

Technical Memorandum

Aamjiwnaang First Nation Community Air Monitoring Station

2015 Report



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Ontario Ministry of the Environment and Climate Change

Southwest Region Technical Support Section

Air, Pesticides, and Environmental Planning Unit

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Executive Summary

The 2015 air monitoring report marks seven years of reporting on the state of air quality at the Aamjiwnaang First Nation air monitoring station. This report summarizes air quality conditions at the station in 2015, and provides an overview of historical conditions.

Key results discussed in this report:

- Since monitoring began at the Aamjiwnaang air monitoring station in 2008, the ministry has observed significant reductions in a number of air pollutants, specifically sulphur dioxide, nitrogen dioxide, total reduced sulphur and fine particulate matter. Increases were observed for suspended particulate, benzo[a]pyrene, benzene and ozone (see chart below).
- Of 148 Volatile Organic Compounds monitored, the ministry has Ambient Air quality Criteria (AAQC) for 41, and only benzene exceeded its AAQC.
- Both benzene and benzo[a]pyrene have exceeded the ministry's Ambient Air Quality Criteria each year since monitoring began.
- The increase in ozone observed at the station since 2009 is consistent with the provincial trend over the last 10 years.
- When the ministry upgraded to a more efficient suspended particulate monitor, a significant increase was observed. Levels still remained well below the AAQC.

At a Glance: Contaminant levels observed since monitoring began and between 2014-2015

2009 - 2015		↑ ↓	2014 - 2015	
Suspended particulate	↑ 82%		Suspended particulate	↑ 75%
Benzo[a]pyrene	↑ 1%	Benzo[a]pyrene	↑ 73%	
Benzene	↑ 12%	Fine particulate matter	↑ 11%	
Ozone	↑ 12%	Benzene	↑ 0.3%	
Total reduced sulphur	↓ 63%	Total reduced sulphur	↓ 67%	
Nitrogen Dioxide	↓ 31%	Nitrogen Dioxide	↓ 4%	
Sulphur Dioxide	↓ 26%	Sulphur Dioxide	↓ 13%	
Fine particulate matter	↓ 19%	Ozone	↓ 2%	

To address contaminants of concern in Sarnia, the ministry developed the Sarnia Air Action Plan. The plan includes implementing technical standards for the petroleum refining and petrochemical sectors, enhancing inspections, and improving public information sharing/collaboration. The Technical Standards require industries to take a variety of actions to reduce emissions using best available technology.

Introduction

The Aamjiwnaang First Nation is situated along the shores of the St. Clair River, within the boundaries of the City of Sarnia, Ontario. The Ontario Ministry of the Environment and Climate Change (MOECC or 'the ministry') has been monitoring air quality in Sarnia for many years to measure levels of air pollutants in the area. In September 2008, the MOECC established an air monitoring station in the area of the First Nation community in partnership with the Aamjiwnaang First Nation and Environment and Climate Change Canada (ECCC). The air monitoring station is a secured and fenced building located at the intersection of Tashmoo Avenue and Lasalle Road (1300 Tashmoo Avenue, Sarnia, ON), west of Highway 40 (Figure 1). This technical memorandum presents the 2015 results of air monitoring at this station with comparisons to results from earlier years. It should be noted, however, that despite the extensive monitoring data available, the measured concentrations may not fully represent actual exposures in surrounding communities, and should not be interpreted as an evaluation of human health exposure or risk of effects in the area.

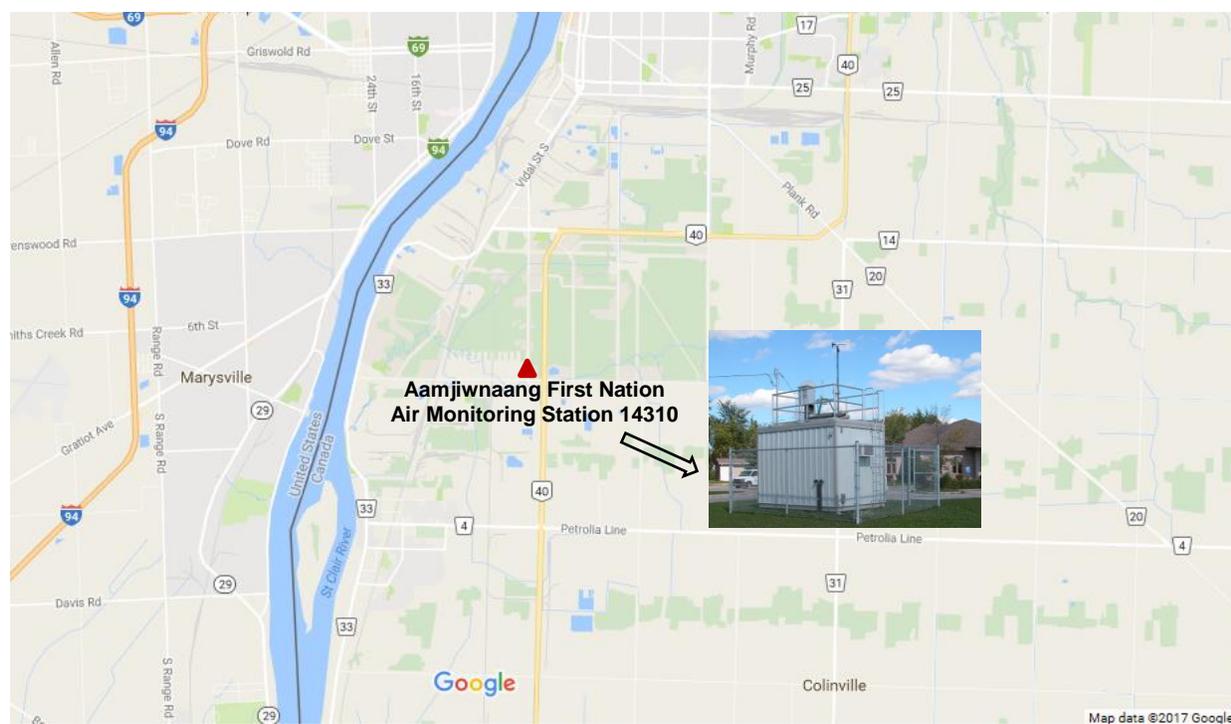


Figure 1: Aamjiwnaang First Nation Air Monitoring Station (Station ID: 14310) in Sarnia, ON

The station is equipped to measure a range of air pollutants as listed in Table 1. Sulphur dioxide (SO_2), nitrogen oxides ($\text{NO}/\text{NO}_2/\text{NO}_x$), total reduced sulphur (TRS) compounds, carbon monoxide (CO), and ground-level ozone (O_3), volatile organic compounds (VOC) are sampled continuously. A wider range of air pollutants are measured by monitors that collect a sample periodically over a 24-hour period. Air samples are collected for measuring VOC and polycyclic

aromatic hydrocarbons (PAH) once every 12 days and for suspended particulate (SP) once every 6 days. The non-continuous sampling can often detect lower concentrations of target pollutants than the continuous sampling. Meteorological data, including wind speed and wind direction, are also collected at the station.

Table 1: Air pollutants measured at the Aamjiwnaang First Nation Air Monitoring Station

	Parameters	Instruments
Continuous	Sulphur dioxide (SO ₂)	Teldyne Model T100
	Nitrogen oxides (NO/NO ₂ /NO _x)	Thermo Scientific Model 42i
	Total reduced sulphur (TRS) compounds	Thermo Scientific Model 43c with Teldyne model 200 oxidizer
	Fine particulate matter (PM _{2.5})	Grimm Dust Monitor EDM180
	Volatile organic compounds (VOC)	Shimadzu Model QP2010s with ACEM 905 Thermal Desorber
	Carbon monoxide (CO)	Thermo Scientific Model 48c
	Ground-level ozone (O ₃)	Thermo Scientific Model 49c
	Wind speed and direction	RM Young model 5103 Anemometer
Non-continuous	Volatile organic compounds (VOC), 24-hour sampling, 12 day cycle	Summa canister (analyzed by Environment and Climate Change Canada Laboratory)
	Polycyclic aromatic hydrocarbons (PAH), 24-hour sampling, 12 day cycle	High volume air sampler (analyzed by MOECC Laboratory)
	Suspended particulate (SP) and constituent metals, 24-hour sampling, 6 day cycle	High volume air sampler (analyzed by MOECC Laboratory)

The ministry compared the monitoring results of 2015 to the results of the station since it began operating in 2008. All of those results can be found in the technical memoranda previously published by the ministry⁽¹⁻⁷⁾. Continuous monitoring results were compared with data from other ministry monitoring stations in southwestern Ontario, including Sarnia (Station ID: 14064, Centennial Park, 430 Front St N, Sarnia) and Windsor (Station ID: 12016, College Ave and South St, Windsor), where available (Appendices: Map 1). Comparison sites were chosen, representing conditions in southwestern Ontario that reflect similar urban conditions. In this report, the ministry compared 2015 results with Ontario's Ambient Air Quality Criteria (AAQC)⁽⁸⁾ (Table 2). An AAQC is a desirable concentration of a contaminant in air, based on protection against adverse effects on health or the environment. Although the averaging time of an AAQC is initially set based on the underlying effect, it may be also be adjusted in order to allow for evaluation of air quality over different averaging periods. Carbon monoxide (CO) was measured

but not reported in 2015 as the 1-hour and 8-hour concentrations were well below the AAQC values and the annual average concentration was well below Ontario-wide average CO concentration.

Table 2: Summary of Ontario's Ambient Air Quality Criteria (AAQC) for selected air pollutants

Pollutant	Time unit	Ambient Air Quality Criteria (AAQC), with ppb equivalents
Sulphur dioxide	1-hour	690 $\mu\text{g}/\text{m}^3$ (250 ppb)
	24-hour	275 $\mu\text{g}/\text{m}^3$ (100 ppb)
	Annual	55 $\mu\text{g}/\text{m}^3$ (20 ppb)
Total reduced sulphur	24-hour	7 $\mu\text{g}/\text{m}^3$ (4.8 ppb)
Nitrogen dioxide	1-hour	400 $\mu\text{g}/\text{m}^3$ (200 ppb)
	24-hour	200 $\mu\text{g}/\text{m}^3$ (100 ppb)
Ozone	1-hour	165 $\mu\text{g}/\text{m}^3$ (80 ppb)
Fine particulate matter ^(a)	24-hour	28 $\mu\text{g}/\text{m}^3$
	Annual	10 $\mu\text{g}/\text{m}^3$
Carbon monoxide	1-hour	36,200 $\mu\text{g}/\text{m}^3$ (30000 ppb; 30 ppm)
	8-hour	15,700 $\mu\text{g}/\text{m}^3$ (13000 ppb; 13 ppm)
Benzene	24-hour	2.3 $\mu\text{g}/\text{m}^3$ (0.71 ppb)
	Annual	0.45 $\mu\text{g}/\text{m}^3$ (0.14 ppb)
Suspended particulate	24-hour	120 $\mu\text{g}/\text{m}^3$
Benzo[a]pyrene (as a surrogate of total polycyclic aromatic hydrocarbons)	24-hour	0.00005 $\mu\text{g}/\text{m}^3$ (0.05 ng/m^3)
	Annual	0.00001 $\mu\text{g}/\text{m}^3$ (0.01 ng/m^3)

- a. The ministry does not have an annual or 24-hour AAQC for $\text{PM}_{2.5}$, but rather uses the Canada-wide standard (CWS) for $\text{PM}_{2.5}$. The Canada-wide standards have now been replaced by the Canadian Ambient Air Quality Standards (CAAQS). The ministry will consider replacing the CWS with the CAAQS on the AAQC list. For this document, the CAAQS for $\text{PM}_{2.5}$ are utilized. Specifically, CAAQS were established for $\text{PM}_{2.5}$ under the Canadian Environmental Protection Act, 1999 (CEPA 1999) in May 2013 by the federal government: a 24-hour value (28 $\mu\text{g}/\text{m}^3$) and an annual value (10 $\mu\text{g}/\text{m}^3$). The form of the CAAQS is the 3-year average of the annual average concentrations, and the form of the 24-hour value is the 3-year average of the annual 98th percentile of the daily 24-hour average concentrations.

In previous reports, the ministry compared the monitoring results with Air Quality Index (AQI) values. In 2015, the ministry replaced AQI with the Air Quality Health Index (AQHI). AQI reports on the air quality based on a specific level of an individual air pollutant whereas AQHI reports on the health risk posed by a mixture of pollutants: ground-level O_3 , $\text{PM}_{2.5}$ and NO_2 . The Aamjiwnaang First Nation monitoring station is not designated as an AQHI station. The Sarnia MOECC air monitoring station (Station ID: 14064) reports AQHI regularly (the closest station to

the Aamjiwnaang First Nation monitoring station; about 8 km away). In this report, the AQHI summary of the Sarnia station is included for comparison purposes. Most of the hourly results for SO₂, NO₂, TRS, and VOC are reported in parts per billion (ppb) while particulate, metals, PAH, and canister (non-continuous) VOC results are reported in micrograms per cubic metre (µg/m³) or nanograms per cubic metre (ng/m³). Where results are reported in ppb and are to be compared to the ministry AAQC (which are published in µg/m³), the ministry's AAQC values are converted to ppb assuming a temperature of 20°C and 1 atmospheric pressure (see appendices for details).

The continuous monitoring data is also presented using pollution roses, which show the connection between the pollutants monitored and wind direction. The direction of the wind is based on the direction the wind is blowing from; i.e., a westerly wind is a wind blowing from the west. The non-continuous monitoring data will not be presented using pollution roses because the wind direction will change during sampling periods and will not show a connection between pollutants monitored and the wind direction.

The ministry collected and reported on air monitoring data as part of the Sarnia Air Action Plan that focusses efforts on reducing levels of priority contaminants in the Sarnia air shed. The plan included the creation of a Heavy Industry Team of Environmental Officers with specialized training for working with heavy industry in the Sarnia area. Focussed inspections are utilizing a risk-based approach both by sector and by contaminants of concern. This targeted approach will allow resources to be directed to areas where they can make the greatest impact. The plan includes enhanced incident response, and improved internal and external communications.

The ministry also developed and implemented new technical standards for the petroleum refining and petrochemical sectors. These Technical Standards require industries to take a variety of actions to reduce emissions of benzene from the petroleum refining and petrochemical sectors. The rules focus on the identified significant sources of emissions which include storage vessels, equipment leaks, sewage treatment operations and truck and railcar product loading racks, and marine vessel loading berths. The reductions will be achieved through the implementation of best available technology and practices, resulting in a decreased risk to public health and the environment. Technical standards are used to promote continuous improvement by reducing exposures and managing risks to the local communities. As part of the Sarnia Air Action Plan, ministry staff will be monitoring and reporting on the compliance of the companies in these sectors with the new technical standards.

Continuous Monitoring Data

Sulphur Dioxide (SO₂)

Sulphur dioxide (SO₂) 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, and petroleum refineries. Small sources include residential, commercial, and industrial space heating. SO₂ emissions contribute to acid rain and are a major precursor to fine particulate matter (PM_{2.5}). SO₂ can travel a considerable distance downwind in certain meteorological conditions. Health effects caused by exposure to high levels of SO₂ include eye and respiratory tract irritation, and exacerbation of respiratory and cardiovascular diseases. People with asthma, chronic lung disease or cardiovascular disease are the most sensitive to SO₂ exposure.

Table 3 shows the average and maximum (1 and 24-hour) SO₂ concentrations observed in 2014 and 2015. Data collected at the ministry's Sarnia and Windsor West AQHI stations are also shown in Table 3 for a comparison. The annual average concentration was lower than the previous year. Overall, the ministry has observed a 26% decrease (based on linear trend analysis) over the seven-year period from 2009 to 2015 (Table 15). The ministry has a 1-hour (250 ppb), a 24-hour (100 ppb), and an annual (20 ppb) AAQC for SO₂. No exceedances of any of the AAQC were observed during this monitoring period. The annual average concentration and maximum 24-hour concentrations were lower than those measured at the Sarnia AQHI station and higher than the Windsor West AQHI station. The maximum 1-hour concentration increased from 2014 and was higher than those at the Sarnia and Windsor West AQHI stations.

Station	Year	Annual Average	Maximum 24-hour	Maximum 1-hour	Exceedances of AAQC		
					Annual (20 ppb)	24-hour (100 ppb)	1-hour (250 ppb)
Aamjiwnaang First Nation	2015	2.1	20.6	119	0	0	0
	2014	2.4	30.1	107	0	0	0
Sarnia	2015	3.2	39.4	72	0	0	0
Windsor West	2015	1.9	15.6	43	0	0	0

Season	Average	Maximum 24-hour	Maximum 1-hour
Winter (Jan, Feb, Dec)	1.6	5.7	22
Spring (Mar, Apr, May)	2.5	18	119
Summer (Jun, Jul, Aug)	2.6	20.6	76
Fall (Sep, Oct, Nov)	1.5	7.5	60

Seasonal and monthly results of hourly SO₂ concentrations at the Aamjiwnaang First Nation station are shown in Table 4 and Figure 2, respectively. Overall, average concentrations in spring and summer

were higher than winter and fall (Table 4). The highest 1-hour concentrations (119 ppb) and monthly averages (3.8 ppb) occurred in May and June (Figure 2), respectively.

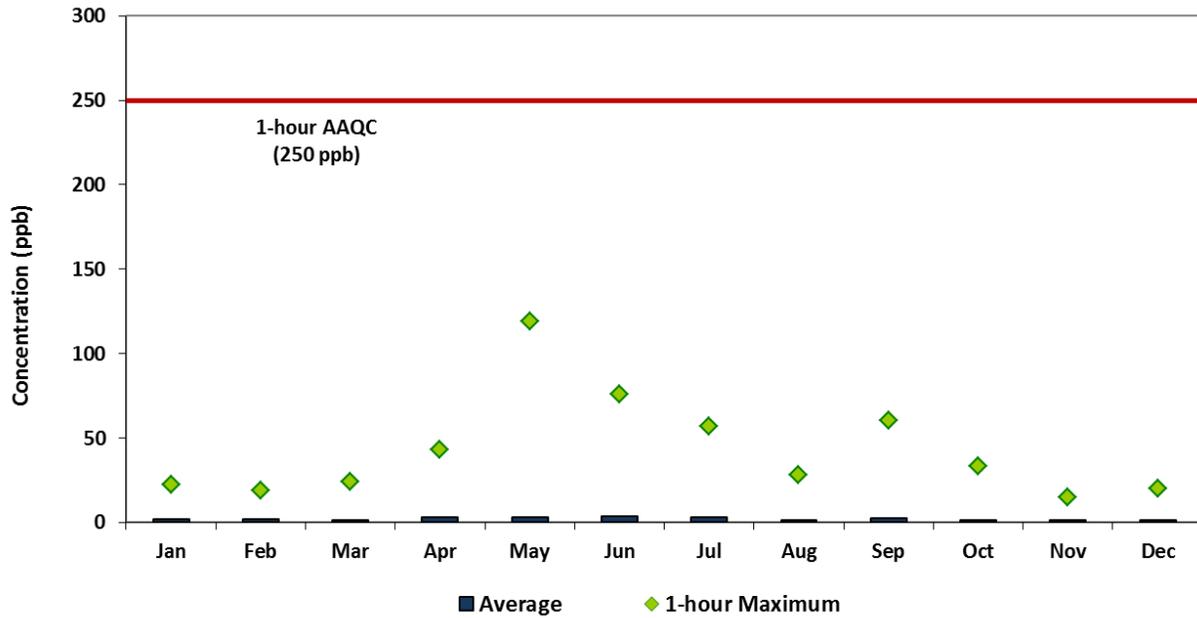


Figure 2: Sulphur Dioxide- Hourly Statistics by Month

The pollution rose in Figure 3 illustrates how SO₂ concentrations vary with wind direction. The highest concentrations were generally associated with winds from the south-west, and north, north-east.

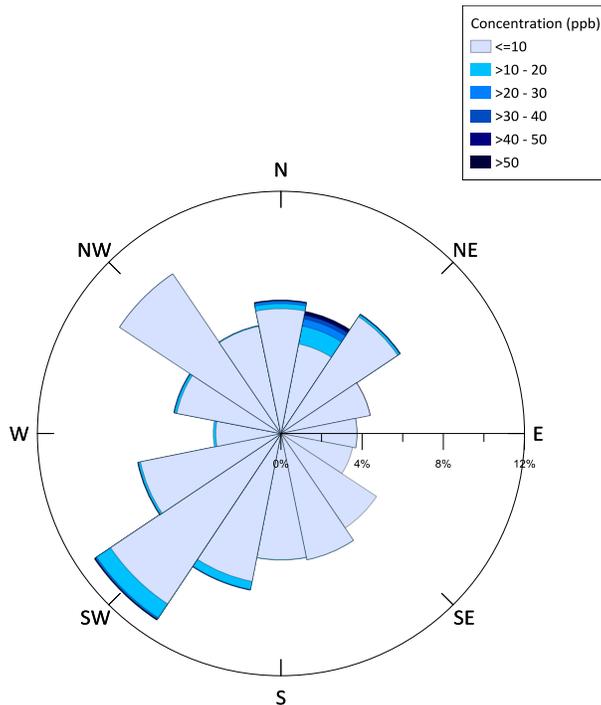


Figure 3: Pollution Rose of SO₂ Concentrations for 2015

Total Reduced Sulphur (TRS) Compounds

Total reduced sulphur (TRS) compounds are a mixture of reduced sulphur compounds including dimethyl disulphide, dimethyl sulphide, hydrogen sulphide and various mercaptans. All sulphur compounds in the TRS category are added together to report the final concentration. TRS compounds come from a variety of industrial sources, such as petroleum refineries 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 except hydrogen sulphide, which has a health-based 24-hour AAQC of 7 $\mu\text{g}/\text{m}^3$ (4.8 ppb) and an odour based 10-minute AAQC of 13 $\mu\text{g}/\text{m}^3$ (9.1 ppb). The other sulphur compounds are a primary cause of odours. The ministry does not have a 1-hour AAQC for TRS.

Table 5 shows the average and maximum (24 and 1-hour) TRS concentrations observed in 2015 and 2014. The annual average and maximum (24-hour and 1-hour) concentrations were lower than the previous year. No exceedances of the 24-hour AAQC were observed during this monitoring period. The ministry observed a decreasing trend of 63% over the 7-year period from 2009 to 2015 (Table 15). The annual average concentration was lower than the Sarnia AQHI station and similar to the Windsor West AQHI station.

Station	Year	Annual Average	Maximum 24-hour	Maximum 1-hour	Exc. of AAQC 24-hour
Aamjiwnaang	2014	0.6	2	10	0
First Nation	2015	0.2	1.6	6	0
Sarnia	2015	0.8	1.8	4	0
Windsor West	2015	0.2	1.3	20	0

Seasonal and monthly statistics of hourly TRS concentrations at the Aamjiwnaang First Nation station are shown in Table 6 and Figure 4, respectively. The average concentration was the highest in winter and was similar in other

Year	Average	Maximum 24-hour	Maximum 1-hour
Winter (Jan, Feb, Dec)	0.3	1.3	6.0
Spring (Mar, Apr, May)	0.1	1.6	2.0
Summer (Jun, Jul, Aug)	0.1	0.9	2.0
Fall (Sep, Oct, Nov)	0.1	1.0	1.0

seasons (Table 6). The highest monthly average (0.5 ppb) concentration was observed in January (Figure 4). As the ministry only has a 24-hour AAQC, 24-hour maximum concentrations across twelve months were compared with the AAQC value of 4.8 ppb. The highest 24-hour maximum concentration (1.6 ppb) occurred in March (Figure 4).

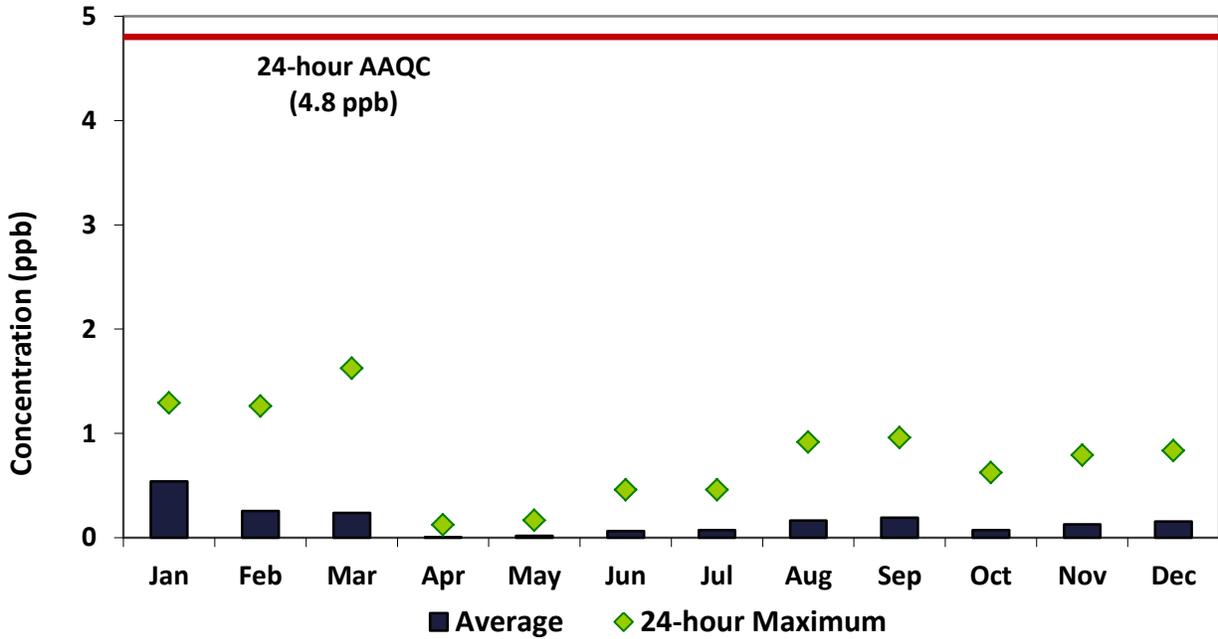


Figure 4: Total Reduced Sulphur Compounds- Hourly Statistics by Month

A pollution rose is shown in Figure 5. Based on the figure, TRS levels appear elevated when wind was coming from the south-west direction.

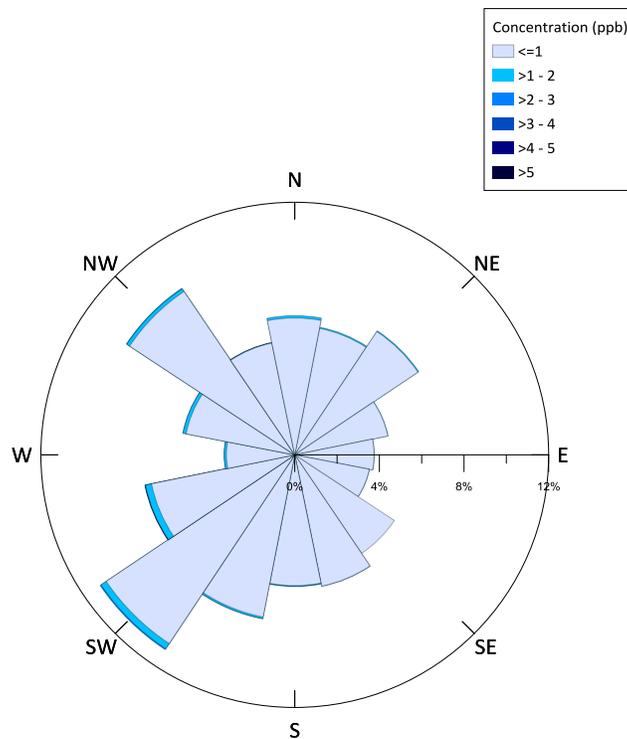


Figure 5: Pollution Rose of TRS Concentrations for 2015

Nitrogen Dioxide (NO₂)

Nitrogen dioxide (NO₂) is a common combustion product. The main sources are motor vehicles and power generation. NO₂ 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. NO₂ can lead to lung irritation and lower resistance to respiratory infection.

The ministry has a 24-hour AAQC of 100 ppb and a 1-hour AAQC of 200 ppb for NO₂. Table 7 shows the average and maximum (24 and 1-hour) NO₂ concentrations observed at the Aamjiwnaang First Nation Stations in 2014 and 2015. The annual average concentration was lower than the previous year. The ministry observed a decreasing trend of NO₂ of 31% over the seven-year period from 2009 to 2015 (Table 15). No exceedances of 24 and 1-hour AAQC were observed in 2015. However, maximum 1-hour and 24-hour concentrations were higher than the previous year. The annual average concentration and maximum 24-hour concentrations were slightly higher than those measured at the Sarnia and lower than the Windsor West AQHI stations. The maximum 1-hour concentration at Aamjiwnaang First Nation was lower than both the Sarnia and Windsor West AQHI stations.

Station	Year	Annual Average	Maximum 24-hour	Maximum 1-hour	Exceedances of AAQC	
					1-hour (200 ppb)	24-hour (100 ppb)
Aamjiwnaang First Nation	2014	10.2	24.6	43	0	0
	2015	9.8	30.3	48	0	0
Sarnia	2015	9.3	29.3	50	0	0
Windsor West	2015	11.4	30.7	62	0	0

Seasonal and monthly statistics of NO₂ concentrations at the Aamjiwnaang First Nation station are shown in Table 8 and Figure 6, respectively. Average concentration was the highest in winter followed by spring, fall, and summer (Table 8). The highest monthly average (13 ppb) and the highest 1-hour concentrations (48 ppb) occurred in February (Figure 6).

Year	Average	Maximum 24-hour	Maximum 1-hour
Winter (Jan, Feb, Dec)	11.5	30.3	20
Spring (Mar, Apr, May)	10.3	23.1	30
Summer (Jun, Jul, Aug)	8.6	16.7	15
Fall (Sep, Oct, Nov)	8.8	16.9	27

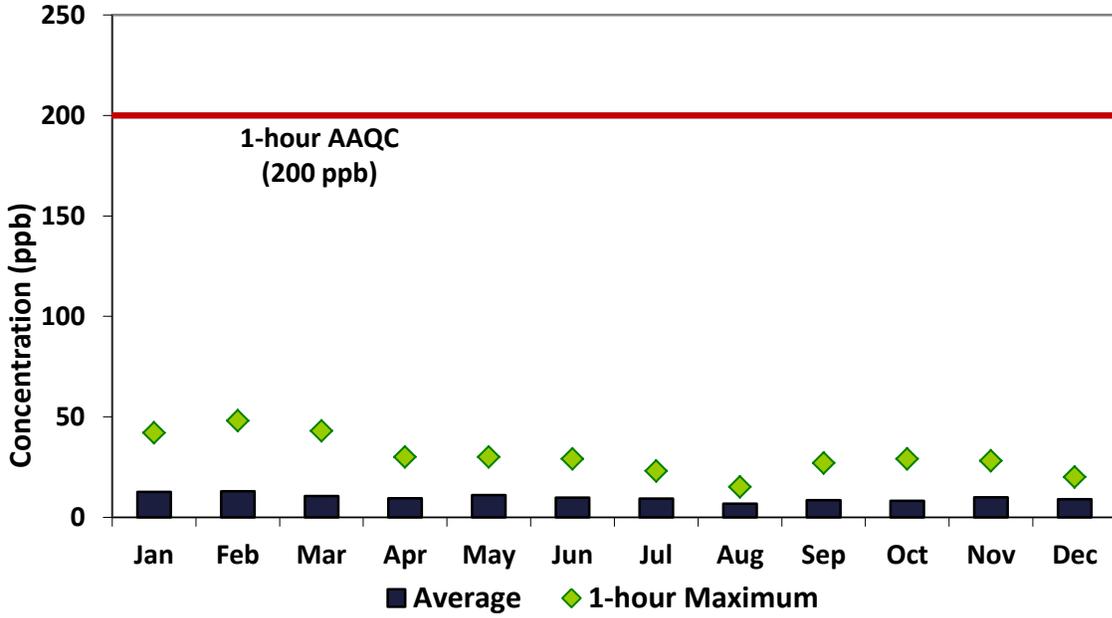


Figure 6: Nitrogen Dioxide- Hourly Statistics by Month

The pollution rose below illustrates how the NO₂ concentration varied with wind direction (Figure 7). The station’s highest concentrations were seen when the wind was coming from the south, which is consistent with previous years (except 2014). In addition to local sources, long range atmospheric transport may also contribute to local concentrations.

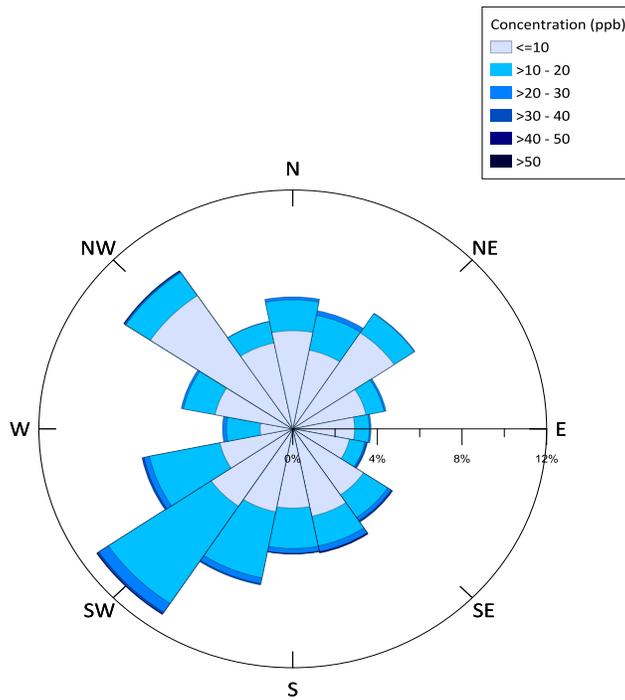


Figure 7: Pollution Rose of NO₂ Concentrations for 2015

Ozone (O₃)

Ozone (O₃) is a reactive, inorganic gas with a distinctive pungent odour and is a major component of smog. 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. Significant amounts of ozone and ozone-forming compounds travel from the United States into Ontario. Strong sunlight and warm conditions speed up production so concentrations tend to rise during the day, and fall at night. Changing weather conditions (such as temperature, wind patterns, etc.) contribute to ozone concentrations hour-to-hour, day-to-day, season-to-season, and year-to-year. Ozone can have adverse effects on human health, especially on respiratory tracts. People with pre-existing respiratory disorders (such as asthma, chronic pulmonary obstructive disease, etc.) and children who are active outdoors during the summer, are particularly at risk. Ozone also causes many losses in agricultural crops each year, with visible leaf damage in many crops, garden plants, and trees, especially during the summer months.

The ministry has a health-based 1-hour AAQC for O₃ of 80 ppb. Table 9 shows the annual average and maximum (24- and 1-hour) O₃ concentrations observed at the Aamjiwnaang First Nation Stations in 2014 and 2015. The 2015 results show an improvement from 2014, with observed decreases in the average and maximum 24-hour concentrations. However, maximum 1-hour concentration as well as the number of AAQC exceedances (five exceedances occurred in 2015 compared to one in 2014) increased. The ministry observed a 12% increase in the O₃ annual average concentration over the seven-year period from 2009 to 2015 (Table 15). The findings at Aamjiwnaang First Nation in previous years have been consistent with the provincial trend⁽⁹⁾. The ministry's Air Quality in Ontario 2015 report highlights the province's increasing ozone annual means between 2006 and 2015⁽⁹⁾. The annual average concentration was lower than the Sarnia AQHI Station but higher than the Windsor West AQHI station.

Station	Year	Annual Average	Maximum 24-hour	Maximum 1-hour	Exceedances of AAQC 1-hour (80 ppb)
Aamjiwnaang First Nation	2014	27.5	51.5	82	1
	2015	27.1	45.1	86	5
Sarnia	2015	27.8	48.1	83	4
Windsor West	2015	26.5	49.6	87	2

Seasonal and monthly statistics for O₃ concentrations at the Aamjiwnaang First Nation station are shown in Table 10 and Figure 8, respectively. Average concentration was the highest in spring followed by summer, fall, and winter (Table 10).

Year	Average	Maximum 24-hour	Maximum 1-hour
Winter (Jan, Feb, Dec)	23.8	35.5	49
Spring (Mar, Apr, May)	31.4	45.1	74
Summer (Jun, Jul, Aug)	28.7	42.8	84
Fall (Sep, Oct, Nov)	24.5	41.6	86

This seasonal trend is observed because ozone formation is directly linked to heat and sunlight. The highest monthly average (31.6 ppb) occurred in March and May (Figure 8). The highest 1-hour concentration (86 ppb) was observed in September. Exceedences of the 1-hr AAQC occurred in summer (2) and fall (3).

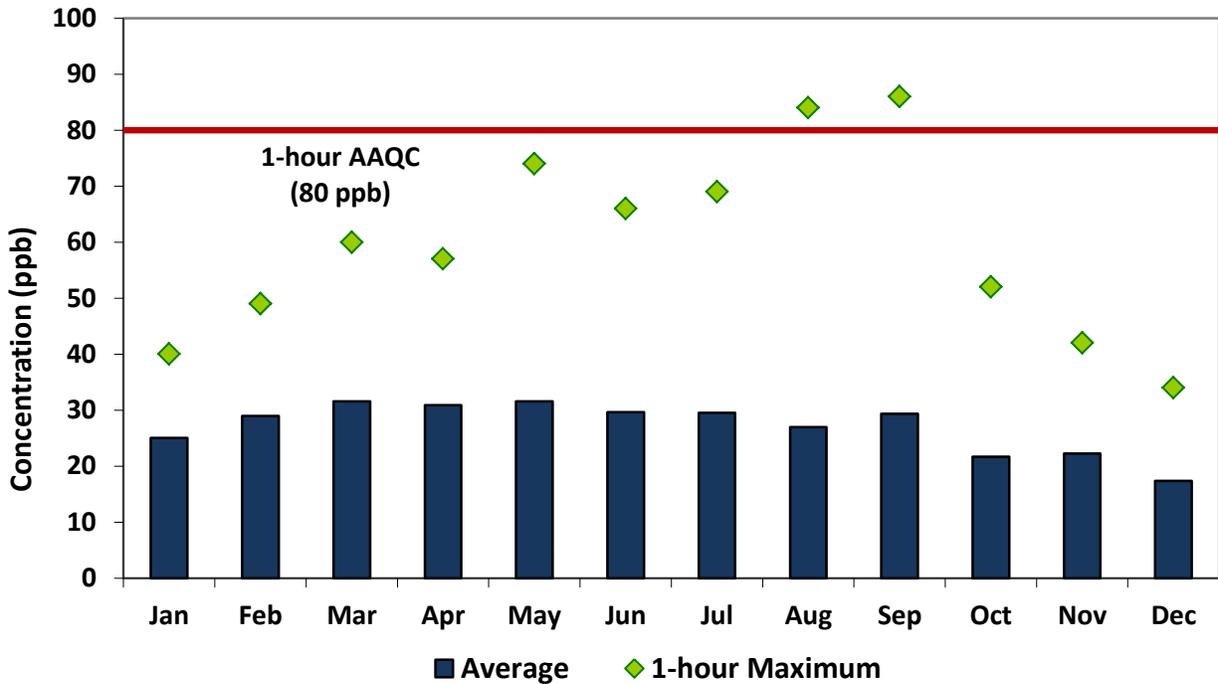


Figure 8: Ozone- Hourly Statistics by Month

The pollution rose below illustrates how the O₃ concentration varied with wind direction (Figure 9). In general, southerly winds bring more of the chemicals that form south to the region. These compounds originate in industrial and developed areas, so concentrations detected at the Aamjiwnaang First Nation station are influenced by the prevailing winds.

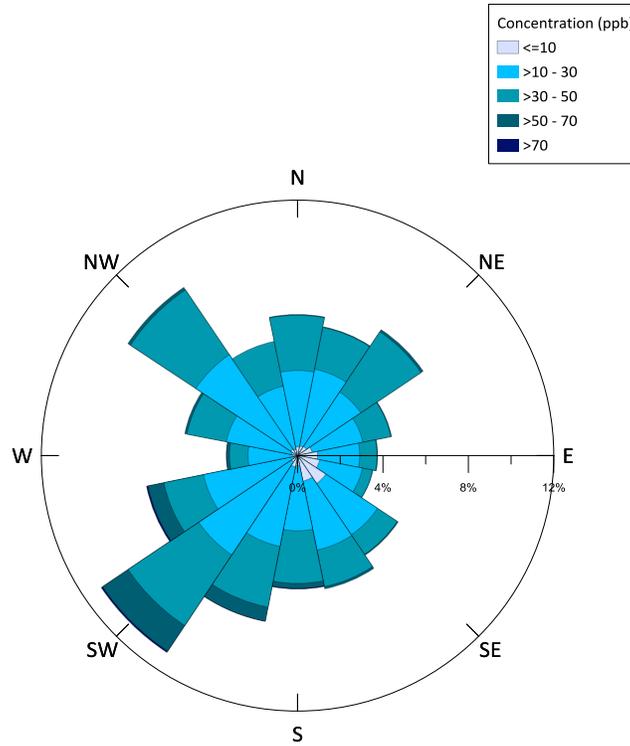


Figure 9: Pollution Rose of Ozone Concentrations for 2015

Fine Particulate Matter (PM_{2.5})

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. Airborne particulate is the mixture of microscopic solid particles and liquid droplets suspended in air. In Ontario, major components of PM_{2.5} are typically nitrates, sulphates, organic matter and particle bound water. PM_{2.5} may be emitted directly into the atmosphere as a by-product of fuel combustion, or it may be formed indirectly in the atmosphere through a series of complex chemical reactions. Major sources of PM_{2.5} in Sarnia include motor vehicles, refineries, power plants, and industrial facilities. PM_{2.5} may be transported hundreds of kilometres from its source. These particles are of great concern because their small size enables them to bypass the body's natural defences and reach the deepest parts of the lung. Susceptible population such as children, older adults, and persons with pre-existing respiratory or cardiovascular diseases are at increased risk of suffering from the adverse effects of PM_{2.5}.

Table 11 shows the annual average and maximum (1 and 24-hour) PM_{2.5} concentrations observed at the Aamjiwnaang First Nation Stations in 2015 and 2014. While the annual average and maximum (1 and 24-hour) concentrations were higher than those in the previous year, the ministry observed a 19% decrease in annual PM_{2.5} concentration over the seven-year period from 2009 to 2015 (Table 15). While the ministry does not have an AAQC for PM_{2.5}, Canadian Ambient Air Quality Standards (CAAQS) for two different time periods are available: an annual standard (10 µg/m³) and a 24-hour standard (28 µg/m³). The CAAQS annual standard is calculated using the 3-year average of the annual average concentrations. The CAAQS 24-hour standard is calculated using the 3-year average of the annual 98th percentile of the daily 24-hour average concentrations. The CAAQS are shown here for comparative purposes only and not for evaluation of the achievement status of the standards. This is because the annual averages presented in Table 11 were calculated as 1-year averages. For the maximum 24-hour concentration, only the maximum daily concentration was considered. The annual average concentration and maximum 24-hour concentrations were higher than those measured at the Sarnia AQHI station and lower than the Windsor West AQHI station. The maximum 1-hour concentration at Aamjiwnaang First Nation was higher than both the Sarnia and Windsor West AQHI stations.

It should be noted that PM_{2.5} was measured with a GRIMM monitor at the Aamjiwnaang First Nation station, and with a SHARP monitor at the Sarnia and Windsor West AQHI stations. In 2013, the ministry installed SHARP monitors at its AQHI stations, which are expected to provide a more accurate measurement of fine particulate matter, and have been found to report higher annual means than previous years^[9]. As a result of these findings, the ministry installed a SHARP monitor at the Aamjiwnaang First Nation station in February, 2016.

Table 11: Summary of Fine Particulate Matter Concentrations (µg/m³)

Station	Year	Annual Average	Maximum 24-hour	Maximum 1-hour
Aamjiwnaang First Nation	2015	9.0	38.8	106
	2014	8.1	35.5	53.3
Sarnia	2015	8.4	35.5	78.0
Windsor West	2015	9.9	42.2	68.0

Seasonal and monthly statistics of PM_{2.5} concentrations at the Aamjiwnaang First Nation station are shown in Table 12 and Figure 10, respectively. Average concentration was the highest in winter followed by spring, fall and summer (Table 12). The highest monthly average (12.1 µg/m³) and 1-hour concentrations (106 µg/m³) occurred in February. 24-hour maximum concentrations across twelve months were plotted against 24-hour CAAQS value of 28 µg/m³ (Figure 10). The CAAQS is shown for comparative purposes only and not for evaluation of the achievement status of the standards.

Table 12: Seasonal PM_{2.5} concentrations (µg/m³)

Year	Average	Maximum 24-hour	Maximum 1-hour
Winter (Jan, Feb, Dec)	11	29.8	106
Spring (Mar, Apr, May)	9.3	38.8	46
Summer (Jun, Jul, Aug)	7.6	22.0	50
Fall (Sep, Oct, Nov)	8	26.3	38

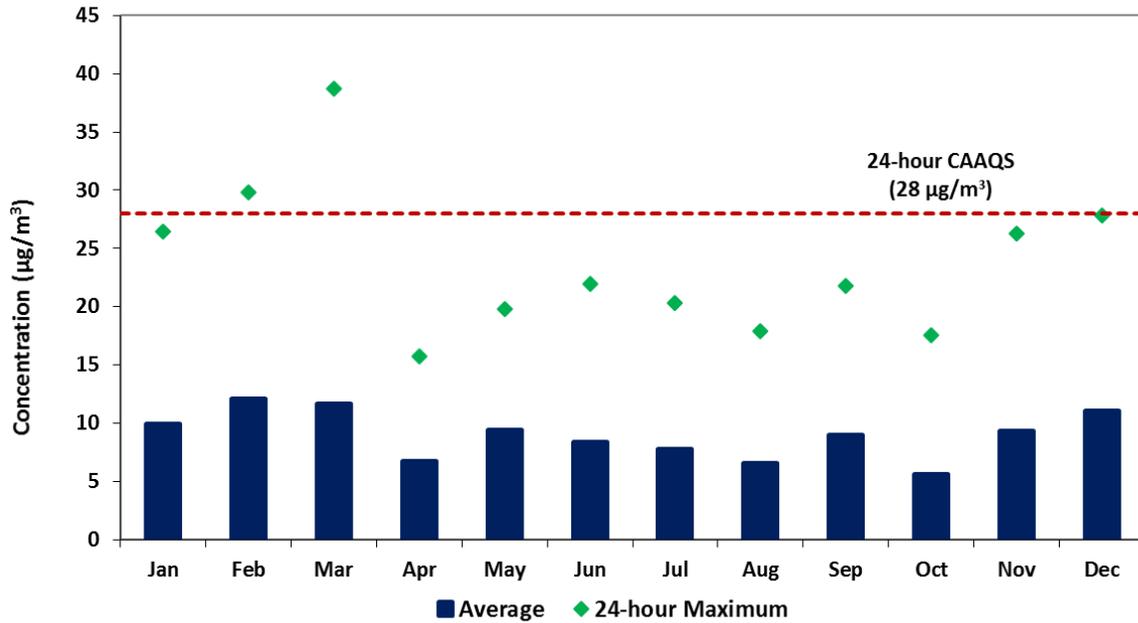


Figure 10: Fine Particulate Matter- Hourly Statistics by Month

The pollution rose below illustrates how the PM_{2.5} concentration varied with wind direction (Figure 11). In general, higher concentrations (>30 µg/m³) of PM_{2.5} were observed when the wind was coming from the south-west.

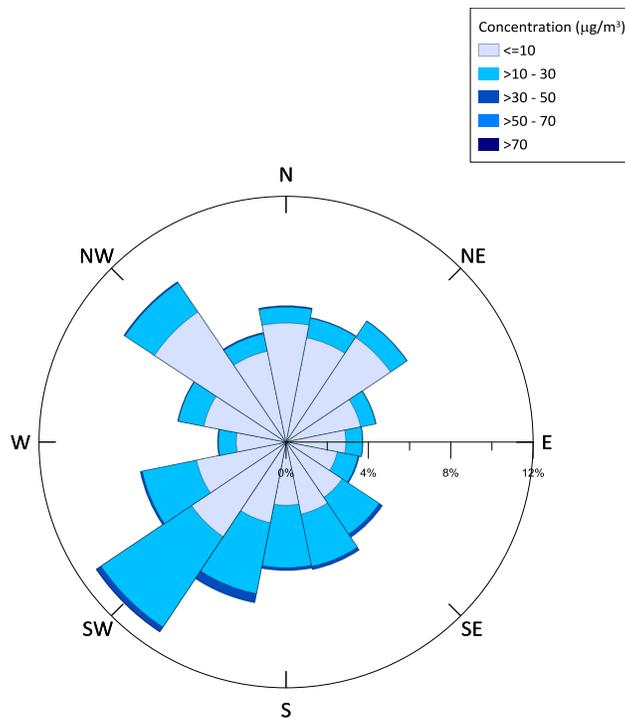


Figure 11: Pollution Rose of Fine Particulate Matter Concentrations in 2015

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 (PM_{2.5}), ECCO and most other sampling networks in Ontario under the National Air Pollution Surveillance (NAPS) program collect 24-hour samples of SP every sixth day following the same schedule. 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. In 2015, samples were analyzed for nine metals: cadmium (Cd), chromium (Cr), copper (Cu), iron (Fe), lead (Pb), manganese (Mn), nickel (Ni), vanadium (V), and zinc (Zn). Samples are taken midnight to midnight EST. In 2015, 56 samples were collected out of 60 sampling days specified by the NAPS schedule of which 50 samples were valid.

In January 2015, the ministry replaced the Low-Volume air sampler with a High-Volume air sampler at the Aamjiwnaang First Nation station. High-volume air samplers provide a more accurate measurement of suspended particulate (for aerosols with the aerodynamic diameter >7 µm), and have been found to report higher annual means than Low-Volume air samplers. While the 2015 data showed the highest average SP concentration values since monitoring began, annual average SP concentrations were consistent during the monitoring with the Low-Volume air sampler from 2009 and 2014 (ranging from 10.69 to 16.09 µg/m³). With the change to the High-Volume air sampler, concentration values of SP increased by 75% between 2014 and 2015 and still remained well below the annual AAQC.

Average concentrations of iron and zinc were higher than previous years, while other metals were similar. The ministry has a 24-hour AAQC for SP and for most of the metal constituents. No exceedances of the 24-hour AAQC were observed in 2014 or 2015.

Table 17 includes the average and maximum concentrations of SP and its constituent metals, as well as the number of samples of each test that were greater than the detection limit for 2015 and 2014. 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 ($\mu\text{g}/\text{m}^3$)							
Compounds	24-hour AAQC	2015			2014		
		Annual Average	Maximum	% > mdl	Annual Average	Maximum	% > mdl
Suspended particulate	120	28.02	66.00	100%	16.09	67.3	100%
Cadmium	0.025	0.001	0.002	6%	---	0.01	49%
Calcium		---	---	---	0.53	1.9	98%
Chromium	0.5	---	0.002	26%	---	0.002	32%
Copper	50	0.036	0.190	100%	0	0.018	78%
Iron	4	0.267	0.680	100%	0.13	0.41	98%
Lead	0.5	---	0.003	46%	---	0.006	39%
Manganese	0.4	0.006	0.018	82%	0	0.012	76%
Nickel	0.2	---	0.006	20%	0	0.005	76%
Silicon		---	---	---	0.29	1.3	98%
Vanadium	2	0.009	0.030	74%	0	0.009	66%
Zinc	120	0.108	0.350	100%	0.01	0.024	90%

¹Results are based on 50 samples

²Calcium and silicon were not analyzed in 2015

Figure 12 shows SP concentrations measured over 2015 in comparison to the 24-hour AAQC. SP levels did not show a great degree of monthly variation, however, levels were generally higher in the spring.

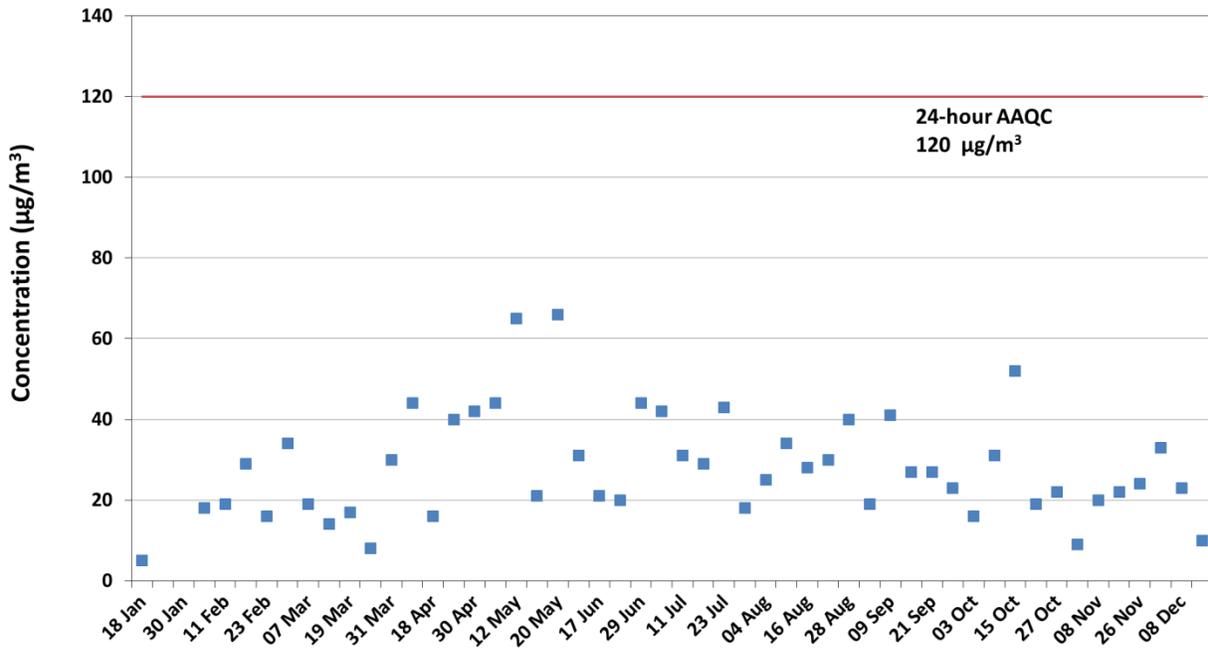


Figure 12: 24-hour Average Suspended Particulate Concentration in 2015

In addition to the 24-hour AAQC, SP, nickel, and cadmium have annual AAQC, which are given in Table 18. There were no exceedances of the annual AAQC for these parameters.

Parameter	Annual AAQC ($\mu\text{g}/\text{m}^3$)	Annual Average ($\mu\text{g}/\text{m}^3$)
Suspended particulate ($< 44 \mu\text{m}$ diameter)	60 (geometric mean)	24.92
Nickel	0.04	0.001
Cadmium	0.005	0.001

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, and are typically found at higher concentrations in urban vs. rural areas. Some PAH are known to be carcinogenic. Benzo[a]pyrene is considered “carcinogenic to humans” by the U.S. EPA, based on strong and consistent evidence in animals and humans. In addition, the International Agency for Research in Cancer (IARC) of the World Health Organization (WHO) considers benzo[a]pyrene as a ‘Group 1’ compound (carcinogenic to humans).

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, 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 (i.e., micrograms; µg).

The ministry collected 29 PAH samples in 2015. The results are summarized in Table 25. 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 below the method detection limit (mdl), as the degree of uncertainty becomes too high. Average and maximum concentrations of all compounds were higher in 2015 than those observed in 2014.

Compounds and Abbreviations		2015			2014		
		Annual Average	Maximum	>mdl (%)	Annual Average	Maximum	>mdl (%)
		ng/m ³	ng/m ³		ng/m ³	ng/m ³	
Benzo[g,h,i]perylene	B[g,h,i]P	0.149	0.659	96.55%	0.093	0.328	87.10%
Dibenz[a,h]anthracene	D[a,h]A	---	0.098	37.93%	---	0.03	6.50%
Indeno[1,2,3-cd]Pyrene	I[1,2,3]P	0.128	0.553	96.55%	0.079	0.292	74.20%
Benzo[a]pyrene	B[a]P	0.078	0.344	82.76%	0.045	0.226	71.00%
Benzo[b]fluoranthene	B[b]F	0.147	0.541	96.55%	0.1	0.348	87.10%
Benzo[k]fluoranthene	B[k]F	0.055	0.215	62.07%	0.038	0.143	67.70%
Chrysene/Triphenylene	Chry/TPh	0.085	0.480	82.76%	0.049	0.256	64.50%
Benz[a]anthracene	B[a]A	---	0.148	48.28%	---	0.129	25.80%

The individual sample results are shown in Figure 13. PAH concentrations tended to be higher in the cooler months (October-March) than the warmer months.

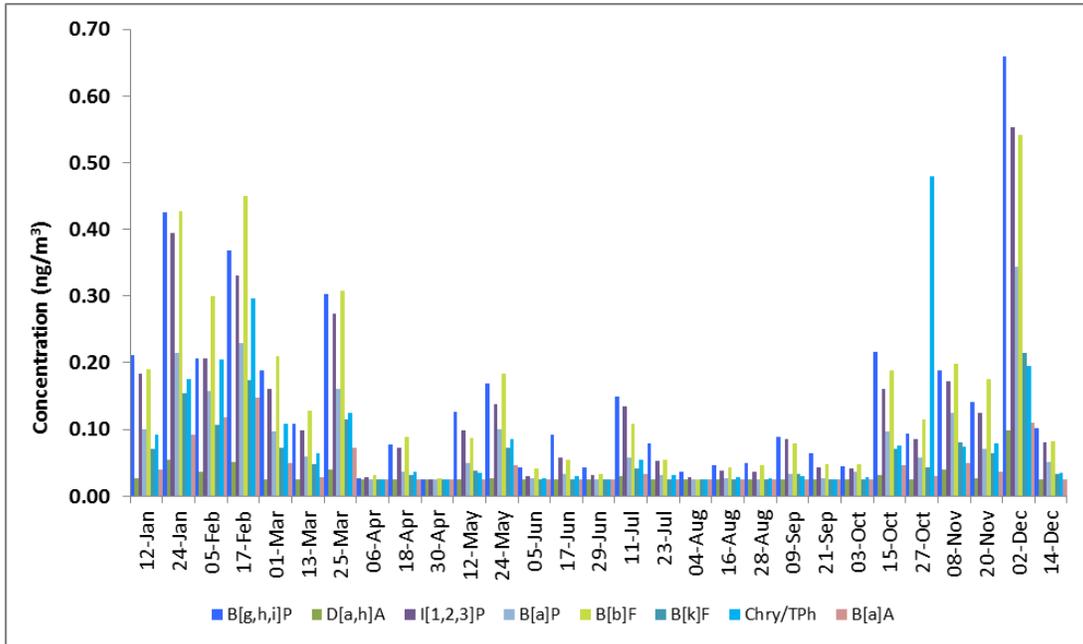


Figure 13: 24-hour Average Polycyclic Aromatic Hydrocarbons (PAH) Concentrations in 2015

Table 26 presents a comparison of the Aamjiwnaang First Nation results with those obtained at two other stations in southwestern Ontario: Windsor and Wallaceburg. The Windsor station is not the same as the AQHI station used for most other pollutants discussed in this report, as there is no PAH monitor at that location. PAH data come from a monitor at the Lou Romano Water Reclamation Plant (Station ID 12015), about 2.5 km to the southwest. The Aamjiwnaang results were lower than levels measured at the ministry’s monitoring station in Windsor, located 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.

Compounds and Abbreviations		Aamjiwnaang First Nation		Windsor		Wallaceburg	
		Avg	Max	Avg	Max	Avg	Max
		ng/m ³	ng/m ³	ng/m ³	ng/m ³	ng/m ³	ng/m ³
Benzo[g,h,i]perylene	B[g,h,i]P	0.149	0.659	0.437	1.400	0.064	0.166
Dibenz[a,h]anthracene	D[a,h]A	---	0.098	0.069	0.310	---	0.029
Indeno[1,2,3-cd]Pyrene	I[1,2,3]P	0.128	0.553	0.315	1.330	0.061	0.151
Benzo[a]pyrene	B[a]P	0.078	0.344	0.203	1.600	0.039	0.124
Benzo[b]fluoranthene	B[b]F	0.147	0.541	0.352	1.830	0.073	0.161
Benzo[k]fluoranthene	B[k]F	0.055	0.215	0.147	0.894	0.029	0.068
Chrysene / Triphenylene	Chry/TPh	0.085	0.480	0.197	1.660	0.035	0.083
Benz[a]anthracene	B[a]A	---	0.148	0.143	1.520	---	0.051

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

The ministry has a 24-hour AAQC for B[a]P of 0.05 ng/m³, and an annual AAQC of 0.01 ng/m³. B[a]P is measured as a representative of carcinogenic risk of exposure to all PAHs. Table 27 shows the annual average and number of exceedances of the B[a]P AAQC in 2015 compared to that of previous years. The average annual B[a]P concentration exceeded the ministry’s AAQC in 2015, as it did each year between 2008 and 2015. The 2015 annual average was the highest since the monitoring started in 2008.

Year	2008/ 2009	2009/ 2010	2011	2012	2013	2014	2015
Number of exceedances of 24-hour AAQC	13*	13*	10*	7	10	9	16
Annual average (ng/m ³)	0.057*	0.071*	0.069	0.043	0.061	0.045	0.078
*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 2015 are shown in Figure 14. 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 (October-March). There were three exceedances observed in warmer months compared to no exceedence in that time of year in 2014. This seasonal trend was found in the results for other PAH as well, which suggests that building heating may be contributing to local PAH concentrations.

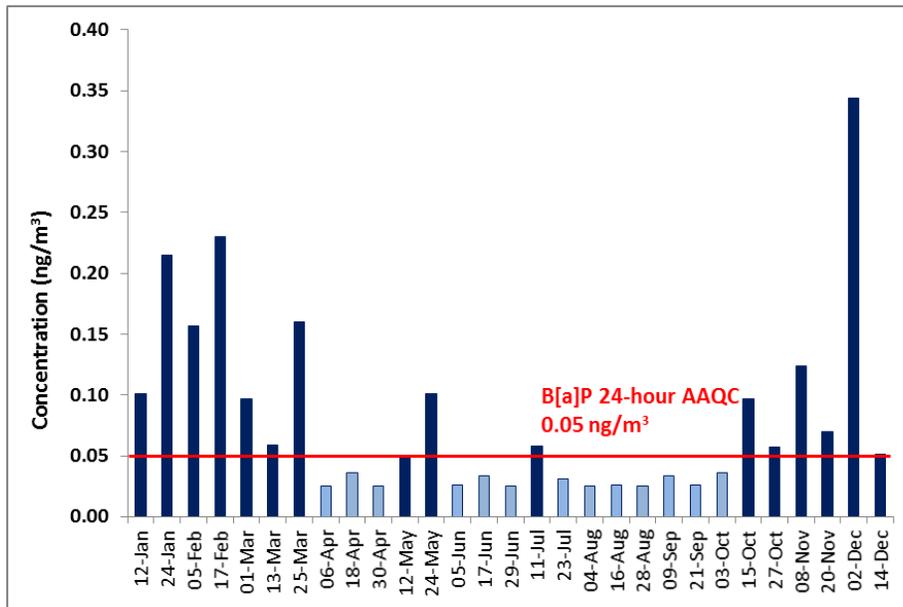


Figure 14: 24-hour Average Benzo[a]pyrene Concentration in 2015

Data Collected with Multiple Methods

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.

VOC are measured with two different methods at the Aamjiwnaang First Nation station. Both continuous and non-continuous methods have been utilized to exploit their differing capabilities. The non-continuous VOC monitoring was performed through ECC National Air Pollution Surveillance Program (NAPS). The samples were collected and analyzed with an internationally recognized method (USEPA TO-15) through their Canadian Association for Laboratory Accreditation Inc. (CALA) accredited laboratory which must adhere to rigorous Quality Assurance/Quality Control (QA/QC) practices. The non-continuous sampling method analyzes one sample collected over the course of the entire day and as such cannot determine variations in concentrations within that day. The goal of the NAPS program is to provide accurate long-term air quality data of a uniform standard across Canada and is appropriate for calculating ambient annual averages. The non-continuous NAPS data collected at the Aamjiwnaang First Nation provides an authoritative data set for determining annual averages and long-term trends at this site. The continuous monitoring of VOC was performed by MOECC using a research grade instrument to supplement the VOC data collected under the NAPS program. The resulting data quality and its applicability will vary depending on a number of factors including the methods developed, QA/QC procedures implemented and instrument performance. The nature of continuous monitoring allows for the collection of high-time resolution data which is capable of capturing short-term concentration spikes leading to better analysis of episodic events and source determination. Using these two methods helps provide a more comprehensive picture of VOC at the Aamjiwnaang First Nation station.

To further improve the quality of the VOC data gathered at the Aamjiwnaang First Nation station, in May of 2017, the ministry replaced the research grade continuous monitor with a commercial grade instrument. This new instrument is designed for long-term continuous measurements and is more dependable and user friendly. It will allow for improved real-time measurements of 1,3-butadiene and benzene. The new instrument has better defined accuracy and precision resulting in a completely new dataset and any future analyses and trends cannot be easily compared to the data collected from the research-grade monitor.

Non-Continuous Volatile Organic Compounds (VOC)

Through ECCC's NAPS program, 24-hour samples were collected every 12 days. Samples were collected using specially prepared evacuated canisters and analyzed at the ECCC laboratory in Ottawa. This method permits determination of a range of 154 target compounds and detection at very low concentrations.

In 2015, ECCC collected 27 samples for VOC analyses. The ministry has 24-hour AAQC for forty-seven of the target compounds. Three of these, 1,1-dichloroethylene, 1,1-dichloroethane, and methyl tertbutylether (MTBE) were not detected in 2015. Some of these compounds were not analyzed in 2015 (1-decene, 1-octene, ethylene dibromide, freon113, cis-1,2-dichloroethylene and trans-1,2-dichloroethylene) because of the lower levels observed in the previous year. The monitoring results for the remainder of these compounds are given in Table 19. To facilitate comparison to the ministry's AAQC, the concentrations of different isomers of trimethylbenzene and xylenes were summed prior to inclusion in Table 19. Benzene was the only compound to exceed its 24-hour AAQC.

Table 19: ECCC VOC Concentrations Compared to 24-hour AAQC

Compound	24-hour AAQC ($\mu\text{g}/\text{m}^3$)	Average ($\mu\text{g}/\text{m}^3$)	Maximum ($\mu\text{g}/\text{m}^3$)	Compound	24-hour AAQC ($\mu\text{g}/\text{m}^3$)	Average ($\mu\text{g}/\text{m}^3$)	Maximum ($\mu\text{g}/\text{m}^3$)
1,1,1-Trichloroethane	115000	0.020	0.031	Ethylene	40	4.158	9.614
1,2,4-Trichlorobenzene	400	0.006	0.032	Freon11	6000	1.596	2.185
1,2-Dichloroethane	2	0.071	0.109	Freon114	700000	0.113	0.131
1,2-Dichloropropane	2400	0.020	0.028	Freon12	500000	2.551	2.988
1,3-Butadiene	10	0.147	1.821	Freon22	350000	0.815	0.987
1,4-Dichlorobenzene	95	0.015	0.034	Heptane	11000	0.220	0.491
Acetylene	56000	0.513	1.058	Hexane	7500	1.563	13.928
Benzene	2.3	1.491	3.230	iso-Propylbenzene	400	0.016	0.034
Bromoform	55	0.015	0.030	Naphthalene	22.5	0.061	0.177
Bromomethane	1350	0.045	0.063	Propylene	4000	3.708	13.142
Carbon tetrachloride	2.4	0.513	0.616	Styrene	400	0.237	1.093
Chloroethane	5600	0.021	0.037	Tetrachloroethylene	360	0.059	0.117
Chloroform	1	0.112	0.161	Toluene	2000	1.480	3.820
Chloromethane	320	1.753	5.978	Trichloroethylene	12	0.034	0.140
Cyclohexane	6100	3.439	21.414	Trimethylbenzenes (1,2,3-; 1,2,4-; 1,3,5-)	220	0.218	0.526
Dichloromethane	220	0.327	0.570	Vinyl chloride	1	0.002	0.007
Ethyl benzene	1000	0.273	1.390	Xylenes (m-,p-, o-)	730	0.598	1.280

Benzene exceeded its 24-hour AAQC on seven occasions (Table 20). This represents the highest number of exceedances in an annual period since monitoring began. Table 20 shows the number of exceedances of the 24-hour AAQC for benzene between 2008/2009 and 2015 in relation to the number of samples taken.

	2008/2009	2009/2010	2011	2012	2013	2014	2015
Samples	29	31	30	31	29	31	27
Number of 24-hour AAQC exceedances	5	4	1	3	3	4	7
% samples that exceeded 24-hour AAQC	17%	13%	3%	10%	10%	13%	26%

Figure 15 shows the benzene concentrations measured in 2015 in comparison to the 24-hour benzene AAQC. In 2015, exceedances were observed in both summer and winter months, similar to 2014.

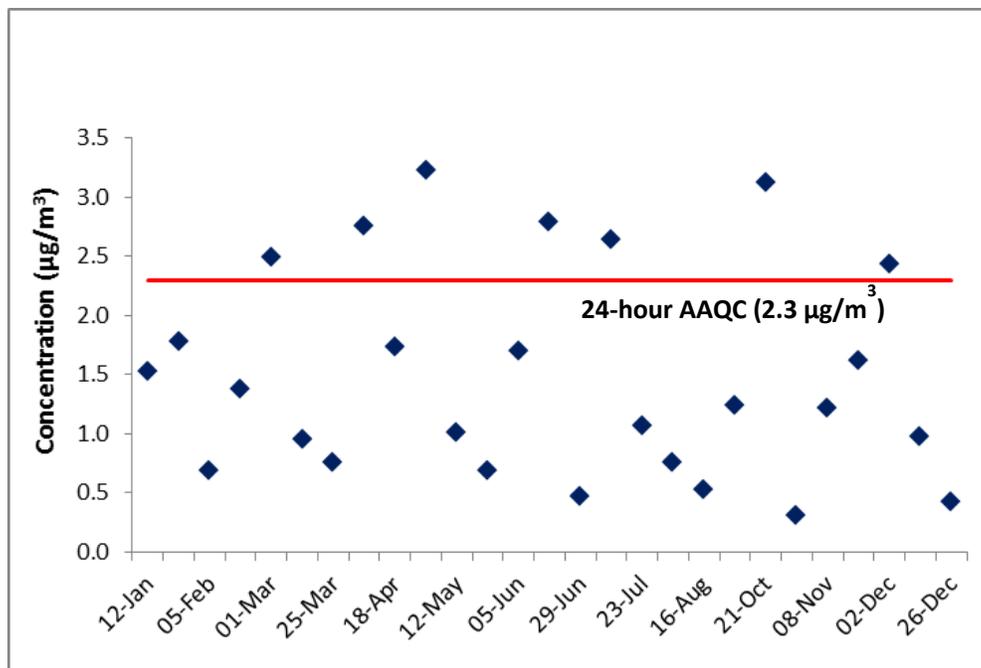


Figure 15: 24-hour Average Benzene Concentrations in 2015

Table 21 presents a comparison of maxima and averages between 2015 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). 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 Section 17 of O.Reg. 419/05 to calculate equivalent concentrations for comparison purposes. These values were determined for each of these four compounds and the 24-hour monitoring results were compared to these converted 24-hour values. The converted values are summarized in Table 21, along with the maximum and average concentrations for the compounds. The four substances with AAQC for periods other than 24-hour are in italics.

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 2014 results. However, notable increases (e.g. cyclohexane) and decreases (e.g. chloromethane) were seen for several components. The average benzene concentration remained almost the same; however, the maximum benzene concentration decreased from the 2014 value, and as previously indicated, exceedances of the 24-hour AAQC were observed.

Compounds	24-hour AAQC	2015		2014	
		Maximum	Average	Maximum	Average
1,1,1-Trichloroethane	115000	0.031	0.020	0.03	0.022
1,2,4-Trichlorobenzene	400	0.032	0.006	0.019	0.006
<i>1,2-Dichlorobenzene</i>	<i>12500</i>	0.009	0.003	0.006	0.003
1,2-Dichloroethane	2	0.109	0.071	0.123	0.074
1,2-Dichloropropane	2400	0.028	0.020	0.024	0.016
1,3-Butadiene	10	1.821	0.147	1.272	0.212
1,4-Dichlorobenzene	95	0.034	0.015	0.061	0.018
1-Decene	60000	---	---	0.059	0.012
1-Octene	50000	---	---	0.289	0.056
Acetylene	56000	1.058	0.513	0.873	0.499
Benzene	2.3	3.230	1.491	6.247	1.487
Bromoform	55	0.030	0.015	0.033	0.016
Bromomethane	1350	0.063	0.045	0.076	0.051
Carbon tetrachloride	2.4	0.616	0.516	0.56	0.477
<i>Chlorobenzene</i>	<i>1400</i>	0.023	0.013	0.032	0.012
Chloroethane	5600	.037	.021	0.036	0.019
Chloroform	1	0.014	0.022	0.177	0.099
Chloromethane	320	5.978	1.753	12.055	2.006
cis-1,2-Dichloroethylene	105	---	---	0.003	0
Cyclohexane	6100	21.414	3.439	15.404	1.709
<i>Decane</i>	<i>25000</i>	1.100	0.152	0.855	0.14

Dichloromethane	220	0.570	0.327	0.348	0.277
Ethylbenzene	1000	1.390	0.273	3.103	0.314
Ethylene	40	9.614	4.158	15.214	3.653
Ethylene dibromide	3	----	---	0.002	0
Freon11	6000	2.185	1.596	1.816	1.471
Freon113	800000	---	---	0.737	0.581
Freon114	700000	0.131	0.113	0.135	0.117
Freon12	500000	2.988	2.551	3.36	2.545
Freon22	350000	0.987	0.815	0.96	0.761
Heptane	11000	0.491	0.220	0.707	0.238
Hexane	7500	13.928	1.563	21.451	2.184
Iso-propylbenzene	400	0.034	0.016	0.043	0.016
Naphthalene	22.5	0.177	0.061	0.368	0.094
Octane	15000	0.310	0.128	0.853	0.149
Propylene	4000	13.142	3.708	16.339	3.193
Styrene	400	1.093	0.237	1.614	0.304
Tetrachloroethylene	360	0.117	0.059	0.187	0.062
Toluene	2000	3.820	1.480	6.107	1.538
trans-1,2-Dichloroethylene	105	---	---	0.238	0.04
Trichloroethylene	12	0.140	0.034	0.127	0.022
Trimethylbenzenes (1,2,3-, 1,2,4-, 1,3,5-)	220	0.526	0.218	0.699	0.231
Vinyl chloride	1	0.007	0.002	0.008	0.002
Xylenes	730	1.280	0.598	2.599	0.616

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 21, six compounds also have annual AAQCs, which are listed in Table 22. The annual averages from 2008-2014 are also included in the table for comparison purposes.

Compound	Annual AAQC (µg/m ³)	Average (µg/m ³)						
		2008/2009	2009/2010	2011	2012	2013	2014	2015
1,3-Butadiene	2	0.107*	0.184*	0.091	0.095	0.194	0.204	0.147
Benzene	0.45	1.362*	1.234*	1.204	1.122	0.997	1.487	1.491
Vinyl chloride	0.2	0.020	0.005	0.004	0.003	0.003	0.002	0.002
Dichloromethane	44	0.249	0.242	0.233	0.246	0.291	0.279	0.327
Chloroform	0.2	0.080	0.082	0.088	0.095	0.090	0.100	0.022
1,2-Dichloroethane	0.4	0.063	0.081	0.069	0.073	0.069	0.074	0.071

*Annual 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 2015, as it has in each of the six previous monitoring periods. The average benzene concentration had decreased each year between 2008 and 2013, however, the 2014 and 2015 average concentrations increased to the highest values observed

since monitoring began at the Aamjiwnaang First Nation station. Notably however, there was no significant increase in the annual benzene concentration between 2014 and 2015 (0.3% increase). Overall, an increasing trend of 12% was observed for the 7-year period from 2008/2009 to 2015. No other VOC exceeded its annual AAQC in 2015, and results have remained relatively consistent with previous years.

ECCC also samples VOC at various sites across the country. VOC results from the Aamjiwnaang First Nation station and three other stations in southwestern Ontario are provided in Table 23. It should be noted that VOC were sampled every 12 days at the Aamjiwnaang station and every 6 days at the Sarnia, Windsor, and London stations. As such, there are approximately twice as many data points available for Sarnia, Windsor, and London. In 2016, the frequency of VOC sampling at the Aamjiwnaang First Nation station was increased to match that of the other stations. Table 23 shows similar average values for several of the compounds across the region, including carbon tetrachloride, chloroform, naphthalene, and vinyl chloride.

Table 23: Comparison of Selected VOC in the Southwestern Region ($\mu\text{g}/\text{m}^3$)						
Compound	24-hour AAQC		Aamjiwnaang (2015)	Sarnia (2015)	Windsor (2015)	London (2015)
Benzene	2.3	Annual Average	1.491	1.191	0.566	0.451
		Maximum	3.230	5.428	1.131	0.954
Carbon tetrachloride	2.4	Annual Average	0.513	0.532	0.519	0.530
		Maximum	0.616	0.744	0.645	0.639
Chloroform	1	Annual Average	0.112	0.115	0.133	0.130
		Maximum	0.161	0.224	0.357	0.250
Ethylene	40	Annual Average	4.158	2.969	1.162	0.809
		Maximum	9.614	12.671	3.192	1.873
1,2-Dichloroethane	2	Annual Average	0.071	0.079	0.067	0.065
		Maximum	0.109	0.269	0.096	0.092
1,3-Butadiene	10	Annual Average	0.147	0.218	0.037	0.028
		Maximum	1.821	1.412	0.083	0.1
Chloromethane	320	Annual Average	1.753	1.693	1.141	1.130
		Maximum	5.978	4.602	1.490	1.570
Naphthalene	22.5	Annual Average	0.061	0.048	0.076	0.046
		Maximum	0.177	0.149	0.684	0.201
Vinyl chloride	1	Annual Average	0.002	0.002	0.002	0.002
		Maximum	0.007	0.006	0.006	0.006
Trichloroethylene	12	Annual Average	0.034	0.035	0.024	0.041
		Maximum	0.140	0.113	0.152	0.126
Dichloromethane	220	Annual Average	0.327	0.326	0.336	0.342
		Maximum	0.570	0.562	0.820	0.568

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

Number of samples: Aamjiwnaang=27, Sarnia=46, Windsor=45, London=49

Annual average benzene concentrations measured at Sarnia, Windsor and London from 1989-2015 are shown in Figure 16, along with the results for Aamjiwnaang from 2008/2009 to 2015. The absence of data points for a particular station and year indicates that benzene sampling either did not occur at the station, that there were an insufficient number of samples collected, or data for the whole year was not available 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. Benzene concentrations have decreased over time at the Windsor station, and to a minor extent, in London as well. The benzene concentrations measured at the Aamjiwnaang station over the last seven years fell within the range of concentrations measured in Sarnia between 2000 and 2015, 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 2012-2015, that is, every year that benzene data was available for both stations.

The increase in the annual average benzene concentration observed from 2013 to 2015 was not unique to the Aamjiwnaang air monitoring station. An increase over the same time period was also observed at the Sarnia and Windsor air monitoring stations.

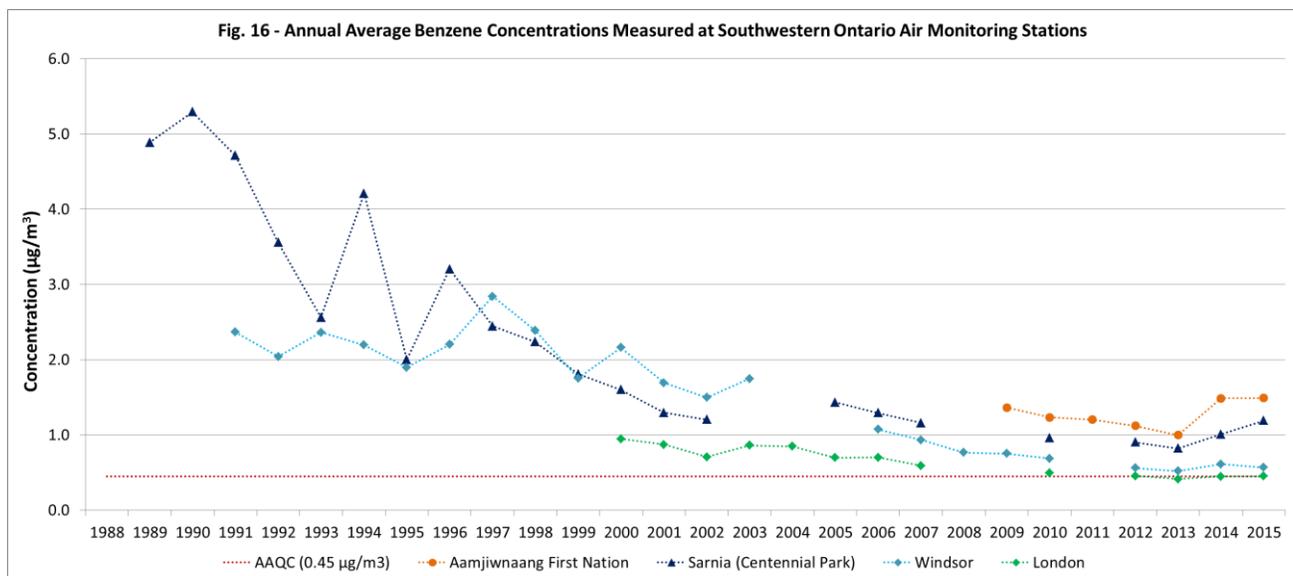


Figure 16: Annual Average Benzene Concentrations Measured at Southwestern Ontario Air Monitoring Stations

Continuous Volatile Organic Compounds (VOC)

The ministry also measured VOC on a continuous, or hourly basis, at the Aamjiwnaang First Nation station using a gas chromatograph/mass spectrometer (GC/MS). Since monitoring began, there have been changes made to the list of target compounds. Some compounds were not detected and were subsequently removed, and others were added. The ministry makes changes to the list of target compounds based upon the results and the ministry's expectations of what might be detected in the area. Chloroform and carbon tetrachloride were added to the list in 2014, but were removed in 2015 as both of the compounds were not detected.

In comparison to the continuous monitoring, the ECCC non-continuous monitoring method is an established, robust method and can be expected to provide accurate and representative ambient annual averages, though it cannot detect short-term spikes in concentrations. In contrast, the accuracy and precision of the MOECC continuous monitoring is not as well defined, but has good temporal resolution, and can provide information not possible with the non-continuous method. The continuous instrument can produce useful semi-quantitative data which has been presented in this section.

Table 13 summarizes the 2015 maximums and compares them to 2014. Similar to 2014, most of the VOC were detected intermittently. VOC are typically present in the environment at very low levels. When they are not detected, they still may be present at low concentrations.

	2015	2014
1,3-Butadiene	31.40	14.41
Benzene	38.26	18.24
Chloromethane	43.04	51.49
Cyclohexane	53.21	51.62
Ethyl benzene	2.21	1.56
Hexane	59.33	60.29
m & p-Xylene	4.42	1.83
o-Xylene	1.52	2.23
Propylene	273.00	239.18
Styrene	1.65	0.97
Toluene	13.09	9.85

Air Quality Health Index (AQHI)

On June 24, 2015, in partnership with ECCC, the ministry introduced the new AQHI to replace the previous AQI. The AQI was based on daily measurements from up to six air quality criteria pollutants (CO, O₃, NO₂, PM_{2.5}, SO₂ and TRS). The AQI reported air quality based on the pollutant recording the highest sub-index for a single pollutant at each site. The purpose of the AQI was to inform the public about air quality and the potential of smog to influence public/industry behaviour and protect public health. AQHI is a scale designed to help the public understand what the air quality around them means to their health.

AQHI is a health protection tool that is designed to help people make decisions to protect their health by limiting short-term exposure to air pollution and adjusting their activity levels during increased levels of air pollution. It also provides advice on how one can improve the quality of the air they breathe. This index pays particular attention to people who are sensitive to air pollution and provides them with advice on how to protect their health during air quality levels associated with low, moderate, high and very high health risks.

The AQHI is calculated based on the relative risks of a combination of common air pollutants that are known to harm human health. These pollutants are O₃, PM_{2.5}, and NO₂. The AQHI is measured on a scale ranging from 1-10+. The AQHI index values are grouped into health risk categories as shown below. These categories help one to easily and quickly identify their level of risk.



- 1-3 Low health risk
- 4-6 Moderate health risk
- 7-10 High health risk
- 10 + Very high health risk

Table 14: Health messages for ‘at risk’ individuals and the general public for each of the AQHI Health Risk Categories.

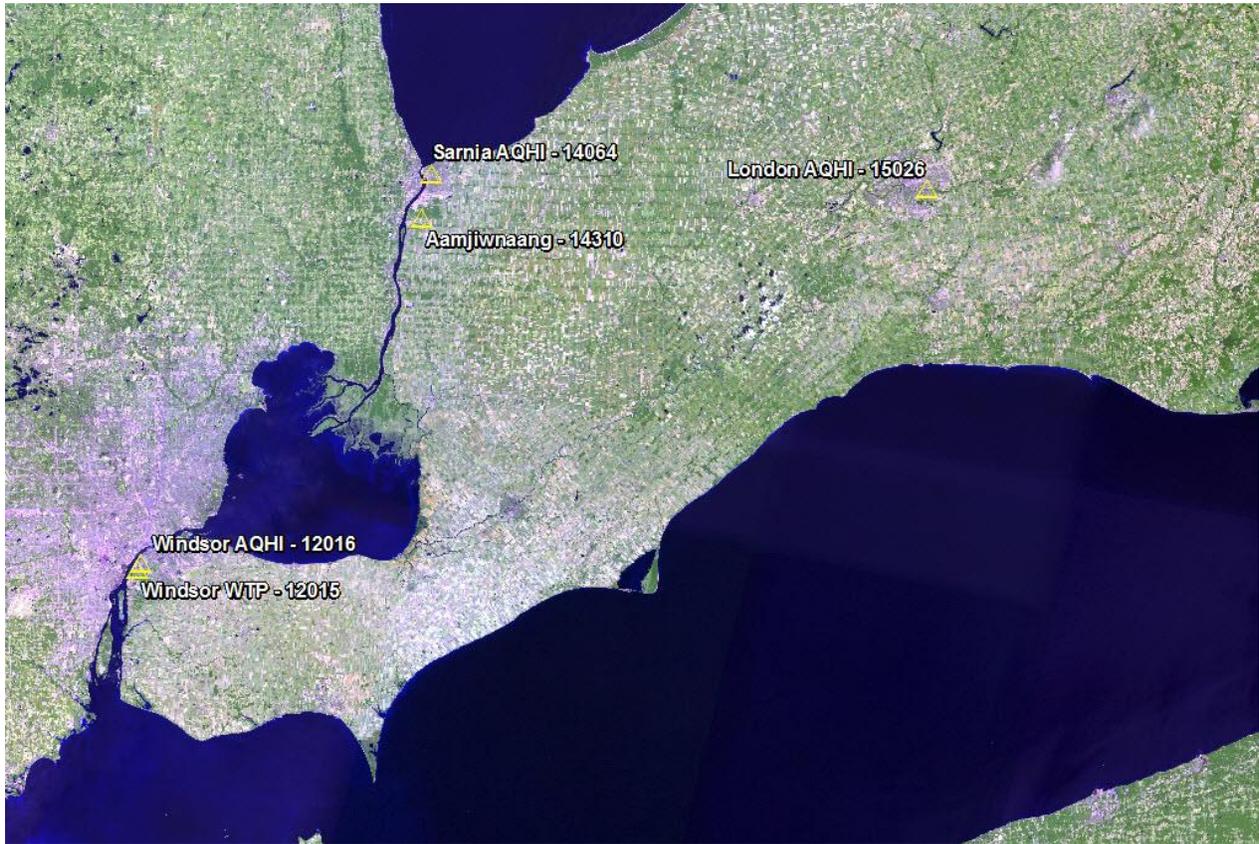
Health Risk	Air Quality Health Index	Health Messages	
		At Risk Population*	General Population
Low	1 - 3	Enjoy your usual outdoor activities.	Ideal air quality for outdoor activities.
Moderate	4 - 6	Consider reducing or rescheduling strenuous activities outdoors if you are experiencing symptoms.	No need to modify your usual outdoor activities unless you experience symptoms such as coughing and throat irritation.
High	7 - 10	Reduce or reschedule strenuous activities outdoors. Children and the elderly should also take it easy.	Consider reducing or rescheduling strenuous activities outdoors if you experience symptoms such as coughing and throat irritation.
Very High	Above 10	Avoid strenuous activities outdoors. Children and the elderly should also avoid outdoor physical exertion.	Reduce or reschedule strenuous activities outdoors, especially if you experience symptoms such as coughing and throat irritation.

* People with heart or breathing problems are at greater risk. Follow your doctor's usual advice about exercising and managing your condition.

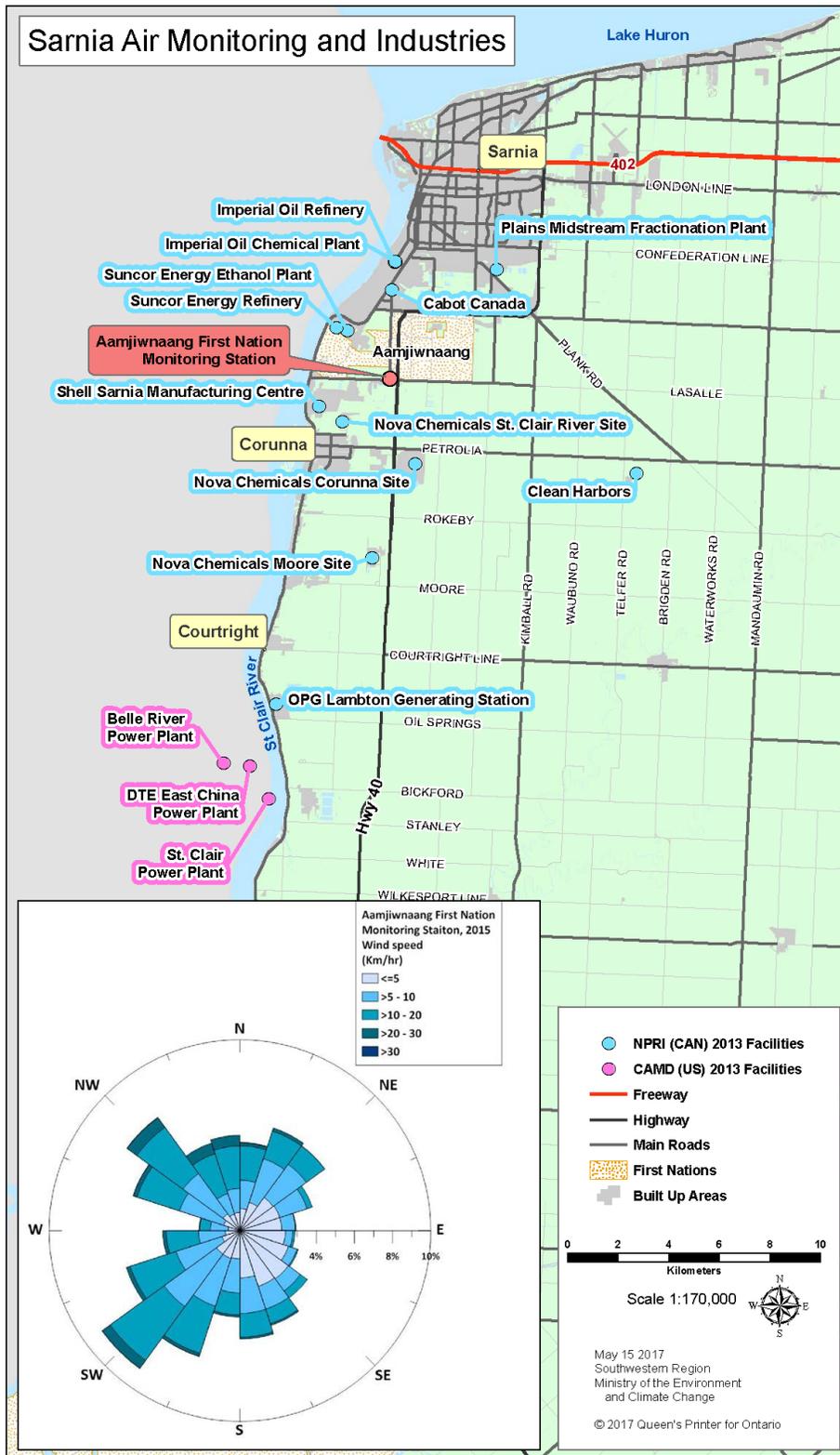
Based on the AQHI categories (2015), Sarnia MOECC air monitoring station (Station ID: 14064, about 8 km from Aamjiwnaang First Nation Monitoring Station) reported low risk air quality 85.5% of the time, moderate risk 14.4% of the time, and high risk only 0.1% of the time. There were no very high risk hours reported.

Appendices

Map 1: Aamjiwnaang First Nation and Other Air Monitoring Stations



Map 2: Aamjiwnaang First Nation Air Monitoring Station and Industries



Glossary

Ambient Air Quality Criteria (AAQC): Maximum desirable average concentrations for specific atmospheric pollutants. 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. In 2015, the AQI was replaced by the *Air Quality Health Index (AQHI)*. More information may be found on the ministry's air quality web site:

<http://www.airqualityontario.com/>.

Air Quality Health Index (AQHI): The Air Quality Health Index (AQHI) is a scale designed to help you understand what the air quality around you means to your health. It is a health protection tool that is designed to help you make decisions to protect your health by limiting short-term exposure to air pollution and adjusting your activity levels during increased levels of air pollution. It also provides advice on how you can improve the quality of the air you breathe. This index pays particular attention to people who are sensitive to air pollution and provides them with advice on how to protect their health during air quality levels associated with low, moderate, high and very high health risks. More information may be found on the ministry's air quality web site: <http://www.airqualityontario.com/>.

AQHI Station: There are 39 AQHI monitoring stations in Ontario. To help plan your day, the ministry, in partnership with Environment Canada, issues a prediction of the AQHI value for today, tonight and tomorrow.

Ambient air: Outdoor or open air.

Method 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 ($\mu\text{g}/\text{m}^3$): 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 and Climate Change 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/rnsps-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 method detection limit (mdl), 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 detection limit and zero.

A standard practice in situations such as this is to use half of the mdl when calculating averages. This usually offers a reasonably good estimates if the number of values below mdl 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 the values are below mdl. 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 monitoring of SO₂, TRS, NO₂, O₃ and PM_{2.5}. The ministry has been reporting results from 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 other ministry reports. While most real-time instruments will record a “0” from time to time, this decision will only have a noticeable impact on SO₂, and TRS which usually exhibit very low levels.

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 ($\mu\text{g}/\text{m}^3$) 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]).

Data Completeness Criteria

The following criteria are used to determine which stations have sufficient hourly and daily measurements in each year to be considered valid for inclusion in the indicators. In general, they follow the same criteria as those found in the Canadian Council of Ministers of the Environment's (CCME) Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone.

For fine particulate matter (PM_{2.5}):

- A valid day has data for at least 18 hours (75%);
- A station is included only when
- At least 75% of days in the year are valid; and
- At least 60% of days in each quarter (three months) 19 in a calendar year are valid.

The quarters are: quarter 1 from 1 January to 31 March; quarter 2 from 1 April to 30 June; quarter 3 from 1 July to 30 September; and quarter 4 from 1 October to 31 December.

For ground-level ozone (O₃):

- A valid 8-hour period has data for at least 6 hours (75%);
- A valid day requires data for at least 18 hours (75%); and
- A station is included only when at least 75% of days in the combined second and third quarters (1 April to 30 September) are valid.

For sulphur dioxide (SO₂) and nitrogen dioxide (NO₂):

- A valid day requires data for at least 18 hours (75%);
- A valid month requires data for at least 50% of valid days;
- A valid quarter (three months) requires data for at least two valid months; and
- A station is included only if the year has four valid quarters.

There are fewer data for volatile organic compounds (VOCs), and therefore data completeness criteria are different. At urban monitoring stations, VOC samples are usually collected over a 24-hour period once every six days, and, at rural stations, samples are collected over a 4-hour sampling period (12:00 to 16:00) once every three days. For VOCs, data completeness criteria are as follows:

- A valid day requires data for a consecutive 24 hours in an urban station and for a consecutive four hours in a rural area;
- A valid quarter (three months) requires data for at least five samples; and
- A station is included only if the year has three valid quarters.

Historical Air Pollutant Monitoring Data

Table 135: Change in Air Pollutant Annual Average Concentrations over Seven Years (2009-2015) - Determined Using Linear Trend Analysis¹

Pollutant	Type	2009	2010	2011	2012	2013	2014	2015	Change in concentrations
SO ₂	C	3	2.7	2.5	2.4	2.4	2.4	2.06	↓ 26%
TRS	C	0.9	0.8	0.4	0.5	0.6	0.6	0.16	↓ 63%
NO ₂	C	13.7	14.6	11	11.5	11.5	10.2	9.8	↓ 31%
O ₃	C	24.1	24.8	28.6	29.4	28.4	27.5	27	↑ 12%
PM _{2.5}	C	10.1	10.2	9.8	9.1	8.3	8.1	9	↓ 19%
SP	NC	15.4	12.2	15.3	10.7	12.2	16.1	28	↑ 82%
Benzene	NC	1.362	1.234	1.204	1.122	0.997	1.487	1.491	↑ 12%
B[a]P	NC	0.057	0.071	0.069	0.043	0.061	0.045	0.076	↓ 1%

C: continuous; NC: non-continuous monitoring

¹Concentrations are presented in ppb, with the exception of PM2.5 (which is in µg/m³)

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