Hamilton Neighbourhoods

Mobile Air Quality Monitoring to Determine Local Impacts

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Acknowledgements

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1.0 Executive Summary

Fixed station monitoring in the City of Hamilton gives ongoing information about air quality, providing data for the Air Quality Health Index and forming the basis for air pollution control actions. However, for detailed knowledge of the air quality status of individual neighbourhoods, mobile monitoring is required.

As part of a community support grant program, the mobile air quality monitoring of individual neighborhoods was supported by ArcelorMittal Dofasco in partnership with the Conserver Society, Hamilton Public Health Services, Green Venture, the Ontario Ministry of the Environment, and Rotek Environmental. Hamilton Public Health Services funded the Red Hill neighbourhoods portion of this study.

Green Venture was tasked with neighbourhood outreach and report production, while Rotek Environmental performed the mobile air monitoring and data evaluation components of the program.

Consultation with a number of stakeholders, including neighbourhood associations, led to a target list of 26 neighbourhood locations to be monitored. For this initial phase of the program, 11 locations were monitored.

Mobile air monitoring techniques were used to evaluate levels of Carbon Monoxide (CO), Oxides of Nitrogen (NOX), Sulphur Dioxide (SO2), Inhalable Particulate (particulate matter less than 10 microns aerodynamic diameter, PM10) and Respirable Particulate (particulate matter less than 2.5 microns aerodynamic diameter, PM2.5). Regional wind directions were measured at the main Hamilton meteorological tower on Woodward Avenue. GPS monitors were used to specify monitoring locations and GIS (Geographic Information System) techniques were used to evaluate the data.

An innovative data evaluation technique was developed for this program. In order to provide the most meaningful results for neighborhood residents concerned about health effects as well as government officials pursuing air pollution control actions, total health effects (additional mortality percentages) due to air pollution were calculated for each neighborhood. These total values were then further structured into values for each individual pollutant, allowing diagnosis of the particular problems in each neighborhood.

Of the 11 neighbourhoods monitored, all showed some air pollution impacts, ranging from 6.8% to 18.4% increased mortality, with an overall average of 11.5% increased mortality due to air pollution. The majority of impacts were due to particulate matter and oxides of nitrogen. Five neighbourhoods showed above average levels of air pollution effects and this report details the specific pollutants responsible.

Special attention was paid to the Red Hill Valley area due to concerns about the impact of the Red Hill Valley Parkway. A number of measurements were made directly upwind and downwind of the road in order to evaluate expressway effects. All measurements in neighbourhoods close to the Red Hill Valley Parkway showed pollutant levels well below Ministry Ambient Air Quality Criteria (AAQC) and the average for the neighbourhoods was below the city wide average for calculated mortality increases. Analysis of upwind vs. downwind data showed very little or no effect of the Red Hill Parkway on neighbouring air quality. It is proposed that the channeling effects of the valley, in combination with the southwest prevailing winds, tend to contain vehicle emissions in the valley so that they are not dispersed laterally into bordering residential areas.

2.0 Introduction

Fixed station monitoring in the City of Hamilton gives ongoing information on air quality and provides data for the Air Quality Health Index and air pollution control actions. However, for detailed knowledge of the air quality status of individual neighbourhoods, mobile monitoring is required.

As part of a community support grant program, mobile air quality monitoring of individual neighborhoods was supported by ArcelorMittal Dofasco in partnership with the Conserver Society, Hamilton Public Health Services, Green Venture, the Ontario Ministry of the Environment, and Rotek Environmental. Hamilton Public Health Services funded the Red Hill neighbourhoods portion of this study.

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Special attention was paid to the Red Hill Valley area due to concerns about the impact of the Parkway. A number of measurements were made directly upwind and downwind of the road in order to evaluate expressway effects. Fixed station monitoring had been conducted at a specific location adjacent to the Parkway, but neighbourhood residents had expressed local concerns.

3.0 Monitoring Methodologies

3.1 Mobile Sampling Unit

The mobile sampling unit had originally been designed as an MOE command centre and thus required modifications to use as a monitoring facility. Figures 1, 2 and 3 show details of the sampling systems.

Figure 1 – Mobile Command Centre

Rack mounts were installed to accept continuous monitoring instruments. The Grimm Dust Monitor was mounted separately, since a straight sampling path to ambient air is required to avoid unwanted particle size selection artifacts during sampling.

Figure 2 – Rack Mounting

Figure 3 – Particle Analyzer

Ambient air for the gaseous analyzers was sampled through a specially constructed gooseneck sampling head which passed through the roof of the vehicle, see Fig.4. A rain shield attachment was added to prevent precipitation entering the system. Sampling intake height was approximately 3 metres above ground level. This sampling height is important to mitigate instantaneous fluctuations in pollutant concentrations due to tailpipe emissions. One quarter inch diameter Teflon tubing with particle pre-filters was used to distribute the incoming air to the gas analyzers. The Grimm Dust Monitor was modified with a 2 metre-long sampling intake to reach through the vehicle roof.

Figure 4 – Sampling Intakes on Roof of Vehicle

Positional information was captured through a roof-mounted Garmin GPS16-HVS detector. A second GPS unit was attached to the vehicle windshield (Garmin 18 laptop-enabled GPS) and used as a backup, Figure 5.

The following Air Quality contaminants were measured:

- Carbon Monoxide (CO)
- Oxides of Nitrogen (NO, NO2, NOX)
- Sulphur Dioxide (SO2)
- PM10 (Inhalable Particulate, particulate matter < 10 microns aerodynamic diameter)
- PM2.5 (Respirable Particulate, particulate matter < 2.5 microns aerodynamic diameter)
- Meteorological parameters (at Woodward Ave.)
    - Wind Speed
    - Wind Direction
    - Ambient Temperature

All pollution and GPS data were collected simultaneously using a Campbell CR1000 data logger and stored in an integrated database, Figure 6. The temporal resolution of both the pollutant information and the positional information was 1 second.

Figure 5 – Dashboard-mounted GPS head, Garmin 18

Figure 6 – Display on Laptop Computer of Geographic Information System (GIS)

Detailed hand-written sampling logs were maintained to assist in data interpretation.

3.2 Continuous Air Quality Instrumentation

Table 1 lists the make, model and principle of operation of the continuous air quality monitoring instrumentation used during the survey.

Table 1 Air Quality Continuous Monitoring Instrumentation

Air Quality Parameter	Instrument Type	Principle of Operation
Oxides of Nitrogen NO, NO2, NOX	Thermo Scientific Model 42i	Chemiluminescence
Carbon Monoxide CO	Thermo Scientific Model 48	Gas Filter Correlation
Sulphur Dioxide SO2	Monitor Labs 8850	Fluorescence
Inhalable / Respirable Particulate PM10, PM2.5	Grimm Model 1.107	Laser Optical

Table 2 lists the performance specifications for the continuous monitoring instruments.

Table 2 Air Quality Continuous Monitoring Instrument Specifications

Specification	CO	NOX	SO2	PM10 / PM2.5
Operating Range	0-50 ppm	0-1000 ppb	0-10000 ppb	0-500 ug/m^3
Minimum Detectable Limit	0.10 ppm	0.4 ppb	1 ppb	0.06 ug/m^3
Precision	0.1 ppm	0.4 ppb	5 ppb	1.5 ug/m^3
Linearity	1%	1%	1%	0.75%
Zero Drift	0.2 ppm / 24 hr	0.4 ppb / 24 hr	2 ppb / 24 hr	NA
Span Drift	1% / 24 hr	1% / 24 hr	4% / 24 hr	NA

4.0 Methodology

The requirements of this neighborhood-specific program demanded that new techniques for analyzing data be used. Total health effects, which is to say additional mortality percentages, were calculated on a neighborhood –by-neighborhood basis. These results were further detailed into mortality data for individual pollutants, allowing diagnosis of the particular problems in each neighborhood.

This process was intended to yield results that would meet the needs of both residents who are concerned about health effects and government officials who are interested in controlling air pollution where controls are most appropriate.

After the mobile data were collected, they were reviewed, quality controlled and edited using the detailed field notes collected during sampling. GPS and pollutant data were both time-stamped so that GIS software could be used to link geographic locations to pollutant concentrations.

Clean Air Hamilton has developed a list of individual health impacts by pollutant and concentration see http://www.cleanair.hamilton.ca/downloads/Health-Study-%28Executive-Summary%29%20.pdf . These values were then used to calculate the localized health impacts in each neighbourhood for given wind directions.

5.0 Ambient Air Quality Mobile Monitoring Results

Consultation with a number of stakeholders, including neighbourhood associations, led to a target list of 26 neighbourhood locations to be monitored.

5.1 Total Health Effects and Ranking

For this initial phase of the program, 11 locations were monitored.
These locations were:

- Dundas
- Limeridge Mall
- Near Mountain
- Red Hill Neighbourhoods
- Delta
- Lawrence Ave to Burlington St
- North West End
- Wentworth North
- McAnulty Blvd
- Beach Blvd/Eastport Dr
- Jones Rd/Arvin Ave.

Figure 7 shows the GIS plot of the calculated % mortality data across Hamilton (excepting the Red Hill area which was analyzed separately). Highest risk levels are on expressways.

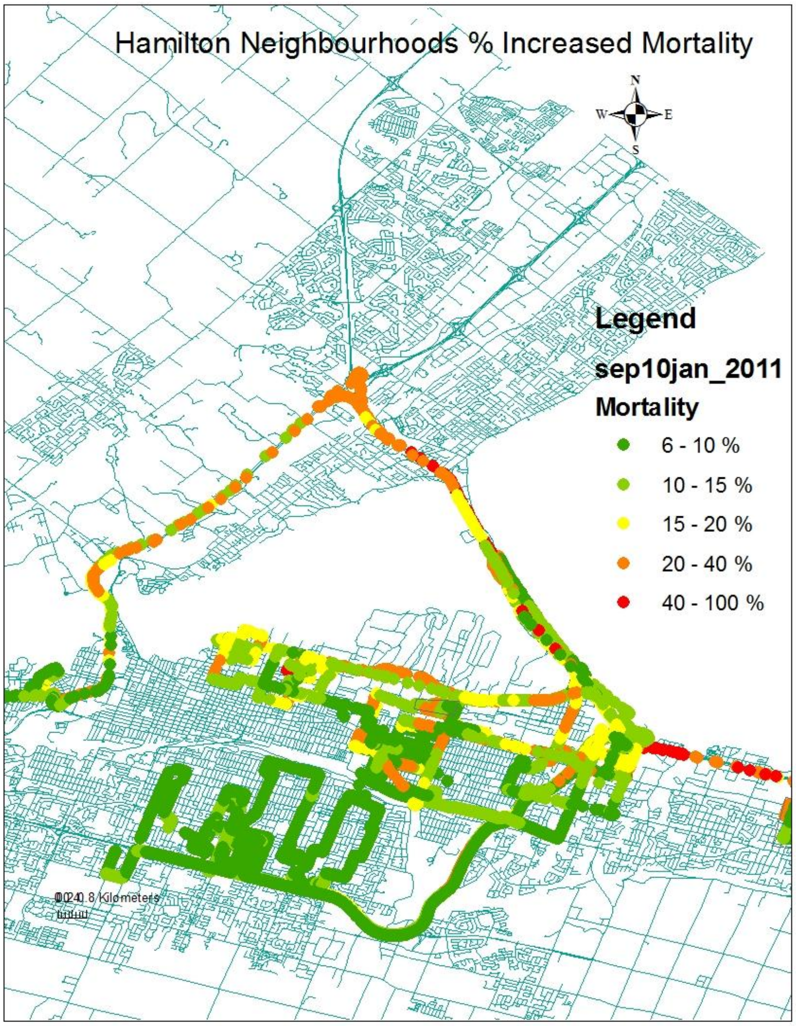


Figure 7 – Hamilton Neighbourhoods, GIS Map of Calculated Percentage Increased Mortality

All neighbourhoods showed some air pollution impacts, ranging from 6.8% to 18.4% increased mortality. The overall average was 11.5% increased mortality. The majority of impacts Page: 8 that are represented here were caused by particulate and oxides of nitrogen. Five neighbourhoods showed above average levels of air pollution effects.

The results of the health evaluations are combined in Figure 8 to show a city-wide ranking of health impacts. The five neighbourhoods above average were the McAnulty Blvd. area, North West End, Jones Rd./Arvin Ave., Eastport Dr. and Wentworth North. Due to limitations in wind directions during the study, these data mostly represent winds from the south west, except for Eastport Dr., Beach Blvd. and Red Hill. For Eastport Dr. and Beach Blvd., the detailed differences between east and southwest winds allowed identification of particular effects due to upwind-downwind differences.

Note that highway exposures are far above any neighbourhood mortality values.

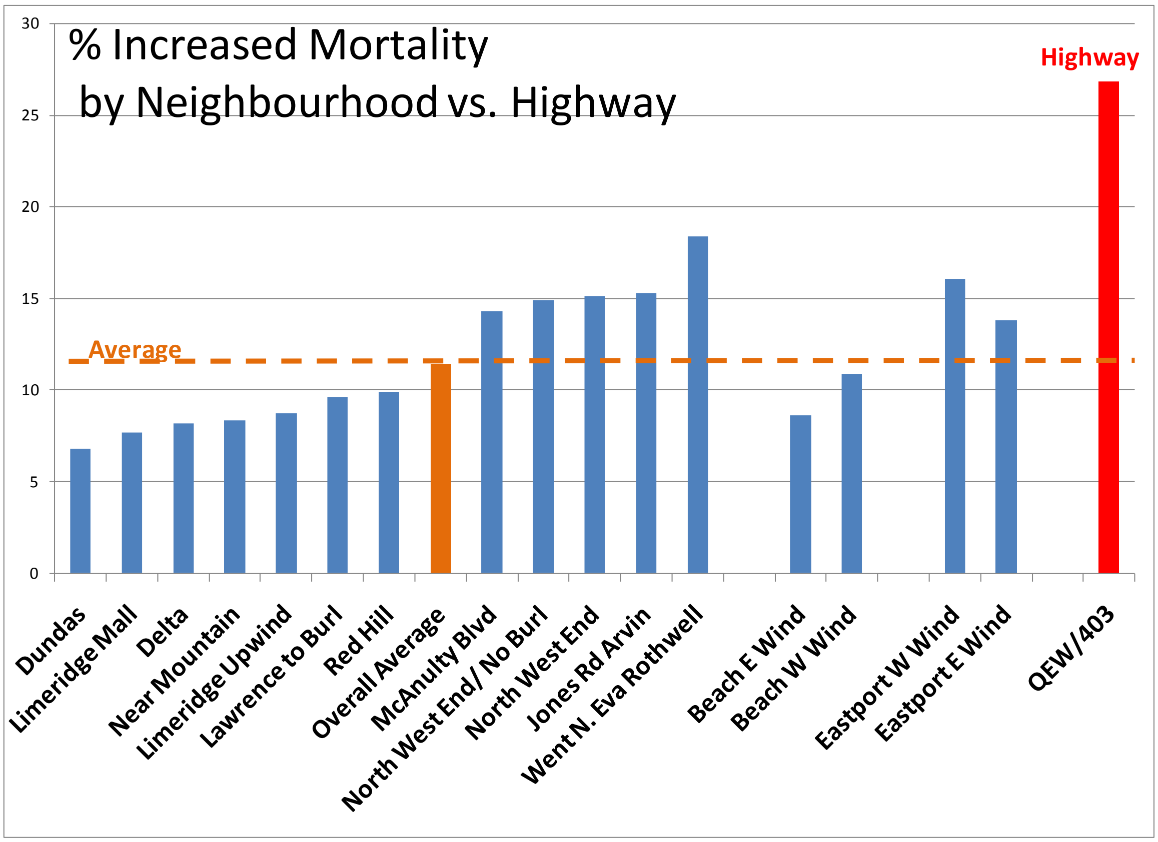


Figure 8 – Ranking of Hamilton Neighbourhoods by Calculated Percentage Increased Mortality

5.2 City Average Health Impacts by Pollutant

Averages for the entire city for calculated increased mortality by pollutant are shown in Figure 9. The overall average is 11.5% calculated increased mortality.

Particulates, i.e., PM10 and PM2.5 remain the most problematic pollutants for the City, followed closely by oxides of nitrogen, NO and NO2. Although NO2 has received much attention because of its greater inherent toxicity, clearly, NO is also a very significant pollutant and should probably have a separate provincial criterion.

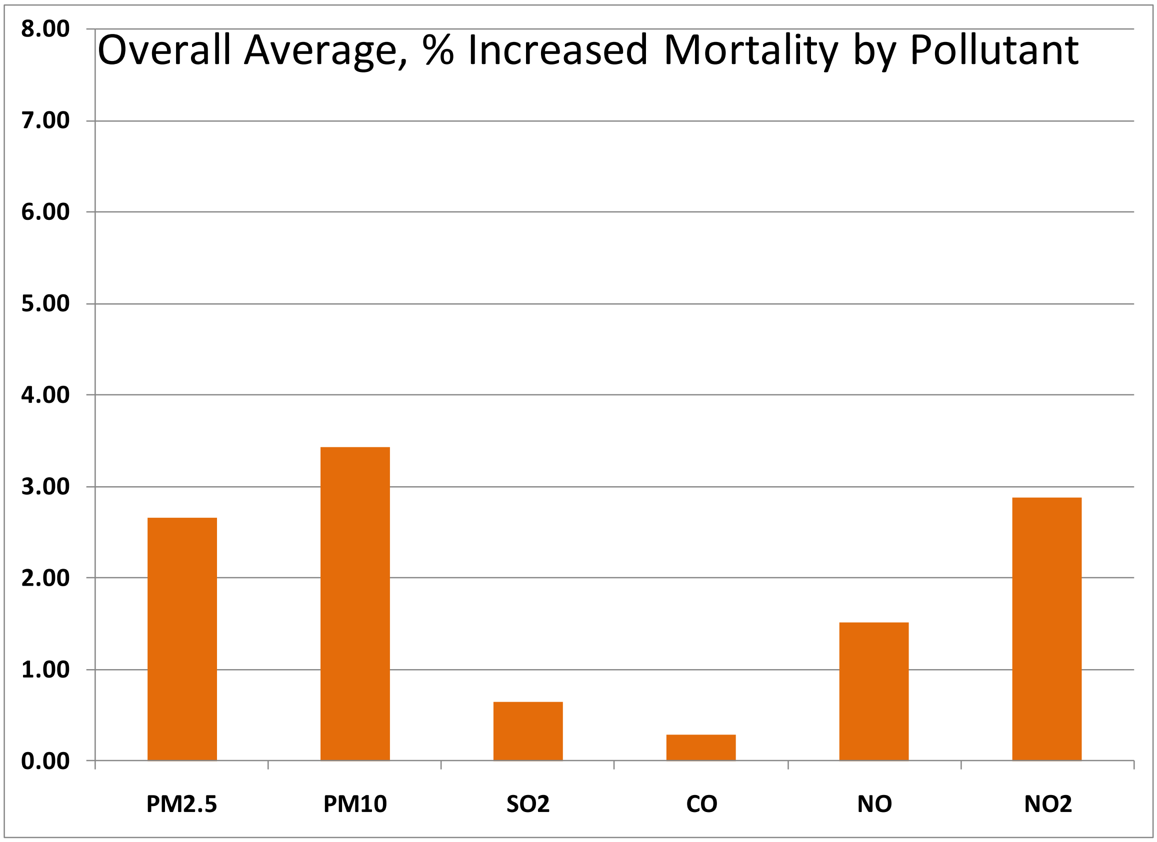


Figure 9 – City Average Health Impacts by Pollutant

These next sections deal with neighbourhoods with above average calculated mortality percentages, in increasing rank order.

5.3 McAnulty Blvd

The McAnulty Blvd area had a calculated increased mortality of 14.3% due to air pollutants compared to the city wide average of 11.5%. Figure 10 shows the GIS plot of calculated mortality for the McAnulty area.

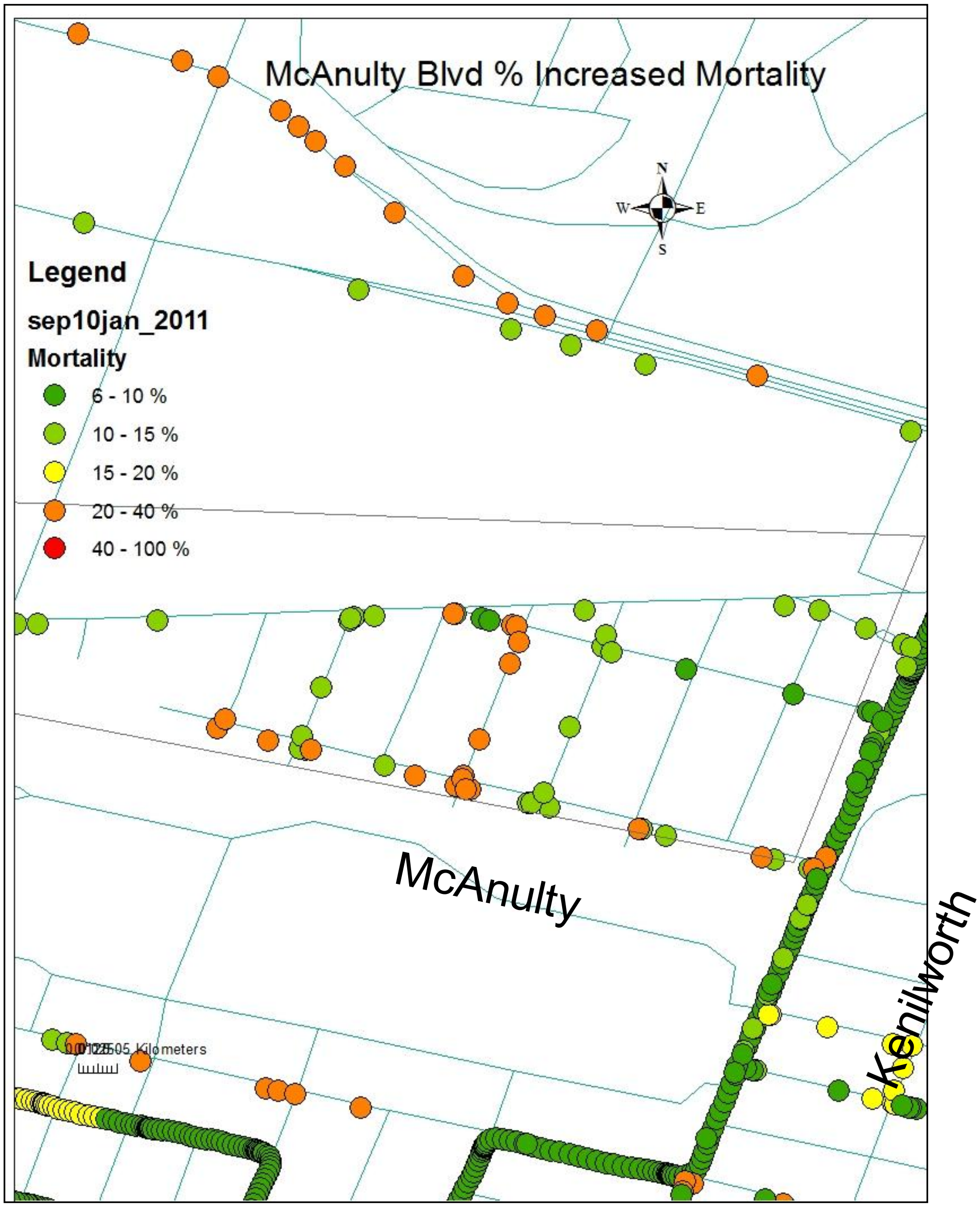


Figure 10 – McAnulty Blvd, GIS Map of Calculated Percentage Increased Mortality

Figure 11 shows the comparison between city averages and the McAnulty area for % increased mortality by pollutant. The additional risk is entirely due to particulate, mostly PM10. Identification and control actions should therefore be directed at particulate sources, including fugitive sources and resuspended road dust.

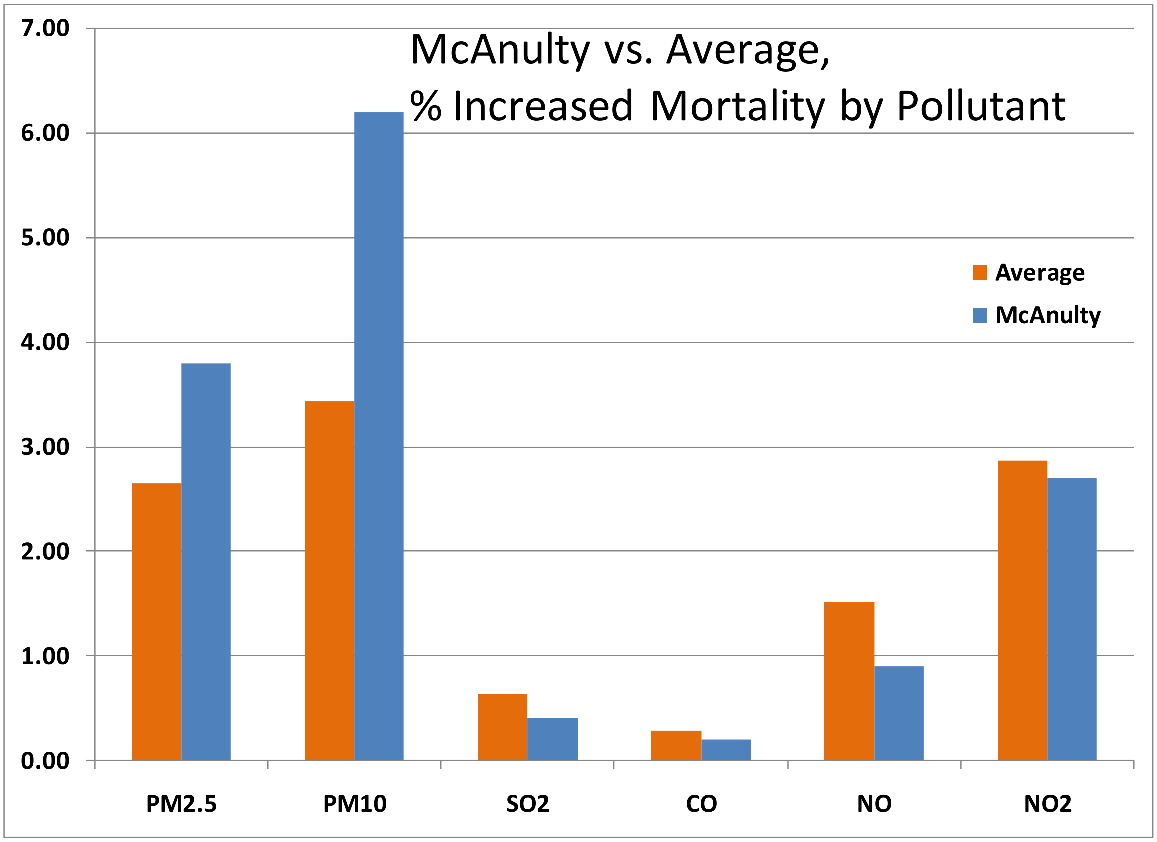


Figure 11 – Comparison of McAnulty and City Average Health Impacts by Pollutant

5.4 North West End

The North West End area had a calculated increased mortality of 15.1% due to air pollutants compared to the city wide average of 11.5%. Figure 12 shows the GIS plot of calculated mortality for the North West end.

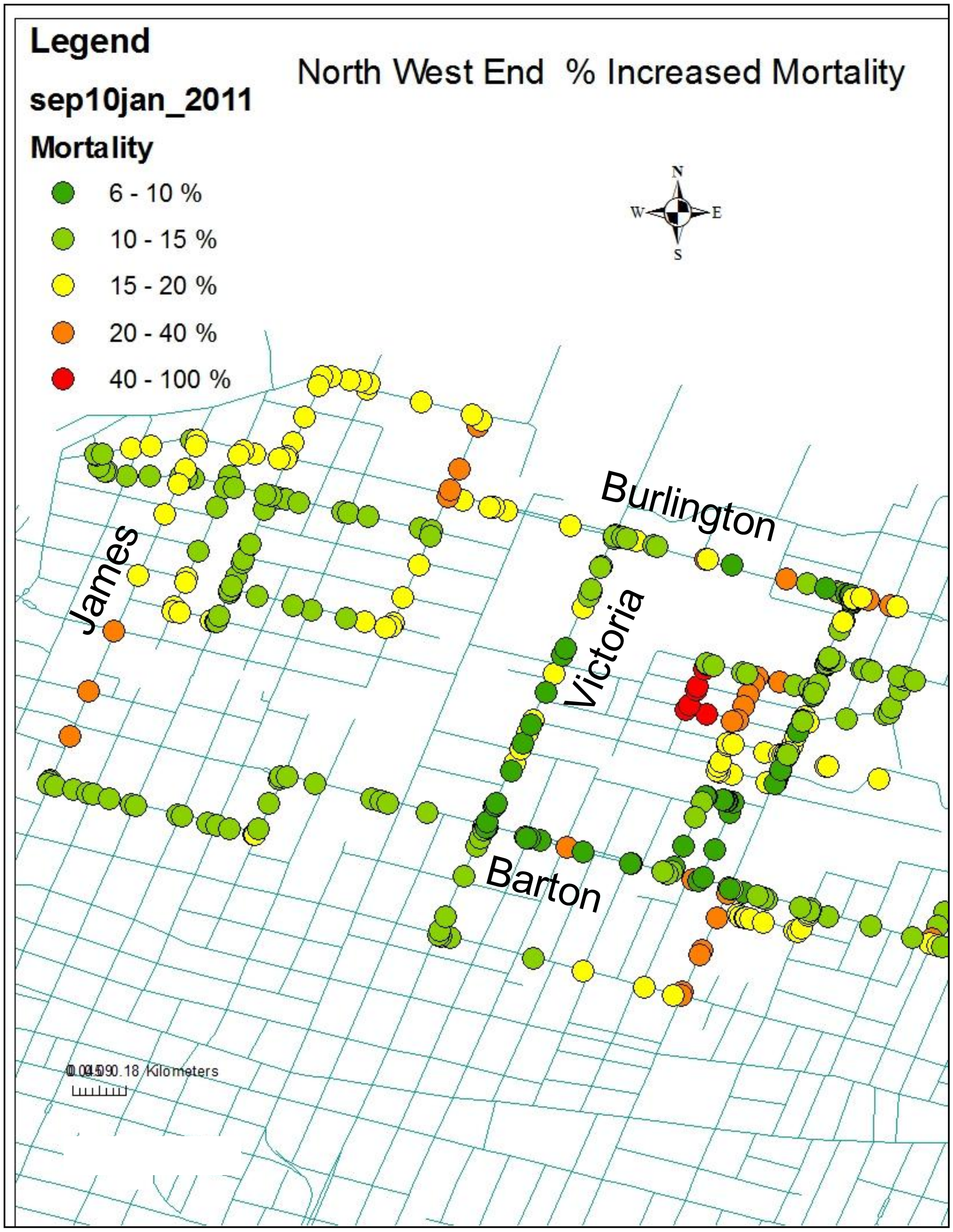


Figure 12 – NorthWest End, GIS Map of Calculated Percentage Increased Mortality

Figure 13 shows the comparison between city averages and the North West End for % increased mortality by pollutant. The additional risk is mainly due to NO2, with some particulate effects. Local vehicle emissions would be expected to give higher values of NO as well as NO2. Identification and control actions should therefore be directed at potential NO2 sources as well as particulate sources, including fugitive sources and resuspended road dust.

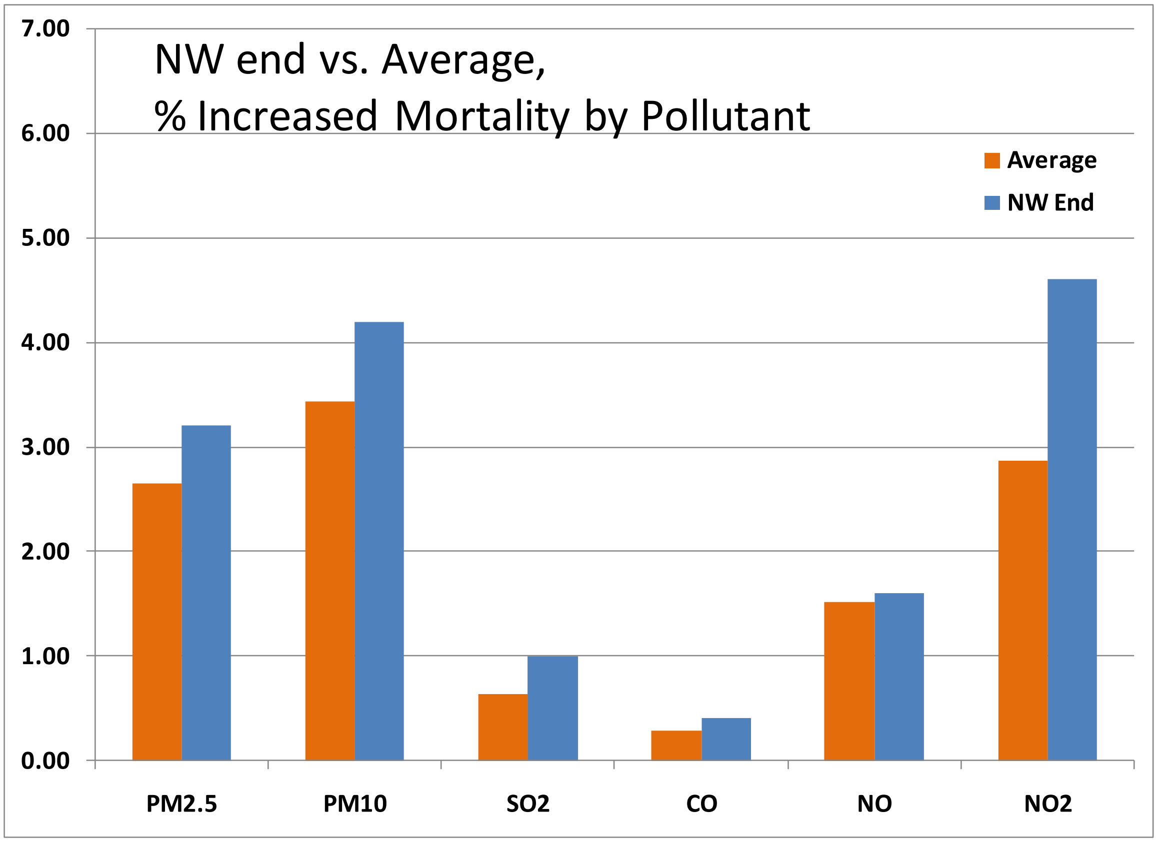


Figure 13 – Comparison of NorthWest End and City Average Health Impacts by Pollutant

Since the west end of Burlington Street runs through the sampling area and there is the potential for truck traffic to affect the results, a separate calculation of % mortality was made with the Burlington Street roadway measurements removed, see figure 14. Removing the roadway data did not make any difference, i.e., light blue and dark blue bars on the graph are the same. The reason for this is probably that most Burlington Street truck traffic turns north before reaching this particular study area

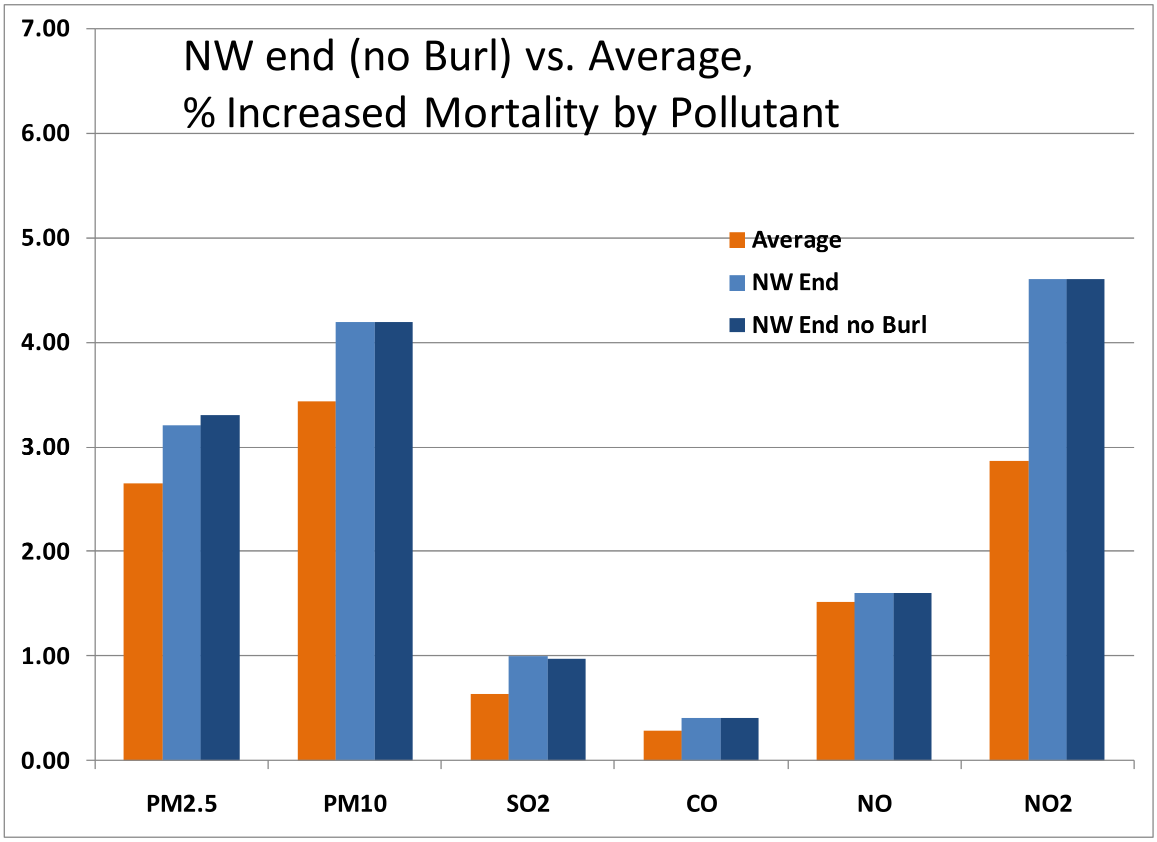


Figure 14 – Comparison of NorthWest End without Burlington St and City Average Health Impacts by Pollutant

5.5 Jones Rd/Arvin Ave

The Jones Rd/Arvin Ave area had a calculated increased mortality of 15.3% due to air pollutants compared to the city wide average of 11.5%. Figure 15 shows the GIS plot of calculated increased mortality for the Jones Rd/Arvin Ave area. Note the consistently high levels on the highway QEW.

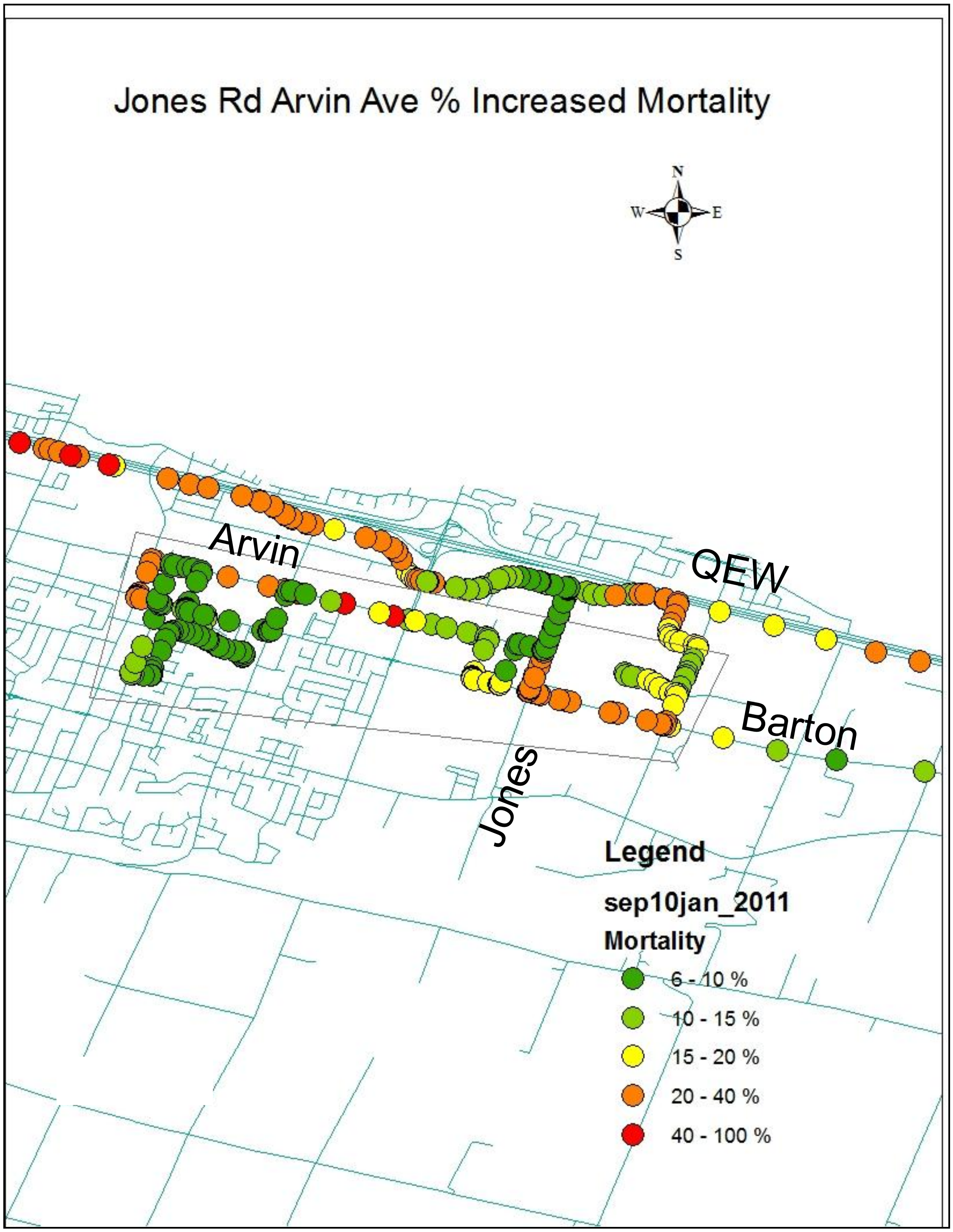


Figure 15 – Jones Rd/Arvin Ave, GIS Map of Calculated Percentage Increased Mortality

Figure 16 shows the comparison between city averages and the Jones Rd/Arvin Ave area for % increased mortality by pollutant. The additional risk is entirely due to particulate, mostly PM10. Identification and control actions should therefore be directed at particulate sources, including fugitive sources and resuspended road dust.

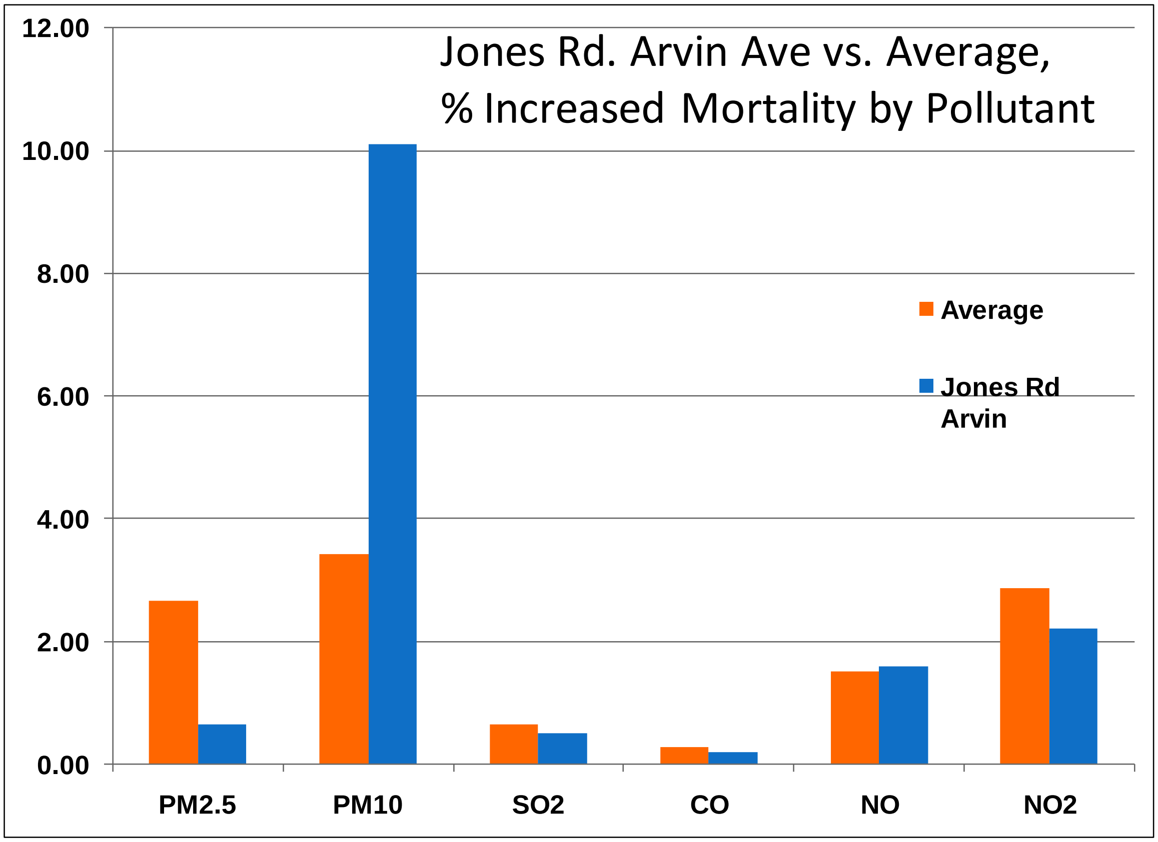


Figure 16 – Comparison of JonesRd/Arvin Ave and City Average Health Impacts by Pollutant

5.6 Wentworth North/Eva Rothwell Centre

The Wentworth North/Eva Rothwell Centre area had a calculated increased mortality of 18.4% due to air pollutants compared to the city wide average of 11.5%. Figure 17 shows the GIS plot of calculated increased mortality for the Wentworth North/Eva Rothwell Centre area.

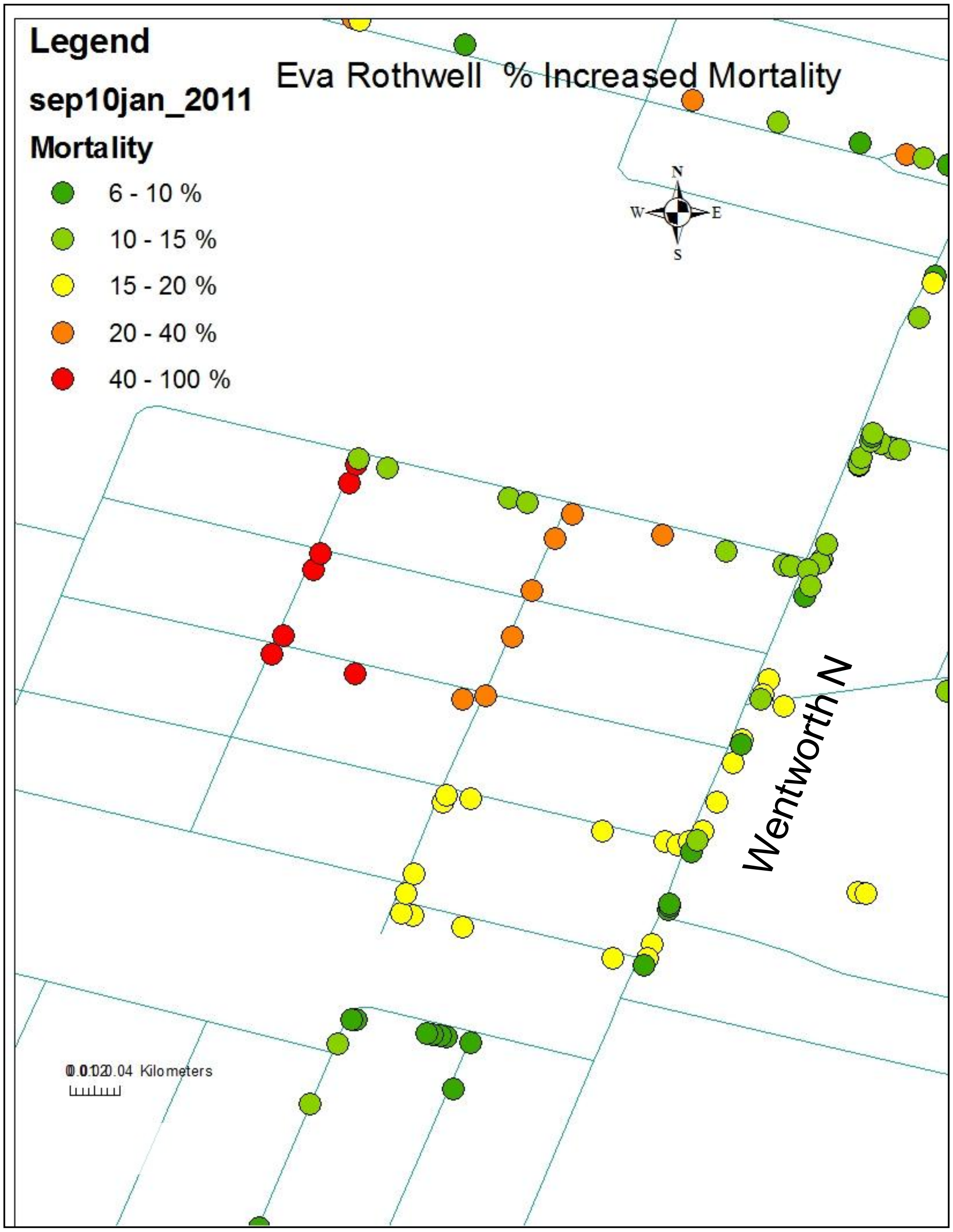


Figure 17 – Wentworth N/Eva Rothwell Centre, GIS Map of Calculated Percentage Increased Mortality

Figure 18 shows the comparison between city averages and the Wentworth North/Eva Rothwell Centre area for % increased mortality by pollutant. The additional risk is mainly due to particulate, mostly PM10, although PM2.5 and NO2 also contribute. Identification and control actions should therefore be directed at particulate sources and NO2, including fugitive sources and resuspended road dust.

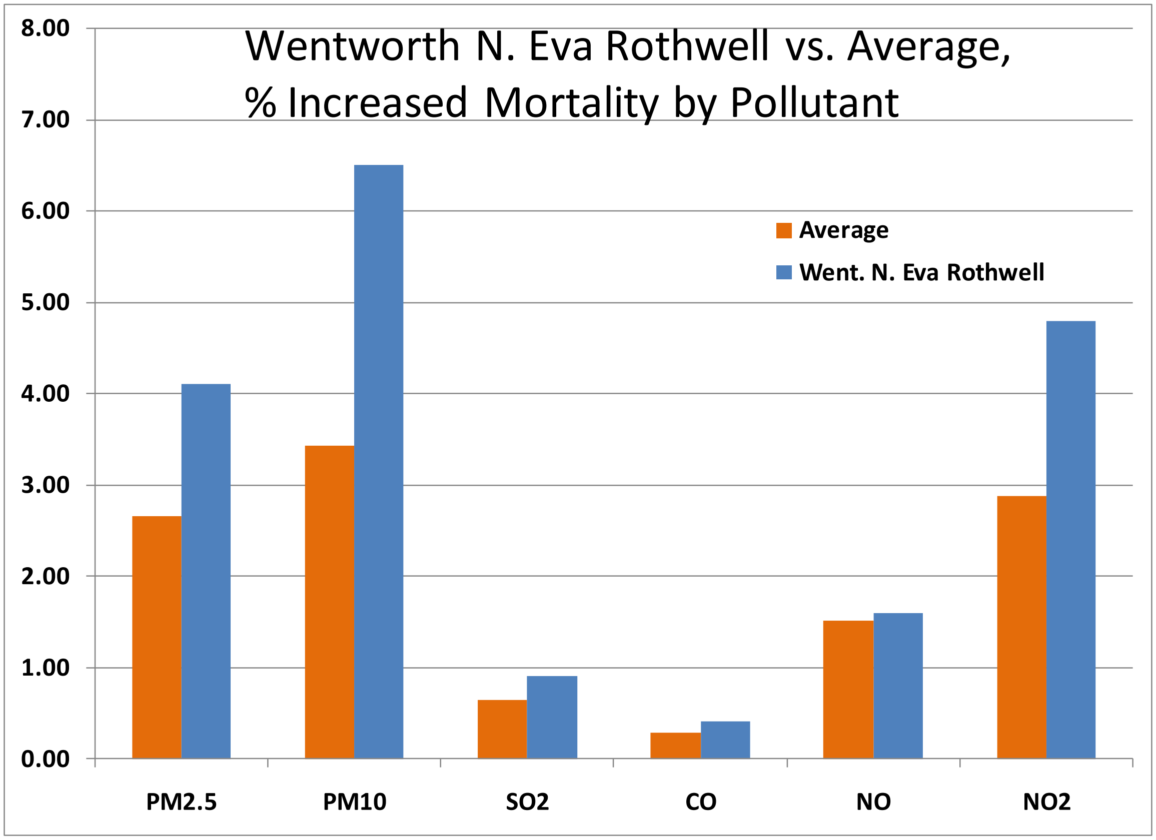


Figure 18 – Comparison of Wentworth N./Eva Rothwell Centre and City Average Health Impacts by Pollutant

5.7 Eastport Dr and Beach Blvd

The Eastport Dr/Beach Blvd area had a particularly interesting set of results. Eastport Dr. under southwest winds had a calculated increased mortality of 16.1% due to air pollutants compared to the city wide average of 11.5%. With east winds (from Lake Ontario and the QEW), calculated increased mortality was 13.8 %. For Beach Blvd., southwest winds gave 10.9% while east winds from the lake gave 8.6%/ Figure 19 shows the GIS plot of calculated increased mortality for the Eastport Dr/Beach Blvd area.

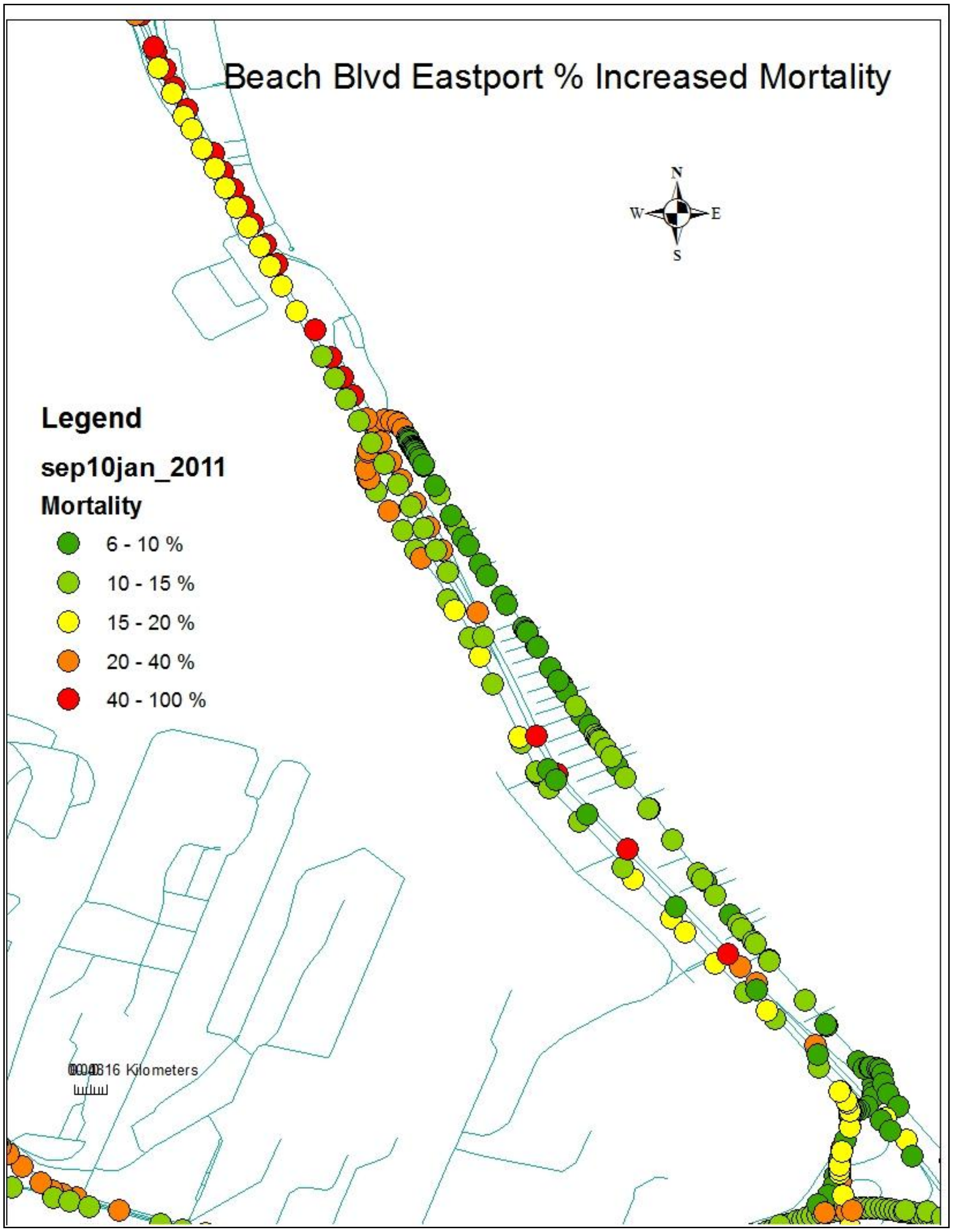


Figure 19 – Eastport Dr/Beach Blvd, GIS Map of Calculated Percentage Increased Mortality

Figure 20 shows the comparison between city averages and the Eastport Dr. area for % increased mortality by pollutant. When the wind is from the east the additional risk is mainly due to NO and NO2, clearly from truck traffic on the QEW. When the wind is from the west and Eastport Drive is downwind of the industrial area and the city, the additional risk is mainly due to particulate, mostly PM10, although PM2.5 also contributes. Identification and control actions should therefore be directed at particulate sources and NO2, including fugitive sources and resuspended road dust.

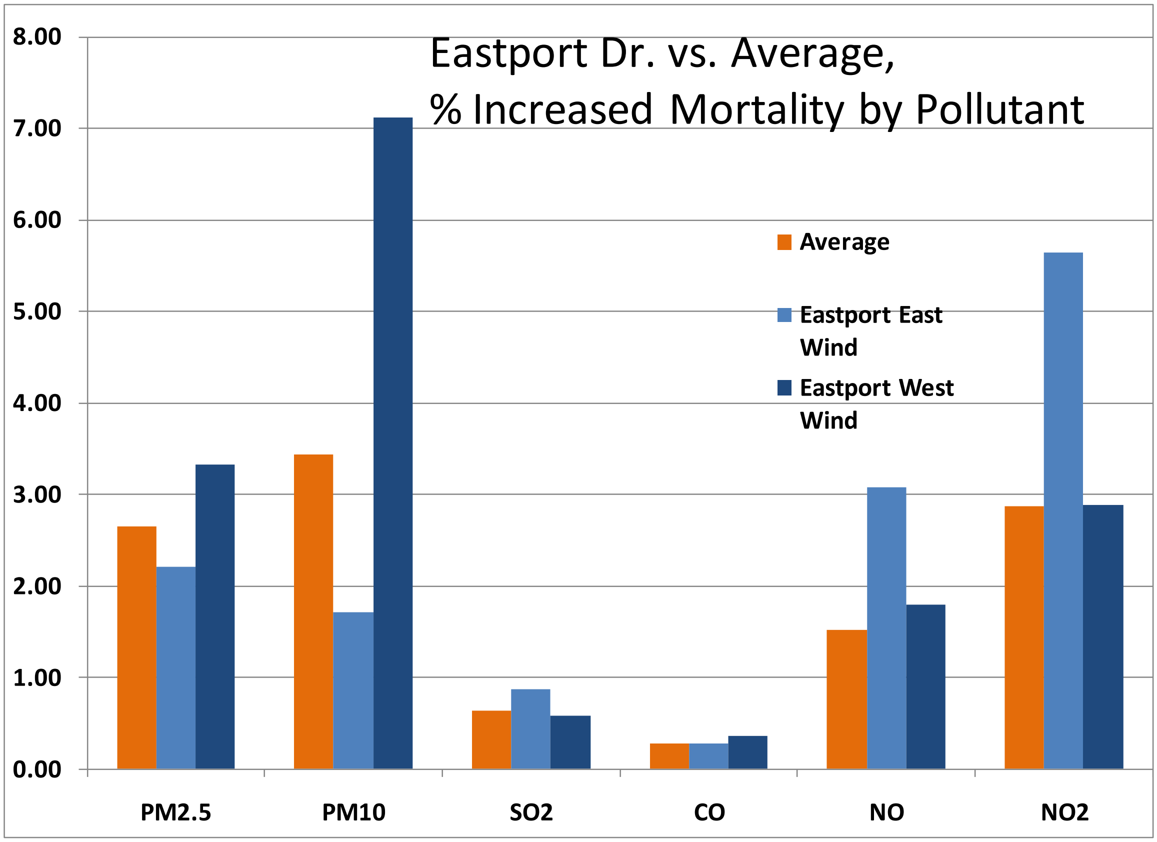


Figure 20 – Comparison of Eastport Dr with East and West Winds and City Average Health Impacts by Pollutant

Figure 21 shows the comparison between city averages and the Beach Blvd area for % increased mortality by pollutant. When the wind is from the east, coming off the lake, the risk levels are mainly lower than city average, particularly for PM10 although there is a small increase in NO2. When the wind is from the west and Beach Blvd is downwind of both the industrial area and the QEW, rather surprisingly, the calculated mortality percentages are very close to city averages instead of being elevated. It is noteworthy that most of Beach Blvd is protected by sound barriers which have been shown in other studies to reduce air pollution levels downwind.

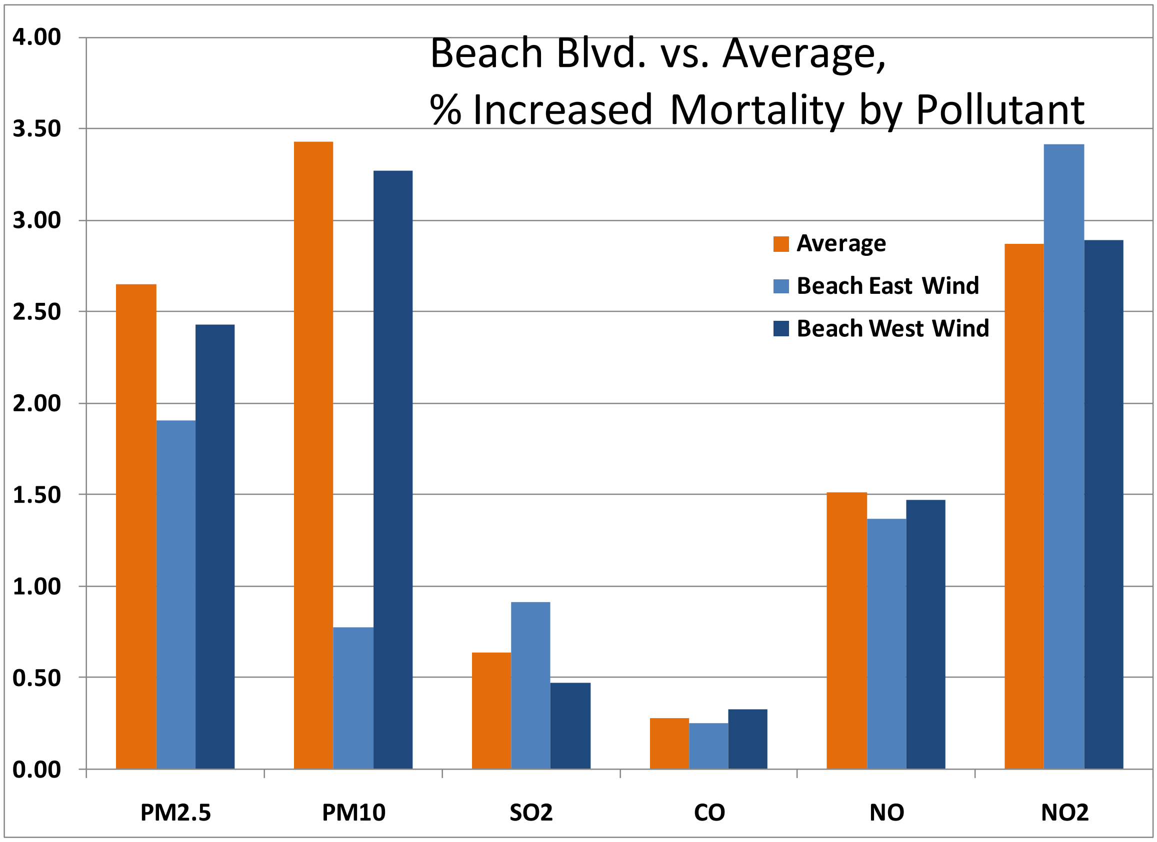
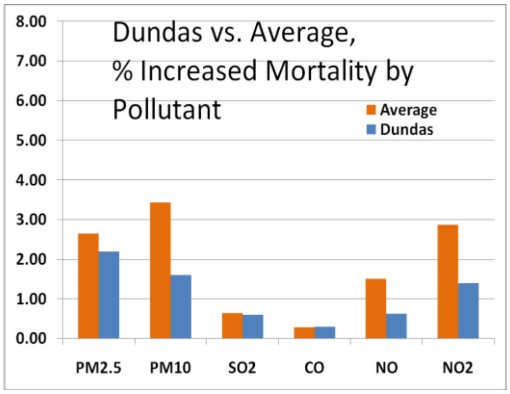


Figure 21 – Comparison of Beach Blvd with East and West Winds and City Average Health Impacts by Pollutant

5.8 Neighbourhoods with Lower than City Average % Mortality

For completeness, comparison graphs by pollutant, Figures 22, 23, 24, 25, 26 and 27 are included for neighbourhoods with lower than city average % mortality, including the Red Hill neighbourhoods.



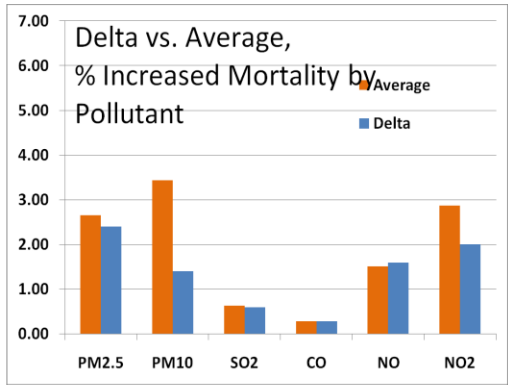
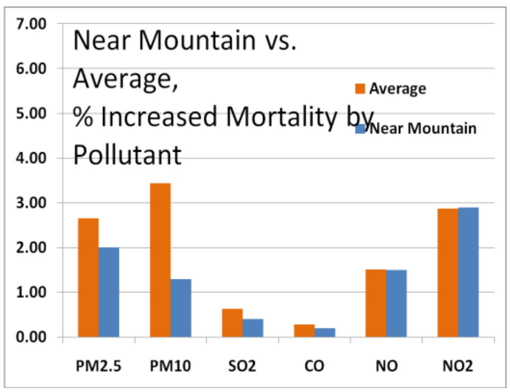


Figure 22 – Dundas Comparison

Figure 23 – Delta Comparison



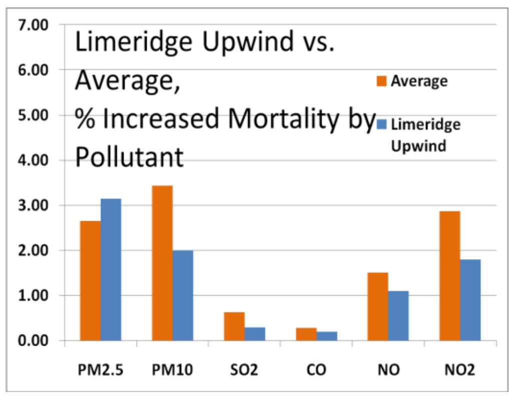
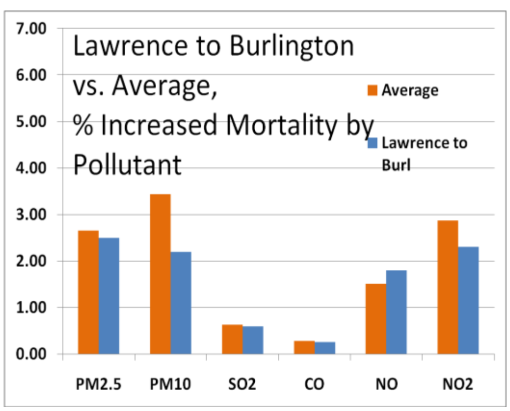


Figure 24 – Near Mtn Comparison

Figure 25 – Limeridge Upwnd Comparison



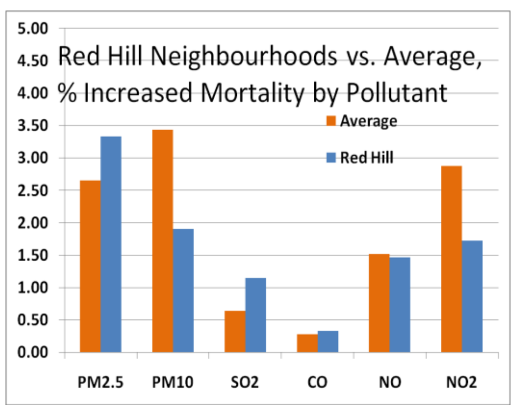


Figure 26 – Lawrence to Burl Comparison

Figure 27 – Red Hill Comparison

6.0 Red Hill Neighbourhoods Methodology

Measurements were made on ten sampling days from November 2009 to March 2010. Comparisons to relevant AAQCs were made, as well as to air monitoring measurements in other parts of the city.

In addition, air pollution measurements from neighbourhoods upwind and downwind of the Red Hill Parkway were identified using the GPS location data and upwind and downwind averages calculated. Comparison of upwind and downwind averages allows estimation of potential Parkway impacts.

6.1 Ministry of the Environment Ambient Air Quality Criteria

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 air quality standards used in this report are the current Ontario AAQCs as published by MOE Standards Development Branch, dated February 2008. The full list of 339 Ambient Air Quality Criteria is available at http://www.ene.gov.on.ca/publications/6570e-chem.pdf with details of averaging times and the limiting effects on which each criterion is based. For this study, hourly AAQCs were the most appropriate for comparison. In the case of PM10 and PM2.5, these particulate pollutants have a minimum 24 hour averaging time, so the relevant levels are used as indicator levels only.

The pollutants monitored were Carbon Monoxide (CO), Oxides of Nitrogen (NOX), Sulphur Dioxide (SO2) and Particulates (PM10 and PM2.5). Relevant AAQCs are summarized below in Table 3.

6.2 Continuous Gas and Particulate AAQCs

Table 3 Ministry of the Environment Ambient Air Quality Criteria Continuous Gaseous and Particulate Pollutants

Contaminant	CO	NOX	SO2	PM10	PM2.5
Criterion	30	200	250	50	30
Units	ppm	ppb	ppb	µg/m^3	µg/m^3
Average Period	1 Hr	1 Hr	1 Hr	24 Hr	24 Hr

Note 1. **NOX** NOX is normally the sum of NO and NO2. In the case of air quality assessments, e.g. annual air quality reports and special study reports (such as this one), 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.

Note 2. **PM10** The value of 50 ug/m3 (24 hr average) is an interim AAQC and is provided by MOE as a guide for decision-making with no conversion to other averaging times.

Note 3. **PM2.5** The value of 30 ug/m3 (24 hr average) is the Canada-wide Standard (CWS) for PM2.5, 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 PM2.5 CWS (by the year 2010) in various airsheds is to be based on the 24 hour 98th percentile ambient measurement annually, averaged over three consecutive years.

6.3 Red Hill Neighbourhoods Upwind/Downwind Averages

Winds were mainly from either the southwest or the northeast, which are the prevailing major wind directions in the Hamilton area. Background (upwind) concentrations varied considerably, but it had been expected that emissions from the Parkway could cause a noticeable increase in pollution concentrations downwind. In order to separate upwind and downwind concentrations for each sampling day, data for each day from the Red Hill residential neighbourhoods were isolated, then further stratified into upwind and downwind according to the wind direction on that day. Upwind residential data for that day were combined to give an upwind average and downwind data combined to give a downwind average. Comparing these averages should give information on Parkway effects.

Table 4 shows the overall summary statistics for the measured pollutants, with no exceedances of the AAQC during the study. Upwind and downwind levels were very close. Surprisingly, the overall upwind overall averages were consistently higher than the downwind averages, contrary to expectations that the Red Hill Parkway would have significant downwind impacts.

Table 4 Red Hill Overall Averages Upwind vs. Downwind Comparison

Pollutant	CO	NO2	SO2	PM2.5	PM10
Units	ppm	ppb	ppb	ug/m3	ug/m3
AAQC	30	200	250	30	50
Upwind	0.92	12.44	5.93	11.64	27.10
Downwind	0.86	10.52	5.57	11.38	22.72

In order to investigate further, graphs were made of upwind/downwind variations by individual sampling day and indeed this showed a more conventional pattern on some sampling days, i.e., the upwind pollutant levels were lower than downwind pollutant values, but others reversed this pattern.

The following sections show the Geographic Information System mapping of the spatial variation of air pollutants on and beside the Parkway as well as on the Queen Elizabeth Way and downtown for comparison purposes. Figures showing the daily variations in upwind vs.downwind values by pollutant are also included

6.4 Carbon Monoxide - Upwind/Downwind Averages by Day

CO is a colourless, odourless, tasteless, and, at high concentrations, a poisonous gas. CO sources due to human activity include the burning of fossil fuels, e.g., gasoline, diesel and coal.

The transportation sector accounts for 65 percent of all CO emissions from human activity in Ontario. A large part of the remainder comes from primary metal producers (24 percent) and from fuel combustion in building heating and industrial processes (6 percent).

Figure 28 shows the GIS map of CO concentrations in the Red Hill neighbourhoods as well as on the Parkway, the QEW, Centennial Parkway, Nash Road and downtown. Neighbourhood values were low, well below standards, with the highest pollution concentrations being on major roads, especially at on and off ramps. Accelerating and decelerating at on and off ramps will result in higher vehicle emissions compared to vehicles operating at constant speeds when engines are at their most efficient. Downtown measurements were influenced by heavy stop and go traffic, with similar effects.

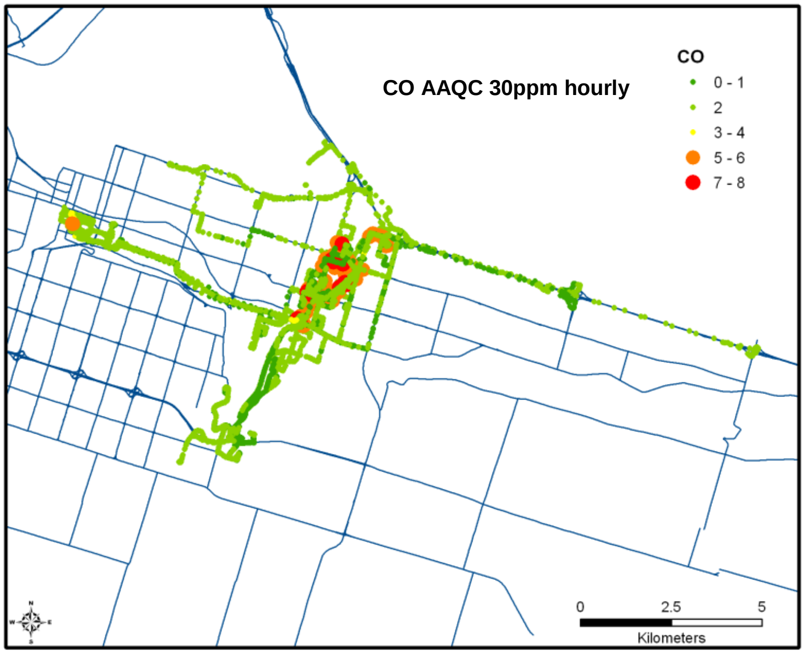


Figure 28 GIS chart of CO concentrations in ppm in Red Hill Neighbourhoods, Parkway, QEW, Downtown

Figure 29 shows the upwind vs. downwind comparisons of CO measurements in the neighbourhoods beside the Red Hill Parkway. It would be expected that the neighbourhoods downwind of the Parkway would experience higher concentrations of CO, but there is no such clear pattern. Upwind and downwind levels were essentially the same. In fact, on seven of the ten sampling days, upwind concentrations were higher. This indicates little effect of the Parkway, with localized traffic and longer range regional effects dominating.

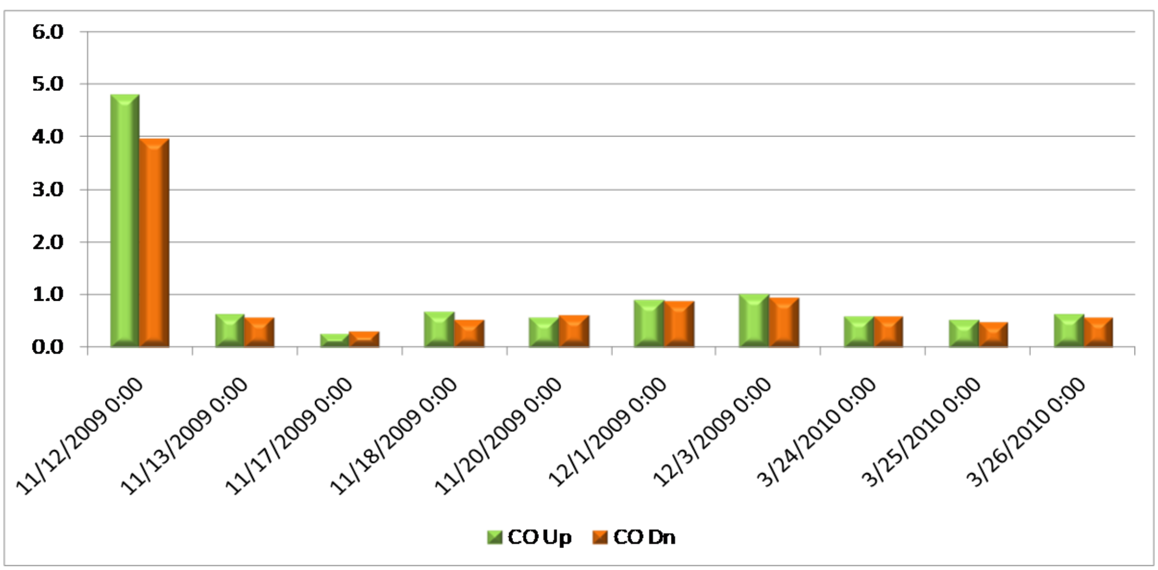


Figure 29 CO Upwind vs. Downwind Concentrations in ppm by Date in Red Hill Neighbourhoods

6.5 Oxides of Nitrogen (NOX) - Upwind/Downwind Averages by Day

NOX is usually reported as the sum of Nitric Oxide (NO) and Nitrogen Dioxide (NO2). In the case of air quality assessments, e.g. annual air quality reports and special study reports such as this one, 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. This report therefore focuses on NO2 concentrations with reference to appropriate criteria.

In high concentrations, NO2 is a reddish-brown gas with a strong and irritating odour. It transforms in the air to form gaseous nitric acid. 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, leading to more respirable particles in the atmosphere. NO2 can combine with water molecules to form nitric acid, which contributes to the formation of acid rain, acid snow and acid fog. NO2 is one of the most common smog-causing pollutants.

The main source of NO2 resulting from human activities is the combustion of fossil fuels (coal, gas and oil), especially gasoline used in cars. All combustion in air produces NOX, of which NO2 is a significant part. Approximately 63 percent of NOX in Ontario comes from the transportation sector. A large part of the remaining 37 percent comes from power generation, primary metal production and incineration.

Nitric Oxide (NO) is also a by-product of fossil fuel combustion, but is much less toxic than NO2. However, it is worth noting that atmospheric NO converts readily to NO2 within hours.

Figure 30 shows a GIS map of NO2 concentrations in the Red Hill neighbourhoods as well as on the Parkway, the QEW, Centennial Parkway, Nash Road and downtown. The lowest levels measured were in the Red Hill Neighbourhoods. Overall values were low, well below standards, with the highest pollution concentrations being on major roads, most notably at on and off ramps. As noted above this accords with the fact that when vehicles are operating at constant speeds, engines are at their most efficient, with correspondingly lower emissions. In contrast, accelerating and decelerating at on and off ramps will result in higher vehicle emissions. Downtown measurements were influenced by heavy stop and go traffic, with similar effects, although even here pollutant levels were well below standards.

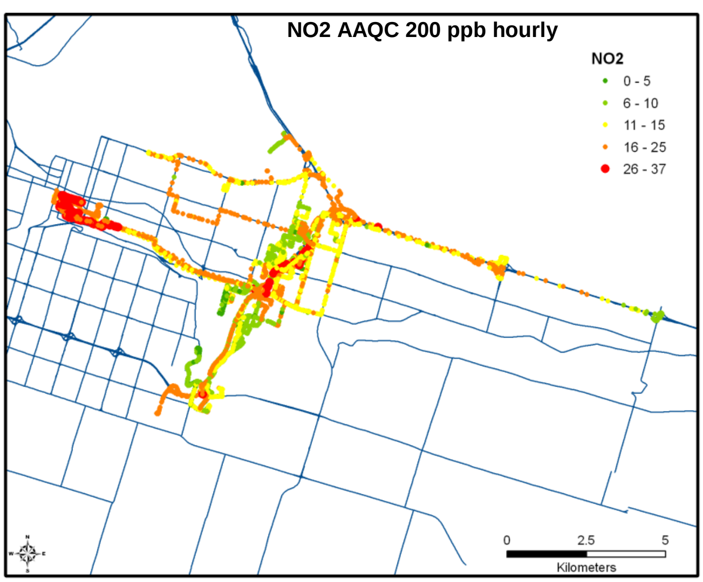


Figure 30 GIS chart of NO2 concentrations in ppb in Red Hill Neighbourhoods, Parkway, QEW, Downtown

Figure 31 shows the upwind vs. downwind comparisons of NO2 measurements in the neighbourhoods beside the Red Hill Parkway. All averages are far below (less than 10 percent) of the Ambient Air Quality Criterion of 200 ppb. It would be expected that the neighbourhoods downwind of the Parkway would experience higher concentrations of NO2 than the upwind neighbourhoods, but there is no such clear pattern. In fact, on four of the ten sampling days, upwind concentrations were higher. Even when the downwind concentrations were higher, both upwind and downwind concentrations were nearly equivalent. This indicates little effect of the Parkway, with localized traffic and longer range regional effects dominating.

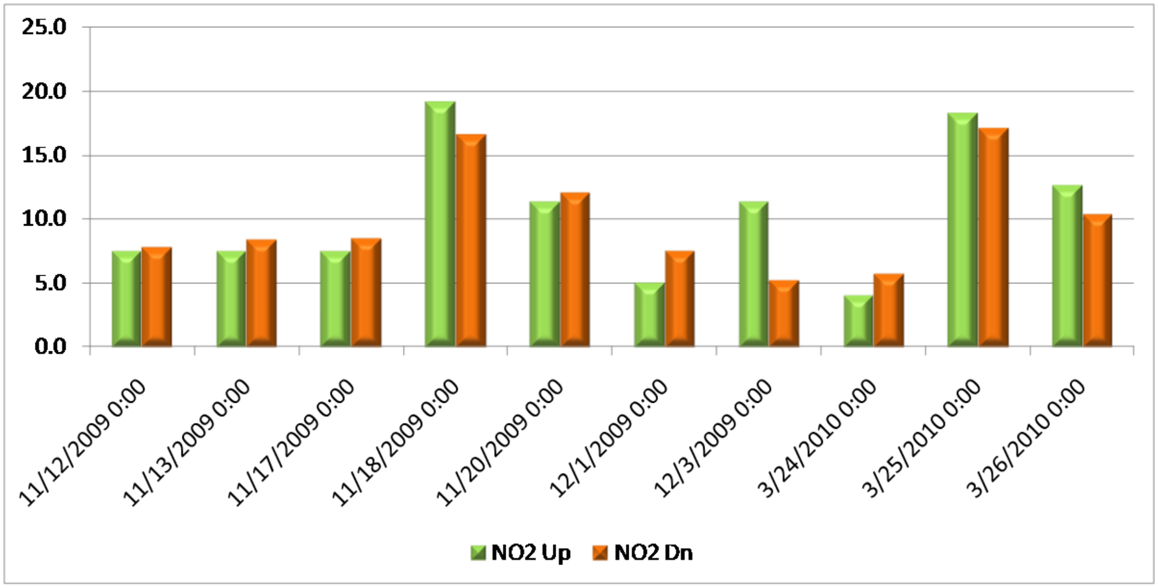


Figure 31 NO2 Upwind vs. Downwind Concentrations in ppb by Date in Red Hill Neighbourhoods

Figure 32 shows a GIS map of NO concentrations in the Red Hill neighbourhoods as well as on the Parkway, the QEW, Centennial Parkway, Nash Road and downtown. There is no Ambient Air Quality Criterion for NO, however it is a useful indicator of direct emissions from vehicles. Both NO and NO2 are emitted from vehicles, but NO is present in larger quantities. Neighbourhood values were low, with the higher pollution concentrations being on major roads, particularly at on and off ramps. As before, this is consistent with accelerating and decelerating vehicles at on and off ramps resulting in higher vehicle emissions. In this case, the QEW showed highest concentrations of NO, due to the frequency of heavy truck traffic directly emitting this contaminant.

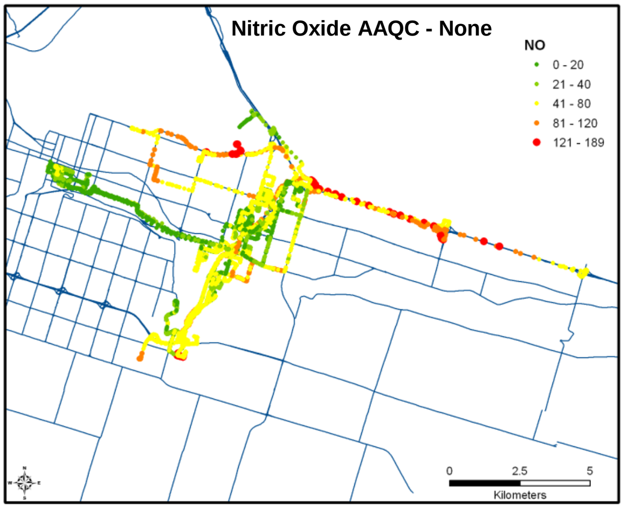


Figure 32 GIS chart of NO concentrations in ppb in Red Hill Neighbourhoods, Parkway, QEW, Downtown

Figure 33 shows the upwind vs. downwind comparisons of NO measurements in the neighbourhoods beside the Red Hill Parkway. Since there is no Ambient Air Quality Criterion for NO, we cannot compare these levels to a standard but they vary from 10 to 70 ppb, within normal city range. Once again there is no clear pattern of downwind areas showing higher measurements than upwind areas. On seven of the ten sampling days, upwind concentrations were higher than downwind concentrations. Even when the downwind concentrations were higher, both averages were nearly equivalent. Clearly other effects rather than the Parkway dominate, such as localized traffic and longer range regional effects, including the QEW and Centennial Parkway.

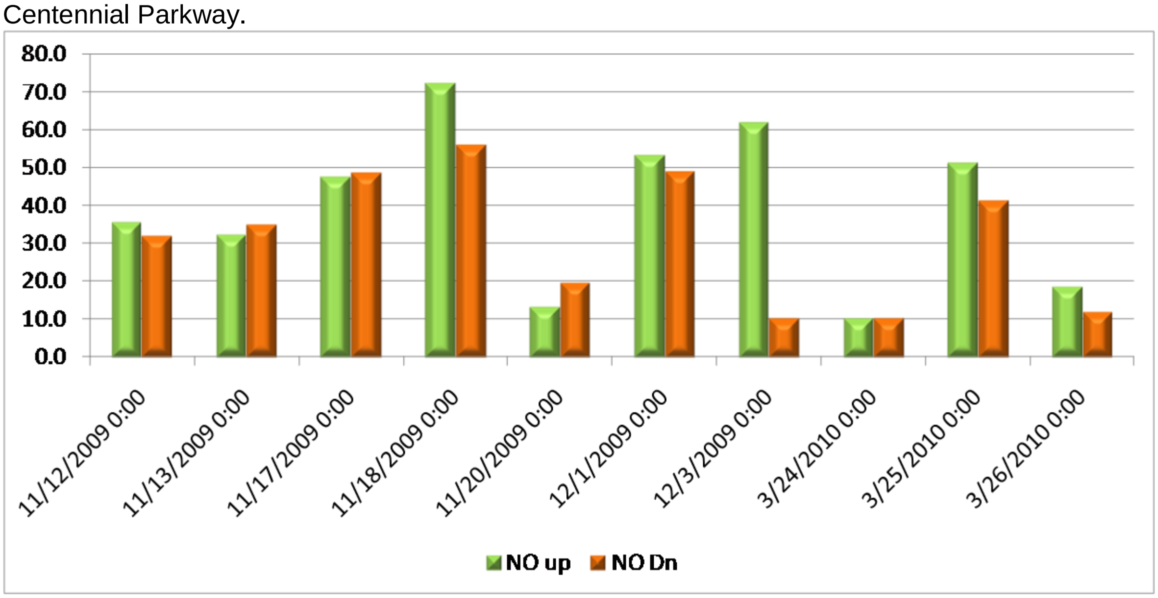


Figure 33 NO Upwind vs. Downwind Concentrations in ppb by Date in Red Hill Neighbourhoods

6.6 Sulphur Dioxide - Upwind/Downwind Averages by Day

Sulphur dioxide (SO2) is a colourless gas that smells like burnt matches. SO2 can combine with water molecules to form sulphuric acid, which contributes to the formation of acid rain, acid snow and acid fog. SO2 is a precursor to sulphates, which are one of the main ingredients of airborne fine particulate matter.

Approximately 69 percent of the SO2 emissions in Ontario in 2000 came from smelters and utilities, especially electrical generation. It is produced mainly from the combustion of fossil fuels that contain sulphur, such as coal and oil (for example, coal being burnt for electricity generation or fuel used in diesel-powered vehicles). Other industrial sources include iron and steel mills, petroleum refineries, and pulp and paper mills. Small sources include residential, commercial and industrial space heating.

Figure 34 shows the GIS map of SO2 concentrations in the Red Hill neighbourhoods as well as on the Parkway, the QEW, Centennial Parkway, Nash Road and downtown. Neighbourhood values were low, well below standards, with the highest pollution concentrations being on major roads and downtown. These concentrations were probably due to industrial impacts while winds were from the north-east.

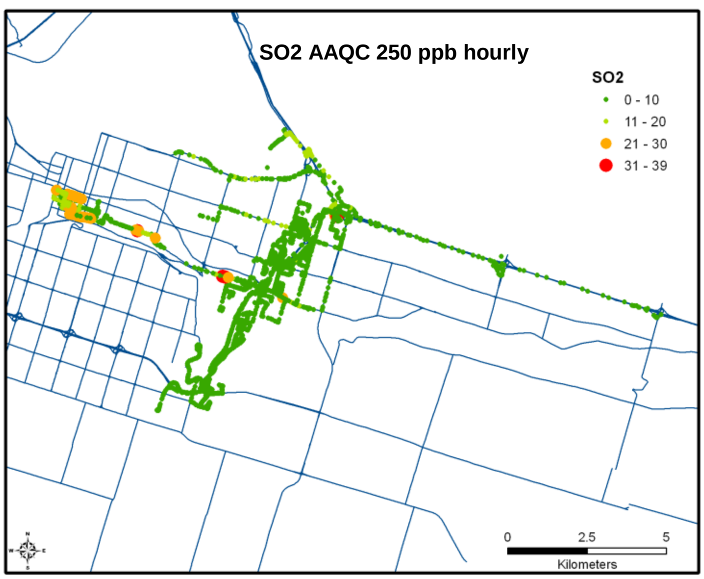


Figure 34 GIS chart of SO2 concentrations in ppb in Red Hill Neighbourhoods, Parkway, QEW, Downtown

Figure 35 shows the upwind vs. downwind comparisons of SO2 measurements in the neighbourhoods beside the Red Hill Parkway. On seven of the ten sampling days, upwind concentrations were higher. This indicates little or no effect of the Parkway, with longer range and industrial effects dominating.

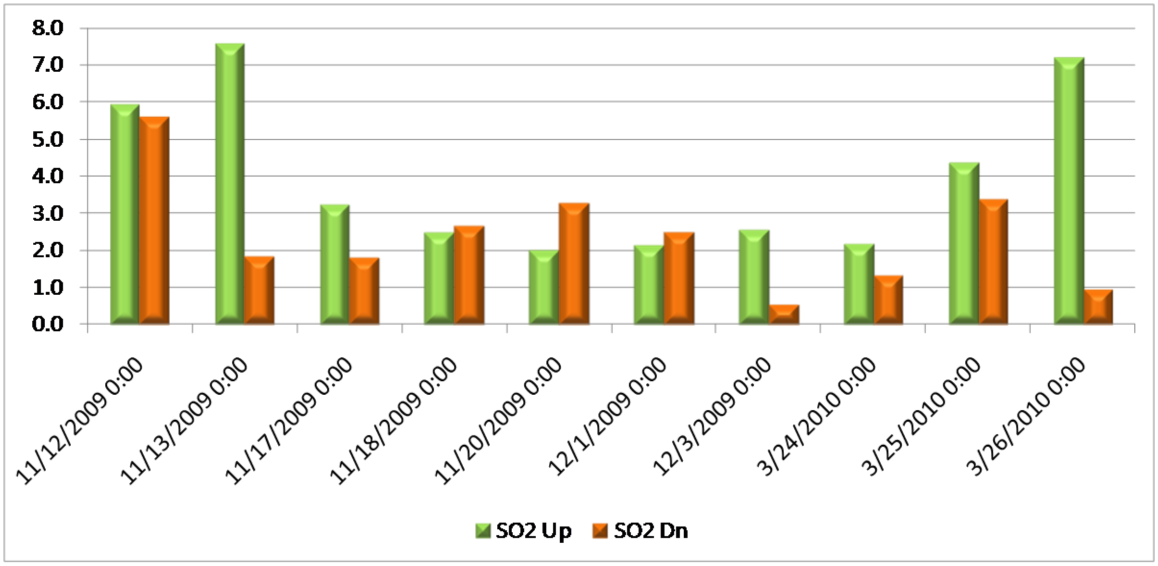


Figure 35 SO2 Upwind vs. Downwind Concentrations in ppb by Date in Red Hill Neighbourhoods

6.7 Particulate Matter - Upwind/Downwind Averages by Day

Airborne particulate matter (PM) is the general term used to describe a mixture of microscopic solid particles and liquid droplets found in the air we breathe. Particulate matter is categorized by its size because different sizes correspond to different health effects. Categories include inhalable particulate and respirable particulate as shown below.

Particulate matter definitions are:

Inhalable Particulate Matter < 10 microns (PM10): airborne particulate matter with a mass median diameter less than 10 µm. People can inhale these particles and they mainly deposit in the central part of our lungs, but not at the periphery.

Respirable Particulate Matter < 2.5 microns (PM2.5): airborne particulate matter with a mass median diameter less than 2.5 µm. The greatest health hazard from particles comes from the smallest fraction of 2.5 microns in diameter or less. The small particles are easily inhaled and can penetrate deep into our lungs, unlike larger particles which tend to deposit in the mouth and throat. These smaller particles are called Fine Particulate Matter 2.5 or PM2.5. To put things in perspective, a fine particle is approximately 30 times smaller that the average diameter of a human hair.

Particulate matter generally can come from aerosols, smoke, fumes, fly ash and pollen. Fine particulate matter comes from fuel combustion, including that performed by motor vehicles, smelters, power plants, industrial facilities, residential fireplaces, woodstoves, agricultural burning and forest fires. It can also be formed indirectly through a series of complex chemical reactions in the atmosphere.

Significant amounts of PM2.5 are carried into Ontario from the United States. During periods of widespread elevated levels of fine particulate matter, it is estimated that more than 50% of

Ontario's PM2.5 comes from the U.S. In Hamilton, this comes from a south-westerly direction, mainly from the Ohio Valley.

Figure 36 shows a GIS map of PM2.5 concentrations in the Red Hill neighbourhoods as well as on the Parkway, the QEW, Centennial Parkway, Nash Road and downtown. There exists a Canada-wide Standard for PM2.5 of 30 ug/m3 for a 24 hour average concentration. However this level can only be used for 24 hour averaging times, so the 30 ug/m3 is used here as an indicator level only with the understanding that longer averaging times would result in lower pollutant averages. Neighbourhood values were low, with the higher pollution concentrations being on major roads, highways, at on and off ramps and downtown. As before, this is consistent with accelerating and decelerating vehicles at on and off ramps as well as high speed vehicle traffic resulting in higher vehicle emissions.

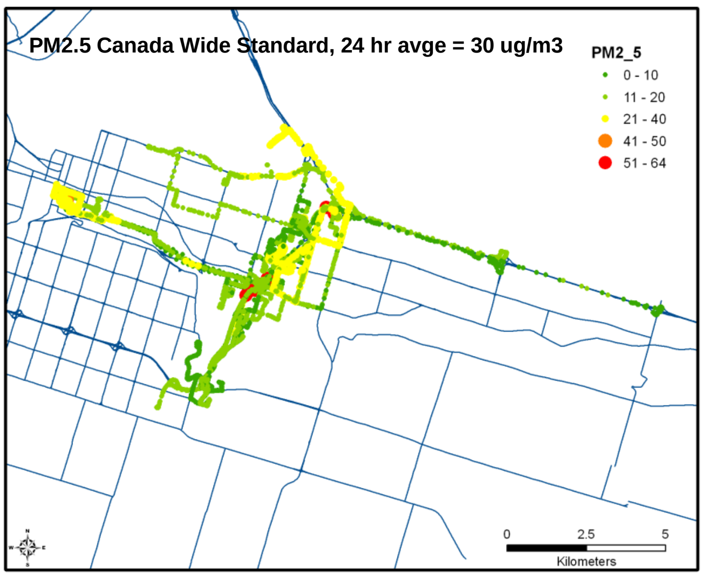


Figure 36 GIS chart of PM2.5 concentrations in ug/m3 in Red Hill Neighbourhoods, Parkway, QEW, Downtown

Figure 37 shows the upwind vs. downwind comparisons of PM2.5 measurements in the neighbourhoods beside the Red Hill Parkway. The Canada-wide Standard for PM2.5 of 30 ug/m3/ 24 hour average is used here as an indicator level only with the understanding that such longer averaging times result in lower pollutant averages. This CWS is expressly stated to be used only with 24 hour average data. All averages are below the 30 ug/m3 indicator level. There is no pattern of downwind areas showing higher measurements than upwind areas and both sets of averages are equivalent, showing no significant Parkway impacts.

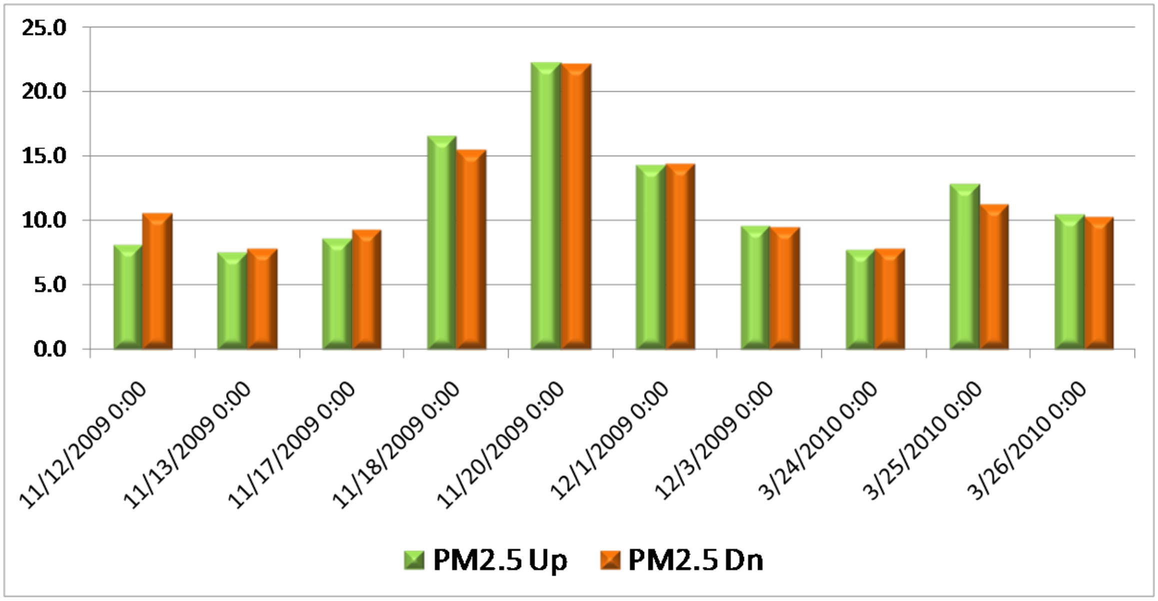


Figure 37 PM2.5 Upwind vs. Downwind Concentrations in ug/m3 by Date in Red Hill Neighbourhoods

Figure 38 shows a GIS map of PM10 concentrations in the Red Hill neighbourhoods as well as on the Parkway, the QEW, Centennial Parkway, Nash Road and downtown. The interim Ambient Air Quality Criterion for PM10 is 50 ug/m3 for a 24 hour average concentration with no conversion to other averaging times. Since this level can only be used for 24 hour averaging times, the 50 ug/m3 is used here as an indicator level with the understanding that longer averaging times result in lower pollutant averages. Neighbourhood values were low, with the higher pollution concentrations being on major roads, highways, at on and off ramps and downtown. This is consistent with accelerating and decelerating vehicles, fugitive road dust emissions and high speed vehicle traffic.

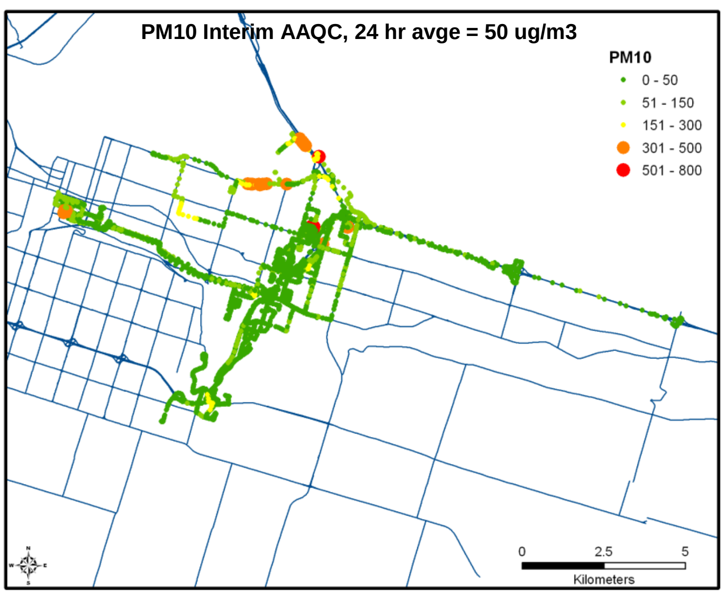


Figure 38 GIS chart of PM10 concentrations in ug/m3 in Red Hill Neighbourhoods, Parkway, QEW, Downtown

Figure 39 shows the upwind vs. downwind comparisons of PM10 measurements in the neighbourhoods beside the Red Hill Parkway. The interim Ambient Air Quality Criterion for PM10 of 50 ug/m3/ 24 hour average is used here as an indicator level only with the understanding that such longer averaging times result in lower pollutant averages. All averages are below the 50 ug/m3 indicator level. There is no pattern of downwind areas showing higher measurements than upwind measurements thus showing no significant Parkway impacts.

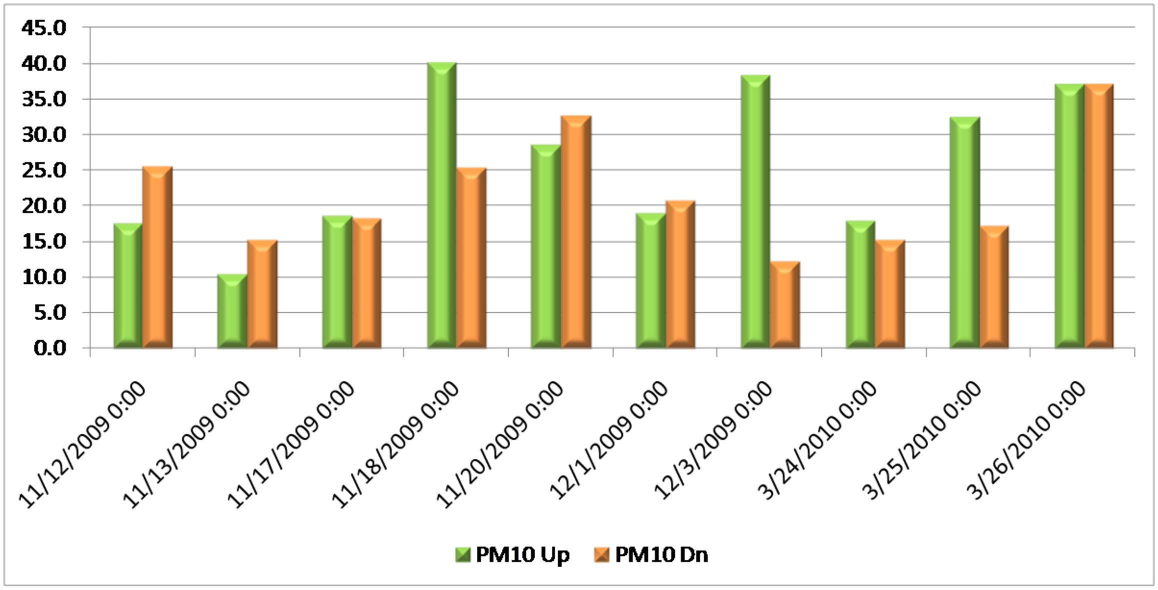


Figure 39 PM10 Upwind vs. Downwind Concentrations in ug/m3 by Date in Red Hill Neighbourhoods

8.0 Summary and Conclusions

As part of a community support grant program, mobile air quality monitoring of individual neighborhoods was supported by ArcelorMittal Dofasco in partnership with the Conserver Society, Hamilton Public Health Services, Green Venture, the Ontario Ministry of the Environment, and Rotek Environmental. Hamilton Public Health Services funded the Red Hill neighbourhoods portion of this study.

Green Venture was tasked with neighbourhood outreach and report production, while Rotek Environmental performed the mobile air monitoring and data evaluation parts of the program.

Consultation with a number of stakeholders, including neighbourhood associations, led to a target list of 26 neighbourhood locations to be monitored. For this initial phase of the program, 11 locations were monitored.

Mobile air monitoring techniques were used to evaluate levels of Carbon Monoxide (CO), Oxides of Nitrogen (NOX), Sulphur Dioxide (SO2), Inhalable Particulate (particulate matter less than 10 microns aerodynamic diameter, PM10) and Respirable Particulate (particulate matter less than 2.5 microns aerodynamic diameter, PM2.5). Regional wind directions were measured at the main Hamilton meteorological tower on Woodward Avenue. GPS monitors were used to specify monitoring locations and GIS (Geographic Information System) techniques were used to evaluate the data.

An innovative data evaluation technique was developed for this program. In order to provide the most meaningful results for neighborhood residents concerned about health effects, as well as government officials pursuing air pollution control actions, total health effects (additional mortality percentages) due to air pollution were calculated for each neighborhood. These total values were then further structured into values for each individual pollutant, allowing diagnosis of the particular problems in each neighborhood.

Of the 11 neighbourhoods monitored, all showed some air pollution impacts, ranging from 6.8 to 18.4% increased mortality with an overall average of 11.5% increased mortality due to air pollution. The majority of impacts were due to particulate and oxides of nitrogen. Five neighbourhoods showed above average levels of air pollution effects and this report details the specific pollutants responsible. The Jones Rd/Arvin Ave, McAnulty Blvd, NW end, Wentworth N. and Eastport Dr. areas all showed increased particulate effects above city averages, while the NW end, Wentworth N and Eastport Dr. areas showed increased nitrogen oxides impacts.

Special attention was paid to the Red Hill Valley area due to concerns about the impact of the Red Hill Valley Parkway. A number of measurements were made directly upwind and downwind of the road in order to evaluate expressway effects. All measurements in neighbourhoods close to the Red Hill Valley Parkway showed pollutant levels well below Ministry Ambient Air Quality Criteria (AAQC) and the average for the neighbourhoods was below the city wide average for calculated mortality increases. Analysis of upwind vs. downwind data showed very little or no effect of the Red Hill Parkway on neighbouring air quality. It is proposed that the channeling effects of the valley, in combination with the southwest prevailing winds, tend to contain vehicle emissions in the valley so that they are not dispersed laterally into bordering residential areas.

These measurements show that there is no clear pattern of Parkway air quality impacts on the Red Hill neighbourhoods. The current mobile monitoring data support the conclusions of the post-construction air monitoring at the King St. interchange which showed dramatic improvements in the levels of airborne contaminants in the vicinity of the Parkway, compared to pre construction levels, see http://www.hamilton.ca/CityDepartments/PublicWorks/RedHill/ .

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2. A Public Health Assessment of Mortality and Hospital Admissions Attributable to Air Pollution in Hamilton, School of Geography and Geology and McMaster Institute of Environment and Health
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3. Red Hill Valley Parkway, North - South Section, Post Construction Ambient Air Quality Monitoring Prepared by: Rotek Environmental, February 2010.
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