Air Quality in Halton

Air Monitoring Report 2017

September 2018

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Reference:

Halton Region Health Department, *Air Quality in Halton: Air Monitoring Report 2017*. Oakville, Ontario, October 2018.

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Executive Summary

The Health Department operates an air quality monitoring station in Milton to measure the level of five common pollutants in the surrounding outdoor air. The five common air pollutants are ozone (O_3), fine particulate matter ($PM_{2.5}$), nitrogen dioxide (NO_2), carbon monoxide (CO), and sulphur dioxide (SO_2). Pollutants such as NO_2, CO, SO_2 and $PM_{2.5}$ are released directly into the air mainly from vehicles and industry. Ozone (O_3) is not released directly into the environment but forms indirectly in the atmosphere through complex chemical reactions. $PM_{2.5}$ is released directly from places such as construction sites, unpaved roads and fires but can also form in-directly in the atmosphere from chemical reaction of gases such as SO2 and nitrogen oxides (NO_x). Poor air quality created by the presence of air pollutants, especially ground level O_3 and $PM_{2.5}$, can have harmful effects on human health.

The levels for three of the air pollutants (O_3, $PM_{2.5}$ and NO_2) measured at the Milton station are compared to results from two air quality-monitoring stations that are operated by the Ontario Ministry of the Environment, Conservation and Parks (MECP) in Burlington and Oakville. CO and SO_2 are only measured in Milton therefore; comparisons are made to the next closest monitoring locations which are Toronto West and Hamilton Downtown.

In 2017 air monitoring results from Burlington, Oakville and Milton did not exceed the Ambient Air Quality Criteria (AAQC) for NO_2, CO and SO_2. There Canadian Ambient Air Quality Standards (CAAQS) were met in Burlington, Oakville and Milton for $PM_{2.5}$. O_3 exceeded the AAQC in Burlington and Oakville, and exceeded the CAAQS in Burlington, Milton and Oakville. The AAQC are set by the MECP and the CAAQS are set by Health Canada and Environment and Climate Change Canada.

A review of the Air Quality Health Index (AQHI) data is also presented in this report. The AQHI is a health-based scale that indicates the level of health risk associated with local air pollution levels. The AQHI is calculated using levels of ground-level O_3, $PM_{2.5}$ and NO_2. In 2017, the AQHI was in the low health risk category 86% of the time in Milton, 91% of the time in Burlington and 93% of the time in Oakville.

Introduction

Air quality in Halton Region is affected by pollution that is released locally as well as by pollution that is carried in the upper atmosphere to the Region from other areas. Sources of air pollution include transportation sector, industry, heating, electrical energy generation and agricultural activities such as the use of fertilizers and the raising of livestock. Air pollution also comes from natural sources such as trees and vegetation that emit pollen and chemicals that are important in the formation of O_3. Other natural sources include wind erosion as well as forest and grassland fires. Local surroundings such as the presence of tall buildings that create a canyon-like effect can slow down the movement of pollution in an area. Wind speed and wind direction as well as sunlight intensity and the amount of rainfall are other factors that affect the level of air pollution.

This is the ninth annual report on ambient (outdoor) air quality in Halton Region. The report focuses on five common air pollutants: ground-level ozone (O_3), fine particulate matter ($PM_{2.5}$), nitrogen dioxide (NO_2), carbon monoxide (CO), and sulphur dioxide (SO_2). This report will also report on the AQHI levels in Burlington, Milton and Oakville. The AQHI is updated hourly and lets the public know the health risk associated with local air pollution levels. The AQHI information allows the general population and at-risk groups to plan when to safely enjoy outdoor activities.

In this report, 2017 air quality data (NO_2, O_3 and $PM_{2.5}$) collected from the Milton station are compared to air quality data from Burlington and Oakville (http://www.airqualityontario.com/) air monitoring stations. The results (NO_2, O_3, $PM_{2.5}$ and SO_2) from Burlington, Milton and Oakville are compared to the Ambient Air Quality Criteria (AAQC). O_3 and $PM_{2.5}$ results are compared to the Canadian Ambient Air Quality Standards (CAAQS) to determine achievement of the standards. The AAQC are set by the MECP and the CAAQS are set by Health Canada and Environment and Climate Change Canada to protect human health and the environment. The AAQC and the CAAQS are set at levels of a pollutant where harmful human health effects or harm to the environment are not expected. SO_2 and CO are not monitored in Burlington or Oakville; therefore SO_2 and CO levels from Milton are compared to results from the Toronto West and Hamilton Downtown stations.

Comparisons of the air quality in Halton to air quality in surrounding locations helps to show that the air quality in Halton is similar to air quality in neighbouring municipalities.

Ambient Air Monitoring in Halton Region

Air quality is monitored by the MECP at two stations in Halton Region. In 2017, these stations are a part of a network of 39 air quality monitoring stations throughout Ontario. One monitoring station is located in Burlington, at Highway 2 and North Shore Boulevard East and one station is located in Oakville, at Eighth Line and Glenashton Drive. In 2008, Halton Region established an air quality monitoring station in Milton. This monitoring station is located on the property of Bishop Reding School at 1120 Main Street East.

The Milton station has air monitoring equipment that is the same as equipment used by the provincial air quality monitoring network and is periodically audited by the MECP and the Milton monitoring equipment are operated using MECP protocols, therefore the quality of data collected at the Milton station is equivalent to the two MECP stations in Halton.

The MECP has agreed in principle to assume ownership and operation of the Halton Region Health Department's air quality monitoring station in Milton. In partnership with Environment and Climate Change Canada the MECP will be able to provide an AQHI forecast for residents of Milton which is a service the Health Department cannot provide. The Health Department and MECP are working towards a transfer date in late 2018.

Presentation of results

The results for the five common air pollutants are described in different sections of the report. A section on the AQHI is also included. The air quality data for Milton is calculated and compared to the AAQC and the CAAQS. There are AAQC for four of the five pollutants: O_3, NO_2, CO and SO_2. The CAAQS has standards for O_3 and $PM_{2.5}$. Data collected in Milton are used to provide the AQHI for residents in Milton and Halton Hills. Air quality data are available from the Region's air quality web page: www.halton.ca.

Ambient Air Quality Criteria (AAQC)

AAQC for air pollutants are developed by the MECP for different averaging times (e.g.1-hour, 24-hour and annual) depending upon the effect of interest. The AAQC represent a level below which harmful effects on human health and/or the environment are not expected to occur. AAQC are shown in Table 1 for four of the common air pollutants.

Table 1: AAQC for O_3, NO_2, CO, and SO_2.

Pollutant	Averaging Time	Criterion
O_3 (ppb)	1-hour	80
NO_2 (ppb)	1-hour	200
	24-hour	100
CO (ppm)	1-hour	30
	8-hour	13
SO_2 (ppb)	1-hour	250
	24-hour	100
	Annual	20

Canadian Ambient Air Quality Standards (CAAQS)

The CAAQS replace the Canada-wide Standards for ground-level O_3 and $PM_{2.5}$ in outdoor air. O_3 and $PM_{2.5}$ are a concern for human health and are the major components of smog. The CAAQS are voluntary standards which set objectives for provinces and territories to work towards achieving by 2015 and 2020 (three years of data are required to calculate CAAQS). In 2020, new CAAQS for SO_2 and NO_2 will come into effect and the

existing CAAQS for O_3 and $PM_{2.5}$ will be lowered to better protect human health. The CAAQS for O_3 and $PM_{2.5}$ are shown in Table 2.

The level of O_3 and $PM_{2.5}$ detected locally may be influenced by movement of air pollution across international boundaries (transboundary flows (TF), for example O_3 moving into Ontario from the United States). Exceptional events (EE) such as fine particulate matter from forest fires in northern Ontario or even outside the province may be taken into consideration when accounting for achievement of the CAAQS for $PM_{2.5}$. Assessing TF and EE is important for air quality management purposes. Local actions can impact the amount of pollution produced locally however residents are exposed to locally produced pollution as well as pollution carried into an area. TF and EE were not assessed for this report.

Table 2: Canadian Ambient Air Quality Standards for 2015 for O_3 and $PM_{2.5}$.

Pollutant	Averaging Time	Standard	Metric
O_3 (ppb)	8-hour	63	The 3-year average of the annual 4th-highest daily maximum 8-hour average concentrations.
$PM_{2.5}$ (µg/m³)	24-hour	28	The 3-year average of the annual 98th percentile of the daily 24-hour average concentrations.
$PM_{2.5}$ (µg/m³)	annual	10.0	The 3-year average of the annual average concentrations.

Ground-Level Ozone (O_3)

O_3 is not released directly to the atmosphere but forms and builds up during sunny days. It is a colourless and irritating gas that forms when NO_x [nitrogen dioxide (NO_2) and nitric oxide (NO)] and volatile organic compounds react in the presence of oxygen and sunlight. The highest levels of O_3 tend to occur in the summer months (May to September) when sunlight is most intense.

Short-term exposure (lasting minutes, hours, or, at most, a few days) to O_3 can irritate the eyes and respiratory tract and can cause coughing, chest tightness and wheezing. Short-term and long-term exposure (months to years) have also been linked to cardiovascular effects and death. Those most at risk from ozone exposure are children, the elderly, people who already have respiratory or heart and lung conditions, and those who are active outside during the summer months.

The summarized air quality monitoring results for O_3 in 2017 are presented in Table 3. Shown are the annual average concentration, maximum 24-hour (daily) concentration, maximum 1-hour concentration, and the number of hours recorded above the 1-hour AAQC of 80 ppb. Annual average and daily maximum O_3 concentrations do not vary much between municipalities, while the 1-hour maximum values show some slight differences.

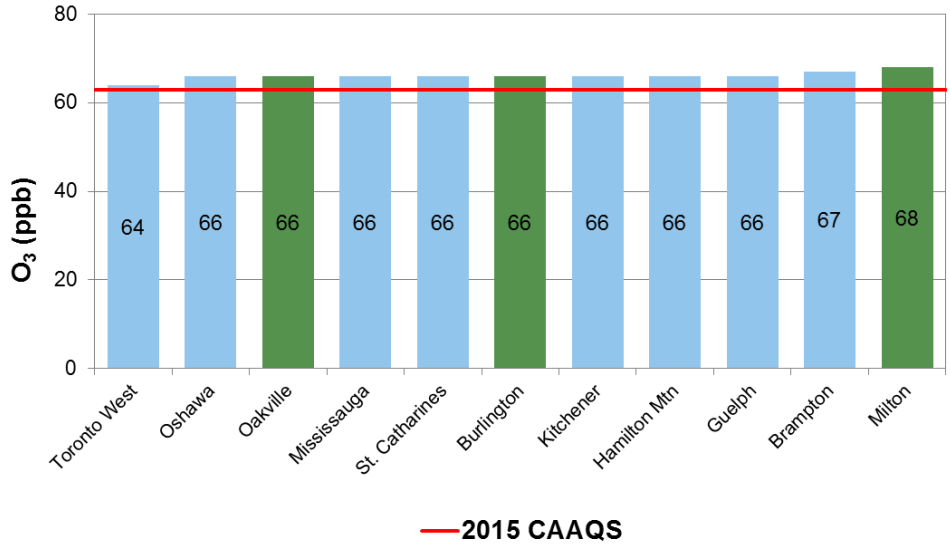
Table 3: Summary statistics for O_3 (ppb), Halton Region, 2017.

Concentration units are: parts per billion (ppb)	Milton	Oakville	Burlington
Annual average	28	27	27
24-hour maximum	62	60	61
1-hour maximum	74	84	88
# of hours over the AAQC of 80 ppb	0	1	4

Ozone Canadian Ambient Air Quality Standard

Figure 1 shows the CAAQS for ozone for monitoring sites in Halton Region (green bars) compared to other MECP monitoring sites (blue bars) in the surrounding area. Of the comparison locations shown here, none of

the locations met the CAAQS for O_3 in 2017. However, the MECP 2016 *Air Quality in Ontario Report* states that O_3 exceedances reported in these sites typically result from transboundary flow of pollutants.



The annual average of O_3 concentrations measured at monitoring sites in Halton Region and surrounding area are presented in Figure 2. The green circles represent Halton sites and the blue circles represent surrounding area sites. Comparisons of the O_3 results help demonstrate that the annual average O_3 concentrations over a wider area are not very different around the western end of Lake Ontario. Toronto West is a roadside monitoring site where higher concentrations of vehicle emissions may react with O_3 in the atmosphere to lower O_3 concentrations.

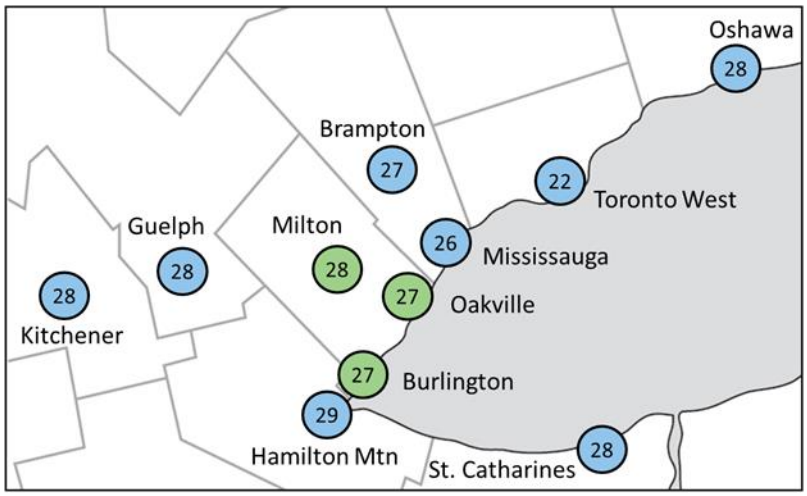


Figure 2: Annual mean O_3 concentrations (ppb) in Halton Region (green circles) and surrounding area (blue circles), 2017.

Fine Particulate Matter ($PM_{2.5}$)

$PM_{2.5}$ is a mixture of both solid particles and liquid droplets suspended in air. $PM_{2.5}$ is classified by its size, which is important because smaller particles are inhaled deeper into the respiratory system. $PM_{2.5}$ refers to particles that are less than or equal to 2.5 microns in diameter (a micron is one-millionth of a metre). $PM_{2.5}$ comes from a number of sources including fuel combustion (from transportation, industry, heating, and power generation), paved and unpaved roads, construction activity, agricultural burning and forest fires. $PM_{2.5}$ may be 'primary' (emitted directly from a source) or 'secondary' (formed in the atmosphere from other emissions).

$PM_{2.5}$ matter affects the respiratory and cardiovascular systems. Short-term exposure to elevated levels of $PM_{2.5}$ can cause eye, nose, and throat irritation, and can worsen symptoms of pre-existing respiratory conditions such as asthma and chronic bronchitis. Both short-term and long-term exposures to $PM_{2.5}$ have been linked to illness and premature death.

Results for $PM_{2.5}$ in 2017 are summarized in Table 4. Shown are the annual average, the 24-hour (daily) maximum, the 1-hour maximum, and the number of days that the 24-hour concentration exceeded 28 µg/m^3. The number of days that the 24-hour concentration of $PM_{2.5}$ is over 28 µg/m^3 can be used as an indication of worsening air quality.

The annual average for $PM_{2.5}$ is similar at all three sites. $PM_{2.5}$ is usually a region-wide measurement with very little variation in the fine particulate matter reading from one part of a local area to the next. However, if there are local sources that are intermittent spikes can be observed in short-term $PM_{2.5}$ readings as compared to the longer-term annual average, which is more likely to paint the true picture of the overall air quality in the Region. The higher 24-hour maximum and 1-hour maximum values in Burlington may be due to short-term influences from intermittent construction or road dust from rush hour traffic and therefore do not have a great enough influence to affect the $PM_{2.5}$ annual average which is very similar to Oakville and is the same as Milton.

Table 4: Summary statistics for $PM_{2.5}$ (µg/m^3), Halton Region, 2017.

Concentration units are: micrograms per cubic metre (µg/m^3)	Milton	Oakville	Burlington
Annual average	7.0	6.9	7.0
24-hour maximum	24	24	38
1-hour maximum	44	40	57
# of days over 28 µg/m^3	0	0	1

$PM_{2.5}$ Canadian Ambient Air Quality Standard

There are two Canadian Ambient Air Quality Standards for $PM_{2.5}$. One is 28 µg/m^3 based on a 24-hour averaging time, and the other is 10 µg/m^3 based on an annual average. Figure 3 presents the results for the 24-hour $PM_{2.5}$ CAAQS in Halton Region represented by the green bars. These results are compared to surrounding area monitoring sites represented by the blue bars. The 2017 results for all of the air monitoring locations show that they were all below the 24-hour CAAQS of 28 µg/m^3.

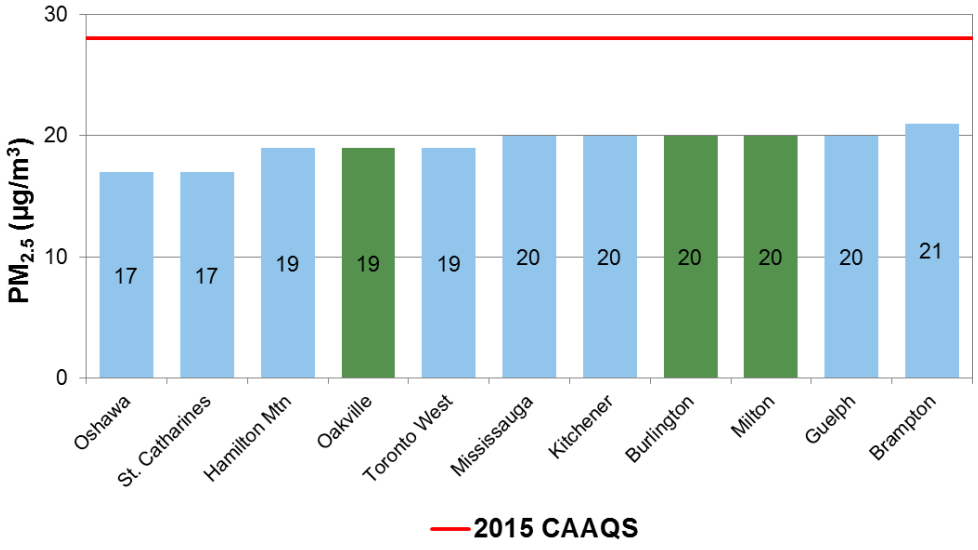


Figure 4 shows the annual average CAAQS metrics for $PM_{2.5}$ for Halton Region in 2017 (represented by the green bars) compared to surrounding area monitoring sites (represented by the blue bars). For 2017, all of the monitoring locations compared were below the annual CAAQS of 10µg/m^3.

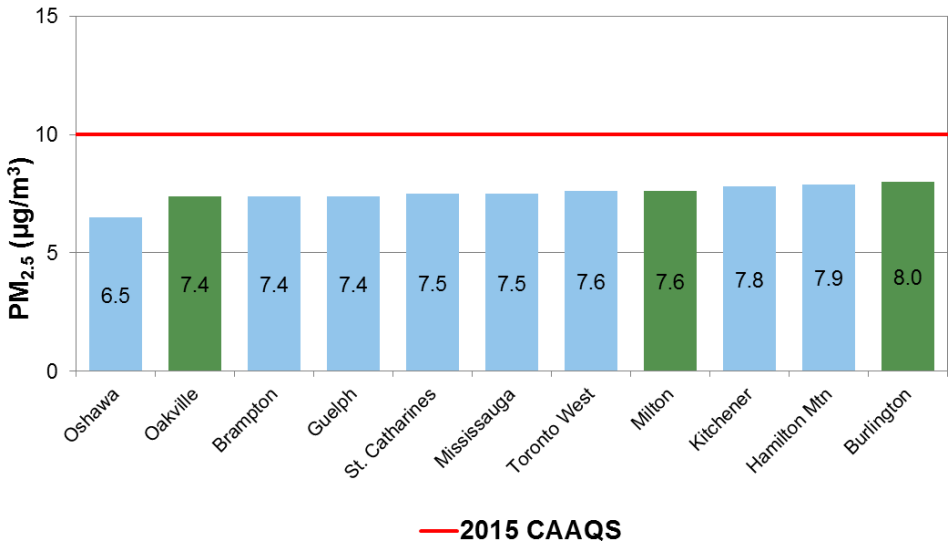


Figure 4: Annual CAAQS for $PM_{2.5}$ (µg/m^3), Halton Region (green bars) and surrounding area (blue bars), based on data collected in 2015, 2016, and 2017.

The annual average for $PM_{2.5}$ concentrations measured at monitoring sites in Halton Region (green circles) are compared to results from several other locations (blue circles) in the surrounding area (Figure 5). This comparison helps to demonstrate that there is not much variation of the annual average concentrations for $PM_{2.5}$ over a wider area among the comparison sites

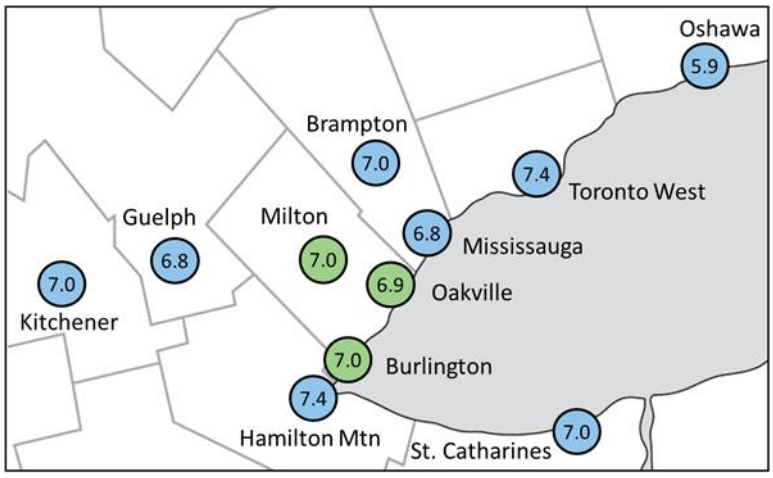


Figure 5: Mean annual $PM_{2.5}$ concentrations (µg/m^3) in Halton Region (green circles) and surrounding area (blue circles), 2017.

Nitrogen Dioxide (NO_2)

Most NO_2 in the atmosphere is not directly emitted, but forms from NO which is formed during the burning of fossil fuels. Together, NO_2 and NO make up NO_x. NO_x are directly released from all combustion processes, mostly as NO and with about 5-10 per cent emitted as NO_2.

Exposure to NO_2 affects mainly the respiratory system by increasing proneness to respiratory infections and making pre-existing respiratory conditions worse. For example, people with asthma or chronic bronchitis have an increased sensitivity to NO_2. Childhood exposure to NO_2 has been linked to reduced lung function in later life.

The summarized results for NO_2 in 2017 including the annual average, the 24-hour (daily) maximum, the 1-hour maximum, the number of days over the 24-hour AAQC of 100 ppb and the number of hours over the 1-hour AAQC of 200 ppb are shown in table 5. For Milton, Oakville, and Burlington the maximum 1-hour and 24-hour measurements are all well below their respective AAQC values.

Table 5: Summary statistics for NO_2 (ppb), Halton Region, 2017.

Concentration units are: parts per billion (ppb)	Milton	Oakville	Burlington
Annual average	9.9	8.2	9.7
24-hour maximum	53.1	38.0	31.3
1-hour maximum	87.0	56.0	49.0
# of days over the 24-hour AAQC of 100 ppb	0	0	0
# of hours over the 1-hour AAQC of 200 ppb	0	0	0

Carbon Monoxide (CO)

CO is a colourless, odourless and tasteless gas which is emitted primarily from incomplete combustion of fossil fuels. Vehicle emission is the single largest source of CO to the atmosphere in Ontario. The second largest sector emitting CO to the atmosphere is the commercial/residential/institutional sector, due largely to firewood burning in homes.

Short periods of exposure to CO levels from 70-800 ppm can cause headache, dizziness and disorientation. CO levels greater than 800 ppm may lead to unconsciousness and respiratory failure and levels above 1900-2000 ppm are fatal within a short period of time. Due to its cumulative effects of CO in the bloodstream, even exposure to low concentrations of CO can lead to adverse outcomes if exposure is prolonged. Outdoor levels of CO detected in Halton Region are not considered a health risk.

CO is not measured at the Oakville or the Burlington monitoring locations therefore readings from the Milton site were compared with Toronto West and Hamilton Downtown. Toronto West is located near Highway 401 on Resources Road, and Hamilton Downtown is located at Elgin Street and Kelly Street, two of only four sites in Ontario where CO is monitored (excluding Milton). Summary results for CO are shown in Table 6 including the annual average, the 8-hour maximum, and the 1-hour maximum. The number of occurrences over the 8-hour AAQC of 13 ppm, and the number of hours over the 1-hour AAQC of 30 ppm are also presented. For Milton, Toronto West and Hamilton Downtown, the maximum 1-hour and 8-hour measurements are well below their respective AAQC values.

Table 6: Summary statistics for CO (ppm), Milton, Toronto West and Hamilton Downtown, 2017.

Concentration units are: parts per million (ppm)	Milton	Toronto West	Hamilton Downtown
Annual average	0.2	0.2	0.2
8-hour maximum	0.6	0.9	0.75
1-hour maximum	0.9	1.2	2.1
# of occurrences over the 8-hour AAQC of 13 ppm	0	0	0
# of hours over the 1-hour AAQC of 30 ppm	0	0	0

Sulphur Dioxide (SO_2)

SO_2 is a colourless gas with an odour similar to burnt matches. It is formed mainly from the combustion of fuels containing sulphur and smelters are the main source of SO_2 in Ontario. Other smaller, but important, sources include petroleum refining, cement and concrete manufacturing, as well as iron and steel industries.

SO_2 aggravates asthma and can reduce lung function and worsen symptoms of respiratory and cardiovascular conditions. People with asthma or chronic heart and lung conditions are most susceptible to SO_2.

SO_2 is also only measured in a few locations across Ontario; the SO_2 results from Milton were compared with Toronto West and Hamilton Downtown. Summary results are presented in Table 7 which includes the annual average, the 24-hour maximum, the 1-hour maximum, and the number of times any of the SO_2 AAQC were exceeded. For all three monitoring stations, the maximum 1-hour, 24-hour, and annual average measurements are all well below their respective AAQC values. The higher results for Hamilton Downtown may be due to infrequent winds from the industrial area of Hamilton (for two-thirds of the year, SO_2 concentrations were less than 2 ppb).

Table 7: Summary statistics for SO_2 (ppb), Milton, Toronto West and Hamilton Downtown, 2017.

Concentration units are: parts per billion (ppb)	Milton	Toronto West	Hamilton Downtown
Annual average	0.7	0.5	3.5
24-hour maximum	4.0	2.8	23.3
1-hour maximum	15	11	86
# of occurrences over the annual AAQC of 20 ppb	0	0	0
# of days over the 24-hour AAQC of 100 ppb	0	0	0
# of hours over the 1-hour AAQC of 250 ppb	0	0	0

Air Quality Health Index (AQHI)

The AQHI was developed by the Federal and Provincial governments in consultation with health professionals. The AQHI is a health-based scale that indicates the level of health risk associated with local air pollution levels. The scale ranges from 1 to 10+ (see Table 8).

The AQHI is a communication tool which indicates:

- An air quality reading that ranges from 1 to 10+. A higher number indicates greater health risk.
- The category that describes the level of health risk associated with the index reading—low, moderate, high or very high health risk.
- Health messages tailored to an “at-risk” population and the general population.
- Current hourly AQHI readings and maximum forecast values for today, tonight and tomorrow.

Table 8: Air Quality Health Index health messages (Source: Environment Canada).

Health Risk	Air Quality Health Index	Health Messages	
		At Risk Population[1]	General Population
Low	1 - 3	**Enjoy** 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	>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.

[1] The at-risk population includes children, elderly people, and people of all ages with pre-existing heart & lung conditions.

Special Air Quality Statements (SAQS) are issued by the MECP in partnership with Environment and Climate Change Canada when forecast AQHI levels are predicted to reach high risk levels and to last for one to two hours. If a high risk AQHI level is forecast for a length of time of at least three hours, then a Smog and Air Health Advisory (SAHA) is issued. There were no SAHA's issued in Ontario in 2017.

In 2017, two SAQS were issued for Halton-Peel (on July 18th and on September 24th) however the AQHI readings did not reach the high risk category at any time.

Table 9 shows the AQHI readings from Milton and the percentage of readings in the different health risk categories over an eight-year period. In 2016 there were no readings in the high risk category (>6). However, there were AQHI in the high risk category in 2015 and 2017. In 2017, readings were in the high risk category 0.31% of the time (which equates to 27 hours). Invalid readings are reported for hours when an AQHI readings are not available.

Table 9: AQHI readings from Milton for three years (per cent of hourly readings in low, moderate, high and very high risk categories*).

	Low Risk	Moderate Risk	High Risk	Very High Risk	Invalid Readings
2015	86%	14%	0.02%	0.00%	1%
2016	89%	10%	0.00%	0.00%	1%
2017	86%	12%	0.31%	0.00%	1%

* Totals may not sum to 100% due to rounding.

The AQHI for Milton can be viewed here: Air Quality Health Index for Milton

Table 10 shows the percentage of readings in the different health risk categories AQHI readings from Burlington and Oakville in 2017.

Table 10: AQHI readings from Burlington and Oakville, 2017 (per cent of hourly readings in low, moderate, high and very high risk categories*).

	Low Risk	Moderate Risk	High Risk	Very High Risk	Invalid Readings
Burlington	91%	9%	0.05%	0.00%	0.33%
Oakville	93%	6%	0.01%	0.00%	0.81%

* Totals may not sum to 100% due to rounding.

Summary

Air quality data in Milton from 2017 were compared to 2017 data available from for Oakville and Burlington and some locations surrounding Halton Region.

Results of the analysis showed that the annual average concentration of O_3 is relatively consistent among the Milton, Oakville, and Burlington monitoring stations. The Halton results for O_3 were also similar to results from monitoring stations in surrounding municipalities. The Milton O_3 results did not exceed the AAQC, however, Oakville reported 1 hour and Burlington reported 4 hours over the AAQC of 80 ppb in 2017.

For $PM_{2.5}$ the annual averages were similar for all three sites, however, the 1-hour and 24-hour maximum concentrations were higher in Burlington. Averages for $PM_{2.5}$ were similar to results from surrounding municipalities. Burlington was the only site to report 1 day over the CAAQS of 28µg/m³.

For NO_2, the annual average and the 24-hour maximum concentrations are similar for all three sites. However, for the 1-hour and 24-hour maximum concentrations, Milton is higher than Oakville or Burlington.

Carbon monoxide and sulphur dioxide are not measured in Oakville or Burlington so Milton results were compared to Toronto West and Hamilton Downtown. For CO the Milton monitoring station results were slightly lower than those from Toronto West and Hamilton Downtown.

For SO_2 the annual average, 1-hour maximum and 24-hour maximum concentrations were all higher in Hamilton Downtown compared with Toronto West and Milton. Sulphur dioxide results at the Milton, Toronto West and Hamilton Downtown locations did not exceed the AAQC.

The CAAQS for O_3 was not achieved at any of the monitoring stations in Halton Region, nor in any of the surrounding comparison locations with the exception of Toronto West. Both the 24-hour and the annual CAAQS for fine particulate matter were achieved in Halton Region and the surrounding comparison locations.

Due to an improvement in monitoring technology $PM_{2.5}$ measurements from 2013 onwards should not be compared to previous years.

References & Sources Consulted

Ayala, A., Brauer, M., Mauderly, J.L., and Samet, J.M., 2012. Air pollutants and sources associated with health effects. *Air Quality Atmosphere & Health*, 5:151-167.

BC Lung Association, 2014. State of the Air 2013. Available at: http://www.bc.lung.ca/airquality/documents/StateOfTheAir2013-UpdatedVersionJune21.pdf, last accessed May 6, 2015.

Brook, R.D., Rajagopalan, S., Pope, C. Arden III, Brook, J.R., Bhatnagar, A., Diez-Roux, A.V., Holguin, F., Hong, Y., Luepker, R., Mittleman, M.A., Peters, A., Siscovick, D., Smith, S.C., Jr., Whitsel, L., and Kaufman, J.D., 2010. Particulate matter air pollution and cardiovascular disease: An update to the scientific statement from the American Heart Association. *Circulation*, 121:2331-2378.

Canadian Council of Ministers of the Environment, 2012. Guidance Document on Achievement Determination Canadian Ambient Air Quality Standards for Fine Particulate Matter and Ozone. CCME, ISBN: 978-1-896997-91-9 PDF.

European Environment Agency, 2013. Air Pollution Fact Sheet 2013 Germany. © European Environment Agency, 2013.

Government of Canada, 2017. Air Pollutant Emission Inventory 1990-2015. Available at: http://www.ec.gc.ca/pollution/default.asp?lang=En&n=E96450C4-1

Institute for Risk Research, 2007. Air Pollution and Public Health: A Guidance Document for Risk Managers. IRR, 2007. ISBN: 978-0-9684982-5-5.

International Institute for Sustainable Development, 2017. Costs of Pollution in Canada: Measuring the impacts on families, businesses and governments. Winnipeg, Manitoba, June 2017.

Ontario Ministry of the Environment, 2017. Air Quality in Ontario: 2015 Report. © Queen's Printer for Ontario, 2017. ISSN 1710-8136.

Ontario Ministry of the Environment and Climate Change. Ambient air quality data available at: http://www.airqualityontario.com/

Royal College of Physicians. Every breath we take: the lifelong impact of air pollution. Report of a working party. London: RCP, 2016.

Seinfeld, J.H. and S.N. Pandis, 2006. *Atmospheric Chemistry and Physics From Air Pollution to Climate Change*. Second Edition, John Wiley & Sons Inc., 2006.

U.S. EPA, 2016. *Integrated Science Assessment for Oxides of Nitrogen – Health Criteria*. U.S. Environmental Protection Agency, January 2016. EPA/600/R-15/068.

U.S. EPA, 2016. *Integrated Science Assessment for Sulfur Oxides – Health Criteria*. Second External Review Draft, U.S. Environmental Protection Agency, December 2016. EPA/600/R-16/351.

U.S. EPA, 2009. *Integrated Science Assessment for Particulate Matter*. U.S. Environmental Protection Agency, December 2009. EPA/600/R-08/139F.

U.S. EPA, 2010. *Integrated Science Assessment for Carbon Monoxide*. U.S. Environmental Protection Agency, January 2010. EPA/600/R-09/019F.

U.S. EPA, 2013. *Integrated Science Assessment for Ozone and Related Photochemical Oxidants*. U.S. Environmental Protection Agency, February 2013. EPA/600/R-10/076F.

West, J.J., Cohen, A., Dentener, F., Brunekreef, B., Zhu, T., Armstrong, B., Bell, M.L., et al., 2016. "What we breathe impacts our health: Improving understanding of the link between air pollution and health". *Environmental Science & Technology*, 50:4895-4904