiant	NV
Ethane	74-84-0	C <sub>2</sub> H <sub>6</sub>	ppmv	50 ppbv	150	Nagata (2003)	simple asphyxiant	NV
Ethylene	74-85-1	C <sub>2</sub> H <sub>4</sub>	ppmv	50 ppbv	270	TCEQ (2010)	500	AMCV
Propane	74-98-6	C <sub>3</sub> H <sub>8</sub>	ppmv	50 ppbv	1 000	Ruth (1986)	simple asphyxiant	NV
Propylene	115-07-1	C <sub>3</sub> H <sub>6</sub>	ppmv	50 ppbv	13	TCEQ (2010)	simple asphyxiant	AMCV
Isobutane	75-28-5	C <sub>4</sub> H <sub>10</sub>	ppmv	50 ppbv	2	TCEQ (2010)	8	AMCV
Acetylene	74-86-2	C <sub>2</sub> H <sub>2</sub>	ppmv	50 ppbv	620	TCEQ (2010)	25	AMCV
Butane	106-97-8	C <sub>4</sub> H <sub>10</sub>	ppmv	50 ppbv	1.2	Ruth (1986)	8	AMCV
trans-2-Butene	624-64-6	C <sub>4</sub> H <sub>8</sub>	ppmv	50 ppbv	2.1	TCEQ (2010)	15	AMCV
1-Butene	106-98-9	C <sub>4</sub> H <sub>8</sub>	ppmv	50 ppbv	0.36	Nagata (2003)	50	AMCV
Isobutylene	115-11-7	C <sub>4</sub> H <sub>8</sub>	ppmv	50 ppbv	1.3	TCEQ (2010)	480	AMCV
cis-2-Butene	590-18-1	C <sub>4</sub> H <sub>8</sub>	ppmv	50 ppbv	2.1	TCEQ (2010)	15	AMCV
Propyne	74-99-7	C <sub>3</sub> H <sub>4</sub>	ppmv	50 ppbv	620	based on acetylene	10 000	ESL
1,3-Butadiene	106-99-0	C <sub>4</sub> H <sub>6</sub>	ppmv	50 ppbv	0.23	Nagata (2003)	1.7	AMCV
Ethylacetylene	107-00-6	C <sub>4</sub> H <sub>6</sub>	ppmv	50 ppbv	620	based on acetylene	16 400	ESL

**Table 32. FMSD-supplied odour thresholds (OTs) and short-term health-effect screening levels (ESLs) for target reduced sulphur compounds used to identify potential air contaminants of interest from the FMSD air canister sampling program and the basis for these OTs and ESLs**

Compound	Chemical Abstract Service number (CAS)	Molecular Formula	Conc. Units	Method Detection Limit	Odour Threshold	Basis for Odour Thresholds	Texas Commission for Environmental Quality (TCEQ) Short-Term Exposure Criteria	
							Health Effects Criteria	Basis for Criteria: ESL, AMCV or NV
Hydrogen sulphide	7783-06-4	H <sub>2</sub> S	ppbv	~1ppbv	0.41	Nagata (2003)	10	NV (based on ESL for 75-15-0)
Carbonyl sulphide	463-58-1	COS	ppbv	~1ppbv	55	Nagata (2003)	11	Based on 10× long-term ESL value
Methyl mercaptan	74-93-1	CH <sub>4</sub> S	ppbv	~1ppbv	0.07	Nagata (2003)	7	Based on 10× long-term ESL value
Ethyl mercaptan	75-08-1	C <sub>2</sub> H <sub>6</sub> S	ppbv	~1ppbv	0.0087	Nagata (2003)	5.5	Based on 10× long-term ESL value
Dimethyl sulphide	75-18-3	C <sub>2</sub> H <sub>6</sub> S	ppbv	~1ppbv	1	Ruth (1986)	55	Based on 10× long-term ESL value
Carbon disulphide	75-15-0	CS <sub>2</sub>	ppbv	~1ppbv	8	Ruth (1986)	10	ESL
Isopropyl mercaptan	75-33-2	C <sub>3</sub> H <sub>8</sub> S	ppbv	~1ppbv	0.006	Nagata (2003)	0.26	ESL
tert-Butyl mercaptan	75-66-1	C <sub>4</sub> H <sub>10</sub> S	ppbv	~1ppbv	0.029	Nagata (2003)	3.8	Based on 10× long-term ESL value
Propyl mercaptan	107-03-9	C <sub>3</sub> H <sub>8</sub> S	ppbv	~1ppbv	0.013	Nagata (2003)	0.5	Based on 10× long-term ESL value
Thiophene	110-02-1	C <sub>4</sub> H <sub>4</sub> S	ppbv	~1ppbv	0.56	Nagata (2003)	20	Based on 10× long-term ESL value
sec-Butyl mercaptan	513-53-1	C <sub>4</sub> H <sub>10</sub> S	ppbv	~1ppbv	0.03	Nagata (2003)	3.5	NV (based on ESL for 109-79-5)
Isobutyl mercaptan	513-44-0	C <sub>4</sub> H <sub>10</sub> S	ppbv	~1ppbv	0.0068	Nagata (2003)	3.8	Based on 10× long-term ESL value
Ethyl sulphide	352-93-2	C <sub>4</sub> H <sub>10</sub> S	ppbv	~1ppbv	0.033	Nagata (2003)	38	Based on 10× long-term ESL value
Butyl mercaptan	109-79-5	C <sub>4</sub> H <sub>10</sub> S	ppbv	~1ppbv	0.029	Nagata (2003)	3.5	Based on 10× long-term ESL value
tert-Pentyl mercaptan	1679-09-0	C <sub>5</sub> H <sub>12</sub> S	ppbv	~1ppbv	0.03	based on Pentyl mercaptan Nagata (2003)	3.5	NV (based on ESL for 109-79-5)

Compound	Chemical Abstract Service number (CAS)	Molecular Formula	Conc. Units	Method Detection Limit	Odour Threshold	Basis for Odour Thresholds	Texas Commission for Environmental Quality (TCEQ) Short-Term Exposure Criteria	
							Health Effects Criteria	Basis for Criteria: ESL, AMCV or NV
Dimethyl disulphide	624-92-0	C <sub>2</sub> H <sub>6</sub> S <sub>2</sub>	ppbv	~1ppbv	0.2	Nagata (2003)	3.5	Based on 10× long-term ESL value
2-methyl Thiophene	554-14-3	C <sub>5</sub> H <sub>6</sub> S	ppbv	~1ppbv	0.56	Based on Thiophene Nagata (2003)	25	ESL
3-methyl Thiophene	616-44-4	C <sub>5</sub> H <sub>6</sub> S	ppbv	~1ppbv	0.56	Based on Thiophene Nagata (2003)	25	ESL
Pentyl mercaptan	110-66-7	C <sub>5</sub> H <sub>12</sub> S	ppbv	~1ppbv	0.0078	Nagata (2003)	2.8	Based on 10× long-term ESL value
2-ethyl Thiophene	872-55-9	C <sub>6</sub> H <sub>8</sub> S	ppbv	~1ppbv	0.56	Based on Thiophene Nagata (2003)	22	ESL
Allyl sulphide	592-88-1	C <sub>6</sub> H <sub>10</sub> S	ppbv	~1ppbv	0.02	TCEQ (2010)	30	Based on 10× long-term ESL value
2,5-dimethyl Thiophene	638-02-8	C <sub>6</sub> H <sub>8</sub> S	ppbv	~1ppbv	0.56	Based on Thiophene Nagata (2003)	22	ESL



**Table 33. The odour thresholds (OTs) and short-term health-effect screening levels (ESLs) for target volatile organic compounds (VOCs) used to identify potential air contaminants of interest from the FMSD air canister sampling program and the basis for these OTs and ESLs**

Compound	Chemical Abstract Service number (CAS)	Molecular Formula	Conc. Units	Method Detection Limit	Odour Threshold	Basis for Odour Thresholds	Texas Commission for Environmental Quality (TCEQ) Short-Term Exposure Criteria	
							Health Effects Criteria	Basis for Criteria: ESL, AMCV or NV
Freon-12	75-71-8	CCl <sub>2</sub> F <sub>2</sub>	ppbv	≤0.5 ppbv	5 000	Based on Freon 11	10 000	AMCV
Isobutane	75-28-5	C <sub>4</sub> H <sub>10</sub>	ppbv	≤0.5 ppbv	2040	TCEQ (2009)	8 000	AMCV
Freon-114	76-14-2	C <sub>2</sub> Cl <sub>2</sub> F <sub>4</sub>	ppbv	≤0.5 ppbv	5 000	Based on Freon 11	10 000	ESL
Vinyl chloride	75-01-4	C <sub>2</sub> H <sub>3</sub> Cl	ppbv	≤0.5 ppbv	3 900	Based on Trichloroethylene (Nagata 2003)	26 000	AMCV
1-Butene	106-98-9	C <sub>4</sub> H <sub>8</sub>	ppbv	≤0.5 ppbv	360	Nagata (2003)	50 000	AMVC
Butane	106-97-8	C <sub>4</sub> H <sub>10</sub>	ppbv	≤0.5 ppbv	1200	Ruth (1986)	8 000	AMCV
1,3-Butadiene	106-99-0	C <sub>4</sub> H <sub>8</sub>	ppbv	≤0.5 ppbv	230	Nagata (2003)	1 700	AMCV
trans-2-Butene	624-64-6	C <sub>4</sub> H <sub>8</sub>	ppbv	≤0.5 ppbv	2 100	TCEQ (2010)	15 000	AMCV
cis-2-Butene	590-18-1	C <sub>4</sub> H <sub>8</sub>	ppbv	≤0.5 ppbv	2 100	Based on trans-2-Butene	15 000	AMCV
Chloroethane	75-00-3	C <sub>2</sub> H <sub>5</sub> Cl	ppbv	≤0.5 ppbv	420	1/10 of Amoores and Hautala (1983)	190	ESL
Ethanol	64-17-5	C <sub>2</sub> H <sub>6</sub> O	ppbv	≤0.5 ppbv	520	Nagata (2003)	10 000	ESL
Isopentane	78-78-4	C <sub>5</sub> H <sub>12</sub>	ppbv	≤0.5 ppbv	1 300	Nagata (2003)	1200	AMCV
Freon-11	75-69-4	CCl <sub>3</sub> F	ppbv	≤0.5 ppbv	5 000	TCEQ (2010)	10 000	AMCV
1-Pentene	109-67-1	C <sub>5</sub> H <sub>10</sub>	ppbv	≤0.5 ppbv	100	Nagata (2003)	2600	AMCV
Acrolein	107-02-8	C <sub>3</sub> H <sub>4</sub> O	ppbv	≤0.5 ppbv	3.6	Nagata (2003)	4.8	AMCV
Acetone	67-64-1	C <sub>3</sub> H <sub>6</sub> O	ppbv	≤0.5 ppbv	3 600	TCEQ (2010)	2 500	AMCV
Pentane	109-66-0	C <sub>5</sub> H <sub>12</sub>	ppbv	≤0.5 ppbv	1 400	Nagata (2003)	68 000	AMCV
Isopropyl Alcohol	67-63-0	C <sub>3</sub> H <sub>8</sub> O	ppbv	≤0.5 ppbv	50	Based on AIHA (1989)	2000	ESL
Isoprene	78-79-5	C <sub>5</sub> H <sub>8</sub>	ppbv	≤0.5 ppbv	5	TCEQ (2010)	20	AMCV
trans-2-Pentene	646-04-8	C <sub>5</sub> H <sub>10</sub>	ppbv	≤0.5 ppbv	50	1/2 of the OT for Pentene	2600	AMCV
cis-2-Pentene	627-20-3	C <sub>5</sub> H <sub>10</sub>	ppbv	≤0.5 ppbv	50	1/2 of the OT for Pentene	2600	AMCV
1,1-Dichloroethylene	75-35-4	C <sub>2</sub> H <sub>2</sub> Cl <sub>2</sub>	ppbv	≤0.5 ppbv	19 000	1/10 of Amoores and Hautala (1983)	180	AMCV
Freon-113	76-13-1	C <sub>2</sub> Cl <sub>3</sub> F <sub>3</sub>	ppbv	≤0.5 ppbv	5 000	Based on Freon 11	5 000	ESL
2,2-Dimethylbutane	75-83-2	C <sub>6</sub> H <sub>14</sub>	ppbv	≤0.5 ppbv	38 000	Nagata (2003)	1 000	AMCV
Carbon Disulphide	75-15-0	CS <sub>2</sub>	ppbv	≤0.5 ppbv	8	Ruth (1986)	10	ESL
Methylene chloride	75-09-2	CH <sub>2</sub> Cl <sub>2</sub>	ppbv	≤0.5 ppbv	1200	AIHA (1989)	3 500	AMCV



Compound	Chemical Abstract Service number (CAS)	Molecular Formula	Conc. Units	Method Detection Limit	Odour Threshold	Basis for Odour Thresholds	Texas Commission for Environmental Quality (TCEQ) Short-Term Exposure Criteria	
							Health Effects Criteria	Basis for Criteria: ESL, AMCV or NV
2,3-Dimethylbutane	79-29-8	C6H14	ppbv	≤0.5 ppbv	420	Nagata (2003)	990	AMCV
Cyclopentane	287-92-3	C5H10	ppbv	≤0.5 ppbv	420	based on cyclohexane	1200	AMCV
trans-1,2-Dichloroethylene	156-60-5	C2H2Cl2	ppbv	≤0.5 ppbv	85	Ruth (1986)	2000	ESL
2-Methylpentane	107-83-5	C6H14	ppbv	≤0.5 ppbv	83	TCEQ (2010)	1 000	AMCV
Methyl Tert-Butyl Ether	1634-04-4	C5H12O	ppbv	≤0.5 ppbv	130	TCEQ (2010)	500	AMCV
1,1-Dichloroethane	75-34-3	C2H4Cl2	ppbv	≤0.5 ppbv	11 000	1/10 TCEQ (2010)	1 000	AMCV
3-Methylpentane	96-14-0	C6H14	ppbv	≤0.5 ppbv	8 900	Nagata (2003)	1 000	AMCV
Vinyl Acetate	108-05-4	C4H6O2	ppbv	≤0.5 ppbv	870	Nagata (2003)	40	ESL
1-Hexene	592-41-6	C6H12	ppbv	≤0.5 ppbv	20	TCEQ (2010)	500	AMCV
Methyl ethyl ketone	78-93-3	C4H8O	ppbv	≤0.5 ppbv	8	TCEQ (2012)	19	AMCV
Hexane	110-54-3	C6H14	ppbv	≤0.5 ppbv	1 500	Nagata (2003)	1 800	AMCV
cis-1,2-Dichloroethylene	156-59-4	C2H2Cl2	ppbv	≤0.5 ppbv	85	Based on trans-1,2-Dichloroethylene	38	ESL
Ethyl Acetate	141-78-6	C4H8O2	ppbv	≤0.5 ppbv	870	Nagata (2003)	4 000	AMCV
Chloroform	67-66-3	CHCl3	ppbv	≤0.5 ppbv	600	AIHA (1989)	20	AMCV
2,4-Dimethylpentane	108-08-7	C7H16	ppbv	≤0.5 ppbv	940	Nagata (2003)	850	AMCV
Methylcyclopentane	96-37-7	C6H12	ppbv	≤0.5 ppbv	1 700	TCEQ (2010)	750	AMCV
Tetrahydrofuran	109-99-9	C4H8O	ppbv	≤0.5 ppbv	92	Lowest recorded OT in AIHA (1989)	500	ESL
1,1,1-Trichloroethane	71-55-6	C2H3Cl3	ppbv	≤0.5 ppbv	16 000	AIHA (1989)	1 700	AMCV
1,2-Dichloroethane	107-06-2	C2H4Cl2	ppbv	≤0.5 ppbv	6000	TCEQ (2009)	40	AMCV
Cyclohexane	110-82-7	C6H12	ppbv	≤0.5 ppbv	180	TCEQ (2010)	1 000	AMCV
Benzene	71-43-2	C6H6	ppbv	≤0.5 ppbv	2 700	Nagata (2003)	180	AMCV
Carbon tetrachloride	56-23-5	CCl4	ppbv	≤0.5 ppbv	4 600	Nagata (2003)	20	AMCV
2-Methylhexane	591-76-4	C7H16	ppbv	≤0.5 ppbv	420	Nagata (2003)	750	AMCV
2,3-Dimethylpentane	565-59-3	C7H16	ppbv	≤0.5 ppbv	4 500	Nagata (2003)	850	AMCV
3-Methylhexane	589-34-4	C7H16	ppbv	≤0.5 ppbv	840	Nagata (2003)	750	AMCV
2,2,4-Trimethylpentane	540-84-1	C8H18	ppbv	≤0.5 ppbv	670	Nagata (2003)	750	AMCV
1,2-Dichloropropane	78-87-5	C3H6Cl2	ppbv	≤0.5 ppbv	250	TCEQ (2010)	100	AMCV
Trichloroethylene	79-01-6	C2HCl3	ppbv	≤0.5 ppbv	500	AIHA (1989)	100	AMCV

Compound	Chemical Abstract Service number (CAS)	Molecular Formula	Conc. Units	Method Detection Limit	Odour Threshold	Basis for Odour Thresholds	Texas Commission for Environmental Quality (TCEQ) Short-Term Exposure Criteria	
							Health Effects Criteria	Basis for Criteria: ESL, AMCV or NV
Heptane	142-82-5	C7H16	ppbv	≤0.5 ppbv	670	Nagata (2003)	850	AMCV
Bromodichloromethane	75-27-4	CHBrCl <sub>2</sub>	ppbv	≤0.5 ppbv	2 500	1/100 of OT reported in <a href="http://www.scottecatalog.com/msds.nsf/MSDSNo/75-27-4?OpenDocument">http://www.scottecatalog.com/msds.nsf/MSDSNo/75-27-4?OpenDocument</a>	100	ESL
1,4-Dioxane	123-91-1	C4H8O <sub>2</sub>	ppbv	≤0.5 ppbv	800	AQHI (1989)	250	ESL
Methyl Methacrylate	80-62-6	C5H8O <sub>2</sub>	ppbv	≤0.5 ppbv	80	TCEQ (2010)	80	ESL
Methylcyclohexane	108-87-2	C7H14	ppbv	≤0.5 ppbv	150	Nagata (2003)	4 000	AMCV
Methyl isobutyl ketone	108-10-1	C6H12O	ppbv	≤0.5 ppbv	100	TCEQ (2010)	500	AMCV
cis-1,3-Dichloropropylene	542-75-6	C3H4Cl <sub>2</sub>	ppbv	≤0.5 ppbv	250	Based on 1,2-Dichloropropane	10	ESL
2,3,4-Trimethylpentane	565-75-3	C8H18	ppbv	≤0.5 ppbv	650	Based on 2,2,4-trimethyl pentane	750	AMCV
2-Methylheptane	592-27-8	C8H18	ppbv	≤0.5 ppbv	420	Based on 2-methylhexane	750	AMCV
trans-1,3-Dichloropropylene	542-75-6	C3H4Cl <sub>2</sub>	ppbv	≤0.5 ppbv	250	Based on 1,2-Dichloropropane	10	ESL
Toluene	108-88-3	C7H8	ppbv	≤0.5 ppbv	170	TCEQ (2010)	4 000	AMCV
1,1,2-Trichloroethane	79-00-5	C2H3Cl <sub>3</sub>	ppbv	≤0.5 ppbv	1 500	Based on tetrachloroethane (Amoore & Hautala, 1983)	100	AMCV
3-Methylheptane	589-81-1	C8H18	ppbv	≤0.5 ppbv	1 700	Based on 4-methylheptane	750	AMCV
Methyl Butyl Ketone	591-78-6	C6H12O	ppbv	≤0.5 ppbv	24	Nagata (2003)	10	AMCV
Dibromochloromethane	124-48-1	CHBr <sub>2</sub> Cl	ppbv	≤0.5 ppbv	200	Based on bromoform (AIHA, 1989)	3	ESL
Octane	111-65-9	C8H18	ppbv	≤0.5 ppbv	1 700	TCEQ (2010)	750	AMCV
1,2-Dibromoethane	106-93-4	C2H4Br <sub>2</sub>	ppbv	≤0.5 ppbv	200	Based on bromoform (AIHA, 1989)	0.05	AMCV
Tetrachloroethylene	127-18-4	C2Cl <sub>4</sub>	ppbv	≤0.5 ppbv	770	Nagata (2003)	1 000	AMCV
Chlorobenzene-d5	3114-55-4	C6D5Cl	ppbv	≤0.5 ppbv	217	<a href="http://www.epa.gov/ttnatw01/hlthef/chlorobe.html">http://www.epa.gov/ttnatw01/hlthef/chlorobe.html</a>	100	ESL for chloro-benzene (108-90-7)
Chlorobenzene	108-90-7	C6H5Cl	ppbv	≤0.5 ppbv	210	TCEQ (2009)	100	AMCV
Ethyl benzene	100-41-4	C8H10	ppbv	≤0.5 ppbv	170	Nagata (2003)	1 000	AMCV
m,p-Xylene	108-38-3 106-42-3	C8H10	ppbv	≤0.5 ppbv	50	Nagata (2003)	1 700	AMCV
Tribromomethane	75-25-2	CHBr <sub>3</sub>	ppbv	≤0.5 ppbv	200	Based on bromoform (AIHA, 1989)	5	ESL
Styrene	100-42-5	C8H8	ppbv	≤0.5 ppbv	25	TCEQ (2010)	5 100	AMCV

Compound	Chemical Abstract Service number (CAS)	Molecular Formula	Conc. Units	Method Detection Limit	Odour Threshold	Basis for Odour Thresholds	Texas Commission for Environmental Quality (TCEQ) Short-Term Exposure Criteria	
							Health Effects Criteria	Basis for Criteria: ESL, AMCV or NV
o-Xylene	95-47-6	C8H10	ppbv	≤0.5 ppbv	380	Nagata (2003)	1 700	AMCV
Nonane	111-84-2	C9H20	ppbv	≤0.5 ppbv	2 200	Nagata (2003)	2000	AMCV
1,1,2,2-Tetrachloroethane	79-34-5	C2H2Cl4	ppbv	≤0.5 ppbv	1 500	Amoore and Hautala (1983)	10	AMCV
Isopropylbenzene	98-82-8	C9H12	ppbv	≤0.5 ppbv	8.4	Nagata (2003)	500	AMCV
n-Propylbenzene	103-65-1	C9H12	ppbv	≤0.5 ppbv	3.8	Nagata (2003)	250	AMCV
m-Ethyltoluene	620-14-4	C9H12	ppbv	≤0.5 ppbv	18	Nagata (2003)	250	AMCV
p-Ethyltoluene	622-96-8	C9H12	ppbv	≤0.5 ppbv	8.3	Nagata (2003)	250	AMCV
1,3,5-Trimethylbenzene	108-67-8	C9H12	ppbv	≤0.5 ppbv	27	USEPA (2000)	250	AMCV
o-Ethyltoluene	611-14-3	C9H12	ppbv	≤0.5 ppbv	74	Nagata (2003)	250	AMCV
Decane	124-18-5	C10H22	ppbv	≤0.5 ppbv	620	Nagata (2003)	1 750	AMCV
1,2,4-Trimethylbenzene	95-63-6	C9H12	ppbv	≤0.5 ppbv	120	Nagata (2003)	250	AMCV
1,3-Dichlorobenzene	541-73-1	C6H4Cl2	ppbv	≤0.5 ppbv	120	Based on 1,4-Dichlorobenzene	120	ESL
1,4-Dichlorobenzene	106-46-7	C6H4Cl2	ppbv	≤0.5 ppbv	120	TCEQ (2010)	320	Long-Term ESL × 10
Benzyl Chloride	100-44-7	C7H7Cl	ppbv	≤0.5 ppbv	41	AIHA (1989)	10	ESL
1,2,3-Trimethylbenzene	526-73-8	C9H12	ppbv	≤0.5 ppbv	120	Based on 1,2,4-Trimethylbenzene (Nagata, 2003)	250	AMCV
1,2-Dichlorobenzene	95-50-1	C6H4Cl2	ppbv	≤0.5 ppbv	120	Based on 1,4-Dichlorobenzene	120	ESL
m-Diethylbenzene	141-93-5	C10H14	ppbv	≤0.5 ppbv	70	Nagata (2003)	460	AMCV
p-Diethylbenzene	105-05-5	C10H14	ppbv	≤0.5 ppbv	0.39	Nagata (2003)	460	AMCV
Undecane	1120-21-4	C11H24	ppbv	≤0.5 ppbv	870	Nagata (2003)	550	AMCV
Dodecane	112-40-3	C12H26	ppbv	≤0.5 ppbv	111	Nagata (2003)	500	ESL
1,2,4-Trichlorobenzene	120-82-1	C6H3Cl3	ppbv	≤0.5 ppbv	140	1/10 of Amoore and Hautala (1983)	54	ESL
Naphthalene	91-20-3	C10H8	ppbv	≤0.5 ppbv	38	AIHA (1989)	95	AMCV
Hexachlorobutadiene	87-68-3	C4Cl6	ppbv	≤0.5 ppbv	112	1/10 of Ruth (1986)	0.2	ESL

Table 34. The odour thresholds (OTs) and short-term health-effect screening levels (ESLs) for nontarget volatile organic compounds (VOCs) used to identify potential air contaminants of interest from the FMSD air canister sampling program and the basis for these OTs and ESLs

Compound	Chemical Abstract Service number (CAS)	Molecular Formula	Conc. Units	Method Detection Limit	Odour Threshold	Basis for Odour Thresholds	Texas Commission for Environmental Quality (TCEQ) Short-Term Exposure Criteria	
							Health Effects Criteria	Basis for Criteria: ESL, AMCV or NV
1-methyl-2-ethylcyclopentane isomer 1	0-00-0	C8H16	ppbv	≤0.5 ppbv	150	Based on Methylcyclohexane (Nagata 2003)	870	NV (based on ESL for 1759-58-6)
2-pentenal, (e)-	1576-87-0	C5H8O	ppbv	≤0.5 ppbv	0.41	Based on n-valeraldehyde from Nagata 2003	3	ESL
1,3-cyclopentadien, 2-methyl-	0-00-0	C6H8	ppbv	≤0.5 ppbv	150	Based on Methylcyclohexane (Nagata 2003)	750	NV based on 542-92-7
2-methyl-cyclohexa-1,3-diene	0-00-0	C7H10	ppbv	≤0.5 ppbv	150	Based on Methylcyclohexane (Nagata 2003)	750	NV based on 542-92-7
3-butene-2-amine	0-00-0	C4H9N	ppbv	≤0.5 ppbv	1.5	Based on Isobutyleamine (Nagata 2003)	30	NV based on 141-43-5
7h-benzocycloheptene	0-00-0	C11H10	ppbv	≤0.5 ppbv	0.1	No Value found but substituted Benzocycloheptenes are very odorous use 0.1	175	NV based on 827-52-1*
methycyclopenta-1,3-diene	0-00-0	C6H8	ppbv	≤0.5 ppbv	150	Based on Methylcyclohexane (Nagata 2003)	260	NV based on 26519-91-5
propanal, 2-methyl-3-phenyl	0-00-0	C10H12O	ppbv	≤0.5 ppbv	10	Based on 2-methyl-3-[4-(2-methylpropyl)phenyl]propanal which has medium odour <a href="http://www.thegoodscentscopy.com/data/rw1418091.html">http://www.thegoodscentscopy.com/data/rw1418091.html</a>	330	NV based on 110-42-5
propyldithio propane	0-00-0	C6H14S2	ppbv	≤0.5 ppbv	1	NV but based on dipropyl disulphide would expect to be very odorous <a href="http://www.thegoodscentscopy.com/data/rw1035611.html">http://www.thegoodscentscopy.com/data/rw1035611.html</a>	100	NV based on 542-92-7
styrene	100-42-5	C8H8	ppbv	≤0.5 ppbv	25	TCEQ (2010)	5 100	AMCV
benzaldehyde	100-52-7	C7H6O	ppbv	≤0.5 ppbv	5	TCEQ (2012)	21	AMCV
benzene ethanamine,,alpha.,,3,4-trimethyl	102-31-8	C11H17N	ppbv	≤0.5 ppbv	1	based on lower values for alkylated benzenes Nagata (2003)	460	NV based on AMCV for 105-05-5
2 ethyl hexanol	104-76-7	C8H18O	ppbv	≤0.5 ppbv	140	TCEQ (2010)	300	Based on 10× the long-term value
benzene, 1,4-diethyl-	105-05-5	C10H14	ppbv	≤0.5 ppbv	0.39	Nagata (2003)	460	AMCV
phenol, 4-methyl-	106-44-5	C7H8O	ppbv	≤0.5 ppbv	1.1	TCEQ (2012)	5	Long-term ESL × 10
benzene, 1,4-dichloro-	106-46-7	C6H4Cl2	ppbv	≤0.5 ppbv	120	TCEQ (2012)	54	Long-term ESL × 10
heptane, 2,6-dimethyl-	1072-05-5	C9H20	ppbv	≤0.5 ppbv	110	based on 2-methyl heptane (Nagata, 2003)	680	ESL
2-methylpentane	107-83-5	C6H14	ppbv	≤0.5 ppbv	83	TCEQ (2010)	1 000	AMCV
cyclohexanone	108-94-1	C6H10O	ppbv	≤0.5 ppbv	120	TCEQ (2012)	200	Long-Term ESL × 10
benzenethiol	108-98-5	C6H6S	ppbv	≤0.5 ppbv	0.9	TCEQ (2012)	5	Long-Term ESL × 10
furan, tetrahydro-	109-99-9	C4H8O	ppbv	≤0.5 ppbv	2	Lowest recorded OT in AIHA for furfural (1989)	500	ESL
hexyl mercaptan	111-31-9	C6H14S	ppbv	≤0.5 ppbv	0.015	Nagata (2003)	5	ESL
1-octene	111-66-0	C8H16	ppbv	≤0.5 ppbv	1	Nagata (2003)	750	ESL
heptanal	111-71-7	C7H14O	ppbv	≤0.5 ppbv	50	TCEQ (2012)	2000	AMCV
1-octanamine	111-86-4	C8H19N	ppbv	≤0.5 ppbv	170	Based on n-butylamine from Nagata 2003	20	NV based on 122-09-08
1-octanol	111-87-5	C8H18O	ppbv	≤0.5 ppbv	2.7	Nagata (2003)	500	ESL
octyl mercaptan	111-88-6	C8H18S	ppbv	≤0.5 ppbv	0.015	Based on Hexyl mercaptan from Nagata 2003	5	ESL
decanal	112-31-2	C10H20O	ppbv	≤0.5 ppbv	0.4	Based on decylaldehyde Nagata (2003)	6.3	ESL
dodecanal	112-54-9	C12H24O	ppbv	≤0.5 ppbv	0.4	Based on decylaldehyde Nagata (2003)	5	ESL
propylene	115-07-1	C3H6	ppbv	≤0.5 ppbv	1 300	TCEQ (2012)	Asphyxiant	AMCV
isobutylene	115-11-7	C4H8	ppbv	≤0.5 ppbv	1 300	TCEQ (2012)	480 000	AMCV
furan, 2,3-dihydro-	1191-99-7	C4H6O	ppbv	≤0.5 ppbv	2	Lowest recorded OT in AIHA for furfural (1989)	350	ESL
cyclopentane, 1,2-dimethyl-, cis-	1192-18-3	C7H14	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	870	NV (based on ESL for 1759-58-6)
ethanone, 1-(4-methylphenyl	122-00-9	C9H10O	ppbv	≤0.5 ppbv	170	Based on acetophenone <a href="http://sis4.nlm.nih.gov/cgi-bin/changcgcgi-bin/hazmap_generic?tbl=TblAgents&amp;id=2193">http://sis4.nlm.nih.gov/cgi-bin/changcgcgi-bin/hazmap_generic?tbl=TblAgents&amp;id=2193</a>	50	NV (based on ESL for 108-95-2)
hexanal, 2-ethyl-	123-05-7	C8H16O	ppbv	≤0.5 ppbv	0.28	Based on n-hexylaldehyde Nagata (2003)	270	ESL
butanal	123-72-8	C4H8O	ppbv	≤0.5 ppbv	0.67	Nagata (2003)	2 700	AMCV
octanal	124-13-0	C8H16O	ppbv	≤0.5 ppbv	0.01	Nagata (2003)	286	Long-Term ESL × 10

Compound	Chemical Abstract Service number (CAS)	Molecular Formula	Conc. Units	Method Detection Limit	Odour Threshold	Basis for Odour Thresholds	Texas Commission for Environmental Quality (TCEQ) Short-Term Exposure Criteria	
							Health Effects Criteria	Basis for Criteria: ESL, AMCV or NV
decane	124-18-5	C10H22	ppbv	≤0.5 ppbv	620	Nagata (2003)	1 750	AMCV
nonanal	124-19-6	C9H18O	ppbv	≤0.5 ppbv	0.34	Nagata (2003)	260	ESL
1-dodecanamine	124-22-1	C12H27N	ppbv	≤0.5 ppbv	170	Based on n-butylamine from Nagata 2003	13	ESL
1-octadecanamine	124-30-1	C18H39N	ppbv	≤0.5 ppbv	170	Based on n-butylamine from Nagata 2003	9	ESL
cyclooctane, 1,4-dimethyl-, trans-	13151-98-9	C10H20	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	1 000	NV (based on ESL for 110-82-7)
.delta.3-carene	13466-78-9	C10H16	ppbv	≤0.5 ppbv	100	1/10 of OT reported by <a href="http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.1998.tb10640.x/full">http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.1998.tb10640.x/full</a>	200	ESL
cyclopentene	142-29-0	C5H8	ppbv	≤0.5 ppbv	420	based on cyclohexane	2 900	AMCV
cyclobutane, (1-methylethylidene)-	1528-22-9	C8H16	ppbv	≤0.5 ppbv	42	1/10 of cyclohexane	1200	NV (based on ESL for 287-92-3)
benzenethiol-s-d	15570-03-3	C6H5DS	ppbv	≤0.5 ppbv	0.3	AIHA (1989)	2	NV based on 110-02-1
cycloprop[a]indene, 1,1a, 6,6a-tetrahydro	15677-15-3	C10H10	ppbv	≤0.5 ppbv	10	Odorous but no threshold found so using 10	50	NV based on 95-13-6
2-butenal, (z)-	15798-64-8	C4H6O	ppbv	≤0.5 ppbv	0.67	Based on n-butylaldehyde from Nagata 2003	3	ESL
benzene, 1-methyl-2-(2-prop	1587-04-8	C10H12	ppbv	≤0.5 ppbv	37	Based on 1/2 of o-ethyltoluene (Nagata, 2003)	230	ESL
cyclopentane, 1,2,3-trimethyl-, cis,cis,	15890-40-1	C9H18	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	870	NV (based on ESL for 1759-58-6)
heptane, 4-methylene-	15918-08-8	C8H16	ppbv	≤0.5 ppbv	850	1/2 of 4-methylheptane (Nagata, 2003)	850	NV based on 142-82-5
heptyl mercaptan	1639-09-4	C7H16S	ppbv	~1ppbv	0.2	TCEQ (2010)	5	Long-Term ESL × 10
cyclopentane, ethyl-	1640-89-7	C7H14	ppbv	≤0.5 ppbv	150	870		
cyclohexane, 1,2,3-trimethyl-	1678-97-3	C9H18	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	1 000	NV (based on ESL for 110-82-7)
cyclopentane, 1,3-dimethyl-, trans-	1759-58-6	C7H14	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	870	ESL
cyclopentene, 4-methyl-	1759-81-5	C6H10	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	2 400	ESL
beta pinene	18172-67-3	C10H16	ppbv	≤0.5 ppbv	33	Nagata (2003)	200	AMCV
1-cyclohexyl-1-propyne	18736-95-3	C9H14	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	1 000	NV (based on ESL for 110-82-7)
1,2,3,5-tetramethylcyclohexane (1r,2t,3c	19899-28-6	C10H20	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	1 000	NV (based on ESL for 110-82-7)
4-nonyne	20184-91-2	C9H16	ppbv	≤0.5 ppbv	0.54	based on 1-Nonene (Nagata, 2003)	750	NV (based on ESL for 25377-83-7)
methyl ethyl disulphide	20333-39-5	C3H8S2	ppbv	≤0.5 ppbv	2	based on diethyl disulphide (Nagata, 2003)	3.5	NV (based on ESL for 624-92-0)
cyclopentane, propyl-	2040-96-2	C9H20	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	870	NV (based on ESL for 1759-58-6)
2-butenal, 2-ethenyl-	20521-42-0	C6H8O	ppbv	≤0.5 ppbv	10	Default – is an odorous compound	140	NV (based on ESL for 110-63-4)*
disulfide, methyl propyl	2179-60-4	C4H10S2	ppbv	≤0.5 ppbv	2	based on diethyl disulphide (Nagata, 2003)	16	NV (based on ESL for 624-89-5)
cyclohexane, 1,2-dimethyl-, cis-	2207-01-4	C8H16	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	1 000	NV (based on ESL for 110-82-7)
cyclohexane, 1,3-dimethyl-, trans-	2207-03-6	C8H16	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	1 000	NV (based on ESL for 110-82-7)
propanoic acid, heptyl ester	2216-81-1	C10H20O2	ppbv	≤0.5 ppbv	7	based on n-butyl propionate (Nagata, 2003)	43	NV (based on ESL for 590-01-2)
cyclohexane, 1,2,4-trimethyl-	2234-75-5	C8H16	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	1 000	NV (based on ESL for 110-82-7)
2,4-decadienal	2363-88-4	C10H16O	ppbv	≤0.5 ppbv	10	Based high odour potential rating <a href="http://www.thegoodscentscompany.com/data/rw1537401.html">http://www.thegoodscentscompany.com/data/rw1537401.html</a>	60	NV (based on long-term ESL for 124-18-5 × 10)
cyclopentane, 1,2-dimethyl-	2452-99-5	C7H14	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	870	NV (based on ESL for 1759-58-6)
cyclopentane, 1,3-dimethyl-	2453-00-1	C7H14	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	870	NV (based on ESL for 1759-58-6)
2-octenal, (e)-	2548-87-0	C8H14O	ppbv	≤0.5 ppbv	0.01	based on n-octylaldehyde (Nagata, 2003)	260	NV (based on ESL for 124-13-0)
cyclopentane, 1-ethyl-3-methyl-, cis-	2613-66-3	C8H16	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	870	NV (based on ESL for 1759-58-6)
cyclopentane, 1,2,3-trimethyl-, (1.alpha	2613-69-6	C8H16	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	870	NV (based on ESL for 1759-58-6)
acetic acid, [o-(trimethylsiloxy)phenyl]	27750-52-3	C14H24O <sub>3</sub> Si2	ppbv	≤0.5 ppbv	10	Default	10	default value
1,3-pentadiene, 3-methyl-, (e)-	2787-43-1	C6H10	ppbv	≤0.5 ppbv	10	Default – is an odorous compound	100	NV (based on ESL for 109-67-1)
cyclopentane, 1,2,4-trimethyl-	2815-58-9	C8H16	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	870	NV (based on ESL for 1759-58-6)
1-hepten-3-one	2918-13-0	C7H12O	ppbv	≤0.5 ppbv	7	based on methyl n-amyl ketone (Nagata, 2003)	960	NV (based on ESL for 110-43-0)



Compound	Chemical Abstract Service number (CAS)	Molecular Formula	Conc. Units	Method Detection Limit	Odour Threshold	Basis for Odour Thresholds	Texas Commission for Environmental Quality (TCEQ) Short-Term Exposure Criteria	
							Health Effects Criteria	Basis for Criteria: ESL, AMCV or NV
cyclooctane	292-64-8	C8H16	ppbv	≤0.5 ppbv	420	based on cyclohexane	750	ESL
benzene, 2-propenyl-	300-57-2	C9H10	ppbv	≤0.5 ppbv	3.8	Based on n-propylbenzene (Nagata, 2003)	230	NV based on 1587-04-8
ethyl n-propyl disulfide	30453-31-7	C5H12S2	ppbv	≤0.5 ppbv	2	Based on diethyl disulphide (Nagata, 2003)	16	NV (based on ESL for 624-89-5)
cyclohexane, 1,1,3-trimethyl-	3073-66-3	C9H18	ppbv	≤0.5 ppbv	150	based on methyl cyclohexane Nagata (2003)	1 000	NV (based on ESL for 110-82-7)
2-hexene, 2,5-dimethyl-	3404-78-2	C7H12	ppbv	≤0.5 ppbv	20	based on hexene (TCEQ, 2010)	750	NV (based on ESL for 589-34-4)
c2f5h	354-33-6	C2HF5	ppbv	≤0.5 ppbv	1 000	Default value (has a slight ethereal odour)	10 000	ESL
cyclohexane, 1,2-diethyl-	3642-13-5	C10H20	ppbv	≤0.5 ppbv	150	based on methyl cyclohexane Nagata (2003)	1 000	NV (based on ESL for 110-82-7)
trisulfide, dimethyl	3658-80-8	C2H6S3	ppbv	≤0.5 ppbv	0.005	www.leffingwell.com	3.5	NV (based on ESL for 624-92-0)
1-hexadecanol	36653-82-4	C16H34O	ppbv	≤0.5 ppbv	10	TCEQ (2012)	200	Long-Term ESL × 10
cyclopentane, 1-ethyl-3-methyl-	3726-47-4	C8H16	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	870	NV (based on ESL for 1759-58-6)
1,3,6-octatriene, 3,7-dimethyl-, (e)- (c	3779-61-1	C10H16	ppbv	≤0.5 ppbv	50	default based on "medium" odour classification The Good Scents Company	300	ESL
cyclopentane, (2-methylpropyl)-	3788-32-7	C9H18	ppbv	≤0.5 ppbv	150	based on methyl cyclohexane Nagata (2003)	870	NV (based on ESL for 1759-58-6)
2-butynoic acid, 4-(4-morpholinyl)- (cas	38346-95-1	C8H11NO <sub>3</sub>	ppbv	≤0.5 ppbv	0.19	Based on n-butyric acid (Nagata, 2003)	250	Long-Term ESL × 10 for 107-92-6
trans-2-hexene	4050-45-7	C6H12	ppbv	≤0.5 ppbv	20	TCEQ (2012)	500	AMCV
cycloheptane, methyl-	4126-78-7	C8H16	ppbv	≤0.5 ppbv	150	based on methyl cyclohexane Nagata (2003)	1 000	NV (based on ESL for 110-82-7)
2-butenal	4170-30-3	C4H6O	ppbv	≤0.5 ppbv	23	Nagata (2003)	3	AMCV
1-octen-3-one	4312-99-6	C8H14O	ppbv	≤0.5 ppbv	8	based on methyl n-amyl ketone (Nagata, 2003)	960	NV based on 110-43-0
1,4-cyclohexadiene, 1-methyl-	4313-57-9	C7H10	ppbv	≤0.5 ppbv	150	based on methyl cyclohexane Nagata (2003)	750	NV based on 542-92-7
cyclohexane, 1-ethyl-2-methyl-, cis-	4923-77-7	C9H18	ppbv	≤0.5 ppbv	150	based on methyl cyclohexane Nagata (2003)	1 000	NV (based on ESL for 110-82-7)
1h-indene, 2,3-dihydro-	496-11-7	C9H10	ppbv	≤0.5 ppbv	4.2	Based on Indene (AIHA, 1989)	100	ESL
formaldehyde	50-00-0	CH2O	ppbv	≤0.5 ppbv	500	Nagata (2003)	41	AMCV
glycocyanidine	503-86-6	C3H5N3O	ppbv	≤0.5 ppbv	10	default value	100	NV (based on ESL for 64-19-7)
cyclohexane, 1,1,3,5-tetramethyl-, trans	50876-31-8	C10H20	ppbv	≤0.5 ppbv	150	based on methyl cyclohexane Nagata (2003)	1 000	NV (based on ESL for 110-82-7)
cyclohexane, 1,1,3,5-tetramethyl-, cis-	50876-32-9	C10H20	ppbv	≤0.5 ppbv	150	based on methyl cyclohexane Nagata (2003)	1 000	NV (based on ESL for 110-82-7)
benzene, 1,2,3-trimethyl-	526-73-8	C9H12	ppbv	≤0.5 ppbv	120	Based on 1,2,4-Trimethylbenzene (Nagata, 2003)	250	AMCV
benzene, 1-methyl-2-(1)-meth	527-84-4	C10H14	ppbv	≤0.5 ppbv	41	Based on m-xylene (Nagata, 2003)	230	NV based on 1587-04-8
benzaldehyde, 2-methyl-	529-20-4	C8H8O	ppbv	≤0.5 ppbv	0.28	Based on n-hexylaldehyde (Nagata, 2003)	18	ESL
benzene, 1-methyl-3-(1-methylethyl)- (ca)	535-77-3	C10H14	ppbv	≤0.5 ppbv	8	Based on p-ethyltoluene (Nagata, 2003)	500	ESL
cyclobutanone, 2,3,3,4-tetramethyl-	53907-62-3	C8H14O	ppbv	≤0.5 ppbv	7	based on methyl n-amyl ketone (Nagata, 2003)	960	NV (based on ESL for 110-43-0)
2h-pyrrole, 3,4-dihydro-5-[2-(methylthio	54031-34-4	C8H13NS	ppbv	≤0.5 ppbv	1	Default based on thiol functional group	10	default value
1,3-cyclopentadiene	542-92-7	C5H6	ppbv	≤0.5 ppbv	420	based on cyclohexane	750	ESL
butyl sulphide	544-40-1	C8H18S	ppbv	≤0.5 ppbv	0.033	Based on Ethyl Sulphide Nagata (2003)	16	NV (based on ESL for 624-89-5)
propanal, 2-methyl-3-phenyl	5445-77-2	C10H12O	ppbv	≤0.5 ppbv	1	No value so based on low OT for aldehydes	140	NV (based on ESL for 110-63-4)*
cyclohexane, 1,3,5-trimethyl-2-octadecyl	55282-34-3	C27H54	ppbv	≤0.5 ppbv	150	based on methyl cyclohexane Nagata (2003)	1 000	NV (based on ESL for 110-82-7)
thiophene, 2-methyl-	554-14-3	C7H14	ppbv	≤0.5 ppbv	0.56	Based on Thiophene (Nagata, 2003)	25	ESL
thiocyanic acid, methyl est	556-64-9	C2H3NS	ppbv	≤0.5 ppbv	1	Default value based on high odour potential <a href="http://www.thegoodscentscompany.com/data/rw1260411.html">http://www.thegoodscentscompany.com/data/rw1260411.html</a>	20	NV (based on ESL for 57-12-5)
hexane, 3,3-dimethyl-	563-16-6	C8H18	ppbv	≤0.5 ppbv	840	Based on 3-methylhexane Nagata (2003)	750	NV (based on ESL for 589-34-4)
3-methyl-1-butene	563-45-1	C5H10	ppbv	≤0.5 ppbv	250	TCEQ (2012)	8 000	AMCV
2-methyl-2-butene	563-46-2	C5H10	ppbv	≤0.5 ppbv	250	TCEQ (2010)	500	AMCV

Compound	Chemical Abstract Service number (CAS)	Molecular Formula	Conc. Units	Method Detection Limit	Odour Threshold	Basis for Odour Thresholds	Texas Commission for Environmental Quality (TCEQ) Short-Term Exposure Criteria	
							Health Effects Criteria	Basis for Criteria: ESL, AMCV or NV
17-octadecenal	56554-86-0	C18H34O	ppbv	≤0.5 ppbv	0.4	based on n-decaldehyde (Nagata, 2003)	100	NV (based on ESL for 122-92-5)
(e)-3,3-dimethyl(1-d)but-1-ene	57002-05-8	C6H11D	ppbv	≤0.5 ppbv	360	Based on 1-butene Nagata (2003)	290	NV (based on ESL for 563-78-0)
dimethyl tetrasulphide	5756-24-1	C2H6S4	ppbv	≤0.5 ppbv	0.005	Based on dimethyl trisulphide <a href="http://www.leffingwell.com/odorthre.htm">http://www.leffingwell.com/odorthre.htm</a>	16	NV (based on ESL for 624-89-5)
ethanone, 1-(2)-methylphenyl	577-16-2	C9H10O	ppbv	≤0.5 ppbv	2.1	based on methyl iosamyl ketone (Nagata, 2003)	25	NV (based on ESL for 100-42-5)
cyclohexane, 1,2-dimethyl-(cis/trans)	583-57-3	C8H16	ppbv	≤0.5 ppbv	150	based on methyl cyclohexane Nagata (2003)	1 000	NV (based on ESL for 110-82-7)
heptane, 4-methyl-	589-53-7	C8H18	ppbv	≤0.5 ppbv	1 700	Nagata (2003)	750	ESL
3-methylheptane	589-81-1	C8H18	ppbv	≤0.5 ppbv	1 500	Nagata (2003)	750	ESL
cyclohexane, 1,4-dimethyl-	589-90-2	C8H16	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	3.5	NV (based on 624-92-0)
1-hexene	592-41-6	C6H12	ppbv	≤0.5 ppbv	140	Nagata (2003)	500	ESL
1-heptene	592-41-7	C7H12	ppbv	≤0.5 ppbv	370	Nagata (2003)	850	NV (based on ESL for 142-82-5)
1,3-cyclohexadiene	592-57-4	C6H8	ppbv	≤0.5 ppbv	420	based on cyclohexane	3000	NV (based on 10× Long-Term ESL for 110-83-8)
1-propen-1-one, 2-methyl-	598-26-5	C4H6O	ppbv	≤0.5 ppbv	24	Based on methyl n-butyl ketone (Nagata, 2003)	200	NV ( based on ESL for 108-10-1)
n-propyl sec-butyl disulphide	59849-54-6	C7H16S2	ppbv	≤0.5 ppbv	2	Based on Diethyl sulphide (Nagata, 2003)	16	NV (based on ESL for 624-89-5)
cyclohexene, 1-methyl-4-(1-methylethenyl	5989-54-8	C10H16	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	3.5	NV (based on 624-92-0)
2,4(1h,3h)-pyrimidinedione, 5-nitro-	611-08-5	C4H3N3O4	ppbv	≤0.5 ppbv	10	Default based on amines	126	NV (based on 36315-01-2)
benzene, 1-ethyl-2-methyl-	611-14-3	C7H14	ppbv	≤0.5 ppbv	41	Based on m-xylene (Nagata, 2003)	250	AMCV
cyclopentane, 1-hexyl-3-methyl-	61142-68-5	C12H24	ppbv	≤0.5 ppbv	150	870		
sulphurous acid, dimethyl ester	616-42-2	C2H6O <sub>3</sub> S	ppbv	≤0.5 ppbv	500	Default – does not appear to be an odorous compound (web search)	10	NV (based on ESL for 7757-83-7)
thiophene, 3-methyl-	616-44-4	C7H14	ppbv	≤0.5 ppbv	0.56	Based on Thiophene (Nagata, 2003)	25	ESL
benzene, 1-ethyl-3-methyl-	620-14-4	C9H12	ppbv	≤0.5 ppbv	0.39	Based on p-diethlybenzene (Nagata, 2003)	250	AMCV
decane, 2,3,6-trimethyl-	62238-12-4	C13H28	ppbv	≤0.5 ppbv				
benzene, 1-ethyl-4-methyl-	622-96-8	C9H12	ppbv	≤0.5 ppbv	0.39	Based on p-diethlybenzene (Nagata, 2003)	250	AMCV
benzene, 1-ethenyl-4-methyl-	622-97-9	C9H10	ppbv	≤0.5 ppbv	0.39	Based on p-diethlybenzene (Nagata, 2003)	50	ESL
ethyl methyl sulphide	624-89-5	C3H8S	ppbv	~1 ppbv	0.033	Based on Ethyl Sulphide Nagata (2003)	16	ESL
dimethyldisulphide	624-92-0	C2H6S2	ppbv	≤0.5 ppbv	2.2	Nagata (2003)	3.5	Long-Term ESL × 10
piperidine, 3-methyl-	626-56-2	C6H13N	ppbv	≤0.5 ppbv	15	1/10 of methylcyclohaxane (Nagata, 2003)	10	ESL
1,4-cyclohexadiene	628-41-1	C6H8	ppbv	≤0.5 ppbv	270	1/10 of benzene (Nagata, 2003)	3000	NV (based on 10× Long-Term ESL for 110-83-8)
hexanenitrile	628-73-9	C6H11N	ppbv	≤0.5 ppbv	150	1/10 of hexane (Nagata, 2003)	570	NV (based on 10× Long-Term ESL for 124-09-4)
disulfide, dipropyl	629-19-6	C6H14S2	ppbv	≤0.5 ppbv	2	Based on diethyl disulphide (Nagata, 2003)	14.5	ESL
disulfide, dibutyl	629-45-8	C8H18S2	ppbv	≤0.5 ppbv	2	Based on diethyl disulphide (Nagata, 2003)	14.5	NV (based on ESL for 629-19-6)
2,4-nonadiyne	63621-15-8	C9H12	ppbv	≤0.5 ppbv	0.54	Based on 1-Nonene (Nagata, 2003)	3 200	NV (based on ESL for nonyne,1)
cyclohexane, 1,3-dimethyl-, cis-	638-04-0	C8H16	ppbv	≤0.5 ppbv	420	based on cyclohexane	1 000	NV (based on ESL for 110-82-7)
hexanal	66-25-1	C6H12O	ppbv	≤0.5 ppbv	20	TCEQ (2010)	2000	AMCV
methanol	67-56-1	CH <sub>4</sub> O	ppbv	≤0.5 ppbv	4 260	Hellman and Small (1974)	1 000	ESL
2-propanone	67-64-1	C3H6O	ppbv	≤0.5 ppbv	42 000	Nagata (2003)	3300	ESL
4-methyl-1-pentene	691-37-2	C6H12	ppbv	≤0.5 ppbv	20	TCEQ (2012)	500	AMCV
1-butanol	71-36-3	C4H10O	ppbv	≤0.5 ppbv	38	Nagata (2003)	200	ESL
n-propyl n-butyl disulphide	72437-64-0	C7H16S2	ppbv	≤0.5 ppbv	2	Based on diethyl disulphide (Nagata, 2003)	14.5	NV (based on ESL for 629-19-6)
(1l)-(1,2,4/3,5)-1',2'-anhydro-1-hydroxy	73111-27-0	C13H15NO6	ppbv	≤0.5 ppbv	10	Default	14.5	NV (based on ESL for 629-19-6)
sulphur dioxide	7446-09-5	O2S	ppbv	≤0.5 ppbv	9	<a href="http://www.extension.iastate.edu/Publications/PM1963A.pdf">http://www.extension.iastate.edu/Publications/PM1963A.pdf</a>	114	WHO converted to 1 hour
3,5-dimethylcyclopentene	7459-71-4	C7H14	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	870	NV (based on ESL for 1759-58-6)
acetaldehyde	75-07-0	C2H4O	ppbv	≤0.5 ppbv	0.8	between Nagata (2003) and Ruth (1986)	250	AMCV

Compound	Chemical Abstract Service number (CAS)	Molecular Formula	Conc. Units	Method Detection Limit	Odour Threshold	Basis for Odour Thresholds	Texas Commission for Environmental Quality (TCEQ) Short-Term Exposure Criteria	
							Health Effects Criteria	Basis for Criteria: ESL, AMCV or NV
carbon disulfide	75-15-0	CS <sub>2</sub>	ppbv	≤0.5 ppbv	8	Ruth (1986)	10	ESL
ethane, 1,1-difluoro-	75-37-6	C2H4F2	ppbv	≤0.5 ppbv	100	Default value as is reported to have slight odour	10 000	Based on AMCV for 75-69-4
trichloromonofluoromethane	75-69-4	CCl3F	ppbv	≤0.5 ppbv	500	1/10 of lowest OT reported at <a href="http://www.speclab.com/compound/c75694.htm">http://www.speclab.com/compound/c75694.htm</a>	10 000	AMCV
camphor	76-22-2	C10H16O	ppbv	≤0.5 ppbv	3	Lowest OT reported in AIHA (1989)	3.3	ESL
2-methyl-1-pentene	763-29-1	C6H12	ppbv	≤0.5 ppbv	20	TCEQ (2012)	500	AMCV
1h-indene, 1-methyl-	767-59-9	C10H10	ppbv	≤0.5 ppbv	38	Based on naphthlene (AIHA, 1989)	50	NV (based on 10× long-term ESL for 95-13-6)
cis-2-hexene	7688-21-3	C6H12	ppbv	≤0.5 ppbv	20	TCEQ (2012)	500	AMCV
1,3-butadiene, 2-methyl-	78-79-5	C5H8	ppbv	≤0.5 ppbv	5	TCEQ (2012)	20	AMCV
2-propenal, 2-methyl-	78-85-3	C4H6O	ppbv	≤0.5 ppbv	8.5	<a href="http://www.tceq.state.tx.us/assets/public/implementation/tox/dsd/final/october09/methacrolein_78-85-3.pdf">http://www.tceq.state.tx.us/assets/public/implementation/tox/dsd/final/october09/methacrolein_78-85-3.pdf</a>	19	AMCV
3-butene-2-one	78-94-4	C4H6O	ppbv	≤0.5 ppbv	2.1	Based on methyl n-amyl ketone (Nagata, 2003)	2	ESL
camphene	79-92-5	C10H16	ppbv	≤0.5 ppbv	100	Based on "medium" odour strength from <a href="http://www.thegoodscentscompany.com/data/rw1006291.html">http://www.thegoodscentscompany.com/data/rw1006291.html</a>	9	ESL
alpha pinene	80-56-8	C10H16	ppbv	≤0.5 ppbv	10	TCEQ (2012)	628	AMCV
cyclopentane, 1,2-dimethyl-, trans-	822-50-4	C7H14	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	875	ESL
naphthalene, 2-methyl	91-57-6	C11H10	ppbv	≤0.5 ppbv	10	Ruth (1986)	5	ESL
hexane, 2,3,4-trimethyl-	921-47-1	C9H20	ppbv	≤0.5 ppbv	900	Based on 2,2,5 trimethylhexane Nagata (2003)	670	ESL
4-methyl-1,3-pentadiene	926-56-7	C6H10	ppbv	≤0.5 ppbv	100	Based on 1,3 butadiene (AIHA, 1989)	100	NV (based on ESL for 109-67-1)
cyclopropane, 1,2-dimethyl-, cis-	930-18-7		ppbv	≤0.5 ppbv	1 700	Based on methylcyclopentane Nagata (2003)	1 500	NV (based on ESL for 594-11-6)
2-cyclopenten-1-one	930-30-3	C5H6O	ppbv	≤0.5 ppbv	10	Default web search indicates will have odour at some conc.	500	NV (based on ESL for 120-92-3)
cyclopentane, 1-ethyl-2-methyl-, cis- (c	930-89-2	C8H16	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	870	NV (based on ESL for 1759-58-6)
indene	95-13-6	C9H8	ppbv	≤0.5 ppbv	15	TCEQ (2010)	50	Long-Term ESL × 10
2,3-butanedione, dioxime	95-45-4	C4H8N2O2	ppbv	≤0.5 ppbv	100	Default web search indicates will have odour at some conc.	10	Default value
benzene, 1,2-dichloro-	95-50-1	C6H4Cl2	ppbv	≤0.5 ppbv	200	1/10 of lowest OT for 1,2-dichlorobenzene <a href="http://www.speclab.com/compound/c95501.htm">http://www.speclab.com/compound/c95501.htm</a>	120	ESL
1,3-cyclopentadiene, 1-methyl-	96-39-9	C6H8	ppbv	≤0.5 ppbv	150	TCEQ for methylcyclohexane	750	NV based on 542-92-7
2-furancarboxaldehyde	98-01-1	C5H4O2	ppbv	≤0.5 ppbv	50	default based on "medium" odour classification The Good Scents Company	20	ESL
benzene, (1-methylethyl)-	98-82-8	C9H12	ppbv	≤0.5 ppbv	8	<a href="http://www.speclab.com/compound/c98828.htm">http://www.speclab.com/compound/c98828.htm</a>	500	AMCV
cyclohexene, 4-methylene-1-(1-methylethy	99-84-3	C10H16	ppbv	≤0.5 ppbv	150	based on methyl cyclohexane Nagata (2003)	200	ESL
alpha-terpinene	99-86-5	C10H16	ppbv	≤0.5 ppbv	100	Based on Good Scents Company rating of medium odour	200	ESL for 68956-56-9

Table 35. AER-applied health-based daily (24 hour) thresholds for comparison of various parameters collected in canister air samples (thresholds in ppb)

Pollutants	AAAQO	AALs	Alberta Health	US EPA IRIS Chronic Threshold Effects	OMOE
1,2,4-Trimethylbenzene*	—	—	44.8	—	44.8
1,3,5-Trimethylbenzene*	—	—	44.8	—	44.8
1-Butene	—	—	—	—	—
1-Pentene	—	—	—	—	—
2,2,4-Trimethylpentane	—	—	—	—	—
2,2-Dimethylbutane	—	—	—	—	—
2,3,4-Trimethylpentane*	—	—	—	—	—
2,3-Dimethylbutane	—	—	—	—	—
2,3-Dimethylpentane	—	—	—	—	—
2,4-Dimethylpentane	—	—	—	—	—
2,5-dimethyl Thiophene*	—	—	—	—	—
2-ethyl Thiophene*	—	—	—	—	—
2-methyl Thiophene*	—	—	—	—	—
2-Methyl-1-pentene	—	—	—	—	—
2-Methyl-2-butene	—	—	—	—	—
2-Methylheptane	—	—	—	—	—
2-Methylhexane	—	—	—	—	—
2-Methylpentane	—	—	—	—	—
3-methyl Thiophene*	—	—	—	—	—
3-Methyl-1-butene	—	—	—	—	—
3-Methylheptane	—	—	—	—	—
3-Methylhexane	—	—	—	—	—
3-Methylpentane	—	—	—	—	—
4-Methyl-1-pentene	—	—	—	—	—
Acetaldehyde	—	20	—	5	277.53
Acetone	—	68.03	—	—	5 002
Allyl sulphide	—	—	—	—	—
alpha Pinene	—	—	—	—	—

Pollutants	AAAQO	AALs	Alberta Health	US EPA IRIS Chronic Threshold Effects	OMOE
Benzene	—	0.2	—	9.39	0.7
beta Pinene	—	—	—	—	—
Butane	—	—	—	—	—
Butyl mercaptan	—	—	—	—	—
Carbon disulphide	—	0.032	—	225	106
Carbonyl sulphide	—	0.041	—	—	—
cis-2-Butene	—	—	—	—	—
cis-2-Hexene	—	—	—	—	—
cis-2-Pentene	—	—	—	—	—
Cyclohexane	—	—	—	—	1 772.5
Cyclopentane	—	—	—	—	—
Cyclopentene	—	—	—	—	—
Decane	—	—	—	—	—
Dimethyl disulphide	—	—	—	—	—
Dimethyl sulphide	—	—	—	—	—
Dodecane	—	—	—	—	—
Ethyl benzene	—	—	—	230.31	230
Ethyl mercaptan	—	—	—	—	—
Ethyl sulphide*	—	—	—	—	—
Formaldehyde	—	2	—	—	52.92
Heptane	—	—	—	—	2 684.5
Hexane	1 990	—	—	—	709.4
Hydrogen sulphide	3	0.65	—	1.43	5.02
Isobutane*	—	—	—	—	—
Isobutyl mercaptan	—	—	—	—	—
Isopentane	—	—	—	—	—
Isoprene	—	—	—	—	—
Isopropyl mercaptan	—	—	—	—	—

Pollutants	AAAQO	AALs	Alberta Health	US EPA IRIS Chronic Threshold Effects	OMOE
Isopropylbenzene	—	—	—	—	—
m,p-Xylene	161	2.72	—	0.023	168.1
Methanol	—	—	—	15.26	—
Methyl ethyl ketone	—	67.82	—	—	339.14
Methyl isobutyl ketone	—	13.61	—	0.73	293
Methyl mercaptan	—	—	—	—	—
Methylcyclohexane	—	—	—	—	—
Methylcyclopentane	—	—	—	—	—
Naphthalene	—	2.72	—	0.57	4.3
Nonane	—	—	—	—	—
n-Propylbenzene	—	—	—	—	—
Octane	—	—	—	—	—
o-Xylene	161	2.72	—	23.03	168.1
Pentane	—	—	—	—	—
Pentyl mercaptan	—	—	—	—	—
Propyl mercaptan	—	—	—	—	—
sec-Butyl mercaptan	—	—	—	—	—
Styrene	—	46.96	—	—	93.4
tert-Butyl mercaptan	—	—	—	—	—
tert-Pentyl mercaptan*	—	—	—	—	—
Thiophene	—	—	—	—	—
Toluene	106	21.23	—	—	530.8
trans-2-Butene*	—	—	—	—	—
trans-2-Hexene*	—	—	—	—	—
trans-2-Pentene*	—	—	—	—	—
Undecane	—	—	—	—	—

**Table 36. AER-applied odour-detection-based thresholds for comparison of various parameters collected in ambient air samples**

Pollutants	Unit	Odour Threshold	Source
1,2,4-Trimethylbenzene*	ppb	120	Nagata, 2003
1,3,5-Trimethylbenzene*	ppb	170	Nagata, 2003
1-Butene	ppb	360	Nagata, 2003
1-Pentene	ppb	100	TCEQ
2,2,4-Trimethylpentane	ppb	670	Nagata, 2003
2,2-Dimethylbutane	ppb	20 000	Nagata, 2003
2,3,4-Trimethylpentane*	ppb	670	thiophene surrogate, Nagata, 2003
2,3-Dimethylbutane	ppb	420	Nagata, 2003
2,3-Dimethylpentane	ppb	4 500	Nagata, 2003
2,4-Dimethylpentane	ppb	940	Nagata, 2003
2,5-dimethyl Thiophene*	ppb	0.56	thiophene surrogate, Nagata, 2003
2-ethyl Thiophene*	ppb	0.56	thiophene surrogate, Nagata, 2003
2-methyl Thiophene*	ppb	0.56	thiophene surrogate, Nagata, 2003
2-Methyl-1-pentene	ppb	—	Nagata, 2003
2-Methyl-2-butene	ppb	—	Nagata, 2003
2-Methylheptane	ppb	110	Nagata, 2003
2-Methylhexane	ppb	420	Nagata, 2003
2-Methylpentane	ppb	7 000	Nagata, 2003
3-methyl Thiophene*	ppb	0.56	thiophene surrogate, Nagata, 2003
3-Methyl-1-butene	ppb	—	Nagata, 2003
3-Methylheptane	ppb	1 500	Nagata, 2003
3-Methylhexane	ppb	840	Nagata, 2003
3-Methylpentane	ppb	8 900	Nagata, 2003
4-Methyl-1-pentene	ppb	—	—
Acetaldehyde	ppb	1.5	Nagata, 2003
Acetone	ppb	42 000	FMSD 42 ppb
Allyl sulphide	ppb	0.22	Nagata, 2003
alpha Pinene	ppb	18	Nagata, 2003
Benzene	ppb	2 700	Nagata, 2003
beta Pinene	ppb	33	Nagata, 2003
Butane	ppb	1 200 000	Nagata, 2003
Butyl mercaptan	ppb	0.0028	Nagata, 2003
Carbon disulphide	ppb	210	10 proposed by ESRD and FMSD, adopted from Nagata, 2003
Carbonyl sulphide	ppb	55	Nagata, 2003
cis-2-Butene	ppb	360	butene as surrogate, Nagata, 2003
cis-2-Hexene	ppb	140	hexene as surrogate, Nagata, 2003
cis-2-Pentene	ppb	100	pentene as surrogate, Nagata, 2003
Cyclohexane	ppb	2 500	Nagata, 2003
Cyclopentane	ppb	1 700	methylcyclopentane as surrogate, Nagata 2003
Cyclopentene	ppb	—	Nagata, 2003
Decane	ppb	620	Nagata, 2003
Dimethyl disulphide	ppb	2.2	Note: FMSD proposed 0.2 incorrect units?
Dimethyl sulphide	ppb	1	UK 2007; FMSD proposed 3, based on Nagata, 2003
Dodecane	ppb	110	Nagata, 2003
Ethyl benzene	ppb	170	Nagata, 2003
Ethyl mercaptan	ppb	0.0087	Note: Nagata 100–1000× lower than other sources
Ethyl sulphide*	ppb	0.033	diethyl sulphide as surrogate



<b>Pollutants</b>	<b>Unit</b>	<b>Odour Threshold</b>	<b>Source</b>
Formaldehyde	ppb	500	Nagata, 2003
Heptane	ppb	670	Nagata, 2003
Hexane	ppb	1 500	Nagata, 2003
Hydrogen sulphide	ppb	0.41	Nagata, 2003
Isobutane*	ppb	10 000	Isobutene as surrogate
Isobutyl mercaptan	ppb	0.0068	Nagata, 2003
Isopentane	ppb	1 300	Nagata, 2003
Isoprene	ppb	48	Nagata, 2003
Isopropyl mercaptan	ppb	0.006	Nagata, 2003
Isopropylbenzene	ppb	8.4	Nagata, 2003
m,p-Xylene	ppb	58	Nagata, 2003
Methanol	ppb	33 000	Nagata, 2003
Methyl ethyl ketone	ppb	440	Nagata, 2003
Methyl isobutyl ketone	ppb	170	Nagata, 2003
Methyl mercaptan	ppb	0.07	Nagata, 2003
Methylcyclohexane	ppb	150	Nagata, 2003
Methylcyclopentane	ppb	1 700	Nagata, 2003
Naphthalene	ppb	38	FMSD, no source reported
Nonane	ppb	2 200	Nagata, 2003
n-Propylbenzene	ppb	3.8	Nagata, 2003
Octane	ppb	1 700	Nagata, 2003
o-Xylene	ppb	380	Nagata, 2003
Pentane	ppb	1 400	Nagata, 2003
Pentyl mercaptan	ppb	0.0078	FMSD proposed based on Nagata but source not verified
Propyl mercaptan	ppb	0.013	Nagata, 2003
sec-Butyl mercaptan	ppb	0.03	Nagata, 2003
Styrene	ppb	35	Nagata, 2003
tert-Butyl mercaptan	ppb	0.029	Nagata, 2003
tert-Pentyl mercaptan*	ppb	0.029	tert-Butyl mercaptan as surrogate
Thiophene	ppb	0.56	Nagata, 2003
Toluene	ppb	330	Nagata, 2003
trans-2-Butene*	ppb	360	1-butene as surrogate
trans-2-Hexene*	ppb	140	1-hexene as surrogate
trans-2-Pentene*	ppb	100	1-pentene as surrogate
Undecane	ppb	870	Nagata, 2003

**Table 37. AER-applied short-term health thresholds for comparison of hourly (average and 98th percentile) concentrations of various parameters in ambient air**

Pollutants	Unit	CAAQS	AAAQO	Endpoint	TCEQ Short term	Endpoint	US EPA NAAQS	Endpoint	WHO AQG	Endpoint
Hexane	ppb	—	5 960	Derived from Cal 24 hr	1 800	Odour/ Health	—	—	—	—
Benzene	ppb	—	9	Haematological effects, US EPA IRIS	180	Health	—	—	—	—
Heptane	ppb	—	—	—	850	Health	—	—	—	—
Toluene	ppb	—	499	Adopted from TCEQ	4 000	Health	—	—	—	—
Octane	ppb	—	—	—	750	Health	—	—	—	—
Ethylbenzene	ppb	—	460	Adopted from TCEQ (discrepancy)	20 000	Health	—	—	—	—
m,p-xylene & o-xylene	ppb	—	530	Adopted from OMOE	1 700	Health	—	—	—	—
SO <sub>4</sub>	ppb	—	—	—	—	—	—	—	—	—
NO <sub>3</sub>	ppb	—	—	—	—	—	—	—	—	—
NH <sub>3</sub>	ppb	—	2 000	Odour Threshold	—	—	—	—	—	—
CH <sub>4</sub>	ppm	—	—	—	—	—	—	—	—	—
NO <sub>2</sub>	ppb	—	159	Respiratory effects	—	—	100	Health	106.29	Health
SO <sub>2</sub>	ppb	—	172	Decreased pulmonary function	—	—	75	Health	—	—
O <sub>3</sub>	ppb	—	82	Decreased pulmonary function	—	—	—	—	—	—
H <sub>2</sub> S	ppb	—	10	Odour perception	—	—	—	—	—	—
TRS*	ppb	—	10	Odour perception	—	—	—	—	—	—
THC	ppb	—	—	—	—	—	—	—	—	—

**Table 38. AER-applied chronic (noncarcinogenic) health thresholds for comparison of daily (average and 98th percentile) concentrations of various parameters in ambient air**

Pollutants	Unit	US EPA Short Term	TCEQ Short term	Endpoint	AAAQO	Endpoint	WHO AQG	Endpoint	US EPA IRIS Chronic	Endpoint
Hexane	ppb	110 659.16	—	—	1 990	Adopted from California, health based	—	—	198.62	Neurological effects
Benzene	ppb	406.93	—	—	—	—	—	—	9.39	RfC — decreased lymphocyte count
Heptane	ppb	—	—	—	—	—	—	—	—	—
Toluene	ppb	9 819.28	—	—	106	Adopted from Michigan and Washington	—	—	1 326.93	Neurological effects
Octane	ppb	—	—	—	—	—	—	—	—	—
Ethylbenzene	ppb	32 243.78	—	—	—	—	—	—	230.31	Developmental effects
m,p-xylene & o-xylene	ppb	5 066.4	—	—	161	Adopted from California,	—	—	23.03	Neurological effects
SO <sub>4</sub>	ppb	—	—	—	—	—	—	—	—	—
NO <sub>3</sub>	ppb	—	—	—	—	—	—	—	—	—
NH <sub>3</sub>	ppb	—	—	—	—	—	—	—	143.56	Respiratory effects
CH <sub>4</sub>	ppm	—	—	—	—	—	—	—	—	—
NO <sub>2</sub>	ppb	—	—	—	—	—	—	—	—	—
SO <sub>2</sub>	ppb	—	—	—	48	Adopted from EU health	7.63	Health	—	—
O <sub>3</sub>	ppb	—	—	—	—	—	—	—	—	—
H <sub>2</sub> S	ppb	30.13	—	—	3	odour	—	—	1.43	Nasal lesions, olfactory degeneration
TRS*	ppb	30.13	—	—	3	odour	—	—	1.43	Nasal lesions, olfactory degeneration
THC	ppb	—	—	—	—	—	—	—	—	—

Table 39. AER-applied chronic (carcinogenic and noncarcinogenic) annual health thresholds for comparison to (average and 98th percentile) concentrations of various parameters in ambient air

Pollutants	Unit	AAAQO	Endpoint	TCEQ Long Term	Endpoint	US EPA IRIS Chronic	Endpoint	US EPA IRIS Chronic Carcinogen min range 1 in 100 000	US EPA IRIS Chronic Carcinogen max range 1 in 100 000	Endpoint	US EPA NAAQS	Endpoint	WHO AQG2	Endpoint
Hexane	ppb	—	—	190	Health	198.62	Neurological effects	—	—	—	—	—	—	—
Benzene	ppb	0.9	midpoint of 1 in 100 000 US EPA IRIS Risk Value, carcinogenicity	1.4	Health	9.39	RfC — decreased lymphocyte count	0.406	1.41	1 in 100 000 cancer risk, leukemia	—	—	—	—
Heptane	ppb	—	—	85	Health	—	—	—	—	—	—	—	—	—
Toluene	ppb	—	—	1 100	Health	1 326.93	Neurological effects	—	—	—	—	—	—	—
Octane	ppb	—	—	75	Health	—	—	—	—	—	—	—	—	—
Ethylbenzene	ppb	—	—	450	Health	230.31	Developmental effects	—	—	—	—	—	—	—
m,p-xylene & o-xylene	ppb	—	—	140	Health	23.03	Neurological effects	—	—	—	—	—	—	—
SO <sub>4</sub>	ppb	—	—	—	—	—	—	—	—	—	—	—	—	—
NO <sub>3</sub>	ppb	—	—	—	—	—	—	—	—	—	—	—	—	—
NH <sub>3</sub>	ppb	—	—	—	—	143.56	Respiratory effects	—	—	—	—	—	—	—
CH <sub>4</sub>	ppm	—	—	—	—	—	—	—	—	—	—	—	—	—
NO	ppb	—	—	—	—	—	—	—	—	—	—	—	—	—
NO <sub>2</sub>	ppb	24	Vegetation effects	—	—	—	—	—	—	—	53	Health	21.26	Health
SO <sub>2</sub>	ppb	8	Adopted from EU, Ecosystem health	—	—	—	—	—	—	—	—	—	—	—
O <sub>3</sub>	ppb	—	—	—	—	—	—	—	—	—	—	—	—	—
H <sub>2</sub> S	ppb	—	—	—	—	1.43	Nasal lesions, olfactory degeneration	—	—	—	—	—	—	—
TRS*	ppb	—	—	—	—	1.43	Nasal lesions, olfactory degeneration	—	—	—	—	—	—	—
THC	—	—	—	—	—	—	—	—	—	—	—	—	—	—





## Appendix 4 Analysis of Odour Complaints, Ambient Conditions and Industry Plant Operations

**Table 40. February 25, 2010 summary of complaints, ambient air conditions, meteorological conditions, and plant operational details**

<b>Date</b>	February 25, 2010 was chosen due to the large number of complaints received with no noted AAAQO exceedances that day.
<b>Complaints</b>	There were nine complaints on this day. The odours were noted between 12:00 and 14:00. Complaints were described as awful, smell of onions, body odour, propane/gas, or chlorine. The odours made its way indoors in some cases causing concerns. One complaint recorded that the smell was giving the complainant headaches.
<b>Ambient</b>	<p>Possible Inversion 0:00–09:00 with breakup fumigation following SO<sub>2</sub>, TRS, O<sub>3</sub> peaks at AMS01 (Fort McKay) at 01:30 (30 ppb). Details below (X – indicated magnitude of exceedance at Fort McKay as compared to industrial station concentrations)</p> <p>SO<sub>2</sub> – 30 ppb, no correlation (slight increase AMS02-Mildred), does not exceed OT</p> <p>TRS – 1.8 ppb, no correlation, is greater than the OT</p> <p>O<sub>3</sub> – 35 ppb, no correlation,</p> <p>PM<sub>2.5</sub> – 35 µg/m<sup>3</sup>, 2–35 µg/m<sup>3</sup>(AMS15 increase CNRL)</p> <p>NO<sub>x</sub>, NO<sub>2</sub>, NO – ~30 ppb, 30× AMS02, same as AMS15, does not exceed OT</p> <p>THC fluctuates throughout day at all stations, peak at 14:00 and 19:00 in Fort McKay</p> <p>H<sub>2</sub>S was greater than OTs at industrial stations especially Mildred Lake and Lower Camp later in day (after 15:00) TRS is greater than OT in Fort McKay</p> <p>Trend analysis shows correlation between Fort McKay AMS01 CNRL AMS15 (SO<sub>2</sub>, O<sub>3</sub>, NO, NO<sub>2</sub>, NO<sub>x</sub>) – at time of complaint – plume migration</p> <p>Appears to be cumulative impacts from Syncrude and Suncor plant site emissions and inversion resulting in large mass of air with pollutants moving down river valley to Fort McKay</p> <p>Other compounds increase concentrations in Fort McKay but not at industrial monitoring stations</p>

<b>Wind</b>		<p>The predominate wind directions during inversion between 00:00 to 07:00 are:</p> <p>from NNW, WNW, and NW at AMS01 and AMS13; from SSE, ESE, and S at AMS02; from SE and ESE at AMS05; from SW and SSW at AMS15; and from NNW and NW at AMS11</p> <p>The predominate wind directions after inversion breakup between 12:00 and 13:00 are:</p> <p>From S and SSE at AMS01; from S at AMS13; from SSE at AMS02; from SE at AMS05; from SSW and S at AMS15; from SE at AMS11</p> <p>The predominate wind direction three hours before 18:00 to 19:00 are:</p> <p>From N at AMS01; from NW at AMS13; from NE and SE at AMS02; from SSE and S at AMS05; from ENE and N at AMS15; from WSW and WNW at AMS11</p> <p>On this day, the wind pattern shows a clear pattern on how pollutant travelled down the river valley from SE of the AMS01 during the morning hours. When inversion breaks up after sun rise, the accumulation of the pollution will impact Fort McKay.</p> <p>The 2nd peak observed in the afternoon is likely caused by wind direction changes, resulting another round of accumulation.</p>
<b>Plant Issues</b>	<b>Syncrude Mildred Lake (EPEA #26)</b>	Nothing Significant. Higher emissions from FGD unit (23.2 t/d) – yearly average was 10.5 t/d. Smaller amounts flared from debutanizer.
	<b>Suncor Base (EPEA #94)</b>	Potential Sources – Flaring of sour butane (4.9 t/d), Low Pressure Sour Gas (0.1 t/d) and High Pressure Sour Gas (10.7 t/d) continued from previous day due to excess butane and high pressure. Continuous routine flaring and sour fuel gas also occurred.
	<b>CNRL Horizon (EPEA #149968)</b>	Nothing Significant on Date – No SO <sub>2</sub> Events Identified on February 25th, 2010 (or 3 days prior).



Figure 67. Concentration profiles for February 25, 2010

**Table 41. June 1, 2010 summary of complaints, ambient air conditions, meteorological conditions, and plant operational details**

<b>Date</b>	June 1, 2010 was chosen because there were complaints logged and it was one of the two dates FMSD collected canister data during the 2010 odour monitoring event.
<b>Complaints</b>	There was one complaint on this day. The odour was noted around 09:30. The complainant noted a very strong odour that started in the morning and was ongoing. The caller was concerned about air quality and the smell was causing a burning sensation to their eyes.
<b>Ambient</b>	<p>Possible Inversion 00:00–0:600, 22:00–0:00</p> <p>SO<sub>2</sub> – AMS02 – Lower Camp highest concentration, increase between 09:30–11:30 then peaks at 12:30 – likely source, detected in Fort McKay at 09:30 (minor) then spike at 01:30–07:30, peaks at all AMS after 14:00 below OT. Evident trend of dispersion of SO<sub>2</sub> after peak detection at 11:30 from AMS02&gt;AMS01=AMS15&gt;AMS05</p> <p>H<sub>2</sub>S/TRS is greater than OT at all AMS locations except Fort McKay</p> <p>TRS is greater than OT at Fort McKay from 05:30–11:00 comparable concentrations to AMS15 (CNRL)</p> <p>NO<sub>x</sub> (all measured) CNRL and Fort McKay same trends but higher concentrations at Fort McKay – dispersed to CNRL AMS from southern source.</p> <p>THC – multiple spikes throughout day but initial at 02:30 at AMS02 and AMS11, AMS11 continued elevated concentrations correlate with early am detections in Fort McKay (06:00) then appears to increase.</p> <p>AMS15 (CNRL) at same time as detection in Fort McKay. AMS 11 remains elevated in correlation with increases at Fort McKay until 10:00 then Fort McKay concentrations decrease but AMS11 remains elevated.</p> <p>AMS02 and AM11 appear to be near source but notably concentrations in Fort McKay higher for THC than any industrial station (09:30, at time of odour complaint), H<sub>2</sub>S highest at AMS11 (10:30–11:30) and SO<sub>2</sub> highest at AMS02 (between 12:00–13:00).</p>

<b>Wind</b>		<p>The wind direction during the possible inversion hours are not different rest of the day.</p> <p>The predominate wind directions three hours before 09:30 are From SE and SSE at AMS1; from SSE, ESE, and SE at AMS13; from S at AMS02; from SSE;S and ESE at AMS05; from SE and SSE at AMS15; from SE at AMS11</p> <p>The predominate wind directions three hours between 13:00 to 16:00 are From S and SE at AMS1; SSW,SSE and SW at AMS13; from S and SW at AMS02; from ESE and E at AMS05; from E, SE and ESE at AMS15; from E, ESE, and SE at AMS11;</p>
<b>Plant Issues</b>	<b>Syncrude Mildred Lake (EPEA #26)</b>	Some Venting – three tanks were venting some gas – Light Slops received hot product and vented sour gas for 0.17 hours. Treated Naphtha and Hot slops venting intermittently (over 4–9 hrs) due to compressor down for maintenance. Small amount of SO <sub>2</sub> flaring from a few sources (LP Flare, HP Flare, H <sub>2</sub> S Flare)
	<b>Suncor Base (EPEA #94)</b>	Significant Event – Flaring of low pressure sour gas started in May continues into June, 89.99 t of SO <sub>2</sub> over 593.27 hr (3.6 t/d). Also flaring of butane for month of June (0.4 t/d). Coker gas to flare for 2.07 hrs released 35.93 t of SO <sub>2</sub> (416.6 t/d).
	<b>CNRL Horizon (EPEA #149968)</b>	Nothing Significant on Date – No SO <sub>2</sub> Events Identified on June 1, 2010 (or three days prior).



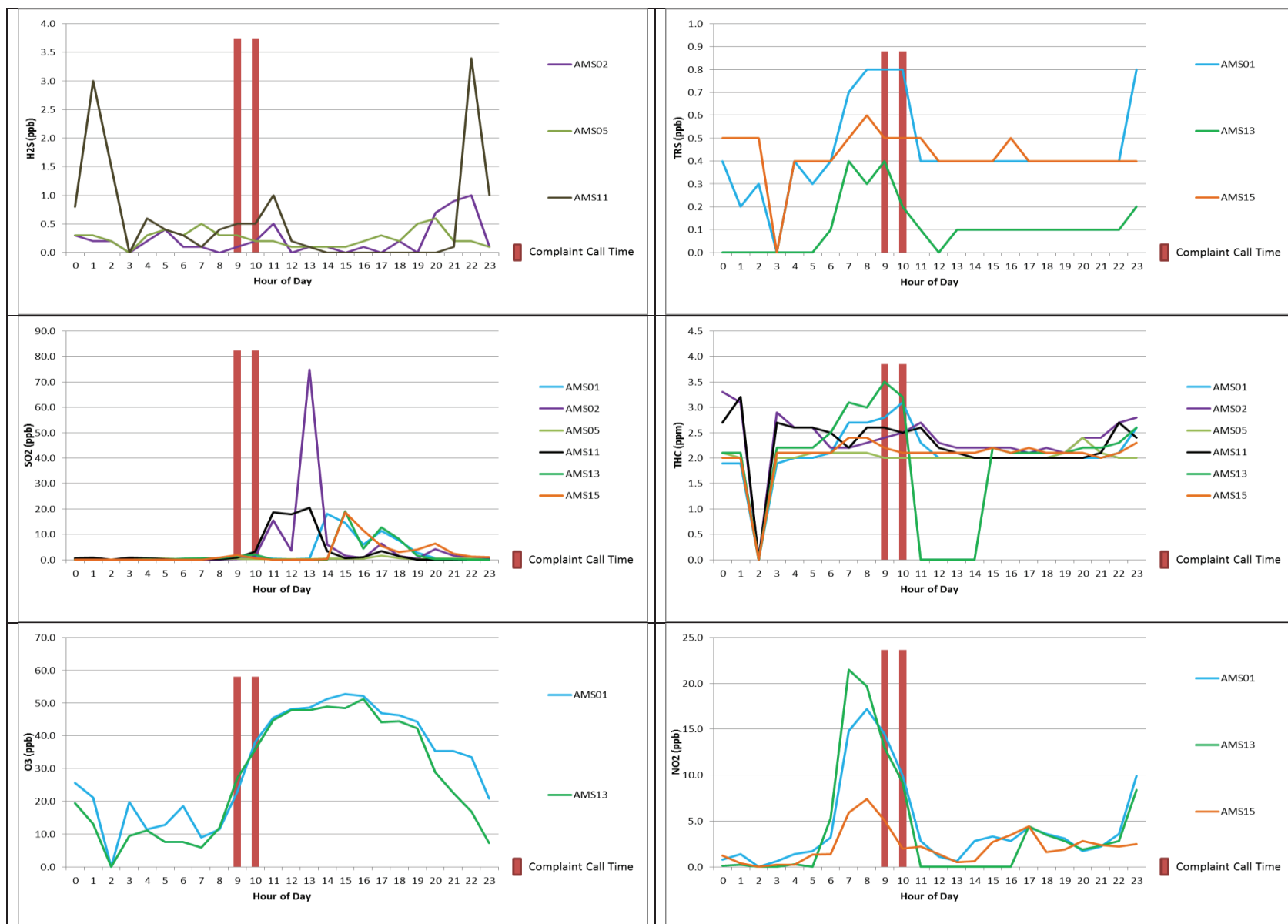


Figure 68. Concentration profiles for June 1, 2010

**Table 42. September 21, 2011 summary of complaints, ambient air conditions, meteorological conditions, and plant operational details**

<b>Date</b>		September 21, 2011 was chosen because there were one or more complaints within EMS and AAAQO exceedances noted.
<b>Complaints</b>		There were two complaints on this day. The odour was noted between 08:00 and 08:30. Both complaints noted a hydrocarbon odour.
<b>Ambient</b>		<p>Possible Inversion: 00:00–07:00</p> <p>SO<sub>2</sub> – peak concentration in Fort McKay at AMS11, slight elevations at AMS15 (02:30 and 05:30) and AMS11 (07:30), second elevation at 16:30 in Fort McKay no increase at any industrial AMS at same time but AMS11 and AMS05 had increases at 11:30 (minor compared to AMS01 concentrations)</p> <p>H<sub>2</sub>S – spikes throughout day at AMS02 correlation with TRS increases in Fort McKay throughout day (time lag apparent). OT exceedances at 03:30 and from 06:30 am for rest of day</p> <p>THC correlation Mildred Lake (AMS02) and Fort McKay all day (2–3.5 ppm)</p> <p>Potential link of odour complaint due to elevated H<sub>2</sub>S and THC at source near AMS02 (Mildred Lake) which elevated TRS (above OTs) and THC in Fort McKay at time of complaint</p>
<b>Wind</b>		<p>The wind direction during the possible inversion hours from 00:00 to 07:00 are not different rest of the day.</p> <p>The predominate wind directions between 8:00 and 13:00 are:            From S and SSE at AMS01; from S and SSE at AMS13; from S, SSE AMS02; from SE and SSE at AMS05; from S and SSW at AMS15; from SE and SSE at AMS11</p> <p>The wind pattern during the during the complaint hours shows a strong pattern of the river channel effects. This indicates the potential of the accumulative effects.</p>
<b>Plant Issues</b>	<b>Syncrude Mildred Lake (EPEA #26)</b>	Turnaround Sep/Oct, No monthly report available for September.
	<b>Suncor Base (EPEA #94)</b>	Potential Sources – No intermittent flaring on 21st but flaring of sweet butane continued from previous day due to high pressure. Continuous routine sour flaring and sour fuel emissions (6.9 t/d).
	<b>CNRL Horizon (EPEA #149968)</b>	Nothing Significant on Date – No SO <sub>2</sub> Events Identified on September 21, 2011 (or three days prior).



Figure 69. Concentration profiles for September 21, 2011

**Table 43. October 13, 2012 summary of complaints, ambient air conditions, meteorological conditions, and plant operational details**

<b>Date</b>	October 13, 2012 was chosen because there was one complaint logged and it was specifically noted in the 2012 HEMP report as a major event with high odotech, wind direction from North and two complaints received.
<b>Complaints</b>	There was one complaint on this day. The odour was noted around 16:30. The complainant described the odour as similar to cat pee and the smell was inside the house. They also provided that their eyes were starting to sting.
<b>Ambient</b>	<p>Unlikely Inversion</p> <p>SO<sub>2</sub> peak at 09:30 (1.2 ppb) and 03:30 (2.2ppb) detected at Mildred Lake AMS, below OT. Lower Camp and Fort McKay signatures correlate with highest concentration at AMS02 at time of complaint (wind?)</p> <p>H<sub>2</sub>S fluctuates between 0.1 and 0.85 ppb at Mildred Lake and Lower Camp all day</p> <p>TRS is greater than OT at Fort McKay from 13:30 for rest of day, peaks at time of odour complaint (1 ppb)</p> <p>THC – peak at Mildred Lake AMS02 and CNRL AMS15 at 0930, higher detection at AMS 11 Lower Camp then peaks in Fort McKay at 15:00–15:30</p> <p>Source of odour complaint appears to be correlated to sources near AM2 (Mildred Lake: SO<sub>2</sub>, H<sub>2</sub>S, THC), AMS 11 (Lower Camp: SO<sub>2</sub>, H<sub>2</sub>S), and AMS13 (Syncrude UE1: SO<sub>2</sub>, THC, TRS)</p>
<b>Wind</b>	<p>The predominate wind direction between are 16:00 to 17:00 are:</p> <p>From SSW and ENE at AMS01; from E and S at AMS13; from SSE at AMS02; from S and SSE at AMS05; from S at AMS15; from SE and SSE at AMS11</p> <p>The wind pattern during the complaint hours shows a strong pattern of the river channel effects. This indicates the potential of the accumulative effects.</p>

<b>Plant Issues</b>	<b>Syncrude Mildred Lake (EPEA #26)</b>	Nothing Very Significant. Flaring flash gas from degasser due to plant upset. Both VRU compressors offline for 1.5 hrs but no reported venting. Recovery on FGD unit below 90% (84.64%), but below 90% for two-thirds of the month. FGD unit emissions for this date was 23 t/d while annual average was 13.8 t/d. Monthly report suggest variable wind directions through the day, coming from the north at time of report.
	<b>Suncor Base (EPEA #94)</b>	Potential Sources – No intermittent flaring reported. Continuous routine flaring and sour fuel gas with SO <sub>2</sub> emissions (2.64 t/d). Liquid stream (34-24 A/B) double monthly average for diluent and bitumen. Liquid stream (10-2C) double monthly average for H <sub>2</sub> S and NH <sub>3</sub> . No stack exceedances, but bypassed SuperClaus 20 minutes as 8F-19 tripped on high H <sub>2</sub> S.
	<b>CNRL Horizon (EPEA #149968)</b>	Potential Source – 13/10/2012 11:00 to 19/11/2012 11:00 Did not meet minimum SRU incinerator stack-top temperature of 538oC. Planned outage from October 11 to October 22, 2012. During the outage the temperature in the incinerator stack is preserved at 375 OC by burning natural gas.

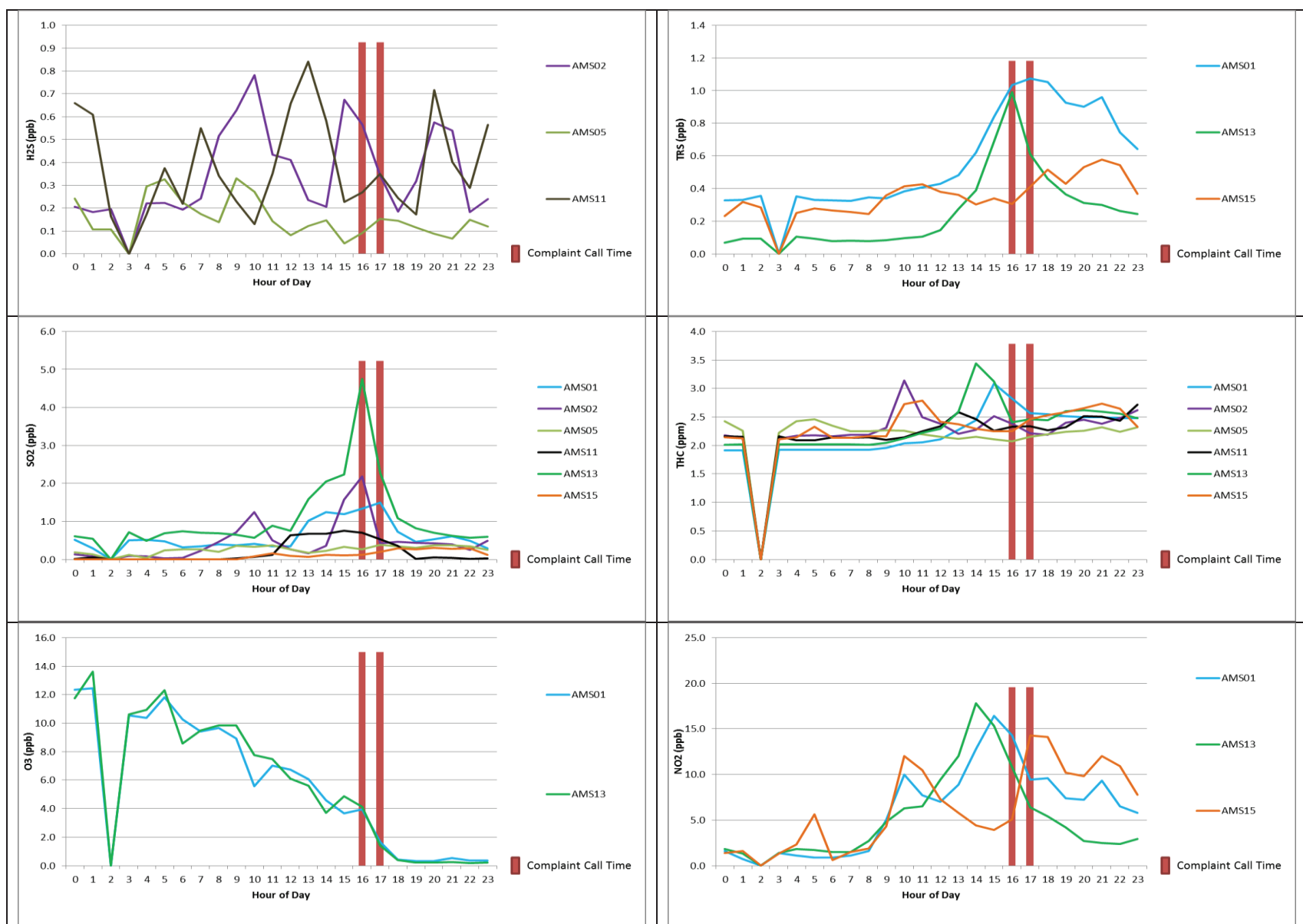


Figure 70. Concentration profiles for October 13, 2012



**Table 44. August 24, 2013 summary of complaints, ambient air conditions, meteorological conditions, and plant operational details**

<b>Date</b>	August 24, 2013 was chosen because there was one complaint logged and it was specifically noted in the 2013 HEMP report as a major event with high TRS.
<b>Complaints</b>	There was one complaint on this day. The odour was noted around 10:00. The complainant described a sulphur or hydrocarbon smell that is very bad. There was no wind at the time.
<b>Ambient</b>	<p>Possible Inversion: 00:00–07:00 with breakup fumigation later in morning</p> <p>TRS peaks at 10:00 in Fort McKay (AMS01 ~3.5 ppb, is greater than OT), AMS 2 (max 5 ppb) and AMS 11 (&lt;1 ppb) H<sub>2</sub>S detected prior to odour complaint in Fort McKay – cumulative, no large point-source release detected at industrial site. Oski-ôtin (EC) detects TRS at 1 ppb at time of complaint with peak of 4 ppb at 1500.</p> <p>SO<sub>2</sub> elevated later in day, AMS01 (Fort McKay 12 ppb), AMS02 (Mildred Lake 6 ppb), AMS 5 (Mannix, &lt; 1 ppb) – cumulative, below OT, Primary Source near Mildred Lake</p> <p>THC – AMS 11 ( Lower Camp peaks 3.5 ppm at 0300), AMS02 (Mildred peaks ~3.4 ppm 0430), AMS 11 (Mannix peaks ~3.4 ppm 07:30), AMS01 (Fort McKay peaks between 09:00–10:00 ~2.8 ppb)</p> <p>Potential source of odour is elevated TRS and THC from AMS 11 and 2 (link to Syncrude upset events appear later in day as increased SO<sub>2</sub>) early morning emissions from plant site (Inversion, cumulative source).</p>
<b>Wind</b>	<p>The predominate wind directions during inversion between 00:00–07:00 are:</p> <p>from NW, WNW, and W at AMS-1 and AMS13; from SSE, SSW, and S at AMS02; from SSE at AMS05; from NW, WNW, and NW at AMS15; and from SE and ESE at AMS11</p> <p>The predominate wind direction after the inversion lifted around between 9:00 to 16:00</p> <p>From S and SSE at AMS01; from SSE, ESE, and SE at AMS13; from SSE and SE at AMS02; from SE and SSE at AMS05; from S and SSE at AMS15; from SE at AMS11</p> <p>On this day, the wind pattern shows a clear pattern on how pollutant travel down the river valley from SE of the AMS01 during the morning hours. When inversion lifted after sun rise, the accumulative of the pollution will enter Fort McKay.</p>

<b>Plant Issues</b>	<b>Syncrude Mildred Lake (EPEA #26)</b>	Significant Event Day – FGD Unit below 90% (88.5% recovery) – emissions double normal day 23.5 t/d vs 12 t/d, Flaring from SERP when 15-3 is offline (3.8 t/d), Flaring due to K-3 down for repair (15.8 t/d) and small amount from debutanizer.
	<b>Suncor Base (EPEA #94)</b>	Some flaring day – No stack exceedances but bypassed SuperClaus for 56 minutes. Flared sweet butane for 21.6 hours due to high pressure. Flared low pressure sour gas with 2.44 t for 20.2 hours (2.9 t/d) to avoid compressor trips during low rates (two coker operation).
	<b>CNRL Horizon (EPEA #149968)</b>	Potential Sources – 22/08/2013, 13:00 SCOT unit tripped down and AER was notified immediately. SRU incinerator stack CEMS measured a maximum hourly value of 1827.34 kg/h SO <sub>2</sub> (Maximum Value). CNRL identified this as not an exceedance as during the SCOT shutdown limit should be 7.1 t/h instead of 930 kg/hr SO <sub>2</sub> .



Figure 71. Concentration profiles for August 24, 2013

**Table 45. November 6, 2013 summary of complaints, ambient air conditions, meteorological conditions, and plant operational details**

<b>Date</b>		November 6, 2013 was chosen because of the strong sulphide smell/naphtha and three complaints logged.
<b>Complaints</b>		There were three complaints on this day. The odours were noted around 11:00. The complaints described the odours as a sulphur smell. Two of the complainants did not know the wind direction while the third noted a south wind. The smell is noted to be very strong and was present indoors via an open window.
<b>Ambient</b>		<p>Unlikely Inversion</p> <p>H<sub>2</sub>S and TRS -elevated in Fort McKay at time of complaint (Oski-ôtin TRS 8 ppb/H<sub>2</sub>S 1.6 ppb; WBEA AMS01 TRS &lt;1 ppb). H<sub>2</sub>S releases detected at AMS02 (Mildred max 0.7 ppb) AMS11 (Lower Camp, max 0.3 ppb), and AMS 05 (Mannix, max 0.4 ppb) between 00:00 and 08:00</p> <p>THC peak at AMS 2 Mildred max ~6.2 ppm at 02:30, no peaks at complaint time or later in day – unlikely source</p> <p>SO<sub>2</sub> peaks at AMS02 at ~20 ppb at 17:00 – not source and interesting that no peak seen in Fort McKay later that day. AMS15 (CNRL) had early morning peak ~13 ppb at 03:00</p> <p>Potential source of odour complaint is source near AMS02 and to lesser extent AMS 5 and 11 early morning H<sub>2</sub>S/TRS releases/ industrial detections.</p>
<b>Wind</b>		<p>The predominate wind directions after the inversion lifted around between 10:00 to 12:00 are:</p> <p>From S and SSE at AMS01, AM13; &amp; Oski-ôtin; from SSE and S at AMS02; from SE and SSE at AMS05; from S at AMS15; from SE at AMS11</p>
<b>Plant Issues</b>	<b>Synchrude Mildred Lake (EPEA #26)</b>	Significant Event – Plant 26-1 increased feed rates, too much ammonia injected. Highest vapour losses for the month as reported on the plant 12 summary. Highest SO <sub>2</sub> emissions of the month from the FGD unit (24.6 tonnes vs annual average of 13.2 t/d).
	<b>Suncor Base (EPEA #94)</b>	Insignificant Event – Flare sweet butane for 11.73 hours due to 56 D-1001 being full. Flared Low Pressure Sour Gas with low SO <sub>2</sub> emissions for 0.55 hours (2.2 t/d) due to increased inlet water concentration. No stack exceedances.
	<b>CNRL Horizon (EPEA #149968)</b>	Nothing Significant – No SO <sub>2</sub> Events Identified on November 6, 2013 (or 3 days prior).

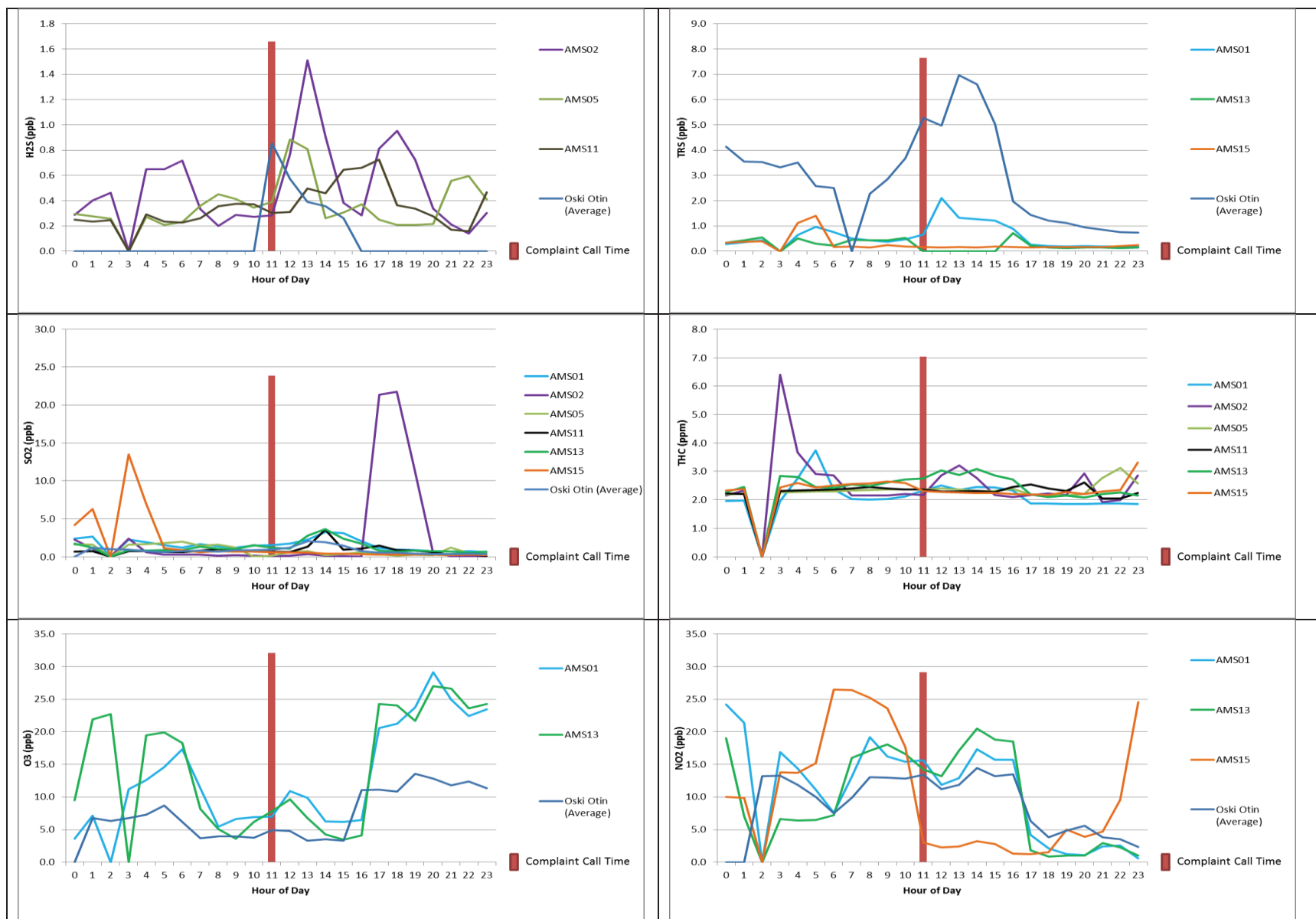


Figure 72. Concentration profiles for November 6, 2013

**Table 46. March 2, 2014 summary of complaints, ambient air conditions, meteorological conditions, and plant operational details**

<b>Date</b>		March 2, 2014 was chosen because of large number of complaints.
<b>Complaints</b>		There were five complaints on this day. The complaint on the odours was noted between 11:00 and 11:30 a.m. Complaints were described as like bitumen, diesel, and oil and gas. One complainant noted coughing, a headache, and tears in their eyes. Another complainant had a headache and was nauseated
<b>Ambient</b>		<p>Possible Inversion: 00:00–12:00, 20:00–24:00</p> <p>No notable peaks at any AMS for THC at complaint time, slight increase (~3.5 ppm at AMS11 after 15:00) – no link to complaint</p> <p>H<sub>2</sub>S peak detection at AMS11 (Lower Camp ~6.5 ppb) at 12:30. Nominal fluctuations between 0.5 and 1.5 ppb from 03:30 throughout day at AMS02, 11 &amp; 05 (equal contribution). Fort McKay AMS01 max TRS ~3 ppb between 11:30–12:30.</p> <p>SO<sub>2</sub> decreased at all AMS locations between 10:00–17:00, max ~30 ppb at AMS05&gt;Max 15 ppb AMS11&gt;Max 11 ppb AMS01 in Fort McKay – plume dispersion from early morning inversion</p> <p>Potential source – TRS (and SO<sub>2</sub> later in day) elevated from sources near Mildred Lake, Lower Camp, and Mannix but only TRS elevated during complaint time and are greater than the OT. Cumulative from normal plant operations with inversion event.</p>
<b>Wind</b>		<p>The predominate wind directions between 10:00 to 12:00 are:</p> <p>From SE and SSE at AMS01 &amp; Oski-ôtin; from ESE and E at AMS13; from SSW at AMS02; from E and SSE at AMS05; from SSW and SSE at AMS15; from SSE and SE at AMS11</p>
<b>Plant Issues</b>	<b>Syncrude Mildred Lake (EPEA #26)</b>	Some Flaring – Flaring 19.2 t due to K-3 down for repairs. Flaring 7.9 t from 16-1/2/4 when 16-3 is offline.
	<b>Suncor Base (EPEA #94)</b>	Some Flaring – Flaring 0.8 t over 3.86 hours (5.0 t/d) excess low pressure sour gas due to missing recovery during water quench due. Flared sweet butane for 20.35 hours due to high pressure. Routine flaring of Low and High Pressure Sour Gas over 24 hours (9.8 t/d) due to upsets of March 1st.
	<b>CNRL Horizon (EPEA #149968)</b>	Nothing Significant on Date – No SO <sub>2</sub> Events Identified on March 2, 2014 (or three days prior). Information from annual report. No monthly CEMS report for March 2014 available.



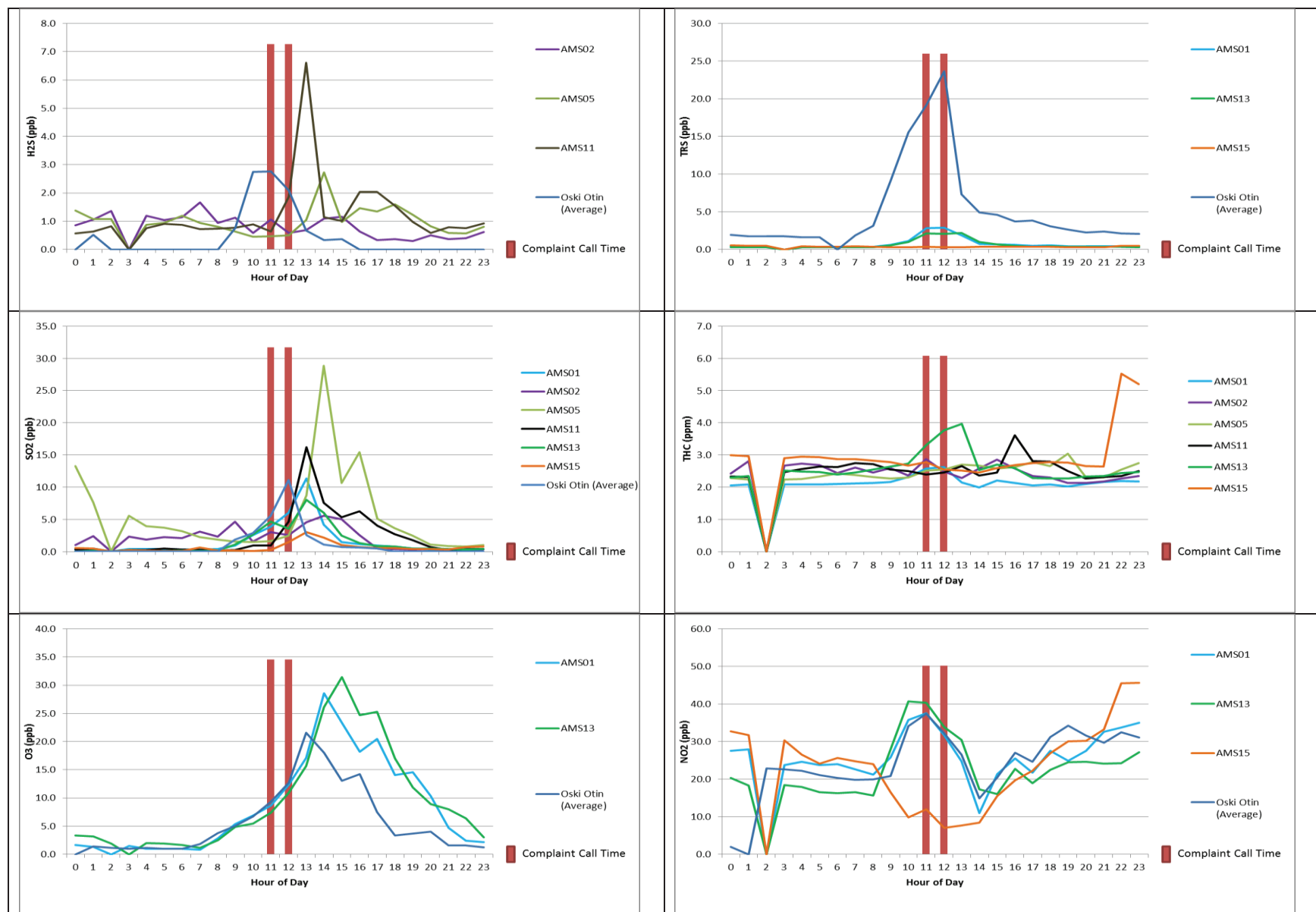


Figure 73. Concentration profiles for March 2, 2014

**Table 47. July 28, 29, and 30 of 2014 summary of complaints, ambient air conditions, meteorological conditions, and plant operational details**

<b>Date</b>	July 28, 29, and 30 of 2014 were chosen because of notable industry performance issues with two complaints logged on July 28.
<b>Complaints</b>	There were two complaints on July 28, 2014 (08:25 am) and there were no complaints on July 29 or 30 of 2014. One complainant described an ammonia smell and both complainants noted the smell was very strong. One complainant noted the wind was blowing northeast while the other noted the wind blowing north however, it was not overly windy. One complainant believes that the source is Syncrude's site since they saw a dark cloud off the stacks.
<b>Ambient</b>	<p>July 28 Inversion Unlikely: Maybe 21:00 – 23:00</p> <p>Early morning H<sub>2</sub>S peaks detected at 03:30; AMS02 (Mildred Lake ~2.6 ppb) &gt; AMS 11 (Lower Camp ~1.2 ppb) &gt; Oski-ôtin (Fort McKay mean ~1 ppb) &gt; AMS05 (Mannix &lt;0.5 ppb).</p> <p>TRS and H<sub>2</sub>S peak in Fort McKay at 09:30 (TRS 21 ppb, Oski-ôtin mean, ~ 1 ppb WBEA AMS01 mean) – link to complaint</p> <p>SO<sub>2</sub> peaks in Fort McKay at 09:30 – link to complaint time</p> <p>Potential source is early morning in vicinity of early morning detections near Syncrude and Suncor – cumulative from upset events at each plant site related to SO<sub>2</sub> and TRS/H<sub>2</sub>S.</p>
<b>Wind</b>	<p>The predominate wind direction between 07:00 to 12:00 are:</p> <p>From SSE and S at AMS01 &amp; Oski-ôtin; from SSE and S at AMS13; from S at AMS02; from SE and ESE at AMS05; from S and SSE at AMS15; from SE at AMS11</p>
<b>Plant Issues</b>	<p><b>Syncrude Mildred Lake (EPEA #26)</b></p> <p>Significant Event Day – Flaring 75 t over 2 hours from amine plants during start-up. Flaring 8.6 t SO<sub>2</sub> from NH<sub>3</sub> stream when 16-3 is offline; 16-1 on recycle. Plant 12-1 shutdown caused 12-3 and 12-4 to run off ratio and too much ammonia was injected. Plant 12-1 shut down caused acid gas to be vented through antisurge valve F-23 for 0.33 hours.</p>
	<p><b>Suncor Base (EPEA #94)</b></p> <p>Possibly Significant Event Day – Flaring 25.7 t over 18 hours of sour water acid gas (34.9 t/d) to make room for acid gas following sulphur recovery unit 2 trip. Also flared sweet butane and low pressure sour gas (2.1 and 11.6 t/d from two flares) intermittently. Continuous routine flaring and sour fuel gas (2.4 t/d).</p> <p>No stack exceedances but bypassed SuperClaus for 3 hours.</p>
	<p><b>CNRL Horizon (EPEA #149968)</b></p> <p>Nothing Significant on Date – No SO<sub>2</sub> events Identified on July 28, 2014 (or three days prior).</p>

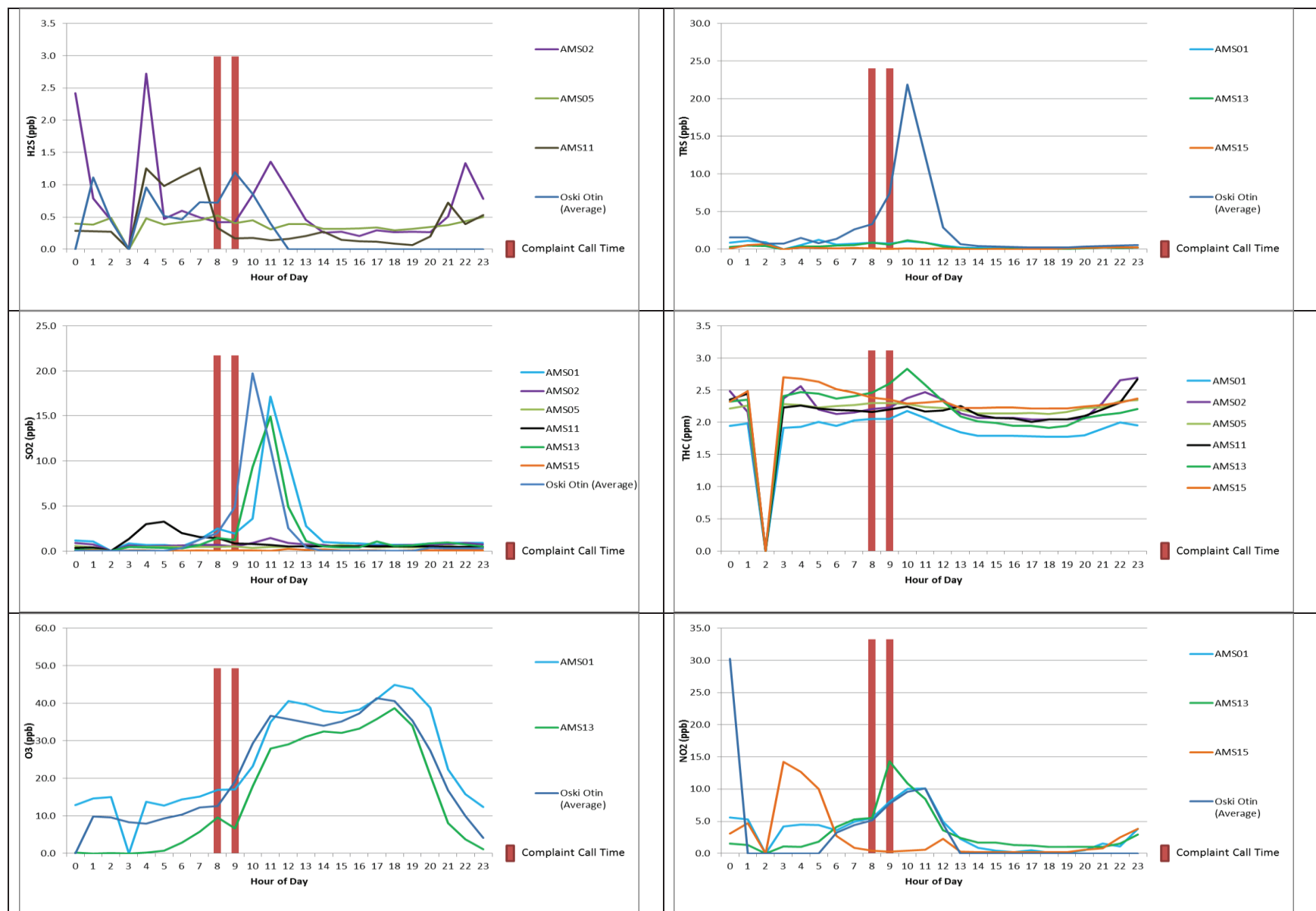


Figure 74. Concentration profiles for July 28, 2014

**Table 48. September 22, 2014 summary of complaints, ambient air conditions, meteorological conditions, and plant operational details**

<b>Date</b>	September 22, 2014 was chosen because there were three H <sub>2</sub> S exceedances in this timeframe and multiple complaints logged.
<b>Complaints</b>	There were eight complaints on this day. The odours were mainly noted between 10:00 and 12:00. Complaints described the odours as smelling like sewage, tailing ponds, ammonia, hydrocarbon and sulphur. In some complaints the wind was noted to be blowing towards the north and northwest directions. The odour was generally described as very intense and some complainants were receiving headaches, watery eyes and sore throats. Many of the complaints described the odours as making its way indoors and they were questioning whether or not there is a need to evacuate.
<b>Ambient</b>	<p>Possible Inversion: 00:00–07:00, 18:00–23:00</p> <p>TRS – elevated in Fort McKay between 10:00–11:00 at complaint time, peak 10 ppb at 10:30 at WBEA AMS01 and ~30 ppb mean at Oski-ôtin at 12:30.</p> <p>H<sub>2</sub>S – AMS02 detected H<sub>2</sub>S concentrations ~ 5 ppb from 00:00–04:00 and 05:00–07:00, ~ 1 ppb at AMS11 and AMS05</p> <p>SO<sub>2</sub> peaks at Fort McKay Oski-ôtin and AMS01 ~ 30 ppb at 13:00 – after complaint. AMS02 spike at 04:00 – 5 ppb and again at 13:00 10 ppb. But SO<sub>2</sub> detections after complaint.</p> <p>THC 6 ppm peak detected at AMS02 at 05:00 but elevated before.</p> <p>Potential source appears to be early morning releases from plant site near AMS02 (Mildred Lake) which increased TRS in Fort McKay. THC concentrations negligible in Fort McKay throughout day and SO<sub>2</sub> elevated from 10:00 on but peaking at 13:00 – not causes of odour complaint.</p>

Wind	<p>The predominate wind directions during morning inversion periods are : From NW,W, and WSW at AMS01; from NNW, and W at Oski-ôtin; from W and SSW at AMS13; from SSE, SE and S at AMS02 &amp; AMS05; from SSW and SW at AMS15; from SE at AMS11</p> <p>The predominate wind directions between complaints hour from 10 to 12 are: From S at AMS01 &amp; Oski-ôtin; from S and SSE at AMS13; from S and SSE at AMS02; from SE and SSE at AMS05; from S at AMS15; from SE at AMS11</p> <p>On this day, the wind pattern shows a clear pattern on how pollutant travel down the river valley from SE of the AMS01 during the morning hours. When inversion lifted after sun rise, the accumulation of the pollution will hit the Fort McKay.</p>
Plant Issues	<p><b>Syncrude Mildred Lake (EPEA #26)</b></p> <p>Significant Event Day – Diverter stack used from Sep 19–22 and SO<sub>2</sub> emissions were 90.6 t over 58 hours. Syncrude noted inversion at the time. Syncrude found no source for exceedances.</p>
	<p><b>Suncor Base (EPEA #94)</b></p> <p>Significant Event Day – U2 power outage caused flaring of sour water acid gas on 21st that extended into 22nd with 63.2 t over 35 hours (29.2 t/d). On 22nd flared LPSG and flash gas with 10.9 t over 5 hours. No stack exceedances.</p>
	<p><b>CNRL Horizon (EPEA #149968)</b></p> <p>Potential Source – 22/09/2014 21:00 – 22:00</p> <p>Due to natural gas high pressure spike on the pressure transmitter 35PI3141, Train 3 at the SRU tripped re-routing the SO<sub>2</sub> directly to the incinerator stack bypassing the SCOT Unit. This resulted in an increase of the SO<sub>2</sub> emissions emitted from the incinerator stack. SRU incinerator stack CEMS measured an hourly value of 1520 kg/h SO<sub>2</sub>. Investigation of the actual exceedance was delayed due to issues with the analyzer.</p>

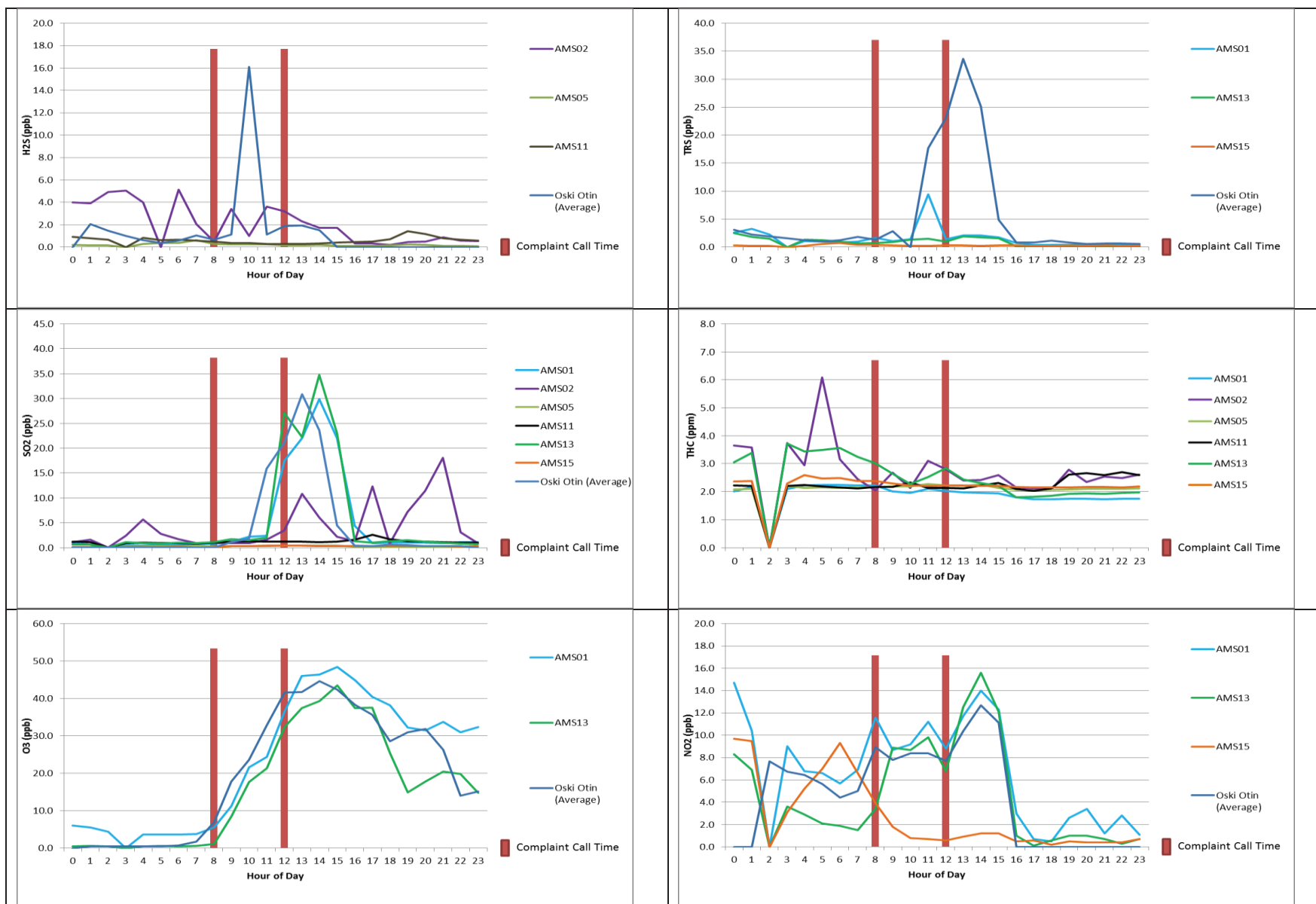


Figure 75. Concentration profiles for September 22, 2014





## Appendix 5 Stakeholder Submissions

This report includes seven submissions from various stakeholders:

- AEMERA, letter dated September 25, 2015, 3 p.
- CAPP, letter dated September 25, 2015, 2 p.
- CAPP, report dated September 2015, 43 p.
- Environment Canada, undated letter, 5 p.
- Fort McKay First Nation, letter dated October 6, 2015, 7 p.
- Fort McKay First Nation, report dated April 2013, 14 p.
- WBEA, letter dated September 25, 2015, 7 p.

Six of them have been incorporated into this report (the rest of this appendix). The CAPP report, however, was too heterogeneous to include. It has instead been attached to the electronic version of this report. To view it, click on the above link. If you are viewing this report in hard copy, please visit our website ([www.aer.ca](http://www.aer.ca)) and download the electronic version to access this attachment.

September 25, 2015

Dr. Monique Dubé  
Chief Environmental Scientist  
Strategy and Regulatory Division  
Alberta Energy Regulator

Monique.dube@aer.ca

Dear Dr. Dubé:

Thank you for your letter of August 6<sup>th</sup> requesting information from AEMERA regarding the Recurrent Human Health Complaint Process initiated for Fort McKay. Provided below are AEMERA's responses to your specific questions, which complement the input that will be provided to you separately by the Wood Buffalo Environmental Association (WBEA).

1. What does AEMERA consider the major odour sources to be? As a starting point we would like to examine facilities within 30 kilometers of Fort McKay.

*The odour issue in the area of Fort McKay is complex and consequently difficult to identify a single source or group of sources that contribute to odours. There are potentially many odour sources that will vary depending on local and regional meteorological conditions (e.g. wind direction, atmospheric stability), time of day or year, and industry operations. Potential sources in the region include tailings ponds and mine faces, fixed sources such as stacks and flares, and mobile/transient sources such as mining vehicles and transportation. Collectively, these sources are highly variable between facilities and also will change over time. Tailings ponds may be a major odour concern from one facility while stack or flaring sources may be a major odour concern from another facility. (I refer you to the response letter from WBEA for a list of specific odour sources within 30 kilometers of Fort McKay.)*

2. Which compounds or air quality parameters do you consider to be of the greatest contribution to the odour issues in Fort McKay?

*There are numerous chemical compounds that can potentially cause odours in this area. The specific compounds will depend on sources which are variable as indicated in our response to question 1. Most odours are associated with sulphur*

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*compounds or hydrocarbons. WBEA has collected extensive air quality data and will be providing details on individual pollutants that are potentially responsible for odours in Fort McKay.*

3. What do you see as key technical challenges associated with linking odour incidents to odour sources?

*Odour incidents are not necessarily linked to one or two common sources. There are many potential sources of odour and these sources can change over time. For example, at a specific time, tailings ponds from specific facility may be the major cause of a series of odour events. At another time, flaring from another facility may be the major cause of odours. The technical challenge is linking a signature from a specific source to the ambient concentrations of pollutants measured in Fort McKay.*

4. Does AEMERA see gaps in the current emissions (on-lease) monitoring of facilities and specifically how odours could be better monitored and assessed?

*Current emissions information collected through the regulatory process is limited to the major point sources such as the large stacks. There are numerous smaller sources and area sources that can also contribute collectively to local and regional odour issues. Through the Oil Sands Monitoring Program, AEMERA is working cooperatively with COSIA and relevant scientific experts to develop an integrated three year focused study that will improve the understanding of potential area odour sources such as tailings ponds and mine faces. This study will help to address knowledge gaps associated with on-site emissions and the results should help inform future source monitoring regulatory requirements applied by the Alberta Energy Regulator (AER).*

5. Does AEMERA see gaps in the current ambient monitoring program in this area and specifically how odours could be better monitored and assessed?

*There are opportunities to improve the ambient air monitoring system to better accommodate odour monitoring. WBEA has been involved in this activity for several years and has applied several different methods to monitor odours. Odours are subjective and different individuals will identify and recognize an odour at varying concentrations. AEMERA is working with the community of Fort McKay,*

...3



*along with other local stakeholders and WBEA to identify opportunities to improve air monitoring in the region to better monitor, evaluate and report odours to the community.*

6. Considering the number of stakeholders involved in this issue (individual operators, AEMERA, Environment Canada, WBEA, Fort McKay, COSIA), the persistence of this issue over time, and the attempts made over the course of time to resolve this issue, is there a collaborative process or a model of interaction that you feel has worked and would be helpful in assessing the issue?

*AEMERA is supportive of a collaborative stakeholder process to address the extremely complex odour issue in Fort McKay region.*

AEMERA is committed to working with Fort McKay, relevant stakeholders and experts to obtain the necessary scientific information and community knowledge related to monitoring, evaluation and reporting to address the odour issue. In this regard, we would be willing to participate in future processes that the AER sees appropriate as part of the Fort McKay Recurrent Human Health Complaint Process.

Yours sincerely,



Frederick J. Wrona, Ph.D.  
Vice-President and Chief Scientist  
Alberta Environmental Monitoring, Evaluation and Reporting Agency

cc. Bob Myrick, Director, Airshed Sciences  
Bill Donohue, Vice-President and Chief Environmental Monitoring Officer  
Val Mellesmoen, Vice-President, Strategy and External Relations



CANADIAN ASSOCIATION  
OF PETROLEUM PRODUCERS

Canada's Oil and Natural Gas Producers

September 25, 2015

Via Email

Monique Dubé, Ph.D.  
Chief Environmental Scientist  
Strategy and Regulatory Division  
Alberta Energy Regulator  
Suite 1000, 250 – 5 Street SW  
Calgary, Alberta T2P 0R4

Dear Ms. Dubé:

**Re: Request for Input into Fort McKay Odour Assessment: Recurrent Human Health Complaint Process**

The Canadian Association of Petroleum Producers (CAPP) has prepared the enclosed submission in response to the AER's letter of August 6, 2015 which requested that CAPP coordinate industry input into the AER's *Recurrent Human Health Complaint Process* that was triggered in relation to odour concerns expressed by the community of Fort McKay.

In preparing this submission, CAPP has worked collaboratively with technical experts from those companies that operate oil sands facilities in closest proximity to Fort McKay including Canadian Natural Resources Limited, Imperial Oil Limited, Shell Canada Limited, Suncor Energy Inc. and Syncrude Canada Ltd. To support continued industry collaboration, CAPP's members have asked that requests for additional information or meetings with industry regarding this submission and the AER's odour assessment be coordinated through CAPP.

CAPP and its members appreciate the opportunity to continue to work collaboratively with the AER and the community of Fort McKay to determine an appropriate response to odour concerns in the region. If you have any questions or require any additional information, please contact the undersigned.

Yours truly,

T. G. Abel, P.Eng.  
Director Oil Sands

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Fax 709-724-4225

310, 1321 Blanshard Street  
Victoria, British Columbia  
Canada V8W 0B5  
Tel 778-410-5000  
Fax 778-410-5001



Enclosure Attached

Cc: Alexia Neumann, Suncor Energy Inc.  
Calvin Duane, Canadian Natural Resources Ltd.  
Tracy Smith, Shell Canada Ltd.  
Diane Phillips, Syncrude Canada Ltd.  
Sandy Campbell, Imperial Oil Ltd.

On 6 August 2015 Environment Canada received a letter from the Alberta Energy Regulator requesting that we answer a series of questions as input into a Recurrent Human Health Process that was implemented to assess odour issues in Fort McKay. The following questions were posed and EC answers are provided.

**Context:**

Environment Canada (EC) has established a comprehensive air quality monitoring station in Fort McKay along with supporting meteorological measurements (e.g., wind direction and speed). The station was designed to help address the primary questions of the Air Quality Component of the Integrated Monitoring Plan for the Oil Sands, namely: What pollutants, which could contribute to ecosystem or human exposure, are being emitted from oil sands operations?; How are they transported in the atmosphere?; How are they transformed chemically in the atmosphere?; and Where are they deposited? The station was not designed to assess or detect odours, although some of the chemical species that are measured are odour causing. Therefore, the air quality measurements by Environment Canada can be used to provide information on questions related to odour. The answers to the questions below must be considered in this context.

**What does Environment Canada consider the major odour sources to be based on their research to date? As a starting point we would like to examine facilities within 30 km of Fort McKay?**

At this point in time, due to incomplete information (see some answers below), we cannot say that any of the suspected odour sources (e.g., sulphur emitters, sulphur emission control technologies, tailings ponds, fugitive hydrocarbon releases) within 30 km around Fort McKay can be ruled out. Although sulphur-related sources seem to be implicated during the cases where we have heard odour reports from residents of Fort McKay, we cannot rule out hydrocarbon-related sources as potential contributors to odour issues in Fort McKay. As hydrocarbon emissions can have many sources (bitumen processing such as dilution and/or extraction, upgrading, storage, combustion) including both point sources and fugitive sources, this further complicates the identification of specific odour-causing sources.

The monitoring being undertaken by EC quantifies concentrations of a range of gaseous and particulate air pollutants, which may be causing or be related to the occurrence of odours, but this monitoring does not measure odour. There is no accepted 'chemical measurement' for odour as it is based upon individual perception.

Our research to date has involved ongoing preliminary analysis of episodes lasting on the order of hours of elevated pollutant concentrations. For certain episodes we have received reports from our partners in Fort McKay (The Fort McKay Sustainability Department), either during the event or afterwards, that odours were also detected. At times such reports have also included a subjective indication of the severity of the odour event and its characteristics (i.e., how it smells). Some case studies using available data (from EC, Fort McKay and Wood Buffalo Environmental Association) have subsequently been included in reports prepared by the Fort McKay Sustainability Department.

A quantitative analysis of the correlation between odour and pollutant concentrations has not been attempted by EC researchers. Generally, reports of detectable odours from The Fort McKay Sustainability Department or our own research staff on site for equipment maintenance, most often accompany increases in sulphur-related pollutants such as sulphur dioxide (SO<sub>2</sub>) and Total Reduced Sulphur compounds (TRS) and surface wind directions that are southerly to southeasterly. On some occasions there is a higher ratio of TRS to SO<sub>2</sub> during odour events in the colder months. We hypothesize this may be due to the TRS sources being closer to the ground relative to the taller stack emitting SO<sub>2</sub> and during colder months the suppressed vertical mixing allows the ground-based emissions to travel horizontally (i.e., towards Fort McKay) while remaining at higher concentrations. This vertical mixing also reduces the mingling of the ground-based emissions and the emissions from the higher stacks, which will stay above the ground more often. Future analyses of the data, once a sufficient amount has been collected, could test this and other hypotheses.

**Which compounds or air quality parameters does Environment Canada consider to be of greatest contribution to the odour issues in Fort McKay?**

Multiple pollutants have the potential to be detected by smell and may represent something unpleasant to certain individuals. We consider that Total Reduced Sulphur (TRS) compounds (e.g., hydrogen sulphide (H<sub>2</sub>S), thiophenes or mercaptans), which are predominantly in the gas phase, but could also be in the particle phase, and hydrocarbons (Volatile Organic Compounds) are the major contributors. EC's monitoring has targeted these classes with some enhanced methods to help inform the odour issue and JOSM (Air Component) science questions related to emissions from oil sands operations. SO<sub>2</sub> is also a possible contributor to the odours noticed in Fort McKay. Ammonia and amines are also considered possible odour contributors.

**What do you view as the key technical challenges associated with linking odour incidents to odour sources?**

Assuming the goal is to identify specific sources at specific industrial facilities, particularly those most-frequently leading to downwind odour complaints, there are several challenges. Some are listed below.

1. Acquisition of a systematic, sub-daily, reliable time series of odour occurrence, severity and location, in conjunction with detailed measurements, in order to capture a sufficient number of unique odour events for subsequent analysis and diagnosis of causes.
2. Cost-effective, robust, very high resolution temporal and spatial coverage of pollutant measurements during odour events impacting Fort McKay from a fixed network of concentration sensors.
3. Based on an appropriate science-based measurement strategy, utilization of a ground-based mobile platform of sensitive measurement instruments and methods that respond rapidly to and quantify pollutants most likely causing the odours. Such instruments should focus on sulphur pollutants (SO<sub>2</sub> and TRS) and VOCs. Mobile surveys are limited by availability of roads, impassible terrain for off-road vehicles and by being unable to move from outside to within facility fence lines.

4. Local-scale high resolution meteorological and chemical tracer models with supporting meteorological data (4 dimensional) that can be used to conduct/support odour case-studies in a “forward” and “backward” trajectory/dispersion mode.
5. Development of improved measurement methods for odour-producing gas phase pollutants. Both sulphur-based and hydrocarbon-based odour causing pollutants are potentially reactive and in some cases semi-volatile. This brings additional challenges to the measurements as such pollutants can be lost on sample inlet lines or other surfaces in the measurement system before being detected by the instrumentation, which leads to greater measurement uncertainty, potential low bias in concentrations and lack of information on potentially important compounds (odour-causes and/or toxic).
6. Knowledge of unique chemical tracers (or fingerprints) that are emitted from the same location (stack, area source or fugitive release) as the odour-causing pollutants and that can be measured downwind to more definitively link the odour to the point(s) of release.
7. Understanding of the meteorological conditions most conducive to odour events downwind also needs to be improved. Whereas wind directions can be linked to the occurrence of events, other factors play a major role. This includes the extent of vertical mixing between source and receptor, the influence of meteorological conditions in enhancing emissions from potential open sources such as tailings ponds, and how local terrain influences the movement of air pollutant plumes horizontally and vertically.

**Does Environment Canada see gaps in the current emissions (on-lease) monitoring of facilities and specifically how odours could be better monitored and assessed?**

To our knowledge the amount of emissions monitoring (i.e., continuous measurements that are accessible to all stakeholders within a defined time line or ideally in near real-time) is limited and focuses on large point sources for SO<sub>2</sub> and NO<sub>x</sub>. Whereas SO<sub>2</sub> does cause odours, and there are large local sources of SO<sub>2</sub>, it is not likely to be the dominant or only cause of the odour events. Furthermore, in many cases the SO<sub>2</sub> emissions from the large point sources come from taller stacks and the plumes have a higher potential to stay above the ground.

The current approach to quantify emissions of a large number of the species reported to inventories, some of which may be responsible for odours, is through indirect calculations using emission factors. There are a number of challenges in obtaining appropriate emission factors. Firstly, obtaining an emission factor for a given pollutant and for a specific emission source in the oil sands facilities can be costly and may only have been done a limited number of times. Secondly, in lieu of measuring the emission factor at the source in question, published emission factors for similar facilities based upon typical operations are often used to estimate emissions. As a result, the emission factors used to estimate emissions may or may not be specific to the sources at the actual oil sands facilities, may have an unspecified uncertainty, may be incorrect or not representative of periods of non-standard operation, and if based upon measurements from the facility in question may not be up to date given the expense in determining facility-specific emission factors.

Ultimately, the emissions factors, measured or selected from a database, are combined with data on activity level (e.g., fuel consumed, raw material processed, reagents used), which can also be uncertain and thus based upon educated estimates. Such inventory calculations (emission factor x activity level) are often derived based upon typical operations (facility performance and activity level) and the results are rolled-up to annual totals. Thus given the potential for short term temporal variability in emissions, annual totals are less likely to reflect the emissions at the time that odour was detected downwind. Real-time monitoring at or very near the points of emission, that targets the likely odour-causing pollutants, would be needed to advance our understanding of emissions.

While facilities report their emissions as required through the regulatory or approval processes, EC estimates of emission rates based on aircraft-derived top-down measurements have shown some differences which may suggest gaps in the emissions estimates that could be improved. Specifically top-down estimates of emission rates from the main oil sands facilities were determined through Environment Canada aircraft-based measurements in Aug.-Sept. 2013. These have been compared to reported emission rates for SO<sub>2</sub>, NO<sub>x</sub>, selected VOCs and Particulate Matter (PM). For each pollutant, the aircraft-determined emission rates were larger than the reported values, in many cases by a significant amount (2-10 times depending on the pollutant). In some cases, VOC compounds were observed with the aircraft-based instruments that were not reported or estimated by the facilities.

**Does Environment Canada see gaps in the current ambient monitoring program in this area and specifically how odours could be better monitored and assessed?**

See the response above regarding technical challenges and gaps in monitoring.

If a specified goal of ambient monitoring is the detection of major odour causing compounds, it is suggested that methodological improvements in the measurement of TRS and VOCs, in total, and by chemical species, are needed. The measurement locations for deployment of the standard air quality and meteorological parameters along with possible improved TRS and VOC measurements could also be optimized to capture the peaks in concentrations during odour events and to help identify the direction or pathways of movement. However, a full-scale reconfiguration of the monitoring network is not being recommended. A potentially more-viable approach would be to add strategic measurements at appropriate existing sites that do not have a full complement of measurements (i.e., nitrogen oxides, total reduced sulphur, carbon monoxide, VOCs) and then to augment the long-term monitoring with short-term studies.

As part of the monitoring, EC has tested in Fort McKay a new method designed to minimize the potential loss of more reactive TRS compounds during sampling. The results suggest that there may be more TRS during some events than the currently accepted measurement method indicates. Furthermore, H<sub>2</sub>S was determined not to be responsible for this additional TRS. Additional testing is required to fully understand these differences in measurements and find out what conditions lead to the largest differences and what compounds are responsible. This information may help point towards more sensitive and representative TRS measurement approaches that could be applied in the future across multiple locations, including near sources, to help better understand the characteristics of odour

episodes. EC is working with Wood Buffalo Environmental Association (WBEA) in the next phase of testing.

Environment Canada has also deployed, at the measurement site in Fort McKay, measurement equipment capable of semi-continuous speciation of multiple VOCs. This has shown that, among the VOCs that can be detected with this method, the most prevalent compounds are related to solvents used by the oil sands mining companies as solvents to help extract the petroleum components from bitumen. This includes hexane, heptane and octane. Similar to TRS, there are suspected limitations in the currently accepted method for total VOCs or total non-methane hydrocarbons (NMHC) measurement. However, new methods to evaluate this issue have not been developed.

**Considering the number of stakeholders involved in this issue (individual operators, AEMERA, Environment Canada, WBEA, Fort McKay, COSIA), the persistence of this issue over time, and the attempts made over the course of time to resolve this issue, is there a collaborative process or model of interaction that you feel has worked and would be helpful in assessing the issue?**

We are not proposing a mechanism that would help integrate or engage the multiple stakeholders involved with this issue. However, from the perspective of a science group in EC who have been involved in the oil sands work for the past four years, the collaborations between WBEA, Fort McKay and EC in support of the objectives associated with the Joint Oil Sands Monitoring Program have resulted in EC making significant contributions to the understanding of the emissions, transport, transformation and fate of oil sands pollutants. The monitoring station established at Fort McKay has been instrumental in improving understanding of the origin and nature of pollutant events impacting the community, as well as providing a site where detailed instrument intercomparisons and instrument development methods could be addressed. The focused measurement study in 2013 significantly augmented our collective understanding of emissions sources and transformation processes of pollutants. This model has worked acceptably (in that it has led to and supported EC studies that have significantly advanced understanding of oil sands pollutants) and could continue to allow the provision of EC expertise and support to future issues such as the one being considered here.

**Are you able to provide additional studies done by Environment Canada since 2013 and provide any reports that are not available on your web page that you think may be particularly helpful to inform our technical assessment?**

Results from the studies of the past four years are starting to be submitted for publication in peer-reviewed journals. Conference and workshop publications and presentations that highlighted early results can be shared with AER. These results do not specifically address odour issues. They do address measurements of numerous pollutants some of which are known to be odour producing. They also address measurement and interpretation methods that could be used to help address the odour issue.





## FORT MCKAY

FIRST NATION

October 6, 2015

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**Re: Request for input into Fort McKay Odour Assessment: Recurrent Human Health Complaint Process**

Thank you for your letter of August 6, 2015 requesting input from the Fort McKay First Nation to assist the AER with the development of a Recurrent Human Health Complaint Process.

Below are some technical and traditional considerations to the questions posed in your letter.

1. Available data strongly indicates that the major originators of odour sources affecting Fort McKay are Syncrude and Suncor (projects to the South of Fort McKay).

More specifically however, based on our own odour event analysis procedure (see attached copy of the procedure) it appears that Suncor is the most significant source of odours with its tailings ponds generally, but not always, the source type. Syncrude is considered the 2<sup>nd</sup> most significant source followed by CNRL Horizon and Shell Muskeg River which are considered relatively minor sources except at times e.g. the August 2, 2012 CNRL Horizon flaring event. Specific operational sources of odours in addition to tailing ponds include upgrading and flaring, as Fort McKay regularly observes elevated levels of SO<sub>2</sub> and PM<sub>2.5</sub> during odour events.

2. The following Table summarizes the current list of odorants that are considered as potentially the major contributors to odour events in Fort McKay. Thiophenes, sulphides and disulphides are considered to be the reduced sulphur compounds



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that make the largest contribution to odours and aldehydes are the VOCs considered of most odour interest/relevance. Monitoring has also shown that during odour events in Fort McKay, particulate matter (PM2.5) is also elevated, and may be contributing to odour intensity/perception (further work is required to confirm this fact).

The list below is based on the following information sources:

- i. Fort McKay's odour event canister sampling data;
- ii. WBEA's semi-continuous GC odour monitoring results;
- iii. 2013 industry tailings pond and mine VOC and reduced sulphur compound (RSC) flux chamber monitoring results; and
- iv. Tailings pond flux chamber and near tailings pond and offsite ambient air quality canister sampling data results which were shared, in confidence, with Fort McKay in November 2012, for a period covering 2009 to 2012.

<b>List of substances that, based on ambient, source monitoring and odour-event sampling results, are considered priority candidate odorants in terms of contributing to odour events in Fort McKay</b>				
<b>Reduced Sulphur Compounds</b>			<b>Volatile Organic Compounds</b>	
Allyl sulphide	Disulphide, dimethyl	Thiophene, 2,3-dimethyl-	Butane	Decanal
Benzenethiol	Disulphide, methyl ethyl	Thiophene, 2,5-dimethyl	Acrolein	Dodecanal
Carbon disulfide	Disulphide, n-Propyl n-butyl	Thiophene, 2-ethyl-	1-Hexene	Hexanal, 2-ethyl-
Carbonyl sulphide	Disulphide, n-Propyl sec-butyl	Thiophene, 2-ethyl-4-methyl	Naphthalene	Butanal
Diallyl sulfide	Heptyl mercaptan	Thiophene, 2-ethyl-5-methyl-	Methyl Ethyl Ketone	Octanal
Dimethyl sulphide	Hydrogen sulphide	Thiophene, 2-methyl	2 ethyl hexanol	Nonanal
Dimethyl tetrasulphide	Methyl mercaptan	Thiophene, 3,4 and 2,4-dimethyl	Benzene, 1,4-diethyl-	Acetaldehyde
Disulfide, dibutyl	Thiophene	Thiophene, 3-methyl	Phenol, 4-methyl-	
Disulfide, dipropyl	Thiophene, 2,3,4-trimethyl-	Thiophene, tetrahydro-	Benzaldehyde	
Disulfide, methyl propyl	Thiophene, 2,3,5-trimethyl	Trisulfide, dimethyl	Heptanal	

3. There are a number of challenges associated with trying to link an odour event to a facility and/or source type e.g. specific point source or tailings pond. These include:
  - i. The complicated emission dispersion patterns in the region (due to the Athabasca River valley) which makes it difficult to use 10m high wind direction and speed profiles to do back trajectories to attribute a source to an event in the community. This problem/issue is most relevant when trying to differentiate between odour events caused by Suncor versus Syncrude. The picture below was taken on Feb. 22, 2015 and shows lower level plumes and emissions moving North from both Suncor and Syncrude but



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emissions from Syncrude's main stack, which extends above the Athabasca Valley, moving ENE. If only the wind direction data at Fort McKay was examined during the air quality event in this instance during the time this photo was taken, the odour event would likely have been attributed to Syncrude, as the WD was ~185° during this period. It is clear from the aerial photo however, that Suncor was the likely/major source. The wind speed and direction profiler (windrass) and LIDAR PM monitor at the Environment Canada AMS (CAM-1) in Fort McKay have helped improve source-receptor determinations, but it can still be a challenge.

- ii. Difficulty in getting information from companies following an odour event in terms of possible on-site issues or activities that could have contributed to the odour event.
- iii. Lack of any odour related characterization of emission sources (either chemical or sensory) which makes it difficult to try and related odour event ambient air sampling results and/or sensory observations to source emission profiles/characteristics.
- iv. Lack of any comprehensive/meaningful facility boundary/fenceline odour monitoring.
- v. Translating/relating concentrations of odorants to an actual sensory odour concentration, intensity and character, which, in part, relates to scientific uncertainty on how mixtures of odorants behave. The selection and use of scientifically based odour thresholds is also an issue in terms of translating monitoring and/or modeling odorant levels into odour concentrations. (Note: This is one of the reasons that the FMSD developed its Guidance Document for odour impact assessments which as noted in question 7 has been provided to the AER.)

In general a more open and transparent approach to data collection and information sharing would enable all parties to better understand, and subsequently manage odour events (both in their frequency and intensity). We believe that there also needs to be some new ways of monitoring developed to help reliably identify the source of these odour events in Fort McKay.



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4. Yes, in Fort McKay's view there are significant gaps and unknowns in the current on-lease emissions monitoring, and thus room for improvement in the current emissions monitoring of facilities. Through Fort McKay's partnership with Environment Canada, a much more comprehensive list of compounds are measured than any regional environmental monitoring system. There is a strong need for species characterization and identification of on-lease odour sources, and Environment Canada's expertise and involvement in this endeavor should be sought.

To the best of Fort McKay's knowledge there is essentially no specific odour related monitoring at any oil sands facility. Fenceline monitoring for H<sub>2</sub>S or TRS, which is based on odours, is really the only monitoring related to odours and is somewhat meaningless since the current 1-hr Alberta Ambient Air Quality Objective



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for H<sub>2</sub>S is 10ppb which is 20 to 200 times above the odour threshold for H<sub>2</sub>S<sup>1,2</sup> and 1 hour is too long an averaging time for assessing the potential for odour issues.

All potential odourant emission sources on facilities need to be characterized chemically and through olfactometry to determine odorant and odour *i.e.* odour unit, emission rates. Continuous and frequently used flares need to be assessed in terms of potential for odorant emissions and should also have combustion efficiencies assessed, and as necessary improved, to minimize odourant emissions.

Fenceline monitoring for odours through the use of eNoses and regular fenceline and development area monitoring using designated odour observers and possibly field olfactometry equipment should be part of facility approvals, especially when these facilities are in relatively close proximity to communities.

5. The current ambient monitoring program in this area does not have enough stations (or the appropriate placement of monitoring points) to be able to contribute odour to source or to follow an odour event, without doubt, from source to sink. Ground stationed air monitoring is insufficient, especially without on-site emissions characterization, to be able to identify sources during odour events. Industry agrees with this shortfall in the current regional monitoring program. Also, because of the close proximity of Syncrude and Suncor to each other, it is often challenging to identify one or the other as the source of an odour event that directly and adversely affects Fort McKay.

As noted in the response to question 4, the current ambient air quality monitoring, be it fenceline or community, is of very limited value/use in assessing and managing odours. In general Fort McKay sees two types of ambient odour monitoring, namely:

- i. Complaint response – this would be ambient air monitoring in response to an odour complaint or concern and could involve 1 or more of the following:
  - a. Odour observation by a trained odour observer or inspector;
  - b. Field olfactometry measurement;
  - c. Ambient air sampling for detailed chemical characterization; and/or
  - d. Ambient air sampling for panel olfactometry analysis.

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<sup>1</sup> Nagata, Y. "Measurement of odor threshold by triangle odor bag method." Odor Measurement Review, Japan Ministry of the Environment. 2003. [www.env.go.jp/en/air/odor/olfactory\\_mm/04ref\\_2.pdf](http://www.env.go.jp/en/air/odor/olfactory_mm/04ref_2.pdf).

<sup>2</sup> Bokowa, A.H. and Bokowa, M. (2014). Estimation of Odour Detection Threshold Values for Selected Pure Compounds. Water Environment Federation Annual Technical Exhibition and Conference, Sept. 27-Oct.1, 2014, New Orleans, USA.





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- ii. Ongoing Routine Regional Odour Related Monitoring – this would involve ambient air monitoring that would be used to assess odours in the region and provide data and information that could be used to identify potential odour issues/hotspots and proactively address them. The type of ambient monitoring that would be involved could include one or more of the following:
  - a. Regular odour observations by trained odour observers or inspectors at designated locations throughout the region;
  - b. Regular field olfactometry measurement at designated locations throughout the region;
  - c. Semi-continuous ambient air quality measurement using GC instruments with sensitive odorant related detectors at key receptor locations e.g. Fort McKay, and/or at locations between major odour sources and receptors; and/or
  - d. eNose type odour monitors between major odour sources and receptors like Fort McKay.
6. Fort McKay's partnership with Environment Canada over the past 2 years (and which is still continuing into the future) has been very beneficial in understanding and characterizing odour issues in Fort McKay. Having additional stations/monitoring tools appropriately placed near industrial sites would strengthen this data. Fort McKay's participation in WBEA has allowed Fort McKay to have additional valuable air quality information in the community (e.g. compound characterization and ambient monitoring), and it is very important that the WBEA's work continues.

CEMA has been working on the issue of odour and odour management for over 3 years and is now at the point of having the information necessary to develop a strategy or framework for addressing odour issues in the region. Fort McKay therefore favours the use of CEMA or a CEMA-like association. It has been Fort McKay's experience to date that industry has been a reluctant, and at times obstructive, player in terms of advancing odour management in the region. Therefore, in the absence of a CEMA type group it would be Fort McKay's preference that this initiative be AER lead with a clear stated intent of significantly reducing odour events in Fort McKay. Regardless of the type of collaborative process or group used, it is Fort McKay's view that nothing substantive in terms of odour management can be achieved without a clear signal from the regulators that the status quo is not acceptable.

7. As of November 2014, Environment Canada CAM-1 data was (and remains) available through the JOSM portal ([raw data](#) from Aug. 2013 – October 2014)

In addition to the CAM-1 data it is important for the AER to consider that while nuisance odours are often not considered a direct impact on health (acute or chronic) due to the generally low concentrations of many individual odour causing chemicals (often of significant concentration when considered in a cumulative manner), we would argue that indirect health impacts are a very real and present





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health impact. This is particularly true in the largely Aboriginal community of Fort McKay. We promote traditional values and as far as practicable promote traditional land use within a modern Aboriginal culture.

Odours impact the lives of community members. From frequent reports of headaches and nausea during odour events to the nuisance factor deterring people from spending time outside, odours remind people that there is pollution around them. The perception that their health is being threatened leads to a decreased sense of personal safety and security and their trust in the health of country foods.

The Fort McKay First Nation looks forward to meeting with you in November to collaborate and advance this important work.

Sincerely

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# **Considerations in Attributing an Air Quality and/or Odour Event in Fort McKay to a Specific Industrial Operation and/or Source(s)**

(Prepared by: David Spink, April 2013)

**Introduction:** This document outlines the general approach and factors that are considered when analyzing an air quality and/or odour event in Fort McKay in terms of attributing the event to a particular facility, emission source and/or operating condition or upset. The key factors considered and evaluated are:

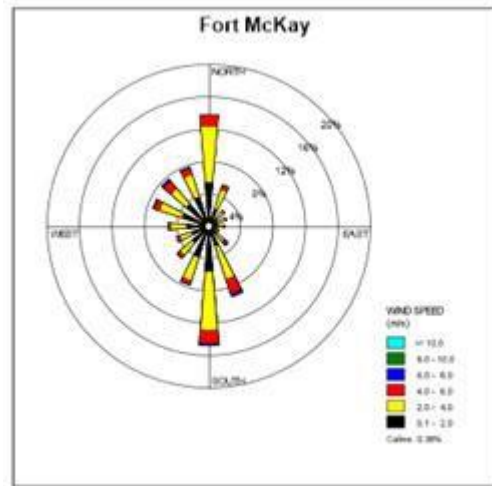
- regional meteorology immediately before and during the odour event,
- air quality readings at monitoring stations in the region and in the community before, during and after the odour event,
- characteristics of the various types (area, volume, stack) and specific emission sources in the region e.g. tailings ponds, sulphur recovery unit stacks, coke and CO boilers, etc.
- the operational status of facilities immediately, during and after the odour event; and
- sensory observations during the odour event e.g. very strong hydrocarbon odour.

How these factors are evaluated and used are summarized below and an example of an actual odour event analysis is provided as an appendices.

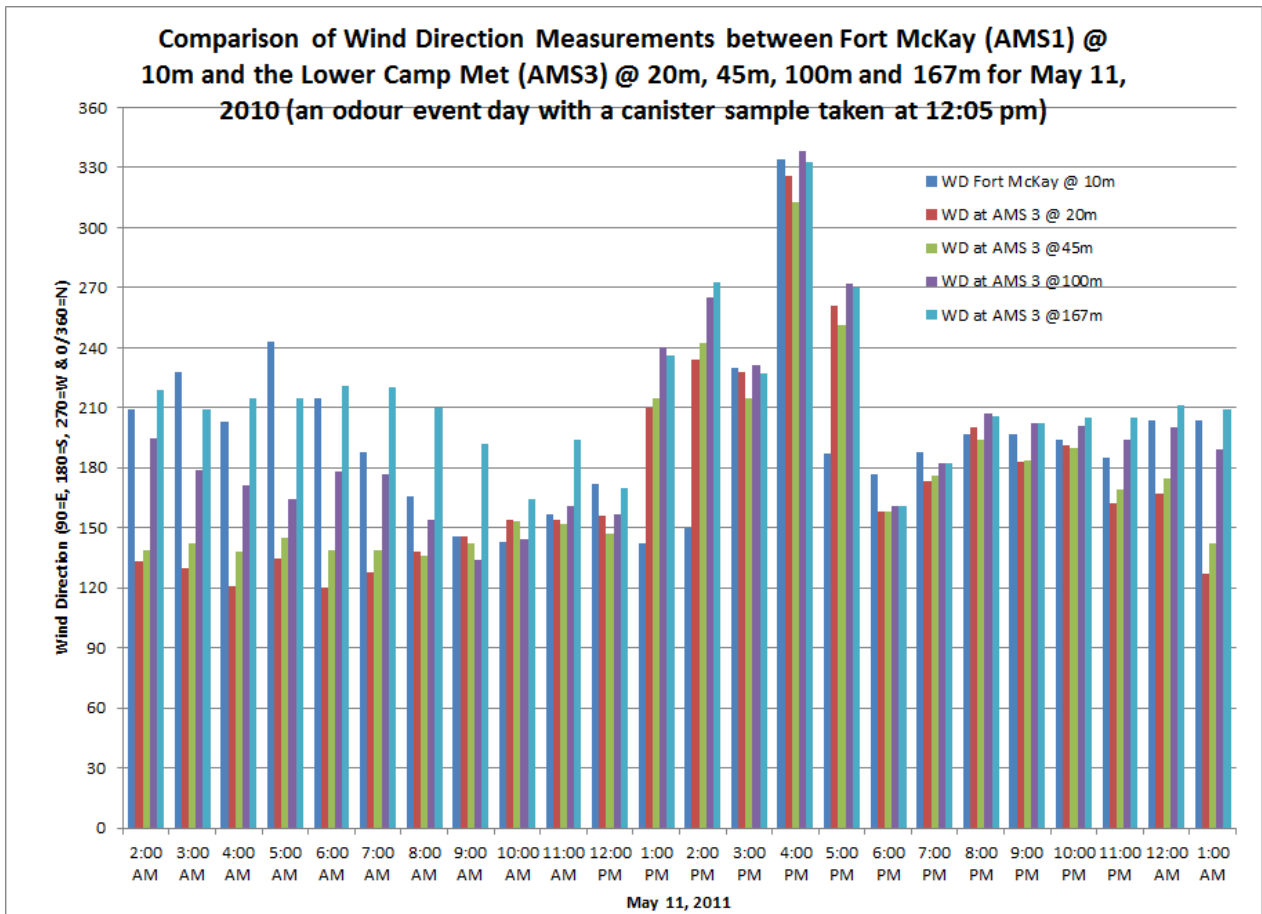
1. **Meteorological Data** – Meteorological conditions determine the transport and dispersion of emissions. Information on the meteorological conditions prior to, and during, an air quality impact event is critical to determining the possible emission type(s) and source(s) causing the event. Wind data, e.g. direction, speed and patterns at multiple heights, and vertical atmospheric temperature profiles are particularly useful meteorological factors when attempting to attribute a particular air quality event to emission source locations and types, e.g. tailings pond vs. stack sources.

The following is a brief summary of how Fort McKay uses meteorological data in its source location/type attribution assessments.

- a. **Wind direction** - The wind direction measured at 10 m at the WBEA AMS1 (Fort McKay) is the initial and most important consideration when determining the possible source of an air quality and/or odour event in Fort McKay. The predominant ground level wind directions at Fort McKay are South and North. The following is a wind rose plot of wind data from the WBEA AMS1 in Fort McKay for the period 2002-2006 inclusive which shows the predominant North/South wind pattern (taken from the Teck Frontier Mine EIA/Application, September 2011).



Fort McKay's location immediately adjacent to the Athabasca River, and in the Athabasca River valley, strongly influences ground level wind direction. This complicates directly linking wind direction to specific sources. Therefore the higher level wind data from both the WBEA AMS 3 (Lower Camp Met Tower – 20m, 45m, 100m and 175m) and AMS 5 (Mannix – 20m, 45m and 75m) are often consulted to better understand general regional wind patterns at the time of an event and to assess the representativeness of the wind data from AMS1. An example of such a wind direction comparison is shown in the chart below which compares wind direction data from AMS1 and AMS3 on May 11, 2010 which was an odour event day in Fort McKay. Based on the consistency of the ground level wind direction data (~120°-160°) between the 2 stations, both before and during the odour event, the source of the event was attributed to Suncor.

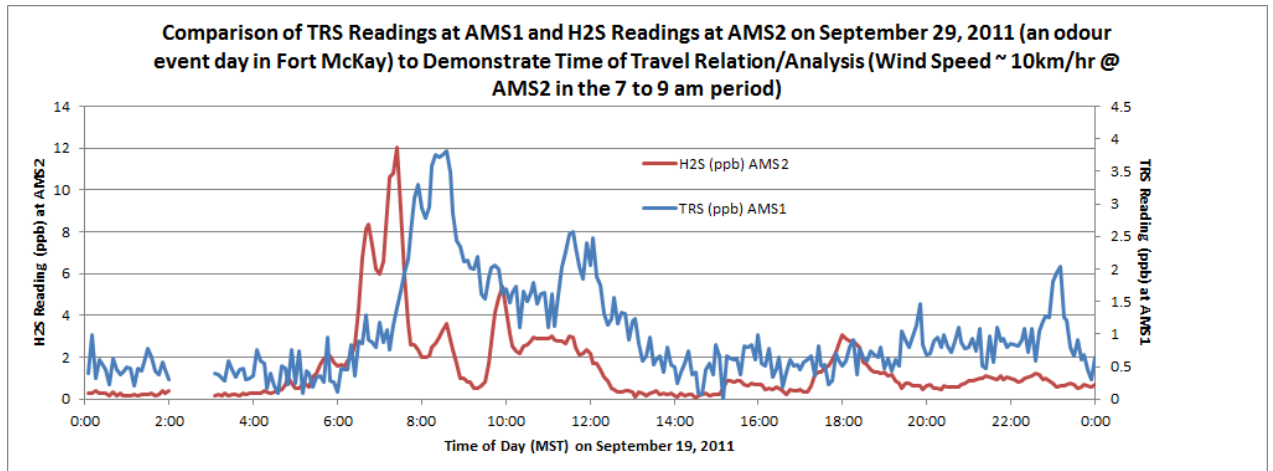


In general the following table summarizes the initial “wind direction: source attributions” that is used:

Wind Direction	Source
NE to ENE (30° to 50°)	Syncrude Aurora North and/or Shell
ENE to E (50° to 90°)	Shell MRM and JPM
SSE to S (146° to 191°)	Suncor (possibly Syncrude if around 180°)
S to SW (180° to 236°)	Syncrude (possibly Suncor if around 180°)
NW (300° to 340°)	CNRL Horizon
All other directions	No significant industrial sources so no preliminary attribution is possible

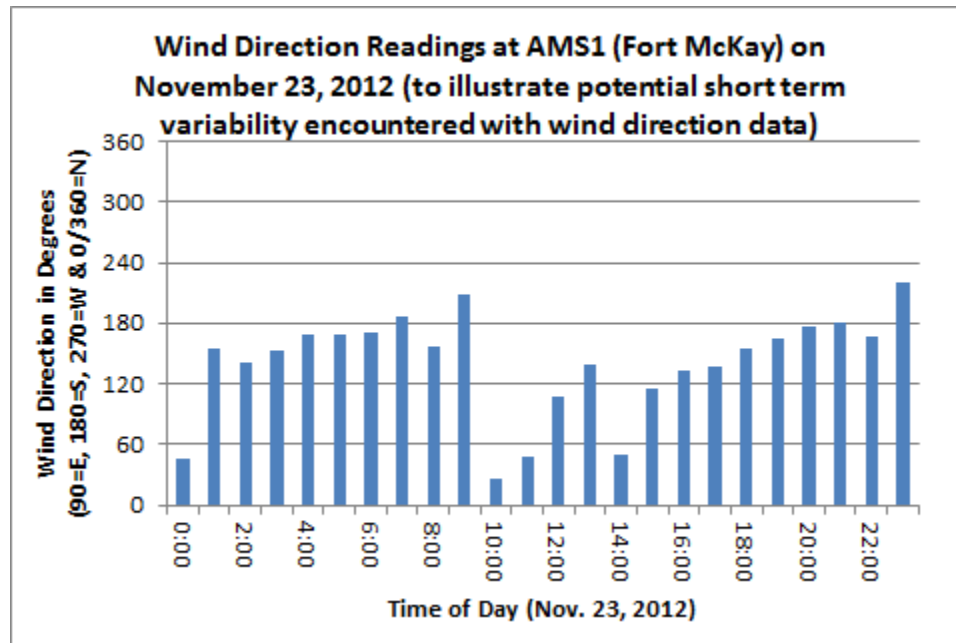
- b. **Wind speed** – Wind speed influences ground level turbulence, the amount of emission dilution (and therefore the atmospheric concentration of emitted pollutants) and the travel time from pollutant emission to detection at downwind monitoring stations or by downwind communities or individuals. The time of travel between monitoring stations is used by Fort McKay to track emissions and help confirm the direction and/or location of an emission source.

In the case of air quality events possibly attributable to Suncor or Syncrude, air quality data and wind speed data from AMS2 (Mildred Lake), AMS13 (UE-1) and AMS1 are used. The following figure demonstrates a clear relationship between air quality at AMS2 and AMS1 with a delay of approximately 1.25-1.5 hours between H2S/TRS peaks at AMS2 and AMS1. This time delay reflects the approximate 16km distance between the 2 stations and a wind speed of ~10km/hr in the 7-9am period. Based on wind direction data at both AMS1 and AMS2 and this type of emission tracking, this event was attributed to ground level (tailings pond) emissions from Suncor.



- c. **Wind Patterns** – Wind patterns are affected by local terrain features as noted above and can vary significantly with height as the data in the above wind direction comparison chart indicates. Also an air mass that has been influenced by air emissions can move back and forth under variable wind direction conditions making simple linkages between air quality and wind direction tenuous.

Wind directions can change significantly over short periods of time (as noted in the following figure showing wind direction variability in Fort McKay on November 23, 2012). This complicates linking air quality to specific emission sources. Fort McKay considers wind variability in its attribution determinations. In general, reasonably consistent wind direction and patterns for a period of at least 4 hours prior to an air quality event are considered desirable when make attribution determinations. This time period could be shorter depending on the likely time of travel from emission source to Fort McKay which is a function of the distance to the emission source and wind speed.



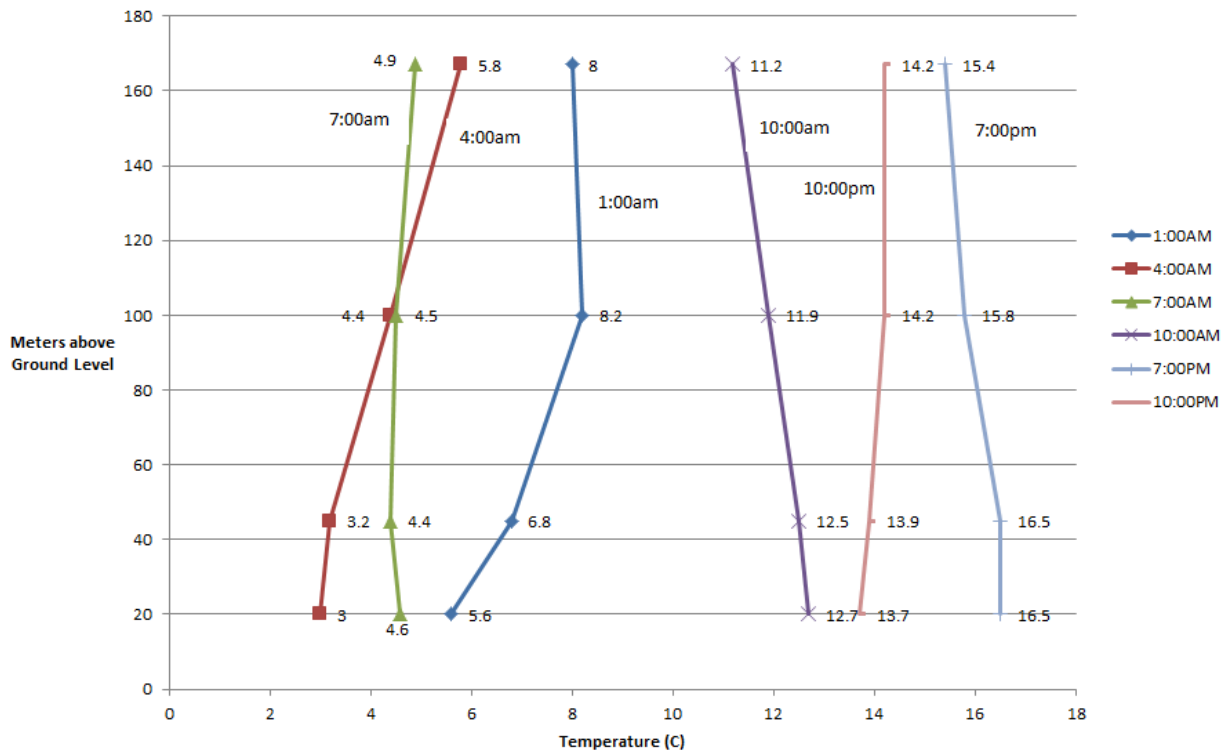
- d. **Atmospheric temperature profiles** – The behavior and dispersion of emissions to the atmosphere is largely a function of the vertical gradient of atmospheric temperature. Atmospheric temperature gradients determine the stability of the atmosphere with respect to vertical motions.

Night time/morning temperature inversions are common in the Fort McMurray region. The result of these inversions is that ground level emissions are trapped near the ground and stack emission sources/plumes stay at or above the stack height. Air quality events that occur during inversions, i.e. at night or in the early morning, therefore provide a good indicator of the nature of the source i.e. ground level (mine fleet or tailings pond) or stack. Attribution of air quality events in Fort McKay to ground level sources is largely based on assumed atmospheric mixing profiles resulting from temperature gradients.

The following figure is a plot of atmospheric temperature gradients measured at AMS3 on May 11, 2010 which was an odour event day in Fort McKay. The plots show an inversion up to 100m at 1:00am, an inversion to 167m at 4:00am, the inversion starting to weaken at 7:00am and there was no ground level inversion by 10:00am. The formation of another inversion can be seen to be starting at 7:00pm and continuing to deepen at 10:00pm.



**Vertical Temperature Gradient Plots from Temperature Data from AMS3  
(Lower Camp Met Tower) for May 11, 2010 (an odour event day in Fort  
McKay)**



2. **Air Quality Profiles and Levels** – The relative concentration of the various air contaminants measured at AMS1 can be used to deduce the nature of the source(s) contributing to an air quality event. For example:

- higher SO<sub>2</sub> readings are generally associated with flue gas desulphurization (FGD) units/issues or sulphur recovery unit (SRU) issues (including flaring)
- higher SO<sub>2</sub> and H<sub>2</sub>S/TRS readings are generally associated with SRU or carbon monoxide (CO) boiler issues
- co-elevated TRS and THC readings (with a possible slight elevation of SO<sub>2</sub> readings) are generally associated with tailings pond emissions
- higher NO<sub>x</sub> and lower ozone readings are generally associated with NO<sub>x</sub> emissions from mine fleets
- higher NO<sub>x</sub>, TRS, THC and PM<sub>2.5</sub> readings are generally associated with brush pile burning and forest fires (higher ozone levels in the summer are also associated with fires/burning)

Relating air quality readings in Fort McKay to specific emission source(s) also requires an understanding of the nature and variability of emission sources. For some emission sources, such as tailings ponds, emission data is limited. This makes it challenging to draw source-

ambient air quality linkages and is the reason Fort McKay has requested, and continues to request, more detailed information on key emission sources in the region.

3. **Facility operational information** – Fort McKay has agreements with many companies that require both advanced notification of planned operational activities and immediate notification of any unplanned events when such activities or events could have ambient air quality implications. Such notification can assist in linking air quality in Fort McKay to specific emission events. Several of Fort McKay's canister samplings were the result of these notifications. Some of the notification incidents have resulted in air quality impacts in Fort McKay and others have not. When an air quality event occurs in Fort McKay, and no notifications have been provided, it would be desirable to be able to get information about possible operational activities that could have contributed to the event. This information is helpful, even if the operational activities are considered normal activities, such as transferring tailings, as these activities have the potential to result in altered facility emissions. Without such information source-air quality impact attributions become more speculative.
4. **Sensory Characterization** – An emission source or type may have a distinct odour character and/or hedonic tone. Since July 2009 the Fort McKay Sustainability and its air consultants have been informally recording odour issues and experiences in the community and on highway #63 when a community or staff member travelling between Fort McKay and Fort McMurray experiences odours. When odour issues are noted an analysis is conducted to try and identify a possible source (see Appendix A for an example of such an analysis).

The characteristics of odours experienced in the community and on Highway #63 include:

- a. tar, hydrocarbon;
- b. sulphury;
- c. weak ammonia;
- d. cat urine; and
- e. rotten eggs, skunk.

The intensity of odours can vary from mild/barely noticeable to very strong/terrible/nauseating.

Based on community odour event/occurrence observations, and subsequent source identification analysis, tailings pond emissions from Suncor have been identified as having odours that generally have a hydrocarbon, ammonia and/or cat pee character. When other information, e.g. meteorological and air quality data from other stations, would indicate Suncor's tailings ponds are the source of the odour, and these odour characteristics are noted, then the odour characteristics are considered further supporting evidence that Suncor's tailings ponds are the odour source.

5. **Summary** – Industrial air emission sources north of Fort McMurray are numerous and varied. When air quality issues, such as odours, occur in Fort McKay, community members want to know:

- what the problem/issue is?
- are there potential health issues associated with the event?
- what is being done to manage the issue? and
- what actions are being taken to prevent or minimize future such occurrences?

Through the use of air quality, meteorological, sensory and/or facility operational information an attempt is made to attribute an odour and/or poor quality air event to a source and, when possible, to provide some context on the event, e.g. a plant upset. In addition to providing information to the community on odour and/or poor quality air events, the assessments conducted are also used in discussions with companies and regulators regarding air quality management issues and needs.

## **Appendix A**

### **Example of an Odour Event (January 24, 2013) Analysis**

## Fort McKay Odour Event Information Summary Form

**Date of Odour Event:** January 24, 2013

**Nature of Odour Event:** This odour event was noted by Karla Buffalo (Fort McKay Sustainability Department) on her drive from Fort McKay the evening (~4:30-5:00pm) of Thursday Jan. 24 2013. The odour was first noticed just to the North of the Syncrude site and persisted for a few miles on the drive South.

**Character and Intensity:** The odour had both a sulphurous and hydrocarbon smell with a 7/10 intensity. It was a somewhat unique odour relative to the odours frequently detected in the area and in Fort McKay.

**Action Taken:** The event was called into Alberta Environment at approximately 5:00pm and Fort McKay's air scientist David Spink was notified and asked to see if a cause or source of the odour could be identified.

**Event Analysis:** Air quality and wind direction data were examined to determine which substance(s) might be responsible for the odour episode and where the odour emissions might have originated. *(Note: when interpreting air quality data it must be recognized that this uncorrected data and not reflective of absolute values and it is therefore the trending/fluctuations of parameters over time that is important/relevant).*

Shortly after the odour event was noted the 5 minute WBEA continuous air quality monitoring data for the Mildred Lake air monitoring station (AMS#2) was downloaded and examined. AMS#2 is a few kilometers to the North of the Suncor and Syncrude tailings ponds that are visible from Highway 63. Air quality data from the Fort McKay South UE1 air monitoring station (AMS#13) and from the Fort McKay air monitoring station (AMS#1) were also checked but at 6:00pm there were no elevated levels of either TRS and THC evident at these other two stations. Air quality data from AMS#2 indicated elevated levels of hydrogen sulphide (H<sub>2</sub>S) and Total Hydrocarbons (THC) which would explain the odours observed (See Figure 1).

The following day all the 5 minute data for AMS#1, AMS#2 and AMS#13 for January 24, 2013 were downloaded and analyzed. Air quality data from these stations was examined because these stations are downwind of where the odour was noted and are along, or near, highway 63.

The attached Figures 2 and 3 show plots of the 5 minute Total Reduced Sulphur (TRS)/Hydrogen Sulphide (H<sub>2</sub>S) and Total Hydrocarbon (THC) data at AMS#1, AMS#2 and AMS#13 respectively for January 24, 2013. These data indicate that the increased elevated levels of H<sub>2</sub>S and THC at AMS#2 during the 4:30-5:00pm period (when the odours were noted) were subsequently observed at AMS#13 and AMS#1 approximate 2 to 3 hours later. The distance between AMS#2 and AMS#13 is approximately 12kms and the distance between AMS#13 and AMS#1 (Fort McKay) is approximately 4kms. The wind

direction during this period was from the SSE (as measured at AMS#2) and the wind speed varied from 2 to 10 km depending on the time and the station (wind velocities at AMS#2 were approximately 2 to 3 times higher than those at AMS#13 and AMS#1). The wind direction, and the time between the THC and reduced sulphur peaks at AMS#2 and at AMS#13 and AMS#1, would indicate that the air mass responsible for the odours noted along Highway 63 moved north to Fort McKay.

The wind direction before and during this period was from the SE/SSE indicating that Suncor was the likely source of the odours. The low and relatively uniform temperatures throughout the day and evening on January 24 and the atmospheric temperature profile (20m to 167m from the Lower Camp Met Tower AMS#3) would indicate that there was a slight inversion most of the day which would have limited boundary layer mixing and kept ground-level emissions source close to the ground and elevated stake sources aloft. This would indicate that the source of the odourous emissions was ground-level which points to tailings ponds. The air quality profile involving elevated levels of TRS, THC and slightly elevated levels of SO<sub>2</sub> are considered characteristic of tailings pond emissions from Suncor that are often seen in Fort McKay during odour events when the wind is from the South.

The description of the odour as both “sulphurous with hydrocarbons” might indicate that a combination of reduced sulphur and volatile organic hydrocarbon compounds were responsible for the noted smell/odours. It should be noted though that based on results from Fort McKay’s odour event canister sampling it appears that hydrocarbon type odours may also be associated with thiophenes which are a reduced sulphur compound.

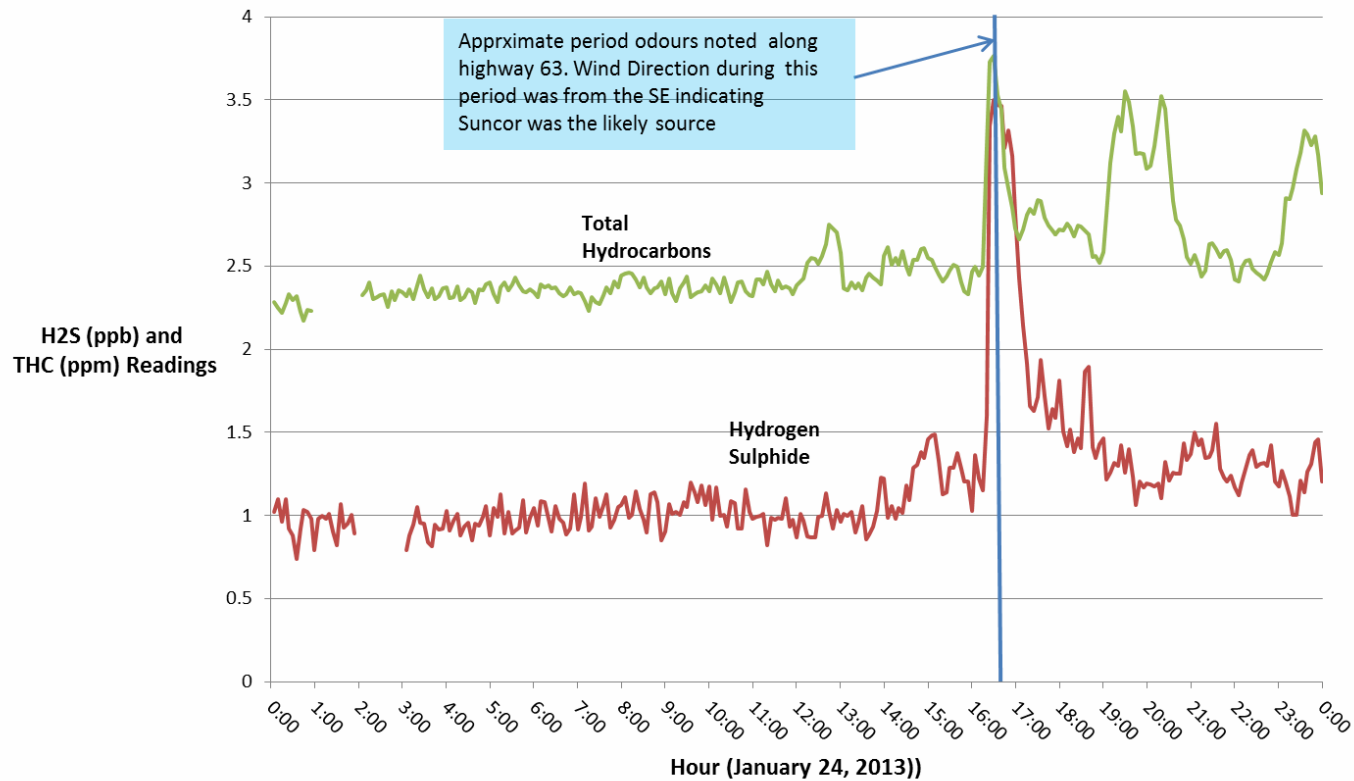
**Conclusion:** The odour event noted on highway 63 on the evening of January 24, 2013 was likely due to tailings pond emissions from Suncor containing reduced sulphur and possibly volatile hydrocarbon compounds and these emissions were subsequently detected by the AMS at Fort McKay.

**Follow-up:** It is recommended that this odour event summary and analysis be sent to Suncor and Alberta Environment with a request for comments and identification of any operating events or additional monitoring data that would help better define or explain this odour event/experience. Since the release associated with the event seems to have been short term, based on the H<sub>2</sub>S/TRS and THC air quality data from AMS#2, AMS#13 and AMS#1 it may be the cause of the event can be identified and options to prevent future such events evaluated.

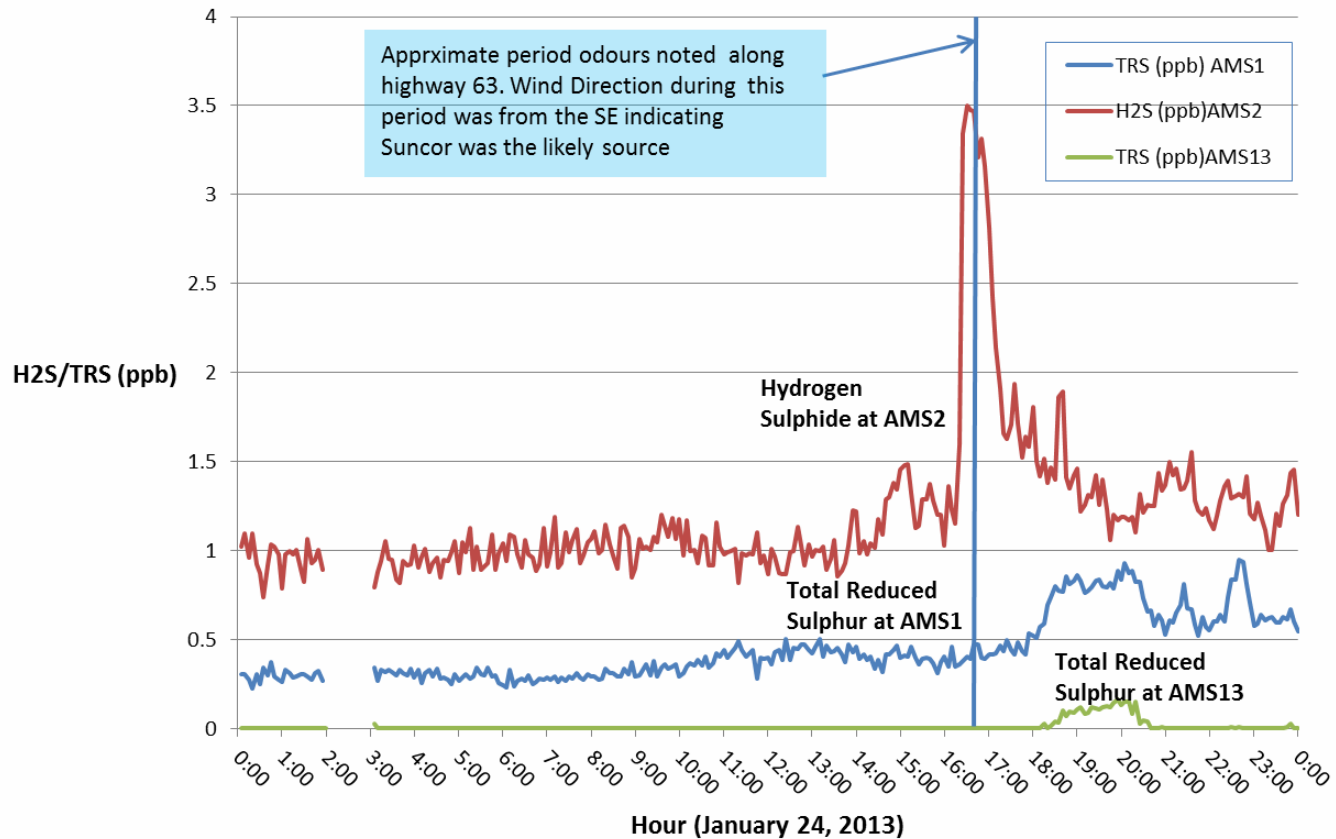
**Prepared by:** Karla Buffalo and David Spink



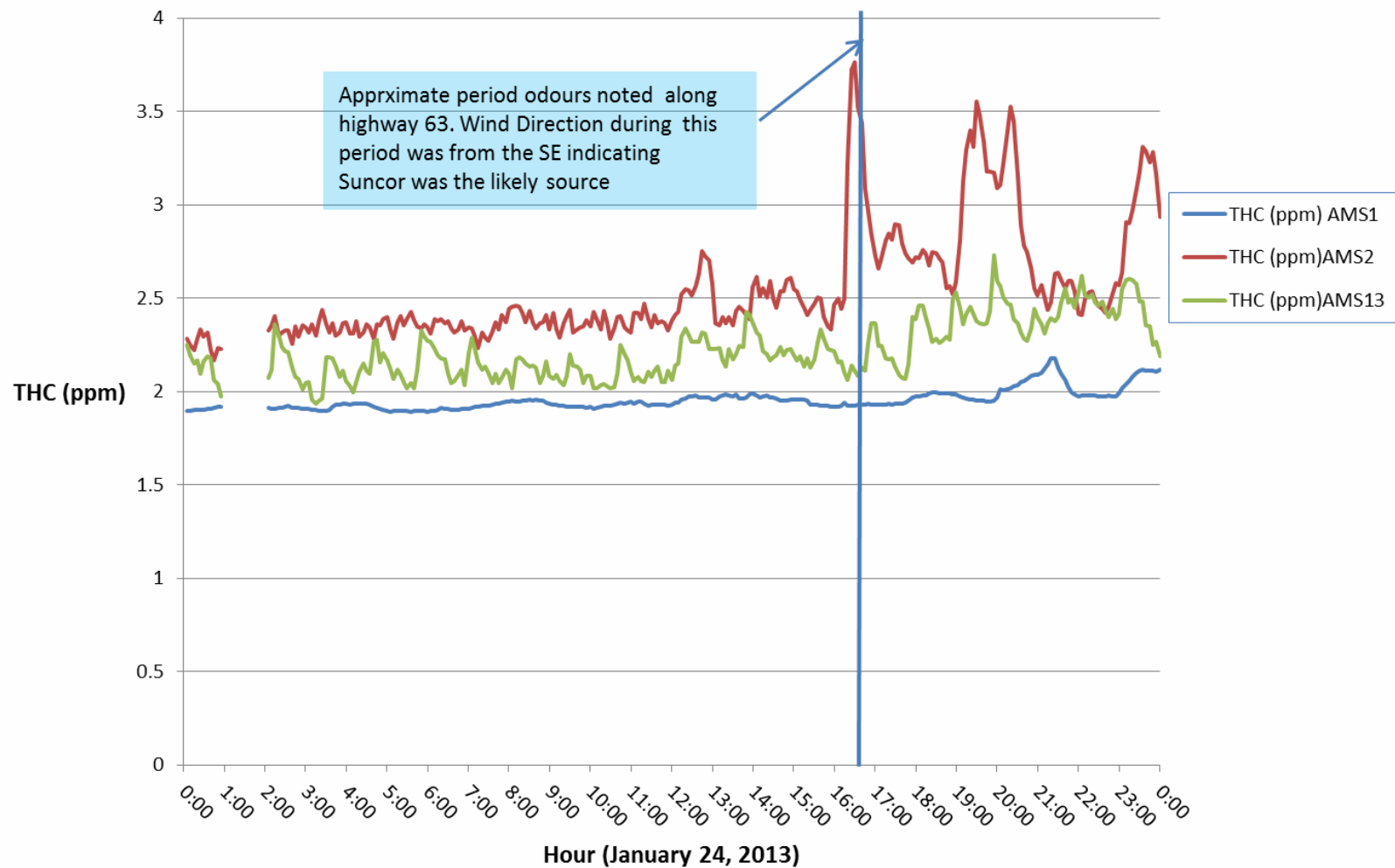
**Figure 1: Hydrogen Sulphide (H<sub>2</sub>S), Total Hydrocarbon (THC) and Sulphur Dioxide (SO<sub>2</sub>) Levels at Mildred Lake (AMS#2) January 24, 2013 Before, During and After a Noted Odour Event along Hwy 63 Near Syncrude**



**Figure 2: Hydrogen Sulphide (H<sub>2</sub>S)/Total Reduced Sulphur (TRS) Levels at AMS#1, AMS#2 and AMS#3 January 24, 2013 Before, During and After a Noted Odour Event along Hwy 63 Near Syncrude at Approximately 4:45pm**



**Figure 3: Total Hydrocarbon (THC) at AMS#1, AMS#2 and AMS#3  
January 24, 2013 Before, During and After a Noted Odour Event along  
Hwy 63 Near Syncrude at Approximately 4:45pm**





September 25, 2015

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Dr. Monique Dubé  
Chief Environmental Scientist  
Strategy and Regulatory Division  
Alberta Energy Regulator  
Delivered electronically

Dear Dr. Dubé:

**1. What does WBEA consider the major odour sources to be?**

WBEA routine and specialized air monitoring data coupled with odour integration reports (2012, 2013, 2014 data years) provides evidence by *association only* (wind direction, back trajectory) of industrial source areas for odour-causing compounds experienced in Fort McKay. Source attribution to emission type (fixed, fugitive) has not been completed by WBEA.

WBEA has published real-world source emissions results (ER/EF for haulers and 3 stacks). ER/EF data for RSC and VOC are found in Watson et al. (2013a,b) and Wang et al. (2015).

WBEA's *integrated approach to air and land monitoring* initiated in 2008 included chemical fingerprinting (with Pb, Hg, S, N, O isotope tracing) of sources and receptors (land sink). WBEA has published source apportionment results using forensic receptor modeling tools for trace elements/S/N (Landis et al., 2012) and parent PAHs (Landis et al., 2015). WBEA is capable of, but has not done a source apportionment for emissions to air from tailings ponds.

WBEA data show that concentrations of some RSC (substituted thiophenes) and TRS were often enhanced when odours occurred. Measurements made at AMS 1, 2, 5, 13 indicated that odours may have been associated with fugitive emissions from tailings ponds. Specialized data show that odours have been accompanied by enhanced concentrations of VOC followed by TRS, or vice versa.

Beginning in 2014-15, there has been a coincidence of enhanced ambient SO<sub>2</sub> concentrations along with enhanced TRS ambient concentrations. As 99% of SO<sub>2</sub> emissions in the model domain emanate from fixed combustion sources (Davies, 2012), there now appears to be a mix of fugitive and fixed combustion (stack) sources contributing potential odour-causing compounds.

The strong directionality of odour complaints at some community air monitoring sites suggests that there are area sources responsible for the odour complaints (Dann, 2015), and that they vary depending upon emissions profiles and meteorology.



**2. Which compounds or air quality parameters do you consider to be of greatest contribution to the odour issues in Fort McKay?**

WBEA has been monitoring for potential odour-causing compounds in air since 1998. The chronology of air monitoring by station and its purpose is found in Percy (2013).

In 2009, the WBEA Human Exposure Monitoring Program re-focused around odour measurement including the chemical speciation of odour episodes. Specialized equipment (PFGC) was installed in AMS 2 in 2009, then moved to AMS 1 Bertha Ganter – Fort McKay in 2010, where it operated until March 31, 2015.

Descriptive statistics (2012-2014) for potentially odour-causing TRS, THC, NMHC compounds at AMS 1 are reported in Dann (2015). This report (Table 12) also shows compound class or single pollutant (SO<sub>2</sub>) concentration at the date/time of 24 publically reported odour events in 2013.

Work reported by O'Brien et al. (2012) using the PFGC was more successful when peak concentrations of H<sub>2</sub>S/TRS were much greater in the 2008-2010 period. Compounds identified were CS<sub>2</sub>, 2-methylthiophene, 3-methylthiophene, 2-ethylthiophene, 2, 5-dimethylthiophene and 2, 4-dimethylthiophene. The authors stated that while measuring VOC and RSC simultaneously using the PFGC, odours were likely, but not certainly, at that point to be caused largely by sulphur compounds.

With the steep drop in peak concentrations 2010 onwards, the S detector (SCD) technology became challenged due to detection limit.

Analysis has shown (unpublished) that there is a “background” SUM0 (sum of hourly concentrations with no threshold target concentration applied) exposure of between 3,000 – 5,000 ppb hrs at monitoring stations equipped with TRS analyzers, and that the SUM0 is typically greatest at AMS 1.

**3. What do you view as the key technical challenges associated with linking odour incidents to odour sources?**

Odours are by far the most complex air quality issue to measure, understand, and attribute. Odour assessment is a complex undertaking as the ability of humans to distinguish different odour intensities is highly subjective with changes in concentration of the order of over 25% needed for an individual to recognize different odour intensities. There is also a wide variation in sensitivity towards odours between individuals and a factor of 100 between the thresholds of two subjects for the same substance is not uncommon. The sensitivity to odours is specific rather than general and the sensitivity of a person to one odour or group of odours does not predict their sensitivity towards other odours (Dann, 2015).



There is a disconnect between odour complaints and occurrence of elevated levels of currently measured ambient species suggesting that the specific compounds responsible for complaints are not being measured and/or detected due to spatial, temporal or technological limitations, or that odour complaint statistics are insufficiently robust. Alternatively, there is always uncertainty over the reliability of odour complaint statistics.

Statistical analysis of multi-parameter 5-minute-averaged AMS 1 (>1 million data points/year) has been completed on several levels. Best subsets regression models are somewhat predictive of ambient TRS and VOC concentrations (unpublished). In all models, wind direction is an important independent variable. The correlation coefficients listed for pollutants measured in Dann (2015) are indicative when taken together of a larger message on source type for VOC emissions.

**4. Does WBEA see gaps in the current emissions (on-lease) monitoring of facilities and specifically how odours could be better monitored and assessed?**

WBEA has not played any role, nor has it influenced how operators measure and monitor on-site emissions. Operator requirements for on-site emissions monitoring are set by the Regulator.

AER is in the best position to establish where the gaps in emissions data are, as it holds the most complete set of reported data. WBEA is not in a position to fully answer this question.

Operators are known to conduct ongoing measurements of air pollutant emissions from ponds and other emission sources. The data are provided publically through the NPRI (on-site releases to air). However, the NPRI substance list does not include many compounds measured in ambient air when odours occur.

As NPRI data are rolled-up into “releases to air”, it is unclear which on-site sources (fugitive, fixed) are contributing to odours. Provision of a more complete suite of emission data (EF/ER) along with their source type (fixed, fugitive) would provide an opportunity for relating source type with the ambient receptor (Fort McKay).

Data on source and control equipment operations during complaint periods could be obtained to see if there are any linkages to odour complaints. This is a vital piece of information to improve our understanding of why odours occur and thus potentially reduce the number of odour complaints in the future (Dann, 2015).

It would be beneficial to carry out source emission characterization for a list of candidate odorous compounds. “Real-world” source emissions data are key contributors linking emissions with receptors. These odorous compounds, when also measured at the downwind receptor site in a targeted campaign, can provide the inputs needed for source apportionment.





WBEA is in position with its current team (EPA receptor model writers) augmented by colleagues in place to complete a campaign-style “real-world” (reduced measurement artifact) source characterization for pond fugitive emissions.

WBEA recommends that in a complex, multipollutant emission and source environment like the AOSR (Hidy and Pennell, 2010), the *source apportionment approach* (Hopke, 2009) provides the best opportunity to link emissions with receptors (i.e. Fort McKay) for environmental management purposes. It has been successfully applied by WBEA in the AOSR using EPA PMF receptor models (<http://www2.epa.gov/air-research/positive-matrix-factorization-model-environmental-data-analyses>).

WBEA “real world” emissions data (ER/EF for stacks, haulers, dust), and source chemical fingerprint data have been used recently in the updated TECK EIA (<http://www.ceaa.gc.ca/050/documents-eng.cfm?evaluation=65505>).

**5. Does WBEA see gaps in the current ambient monitoring program in this area and specifically how odours could be better monitored and assessed?**

In terms of ambient air monitoring, there is no off-the-shelf instrument that will monitor for combined gaseous and PM reduced sulfur compounds. WBEA does not continuously monitor for total S. WBEA monitoring for PM-S is time-integrated on the EC NAPS schedule, one 24-hour filter sample every 6 days. Depending upon full assessment of EC data from Oski Otin and the six-month collaborative WBEA AMS 103 – EC CAM portable co-measurement study, continuous measurement of more S forms may be required at AMS 1.

At present, there is no available, reliable technology to continuously measure a suite of VOC in a non-research, routine ambient operation. EC-MSD has been working with WBEA at AMS 1 since 2011 delivering continuous BTEX data. The U.S. EPA is completing a project which is doing final evaluation on an instrument that will enable continuous GC-based VOC analysis in ambient air in routine ambient operations. This is expected to be designated by the EPA in 2017. WBEA recommends that this instrumentation be installed when available in several stations and co-located with the integrated canister sampling for 15 months on a trial basis. Once proof of concept is complete, WBEA would intend to replace the canister sampling with continuous GCs at some locations including AMS 1. This will be much more cost effective and yield hourly data more in line with duration of odour events.

Routine, NAPS SOP based integrated collection and analysis of RSC in canister samples does not return the degree of detects that is useful in identifying RSC present during odour events. Detects of COS at AMS 1 in 2012 was only 17%, CS<sub>2</sub> 2%, and 3-methyl/2-ethyl thiophene only 3% each (Dann, 2013). This could be due to a number of factors related to detection limit, dilution of an event concentration



in a 24 hour sample, degradation of the compound after capture, and the frequency of sampling.

6. **Considering the number of stakeholders involved in this issue....is there a collaborative process or a model of interaction that you feel has worked and would be helpful in assessing this issue?**

The AER requirement (August 6 letter) is "...to examine facilities within 30 km of Fort McKay."

WBEA has used a stakeholder needs/science balanced process for establishing technical programs, assessing needs, and reaching consensus on the way forward.

WBEA recommends that AER lead a process founded on similar principles as a positive way of advancing the assessment. A workshop should be convened as the first step. The workshop could include process engineers or other operator representatives holding emissions knowledge, WBEA (ambient air quality data specialist, senior science advisor, acting Lead Scientist), Fort McKay air quality specialist, AER and AEMERA technical specialists.

The workshop should be technical in nature and available data should be shared within the confines of a confidentiality agreement if necessary. The objective would be to take the first step in gathering knowledge and coming to a level of "common understanding". The regulator is encouraged not to proceed without this first step in the assessment process. Environmental management is successful when stakeholders are informed.

WBEA advises that there should be a public report following the workshop that would provide AER's interpretation of the "common understanding".

7. **While we have been looking through public reports and reports available on your web we would appreciate it if you could provide the following information:**
- a. **Databases and spreadsheets used in the 2013 and 2012 HEMP report (prepared by RS Environmental for WBEA to allow easier usage in our study)**
  - b. **Is a 2014 HEMP report being prepared? If so, can acquire a draft when it becomes available?**
  - c. **Reports that are not available on your web page that you think may be particularly helpful in better understanding this issue**

WBEA will be pleased to provide the requested data and reports. The 2014 Odour Integration report 2014 is being revised following internal review by the WBEA HEMP Committee and Acting Lead Scientist.



## References

- Dann, T. 2013. Integration of 2013 Odour Integration Data for the Human Exposure Monitoring Program (HEMP). RS Environmental Report to WBEA. 78 pp. <http://wbea.org/resources/human-exposure-monitoring-reports>
- Dann, T. 2014. Integration of 2013 Odour Integration Data for the Human Exposure Monitoring Program (HEMP). RS Environmental Report to WBEA. 121 pp. available at <http://wbea.org/resources/human-exposure-monitoring-reports>
- Dann, T. 2015. Performance of the Fort McKay Air Quality Index (FMAQI) and Comparison with the Air Quality Health Index (AQHI). RS Environmental Report to WBEA.
- Davies, M.J.E. 2012. Air quality modeling in the Athabasca Oil Sands Region. pp. 267-309 In: K.E. Percy (Ed.). *Alberta Oil Sands: Energy, Industry and the Environment*. Elsevier, Oxford, UK.
- Hidy, G.M. and Pennell, W.T. 2010. 2010 Critical Review: Multipollutant Air Quality Management. Journal of the Air and Waste Management Association 60, 645-674.
- Hopke, P. K. 2009. Theory and application of atmospheric source apportionment. pp. 1-33 In: A.H. Legge (Ed.) *Air Quality and Ecological Impacts: Relating Sources To Effects*. Elsevier, Oxford, UK.
- Landis, M., Graney, J., Stevens, R.K., Percy, K.E., Krupa, S. 2012. Source-Receptor modelling as it relates to Alberta Oil Sands development. pp. 427-467 In: K. E. Percy (Ed.) *Alberta Oil Sands: Energy, Industry and the Environment*. Elsevier. Oxford, UK.
- Landis et al. 2015. Receptor Modeling of Epiphytic Lichens and Ambient Particulate Matter to Elucidate the Sources and Spatial Distribution of Poly-nuclear Aromatic Hydrocarbons (PAHs) in the Athabasca Oil Sands Region. Report to WBEA, Fort McMurray, AB.
- O'Brien, R.J., Percy, K.E., Legge, A.H. 2012. Co-measurement of volatile organic and sulfur compounds in the Athabasca Oil Sands Region by Dual Detector Pneumatic Focusing Gas Chromatography. pp. 113-144 in K.E. Percy (Ed.). *Alberta Oil Sands: Energy, Industry and the Environment*. Elsevier, Oxford, UK.
- Percy, K.E. 2013. Ambient air quality and linkage to ecosystems in the Athabasca Oil Sands, Alberta. *Geoscience* 40, 182-201.
- Wang, X., Chow, J., Kohl, S., Percy, K., Legge, A, Watson, J. 2015. Real-World Emission Factors for the Caterpillar 797B during Mining Operations. *Journal of Environmental Engineering* (submitted)



Watson, J.G. et al. 2013a. Characterization of Real-World Emission from Non-Road Mining Trucks in the Athabasca Oil Sands Region during October, 2010. Desert Research Institute Report to WBEA.

Watson, J.G. et al. 2013b. Measurement of Real-World Stack Emissions in the Athabasca Oil Region with a Dilution Sampling System during August, 2008. Desert Research Institute Report to WBEA.



Appendix 6 Recommendations from Fort McKay Recurrent Human Health Complaint Technical Report

No.	Recommendation	Priority	Accountability	
			Lead	Support
1	Ambient air quality monitoring for acute concentrations of H <sub>2</sub> S and SO <sub>2</sub> should be instituted for the purposes of emergency response (including potential evacuation) in the community of Fort McKay within one year. Monitoring should be conducted by EP, funded by industry, and acute thresholds for H <sub>2</sub> S and SO <sub>2</sub> concentrations approved by Alberta Health in discussion with Fort McKay. Review of this monitoring program, including the need for additional parameters, should be conducted annually.	High	EP	AER
2	Policy guidance is needed on the appropriateness of odour thresholds for emergency response purposes in the community of Fort McKay.	Medium	GoA	Alberta Health
3	Oil sands industry ERPs (or relevant sections) should be shared with the community of Fort McKay through a regulatory mechanism or instrument to be determined.	Medium	AER	
4	An AER odour complaint response protocol specific to the community of Fort McKay and consistent with odour management policy of the Government of Alberta is required. The protocol must consider the outcomes of this report, be transparent, establish lines of communication between the AER, industry, and the community of Fort McKay, and improve current complaint closure and resolution rates. The protocol must also consider use of the most appropriate ambient monitoring datasets.	High	AER	
5	A standardized checklist for operating conditions must be developed and used as a best practice by industry when an odour complaint is received by the AER and industry is contacted by the AER. The checklist should be developed collaboratively with the AER, industry, and Fort McKay First Nation, be filed by the AER with the complaint, and be included in the odour response protocol described in recommendation 4. Transparency and access to this checklist as part of complaint closure should be considered in protocol development.	High	AER	
6	Policy guidance is needed on the use and application of odour thresholds in the community of Fort McKay and to clarify the use of environmental protection orders (EPOs) under EPEA by the AER to address offensive odours.	Medium	GoA	Alberta Health, AER, Fort McKay
7	All parties should have access to real-time monitoring data collected by Environment Canada in the community of Fort McKay.	High	Environment Canada	EP, AER
8	Accountability for supporting complaint response and notification of ground-level concentration exceedances through ambient monitoring should be clarified and included in the odour response protocol described in recommendation 4.	High	EP	AER
9	Assessment of fixed and fugitive emission sources focused on the parameters in the Air Quality Focal Parameter List (Section 6.6.4) is required based on the findings of this report. Polycyclic aromatic hydrocarbons must also be considered. The intent is to develop a roadmap outlining a systematic process for examination of the dominant emission sources for the parameters in the Air Quality Focal Parameter List for further consideration and refinement. Further work related to odours may be required pending direction from the Government of Alberta.	High	Industry, AER as required	AER
10	A targeted examination of emissions control through best management practices should be conducted on the basis of findings from recommendation 9. A multiyear continuous-improvement program for implementation is required.	Medium	AER	Industry
11	Air dispersion modelling conducted in EPEA approval applications and environmental impact assessments should consider odours generated during project activities. Additional guidance or review of the Air Quality Model Guideline to improve consistency across operators and applications for air dispersion modelling for odours is needed.	Medium	Government of Alberta	AER
12	Based on the findings of this report, reporting requirements for oil sands EPEA approvals with respect to air emissions should be reviewed to improve consistency across operators for monthly and annual reporting, units of measure, quality assurance and quality control to reduce reporting errors, and inclusion of additional parameters with AAAQOs. Consideration should also be given to transparency and public access to monthly and annual industry reports.	Medium	AER	
13	Assessment of the health implications of the ambient monitoring results in this report to the community of Fort McKay. This assessment should consider the results of this report, specifically the Air Quality and Odorant Focal Parameter Lists (Section 6.6.4) where concentrations greater than standards, limits, objectives, and thresholds have been demonstrated. The assessment must consider data limitations and distributions, applicability of thresholds, and the context of parameters exceeding thresholds in relation to background concentrations and other areas of Alberta.	High	Alberta Health	Government of Alberta, Government of Canada, AER
14	Establish an integrated, consistent approach to air quality monitoring from source (industry emissions), to fenceline (Mildred Lake [AMS02], Mannix [AMS05], and Lower Camp [AMS11]) to ambient monitoring stations (AMS 01 and Oski-ōtin). Changes to monitoring should initially consider contaminants on the Air Quality Focal Parameter List (Section 6.6.4). Polycyclic aromatic hydrocarbons should also be considered in future monitoring plans.	High	EP, AER	Environment Canada
15	Using the best available knowledge, improve consistency of H <sub>2</sub> S and total reduced sulphur monitoring, including examination of individual sulphur compounds in the ambient air monitoring network in the oil sands.	High	EP	Environment Canada, AER
16	Development and application of ambient air quality policy for parameters that do not have AAAQOs in areas of odour, ecological and human health.	Medium	GoA	Alberta Health, AER
17	A Fort McKay Odour and Air Quality Task Force is required to oversee implementation of the recommendations in this report. The task force would be chaired by the AER; include the Government of Alberta, Alberta Health, and EP; and involve participation of industry, Fort McKay, WBEA, Environment Canada, and other parties as required.	High	AER	IRMS partners