Technical Memorandum

Aamjiwnaang First Nation
Community Air Monitoring Station

2014 Report

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Ontario Ministry of the Environment and Climate Change
Southwestern Region Technical Support Section
Air, Pesticides, and Environmental Planning Unit
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Executive Summary

The Aamjiwnaang First Nation community air monitoring station was established in the fall of 2008 in partnership between the Aamjiwnaang First Nation and the provincial and federal governments. The station is equipped to monitor a range of air contaminants. Some of these are sampled on an hourly basis, while others are sampled for 24 hours either once every 6 days or once every 12 days, depending upon the monitor. The monitoring data may be used for long-term air quality studies and to assist in community health assessments.

This report presents an analysis of the data collected between January and December 2014, and highlights key results, such as exceedances of benchmark concentrations, and observed differences in contaminant levels in comparison to previous years. Monitoring results were compared with Ontario's Ambient Air Quality Criteria (AAQC), where such existed. Further elaboration of any of the information presented in this report is available upon request.

Continuous (hourly) data are presented for:

- Sulphur dioxide (SO_2)
- Total reduced sulphur (TRS) compounds
- Nitrogen dioxide (NO_2)
- Carbon monoxide (CO)
- Ground-level ozone (O_3)
- Fine particulate matter ($PM_{2.5}$)
- Specific volatile organic compounds (VOC)

Non-continuous (collected on a 6- or 12-day schedule) data are presented for:

- Suspended particulate and certain suspended particulate constituents – primarily metals
- A wider range of VOC
- Polycyclic aromatic hydrocarbons (PAH)

Key results discussed in this report:

- There were no exceedances measured for four of the Air Quality Index pollutants (SO_2, NO_2, CO, or TRS). Though the average and maximum $PM_{2.5}$ concentrations decreased from those of 2013, there were six exceedances (compared to three in 2013).
- The 2014 average and maximum ozone concentrations, as well as the number of exceedances, have decreased from those observed in 2013. Data from the first five years of operation at the Aamjiwnaang First Nation station (2008-2013) showed an

increase in ozone concentrations and AAQC exceedances. This finding was consistent with the provincial trend in increasing ozone annual means over the last 10 years, as detailed in the ministry's Air Quality in Ontario 2013 Report.

- Analysis of the ministry's continuous and non-continuous VOC monitoring data showed that the 2014 annual average benzene concentration exceeded the AAQC, and was the highest annual average observed since monitoring began at the Aamjiwnaang station in 2008. The 2014 annual average benzene concentration represents a 9.2% increase from the previous highest annual average, which was observed in the first year of monitoring (2008/2009).
- The annual average benzene concentrations measured at the Aamjiwnaang station and Environment Canada's Sarnia monitoring station over the last six years are much lower than the benzene concentrations measured in Sarnia twenty years ago.
- None of the other VOC monitored, continuously or non-continuously, exceeded their respective AAQC in 2014.
- There were no AAQC exceedances for suspended particulate or any of its metal constituents in 2014.
- Average and maximum PAH concentrations were lower in 2014 than those observed in 2013. However, the average annual benzo[a]pyrene concentration exceeded the ministry's AAQC in 2014, as it has in each of the five previous years of monitoring.
- Overall, results were generally similar to previous years and to findings from other communities in southwestern Ontario. However, benzene and 1,3-butadiene concentrations were higher in Aamjiwnaang and Sarnia than in surrounding communities.

Introduction

The Aamjiwnaang First Nation is situated in the heart of the heavily industrialized area located along the St. Clair River to the south of the City of Sarnia. The Aamjiwnaang First Nation community air monitoring station is located on the Aamjiwnaang First Nation at the intersection of Tashmoo Avenue and Lasalle Road, west of Highway 40.

The Aamjiwnaang First Nation station consists of a secured and fenced building containing monitoring equipment targeting a range of air contaminants. The equipment installed at the station monitors the following individual compounds on a continuous basis:

- Sulphur dioxide (SO_2)
- Total reduced sulphur (TRS) compounds
- Nitrogen oxides ($NO/NO_2/NO_x$)
- Carbon monoxide (CO)
- Ground-level ozone (O_3)
- Fine particulate matter ($PM_{2.5}$)
- Volatile organic compounds (VOC) using a Gas Chromatograph/Mass Spectrometer (GC/MS)

In addition to the continuous monitoring, a wider range of air contaminants are measured by monitors that collect a sample periodically over a 24-hour period. These samples are sent to an Environment Canada laboratory for analysis. The non-continuous sampling can often detect lower concentrations of target contaminants than the continuous sampling. The following air contaminants are measured non-continuously at the Aamjiwnaang First Nation station, either on a 6-day or 12-day cycle:

- Volatile organic compounds (VOC)
- Suspended particulate and constituent metals
- Polycyclic aromatic hydrocarbons (PAH)

Meteorological data, including wind speed and wind direction, are also collected at the station.

In this report, monitoring results were compared with Ontario's Ambient Air Quality Criteria (AAQC), where such existed. An AAQC is a desirable concentration of a contaminant in the air, based on protection against adverse effects on human health or the environment. The AAQC were used for comparisons as they are intended to assess general air quality independent of location or source of a contaminant. In contrast, Ontario's Point of Impingement Standards are meant to assess the contribution of any single source, such as emissions from an individual facility.

Some monitoring results were also compared to the Air Quality Index (AQI), which is a rating scale for outdoor air in Ontario, with a lower AQI indicating better air quality. The six key air pollutants that make up the AQI are SO_2, TRS, NO_2, O_3, CO, and $PM_{2.5}$. An AQI sub-index is calculated every hour for each pollutant measured at a station, and the maximum sub-index is reported as the AQI for that station for that hour. Results are not shown for carbon monoxide (CO), as CO measurements remained below the monitor's detection limit over the entire monitoring period.

In 2015, the ministry replaced the AQI with the Air Quality Health Index (AQHI), which provides a rating for outdoor air quality and a category that describes the associated level of health risk. The AQHI is based on three air pollutants: NO_2, O_3, and $PM_{2.5}$. However, the 2014 monitoring results were compared to the AQI, as this was the provincial rating scale in place at the time that data was collected. Future reports will compare monitoring results to the AQHI.

Monitoring results for $PM_{2.5}$ and O_3 were also compared to the Canadian Ambient Air Quality Standards (CAAQS), which were published by the Canadian federal government in 2013, and came into effect in 2015. The CAAQS replaced the existing Canada-Wide Standards for $PM_{2.5}$ and O_3, and introduced stricter targets for ambient air quality. An annual standard for $PM_{2.5}$ was introduced as well, which was developed based on the protection of human health from long-term exposure to fine particles. Although the CAAQS were not in place at the time that the data was collected, the $PM_{2.5}$ and O_3 results have been assessed against these values in order to provide a compasion to the current federal standards.

Monitoring results were compared with data from other ministry or Environment Canada monitoring stations in southwestern Ontario, including Sarnia and Windsor, where available. Comparison sites were chosen which would represent conditions in southwestern Ontario and so reflect similar background conditions.

Monitoring results were also compared to data presented in Aamjiwnaang First Nation air monitoring station technical memoranda previously published by the ministry, including "Results for 2013"[6] and "5-Year Report: Results for the Period Sept. 2008-Dec. 2013"[7], which were released in July 2015 (see the "References" section).

Results are reported in two different concentration units. Particulate, metal, PAH, and canister (non-continuous) VOC results are reported in micrograms per cubic metre ($\mu g/m^3$) or nanograms per cubic metre (ng/m^3), while most of the hourly results are reported in parts per billion (ppb). Where results are reported in ppb and are to be compared to ministry AAQC (which are published in µg/m^3), the ministry's AAQC values are converted to ppb assuming a temperature of 20° C and an atmospheric pressure of 1 atmosphere (101.3 kilopascals [kPa]).

This report includes monitoring data presented using pollution roses, which are diagrams showing how pollutant levels are related to wind direction. All wind data and directions are given based on the direction from which the wind was blowing; i.e., a westerly wind is a wind blowing from the west.

For the calculation of average concentrations of PAH, non-continuous VOC, suspended particulate and metals, half of the detection limit is used where the monitoring data shows non-detects. For the calculation of averages of the AQI pollutants and the continuous VOC, non-detects are included as "0". Additional information on this averaging convention is given in the "Data Averaging and Unit Conversion" appendix.

Hourly Data – Air Quality Index Pollutants

Sulphur Dioxide (SO_2)

Table 1 – 2014 Annual Statistics			
Report Values	**Average (ppb)**	**Maximum (ppb)**	**AAQC Exceedances**
Aamjiwnaang First Nation Station			
2014	2.4	107	0
2013	2.4	75	0
Other Stations, Current Report Period			
Sarnia AQI	3.5	95	0
Windsor West AQI	2.7	59	0

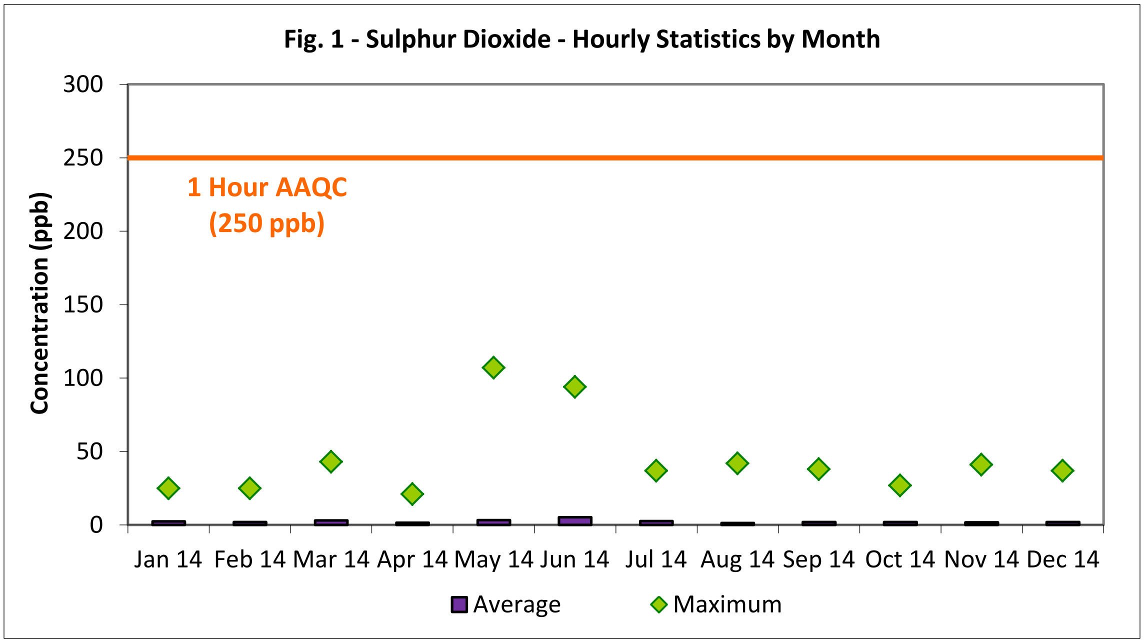
Sulphur dioxide (SO_2) is a colourless gas emitted from industrial facilities and sources that burn sulphur-containing fuel. Industrial sources include electric power generators, iron and steel mills, petroleum refineries, and pulp and paper mills. Small sources include residential, commercial, and industrial space heating. SO_2 and nitrogen oxides (NO_x) are the main contributors to acid rain. Health effects caused by exposure to high levels of SO_2 include eye and respiratory tract irritation, and worsening cardiovascular disease. SO_2 can travel a considerable distance downwind in certain meteorological conditions.

The ministry has a 1-hour AAQC for SO_2 of 250 ppb, a 24-hour AAQC of 100 ppb, and an annual AAQC of 20 ppb. No exceedances of any of the AAQC were observed during this monitoring period. The average sulphur dioxide concentration was unchanged from the previous year, and lower than those measured at the Sarnia and Windsor West AQI stations. However, the maximum concentration increased from 2013, and was higher than those at Sarnia and Windsor West. The highest single-hour concentrations and monthly averages occurred in May and June respectively.

Table 2 – 2014 Month by Month Statistics								
	Concentration		**AAQC Exceedances**	**AQI Sub-index**				
	Average (ppb)	**Maximum (ppb)**		**Very Good**	**Good**	**Moderate**	**Poor**	**Very Poor**
Jan	2.4	25	0	100.0%	0.0%	0.0%	0.0%	0.0%
Feb	2.0	25	0	100.0%	0.0%	0.0%	0.0%	0.0%
Mar	3.0	43	0	100.0%	0.0%	0.0%	0.0%	0.0%
Apr	1.5	21	0	100.0%	0.0%	0.0%	0.0%	0.0%
May	3.2	107	0	99.6%	0.4%	0.0%	0.0%	0.0%
Jun	5.2	94	0	99.4%	0.6%	0.0%	0.0%	0.0%
Jul	2.7	37	0	100.0%	0.0%	0.0%	0.0%	0.0%
Aug	1.4	42	0	100.0%	0.0%	0.0%	0.0%	0.0%
Sep	1.9	38	0	100.0%	0.0%	0.0%	0.0%	0.0%
Oct	1.9	27	0	100.0%	0.0%	0.0%	0.0%	0.0%
Nov	1.8	41	0	100.0%	0.0%	0.0%	0.0%	0.0%
Dec	1.9	37	0	100.0%	0.0%	0.0%	0.0%	0.0%

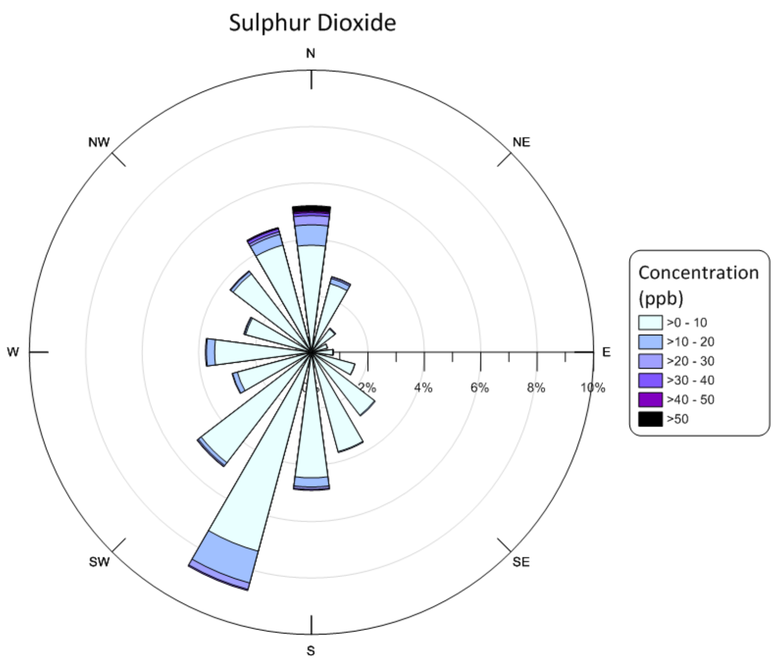
The SO_2 measurements led to a *Very Good* SO_2 AQI sub-index, with the exception of a few hours in May and June where measurements led to a *Good* AQI sub-index. The month by month results are given in the adjacent table and shown in the graph on the next page.

The federal government, in consultation with the provinces, is in the process of updating the Canadian Ambient Air Quality Standards (CAAQS) for SO_2. These updates will inform a revision of Ontario's air quality standards, resulting in new, lower AAQC for SO_2.



The pollution rose in Figure 2 illustrates how SO_2 concentrations vary with wind direction. As seen in previous years, the highest concentrations were generally associated with winds from the north.

Fig. 2



Total Reduced Sulphur (TRS) Compounds

Total reduced sulphur (TRS) compounds are a group of sulphur-based compounds including hydrogen sulphide and various mercaptans. TRS compounds have a variety of industrial sources, such as petrochemical facilities and sewage treatment plants, and natural sources, such as swamps and marshes. TRS compounds are not generally considered a health hazard at typical ambient air concentrations, however, they are a primary cause of odours.

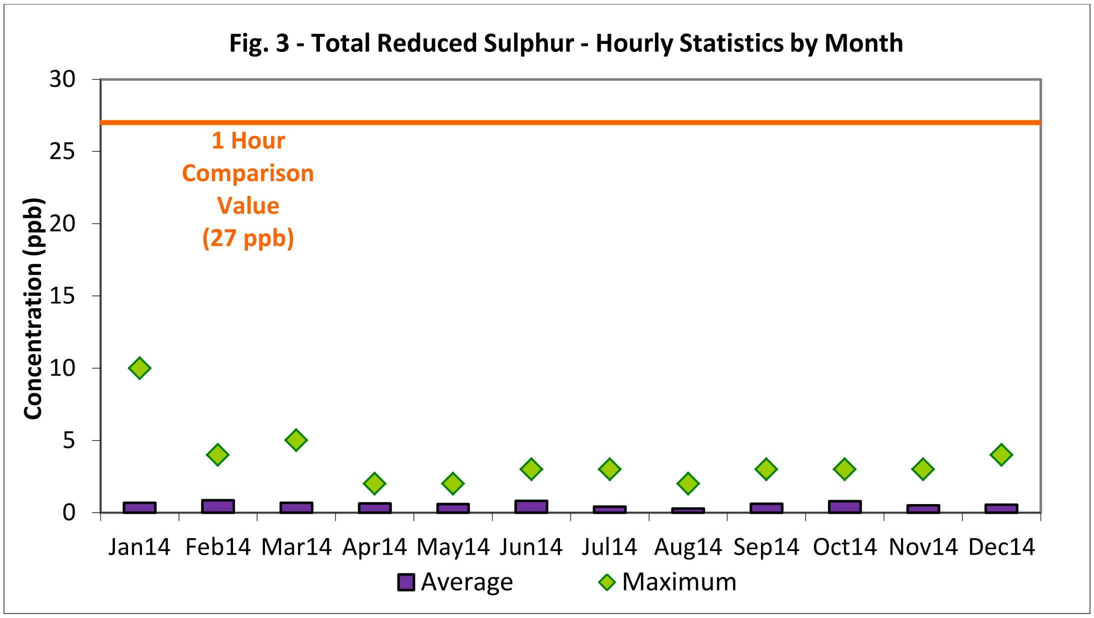
Table 3 – 2014 Annual Statistics			
Report Values	**Average (ppb)**	**Maximum (ppb)**	**AAQC Exceedances**
Aamjiwnaang First Nation Station			
2014	0.6	10	0
2013	0.6	8	0
Other Stations, Current Report Period			
Sarnia AQI	0.8	5	0
Windsor West AQI	0.2	10	0

The ministry does not have a 1-hour AAQC for TRS, so the results were compared to 27 ppb, the highest concentration which would lead to a *Moderate* AQI classification. The ministry has a health-based 24-hour AAQC for TRS of 7 µg/m^3 (4.8 ppb, based on a TRS composition solely of hydrogen sulphide), and an odour-based 10-minute AAQC of 13 µg/m^3 (9.1 ppb).

No exceedances of the comparison value (27 ppb), 24-hour or 10-minute AAQC were measured in 2014. The annual average was the same as the previous year, though the maximum was higher. The average was lower than Sarnia's, but higher that in Windsor, and the maximum concentration was higher than Sarnia's and equal to that in Windsor.

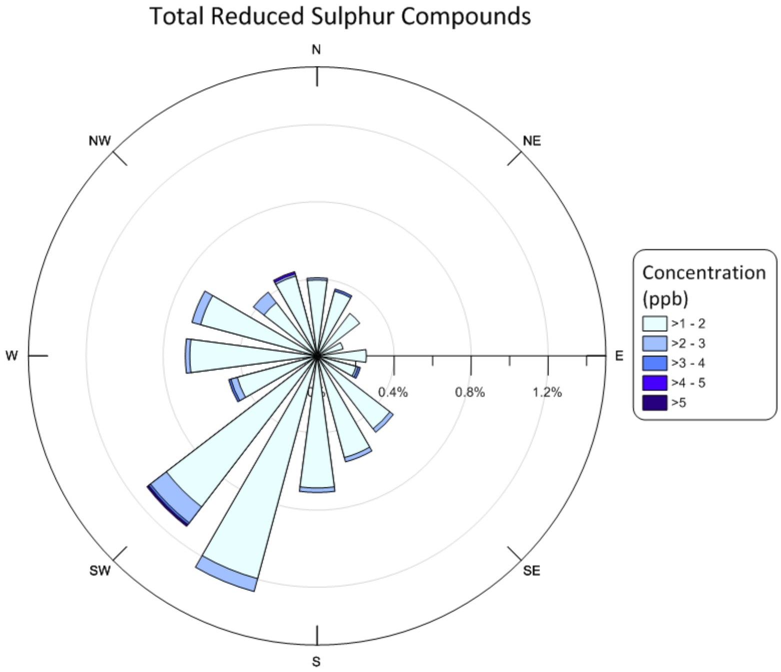
Table 4 – 2014 Month by Month Statistics								
	Concentration		**AAQC Exceedances**	**AQI Sub-index**				
	Average (ppb)	**Maximum (ppb)**		**Very Good**	**Good**	**Moderate**	**Poor**	**Very Poor**
Jan	0.7	10	0	99.9%	0.1%	0.0%	0.0%	0.0%
Feb	0.9	4	0	100.0%	0.0%	0.0%	0.0%	0.0%
Mar	0.7	5	0	100.0%	0.0%	0.0%	0.0%	0.0%
Apr	0.6	2	0	100.0%	0.0%	0.0%	0.0%	0.0%
May	0.6	2	0	100.0%	0.0%	0.0%	0.0%	0.0%
Jun	0.8	3	0	100.0%	0.0%	0.0%	0.0%	0.0%
Jul	0.4	3	0	100.0%	0.0%	0.0%	0.0%	0.0%
Aug	0.3	2	0	100.0%	0.0%	0.0%	0.0%	0.0%
Sep	0.6	3	0	100.0%	0.0%	0.0%	0.0%	0.0%
Oct	0.8	3	0	100.0%	0.0%	0.0%	0.0%	0.0%
Nov	0.5	3	0	100.0%	0.0%	0.0%	0.0%	0.0%
Dec	0.6	4	0	100.0%	0.0%	0.0%	0.0%	0.0%

Monthly results are given in Table 4 and illustrated in Figure 3. January had one hour during which the TRS AQI sub-index was *Good*, while the rest of the year remained in the *Very Good* range. The maximum hourly concentration was seen in January, and the highest monthly average occurred in February. For the remainder of the year, there was minimal variation in the monthly results.



A pollution rose for values greater than 1 ppb is shown in Figure 4. The lowest values (<1 ppb) were omitted so that they did not overwhelm the few higher values. The figure suggests that there is not a dominant source of TRS compounds, but rather there may be a number of smaller sources in the area.

Fig. 4



Nitrogen Dioxide (NO_2)

Nitrogen dioxide (NO_2) is a common combustion product. The main sources are motor vehicles, thermal power generation, metal production, and incineration. NO_2 reacts in the atmosphere to form a number of compounds, some of which have adverse health or environmental effects. It is an ozone precursor, a component of smog and one of the causes of acid rain. NO_2 can lead to lung irritation and lower resistance to respiratory infection.

Table 5 – 2014 Annual Statistics

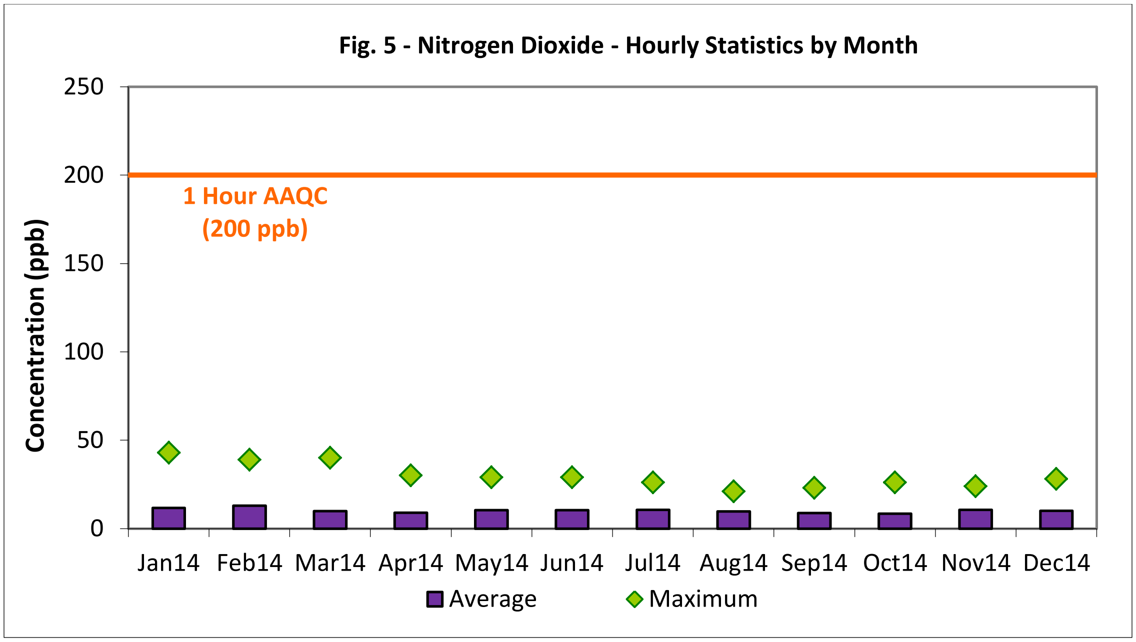
Report Values	Average (ppb)	Maximum (ppb)	AAQC Exceedances
Aamjiwnaang First Nation Station			
2014	10.2	43	0
2013	11.5	38	0
Other Stations, Current Report Period			
Sarnia AQI	9.0	59	0
Windsor West AQI	11.8	73	0

The ministry has a 1-hour AAQC for NO_2 of 200 ppb, and a 24-hour AAQC of 100 ppb. No AAQC exceedances were measured during 2014. The average was lower than that of 2013, though the maximum concentration was higher. The average was higher than that seen at the Sarnia AQI station, but lower than that in Windsor. The maximum concentration was lower than those seen in both Sarnia and Windsor.

A month by month summary of the NO_2 concentrations is given in Table 6. No strong seasonal influence is apparent. The NO_2 AQI sub-index was always in the *Very Good* range, as was observed in the previous year.

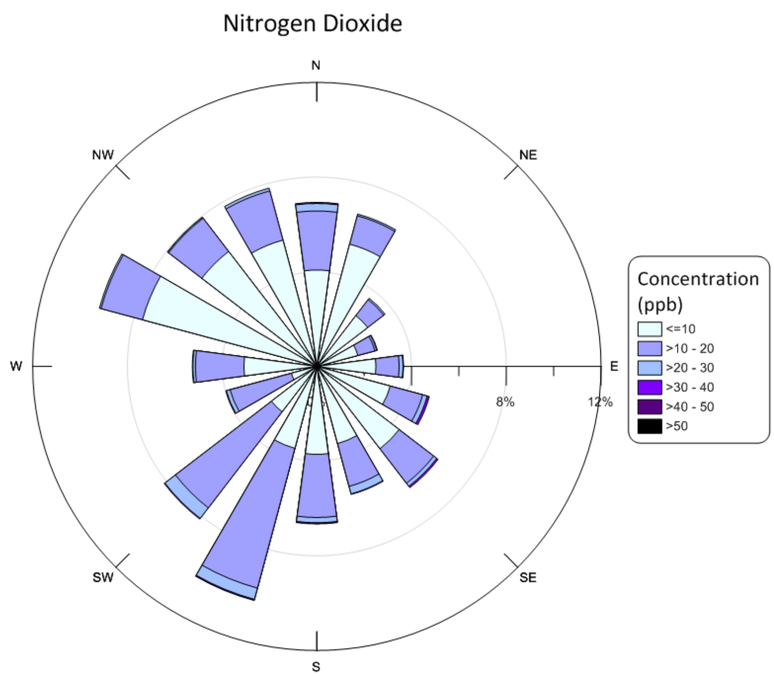
Table 6 – 2014 Month by Month Statistics

	Concentration		AAQC Exceedances	AQI Sub-index				
	Average (ppb)	Maximum (ppb)		Very Good	Good	Moderate	Poor	Very Poor
Jan	11.7	43	0	100.0%	0.0%	0.0%	0.0%	0.0%
Feb	12.9	39	0	100.0%	0.0%	0.0%	0.0%	0.0%
Mar	9.9	40	0	100.0%	0.0%	0.0%	0.0%	0.0%
Apr	9.0	30	0	100.0%	0.0%	0.0%	0.0%	0.0%
May	10.4	29	0	100.0%	0.0%	0.0%	0.0%	0.0%
Jun	10.4	29	0	100.0%	0.0%	0.0%	0.0%	0.0%
Jul	10.5	26	0	100.0%	0.0%	0.0%	0.0%	0.0%
Aug	9.8	21	0	100.0%	0.0%	0.0%	0.0%	0.0%
Sep	8.8	23	0	100.0%	0.0%	0.0%	0.0%	0.0%
Oct	8.4	26	0	100.0%	0.0%	0.0%	0.0%	0.0%
Nov	10.6	24	0	100.0%	0.0%	0.0%	0.0%	0.0%
Dec	10.0	28	0	100.0%	0.0%	0.0%	0.0%	0.0%



The pollution rose below illustrates how the NO_2 concentration varied with wind direction. The station's highest concentrations were seen from all directions, although, as in previous years, they are more frequent when the wind is coming from the south. In addition to local sources, long range atmospheric transport may also contribute to local concentrations.

Fig. 6



Ozone (O_3)

Ozone (O_3) is a reactive, inorganic gas with a distinctive pungent odour. It is not emitted directly into the atmosphere, rather, it is formed in the presence of sunlight in reactions between nitrogen oxides (NO_x) and volatile organic compounds (VOC). The formation and transport of ozone is strongly dependent on meteorological conditions. Signficant amounts of ozone and ozone-forming compounds travel from the United States into Ontario. Strong sunlight and warm conditions speed up production, and so concentrations tend to rise during the day, and fall at night. Year-to-year variations in ozone concentrations are greatly dependant on wind patterns and weather. Ozone is a component of smog and can have human health impacts, particularly respiratory tract irritation. It may also adversely affect certain plants. The ministry has a health-based 1-hour AAQC for O_3 of 80 ppb.

Table 7 – 2014 Annual Statistics			
Report Values	**Average (ppb)**	**Maximum (ppb)**	**AAQC Exceedances**
Aamjiwnaang First Nation Station			
2014	27.5	82	1
2013	28.4	96	12
Other Stations, Current Report Period			
Sarnia AQI	27.1	79	0
Windsor West AQI	27.2	86	3

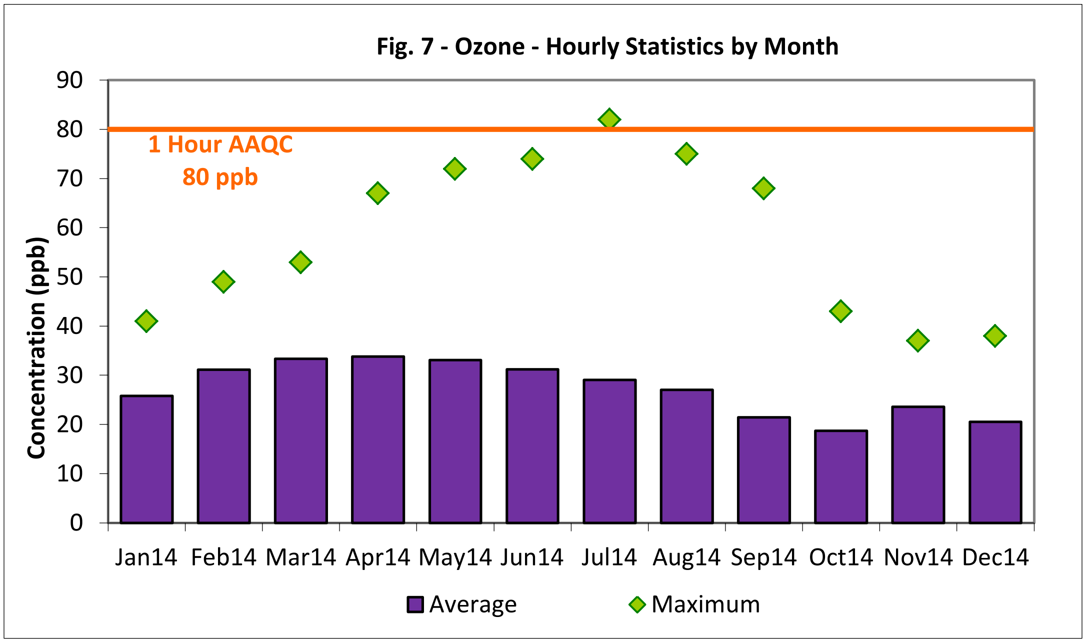
The ministry's *Air Quality in Ontario* 2014 report highlights the province's increasing ozone annual means between 2004 and 2014[8]. The findings at Aamjiwnaang First Nation in previous years have been consistent with this provincial trend[7]. The 2014 results show an improvement from 2013, with observed decreases in the average and maximum concentrations, as well as the number of AAQC exceedances (one exceedance occurred in 2014, which is down from 12 in 2013 and 50 in 2012). The 2014 results at the Aamjiwnaang First Nation are consistent with the concentrations observed at the Sarnia and Windsor West AQI stations. The 2014 results for Sarnia showed similar decreases in the average and maximum concentration, and number of exceedances observed in

Table 8 – 2014 Month by Month Statistics

	Concentration		AAQC Exceedances	AQI Sub-index				
	Average (ppb)	**Maximum (ppb)**		**Very Good**	**Good**	**Moderate**	**Poor**	**Very Poor**
Jan	25.8	41	0	34.7%	65.3%	0.0%	0.0%	0.0%
Feb	31.1	49	0	16.7%	83.3%	0.0%	0.0%	0.0%
Mar	33.3	53	0	10.5%	89.2%	0.3%	0.0%	0.0%
Apr	33.8	67	0	15.4%	79.0%	5.6%	0.0%	0.0%
May	33.1	72	0	24.1%	64.0%	12.0%	0.0%	0.0%
Jun	31.2	74	0	33.3%	54.1%	12.6%	0.0%	0.0%
Jul	29.0	82	1	39.4%	49.4%	11.1%	0.1%	0.0%
Aug	27.0	75	0	40.7%	53.3%	6.0%	0.0%	0.0%
Sep	21.5	68	0	61.3%	35.0%	3.8%	0.0%	0.0%
Oct	18.7	43	0	66.4%	33.6%	0.0%	0.0%	0.0%
Nov	23.6	37	0	46.9%	53.1%	0.0%	0.0%	0.0%
Dec	20.5	38	0	59.2%	40.8%	0.0%	0.0%	0.0%

2013 (28.6 ppb, 83ppb, and 4 exceedances, respectively).

Table 8 and associated Figure 7 show that the average and maximum concentrations increased in the late spring and summer. This seasonal trend is seen because ozone formation is directly linked to heat and sunlight. The single AAQC exceedance observed in 2014 led to a *Poor* Air Quality sub-index for one hour in July.



The Canadian federal government has an 8-hour Canadian Ambient Air Quality Standard (CAAQS) for ozone, which was published in 2013, and came into effect in 2015. The 2014 results from the Aamjiwnaang First Nation station have been assessed against this value in order to provide a comparison to the current federal standard.

Table 9 shows the ozone metric value calculated for the Aamjiwnaang First Nation and the three designated CAAQS monitoring sites located in southwestern Ontario (Windsor Downtown, Chatham, and London) in comparison to the CAAQS. This metric value calculation, as described in the table footnote, is based on a three year average (2012-2014).

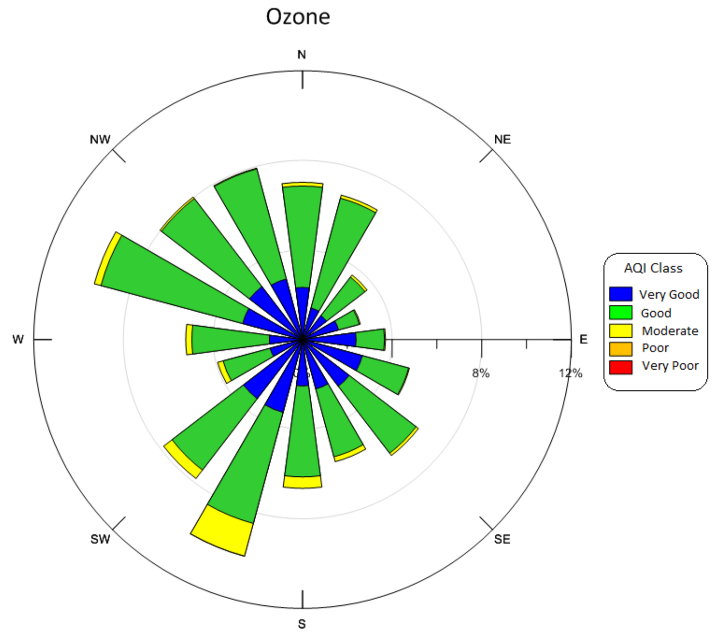
Table 9 - O_3 Metric Value in Comparison to the CAAQS (concentrations in ppb)					
	CAAQS (ppb)	Aamjiwnaang First Nation	Windsor Downtown	Chatham	London
O_3 8-hour[1]	63	73	73	71	71

[1]The 8-hour O_3 metric value is the 3-year average of the annual 4th-highest daily maximum 8-hour average concentrations. Red font indicates an exceedance of the CAAQS.

The 2014 metric value for ozone calculated for the Aamjiwnaang First Nation station (73 ppb) exceeded the CAAQS. There are 21 designated CAAQS monitoring sites in Ontario, and of these, only two sites met the ozone CAAQS in 2014 (Ottawa and Thunder Bay)[8]. The ozone CAAQS metric values for sites across Ontario ranged from 54 ppb to 73 ppb. The result at the Aamjiwnaang station is consistent with the results reported for the three sites located in southwestern Ontario.

In general, southerly winds bring more of the chemicals that form ozone to the region. These compounds originate in industrial and developed areas and so concentrations detected at the Aamjiwnaang First Nation station are influenced by the prevailing winds. The pollution rose below shows that higher frequencies of *Moderate* air quality sub-indices are related to winds from the south.

Fig. 8



Fine Particulate Matter ($PM_{2.5}$)

Table 10 – 2014 Annual Statistics			
Report Values (3-hour)	**Average ($\mu g/m^3$)**	**Maximum ($\mu g/m^3$)**	**AAQC Exceedances**
Aamjiwnaang First Nation Station			
2014	8.1	53.3	6
2013	8.4	54.7	3
Other Stations, Current Report Period			
Sarnia AQI	9.0	91	20
Windsor West AQI	10.7	73	17

Fine particulate matter, also called respirable particulate or $PM_{2.5}$, is the fraction of atmospheric particulate that is smaller than 2.5 microns in aerodynamic diameter. These particles are important because their small size enables them to bypass the body's natural defences and reach the deepest parts of the lung. $PM_{2.5}$ often forms from chemical processes in the atmosphere, and acts much like a gas due to its small size. As a result, fine particulate may be transported hundreds of kilometres from its source.

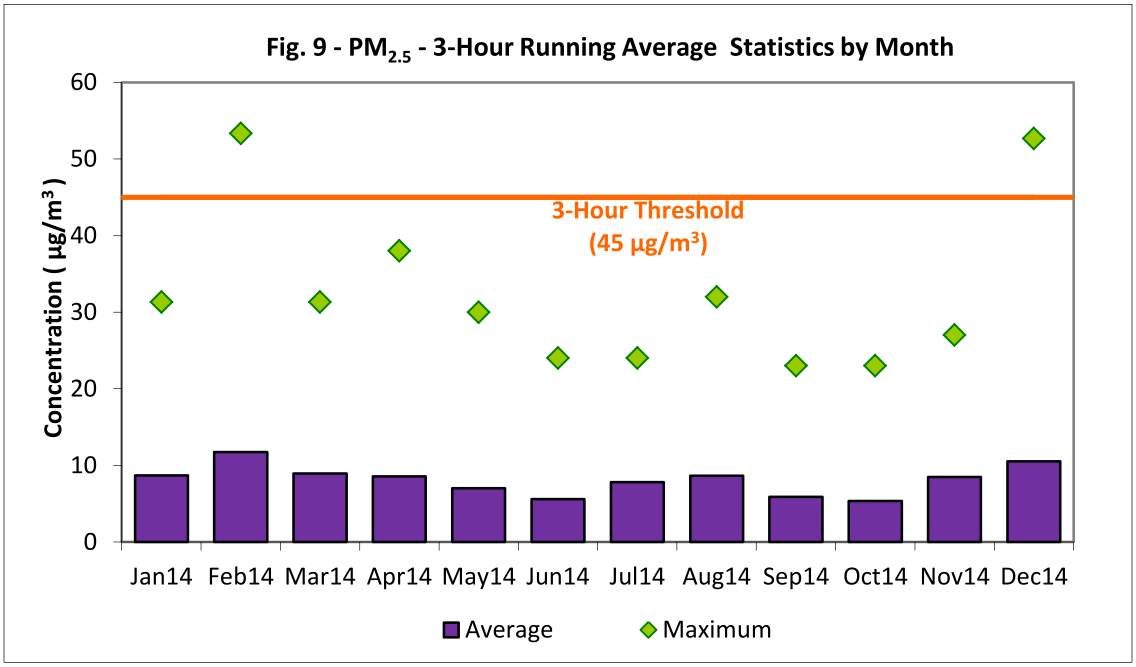
The ministry does not have a 1-hour AAQC for $PM_{2.5}$. "Exceedances" for $PM_{2.5}$ were determined based on surpassing the highest concentration that would lead to a *Moderate* AQI classification (45 $\mu g/m^3$). The $PM_{2.5}$ AQI sub-index is based upon a 3-hour running average, so for consistency, the statistics presented in Table 10 were calculated for 3-hour running averages.

The average and maximum 3-hour concentrations were slightly lower than the previous year, however, the number of exceedances doubled. The average and maximum concentrations were lower than those measured at the Sarnia and Windsor West AQI stations. These differences may partly be due to the different instrumentation that is used to measure fine particulate at these stations. Fine particulate is measured with a GRIMM monitor at the Aamjiwnaang First Nation station, and with a SHARP monitor at the Sarnia and Windsor West AQI stations. In 2013, the ministry installed SHARP monitors at its AQI stations, which are expected to provide a more accurate measurement of

Table 11 – 2014 Month by Month Statistics								
	Concentration (3-hr)		**AAQC Exceedances**	**AQI Sub-index**				
	Average (µg/m3)	**Maximum (µg/m3)**		**Very Good**	**Good**	**Moderate**	**Poor**	**Very Poor**
Jan	8.7	31.3	0	74.1%	23.7%	2.2%	0.0%	0.0%
Feb	11.8	53.3	4	64.0%	24.8%	10.8%	0.5%	0.0%
Mar	9.0	31.3	0	77.2%	16.8%	6.0%	0.0%	0.0%
Apr	8.6	38.0	0	79.7%	18.1%	2.2%	0.0%	0.0%
May	7.0	30.0	0	86.2%	11.7%	2.2%	0.0%	0.0%
Jun	5.6	24.0	0	89.8%	9.3%	0.8%	0.0%	0.0%
Jul	7.8	24.0	0	81.2%	17.8%	1.0%	0.0%	0.0%
Aug	8.6	32.0	0	79.3%	17.4%	3.3%	0.0%	0.0%
Sep	5.9	23.0	0	94.7%	5.1%	0.1%	0.0%	0.0%
Oct	5.4	23.0	0	90.6%	9.1%	0.3%	0.0%	0.0%
Nov	8.5	27.0	0	82.0%	15.3%	2.6%	0.0%	0.0%
Dec	10.5	52.7	2	64.8%	27.0%	8.0%	0.3%	0.0%

fine particulate matter, and have been found to report higher annual means than previous years[8].

A month-by-month summary is given in Table 11 and illustrated in Figure 9. The 3-hour average fine particulate concentration fell in the *Poor* AQI range on four occasions in February and twice in December, and was in the *Moderate, Good* or *Very Good* range for the remainder of the year. The highest average and maximum concentrations were observed in February.



The Canadian federal government has 24-hour and annual Canadian Ambient Air Quality Standards (CAAQS) for $PM_{2.5}$, which were published in 2013. The annual standard introduced for $PM_{2.5}$ was developed based on the protection of human health from long-term exposure to fine particles. The $PM_{2.5}$ CAAQS came into effect in 2015, however, the 2014 results from the Aamjiwnaang First Nation station have been assessed against these values for the purpose of comparison.

Table 12 shows the $PM_{2.5}$ metric values calculated for the Aamjiwnaang First Nation, and three other southwestern Ontario stations, in comparison to the 24-hour and annual CAAQS. These metric value calculations, as described in the table footnotes, are based on a three year average (2012-2014). There were no exceedances of either $PM_{2.5}$ CAAQS at the Aamjiwnaang First Nation station in 2014. The results at the Aamjiwnaang station were within the range of CAAQS metric values reported for the 21 designated monitoring sites in Ontario in 2014 (24-hour CAAQS: 14 µg/m^3 to 25 µg/m^3; annual CAAQS: 5.2 µg/m^3 to 9.7 µg/m^3)[8]. The Aamjiwnaang results were generally slightly higher than those of the three sites located in southwestern Ontario (Windsor Downtown, Chatham, and London).

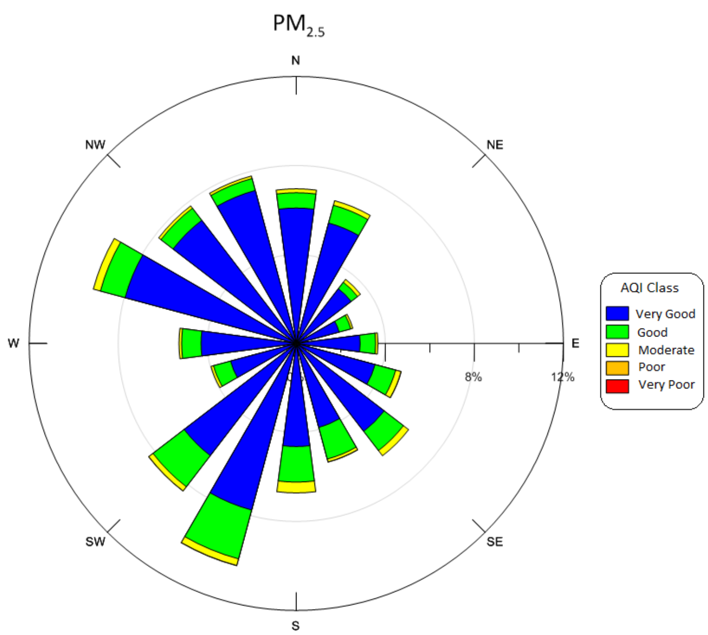
Table 12 - $PM_{2.5}$ Metric Values in Comparison to the CAAQS (concentrations in µg/m^3)					
	CAAQS	**Aamjiwnaang First Nation**	**Windsor Downtown**	**Chatham**	**London**
$PM_{2.5}$ 24-hour[1]	28	23.3	21	18	21
$PM_{2.5}$ Annual[2]	10	8.5	8.9	7.6	8.1

[1]The 24-hour $PM_{2.5}$ CAAQS is based on the 3-year average of the annual 98th percentile of the daily 24-hour average concentrations

[2]The annual $PM_{2.5}$ CAAQS is based on the annual mean averaged over three consecutive years

The pollution rose in Figure 10 shows that *Moderate* levels were more frequent when the wind was from the south, but were occasionally seen for all wind directions.

Fig. 10



Hourly Data – Volatile Organic Compounds (VOC)

Volatile organic compounds (VOC) are organic (carbon-containing) chemicals with a high vapour pressure at typical atmospheric conditions. VOC are emitted into the atmosphere from a variety of both natural and anthropogenic sources. Certain VOC play a role in the formation of ground-level ozone and $PM_{2.5}$. Other, less reactive, VOC may be transported long distances in the atmosphere.

VOC may often be odorous and some are linked to various health or environmental impacts. Most VOC are not encountered at levels that are immediately toxic, although they may cause effects on long exposure. For these reasons, the ministry regulates the atmospheric release of a wide variety of VOC.

Hourly levels of VOC were measured at the Aamjiwnaang First Nation station using a gas chromatograph/mass spectrometer (GC/MS). Since monitoring began, there have been changes to the initial list of target compounds - some compounds were not detected, and subsequently removed, and others were added. Changes to the list of target compounds continue to occur, based upon the results and the ministry's expectations of what might be detected in the area. Trichloroethylene and tetrachloroethylene were added in 2013 but removed in 2014, as trichloroethylene was not detected, and tetrachloroethylene was detected less than 1% of the time. Chloroform was added to the list in 2014.

Hourly VOC Results

Table 13 - Summary of Hourly VOC Measurements

	2014			2013		
	Avg (ppb)	Max (ppb)	% > mdl	Avg (ppb)	Max (ppb)	% > mdl
1,3-Butadiene	0.04	14.41	0.83%	0.04	82.12	0.17%
Benzene	0.21	18.24	12.68%	0.12	15.70	7.69%
Chloromethane	0.24	51.49	3.90%	0.22	63.23	2.30%
Cyclohexane	0.36	51.62	8.85%	0.33	46.90	7.35%
Ethyl Benzene	0.01	1.56	4.10%	0.01	2.80	2.39%
Hexane	0.43	60.29	8.64%	0.52	125.78	4.92%
m & p-Xylene	0.02	1.83	4.10%	0.02	4.80	2.38%
o-Xylene	0.02	2.23	4.10%	0.02	2.55	2.50%
Propylene	3.30	239.18	30.83%	2.96	255.48	19.94%
Styrene	0.00	0.97	0.20%	0.00	0.89	0.36%
Toluene	0.11	9.85	19.56%	0.09	15.06	10.91%

Table 13 summarizes the 2014 results and compares them to the results from the previous year. Chloroform and carbon tetrachloride were not detected during the 2014 monitoring period, and so these results are not included in the table.

As seen in previous years, most of the VOC were detected intermittently. VOC are typically present in the environment, though, in general, at very low levels. When they are not detected, they still may be present at low concentrations.

The average propylene concentration, as well as the percent of samples above the method detection limit, increased from 2013. An increase in propylene concentrations was also seen each year between 2009 and 2013[7]. The average and maximum benzene concentrations increased from those of 2013, as did the percentage of samples above the method detection limit. Increases in percentage of samples above the method detection limit could be due to improvements in the instrument, variations in the wind direction, or changes in processes at local plants. Increases in the percentage of samples detected, that is, an increase in non-zero hourly concentrations detected, may in turn lead to an increase in annual average concentrations.

Comparison to 24-hour AAQC

24-hour averages were compared with the respective 24-hour AAQC. Table 14 gives the maximum 24-hour average and the number of exceedances of the 24-hour AAQC. Since the instrument reports measured values in parts per billion (ppb), the ministry's AAQC presented below have been converted from micrograms per cubic metre (µg/m^3) to parts per billion (ppb). The measurements presented in the table should be compared to the AAQC values given in ppb in the second (blue) column. The maximum concentrations for m&p-xylene and o-xylene have been summed for the purpose of comparison to the ministry's AAQC for xylenes.

Table 14 - Comparison to 24-hour AAQC

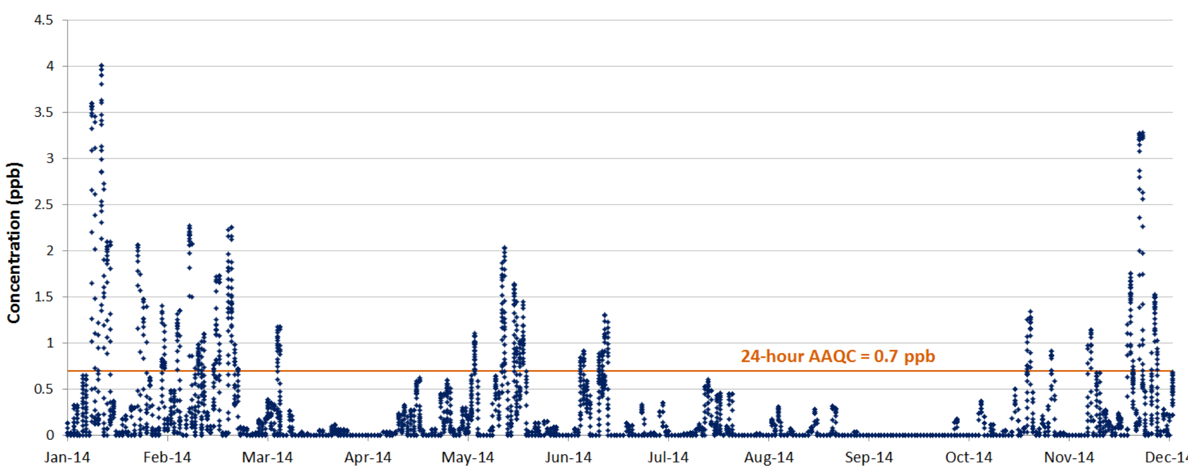
			2014		2013	
	24-hour AAQC (µg/m^3)	24-hour AAQC (ppb)	Max 24-hour Avg (ppb)	#> AAQC	Max 24-hour Avg (ppb)	#> AAQC
1,3-Butadiene	10	4.3	2.76	0	9.93	1
Benzene	2.3	0.7	4.01	43	2.38	22
Chloromethane	320	152	5.66	0	8.99	0
Cyclohexane	6100	1743	11.32	0	8.65	0
Ethyl Benzene	1000	226	0.33	0	0.47	0
Hexane	7500	2093	17.07	0	45.13	0
Propylene	4000	2287	46.71	0	27.05	0
Styrene	400	92	0.10	0	0.15	0
Toluene	2000	522	1.56	0	1.43	0
Xylenes	730	165	1.11	0	1.41	0

Benzene was the only VOC to exceed its 24-hour AAQC, which it did on 43 occasions. The maximum benzene concentration and the number of 24-hour AAQC exceedances have both increased from 2013.

The 43 benzene exceedances correspond to 28 “episodes”, or consecutive periods of time, where the rolling 24-hour average benzene concentration exceeded the AAQC. These episodes ranged from 6 hours to 52 hours in duration. The Data Averaging appendix provides a description of how the number of exceedances within an episode is calculated.

Figure 11 shows the rolling 24-hour average benzene concentrations in comparison to the AAQC. The intermittent detection of benzene can be seen in this figure, specifically, the time periods where benzene was not detected as well as the episodes where the rolling 24-hour average benzene concentration exceeded the AAQC. Half of the episodes occurred in January and February; other episodes occurred in March, May, June, November, and December.

Fig. 11 - Rolling 24-hour Average Benzene Concentration

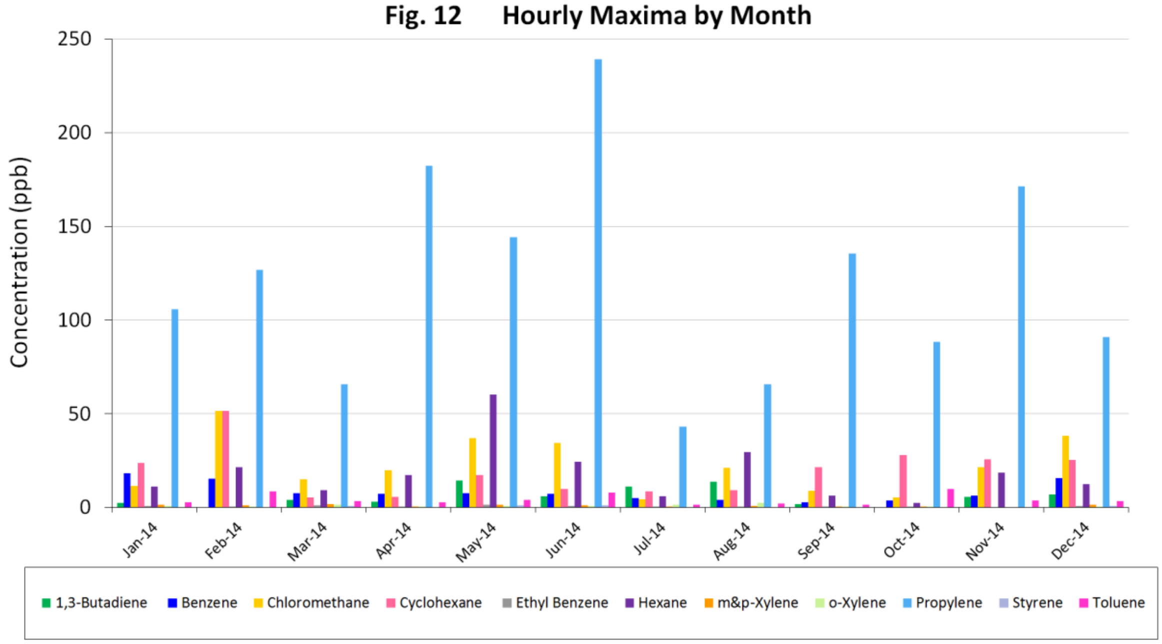


Monthly Variation

Table 15 summarizes the month to month variation in all detected species. Chloroform was not detected, but is included in the table. Benzene concentrations were highest during the winter months (January, February, and December). Eight of the compounds had highest monthly averages in May. Otherwise, there did not seem to be any strong patterns over the year. The monthly variation is illustrated in Figure 12.

Table 15 - Monthly VOC Averages (ppb)												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1,3-Butadiene	0.00	0.00	0.01	0.01	0.23	0.06	0.06	0.03	0.00	0.00	0.02	0.07
Benzene	0.54	0.53	0.09	0.06	0.35	0.18	0.08	0.06	0.03	0.03	0.13	0.40
Chloroform	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Chloromethane	0.04	0.16	0.22	0.36	0.86	0.52	0.02	0.29	0.03	0.02	0.06	0.18
Cyclohexane	0.58	1.05	0.07	0.03	0.39	0.14	0.16	0.24	0.20	0.52	0.65	0.27
EthylBenzene	0.01	0.01	0.01	0.00	0.05	0.03	0.00	0.00	0.00	0.00	0.00	0.03
Hexane	0.09	0.21	0.34	0.42	2.41	0.41	0.05	0.77	0.03	0.02	0.07	0.15
m&p-Xylene	0.01	0.01	0.02	0.01	0.06	0.04	0.01	0.01	0.00	0.00	0.00	0.06
o-Xylene	0.01	0.01	0.01	0.01	0.04	0.03	0.01	0.02	0.00	0.00	0.00	0.04
Propylene	3.43	5.37	1.43	1.58	5.85	4.31	1.41	1.99	2.12	3.49	2.59	6.03
Styrene	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Toluene	0.06	0.22	0.05	0.05	0.24	0.13	0.04	0.07	0.06	0.08	0.02	0.24

Fig. 12 Hourly Maxima by Month



Comparison to Annual AAQC

Benzene and 1,3-butadiene have annual AAQC, given in Table 16 below. The 2014 annual average benzene concentration exceeded the annual AAQC, and was the highest annual average observed since monitoring began in 2008. The annual average 1,3-butadiene concentration has remained below the AAQC each year between 2008 and 2014.

Table 16 - Average Annual Concentration (ppb) in Comparison to Annual AAQC 2008-2014

	Annual AAQC (ppb)	2008/ 2009	2009/ 2010	2011	2012	2013	2014
Benzene	0.134	0.14*	0.06*	0.12	0.12	0.12	0.21
1,3-Butadiene	0.859	**	0.02*	0.05	0.01	0.04	0.04

*24-hour AAQC not in effect at this time; presented for comparison purposes only

**not detected during monitoring period

Red font indicates exceedance of AAQC

Spatial Variation

Figure 13 shows the pollution roses for the VOC, based on hourly concentrations. The roses have been grouped according to the concentration scales which best depict the concentration range and frequency of detection. The roses illustrate diversity in strength and directionality, which reflect the variety of sources in the area. Strong relationships between the compounds are not apparent.

Benzene was the only hourly VOC with exceedances in 2014. Higher concentrations of benzene were measured when the wind was from the west-northwest. Benzene does not appear to bear a strong relationship to any of the other species. Higher concentrations of 1,3-butadiene were measured when the wind was from the north and east-northeast, in contrast to 2013, where 1,3-butadiene was generally not detected when winds were from the east.

Fig. 13 – Hourly VOC Pollution Roses

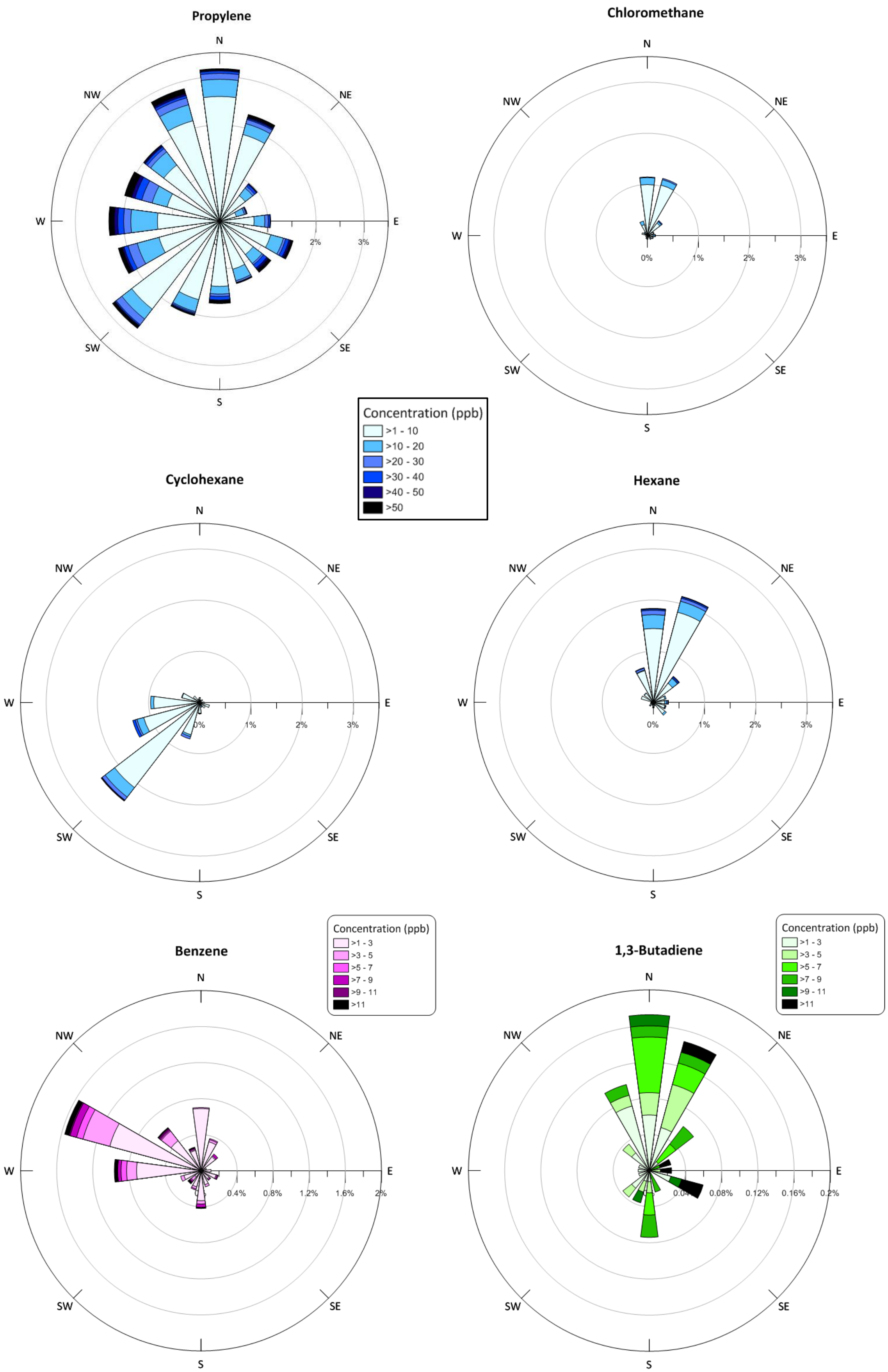
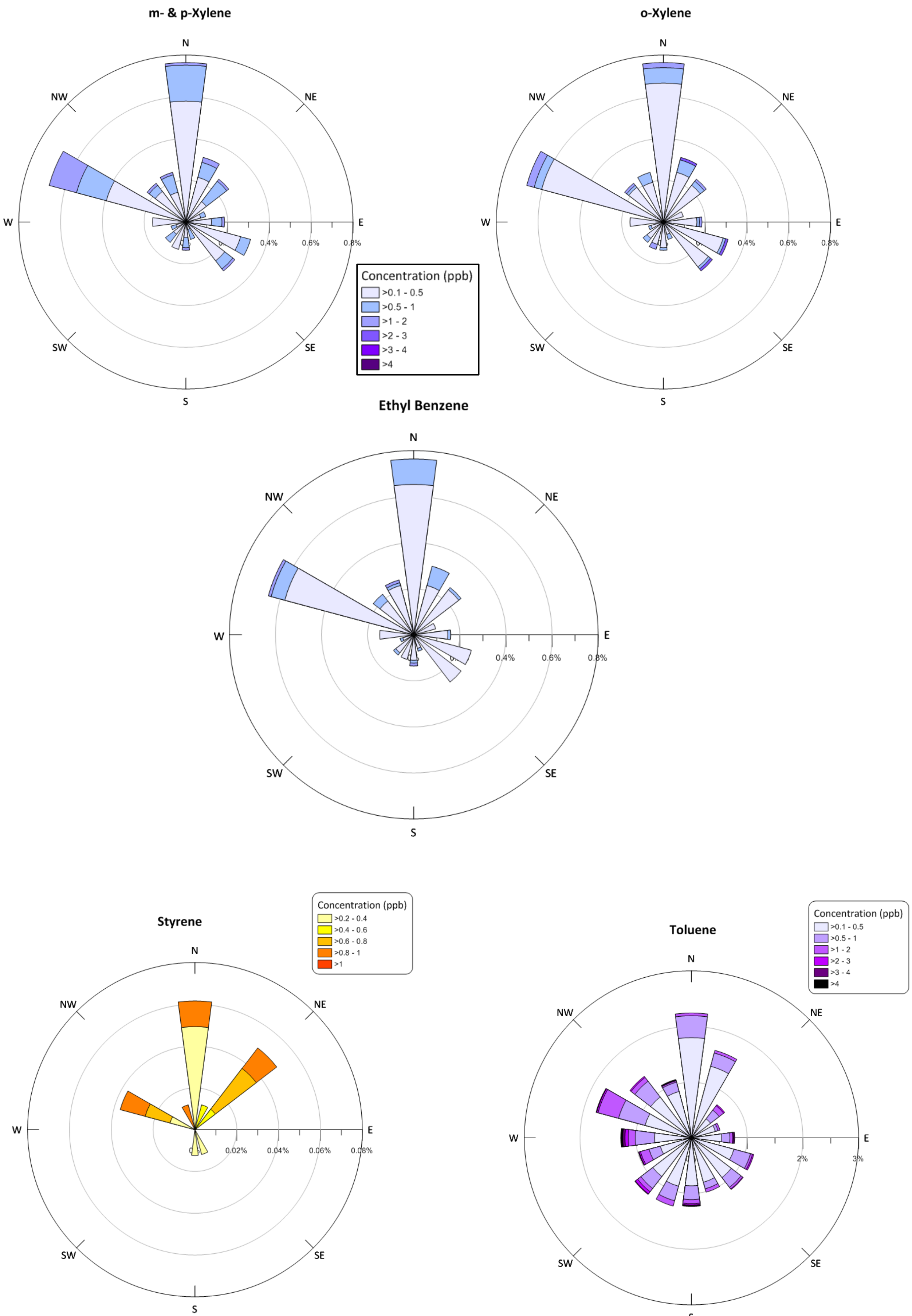


Fig. 13 (continued) – Hourly VOC Pollution Roses



Non-Continuous Data

Suspended Particulate (SP) and Metals

The atmosphere contains a wide assortment of particles, both solid and liquid. They range in size from not much bigger than a molecule to well over the diameter of a human hair (120 µm), and have a wide range of composition and shape. The ministry has a 24-hour AAQC for suspended particulate less than 44 µm in aerodynamic diameter as well as certain common constituents of particulate that may have either health or environmental effects at higher concentrations.

In addition to hourly measurements of respirable particulate, 24-hour samples of suspended particulate are taken every sixth day following the same schedule used by Environment Canada and most other sampling networks in Ontario, the National Air Pollution Surveillance (NAPS) program. The suspended particulate sampling method yields samples which give particulate mass concentrations and permits an analysis for a variety of particulate constituents, such as metals. Samples are taken midnight to midnight EST.

In 2014, the ministry experienced a shortage of the filters used to collect samples. As a result, the ministry was unable to collect samples between mid-June and the end of September, and so the results presented below include approximately two thirds of the number of samples typically collected in a year.

Table 17 includes the average and maximum hourly concentrations for suspended particulate and its constituent metals, as well as the number of samples of each test that were greater than the detection limit. Averages are not reported when more than half of the collected samples in the reporting period are below this level.

Table 17– 24-hour Suspended Particulate Monitoring Results (µg/m³)						
	2014			2013		
	Avg	Max	% > mdl	Avg	Max	% > mdl
Suspended Particulate	16.09	67.3	100%	12.22	30.9	96%
Cadmium	-	0.01	49%	-	0.006	15%
Calcium	0.53	1.9	98%	0.52	2	96%
Chromium	-	0.002	32%	-	0.003	4%
Copper	0.00	0.018	78%	-	0.016	25%
Iron	0.13	0.41	98%	0.131	0.47	96%
Lead	-	0.006	39%	-	0.009	9%
Manganese	0.00	0.012	76%	-	0.012	33%
Nickel	0.00	0.005	76%	-	0.007	18%
Silicon	0.29	1.3	98%	0.32	1.6	93%
Vanadium	0.00	0.009	66%	-	0.011	25%
Zinc	0.01	0.024	90%	0.006	0.014	73%

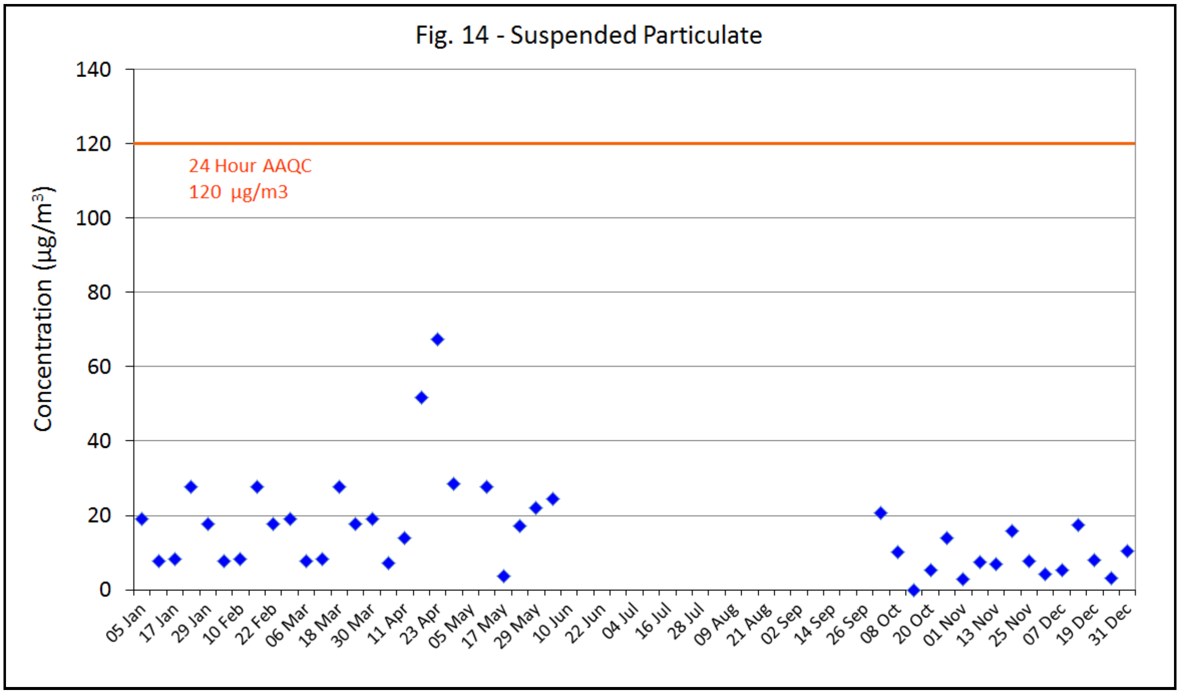
[1]Results are based on 41 of 61 sampling days specified by the NAPS schedule. The ministry was unable to collect 20 samples in 2014 due to a shortage of filters.

The average and maximum suspended particulate concentrations were higher than those seen in the previous year; in addition, the average concentration was higher than the annual averages observed in the five previous years. The concentrations of the metals were generally the same as the previous year.

The ministry has a 24-hour AAQC for suspended particulate and for most of the particulate constituents. Table 18 gives the maximum concentration for each parameter observed in 2014 as a percentage of its 24-hour AAQC. There were no AAQC exceedances for any of the parameters.

Table 18 - Maximum 24-hour Concentrations Compared to AAQC		
Test	AAQC (µg/m³)	% of AAQC
Suspended Particulate	120	56.08%
Cadmium	0.025	40.00%
Calcium	-	-
Chromium	0.5	0.40%
Copper	50	0.04%
Iron	4	10.25%
Lead	0.5	1.20%
Manganese	0.4	0.48%
Nickel	0.2	0.25%
Silicon	-	-
Vanadium	2	0.45%
Zinc	120	0.02%

Figure 14 shows the suspended particulate concentration measured over 2014 in comparison to the 24-hour AAQC. Suspended particulate levels did not show a great degree of monthly variation, however, levels were generally higher in the spring.



Wind direction for the non-continuous data is not shown. Directional information is normally of limited use for 24-hour samples, as the wind variation may allow sources in different directions to contribute to a single sample and it is not possible to separate their contribution.

In addition to the 24-hour AAQC, suspended particulate matter, nickel, and cadmium have annual AAQC, which are given in Table 19. There were no exceedances of the annual AAQC for these parameters.

Table 19 - Annual Averages Compared to AAQC		
Parameter	**Annual AAQC (µg/m^3)**	**Annual Average (µg/m^3)**
Suspended particulate matter (< 44 µm diameter)	60 (geometric mean)	12.37
Nickel	0.04	0.00
Cadmium	0.005	--

Volatile Organic Compounds (VOC)

In addition to the hourly VOC monitoring conducted by the ministry at the Aamjiwnaang First Nation station, Environment Canada (EC) collected 24-hour samples every 12 days. This is conducted in conjunction with EC's National Air Pollution Surveillance (NAPS) program. Samples were collected using specially prepared evacuated canisters and analyzed at the EC laboratory in Ottawa. This method permits determination of a range of 154 target compounds and detection at very low concentrations.

Forty-seven of the target compounds have a 24-hour AAQC. Three of these, 1,1-dichloroethylene, 1,1-dichloroethane, and methyl tertbutylether (MTBE), were not detected. The monitoring results for the remainder of these compounds are given in Table 20. The results for 1,2,3-trimethylbenzene, 1,2,4-trimethylbenzene, and 1,2,5-trimethylbenzene were summed prior to inclusion in Table 20, as were the results for m&p-xylene and o-xylene, to facilitate comparison to the ministry's AAQC for trimethylbenzene mixtures and xylenes respectively.

Table 20 - Environment Canada VOC Concentrations Compared to 24-hour AAQC

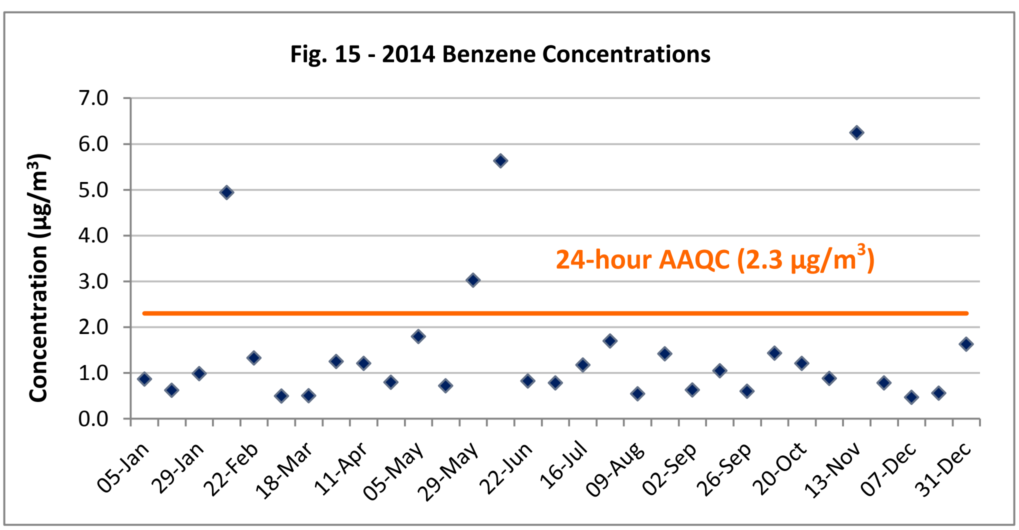
Compound	24-hour AAQC ($\mu g/m^3$)	Average ($\mu g/m^3$)	Maximum ($\mu g/m^3$)	Compound	24-hour AAQC ($\mu g/m^3$)	Average ($\mu g/m^3$)	Maximum ($\mu g/m^3$)
1,1,1-Trichloroethane	115000	0.022	0.030	Ethylbenzene	1000	0.314	3.103
1,2,4-Trichlorobenzene	400	0.006	0.019	Ethylene	40	3.653	15.214
1,2-Dichlorobenzene	30500	0.003	0.006	Freon11	6000	1.471	1.816
1,2-Dichloroethane	2	0.074	0.123	Freon113	800000	0.581	0.737
1,2-Dichloropropane	2400	0.016	0.024	Freon114	700000	0.117	0.135
1,3-Butadiene	10	0.212	1.272	Freon12	500000	2.545	3.360
1,4-Dichlorobenzene	95	0.018	0.061	Freon22	350000	0.761	0.960
1-Decene	60000	0.012	0.059	Heptane	11000	0.238	0.707
1-Octene	50000	0.056	0.289	Hexane	7500	2.184	21.451
Acetylene	56000	0.499	0.873	iso-Propylbenzene	400	0.016	0.043
Benzene	2.3	1.487	6.247	Naphthalene	22.5	0.094	0.368
Bromomethane	1350	0.051	0.076	Propylene	4000	3.193	16.339
Bromoform	55	0.016	0.033	Styrene	400	0.304	1.614
Carbon tetrachloride	2.4	0.477	0.560	Tetrachloroethylene	360	0.062	0.187
Chloroethane	5600	0.019	0.036	Toluene	2000	1.538	6.107
Chloroform	1	0.099	0.177	trans-1,2-Dichloroethylene	105	0.040	0.238
Chloromethane	320	2.006	12.055	Trichloroethylene	12	0.022	0.127
cis-1,2-Dichloroethylene	105	0.000	0.003	Trimethylbenzenes (1,2,3-; 1,2,4-; 1,3,5-)	220	0.231	0.699
Cyclohexane	6100	1.709	15.404	Vinyl chloride	1	0.002	0.008
Dichloromethane	220	0.277	0.348	Xylenes (m-,p-, o-)	730	0.616	2.599
Ethylene dibromide	3	0.000	0.002				

Benzene was the only compound to exceed its 24-hour AAQC, which it did on four occasions. Table 21 shows the number of exceedances of the 24-hour AAQC for benzene between 2008 and 2014 in relation to the number of samples taken. The table lists the month that the exceedance occurred, and the corresponding concentration. The exceedance measured in November of 2014 was the highest 24-hour benzene concentration observed to date.

Table 21 - Comparison of benzene concentrations to 24-hour AAQC (2.3 µg/m³) 2008-2014

	2008/2009	2009/2010	2011	2012	2013	2014
Samples	29	31	30	31	29	31
Number of 24-hour AAQC exceedances	5	4	1	3	3	4
% samples that exceeded 24-hour AAQC	17%	13%	3%	10%	10%	13%
Month of exceedance and corresponding concentration (µg/m³):						
	January 2.89	February 2.52	June 2.87	March 3.46	February 3.54	February 4.94
	June 3.18	March 3.49		April 2.62	May 2.57	May 3.02
	July 2.55	July 2.4		May 2.58	December 2.33	June 5.63
	August 2.99	December 4.15				November 6.25
	December 5.85					

Figure 15 shows the benzene concentrations measured in 2014 in comparison to the 24-hour benzene AAQC. The exceedances detailed in the above table can be seen in this figure.



Four of the target compounds have AAQC for other averaging periods. Octane has a 10-minute AAQC, while decane, 1,2-dichlorobenzene, and chlorobenzene each have a 1-hour AAQC. In cases where AAQC do not exist for the appropriate time scale, the ministry uses a method outlined in O.Reg. 419/05 to calculate equivalent concentrations for comparison purposes. This benchmark level was determined for each of these four compounds and the monitoring results were compared to these converted values. The converted values are summarized in Table 22, along with the maximum and average concentrations for the compounds as a percentage of their equivalent 24-hour AAQC.

Table 22 - Environment Canada VOC Concentrations Compared to Other AAQC

Compound	AAQC ($\mu g/m^3$)	AAQC Averaging time	Equivalent 24 hour benchmark ($\mu g/m^3$)	Maximum (% of benchmark)	Average (% of benchmark)
Octane	61800	10 minutes	15000	0.0057%	0.0010%
Decane	60000	1 hour	25000	0.0034%	0.0006%
1,2-Dichlorobenzene	30500	1 hour	12500	0.0001%	0.0000%
Chlorobenzene	3500	1 hour	1400	0.0023%	0.0008%

Table 23 presents a comparison of maxima and averages between 2014 and the previous year. The 24-hour AAQC for each substance has been included in this table for reference; the maximum concentrations may be directly compared to the 24-hour AAQC. The maximum concentrations are colour-coded based on the concentrations as a percentage of the 24-hour AAQC (see the legend below the table). The four substances with AAQC for periods other than 24 hours are in italics, with their 24-hour AAQC equivalent given in brackets.

Year-to-year variations are to be expected as they depend, in part, on wind direction and speed, and the variation in production cycles. Overall, there were minimal variations in average concentrations from the 2013 results. However, notable increases were seen for ethyl benzene, propylene, and toluene, though concentrations remained well below their respective AAQC. The average and maximum benzene concentrations increased from 2013 levels as well, and as previously indicated, exceedances of the 24-hour AAQC were observed.

Table 23 - Comparison of Canister VOC Results (all values in µg/m³)					
Compounds	**24-hour AAQC**	**2014**		**2013**	
		Max	**Average**	**Max**	**Average**
1,1,1-Trichloroethane	115000	0.030	0.022	0.0351	0.0276
1,1-Dichloroethylene	10	-	-	0.0015	0.0001
1,2,4-Trichlorobenzene	*400*	0.019	0.006	0.0111	0.0053
1,2-Dichlorobenzene	12500	0.006	0.003	0.0054	0.0026
1,2-Dichloroethane	2	0.123	0.074	0.1052	0.0691
1,2-Dichloropropane	2400	0.024	0.016	0.0301	0.0165
1,3-Butadiene	10	1.272	0.212	3.6334	0.1939
1,4-Dichlorobenzene	95	0.061	0.018	0.0419	0.0135
1-Decene	*60000*	0.059	0.012	0.0543	0.0126
1-Octene	50000	0.289	0.056	0.1928	0.0483
Acetylene	56000	0.873	0.499	0.9722	0.4559
Benzene	2.3	6.247	1.487	3.5393	0.9965
Bromoform	55	0.033	0.016	0.0226	0.0129
Bromomethane	*1350*	0.076	0.051	0.1102	0.0534
Carbon tetrachloride	2.4	0.560	0.477	0.6879	0.5194
Chlorobenzene	1400	0.032	0.012	0.0254	0.0125
Chloroethane	5600	0.036	0.019	0.0460	0.0262
Chloroform	1	0.177	0.099	0.1548	0.0901
Chloromethane	320	12.055	2.006	19.7850	2.0659
cis-1,2-Dichloroethylene	105	0.003	0.000	0.0024	0.0003
Cyclohexane	6100	15.404	1.709	15.6757	1.7668
Decane	25000	0.855	0.140	0.3990	0.0824
Dichloromethane	220	0.348	0.277	0.5079	0.2908
Ethylbenzene	1000	3.103	0.314	0.6574	0.1385
Ethylene	40	15.214	3.653	14.4967	4.3757
Ethylene dibromide	*3*	0.002	0.000	0.0011	0.0001
Freon11	6000	1.816	1.471	1.9850	1.5722
Freon113	800000	0.737	0.581	0.7096	0.5870
Freon114	700000	0.135	0.117	0.1318	0.1112
Freon12	500000	3.360	2.545	3.1367	2.5072
Freon22	350000	0.960	0.761	0.9530	0.7489
Heptane	11000	0.707	0.238	0.4515	0.1724
Hexane	7500	21.451	2.184	23.3990	1.4080
iso-Propylbenzene	400	0.043	0.016	0.0517	0.0119
Methyltertbutylether	7000	-	-	0.0154	0.0010
Naphthalene	22.5	0.368	0.094	0.1492	0.0653
Octane	15000	0.853	0.149	0.6596	0.0972
Propylene	4000	16.339	3.193	8.7809	2.2421
Styrene	400	1.614	0.304	2.2793	0.1451
Tetrachloroethylene	360	0.187	0.062	0.4073	0.0650
Toluene	2000	6.107	1.538	3.1589	1.1616
trans-1,2-Dichloroethylene	105	0.238	0.040	0.8713	0.0480
Trichloroethylene	12	0.127	0.022	0.0361	0.0149
Trimethylbenzenes (1,2,3-, 1,2,4-, 1,3,5-)	220	0.699	0.231	0.2911	0.1395
Vinyl chloride	1	0.008	0.002	0.0067	0.0027
Xylenes	730	2.599	0.616	0.9724	0.3829

Legend: Maximum Concentration as a Percentage of 24-hour AAQC				
x < 0.1%	0.1 % < *x* < 1.0 %	1.0% < *x* < 10%	10% < *x* < AAQC	*x* >AAQC

In addition to the 24-hour AAQC listed in Table 23, six compounds also have annual AAQC, which are listed in Table 24. The annual averages from 2008-2013 are also included in the table for comparison purposes.

Table 24 - Annual Averages of VOC in Comparison to Annual AAQC

Compound	Annual AAQC (µg/m^3)	Average (µg/m^3)					
		2008/2009	2009/2010	2011	2012	2013	2014
1,3-Butadiene	2	0.1072*	0.1843*	0.0909	0.0949	0.1939	0.2037
Benzene	0.45	1.3622*	1.2336*	1.2036	1.1219	0.9965	1.4866
Vinyl chloride	0.2	0.0199	0.0050	0.0043	0.0028	0.0027	0.0023
Dichloromethane	44	0.2490	0.2419	0.2327	0.2463	0.2908	0.2790
Chloroform	0.2	0.0803	0.0820	0.0877	0.0945	0.0901	0.1001
1,2-Dichloroethane	0.4	0.0632	0.0806	0.0688	0.073	0.0691	0.0736

*24-hour AAQC not in effect at this time; presented for comparison purposes only

Red font indicates an exceedance of the AAQC.

Benzene exceeded its annual AAQC in 2014, as it has in each of the five previous monitoring periods. The average benzene concentration had decreased each year between 2008 and 2013, however, the 2014 average concentration increased to the highest value observed since monitoring began at the Aamjiwnaang station. The 2014 annual average represents a 9.2% increase from the previous highest annual average, which was observed in the first year of monitoring (2008/2009). No other VOC exceeded its annual AAQC in 2014, and results have remained relatively consistent with previous years.

Environment Canada also samples VOC at various sites across the country, and the results from three stations in southwestern Ontario (Sarnia, Windsor, and London) have been compared to the results from the Aamjiwnaang station. Table 25 presents the results for the 10 species whose averages were highest compared to their respective AAQC, and that were measured at all the stations. VOC results from the ministry's monitoring station in Wallaceburg are included in Table 25 as well. The Wallaceburg station is considered to be indicative of background concentrations, as it is situated in a rural location with few local VOC sources.

It should be noted that VOC were sampled every 12 days at the Aamjiwnaang and Wallaceburg stations, and every 6 days at the Sarnia, Windsor, and London stations, and so there are approximately twice as many data points available for Sarnia, Windsor, and London. As of 2016, the frequency of VOC sampling at the Aamjiwnaang station will be increased to match that at the other stations.

Table 25 shows similar average values for several of the compounds across the region, including carbon tetrachloride, chloroform, naphthalene, and vinyl chloride. Benzene and 1,3-butadiene average and maximum concentrations were higher at the Sarnia and Aamjiwnaang stations than in Wallaceburg, Windsor and London. In most cases, the values at the Sarnia and Aamjiwnaang stations were consistent with one another, with some exceptions. The benzene maximum was notably higher at the Sarnia station than at Aamjiwnaang, however, the average was lower. The chloromethane maximum at Aamjiwnaang was higher than any of the other stations including Sarnia.

Windsor and Wallaceburg values were typically intermediate, though the dichloromethane maximum was higher in Wallaceburg than at the comparison stations. London most often had the lowest values, though it had the second highest dichloromethane maximum.

Table 25 – Comparison of Selected Environment Canada VOC Results (μg/m^3)

Compound	24-hour AAQC		Aamjiwnaang	Sarnia	Wallaceburg[1]	Windsor	London
Benzene	2.3	Avg	**1.487**	1.007	0.776	0.610	0.446
		Max	6.247	**17.371**	2.430	1.629	1.270
Carbon tetrachloride	2.4	Avg	0.477	0.529	**0.541**	0.503	0.513
		Max	0.560	1.198	**2.320**	0.616	0.626
Chloroform	1	Avg	0.099	0.113	0.059	**0.118**	0.105
		Max	0.177	**0.316**	0.180	0.289	0.193
Ethylene	40	Avg	3.653	n/a	n/a	n/a	n/a
		Max	15.214	n/a	n/a	n/a	n/a
1,2-Dichloroethane	2	Avg	0.074	**0.079**	0.060	0.067	0.064
		Max	0.123	**0.553**	0.180	0.089	0.103
1,3-Butadiene	10	Avg	**0.212**	0.124	0.039	0.046	0.029
		Max	**1.272**	1.111	0.190	0.151	0.099
Chloromethane	320	Avg	**2.006**	1.468	n/a	1.206	1.201
		Max	**12.055**	4.347	n/a	1.473	1.387
Naphthalene	22.5	Avg	0.094	0.085	0.140	**0.149**	0.080
		Max	0.368	**0.517**	0.380	0.512	0.292
Vinyl chloride	1	Avg	0.002	0.002	**0.015**	0.002	0.002
		Max	0.008	0.013	**0.060**	0.006	0.006
Trichloroethene	12	Avg	0.022	0.026	0.025	**0.028**	0.026
		Max	0.127	0.155	0.070	**0.371**	0.080
Dichloromethane	220	Avg	0.277	0.304	**0.536**	0.332	0.364
		Max	0.348	0.477	**4.570**	1.063	3.784

Bold font indicates the highest average or maximum concentration of the four monitoring stations.

Number of samples: Aamjiwnaang=34, Sarnia=57, Wallaceburg=28, Windsor=58, London=61

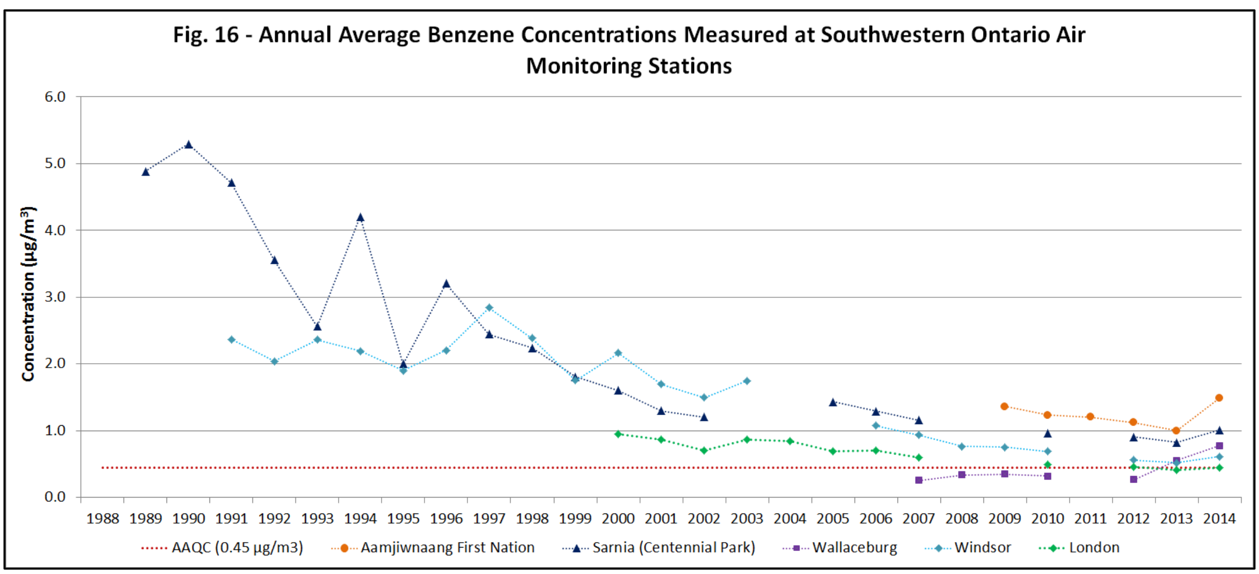
[1]The MOECC uses a different VOC collection and analysis method at the Wallaceburg station than the canister method employed at the Aamjiwnaang and Environment Canada stations.

Annual average benzene concentrations measured at Sarnia, Wallaceburg, Windsor, and London from 1989-2014 are shown in Figure 16, along with the results for Aamjiwnaang from 2008/2009 to 2014. The absence of data points for a particular station and year indicates that benzene sampling either did not occur at the station, or that there were an insufficient number of samples collected, and so a representative average concentration could not be calculated.

Figure 16 indicates that benzene concentrations in Sarnia have greatly decreased since VOC monitoring first began in 1989. Decreases over time are seen at the Windsor station, and to a minor extent, in London as well. The benzene concentrations measured at the Aamjiwnaang station over the last six years fell within the range of concentrations measured in Sarnia between 2000 and 2014, and are much lower than the concentrations measured in Sarnia twenty years ago . However, benzene concentrations were higher at the Aamjiwnaang station than in Sarnia in 2010 and 2012-2014, that is, every year that benzene data was available for both stations.

The increase in the annual average benzene concentration observed from 2013 to 2014 was not unique to the Aamjiwnaang air monitoring station. An increase over the same time period was also observed at the Sarnia, Wallaceburg, and Windsor air monitoring stations.

Figure 16 demonstrates the tendency of environmental data to fluctuate from year to year, illustrating the need for long-term monitoring data in order to assess trends reliably over time.



Comparison of Continuous and Non-Continuous Benzene Monitoring Results

The continuous monitoring of VOC performed by the MOECC and the non-continuous monitoring of VOC performed by EC included several of the same compounds. The benzene monitoring results attained using the two methods were compared in order to determine whether similar conclusions about exceedances of the AAQC for benzene were reached.

Table 26 presents the number of exceedances of the 24-hour AAQC detected in 2014 using the two methods, compared to the results from the previous five years of monitoring. The EC monitoring is non-continuous, with measurements occurring every 12 days (29-31 samples taken each year), and the MOECC sampling is continuous (hourly, 365 days per year), so the percentage of samples taken that exceeded the 24-hour AAQC is given in brackets for comparison purposes. The percentage of exceedances of the 24-hour AAQC found with the MOECC continuous monitoring was approximately equal to that of the EC non-continuous monitoring in 2014 (12-13%).

The 2014 annual average concentration calculated using the EC monitoring data was more than double the annual average attained using the MOECC data (see "Ratio (EC/MOECC)" column in Table 26). However, both datasets showed that the 2014 annual average benzene concentrations exceeded the AAQC and each attained their highest value since monitoring began.

Table 26 – Comparison of Environment Canada (EC) VOC Non-Continuous Results to Continuous MOECC Results for Benzene (AAQC: 0.134 ppb)

	Number of exceedances of 24-hour AAQC (and as a % of total 24-hour samples)		Annual Average Concentration (ppb)		
	EC VOC	MOECC Hourly VOC	EC VOC	MOECC Hourly VOC	Ratio (EC/MOECC)
2009	5 (17%)	38* (10%)	0.405	0.142	2.9
2010	4 (13%)	18* (5%)	0.367	0.062	6.1
2011	1 (3%)	23 (6%)	0.358	0.125	2.9
2012	3 (10%)	23 (6%)	0.334	0.115	2.9
2013	3 (10%)	22 (6%)	0.297	0.124	2.4
2014	4 (13%)	42 (12%)	0.442	0.210	2.1

*24-hour AAQC for benzene not in effect at this time; presented for comparison purposes only

Red font indicates an exceedance of the AAQC

Previous Technical Memoranda[7] include a discussion about the poor correlation between the EC and MOECC VOC annual averages, suggesting a number of potential contributing factors:

- The non-continuous sampling conducted by EC takes one sample over the course of the entire day, allowing for a much larger volume to be sampled. As a result, for relatively steady concentrations, this method leads to much lower detection limits (several orders of magnitude below that of the ministry's method). Therefore, the non-continuous sampling may see low levels that are not detectable by the continuous monitor.
- As the non-continuous sampling "bulks" the sample over 24 hours, short term spikes in concentration of a particular species will be diluted by the comparatively low concentration observed for the rest of the day.
- While the continuous sampling device takes one sample each hour, it only actually samples the air stream for between 10-15 minutes per hour, with the rest of the time used to process the sample and purge the system. As a result, transient spikes may be missed if they occur largely between sampling windows.

The EC non-continuous monitoring method has a high precision and low detection limit, so this method can be expected to provide accurate annual averages, though it may not be able to detect short-term spikes in concentrations of particular species. In contrast, the precision of the MOECC continuous monitoring is not as high as the EC method, but it has a good temporal resolution, and can provide information that the non-continuous method cannot give. The EC and MOECC monitoring methods have different capabilities, and produce complementary results which together provide a better picture of VOC at the Aamjiwnaang First Nation station.

Polycyclic Aromatic Hydrocarbons (PAH)

Polycyclic aromatic hydrocarbons (PAH) are a group of complex hydrocarbons formed by incomplete combustion of organic compounds. They are common products of industrial processes and domestic activities, including burning fuel such as coal or wood, and barbecuing. Some PAH are known to be carcinogenic.

The ministry samples for several PAH at the Aamjiwnaang First Nation station every 12 days, on the same schedule as the NAPS program. PAH are sampled on a filter which is returned to the ministry's laboratory for analysis. Each sample is collected for 24 hours, from midnight to midnight, EST.

PAH are found in very low concentrations in the atmosphere, and so concentrations are given in nanograms per cubic metre, a unit that is one thousand times smaller than the unit used for most other measurements in this report.

The ministry collected 31 PAH samples in 2014. The results are summarized in Table 27, and the individual sample results are shown in Figure 17. Some of the concentrations were so low they could not be determined in these samples. Averages were not reported when more than half of the values during a reporting period are below the method detection limit (mdl), as the degree of uncertainty becomes too high. Average and maximum concentrations were lower in 2014 than those observed in 2013, with the exception of the maximum benz[a]anthracene concentration.

Table 27 - Polycyclic Aromatic Hydrocarbons Monitoring Results

Compounds and Abbreviations		2014			2013		
		Avg ng/m^3	Max ng/m^3	>mdl	Avg ng/m^3	Max ng/m^3	>mdl
Benz[a]anthracene	B[a]A	0.022	0.129	25.8%	0.043	0.444	70.0%
Chrysene / Triphenylene	Chry/TPh	0.049	0.256	64.5%	0.090	0.769	93.3%
Benzo[b]fluoranthene	B[b]F	0.100	0.348	87.1%	0.145	0.866	93.3%
Benzo[k]fluoranthene	B[k]F	0.038	0.143	67.7%	0.053	0.322	93.3%
Benzo[a]pyrene	B[a]P	0.045	0.226	71.0%	0.061	0.48	93.3%
Indeno[1,2,3-cd]Pyrene	I[1,2,3]P	0.079	0.292	74.2%	0.095	0.572	93.3%
Dibenz[a,h]Anthracene/ Dibenz[a,b]Anthracene	D[a,h]A/ D[a,b]A	0.013	0.03	6.5%	0.018	0.098	63.3%
Benzo[g,h,i]perylene	B[g,h,i]P	0.093	0.328	87.1%	0.106	0.569	93.3%

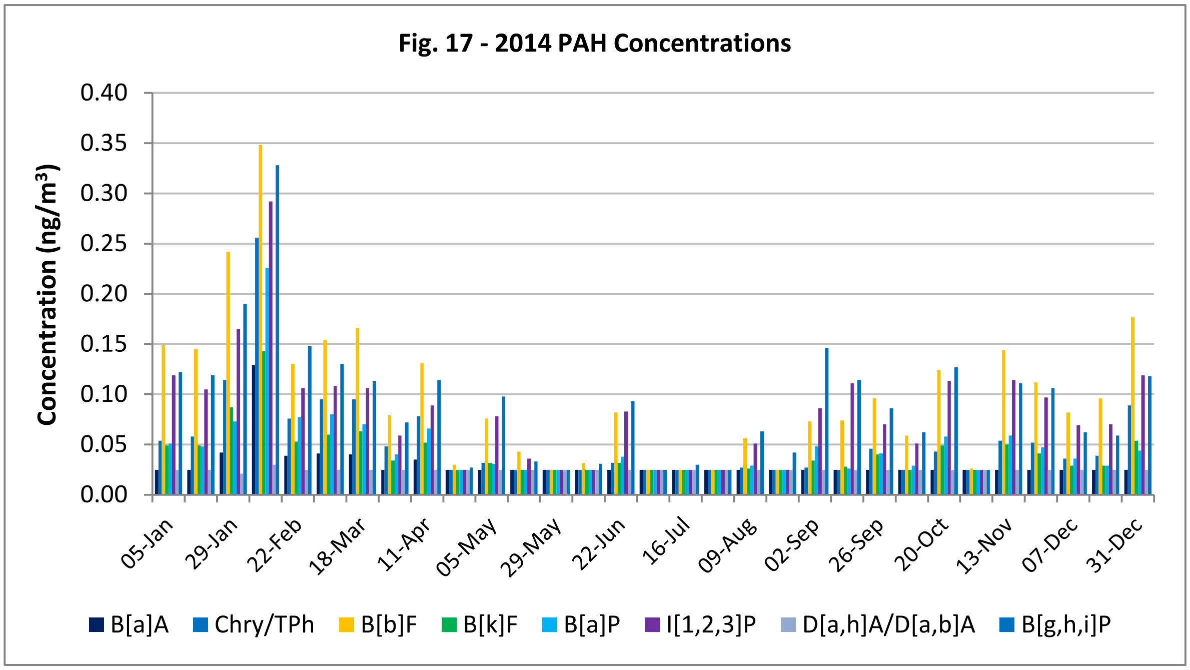


Table 28 presents a comparison of the Aamjiwnaang First Nation results with those obtained at two other stations in southwestern Ontario: Windsor and Wallaceburg. These sites are not the same as the AQI stations used for most other contaminants discussed in this report, as there are not PAH monitors at those locations. The comparison site in Windsor for most other substances is the Windsor West AQI site (College Ave. and South St.), whereas the PAH data come from a monitor at the Lou Romano Water Reclamation Plant, about 2.5 km to the southwest.

The Aamjiwnaang results were lower than levels measured at the ministry's monitoring station in West Windsor, which is across the Detroit River from a steel mill. However, they are higher than those measured at the Wallaceburg site. This is to be expected, as the Wallaceburg site is located in an agricultural area with few local sources of PAH.

Table 28 - Polycyclic Aromatic Hydrocarbons Comparison by Location

	Aamjiwnaang		West Windsor		Wallaceburg	
	Avg ng/m^3	Max ng/m^3	Avg ng/m^3	Max ng/m^3	Avg ng/m^3	Max ng/m^3
Benz[a]anthracene	0.022	0.129	**0.072**	**0.514**	0.016	0.048
Chrysene /Triphenylene	0.049	0.256	**0.127**	**0.635**	0.035	0.127
Benzo[b]fluoranthene	0.100	0.348	**0.258**	**1.190**	0.065	0.180
Benzo[k]fluoranthene	0.038	0.143	**0.104**	**0.520**	0.024	0.060
Benzo[a]pyrene	0.045	0.226	**0.120**	**0.669**	0.029	0.067
Indeno[1,2,3-cd]Pyrene	0.079	0.292	**0.204**	**0.778**	0.049	0.109
Dibenz[a,h]Anthracene/Dibenz[a,b]Anthracene	0.013	0.030	**0.039**	**0.218**	0.013	0.025
Benzo[g,h,i]perylene	0.093	0.328	**0.248**	**0.794**	0.048	0.098

Bold font indicates the highest average or maximum concentration of the three monitoring stations.

The ministry has a 24-hour AAQC for B[a]P of 0.05 ng/m^3, and an annual AAQC of 0.01 ng/m^3. Table 29 shows the annual average and number of exceedances of the B[a]P AAQC in 2014 compared to that of previous years. The average annual B[a]P concentration exceeded the ministry's AAQC in 2014, as it did each year between 2008 and 2013. The 2014 annual average was lower than that in 2013, but within the range of annual averages seen over the previous five years of monitoring.

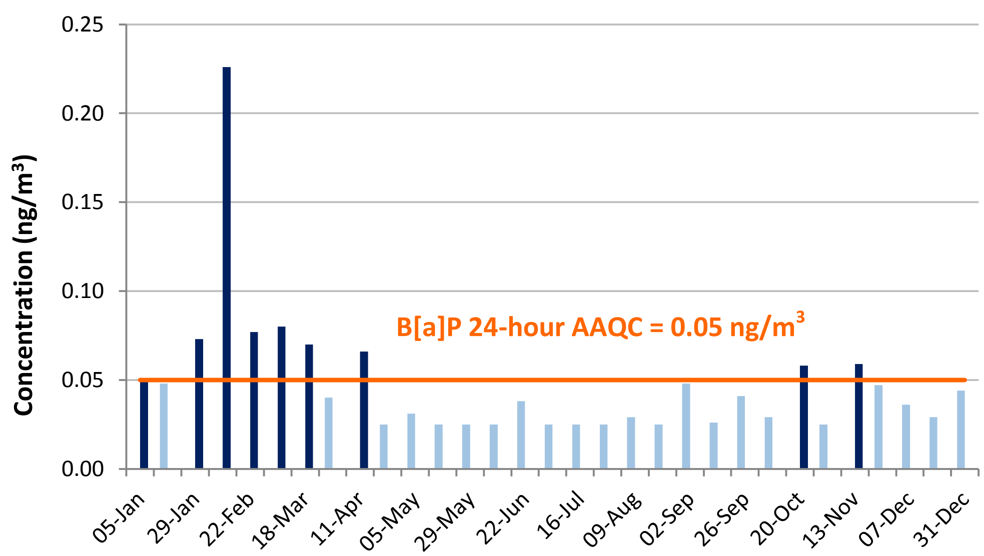
Table 29 - Average annual B[a]P concentrations and AAQC exceedances
24-hour AAQC = 0.05 ng/m^3 Annual AAQC = 0.01 ng/m^3

Year	2008/2009	2009/2010	2011	2012	2013	2014
Number of exceedances of 24-hour AAQC	13*	13*	10*	7	10	9
Annual average (ng/m^3)	0.057*	0.071*	0.069	0.043	0.061	0.045

*Current AAQC not in effect (previous AAQC = 1.1 ng/m^3)
Red font indicates an exceedance of the current AAQC

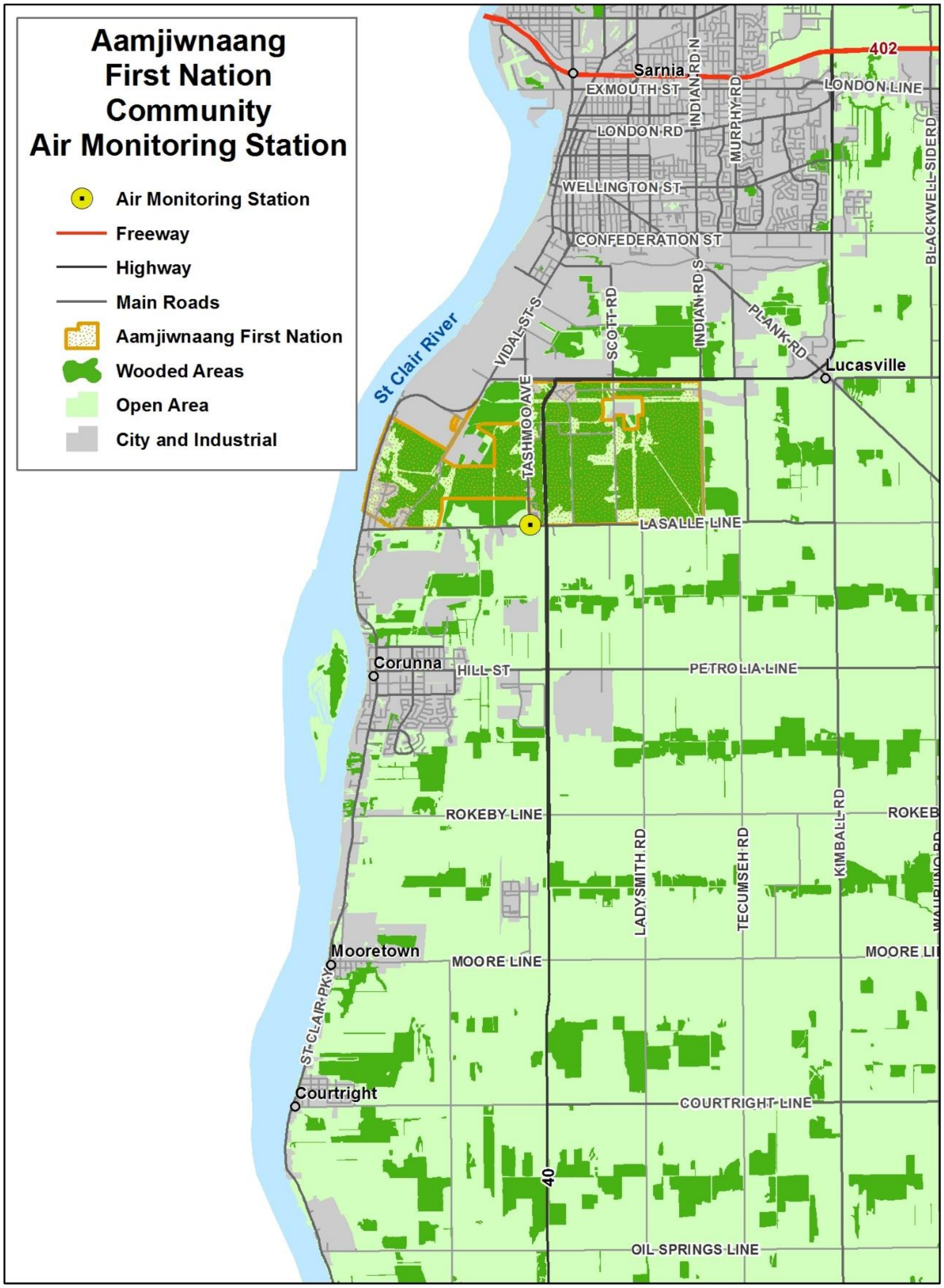
The individual sample results for B[a]P in 2014 are shown in Figure 18. Exceedances of the 24-hour AAQC are represented by the dark blue bars. B[a]P concentrations tended to be highest in the cooler months (November-April); no exceedances occurred during the warmer months. This seasonal trend was found in the results for other PAH as well, which sugggests that building heating may be contributing to local PAH concentrations.

Fig. 18 - B[a]P Concentration



Appendices

Map



Glossary

Ambient Air Quality Criteria (AAQC): Maximum desirable average concentrations for specific atmospheric contaminants. AAQC are based upon the effects on the most sensitive endpoint: human health, environmental effects, odours, or soiling. Where more than one significant effect occurs, the ministry may have multiple AAQC for the same substance. The averaging time is initially set based on the underlying effect, and a comparison value is sometimes derived in order to allow for evaluation of air quality over different averaging periods.

Air Quality Index (AQI): An indicator of air quality, based on air pollutants that have adverse effects on human health and the environment. The pollutants are ozone, fine particulate matter, nitrogen dioxide, carbon monoxide, sulphur dioxide and total reduced sulphur compounds. The air quality is reported as both a number (the index) and one of five classifications based upon the index: *Very Good, Good, Moderate, Poor,* or *Very Poor.* In 2015, the AQI was replaced by the *Air Quality Health Index.* More information may be found on the ministry's air quality web site: http://www.airqualityontario.com/.

Air Quality Sub-index: A value related to the concentration of each AQI pollutant based upon their individual health and environmental effects. A sub-index is calculated every hour for each AQI pollutant measured at a station. The maximum is reported as the AQI for that station for that hour.

AQI station: Continuous monitoring station used to inform the public of general ambient air quality levels over an entire region (not a localized area) on a real-time basis. Each station reports on criteria pollutant levels that are not unduly influenced by a single emission source, but rather are the result of emissions from multiple sources, including those in neighbouring provinces and states.

Ambient air: Outdoor or open air.

Canadian Ambient Air Quality Standards (CAAQS): The federal government's health-based air quality objectives for pollutant concentrations in outdoor air. In 2013, the federal government published CAAQS for fine particulate matter and ozone, two pollutants of concern to human health, and the major components of smog. These standards are more stringent and more comprehensive than the previous Canada-Wide Standards for these pollutants. The CAAQS for fine particulate matter and ozone came into effect in 2015.

Detection Limit (DL): The smallest amount of a substance which an instrument can differentiate from zero. This is related to the Method Detection Limit (MDL) which is the lowest amount of a substance that an entire analysis method (media preparation, sampling, extraction, and instrumental analysis) can reliably determine.

Exceedance: A concentration of a parameter that is higher than the AAQC, standard, or other benchmark for that substance.

Micrograms per Cubic Metre (µg/m^3): A concentration unit used to report pollutant concentrations in the atmosphere. One microgram is a millionth of a gram. PAH are reported in **nanograms per cubic metre** (ng/m^3). A nanogram is a billionth of a gram.

Micron (µm): One millionth of a metre = one thousandth of a millimetre = about three millionths of a foot. Human hair ranges from 40 to 120 microns thick.

NAPS: Environment Canada's *National Air Pollution Surveillance Program* was established in 1969 provide accurate and long-term air quality data of a uniform standard across Canada. More information may be found at http://www.ec.gc.ca/rnspa-naps.

Part per billion (ppb): A concentration unit used by various instruments to report gas concentrations in the atmosphere. This is the approximate equivalent of 50 drops of water in an Olympic size swimming pool. Similarly, "**ppm**" means "part per million", a unit which is 1000 times larger.

Polycyclic Aromatic Hydrocarbons (PAH): A class of molecules composed of fused six-sided carbon rings. They form during most combustion processes when conditions do not allow all the carbon to be oxidized.

Volatile Organic Compounds (VOC): Organic (containing carbon) chemicals that exist as a gas (at least partially), at normal environmental temperatures and pressures.

Data Averaging

The ministry has established procedures for dealing with concentrations that are reported as "0". In general, if an instrument has a well-defined detection limit (DL), which is the lowest concentration at which it can reliably say that a substance is present, then anything below that will be recorded as 0. However, the real value of that concentration could be anywhere between the DL and zero.

A standard practice in situations such as this is to use half of the DL when calculating averages. This usually offers a reasonably good estimate if the number of values below DL is relatively small. However, since the uncertainty of the average grows with the number of these values, an average will not be reported if more than half of these values are below DL. This protocol is followed for the PAH, non-continuous VOC, and suspended particulate and metals.

However this is not the practice that is followed for the continuous monitors. The ministry has been reporting results from AQI (continuous) monitors for years and including non-detects as 0 in average calculations. The ministry has chosen to use the same methodology in this report so that these results may be compared to those found in AQI reports. While most real-time instruments will record a "0" from time to time, this decision will only have a noticeable impact on SO_2, and TRS which usually exhibit very low levels.

The practice of including non-detects as 0 in average calculations was also adopted for the real time VOC monitor but for very different reasons. Because of the experimental nature of the instrument, the ministry has not been able to determine a detection limit for each of the species involved. Therefore there is no value of which one can take half for use in performing calculations. In addition, since detectable levels are seen infrequently, averages could not be presented as they cannot be considered representative. This would greatly limit our ability to discuss the results.

In order to compare hourly results to 24-hour AAQC, rolling 24-hour averages are calculated. An exceedance of a 24-hour AAQC is reported a minimum of 24 hours after the last exceedance. This convention has been adopted in order to ensure that once a particular data point contributes to the calculation of an exceedance, it will not be used to calculate a second exceedance. For example, for an episode in which the rolling 24-hour average concentration of a contaminant is above the 24-hour AAQC for 13 consecutive hours, one exceedance would be reported. For an episode where the rolling 24-hour average concentration is above the 24-hour AAQC for 36 consecutive hours, two exceedances would be reported.

Unit Conversion

Some of the ministry's instruments report in parts per billion (ppb) or parts per million (ppm). Other results are expressed in micrograms per cubic metre (μg/m^3) or nanograms per cubic metre (ng/m^3). Most ministry air standards and AAQC are published in mass per cubic metre.

Comparisons require that the two things being compared be in the same units, and so to compare monitoring data to ministry AAQC in this report, it was necessary to convert units for several measurements. These conversions vary with atmospheric conditions, as they depend on the temperature and pressure as well as the molecular weight.

However, since most measurements rely on samples taken over a period of time (e.g. 24-hour periods), it is possible for both the temperature and pressure to change. Since we do not have instantaneous measurements of all these parameters, there is no practical way to correct for this. In addition, since most instruments reside inside shelters, temperatures of the sample will be affected as they are drawn into the sampler.

As a result, assumptions about the parameter conversion have to be made. Conversions presented in this report were calculated with the temperature assumed to be 20 ° C and the pressure to be 1 atmosphere (101.3 kilopascals [kPa]).

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