



INFORMATION REPORT

TO:	Mayor and Members Board of Health
COMMITTEE DATE:	May 22, 2014
SUBJECT/REPORT NO:	Air Monitoring Pilot Project Findings for Sam Manson Park - BOH10022(a) (Ward 5)
WARD(S) AFFECTED:	Ward 5
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Council Direction:

Board of Health, at its September 27, 2010 meeting, approved the following: "That one-time funding, in the amount of \$69,500, for a Pilot Air Monitoring Project for the East End of Hamilton, be referred to the 2011 Budget Process for consideration". Council subsequently postponed a decision on funding this project until the 2012 Budget Process, at which time it was approved.

Information:

Background

Between 1985 and 1996, the Ontario Ministry of the Environment (MOE) operated an air monitoring station located in Ward 5 at Sam Manson Park. The monitor was named the "East Hamilton AQI Station", and it measured pollutants like haze, ozone, sulphur dioxide and total suspended particulates.

The MOE reports that the former East Hamilton AQI Station was removed in 1996 because the other three Hamilton AQI stations were sufficient to measure smog and long-range pollutants. A ministry review of air monitoring in the mid 1990's indicated the East Hamilton AQI Station measured the best air quality for those contaminants being monitored, provided little data down-wind of any industrial source, and was not providing information that could readily be used to deal with other suspected air quality

issues in North and East Hamilton. The decision to remove the East Hamilton AQI Station upset many area residents who felt that East Hamilton was no longer being represented by way of air monitoring.

The MOE presently operates three Air Quality Index (AQI) monitoring stations in the City: Hamilton Downtown (Ward 2 – Beasley Park), Hamilton Mountain (Ward 7 – Vickers Road, and Hamilton West (Ward 1 – Columbia College/ 403 on-ramp).

Following Council direction in September 2010, staff consulted with members of Clean Air Hamilton, MOE, the Hamilton Air Monitoring Network and Rotek Environmental Inc. about options for the placement, type and cost of air monitoring equipment that are ideal for a pilot project for air monitoring in the east end of Hamilton.

Hamilton East Air Monitoring Pilot

An “AirPointer” air monitoring station was installed in Ward 5 at Sam Manson Park (Station 29105) near Barton Street/Nash Road and measurements were made from December 2012 to December 2013. The location is close to the site of the previous AQI station that was decommissioned in 1996, thus enabling comparisons to be made with historical data and long term trends assessed.

A full suite of pollutants and meteorological parameters were measured, including:

- Air Quality Health Index (AQHI)
- Sulphur Dioxide (SO₂)
- Ozone (O₃)
- Respirable Particulate, less than 2.5 microns (PM_{2.5})
- Carbon Monoxide (CO)
- Nitric Oxide (NO)
- Nitrogen Dioxide (NO₂)
- Oxides of Nitrogen (NO_x)
- Wind Speed (WS)
- Wind Direction (WD)
- Barometric Pressure (BP)
- Ambient Temperature (AMT)
- Relative Humidity (RH)
- Rainfall (Rain)

Air monitoring data for the duration of the pilot at Sam Manson Park Station 29105 was provided on the Hamilton Air Monitoring Network (HAMN) website (www.hamnair.ca);

the archived data is retrievable on that same site. An evaluation of this pilot project was completed (Appendix A) and findings are being shared in this report.

Key Findings

- Air Quality Health Index (AQHI) values for the year showed the station site to have generally good air quality with 85% of the recorded time in the Low Risk category, 15% of the recorded time in the Moderate Risk category and 0% of the recorded time in the High or Very High Risk category.
- NO_x, a pollutant generated mainly by automobile sources, peaked during morning rush hour times and flattened out in the afternoon/evening; this pattern is found in other areas as well.
- O₃ ("ozone"), which is formed when NO_x and volatile organic compounds (VOCs) react in the presence of sunlight, peaked in the afternoon and dropped off at night; this pattern is consistent with that found for NO_x; O₃ at this site previously remained constant from 1986-1996 but the annual average has now risen substantially resulting mainly from long range transport of air pollutants and noted as a city wide phenomenon.
- Particulate matter 2.5 microns diameter or less (PM_{2.5}) includes aerosols, smoke, fumes, dust, ash and pollen was measured in the Hamilton East site and had the lowest concentration in comparison to the three other AQHI stations in the City.
- SO₂, a pollutant mainly associated with industrial activity, was measured at the pilot site and had the lowest concentration in comparison to the three other stations in the City; historical SO₂ trends show that the annual average for 2013 was at its lowest level which can be attributed to reductions in industrial emissions.
- Hamilton Mountain had the lowest NO₂ concentrations and Hamilton Downtown had the lowest O₃ concentrations in comparison to the three other AQHI stations in the City.

Exceedances of Standards or Guidelines

With respect to the protection of air quality, standards consist of specific mandatory controls that help enforce and support air pollution reduction. Guidelines consist of recommended, non-mandatory controls that help support standards or serve as a reference when no applicable standard is in place. Exceedances are recorded measures above a set standard or guideline.

- There were no exceedances of Carbon Monoxide (CO), Sulphur Dioxide (SO₂) or Oxides of Nitrogen (NO_x) under the Ontario Ministry of the Environment Ambient Air Quality Criteria (AAQC).

- SO₂ exceeded the World Health Organization guideline once in October, 2013.
- During the smog season, which is typically on hot and sunny days from May to September, there were 12 Ozone (O₃) exceedances of the 80 ppb hourly AAQC.
- Although three years of data are required to calculate the PM_{2.5} Canada Wide Standard of 30 µg/m³, the one year of PM_{2.5} data available from this station was recorded at 25 µg/m³ which is well below the standard.
- The World Health Organization guideline value for PM_{2.5} (25 µg/m³) was exceeded thrice in July, 2013.

Conclusions

The Sam Manson Pilot Air Monitoring Project provides valuable air quality information for the East End of Hamilton that has not been available to citizens for the past 17 years. The air monitoring project at Sam Manson Park provided benefits which include:

- Added air quality surveillance capacity to the Hamilton Air Monitoring Network (HAMN);
- Advancing knowledge about air quality in the City of Hamilton; and
- Monitoring changes impacting air quality over time (trends).

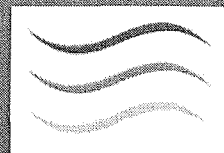
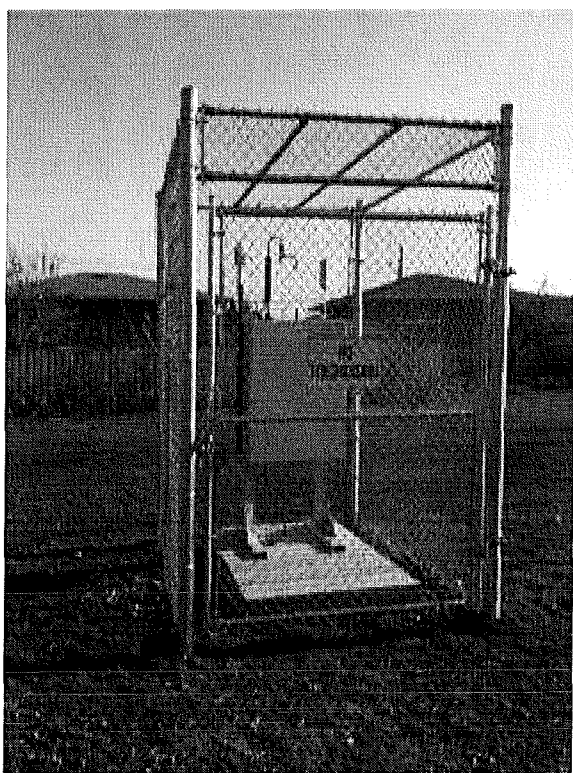
The information gained from the Sam Manson Park air monitoring pilot project provides useful information that allows community members to become informed about air quality in their area of the City and helps Public Health Services staff become more knowledgeable about local variations in air quality when planning to protect public health from the hazards of air pollution.

Appendices Attached:

Appendix A to Report BOH10022(a) - Hamilton East Air Monitoring Station Evaluation Report

2013

Hamilton East Air Monitoring Station Evaluation Report



Corr Research

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Executive Summary

As scientific knowledge about the health impacts of poor air quality has increased, Public Health Services of the City of Hamilton has assumed an increasingly active role in assessing local health effects of air quality, motivating stakeholders to improve air quality and performing citizen outreach to inform about risks and provide tools to reduce personal exposures.

As part of this overall strategy, Public Health Services retained Rotek Environmental Inc. to operate an Air Quality Health Index (AQHI) station for one year in the eastern part of Hamilton so as to address public concerns about air quality in that area of the City.

An AirPointer air quality monitoring station was installed in Sam Manson Park near Barton Street/ Nash Road, close to the site of a previous Ministry of the Environment (MOE) Air Quality Index (AQI) station. This enabled data comparisons to be made and long term trends assessed. The air monitoring was conducted for one year from December 2012 to November 2013.

A full suite of pollutants and meteorological parameters was measured, including:

- Air Quality Health Index (AQHI)
- Sulphur Dioxide (SO₂)
- Ozone (O₃)
- Respirable Particulate, less than 2.5 microns (PM_{2.5})
- Carbon Monoxide (CO)
- Nitric Oxide (NO)
- Nitrogen Dioxide (NO₂)
- Oxides of Nitrogen (NO_x)
- Wind Speed (WS)
- Wind Direction (WD),
- Barometric Pressure (BP)
- Ambient Temperature (AMT)
- Relative Humidity (RH)
- Rainfall (Rain)

Prevailing winds at this site were from the SSW, next most frequent winds were from NW, with a small component from the NE.

Directional analyses indicated that the highest pollutant impacts were from the SSW direction, i.e., from the rest of the City and from long range transport of air pollutants.

Air Quality Health Index (AQHI) values showed the station site to have generally good air quality with 6947 hours in the Low Risk category, 1206 hours in the Moderate Risk category and no High or Very High values.

Variation of pollutants with time of day (diurnal analyses) showed that NO_x had a marked peak during morning rush hour which flattened out in the afternoon evening, as has been measured in other areas. O₃ peaks in the afternoon and drops off at night and this pattern was also observed at this station.

Comparisons with the three other AQHI stations in the City determined that the Hamilton East site had the lowest PM_{2.5} and SO₂ concentrations, Hamilton Mountain had the lowest NO₂ concentrations and Hamilton Downtown had the lowest O₃ concentrations.

The reason for the lower O₃ levels in the downtown area is that ozone levels are reduced by chemical interactions with other pollutants. Locations such as the Downtown and West stations which have higher levels of other pollutants will have correspondingly lower O₃ levels.

The directional analyses also showed little discernible impact from the Red Hill Valley Parkway.

Exceedances of Standards or Guidelines.

- There were no exceedances of the Carbon Monoxide (CO), Sulphur Dioxide (SO₂) or Oxides of Nitrogen (NOX) Ontario Ministry of the Environment Ambient Air Quality Criteria (AAQC). See Note 1 below. SO₂ exceeded the World Health Organization guideline once in October, 2013.
- There were twelve Ozone (O₃) exceedances of the 80 ppb hourly AAQC, one in May, 2013 and eleven in July, 2013 during regional smog episodes.
- Three years of data are required to calculate the PM_{2.5} Canada Wide Standard of 30 µg/m³ (three year community average, 98th percentile). Only one year of data is available from this station, however, the 98th percentile value is 24 µg/m³, which would be well below the standard.
- A PM_{2.5} MOE Reference level of 30 µg/m³ was exceeded twice in July, 2013 and the PM_{2.5} World Health Organization guideline of 25 µg/m³ was exceeded three times in July, 2013.

Note 1 - Oxides of Nitrogen (NOX) are defined to be the sum of Nitrogen Dioxide (NO₂) and Nitric Oxide (NO). In the case of air quality assessments (e.g. annual air quality reports and special study reports) NO₂ not NOX, is the reference contaminant. NOX AAQCs with 1 hour and 24 hour averaging times should only be compared to monitored Nitrogen Dioxide (NO₂) data.

As scientific knowledge about the health impacts of poor air quality has increased, Public Health Services of the City of Hamilton has assumed an increasingly active role in assessing local health effects of air quality, motivating stakeholders to improve air quality and performing citizen outreach to inform about risks and provide tools to reduce personal exposures.

As part of this overall strategy, Public Health Services retained Rotek Environmental Inc. to operate an Air Quality Health Index (AQHI) station for one year in the eastern part of Hamilton so as to address public concerns about air quality in that area of the City.

An AirPointer air quality monitoring station was installed in Sam Manson Park near Barton Street/ Nash Road and measurements were made from December 2012 to December 2013.

The location is close to the site of a previous Ministry of the Environment (MOE) AQI station, thus enabling comparisons to be made with historical data and long term trends assessed.

This report summarizes the air quality measurements and compares these results to other Hamilton AQI/AQHI stations as well as to applicable Ambient Air Quality Criteria and World Health Organization standards. Details of monitoring methodologies, quality assurance, directional and diurnal analyses are also reported.

2.0 Ontario Ministry of the Environment - Ambient Air Quality Criteria (AAQC)

The Ontario Ministry of the Environment AAQCs are based on the best scientific information available and are set at a level that safeguards human health and the natural environment. The effects considered may be based on health, odour, vegetation, soiling, visibility, corrosion or other effects. The relevant AAQCs for this report are summarized in Table 1.

Ontario AAQCs are published by the MOE Standards Development Branch. The full list of Ambient Air Quality Criteria standards with details of averaging times and limiting effects for each criterion is available at www.ene.gov.on.ca.

Depending on the limiting effect on which the standard is based, various averaging times are set, e.g., a pollutant with long term health impacts may have a criterion with a yearly average, while an odour based criterion will be based on a short term average. A single contaminant may also have several criteria based on different averaging times. In cases where a criterion is based on a multi hour average (8 or 24 hours), rolling averages are computed for comparison. For example, Carbon Monoxide has an 8 hour rolling Ambient Air Quality Criterion. The 8 hour rolling average criterion is the average of the current hour and the preceding 7 hours. The Canada Wide Standard (CWS) for PM_{2.5} is based on clock averages (midnight to midnight) over three years.

Ministry of the Environment - AAQC - Table 1

Contaminant	PM _{2.5} ¹	NO ₂ ²	NO ₂	CO	CO	O ₃	SO ₂	SO ₂	SO ₂
Criterion	30	200	100	30	13	80	20	100	250
Units	µg/m ³	ppb	ppb	ppm	ppm	ppb	ppb	ppb	ppb
Averaging Period	24 Hr	1 Hr	24 Hr	1 Hr	8 Hr	1 Hr	1 Yr	24 Hr	1 Hr

Note 1 - This value of 30 µg/m³ (24 hr avg.) is the Canada Wide Standard (CWS) for PM_{2.5}, developed jointly by the Federal government and the Provinces, including Ontario, as a step towards the long-term goal of minimizing the risk that fine particles impose on human health and the environment. Achievement of the PM_{2.5} CWS (by the year 2012) in various air sheds is to be

based on the 24 hour 98th percentile ambient measurement annually, averaged over three consecutive years.

Ambient air PM_{2.5} is a regional pollutant and is of concern all across Ontario and north-eastern North America. It is one of the two key components of smog. Emissions of Sulphur Dioxide (SO₂), Oxides of Nitrogen (NO_x), Volatile Organic Compounds (VOCs), which are precursors of smog and PM_{2.5}, and also primary emissions of PM_{2.5} from individual sources, all contribute to it. In addition, these PM_{2.5} precursors are emitted from point, area, mobile and transboundary U.S. sources.

Note 2 - Oxides of Nitrogen (NO_x) are defined to be the sum of Nitrogen Dioxide (NO₂) and Nitric Oxide (NO). Emissions of NO_x consist mainly of NO, with some NO₂. In ambient air, NO converts to NO₂. NO₂ has adverse effects at much lower concentrations than NO. Recognizing these factors, the standard for Oxides of Nitrogen is based on the health effects of NO₂.

In the case of air quality assessments (e.g. annual air quality reports and special study reports) NO₂, not NO_x, is the reference contaminant. NO_x AAQCs with 1-hour and 24-hour averaging times should only be compared to monitored Nitrogen Dioxide (NO₂) data.

3.0 Hamilton East End Air Monitoring Station 29105, Sam Manson Park

Station 29105 consists of a completely instrumented AirPointer air monitoring station located in Sam Manson Park, in the vicinity of the Barton Street/Nash road intersection.

Figure 1 shows the station location with respect to the existing MOE AQI locations and Figure 2 shows a close up map of the station site.

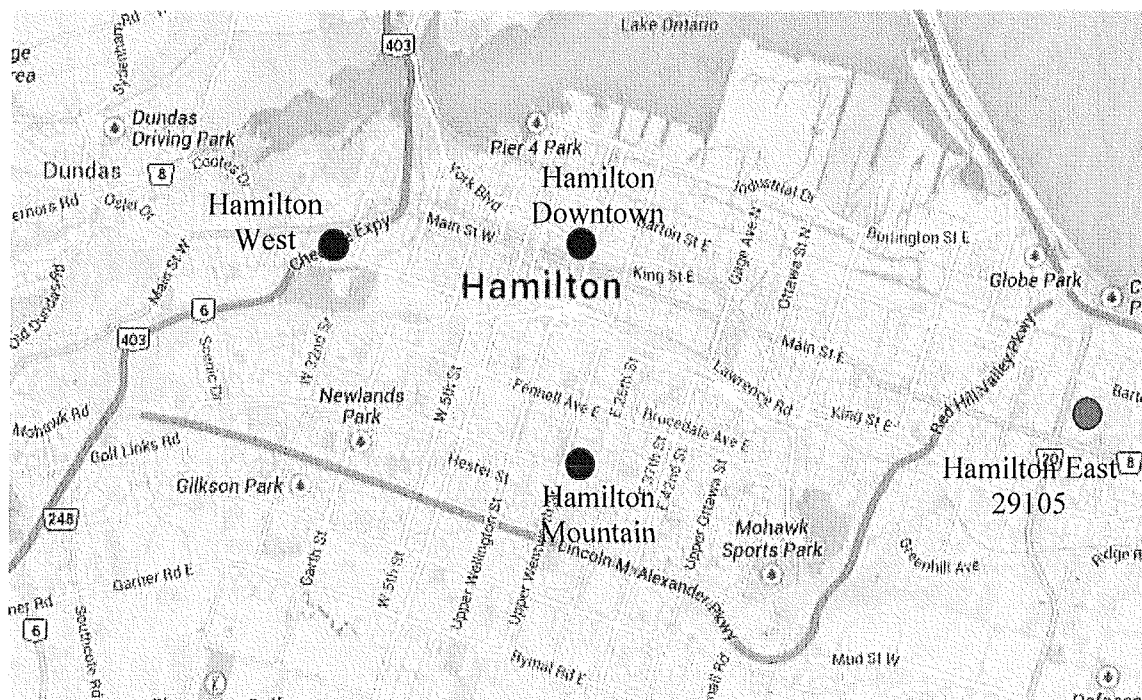


Figure 1 – Map of East Hamilton Sam Manson Park 29105 and MOE Station Locations

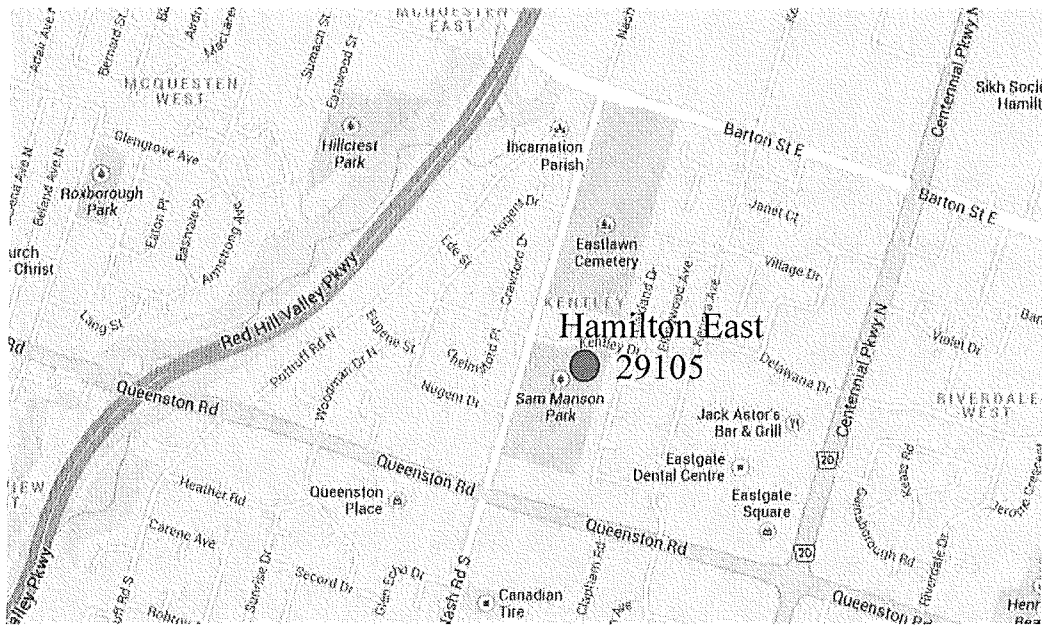


Figure 2 – Detailed Map of East Hamilton Sam Manson Park 29105 Location

Figure 3 shows the AirPointer air monitoring station with security fence and Figure 4 shows the internal modules which measure pollutants individually.

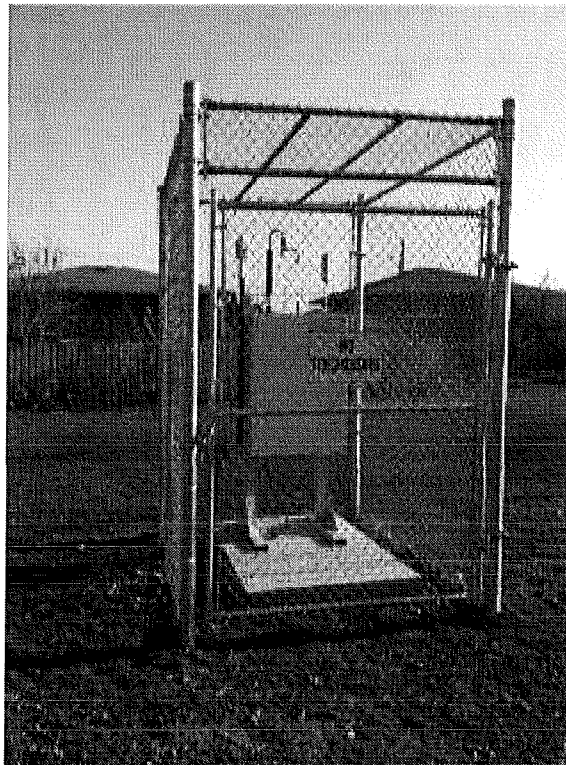


Figure 3 – AirPointer East Hamilton Sam Manson Park Station 29105

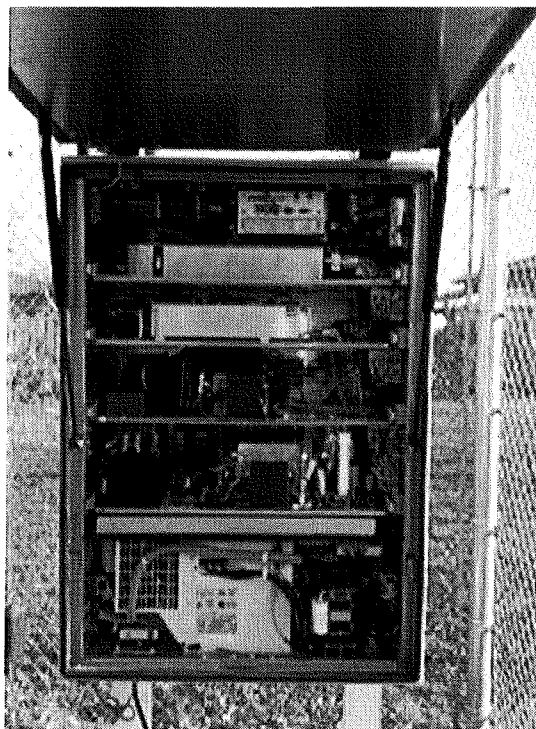


Figure 4 – AirPointer East Hamilton Sam Manson Park Station 29105, internal modules

The following air quality contaminants and meteorological parameters were continuously measured:

- PM2.5 (Particulate matter < 2.5 microns aerodynamic diameter)
- Oxides of Nitrogen (NO, NO₂, NO_x)
- Carbon Monoxide (CO)
- Ozone (O₃)
- Sulphur Dioxide (SO₂)
- Meteorological Parameters (MET)
 - Wind Speed
 - Wind Direction
 - Ambient Temperature
 - Relative Humidity
 - Barometric Pressure
 - Precipitation

4.0 Summary of Operations

Air quality data and instrument performance were evaluated by Rotek personnel. In 2012/2013, Rotek personnel visited the site every two weeks. Gaseous and particulate monitoring equipment were calibrated monthly. Monthly data matrices, station service logs and data edit records are retained in a historical database by Rotek Environmental Inc.

4.1 Collection and Transfer of Data

A data logger was utilized to collect and store data at STN 29105 Hamilton East, Sam Manson Park. The data logger is programmed to continuously scan the outputs from each of the analyzers and process both five minute and hourly data averages. The data logger has the capability to store several years' worth of data.

The Rotek Environmental control room operates an Envitech Envista Air Resource Manager (ARM) application to poll the station data logger and retrieve the collected data on an hourly basis. The data are then verified, quality assured and archived in a central database. The central database server is backed up daily for contingency.

4.2 Valid Data Percentages

The percentage of valid data recovery was 97.5% based on the average from the pollutant parameters monitored, exceeding the Ministry's minimum target of 90% and desirable target of 95%.

5.0 Quality Assurance

Quality assurance measures were implemented during the sampling program to ensure data integrity. The operation, service and maintenance of the stations and sampling equipment were in accordance with the manufacturers' operations manuals and protocols as well as those procedures required by the Ministry of the Environment as outlined in the 'Operations Manual for Air Quality Monitoring in Ontario', March 2008.

6.0 Pollutant Data Summaries and Analyses

A number of methods were used to summarize, display and analyze the 29105 Hamilton East air quality data set:

- 1) **Statistics Tables** - to summarize pollutant means, maximum values for different averaging times and overall percent valid data recoveries.
- 2) **Wind and Pollution Roses** - to illustrate directional information. A wind rose is designed to show the distribution of wind direction experienced at a given location over a considerable period of time, usually shown in polar coordinates (distance from the origin being proportional to the probability of the wind direction coming from a particular wind vector). Pollution roses are used to summarize the average concentrations of a given pollutant seen over a considerable period of time as a function of direction from a given point.
- 3) **Diurnal Profiles** - to illustrate pollutant fluctuations that occur during each day. A single average is generated for each hour of the day in the dataset (i.e. all of the 01:00 data points were averaged, all of the 02:00 data points were averaged etc.). The primary focus of the profile is to assess the impact of local arterial road traffic (i.e. rush hour effect).

6.1 Wind Frequency Distribution

To illustrate annual wind frequency distribution information, i.e., distributions of wind speeds and the frequency of the varying wind directions, a wind rose graphic overlay is provided, superimposed on an aerial view of the area.

Wind roses summarize the occurrence of winds at a location, showing their strength, direction and frequency. Each branch of the rose represents wind coming from that direction, with north to

the top of the graphic. The branches are divided into segments of different colours, which represent wind speed ranges from that direction. The length of each segment within a branch is proportional to the frequency of winds blowing within the corresponding range of speeds from that direction. Wind directions are always characterized by the direction from which the wind blows.

The majority and magnitude of branches in the annual wind rose illustration, Figure 5 below, indicate predominant wind direction vectors from the south-southwest with additional components from the northwest and northeast (these branches represent the data when the wind was blowing from this vector).

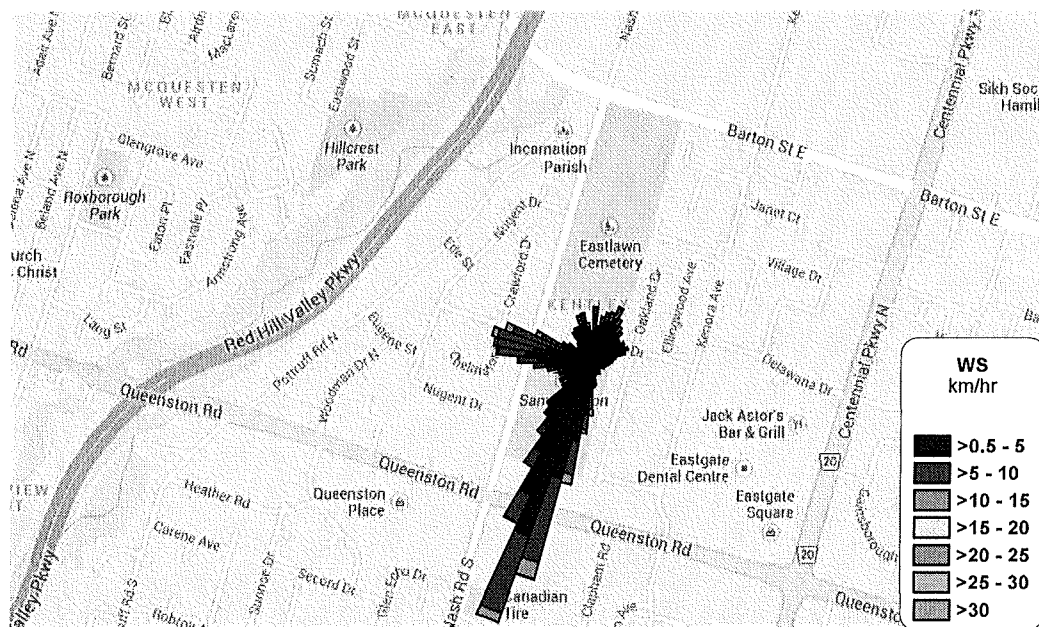


Figure 5 – Wind Rose, AirPointer East Hamilton Sam Manson Park Station 29105

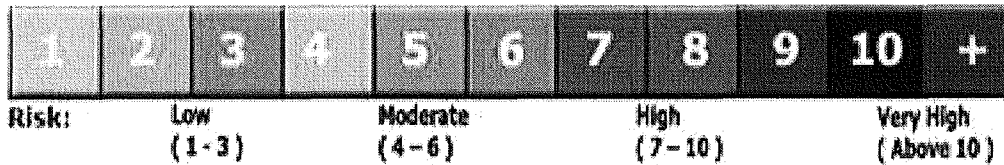
6.2 Air Quality Health Index (AQHI)

The Air Quality Health Index (AQHI) is a tool that helps people determine the current air quality as well as for the next two days. By knowing the AQHI, people can make informed decisions about limiting their exposures to poor air quality. The AQHI was calculated for the Hamilton East Sam Manson Park, Station 29105 during the period of this study

The AQHI is a program of Health Canada and Environment Canada and is measured on a scale ranging from 1-10+. The AQHI index values are also grouped into health risk categories as shown below. These categories help to easily and quickly identify the level of risk.

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

The colour coded scale for the AQHI is shown below in Figure 1. With pale blue being very good air quality and red being poor air quality. For more information, visit www.airhealth.ca.



6.3 AQHI Pollution Rose

The pollution rose in Figure 6 shows AQHI values by wind sector category. The spokes in the graphic below represent AQHI hourly values when the wind was blowing from a specific wind direction vector. The shape is similar to the wind rose, since pollutants can only be detected when the wind is blowing from that particular direction, however the colour coding will show where higher levels of pollutants are originating (a map rather than a satellite view is used for this graphic in order to provide better viewing contrast while using the AQHI colour coding scheme).

Since the wind blows mainly from the SSW, most pollutants originate from that direction. Most of the higher AQHI values also come from that SSW direction.

While it might be expected that higher pollutant levels may come from the Red Hill Valley Parkway, in fact there are less frequent moderate (>3) AQHI levels recorded from that direction. These data are in agreement with previous fixed station and mobile monitoring in the area. These previous studies showed that channeling of winds along the valley seemed to reduce impacts on neighbouring residential areas (Refs. 5 and 6)

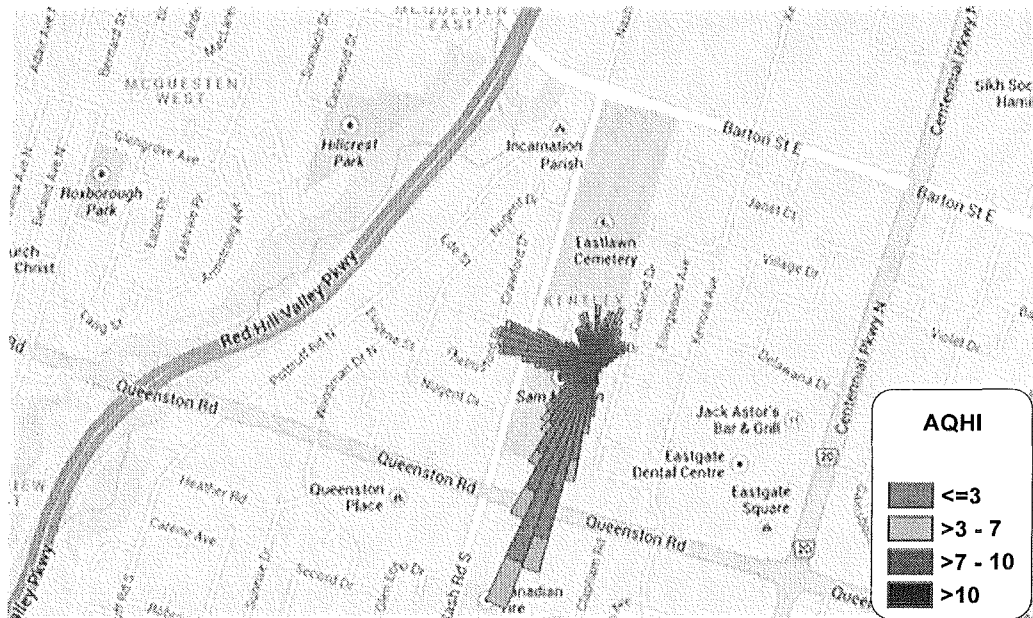


Figure 6 – AQHI Pollution Rose, AirPointer East Hamilton Sam Manson Park Station 29105

6.4 Hours of different AQHI levels

Figure 7 shows the relative number of hours of different AQHI levels experienced at Station 29105. The great majority of hours are in the Low Risk category, less in the Moderate Risk category and none in the High or Very High Risk categories.

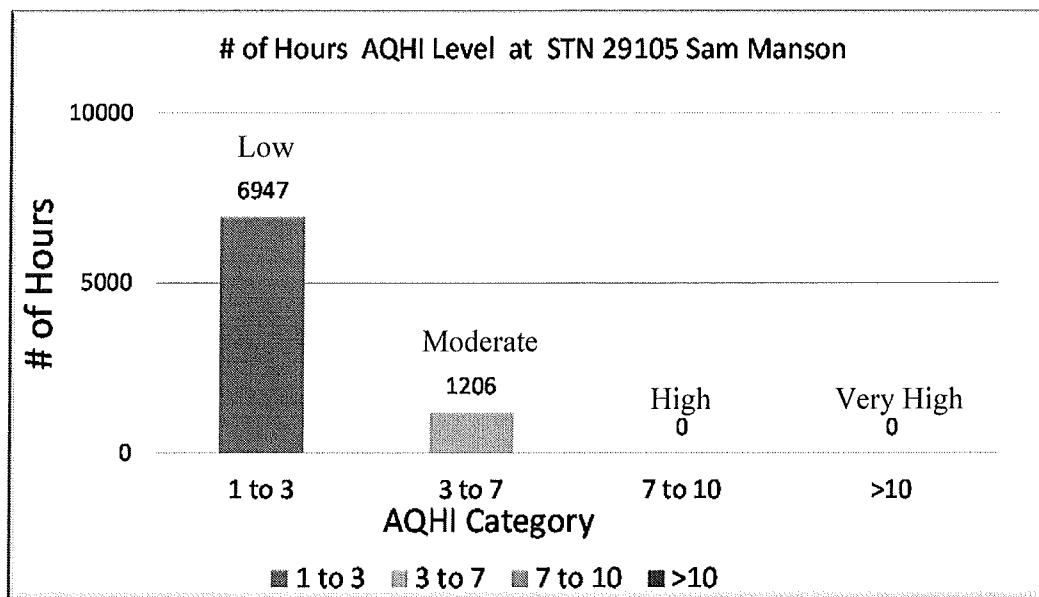


Figure 7 – Number of Hours in Different AQHI Categories , AirPointer East Hamilton Sam Manson Park Station 29105

6.5 Diurnal variation of AQHI

Figure 8 shows that there is very little variation of AQHI levels throughout an average day. This is rather surprising since the AQHI equation is derived on the basis of NO₂, O₃ and PM_{2.5} concentrations, NO₂ has a marked peak during morning rush hour and O₃ has a large peak in the afternoon hours. The reasons for this lack of change with pollutant levels may be that the AQHI is calculated on the basis of a three hour running average and is thus relatively insensitive to short term changes in pollutant concentrations, as well as that the morning and afternoon peaks may equalize.

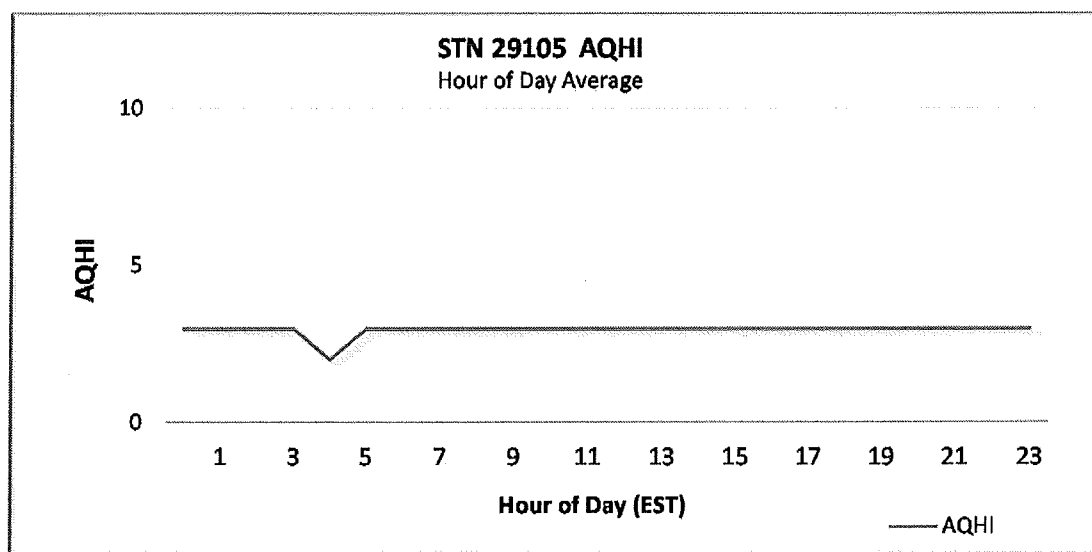


Figure 8 – Diurnal Variation of AQHI, AirPointer East Hamilton Sam Manson Park Station 29105

6.6 Comparison of AQHI from AirPointer East Hamilton Sam Manson Park Station 29105 with other Hamilton Stations

AQHI historical data and annual averages for MOE Hamilton stations are not available since the AQHI was designed as a real time public notification system.

6.7 Characteristics of PM2.5

Particulate matter is characterized according to size - mainly because of the different health effects associated with particles of different diameters. Particulate matter is the general term used for a mixture of solid particles and liquid droplets in the air. It includes aerosols, smoke, fumes, dust, ash and pollen. The composition of particulate matter varies with place, season and weather conditions. Fine particulate matter is particulate matter that is 2.5 microns in diameter and less. It is also known as PM2.5 or respirable particulate because it penetrates further into the respiratory system than larger particles.

PM2.5 particulate is primarily formed from chemical reactions in the atmosphere and through fuel combustion, e.g., motor vehicles, power generation, industrial facilities, residential fire places, wood stoves and agricultural burning.

6.8 Canada Wide Standard (CWS) Calculation Criteria

Calculation of the PM2.5 annual average to compare with the CWS of $30 \mu\text{g}/\text{m}^3$ (98th percentile) must be in accordance with the 'Guidance Document on Achievement Determination', 'Canada-wide Standards for Particulate and Ozone', PN1391, 978-1-896997-74-2.

A daily value for PM2.5 refers to the 24 hour average concentration of PM2.5 in $\mu\text{g}/\text{m}^3$ measured from midnight to midnight. For continuous monitors, at least 18 hourly measurements are required to calculate a valid daily value. An annual data set should be considered complete if at least 75% of the scheduled sampling days in each quarter have valid data.

If there is more than one qualifying monitoring site in the reporting air shed (as is the case in Hamilton), the arithmetic average of the valid daily values for all qualifying monitors should be calculated to provide the representative daily PM2.5 concentrations in $\mu\text{g}/\text{m}^3$ for the community for each day. The arithmetic average value should be rounded to the nearest $0.1 \mu\text{g}/\text{m}^3$. The 98th percentile value is used for comparison with the PM2.5 Canada Wide Standard of $30 \mu\text{g}/\text{m}^3$ rather than the maximum value in order to remove anomalous data and a three year average is used.

For this site there is only one year of data, however the 98th percentile value is $24 \mu\text{g}/\text{m}^3$, which would be well below the standard of $30 \mu\text{g}/\text{m}^3$.

6.9 PM2.5 Data Statistics

The PM2.5 data set is summarized in Table 2.

A 24 hour clock average, as opposed to a rolling average, means that the applicable time would be a calendar day from midnight to midnight. Note that monthly means are an overall average and therefore would correspond to the 50th percentile level, while the CWS is based on the 98th percentile level.

STN 29105 Sam Manson Park PM2.5 Data Statistics Table 2

PM2.5 Statistic	Average	Units	Q1			Q2			Q3			Q4			Annual
			J	F	M	A	M	J	J	A	S	O	N	D	Mean
Period Arithmetic Mean	Clock	µg/m ³	6			6			9			6			7
Monthly Arithmetic Mean	Clock	µg/m ³	8	7	4	5	6	6	---	8	6	5	4	9	---
Maximum 1 Hour	Clock	µg/m ³	40	32	20	26	33	35	82	46	31	56	27	33	---
Maximum 24 Hour	Clock	µg/m ³	24	21	9	14	13	16	61	25	25	17	10	18	---
% Valid Data	---	%	99.9	100.0	100.0	99.9	99.9	100.0	44.6	92.1	99.3	100.0	100.0	99.1	94.5

An MOE PM2.5 Reference level of 30 µg/m³ was exceeded twice in July, 2013 and the World Health Organization PM2.5 guideline of 25 µg/m³ was exceeded three times in July, 2013.

6.10 PM2.5 Pollution Rose

The pollution rose in Figure 9 shows PM2.5 average source strength by wind sector category. The spokes in the graphic below represent PM2.5 hourly averages when the wind was blowing from a specific wind direction vector. The shape is similar to the wind rose, since pollutants can only be detected when the wind is blowing from that particular direction, however the colour coding will show where higher levels of pollutants are originating.

Since the wind blows mainly from the SSW, most pollutants originate from that direction. Also most of the higher particulate values (light blue on the graphic, 10 to 30 µg/m³) come from that SSW direction.

While it might be expected that higher particulate levels may come from the Red Hill Valley Parkway, in fact there are less frequent > 10 µg/m³ levels recorded from that direction. These data are in agreement with previous fixed station and mobile monitoring in the area. These previous studies showed that channeling of winds along the valley seemed to reduce impacts on neighbouring residential areas (Refs. 5 and 6)

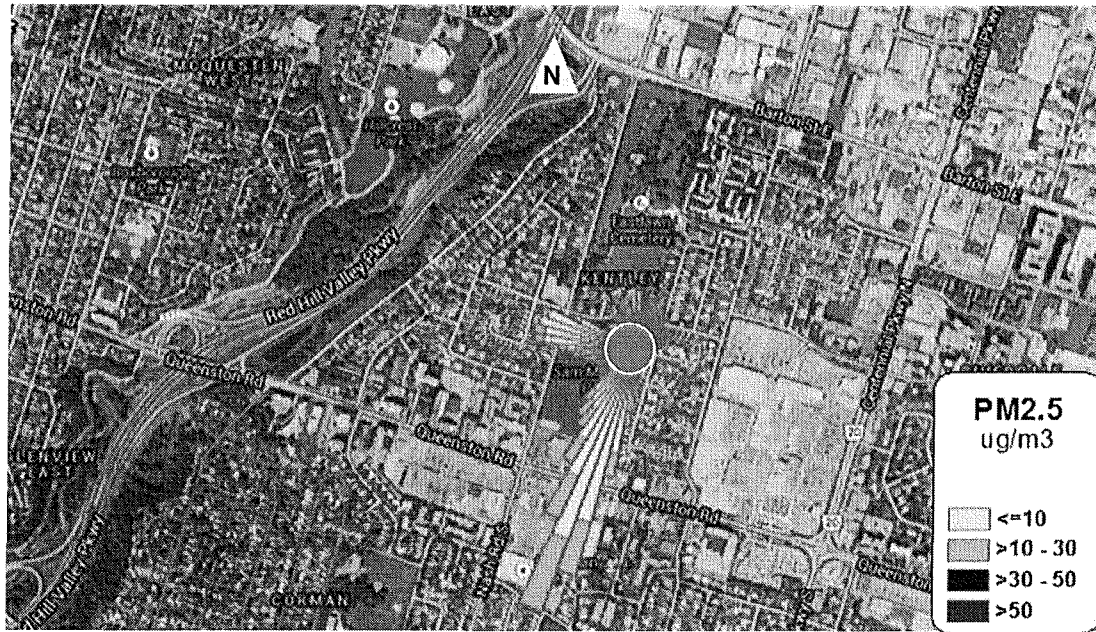


Figure 9 – PM2.5 Pollution Rose, AirPointer East Hamilton Sam Manson Park Station 29105

6.11 PM2.5 Diurnal Analysis

A diurnal analysis were performed to assess whether PM2.5 concentrations can be linked to rush hour traffic emissions. Figure 10 illustrates that the daily variation in PM2.5 concentrations is minimal. This would indicate that local rush hour traffic contributes little to the overall levels of PM2.5 at the Sam Manson Park location.

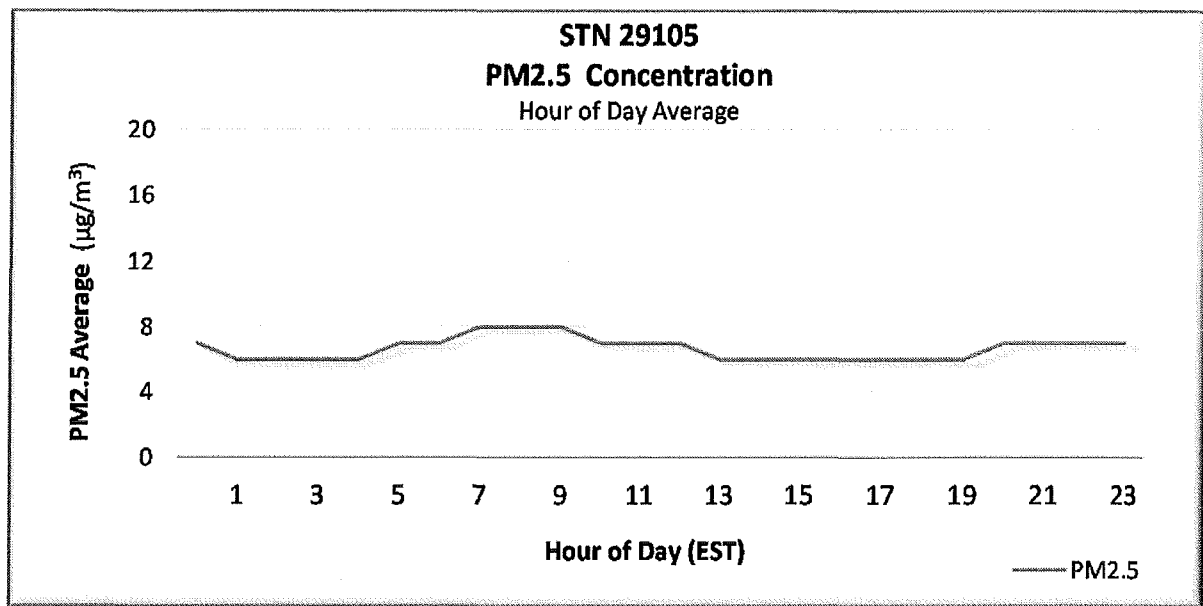


Figure 10 –PM2.5 Diurnal Variation, AirPointer East Hamilton Sam Manson Park STN 29105

6.12 Comparison of PM_{2.5} Concentrations from AirPointer East Hamilton Sam Manson Park Station 29105 with other Hamilton Stations

Comparison of the Hamilton East PM_{2.5} annual average fine particulate concentrations with the MOE AQI stations shows that the levels at Sam Manson Park are significantly lower, i.e., cleaner air than in other parts of the City, see figure 11 below.

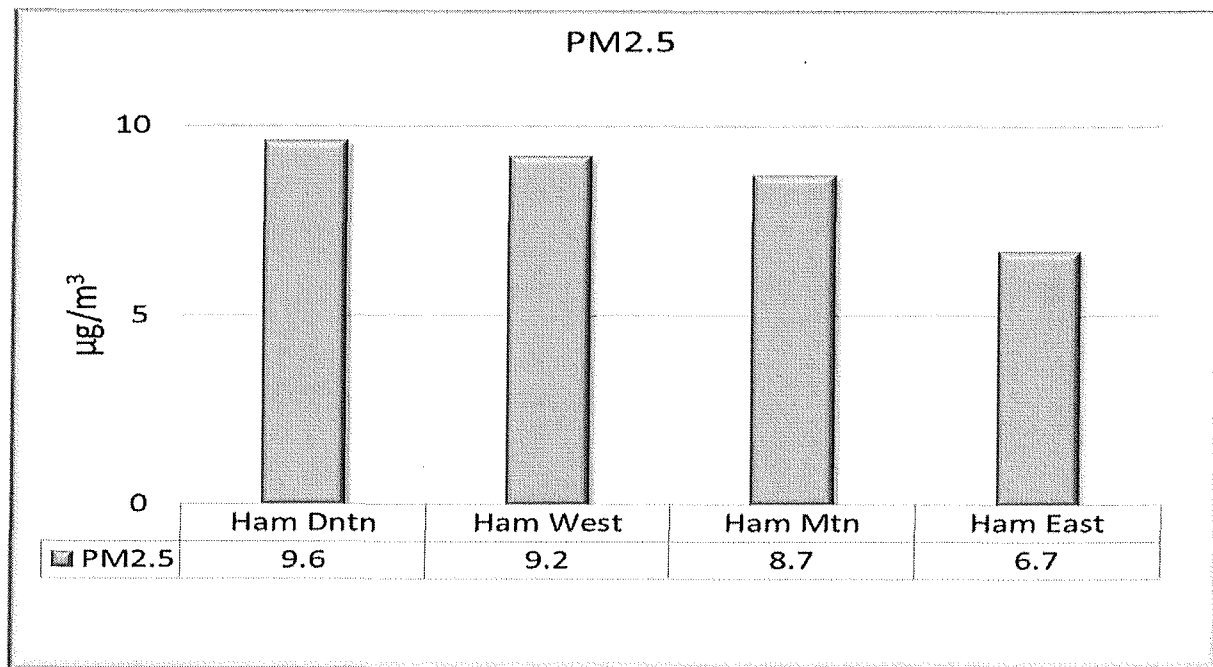


Figure 11 – Comparison of PM_{2.5} Concentrations from AirPointer East Hamilton Sam Manson Park Station 29105 with other Hamilton Stations

6.13 Historical Trend of Particulate Concentrations from East Hamilton Sam Manson Park Station

Since different types of particulate were measured at this site previously, there are no comparable measurements to evaluate long term trends

6.14 Characteristics of NO₂ / NOX

NO₂ (Nitrogen Dioxide) is a reddish-brown gas with a pungent and irritating odour. It transforms in the air to form gaseous nitric acid and toxic organic nitrates. NO₂ also plays a major role in atmospheric reactions that produce ground-level ozone, a major component of smog. It is also a precursor to nitrates, which contribute to increased respirable particle levels in the atmosphere.

NOX (Oxides of Nitrogen) are usually reported as the sum of NO and NO₂. In the case of air quality assessments, e.g. annual air quality reports such as the current report, NO₂, not NOX, is the reference contaminant. NOX AAQCs with 1 hour and 24 hour averaging times should only be compared to monitored NO₂ data. Table 3 summarizes NO₂ statistics for comparison to appropriate Ministry criteria. For directional comparisons, NOX is still used in order to discern the complete pollutant picture.

6.15 NO2 Data Statistics

The NO2 data set is summarized in Table 3.

A 24 hour clock average, as opposed to a rolling average, means that the applicable time would be a calendar day from midnight to midnight.

STN 29105 Sam Manson Park NO2 Data Statistics Table 3

NO2 Statistic	Average	Units	Q1			Q2			Q3			Q4			Annual
	Type		J	F	M	A	M	J	J	A	S	O	N	D	Mean
Period Arithmetic Mean	Clock	ppb	13			10			8			11			10
Monthly Arithmetic Mean	Clock	ppb	13	14	11	10	11	8	7	8	8	11	10	13	---
Maximum 1 Hour	Clock	ppb	52	51	52	47	57	41	29	37	37	36	40	43	---
Maximum 24 Hour	Clock	ppb	30	25	22	25	21	18	13	15	19	22	20	26	---
Maximum 1/2 Hour	Running	ppb	55	52	54	49	63	43	36	38	40	45	41	44	---
Maximum 1 Hour	Running	ppb	52	51	52	47	58	41	34	37	37	40	40	43	---
Maximum 24 Hour	Running	ppb	31	31	28	27	25	19	13	17	20	23	23	26	---
% Valid Data	---	%	98.9	99.9	100.0	100.0	99.9	100.0	94.0	96.6	88.6	100.0	100.0	99.9	98.1

There were no exceedances of any standards or guidelines for NO2.

6.16 NOX Pollution Roses

The pollution rose in Figure 12 shows NOx average source strength by wind sector category. The spokes in the graphic below represent NOx hourly averages when the wind was blowing from a specific wind direction vector. The shape is similar to the wind rose, since pollutants can only be detected when the wind is blowing from that particular direction, however the colour coding will show where higher levels of pollutants are originating.

Since the wind blows mainly from the SSW, most pollutants originate from that direction. Also most of the higher NOx values (light blue on the graphic, 50 to 100 ppb) come from that SSW direction.

While it might be expected that higher NOx levels may come from the Red Hill Valley Parkway, in fact there are less frequent > 50 ppb levels recorded from that direction. These data are in agreement with previous fixed station and mobile monitoring in the area. These previous studies showed that channeling of winds along the valley seemed to reduce impacts on neighbouring residential areas (Refs. 5 and 6)

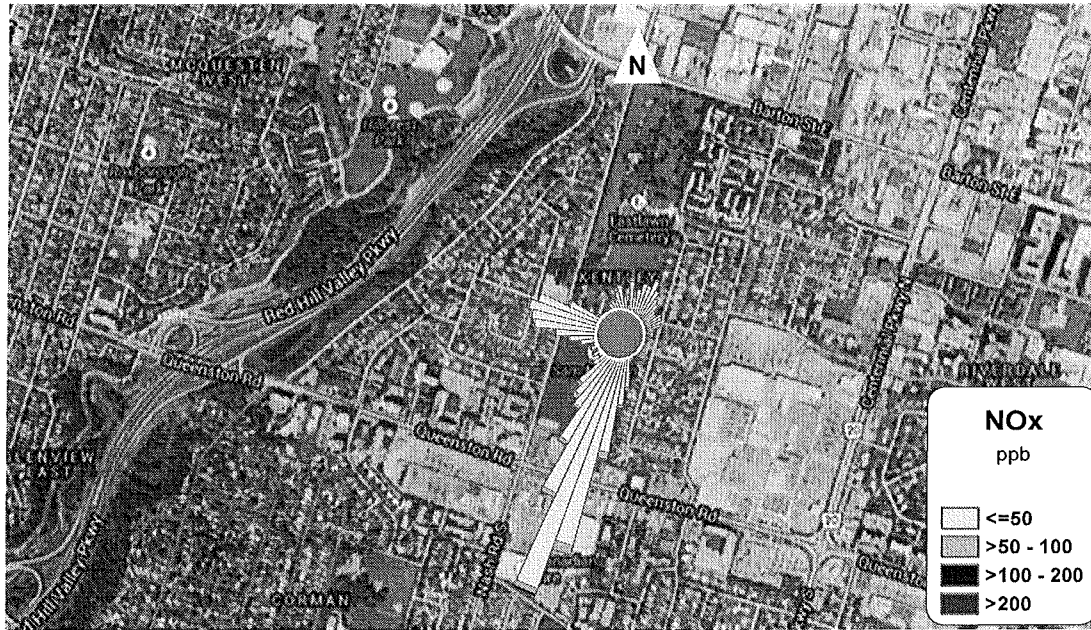


Figure 12 – NOx Pollution Rose, AirPointer East Hamilton Sam Manson Park STN 29105

6.17 NO2 - NOX Diurnal Analysis

The diurnal profile reveals a marked rush hour traffic effect, particularly in the early morning hours. Figure 13 shows the daily variation in NO2 - NOX concentrations. The higher levels in the morning, as compared to evening, are not unexpected since night time and early morning inversions often occur, accompanied by low wind speeds and enhanced pollution concentrations. In the afternoon and early evening increased solar radiation and higher wind speeds lead to better dispersion of pollutants.

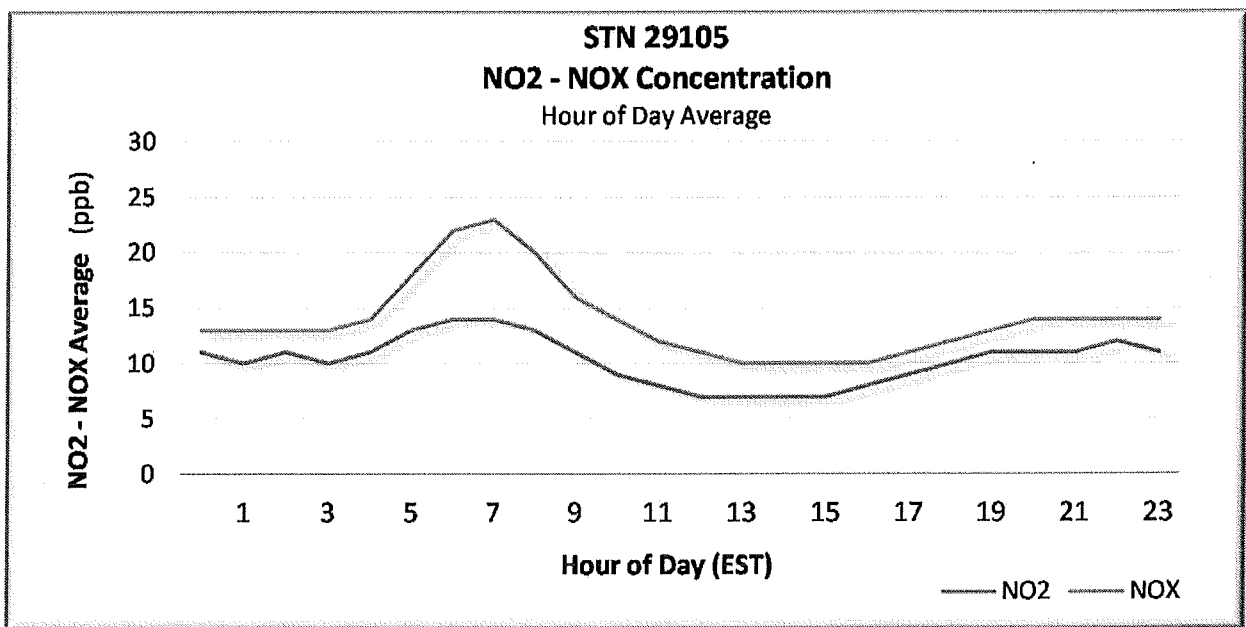


Figure 13 – NO2 - NOx Diurnal Variation, AirPointer East Hamilton Sam Manson Park STN 29105

6.18 Comparison of NO₂ Concentrations from AirPointer East Hamilton Sam Manson Park Station 29105 with other Hamilton Stations

Comparison of the Hamilton East NO₂ annual average concentrations with the MOE AQI stations shows that the NO₂ levels at Hamilton Mountain are lowest, i.e., cleaner air than in other parts of the City, while Sam Manson Park is the next cleanest with Hamilton Downtown and Hamilton West having the highest concentrations, see Figure 14 below.

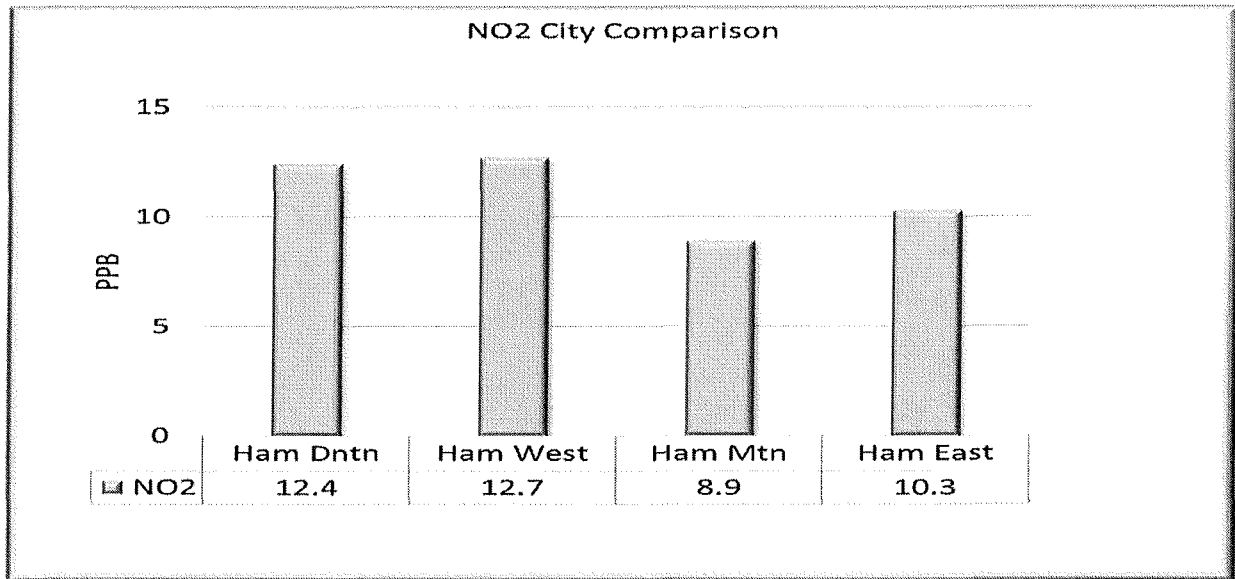


Figure 14 – Comparison of NO₂ Concentrations from AirPointer East Hamilton Sam Manson Park Station 29105 with other Hamilton Stations

6.19 Historical Trend of NO₂ Concentrations from East Hamilton Sam Manson Park Station

Oxides of Nitrogen were not measured at this site previously, so there are no comparable measurements to evaluate long term trends

6.20 Characteristics of CO

Carbon Monoxide (CO) is a colourless, odourless and tasteless but poisonous gas produced primarily by incomplete burning of fossil fuels.

6.21 CO Data Statistics

The CO data set has been summarized in Table 4:

STN 29105 Sam Manson Park CO Data Statistics Table 4

CO Statistic	Average	Units	Q1			Q2			Q3			Q4			Annual
	Type		J	F	M	A	M	J	J	A	S	O	N	D	Mean
Period Arithmetic Mean	Clock	ppm	0.26			0.25			0.22			0.21			0.23
Monthly Arithmetic Mean	Clock	ppm	0.28	0.27	0.23	0.31	0.23	0.20	0.21	0.23	0.23	0.23	0.23	0.17	---
Maximum 1 Hour	Clock	ppm	1.05	1.30	0.71	0.74	0.79	0.45	0.68	0.74	0.82	0.94	1.24	0.83	---
Maximum 24 Hour	Clock	ppm	0.59	0.45	0.33	0.42	0.34	0.29	0.39	0.38	0.38	0.43	0.45	0.33	---
Maximum 1/2 Hour	Running	ppm	1.51	1.78	0.92	1.25	0.86	0.51	0.80	0.86	0.99	0.97	1.44	1.35	---
Maximum 1 Hour	Running	ppm	1.35	1.30	0.89	1.02	0.84	0.46	0.68	0.77	0.96	0.94	1.30	1.04	---
Maximum 8 Hour	Running	ppm	0.82	0.77	0.45	0.48	0.50	0.37	0.42	0.51	0.53	0.64	0.73	0.70	---
% Valid Data	---	%	99.5	99.9	99.6	100.0	100.0	100.0	92.6	94.0	89.9	100.0	100.0	100.0	97.9

There were no exceedances of any standards or guidelines for CO.

6.22 CO Pollution Rose

The pollution rose in Figure 15 shows CO average source strength by wind sector category. The spokes in the graphic below represent CO hourly averages when the wind was blowing from a specific wind direction vector. The shape is similar to the wind rose, since pollutants can only be detected when the wind is blowing from that particular direction, however the colour coding will show where higher levels of pollutants are originating.

Since the wind blows mainly from the SSW, most pollutants originate from that direction. CO concentrations were very low.

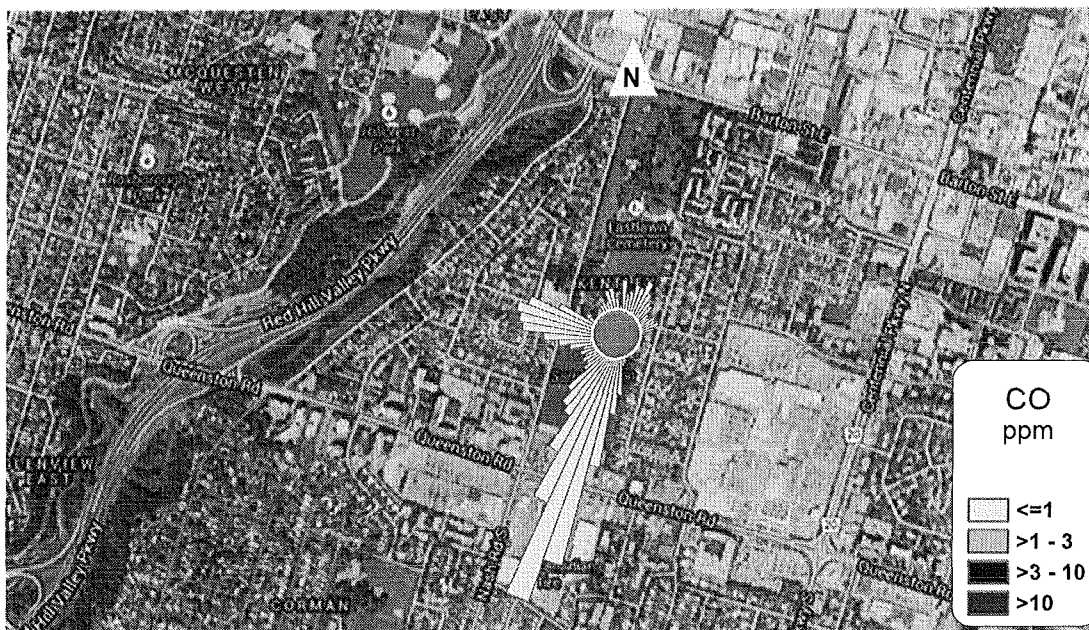


Figure 15 – CO Pollution Rose, AirPointer East Hamilton Sam Manson Park STN 29105

6.23 CO Diurnal Analysis

The diurnal profile reveals a small rush hour traffic effect, particularly in the early morning hours but overall, CO values are low. Figure 16 shows the daily variation in CO concentrations.

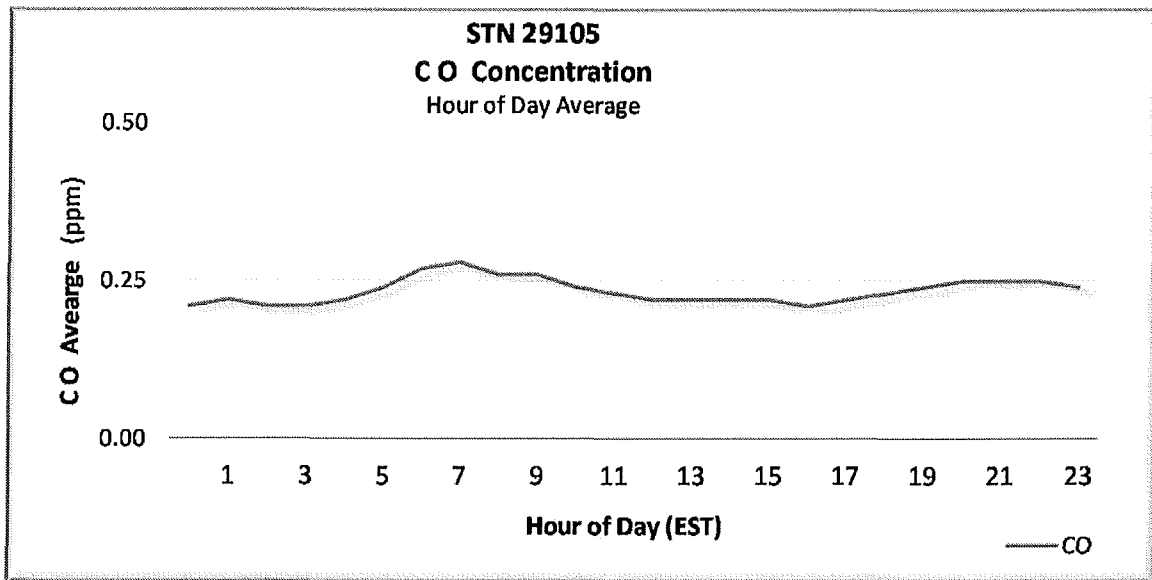


Figure 16 – CO Diurnal Variation, AirPointer East Hamilton Sam Manson Park STN 29105

6.24 Comparison of CO Concentrations from AirPointer East Hamilton Sam Manson Park Station 29105 with other Hamilton Stations

CO is only measured at one other location, Hamilton Downtown. Levels are low at both locations, see Figure 17 below.

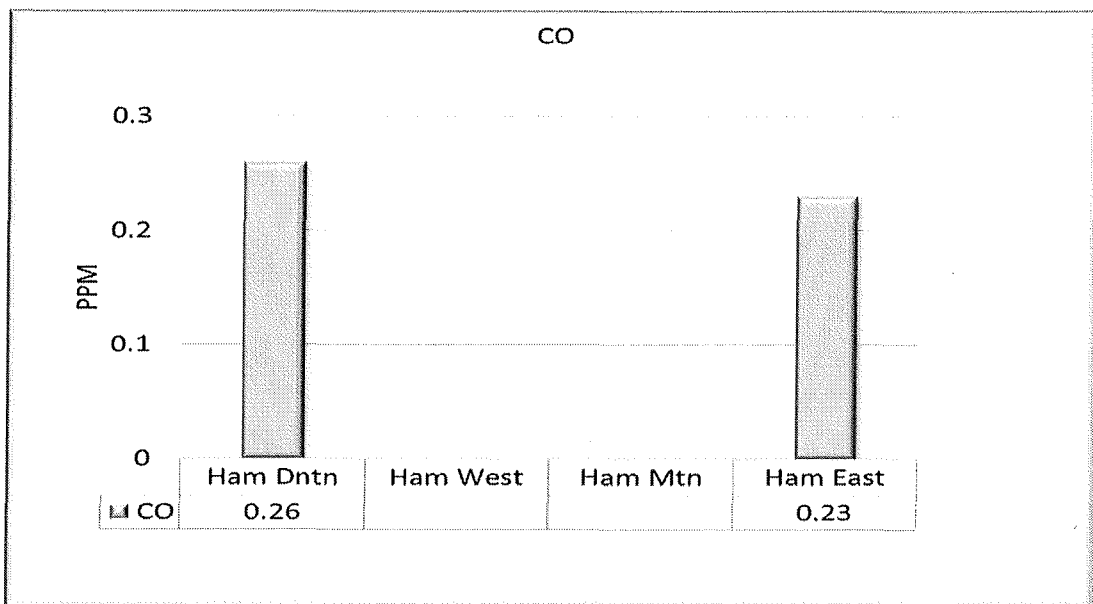


Figure 17 – Comparison of CO Concentrations from AirPointer East Hamilton Sam Manson Park Station 29105 with other Hamilton Stations

6.25 Historical Trend of CO Concentrations from East Hamilton Sam Manson Park Station.

CO was not measured at this site previously, so there are no comparable measurements to evaluate long term trends.

6.26 Characteristics of O3

Ground-level Ozone (O3) is a gas formed when Oxides of Nitrogen (NOX) and Volatile Organic Compounds (VOCs) react in the presence of sunlight. Ozone is a colourless, odourless gas at typical ambient concentrations, and is a major component of smog. Although ozone is not generally emitted directly into the atmosphere, the formation and transport of ozone are strongly dependent on meteorological conditions. Changing weather patterns contribute to differences in ozone concentrations hourly, daily, seasonally and year to year. In Ontario, elevated concentrations of ground-level ozone are typically recorded on hot and sunny days from May to September, between noon and early evening.

6.27 O3 Data Statistics

The O3 data set has been summarized in Table 5.

STN 29105 Sam Manson Park O3 Data Statistics - Table 5

O3 Statistic	Average	Units	Q1			Q2			Q3			Q4			Annual
	Type		J	F	M	A	M	J	J	A	S	O	N	D	Mean
Period Arithmetic Mean	Clock	ppb	29			37			32			22			30
Monthly Arithmetic Mean	Clock	ppb	25	28	34	38	38	36	34	34	27	21	24	19	---
Maximum 1 Hour	Clock	ppb	40	47	60	60	81	75	95	75	72	51	43	39	---
Maximum 24 Hour	Clock	ppb	36	39	46	51	53	61	52	53	52	33	31	36	---
Maximum 8 Hour	Running	ppb	39	44	56	56	70	70	84	67	69	46	41	38	---
% Valid Data	---	%	100.0	100.0	100.0	100.0	100.0	100.0	96.8	97.8	86.0	100.0	100.0	99.9	98.4

There were twelve exceedances of the 80 ppb one hour average AAQC, one in May, 2013 and eleven in July, 2013. All of these would be due to regional episodes.

6.28 O3 Pollution Rose

The pollution rose in Figure 18 shows O3 average source strength by wind sector category. The spokes in the graphic below represent O3 hourly averages when the wind was blowing from a specific wind direction vector. The shape is similar to the wind rose, since pollutants can only be detected when the wind is blowing from that particular direction, however the colour coding will show where higher levels of pollutants are originating.

It is clear that the great majority of higher values originate from the SSW direction, as would be expected from a regionally generated pollutant.

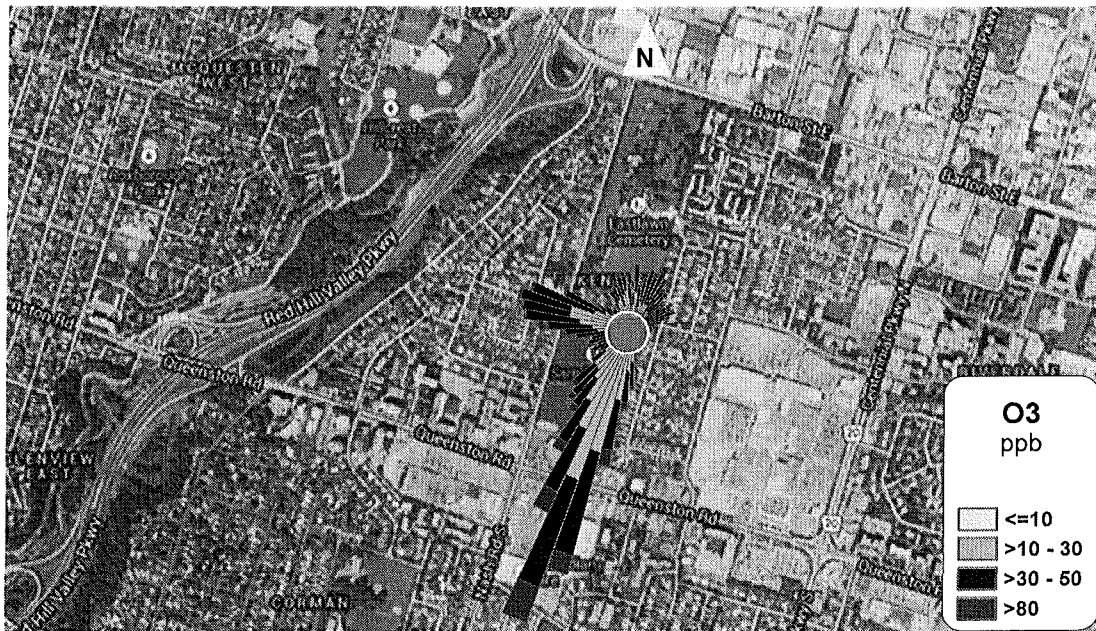


Figure 18 – O3 Pollution Rose, AirPointer East Hamilton Sam Manson Park STN 29105

6.29 O3 Diurnal Analysis

For O₃, which is largely generated by the action of sunlight on pollutants already in the atmosphere, there are no local source contributions. There is a characteristic afternoon peak which is shown in Figure 19.

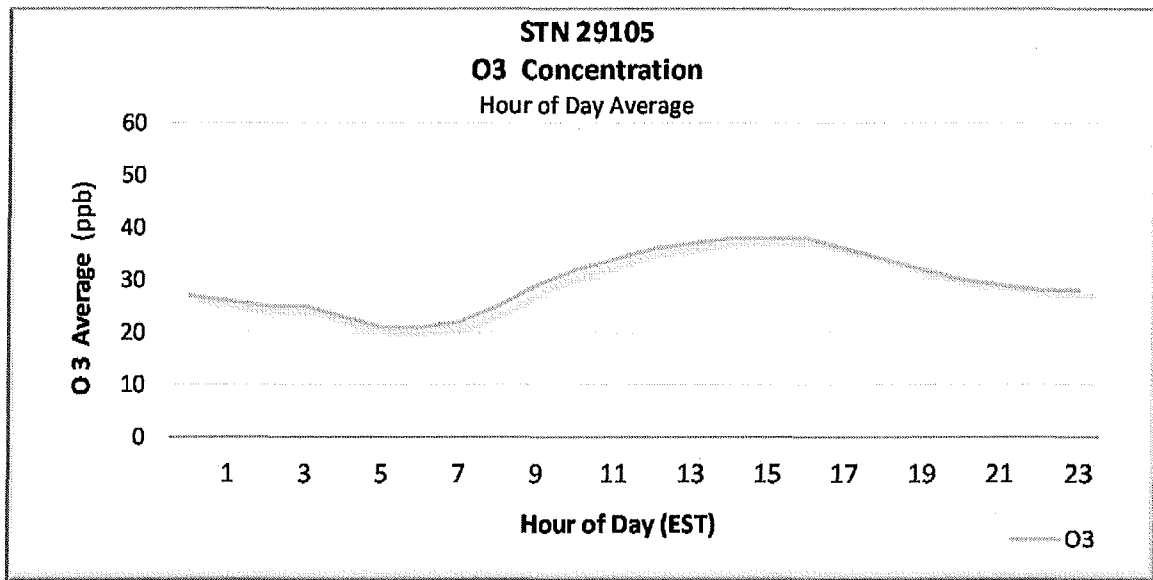


Figure 19 – O₃ Diurnal Variation, AirPointer East Hamilton Sam Manson Park STN 29105

6.30 Comparison of O₃ Concentrations from AirPointer East Hamilton Sam Manson Park Station 29105 with other Hamilton Stations

Along with Hamilton Mountain, Hamilton East has the highest O₃ average. The reason for this is that ozone levels are reduced by chemical interactions with other pollutants. Locations such as the Downtown and West stations which have higher levels of other pollutants will have correspondingly lower O₃ levels, see Figure 20 below.

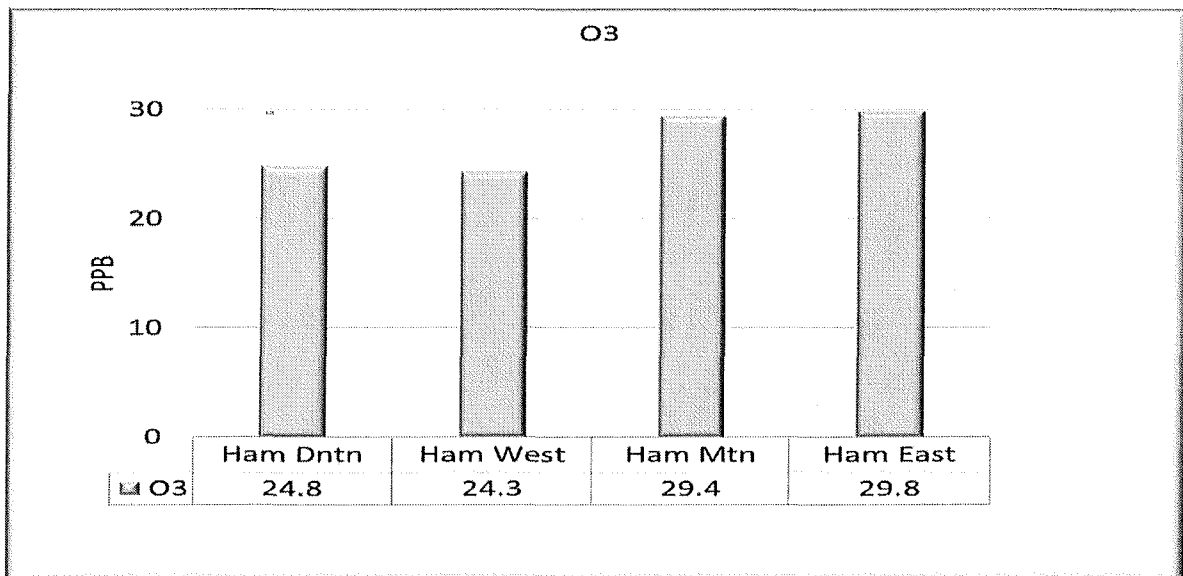


Figure 20 – Comparison of O₃ Concentrations from AirPointer East Hamilton Sam Manson Park Station 29105 with other Hamilton Stations

6.31 Historical Trend of O₃ Concentrations from East Hamilton Sam Manson Park Station.

O₃ at this site previously remained relatively constant from 1986 to 1996, however the annual average has now risen substantially. This effect would be mainly due to long range transport of air pollutants and is a city wide phenomenon.

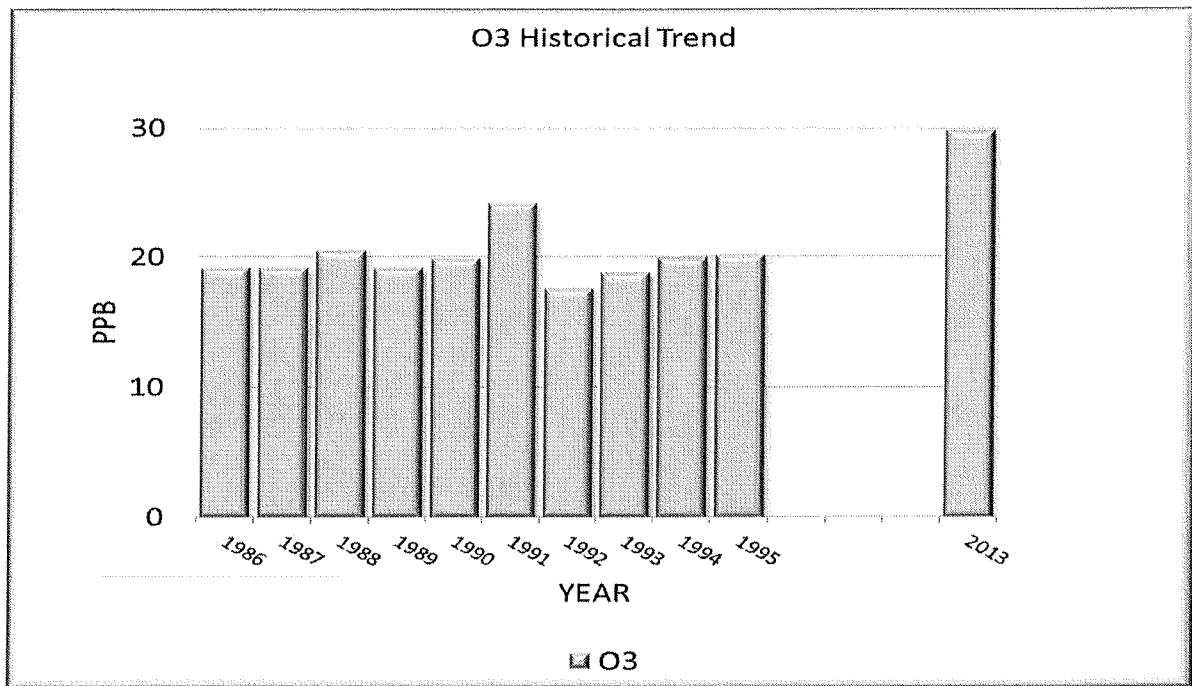


Figure 21 – Historical Trend of O₃ Concentrations at East Hamilton Sam Manson Park Station 29105

6.32 Characteristics of SO₂

SO₂ is a colourless gas. It smells like burnt matches. It can be oxidized to sulphur trioxide, which in the presence of water vapour is readily transformed to sulphuric acid mist. SO₂ can be oxidized to form acid aerosols. SO₂ is a precursor to sulphates, which are one of the main components of respirable particles in the atmosphere.

Approximately 69 per cent of the SO₂ emitted in Ontario in 2006 came from smelters and utilities. Downstream petroleum industry and other industrial processes each accounted for approximately 9 per cent of SO₂ emissions. Lesser sources of SO₂ include transportation, cement and concrete, and miscellaneous.

6.33 SO₂ Data Statistics

The SO₂ data set has been summarized in Table 6.

STN 29105 Sam Manson Park SO2 Data Statistics - Table 6

SO2 Statistic	Average Type	Units	Q1			Q2			Q3			Q4			Annual Mean
			J	F	M	A	M	J	J	A	S	O	N	D	
Period Arithmetic Mean	Clock	ppb	1			1			1			1			1
Monthly Arithmetic Mean	Clock	ppb	1	1	1	1	1	1	1	1	1	1	1	1	---
Maximum 1 Hour	Clock	ppb	20	29	21	34	33	33	37	28	29	76	11	16	---
Maximum 24 Hour	Clock	ppb	3	5	6	4	5	6	6	4	5	10	2	3	---
Maximum 1/2 Hour	Running	ppb	27	34	28	43	36	35	46	35	45	79	12	27	---
Maximum 1 Hour	Running	ppb	22	32	22	34	33	34	43	29	40	76	11	19	---
Maximum 24 Hour	Running	ppb	4	5	6	6	6	6	7	4	6	10	4	4	---
% Valid Data	---	%	100.0	100.0	100.0	100.0	100.0	100.0	94.9	97.3	91.0	100.0	100.0	99.9	98.6

SO2 exceeded the World Health Organization guideline once in October, 2013.

6.34 SO2 Pollution Rose

The pollution rose in Figure 22 shows SO2 average source strength by wind sector category. The spokes in the graphic below represent SO2 hourly averages when the wind was blowing from a specific wind direction vector. The shape is similar to the wind rose, since pollutants can only be detected when the wind is blowing from that particular direction, however the colour coding will show where higher levels of pollutants are originating.

It is clear that the majority of higher values originate from the SSW direction, however, there are also some impacts from the west to north north west directions, i.e., from the Parkway or beyond in central Hamilton. Overall SO2 values are low.

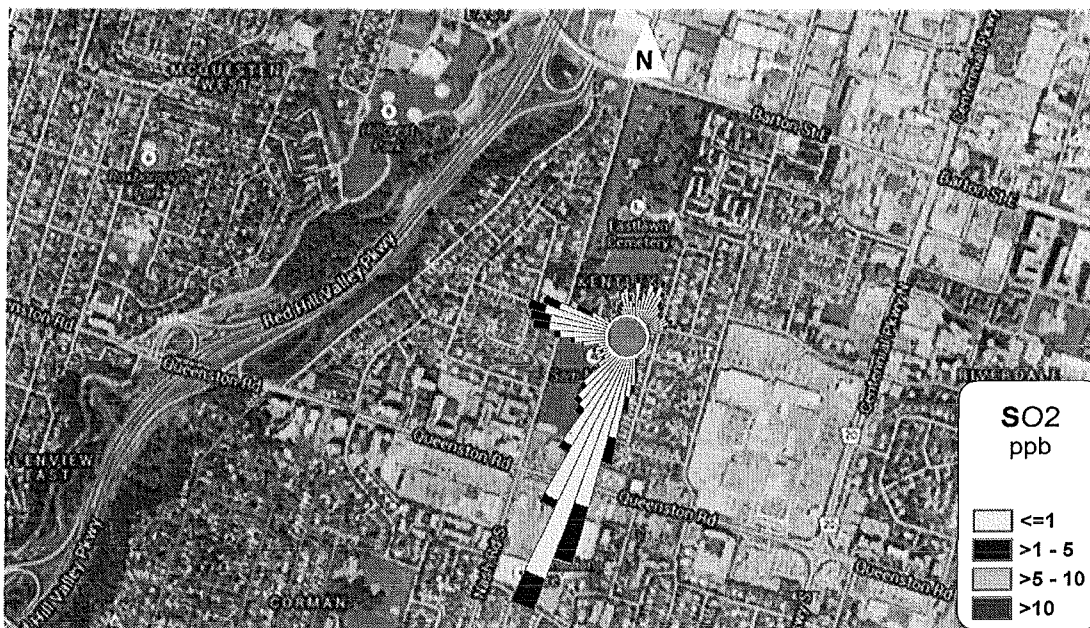


Figure 22 – SO2 Pollution Rose, AirPointer East Hamilton Sam Manson Park STN 29105

6.35 SO2 Diurnal Analysis

The diurnal profile shown in Figure 23 reveals a small rush hour traffic effect in the morning hours but overall, SO₂ values are low.

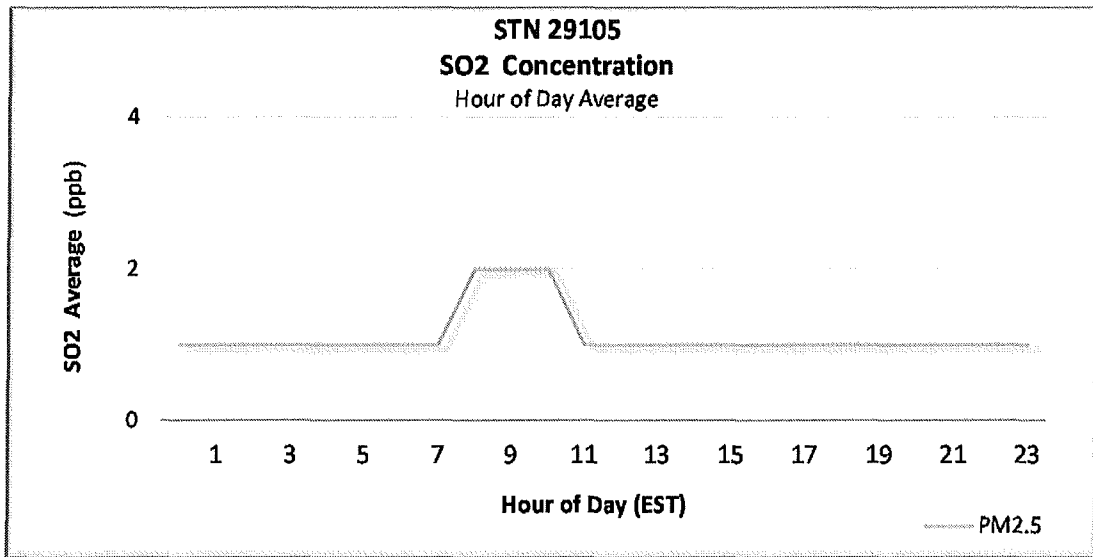


Figure 23 – SO₂ Diurnal Variation, AirPointer East Hamilton Sam Manson Park STN 29105

6.36 Comparison of SO₂ Concentrations from AirPointer East Hamilton Sam Manson Park Station 29105 with other Hamilton Stations

Hamilton East has much lower concentrations of SO₂ than Downtown or Mountain, however levels are low at all locations, see Figure 24 below.

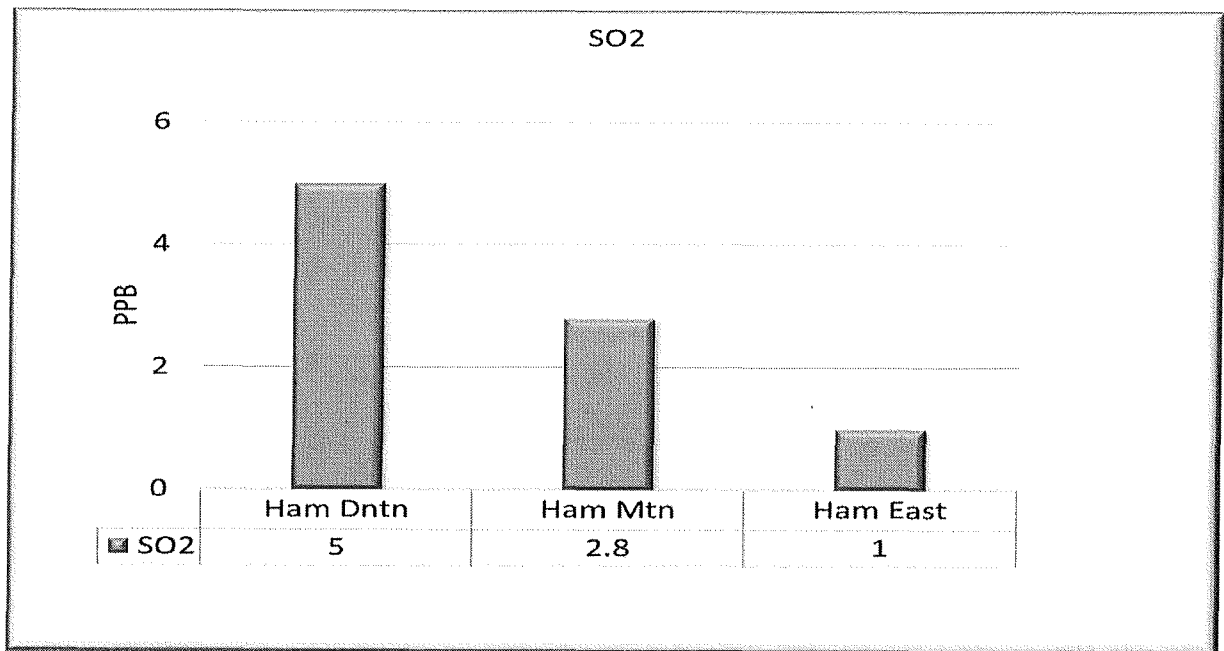


Figure 24 – Comparison of SO2 Concentrations from AirPointer East Hamilton Sam Manson Park Station 29105 with other Hamilton Stations

6.37 Historical Trend of SO2 Concentrations from East Hamilton Sam Manson Park Station.

SO2 levels at this site declined from 1986 to 1996, and the annual average for 2013 was even lower. See Figure 25. This is a city wide effect due to reductions in industrial emissions.

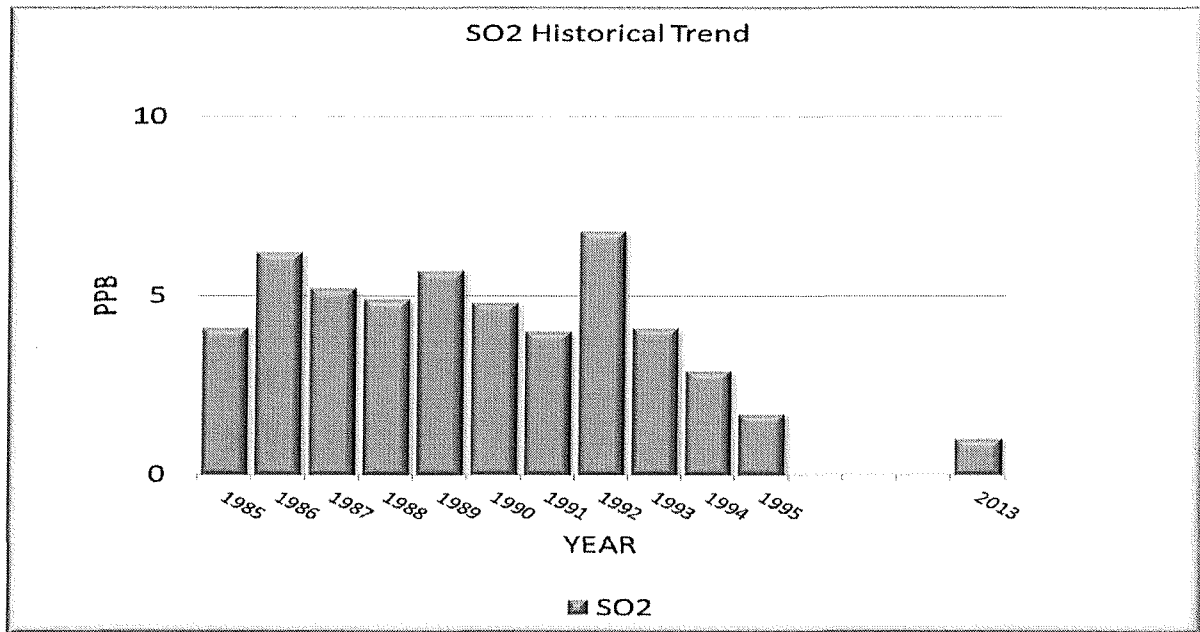


Figure 25 – Historical Trend of SO2 Concentrations at East Hamilton Sam Manson Park Station 29105

7.0 Summary of Exceedances

Table 7 lists the relevant Ambient Air Quality Criteria (AAQC) for the parameters monitored at the Hamilton East Station 29105

Ministry of the Environment – AAQC – Table 7

Contaminant	PM2.5 ¹	NO2 ²	NO2	CO	CO	O3	SO2	SO2	SO2
Criterion	30	200	100	30	13	80	20	100	250
Units	µg/m ³	ppb	ppb	ppm	ppm	ppb	ppb	ppb	ppb
Averaging Period	24 Hr	1 Hr	24 Hr	1 Hr	8 Hr	1 Hr	1 Yr	24 Hr	1 Hr

Note 1 - PM2.5 The value of 30 µg/m³ is the Canada Wide Standard (CWS) for PM2.5, is to be based on the 24 hour 98th percentile ambient measurement annually, averaged over three consecutive years.

Note 2 - Oxides of Nitrogen (NOX) are defined to be the sum of Nitrogen Dioxide (NO2) and Nitric Oxide (NO). Emissions of NOX consist mainly of NO, with some NO2. In ambient air, NO converts to NO2. NO2 has adverse effects at much lower concentrations than NO. Recognizing these factors, the standard for Oxides of Nitrogen is based on the health effects of NO2.

In the case of air quality assessments (e.g. annual air quality reports and special study reports) NO2, not NOX, is the reference contaminant. NOX AAQCs with 1 hour and 24 hour averaging times should only be compared to monitored Nitrogen Dioxide (NO2) data.

7.1 Summary of PM2.5 Exceedances

There were no exceedances of the MOE AAQC however an MOE PM2.5 reference level of 30 µg/m³ was exceeded twice in July, 2013 and the World Health Organization PM2.5 guideline of 25 µg/m³ was exceeded three times in July, 2013.

7.2 Summary of NO2 Exceedances

None to report

7.3 Summary of CO Exceedances

None to report

7.4 Summary of O3 Exceedances

There were twelve exceedances of the 80 ppb one hour average AAQC, one in May, 2013 and eleven in July, 2013. O3 is not a local point source generated pollutant. These exceedances were due to regional smog episodes.

7.5 Summary of SO2 Exceedances

SO2 exceeded the World Health Organization guideline once in October, 2013.

8.0 Results and Conclusions

An AirPointer air quality monitoring station was installed in Sam Manson Park near Barton Street/ Nash Road, close to the site of a previous Ministry of the Environment (MOE) Air Quality Index (AQI) station. This enabled data comparisons to be made and long term trends assessed. The air monitoring was conducted for one year from December 2012 to November 2013.

A full suite of pollutants and meteorological parameters was measured, including:

- Air Quality Health Index (AQHI)
- Sulphur Dioxide (SO2)
- Ozone (O3)
- Respirable Particulate, less than 2.5 microns (PM2.5)
- Carbon Monoxide (CO)
- Nitric Oxide (NO)
- Nitrogen Dioxide (NO2)
- Oxides of Nitrogen (NOX)
- Wind Speed (WS)
- Wind Direction (WD),
- Barometric Pressure (BP)
- Ambient Temperature (AMT)
- Relative Humidity (RH)
- Rainfall (Rain)

Prevailing winds at this site were from the SSW, next most frequent winds were from NW, with a small component from the NE.

Directional analyses indicated that the highest pollutant impacts were from the SSW direction, i.e., from the rest of the City and from long range transport of air pollutants.

Air Quality Health Index (AQHI) values showed the station site to have generally good air quality with 6947 hours in the Low Risk category, 1206 hours in the Moderate Risk category and no High or Very High values.

Variation of pollutants with time of day (diurnal analyses) showed that NO_x had a marked peak during morning rush hour which flattened out in the afternoon evening, as has been measured in other areas. O₃ peaks in the afternoon and drops off at night and this pattern was also observed at this station.

Comparisons with the three other AQHI stations in the City determined that the Hamilton East site had the lowest PM_{2.5} and SO₂ concentrations, Hamilton Mountain had the lowest NO₂ concentrations and Hamilton Downtown had the lowest O₃ concentrations.

The reason for the lower O₃ levels in the downtown area is that ozone levels are reduced by chemical interactions with other pollutants. Locations such as the Downtown and West stations which have higher levels of other pollutants will have correspondingly lower O₃ levels.

The directional analyses also showed little discernible impact from the Red Hill Valley Parkway.

Exceedances of Standards or Guidelines.

- There were no exceedances of the Carbon Monoxide (CO), Sulphur Dioxide (SO₂) or Oxides of Nitrogen (NO_x) Ontario Ministry of the Environment Ambient Air Quality Criteria (AAQC). See Note 1 below. SO₂ exceeded the World Health Organization guideline once in October, 2013.
- There were twelve Ozone (O₃) exceedances of the 80 ppb hourly AAQC, one in May, 2013 and eleven in July, 2013 during regional smog episodes.
- Three years of data are required to calculate the PM_{2.5} Canada Wide Standard of 30 µg/m³ (three year community average, 98th percentile). Only one year of data is available from this station, however, the 98th percentile value is 24 µg/m³, which would be well below the standard.
- A PM_{2.5} MOE Reference level of 30 µg/m³ was exceeded twice in July, 2013 and the PM_{2.5} World Health Organization guideline of 25 µg/m³ was exceeded three times in July, 2013.

Note 1 - Oxides of Nitrogen (NO_x) are defined to be the sum of Nitrogen Dioxide (NO₂) and Nitric Oxide (NO). In the case of air quality assessments (e.g. annual air quality reports and special study reports) NO₂ not NO_x, is the reference contaminant. NO_x AAQCs with 1 hour and 24 hour averaging times should only be compared to monitored Nitrogen Dioxide (NO₂) data.

References

1. Ontario Ministry of the Environment, Ontario's Ambient Air Quality Criteria, Standards Development Branch, PIBS No. 6570e, February 2008.
2. CCME, Canadian Council of Ministers of the Environment, Guidance Document on Achievement for Particulate Matter and Ozone, PN 1391, 2007.

3. Ontario Ministry of the Environment, Operations Manual for Air Quality Monitoring in Ontario, Operations Division, Technical Support, March 2008.
4. Canada-wide Standards for Particulate Matter (PM) and Ozone, endorsed by CCME Council of Ministers, June 5-6, 200, Quebec City.
5. Red Hill Valley Parkway Post Construction Ambient Air Quality Report, City of Hamilton, May, 2010.
6. Red Hill Neighbourhoods, Mobile Air Quality Monitoring to Determine Local Impacts City of Hamilton, July, 2010.