Hamilton Neighbourhoods Phase 2

Mobile Air Quality Monitoring to Determine Local Impacts December 2015

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Acknowledgements

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Executive Summary

Since the 1970s Hamilton's ambient air pollutant concentrations have reduced by approximately 90%. However, there is still a significant public health burden due to air pollution exposures. For instance, in 2008 the Ontario Medical Association estimated that there were 440 premature deaths annually from air pollution in Hamilton, 2,100 in Toronto, 700 in Peel and 330 in Halton. A more recent evaluation by Senes Consultants Limited estimated 186 deaths per year in the Hamilton area.

Between 186 and 440 premature deaths are estimated to occur in Hamilton.

Air monitoring allows for the collection of outdoor air quality data to identify local sources of air emissions and evaluate the potential impacts on human health. Fixed station monitoring in the City of Hamilton provides ongoing information about air quality, providing data for the Air Quality Health Index/AQHI real time mapping (http://www.hamiltonaqhi.com/index.html) 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.

Phase 1 of this mobile air monitoring project was intended to address five neighbourhoods. Consultation with a number of stakeholders, including neighbourhood associations, led to a much larger than anticipated target list. The project received twenty six neighbourhood requests, demonstrating the importance the Hamilton community places on risk associated to air pollution exposure.

Twenty-six neighbourhoods requested local air pollution monitoring.

A community grant program supported by ArcelorMittal Dofasco in partnership with the Conserver Society, Hamilton Public Health Services, Green Venture, the Ontario Ministry of Environment and Climate Change (MOECC) and Rotek Environmental provided funding and resources to assess eleven location in Phase 1.

The Phase 1 report is available on the Clean Air Hamilton website, which was published in 2011. http://www.cleanair.hamilton.ca/downloads/Hamilton%20neighbourhoods%20%202011.pdf

This current Phase 2 report addresses the remaining fifteen neighbourhoods, along with additional special requests received in the interim, for a total of seventeen neighbourhoods. This study was supported by Hamilton Public Health Services and conducted in partnership with the Ontario Ministry of Environment and Climate Change.

Mobile air monitoring techniques were used to evaluate levels of **Carbon Monoxide** (CO), **Oxides of Nitrogen** (NO, NO2 and 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, $PM_{2.5}$). A GPS monitor was used to specify monitoring locations and GIS (Geographic Information System) techniques were used to map and evaluate the data.

Risk factors were calculated during this program to provide the most meaningful results for neighborhood residents who are concerned about health effects and government officials pursuing air pollution control actions. The health effects (additional mortality risk percentages) due to air pollution were calculated for each neighborhood. These risk values were then further structured into values for each individual pollutant, indicating the particular problems in each neighborhood.

Early mortality estimates were calculated in this study, which were based on acute mortality risk factors from the Hamilton Public Health Services/Clean Air Hamilton study on this topic. It should be cautioned that percentage increased mortality risk estimates should only be used as a general indication of, and surrogate for, a broader suite of health impacts, both respiratory and cardiovascular effects, rather than exact counts of death or illness. Intuitively, one would expect that respiratory health impacts would dominate, however cardiovascular effects are equally important.

The majority of air pollution health risk in this study was due to Particulate Matter (PM) and Oxides of Nitrogen (NOx). Additional Sulphur Dioxide (SO2) contributed to the health risk in some locations when winds were from the north east. Winds blow from the south west approximately 60% of the time and from the north east 20% of the time. Most of the remaining winds come from the north or north west. For simplicity in this report, data for all winds from the westerly direction were consolidated and were called south west.

Particulate Matter and Nitrogen Oxides were responsible for the majority of the health risk in Hamilton.

All seventeen neighbourhoods monitored demonstrated increased mortality risk, 2.6% average during south west winds and 4.1% average during north east winds. Individual neighbourhoods ranged from 1.3% (Mountain Brow) to 7.2% (Nebo Rd.) during south west winds and from 1.5% (Rymal/Paradise) to 7.9% (Nebo Rd.) during north east winds.

Three general air pollution patterns emerged.

1. Air pollution concentrations were lowest during south west prevailing winds. Health risk was slightly higher in the downtown core and the north central industrial area.

2. During north east winds higher pollution risk levels were measured in and near the downtown core and industrial areas. Risk decreased greatly the farther from these areas (with some exceptions).

3. The best air quality occurred in areas at the southern edge of the city, which are the furthest from the downtown and industrial emissions. These conditions were not significantly affected by the wind direction, but had slightly lower values during north east winds.

The analysis indicates that both vehicular and industrial emissions are still important contributors to air pollution levels in Hamilton, particularly under north east wind conditions.

There were some notable exceptions to the above patterns:

- Nebo Rd. in the south west of the City was measured at the request of Councillor Jackson's constituents (Mrs. Kate Fraser and group) and showed high particulate levels regardless of wind direction.

- The Barton/Fruitland area in Stoney Creek, in the east of the City, showed unexpectedly high particulate levels during north east winds (i.e., away from downtown area inputs), particularly in the Jones Rd. location. Sulphur dioxide levels were also high.

- Cope St., in the north of the City, beside the north east heavy industry, would have been expected to show higher levels during north east winds, but did not in fact do so.

Each of these exceptional areas could be studied more closely in the future, either by additional mobile monitoring or by using Public Health Services moveable monitoring stations (the AirPointers).

1. Introduction

Although there has been approximately a 90% improvement in Hamilton's air quality since the 1970s, there is still a significant burden of public health due to air pollution exposures. For instance, in 2008 the Ontario Medical Association estimated that there were 440 premature deaths annually from air pollution in Hamilton, 2,100 in Toronto, 700 in Peel and 330 in Halton. A more recent 2012 evaluation by Senes Consultants Limited estimated 186 deaths per year in the Hamilton area.

The use of mobile monitoring to identify health impacts of air pollution in localized areas and neighbourhoods is a relatively new approach to air quality improvement. A mobile monitor has advantages over traditional stationary monitors because it can move around and cover a wide geographic area to collect data, thus identifying the variability of air pollution impacts across a community and helping to prioritize the need for improvement actions. The results of mobile monitoring are thus particularly useful for citizens or schoolchildren who wish to take personal control of their pollution exposures while commuting, walking, jogging or pursuing other activities.

Mobile monitoring studies from around the world have shown that localized, short-term, peak exposures can impact some individuals. Mobile monitoring has also been recognized and reported upon by the Environmental Commissioner of Ontario. The disadvantage of mobile monitoring is that it essentially provides short term snapshots of pollutant conditions and thus fixed stations are more relevant for continuous outputs, longer term trend evaluations or testing for standard/criteria exceedances.

As a result, fixed stations and mobile monitors have complementary advantages and disadvantages.

Fixed stations can provide short and long term averages and trends, allowing comparisons with MOE air quality criteria. However fixed stations are expensive, representative sampling sites can be difficult to establish, a number of stations is usually required and even in a network, cannot capture all of the wide geographical variation of air pollutant concentrations in a community. While fixed stations are automated to some degree and can operate without minute to minute supervision, they are still fairly labour intensive in that they require frequent data review and validation, and ongoing calibration and maintenance.

Hamilton has a network of fixed air monitors, with a number of these monitors focused on the larger industries, i.e., HAMN, the Hamilton Industrial Air Monitoring Network (www.hamnair.ca). In addition, the Ministry of Environment and Climate Change (MOECC) operates several fixed stations in Hamilton to determine the Air Quality Health Index (http://www.ec.gc.ca/cas-aqhi). However, some areas are not served by the fixed air monitors, or certain pollutants not monitored, thereby creating gaps in local knowledge of air emissions and impacts. For detailed knowledge of the air quality status of individual neighbourhoods, targeted mobile monitoring is essential.

An intermediate type of monitoring is moveable monitoring stations, using equipment such as the 'AirPointer' which can be mounted on telephone poles or stands and moved from one previously identified area of interest to another to test for air quality /criteria exceedances.

Each method has its strengths and weaknesses and, together with air dispersion modelling, all can add useful information to the evaluation of the complex picture of air pollutants in a community.

The previously completed Phase 1 of this mobile air monitoring project was intended to address five neighbourhoods only. Consultation with a number of stakeholders, including neighbourhood associations, led to a much larger than anticipated target list, twenty six neighbourhoods in total.

In Phase 1, a community grant program, supported by ArcelorMittal Dofasco allowed eleven locations to be completed in partnership with the Conserver Society, Hamilton Public Health Services, Green Venture, the Ontario Ministry of Environment and Climate Change (MOECC) and Rotek Environmental.

The Phase 1 report, published in 2011 is available on the Clean Air Hamilton website at:
http://www.cleanair.hamilton.ca/downloads/Hamilton%20neighbourhoods%20%202011.pdf

This Phase 2 report addresses the remaining fifteen neighbourhoods, along with some additional requests received in the interim for a total of seventeen neighbourhoods. This study was supported by Hamilton Public Health Services and conducted in partnership with the Ontario Ministry of Environment and Climate Change

Mobile air monitoring techniques were used to evaluate levels of Carbon Monoxide (CO), Oxides of Nitrogen (NO, NO2 and NOX), Sulphur Dioxide (SO2), Inhalable Particulate (particulate matter less than 10 microns aerodynamic diameter, PM_{10}) and Respirable Particulate (particulate matter less than 2.5 microns aerodynamic diameter, $PM_{2.5}$). A GPS monitor was used to specify monitoring locations and GIS (Geographic Information System) techniques were used to map and 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, 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.

Risk values were calculated on the basis of acute mortality risk data from the Hamilton Public Health Services/Clean Air Hamilton 2012 study on this topic. It should be cautioned that percentage increased mortality risk estimates should only be used as a general indication of, and surrogate for, a broader suite of health impacts, both respiratory and cardiovascular effects, rather than exact counts of death or illness. Intuitively, one would expect that respiratory health impacts would dominate, however cardiovascular effects are equally important.

2. Air Monitoring Methodologies

2.1 Mobile Sampling System

The mobile sampling system was designed as an MOECC environmental response unit with a GM Savana van used as the mobile platform (Figure 1).

Figure 1 – Mobile Air Monitoring System

Rack mounts were installed to accept real time, continuous monitoring instruments. A Grimm Dust Particle Monitor was mounted separately, since a straight sampling path to ambient air is required to avoid unwanted particle size selection artifacts during sampling. Figures 2, 3 and 4 show details of the sampling systems.

Ambient air for the gaseous analyzers was sampled through a specially constructed gooseneck sampling head which passed through the roof of the vehicle (Figure 4). A rain shield attachment was added to prevent precipitation entering the system. Sampling intake height was approximately 2.5 metres above ground level. This sampling height is important to mitigate instantaneous fluctuations in pollutant concentrations due to tailpipe emissions. One half inch diameter Teflon tubing with a manifold and particle pre-filters were used to distribute the incoming air to the gas analyzers. The Grimm Dust Monitor was modified with a straight sampling intake to reach through the vehicle roof.

Figure 2 – Rack Mounted Gas Monitors

Figure 3 – Particle Analyzer

Figure 4 – Sampling Intake on Roof of Vehicle

The following Air Quality contaminants were measured:

- Carbon Monoxide (CO)
- Oxides of Nitrogen (NO, NO2, NOX)
- Sulphur Dioxide (SO2)
- PM_{10} (Inhalable Particulate, particulate matter < 10 microns aerodynamic diameter)
- $PM_{2.5}$ (Respirable Particulate, particulate matter < 2.5 microns aerodynamic diameter)

Positional information was captured using a GPS unit attached to the vehicle windshield (Garmin 18 laptop-enabled GPS), see Figures 5 and 6.

Figure 5 – Dashboard-mounted GPS Head, Garmin 18

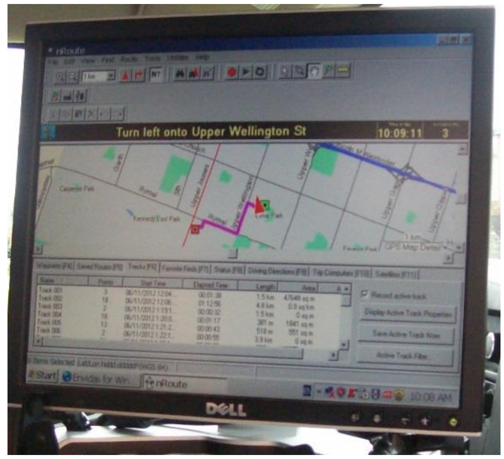


Figure 6 – Display on Laptop Computer of Geographic Information System (GIS)

All pollution and GPS data were collected simultaneously. Pollutant data were collected using a DrDas Envidas/ADAM data logger with specialized software programs and stored as one minute averages. The GPS data were collected using nRoute software and stored as one minute averages.

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

2.2 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
Oxides of Nitrogen NO, NO2, NOX	Teledyne Model 200EU	Chemiluminescence
Carbon Monoxide CO	Thermo Scientific Model 48i	Gas Filter Correlation
Sulphur Dioxide SO2	Thermo Scientific Model 43c	Fluorescence
Inhalable / Respirable Particulate PM_{10}, $PM_{2.5}$	Grimm Model 1.107	Laser Optical

2.3 Sampling Event Methodology

Locations for sampling were chosen so as to give a broad characterization of the air quality within selected neighbourhoods. Sampling was conducted at each location, for both wind directions, on days without significant precipitation, usually between the hours of 10 am and 3 pm. This study was not intended to monitor rush hour conditions and it is reasonable to expect that pollutant levels would be higher during those times.

2.4 Data Analysis Methodology

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

Risk values were calculated on the basis of acute mortality risk data from the Hamilton Public Health Services/Clean Air Hamilton study on this topic. It should be cautioned that percentage increased mortality risk estimates should only be used as a general indication of, and surrogate for, a broader suite of health impacts, both respiratory and cardiovascular effects, rather than exact counts of death or illness. Intuitively, one would expect that respiratory health impacts would dominate, however cardiovascular effects are equally important.

The Hamilton Public Health Services/Clean Air Hamilton list of individual health impacts by pollutant can be found at http://www.cleanair.hamilton.ca/downloads/Health-Study-%28Executive-Summary%29%20.pdf . These values were used to calculate the localized health impacts in each neighbourhood for given wind directions.

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 and provide maps and analysis.

3. Ambient Air Quality Mobile Monitoring Results

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

3.1 Phase 1 Mobile Monitoring

For Phase 1 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.

The highest risk values by far were found on 400 series highways. Five neighbourhoods had risk values above the average.

Subsequent to Phase 1, neighbourhoods adjacent to the Red Hill Valley Parkway were monitored to determine the potential air pollution impacts from the Parkway. None were found and it was postulated that this was due to a combination of wind channeling (parallel to the direction of the roadway) and away from the residential areas. The depth of the valley plus berms would also have a beneficial effect.

Another short study was performed in the West End in Kirkendall South, Kirkendall North and Strathcona, including residential areas, roads, highways and near schools. Chedoke Park and the Chedoke Radial Recreational Trail were added on one day.

These subsequent data showed that the risk levels on 400 series highways on a normal day were equivalent to the worst air quality day in an entire year in Hamilton.

The City of Hamilton has the unique feature of the Niagara Escarpment forest as well as many off-road walking and cycling routes through historical alleyways, allowing recreational and commuting travel away from traffic. Measurements were taken in Chedoke Park and on the Chedoke Radial Recreational Trail to see whether the air was any cleaner than in roads and neighbourhoods. Risk levels were lower than surrounding areas at 3.2%.

Unfortunately, due to the time of year, the trees were not in leaf, so pollutant cleaning effects would not be as pronounced. However these measurements would be a useful benchmark in further studies. The importance of this is that the Chedoke Radial Recreational Trail is a heavily used, accessible trail which could serve as a template for a similar level of forest trail across the city. Such a trail would be within ten minutes walk of 25% of the city population.

Figure 7 shows the integrated mortality risk estimates by neighbourhood for Phase 1 and the above studies.

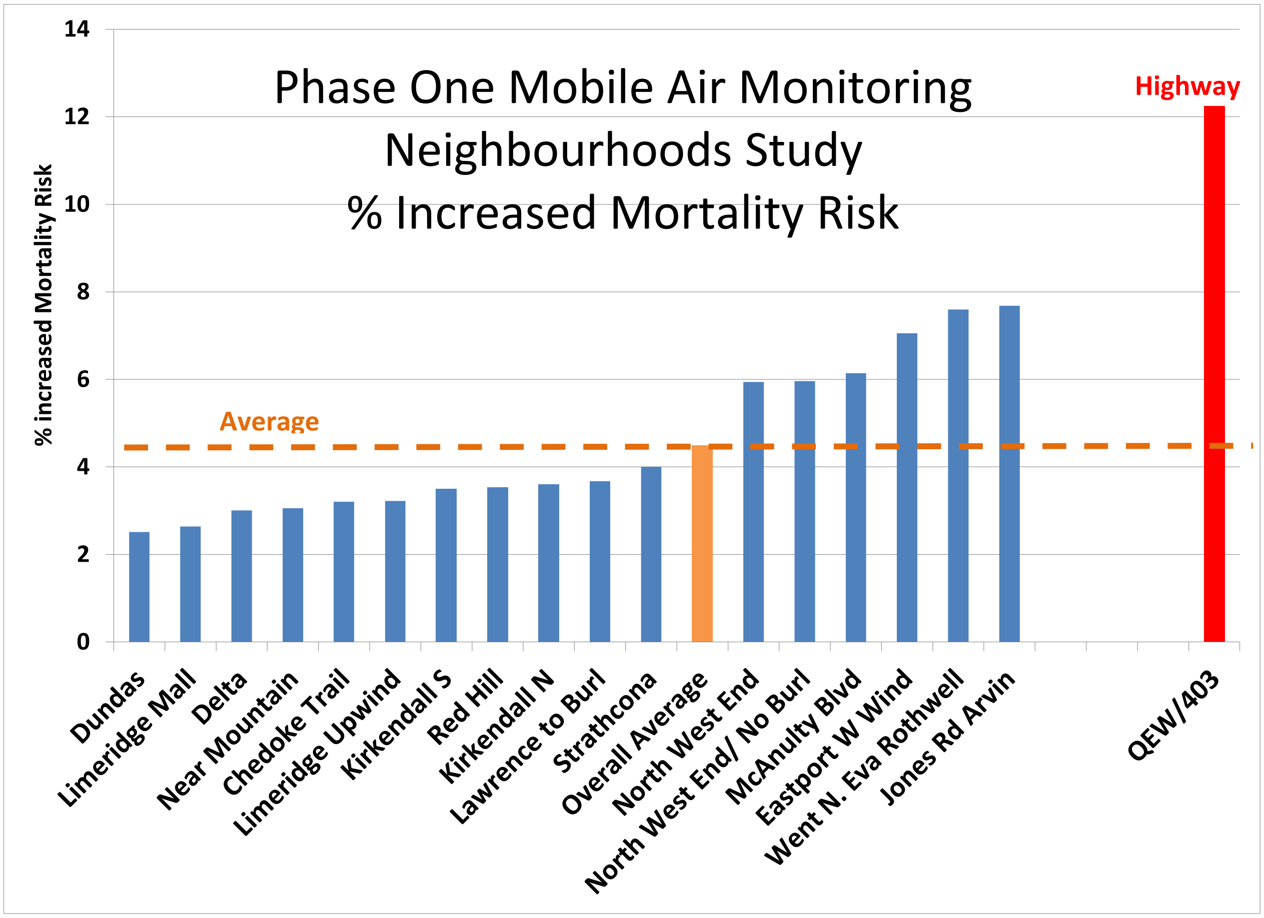


Figure 7 – Phase 1, Hamilton Neighbourhoods, Percentage Increased Mortality Risk

3.2 Phase 2 Mobile Monitoring

In Phase 2 the remaining fifteen neighbourhoods were addressed, as well as Nebo Rd and portions of Ward 6 (measured at Councillor Jackson's request), for a total of seventeen neighbourhoods. These areas were measured during south west to the north west prevailing winds and during the north east winds.

These neighbourhoods were:

- Fruitland and Barton
- Cope St
- Sherman South
- Sanford School Area
- Jolley Cut Area
- Durand
- Waterdown
- Rymal/Mud Area
- Linc/Red Hill Intersection Area
- Nebo Rd.
- Upper Gage/Upper Ottawa/East Mountain Park
- Gourley
- Rymal and Paradise
- Meadowlands
- Ancaster
- Mount Hope Area (Airport)
- Ward 6 Areas (Kenil Access, Mtn Brow)

3.2.1 City Wide Air Quality Risk Estimates by Individual Pollutant and Wind Direction

Estimating the impact of particular air quality events on human mortality is complex. While no methodology is perfect, the results presented here are intended to assist decision-makers with understanding of air quality in the City of Hamilton and its impact on particular neighbourhoods.

The mortality risk estimates represent the additional percentage of Hamilton residents who can be expected to die of non-traumatic causes due to the impacts of particular pollutants. A 1% increase, for example, would mean that if 100 people died as a result of non-traumatic mortality over a particular time period, an additional person would be expected to die as well, who would not have if it were not for elevated pollutant levels on that day.

Approximately 4,000 people die in Hamilton each year from non-traumatic causes. A 1% increase averaged over an entire year would equate to an additional approximate 40 deaths. Using the results in Figures 8 and 9 (discussed below) of mortality risk percentages increasing by 2.6% to 4.1%, on an annual basis, this may result in the additional deaths of approximately 100-160 Hamilton residents over the course of one year. This is in good agreement with the Hamilton Public Health Services/Clean Air Hamilton 2012 study referenced above. These estimates do not include exacerbations of illness or the economic and social costs of increased illness due to poor air quality.

This explanation is somewhat simplified as the results presented below relate to particular days, particular weather conditions and particular neighbourhoods, for which specific non-traumatic mortality statistics are not available. However, the foregoing discussion should provide some context for the interpretation of the mortality risk percentages presented below.

Figures 8 and 9 show the overall percentage mortality risk estimates for Phase 2 for both south west and north east winds. Overall averages were 2.6% for south west winds and 4.1% for north east winds, i.e., there is a 1.5% increase in risk for north east winds.

In terms of individual pollutants, for south west winds, airborne particulates, (PM10 and $PM_{2.5}$) remain the most problematic, followed by Nitrogen Dioxide (NO2). For north east winds, particulates remain the largest problem, followed again by NO2, but significant effects of Sulphur Dioxide (SO2), Carbon Monoxide (CO) and Nitric Oxide (NO), in order of importance, were also visible.

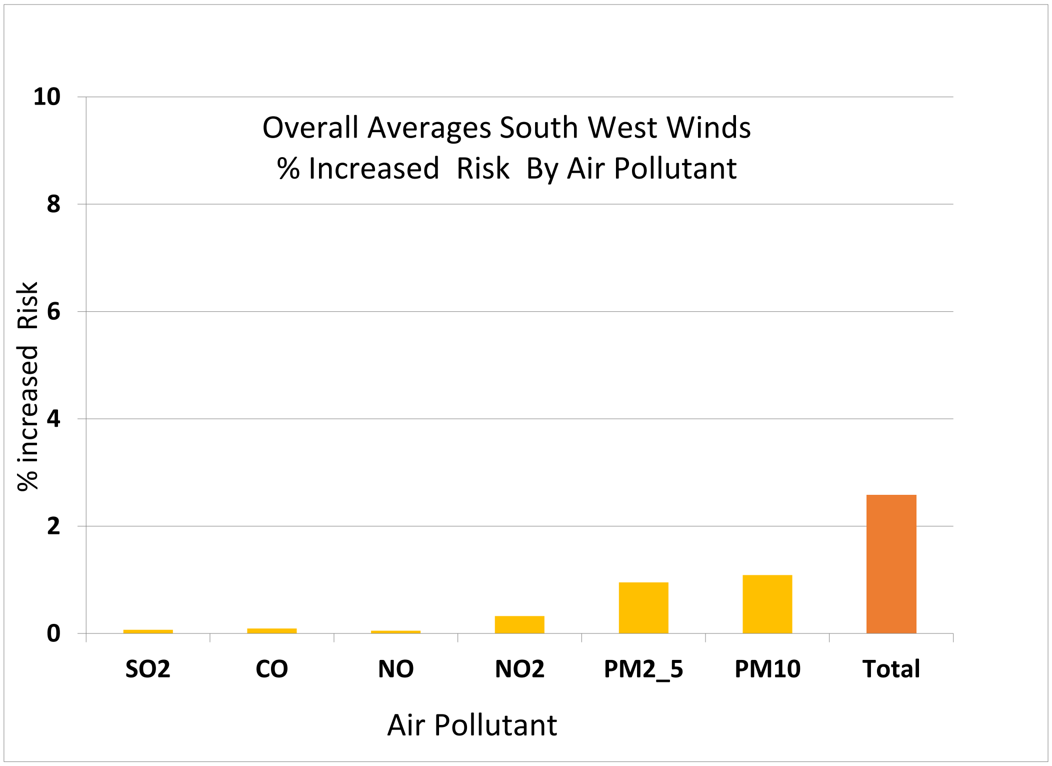


Figure 8 – Phase 2, City Average Risk Percent by Pollutant with Winds from South West

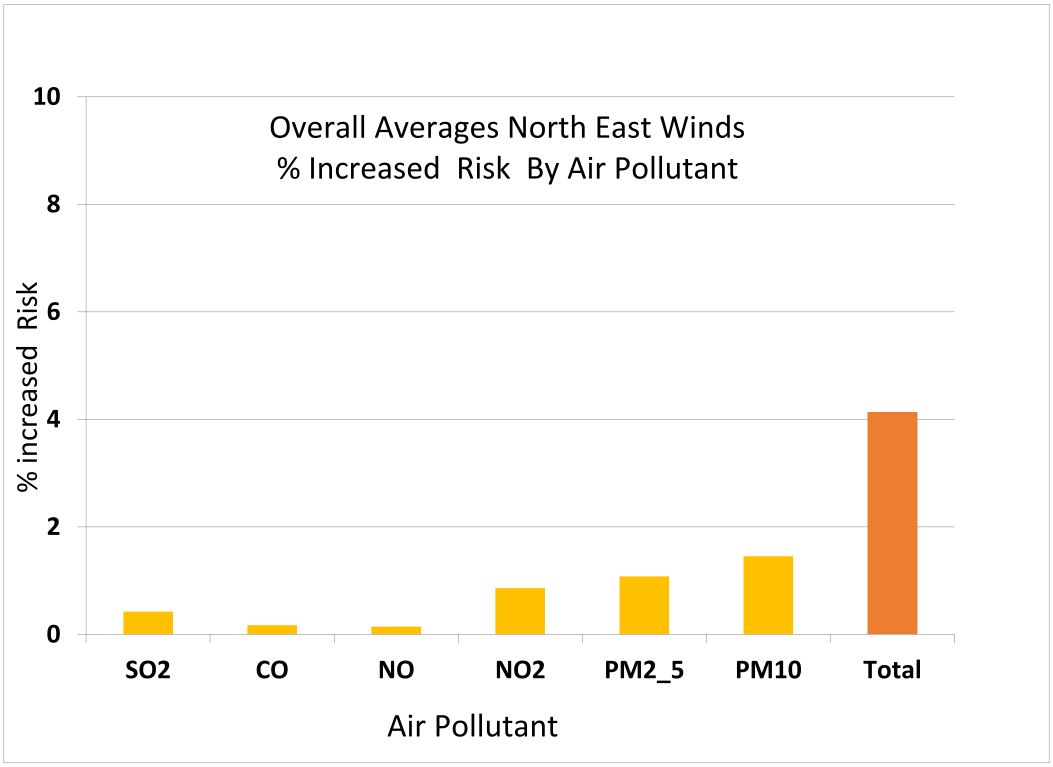


Figure 9 – Phase 2, City Average Risk Percent by Pollutant with Winds from North East

3.2.2 Neighbourhood Air Quality Risk Estimates by Wind Direction

Of the seventeen neighbourhoods monitored, all showed some air pollution impacts. Overall averages of all these neighbourhoods were 2.6% for south west winds and 4.1% for north east winds increased mortality risk. The majority of impacts were due to particulate matter and oxides of nitrogen. For winds from the south west, individual neighbourhoods ranged from 1.3% (Mountain Brow) to 7.2% (Nebo Rd.) increased mortality risk. For north east winds the range was 1.5% (Rymal/Paradise) to 7.9% (Nebo Rd.). Figures 10 and 11 show these results.

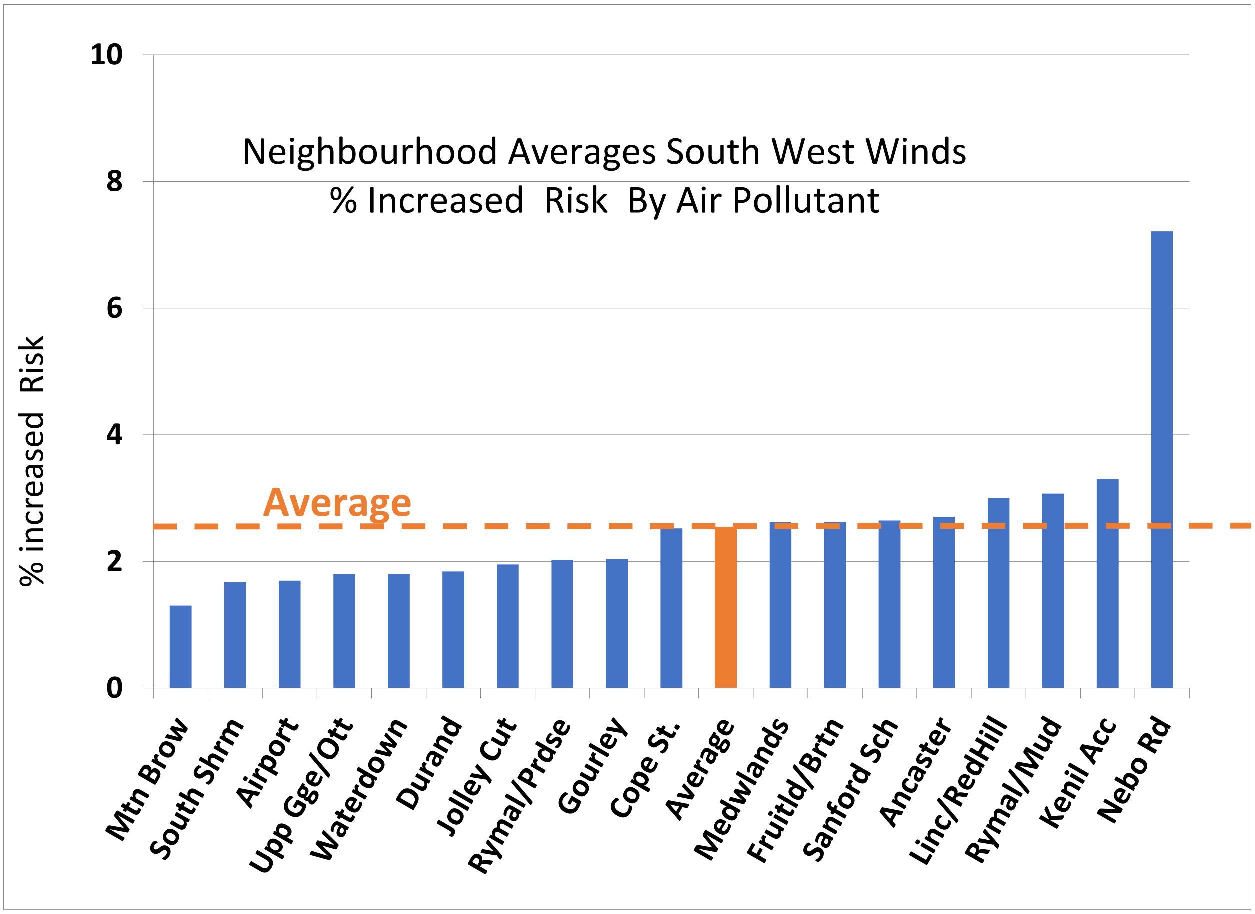


Figure 10 – Phase 2, Neighbourhood Average Risk % by Pollutant with Winds from South West

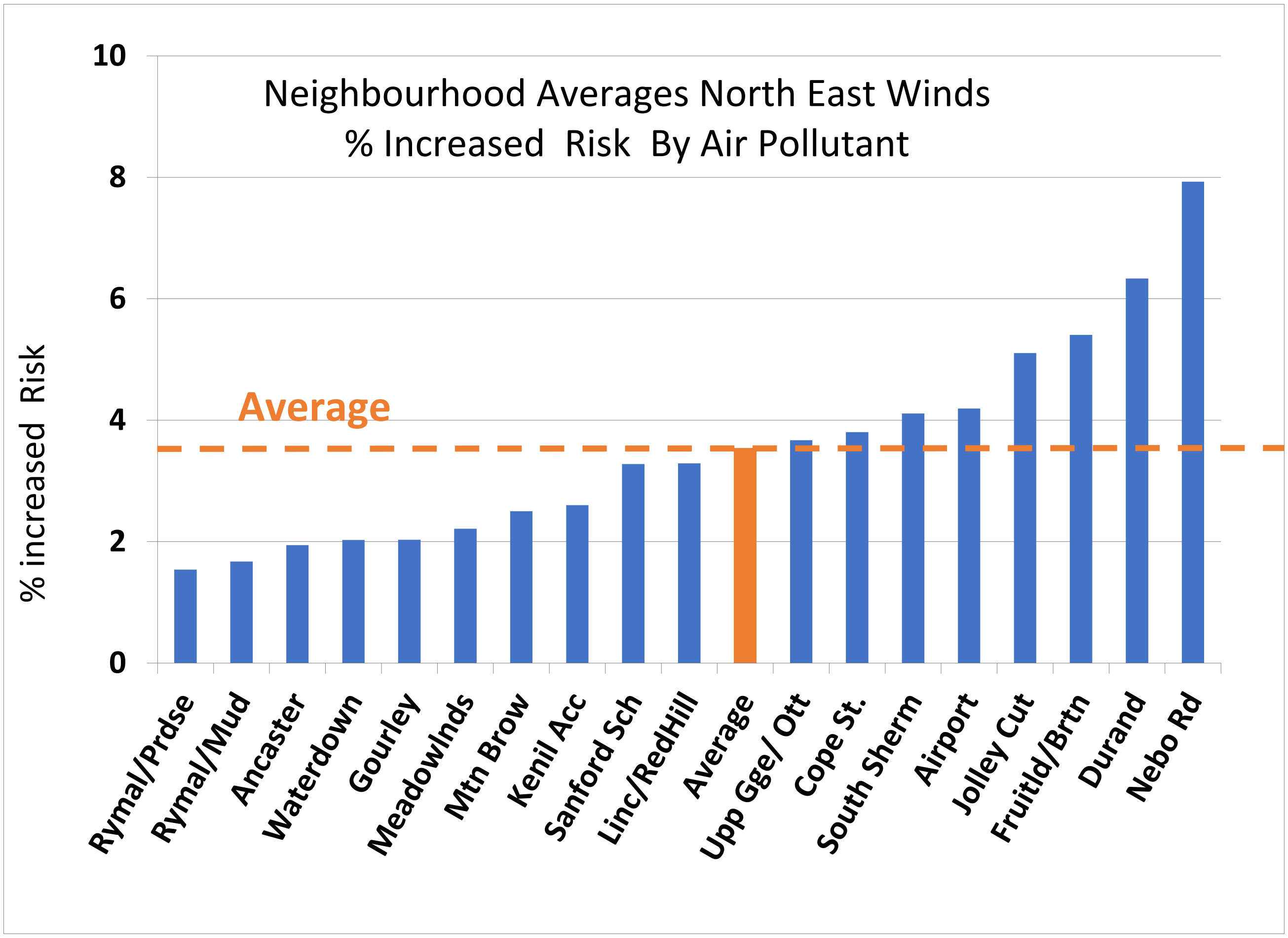


Figure 11 – Phase 2, Neighbourhood Average Risk Percent by Pollutant with Winds from North East

Figure 12 shows the comparison of south west and north east wind effects in different parts of the City and shows that different areas of the City display quite different air quality regimes.

In surrounding wards on the Mountain, in general, there were little or no impacts from the City core and Bayfront industrial complex. Thus, Rymal/Mud, Linc/Red Hill, Gourley, Rymal/Paradise, Meadowlands, Ancaster and Waterdown all have generally good air quality with little differences between south west and north east winds. They would still be susceptible to region wide (SW Ontario) poor air quality on occasion.

The next group are the downtown and near mountain wards which can vary between good air quality with winds from the south west, and markedly higher levels of pollutants when the wind comes from the north east. Under north east wind conditions, these neighbourhoods are exposed to the combined effects of heavy traffic in the downtown core and industrial emissions from the Bayfront (including diesel trucks) and traffic on the 400 series highways. The Durand and lower Jolley Cut areas had the biggest differences in impacts with these changes in wind direction. Ward 6 areas are shown in a separate chart.

Finally, there were three specific areas which showed localized impacts.

The airport area had very clean air with south west winds but higher levels of pollutants when winds were blowing from the airport (north east).

The Fruitland and Barton area was examined in more detail, since it had been expected that it would not be affected by north east winds (wrong wind direction) in the same manner as downtown areas, however the Jones Road and Arvin Avenue locations showed much higher pollutant levels for north east winds, as detailed later in this report.

Nebo Road had the highest levels of mortality risk percentages, with little change under different wind conditions. This area has a number of aggregate type industries with material handling, trackout on to the main road way and obvious road dust resuspension into the air.

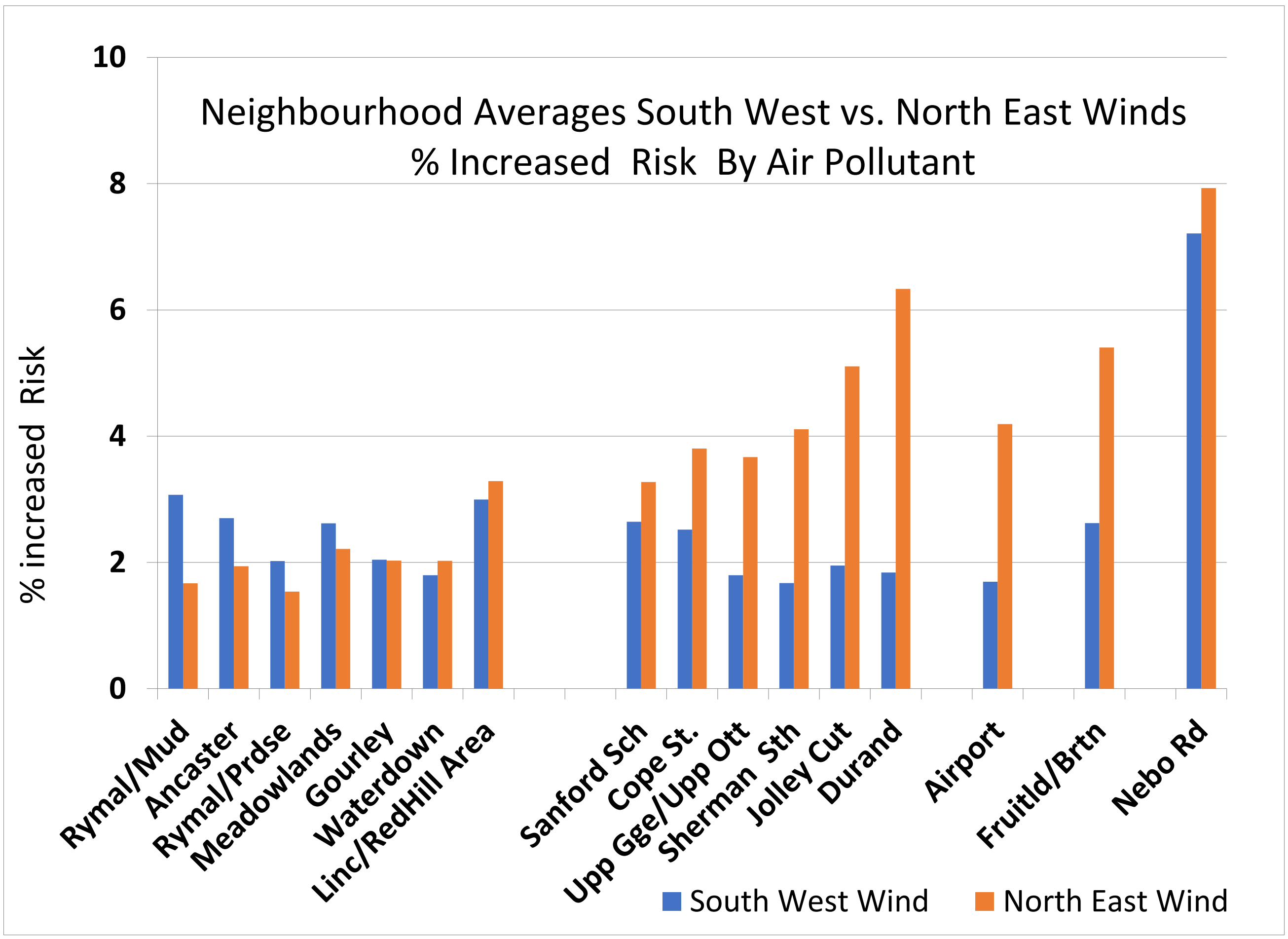


Figure 12 – Phase 2, Neighbourhood Average Risk Percent Comparison of Winds from South West and North East

The following sections of the report deal with neighbourhoods with above average calculated mortality percentages.

3.2.3 Air Quality Risk Estimates – Localized Impacts – Nebo Road

Figure 13 shows air quality risk by pollutant for Nebo Rd. for both south west and north east winds. The major component is heavier particulate, PM_{10}. The similarity under different wind conditions may indicate that local resuspension of road dust is the main source of these emissions.

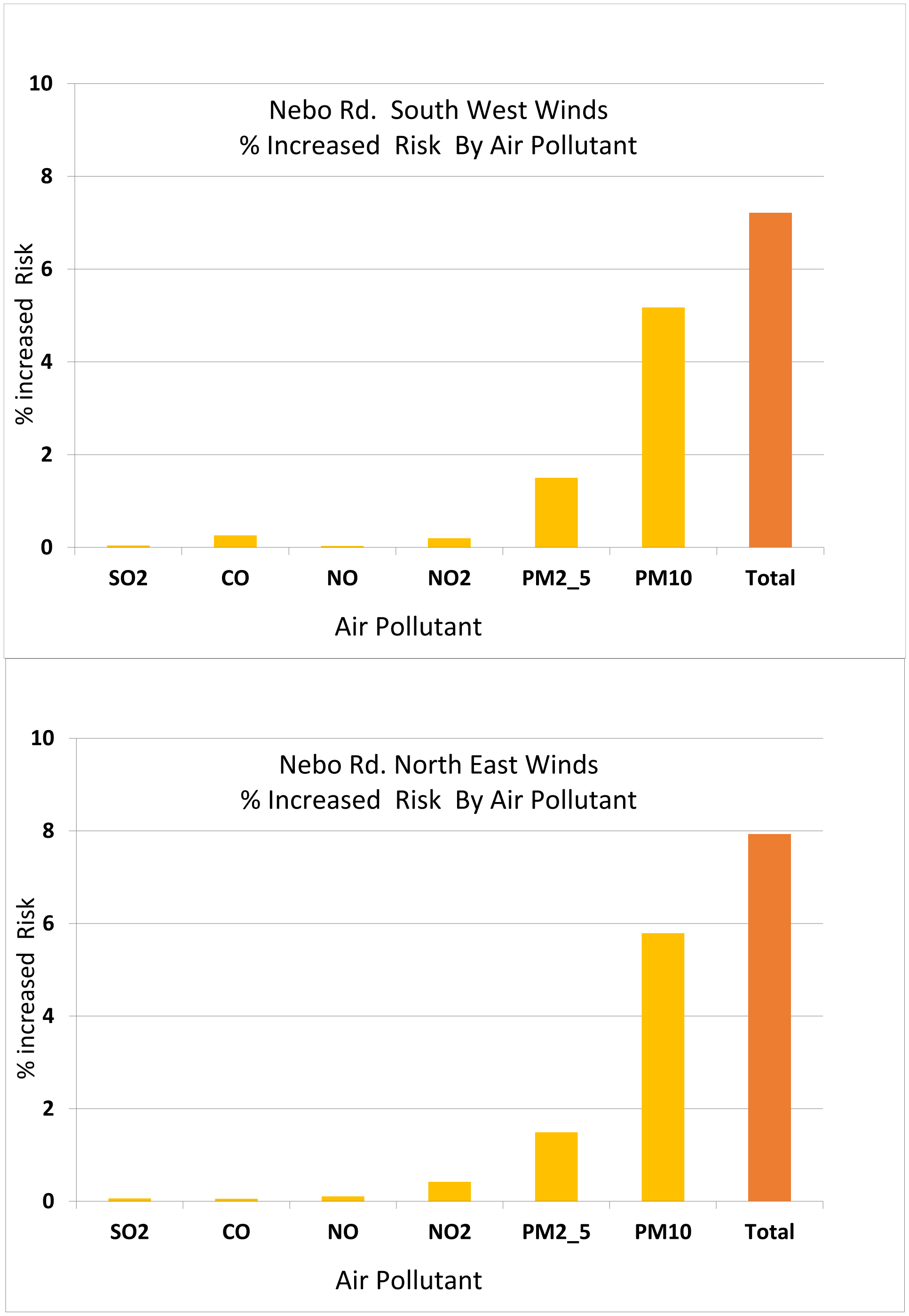


Figure 13 – Nebo Rd. Neighbourhood Percent Increased Early Mortality Risk by Air Pollutant: South West Winds (Top Panel) and North East Winds (Bottom Panel).

Figure 14 shows the estimated risk values on a GIS map and Figure 15 is an aerial photo of the area showing trackout on to the road at one location.

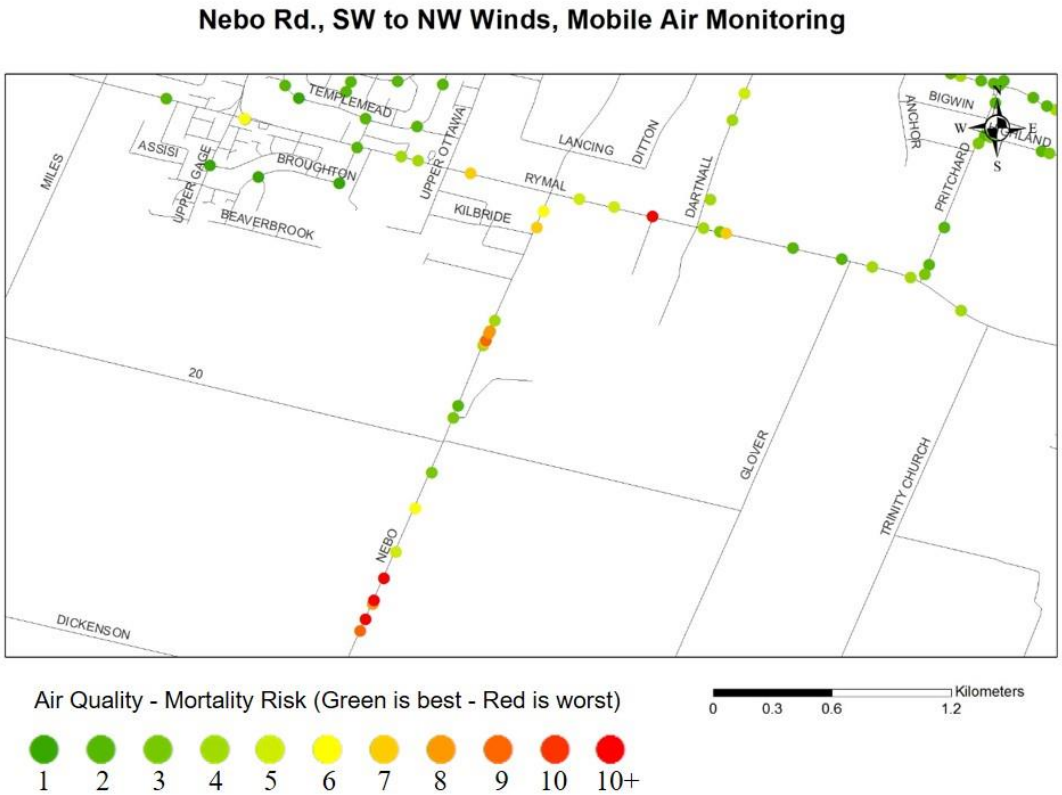


Figure 14 – Nebo Rd., SW Winds, Risk Data GIS Map

Figure 15 – Nebo Rd., Trackout onto Road

3.2.4 Air Quality Risk Estimates – Localized Impacts – Fruitland and Barton

In the Fruitland Barton area, it might be expected that west or north west winds, i.e., downwind of the city/industrial areas would yield higher values of pollutants, while north east winds would bring cleaner air. Unexpectedly, winds from the north east gave much higher pollutant values .

Additional sampling was therefore conducted during north east winds and the data were analyzed separately for:

- Fruitland/Barton Area north west winds
- Fruitland/Barton Area south west winds
- Fruitland/Barton Area north east winds

During north east winds there are significant additional components of PM_{10}, $PM_{2.5}$, Nitrogen Oxides (NO, NO2) and Carbon Monoxide (CO), with some of these probably from the QEW Highway (See Figure 16). Sulphur Dioxide (SO2) was increased as well. The source is unknown but SO2 is usually an industrial emission.

Detailed sampling was conducted for:

- Fruitland Residential north east winds
- Fruitland Road north east winds
- Kenmore Avenue north east winds
- Arvin Avenue north east winds
- Jones Road north east winds

Figure 17 shows the additional sampling areas. Figure 18 shows the percentage risk data plotted on a GIS map of the area. Figure 19 shows the relative risk values for each of these sub areas, as well as the individual pollution risk values, showing the high particulate levels at Jones Rd. and the significant SO2 values at Jones/Kenmore/Arvin.

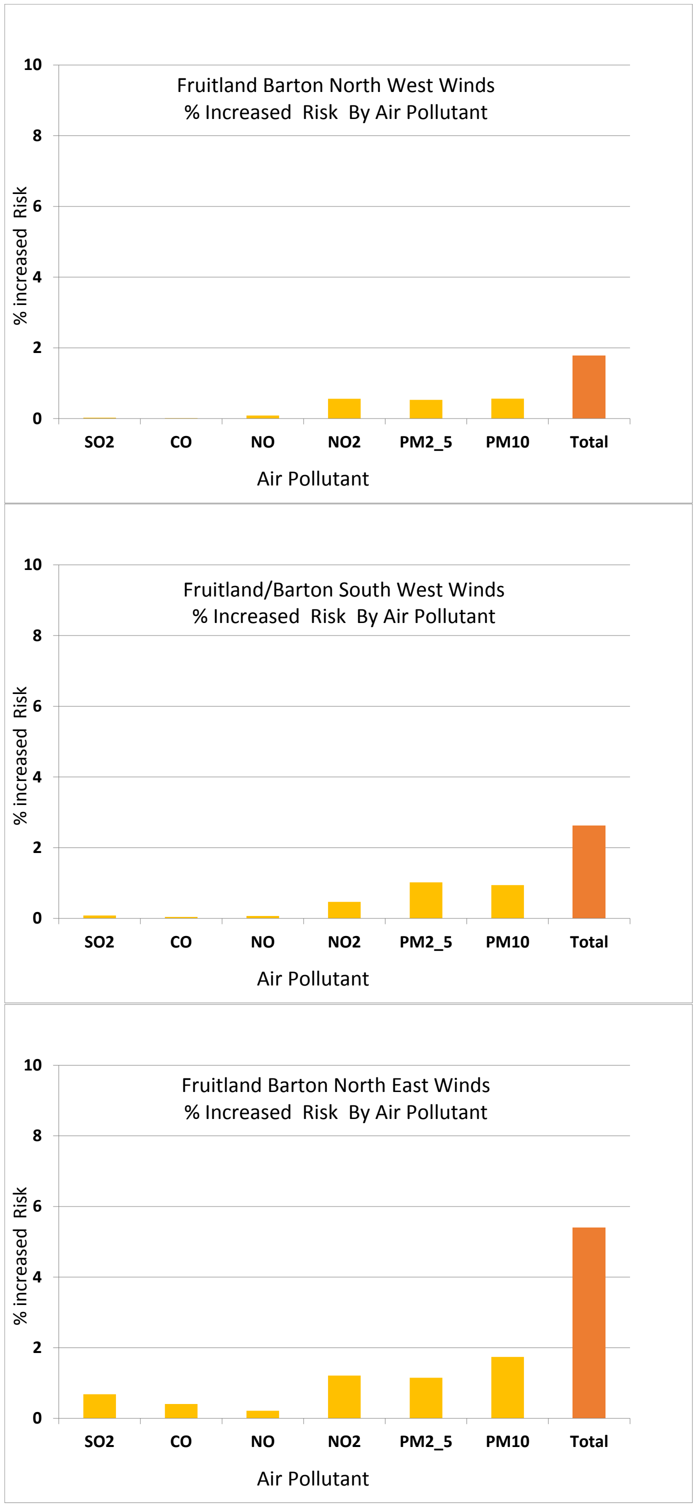


Figure 16 – Fruitland/Barton, Neighbourhood Percent Increased Early Mortality Risk by Air Pollutant: North West Winds (Top Panel), South West Winds (Middle Panel) and North East Winds (Bottom Panel).

Figure 17 – Fruitland/Barton, Area Map, Detailed Sampling Areas

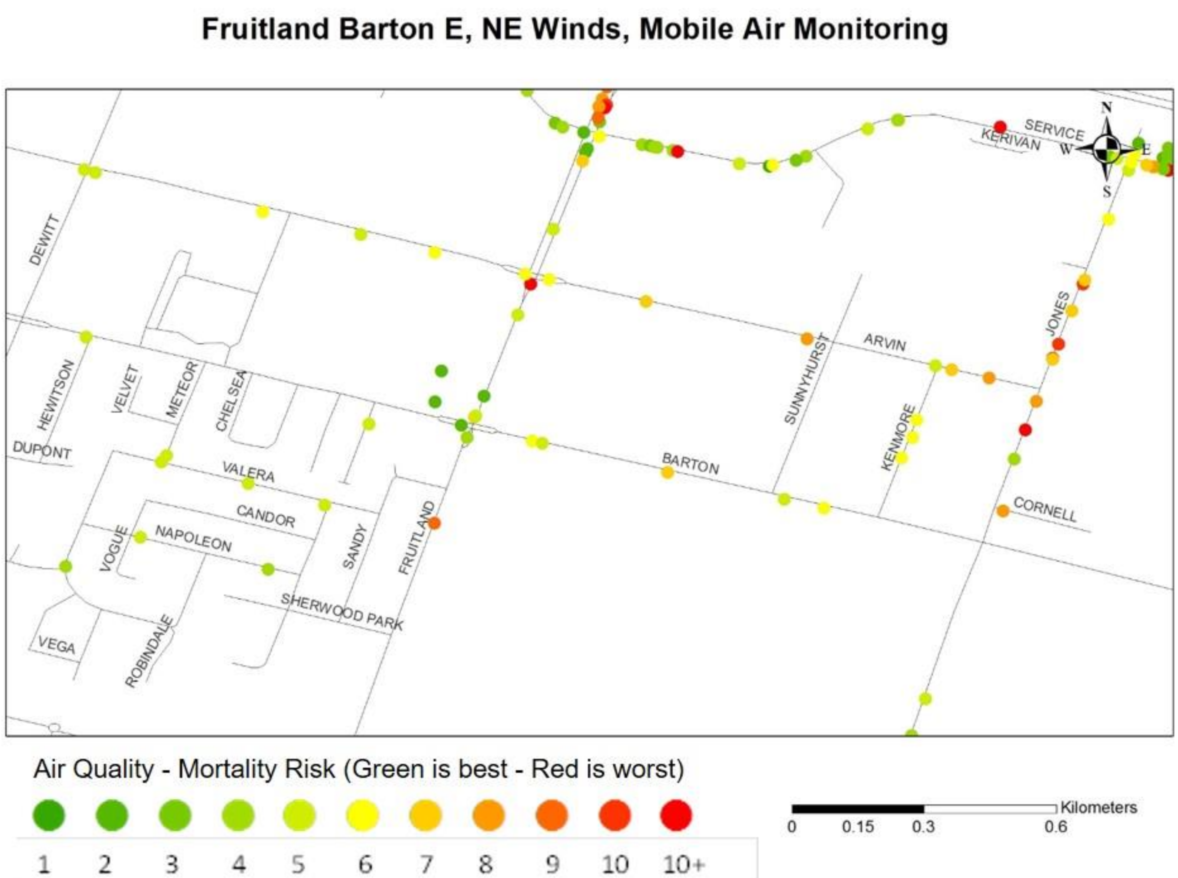


Figure 18 – Fruitland/Barton, Risk Data GIS Map

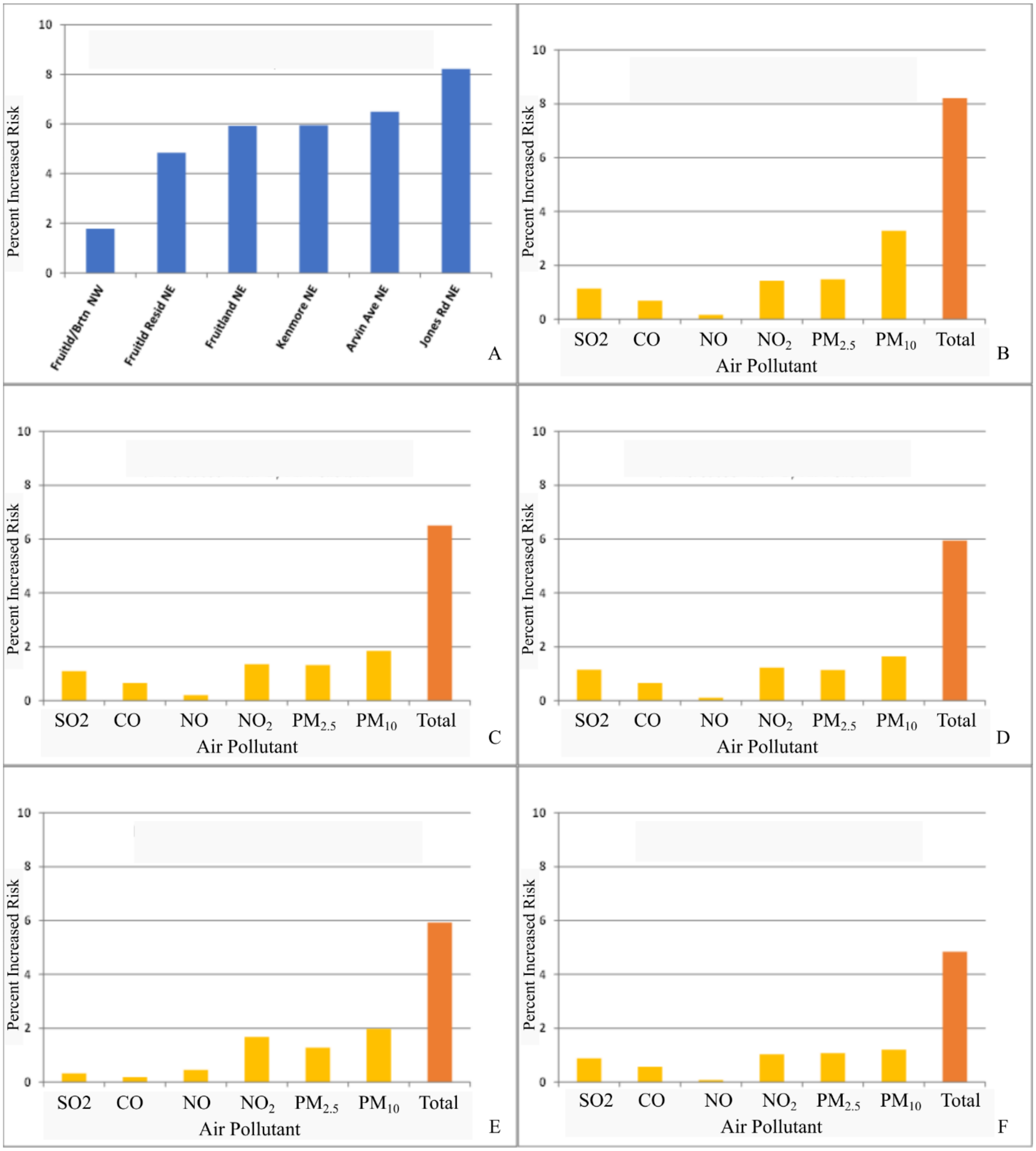


Figure 19 – Fruitland Barton region early mortality risk during north east winds: Totals by region (Panel A), Jones Rd. (Panel B), Arvin Ave (Panel C), Barton Kenmore (Panel D), Fruitland Road (Panel E), Fruitland Residential Area (Panel F).

3.2.5 Air Quality Risk Estimates – Localized Impacts – Cope St.

Cope St. is immediately south of the north east industrial area. Given the apparent impacts under north east winds farther across the city, it might be expected that Cope St. would have significantly higher values for pollutants under these conditions. In fact the Durand and Jolley Cut areas displayed greater north east wind effects than Cope St. averages as shown in Figure 20.

Figure 21 shows the comparison of individual pollutant risks at Cope St. under south west or north east winds. There is little difference in the pollutant pattern, just some additions to Nitrogen Dioxide (NO2) and Sulphur Dioxide (SO2).

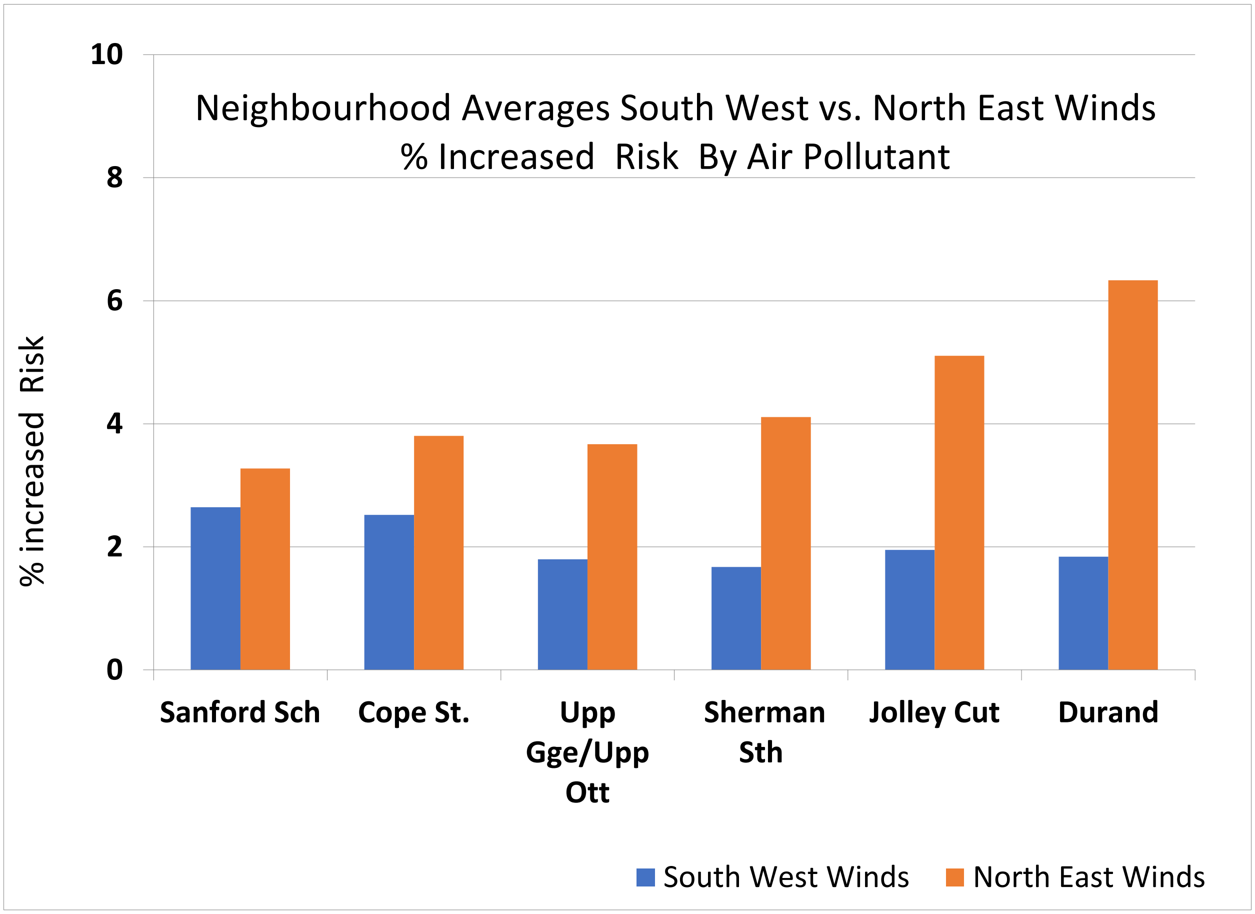


Figure 20 – Cope St., SW vs. NE winds Compared to Other Downtown Neighbourhoods

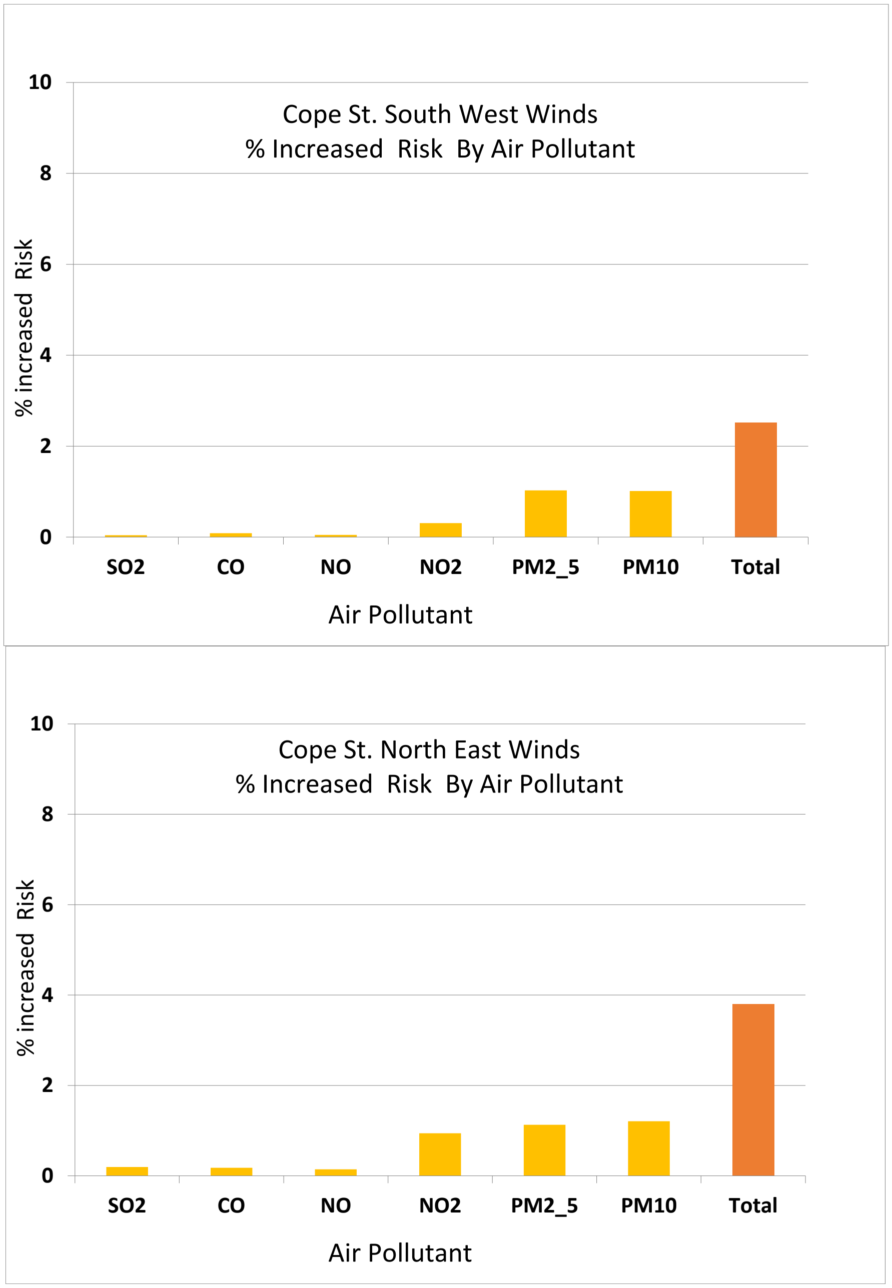


Figure 21 – Cope Street Percent Increased Early Mortality Risk by Air Pollutant: South west winds (Top Panel), North east wind (Bottom Panel).

3.2.6 Air Quality Risk Estimates – Localized Impacts – Airport Area

The airport area had very clean air with south west winds but higher levels of pollutants when winds were blowing from the airport (north east). Figure 22 shows two maps of the different risk values by location for different winds for comparison and Figure 23 shows the respective values by pollutant for different wind directions. While there is some increase with north east winds in PM_{10}, potentially road dust, the most marked increases are in $PM_{2.5}$ and Nitrogen Dioxide (NO2), both of which are products of combustion. Some Sulphur Dioxide (SO2) was also detected downwind. SO2 is emitted from jet engines due to the sulphur content of the fuel. Total SO2 values monitored were still relatively low.

Previous monitoring along Airport Rd. had shown little impact when the wind was blowing from the direction of airport. The difference could be due to the intermittent nature of airport operations.

Figure 22 – Airport Area Risk Maps: South west (Top Panel), North East (Bottom Panel)

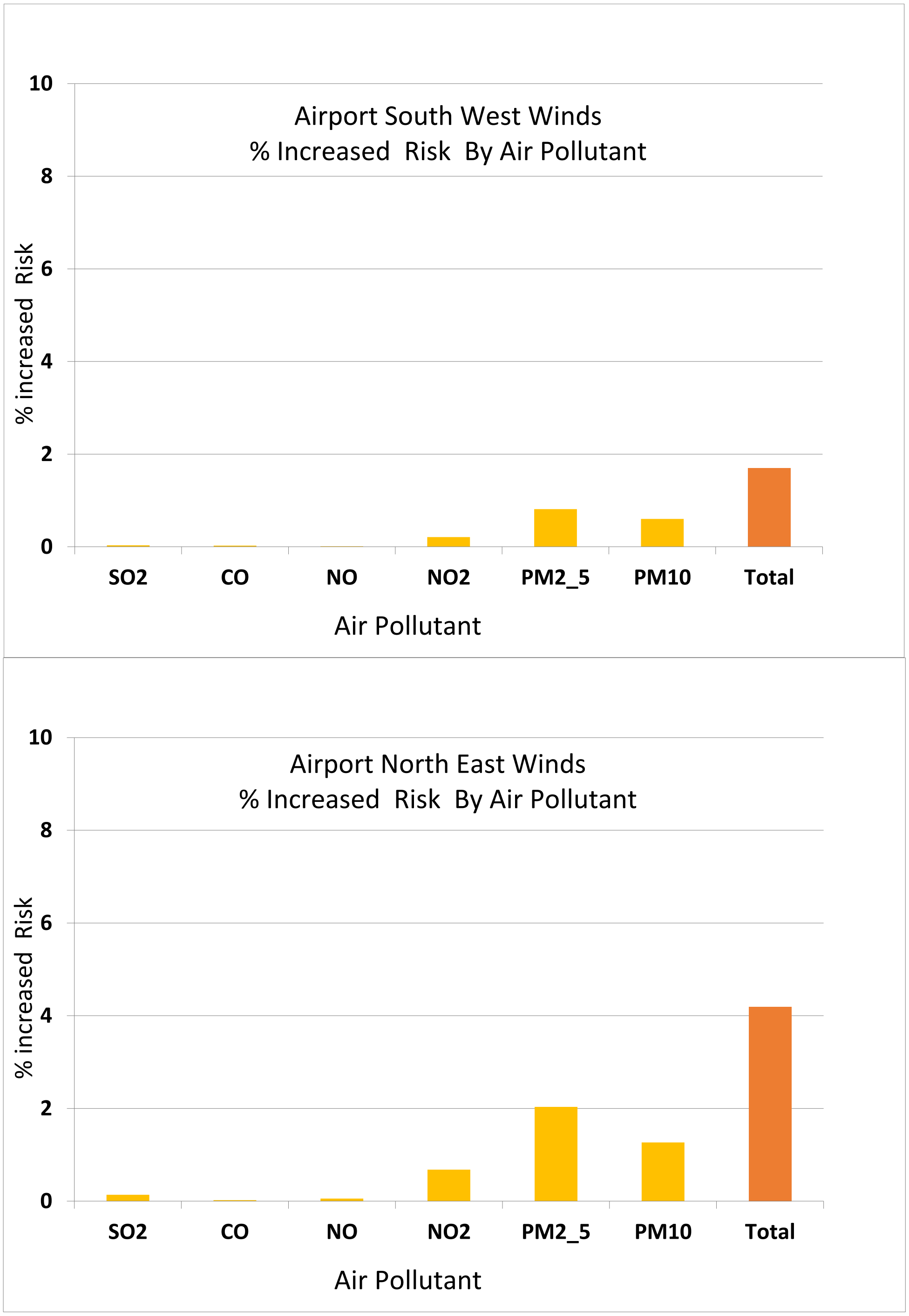


Figure 23 – Airport Area Percent Increased Early Mortality Risk by Air Pollutant: South west winds (Top Panel), North east wind (Bottom Panel).

3.2.7 Air Quality Risk Estimates – Localized Impacts – Other Neighbourhoods with Higher NE Wind Impacts

Other neighbourhoods with higher north east wind impacts were:

- Sanford School
- Sherman South
- Jolley Cut
- Durand
- Upper Gage/Upper Ottawa.

Four out of five of these were in the downtown area and one is on the near mountain, close to the escarpment.

Figures 24, 25, 26, 27 and 28 show the risk breakdown by pollutant for each of south west and north east winds.

The downtown neighbourhoods all show a definite pattern in terms of their increased north east risk values. Sulphur dioxide (SO2) was increased, and would be a result of industrial sources. Nitrogen Dioxide (NO2) and $PM_{2.5}$ increased and these would be due to combustion sources, both industrial and vehicular. PM_{10}, the heavier, larger particulate, also increased, probably due to road dust resuspension and construction type sources.

The escarpment neighbourhood, Upper Gage/Upper Ottawa showed a quite different pattern, with the increase under north east winds being due mainly to PM_{10} increases with some additional Nitrogen Dioxide (NO2).

Figure 29 shows that the higher risk levels were on major roadways such as Fennell, Mohawk, Upper Gage and Upper Ottawa. It is not clear why PM_{10} levels should be higher for north east winds in this case. One possibility is summer road construction which, with the lower wind speeds associated with north east winds, may have greater local impacts.

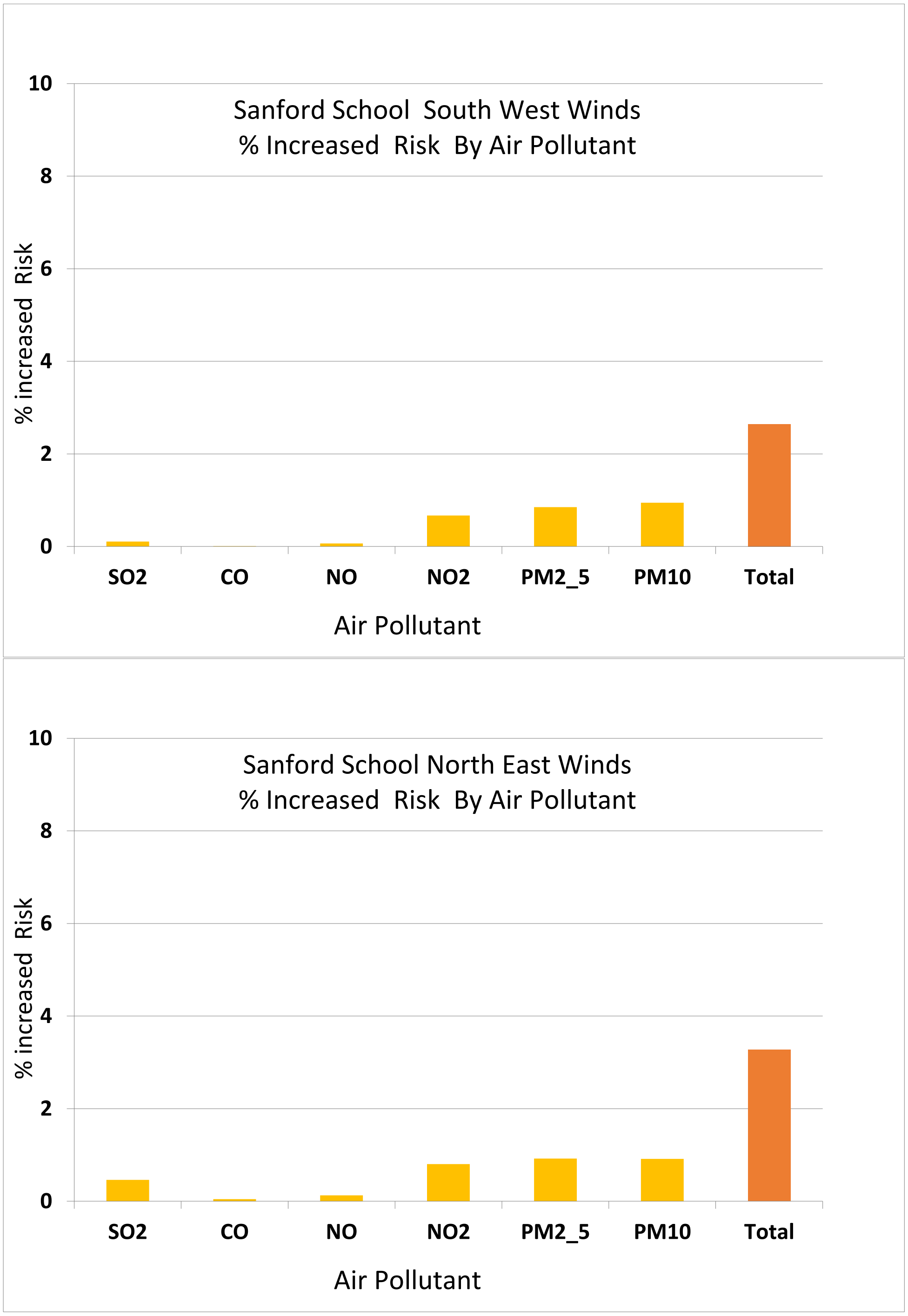


Figure 24 – Sanford School Percent Increased Early Mortality Risk by Air Pollutant: South West Winds (Top Panel) and North East Winds (Bottom Panel).

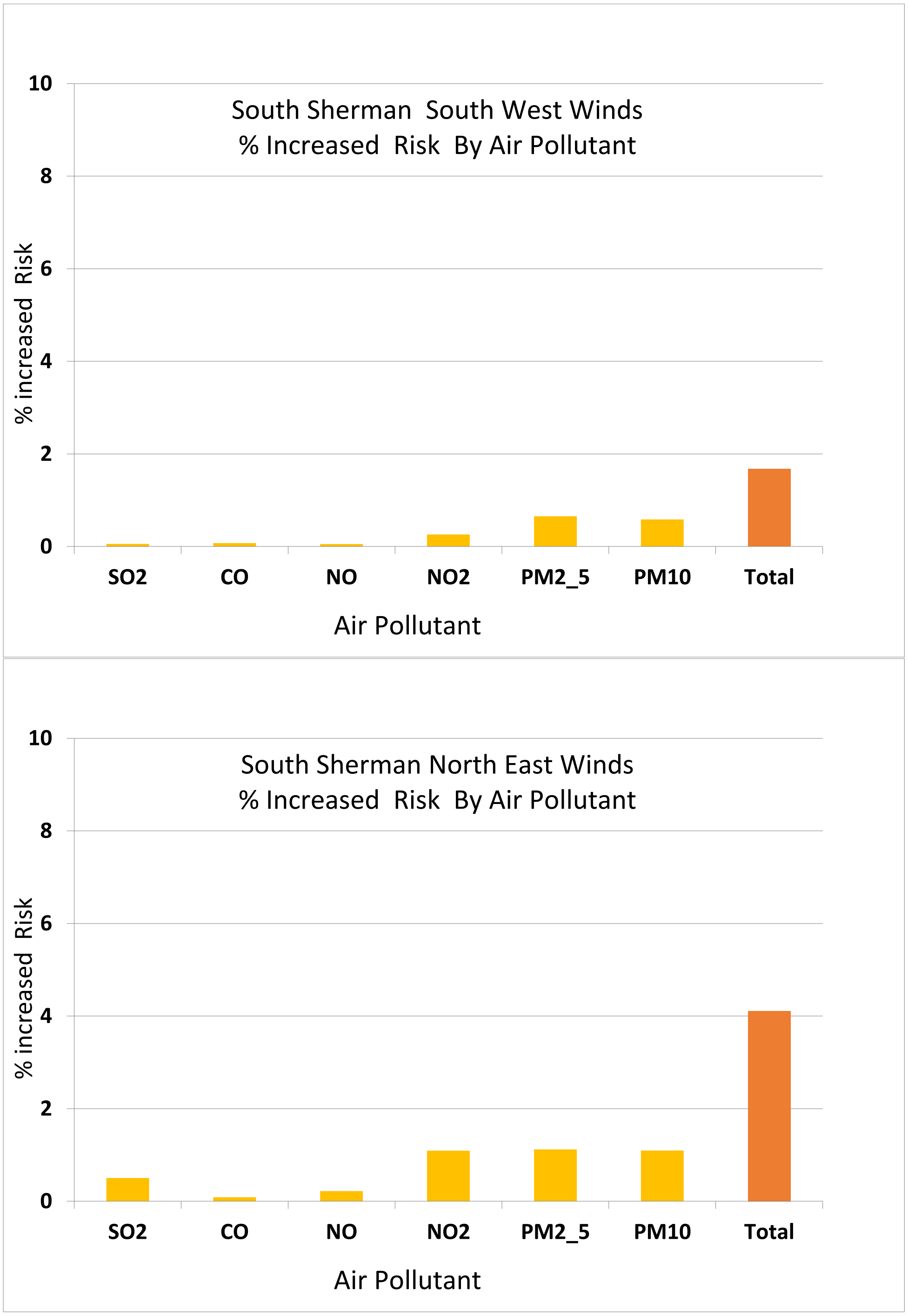


Figure 25 – South Sherman Percent Increased Early Mortality Risk by Air Pollutant: South West Winds (Top Panel) and North East Winds (Bottom Panel).

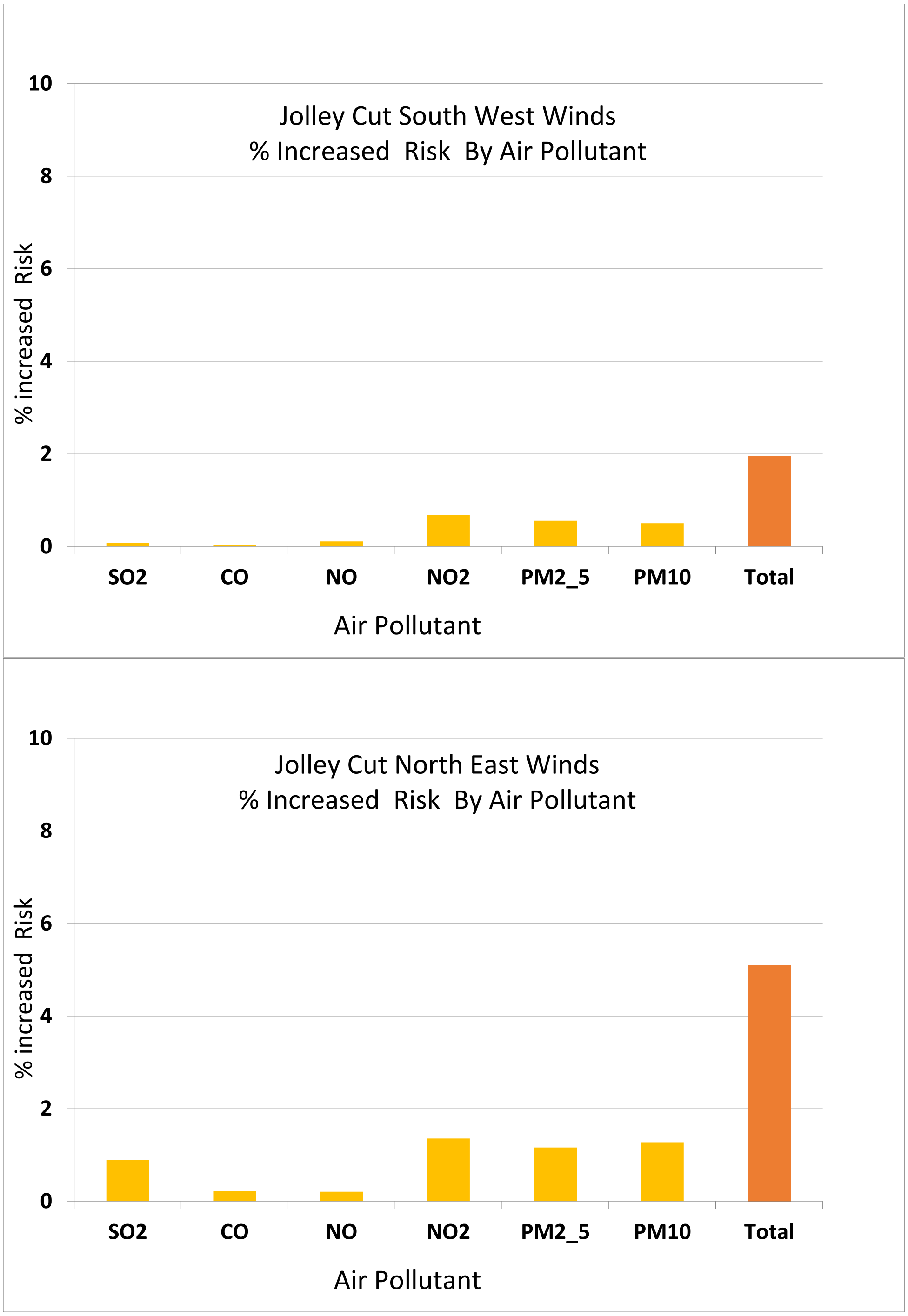


Figure 26 – Jolley Cut Percent Increased Early Mortality Risk by Air Pollutant: South West Winds (Top Panel) and North East Winds (Bottom Panel).

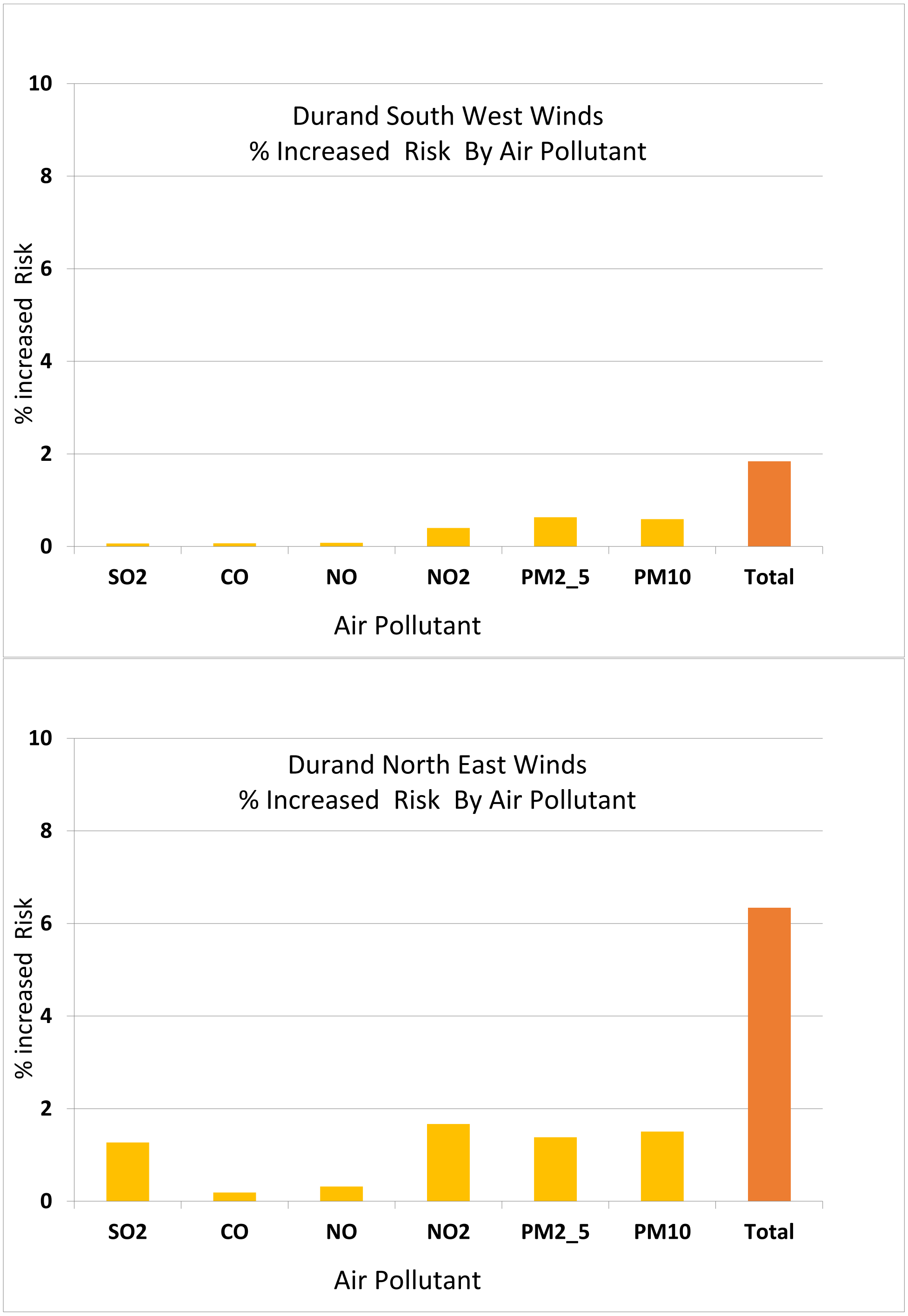


Figure 27 – Durand Percent Increased Early Mortality Risk by Air Pollutant: South West Winds (Top Panel) and North East Winds (Bottom Panel).

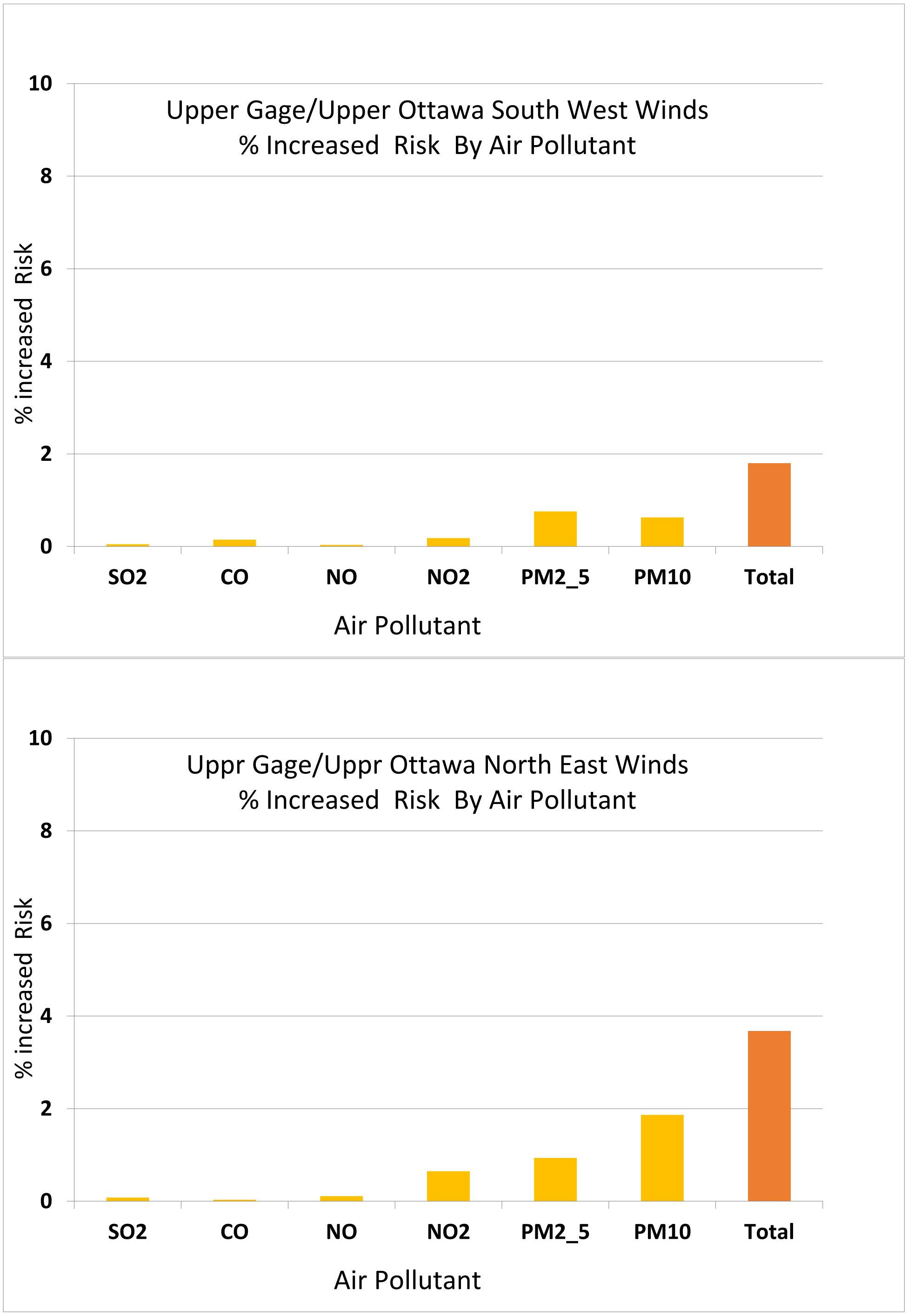


Figure 28 – Upper Gage/Upper Ottawa Percent Increased Early Mortality Risk by Air Pollutant: South West Winds (Top Panel) and North East Winds (Bottom Panel).

Figure 29 – Upper Gage/Upper Ottawa Risk Maps: South west (Top Panel), North East (Bottom Panel)

3.2.8 Air Quality Risk Estimates – Localized Impacts – Neighbourhoods Distant from Central City Core

The remaining group of neighbourhoods, Rymal/Mud Area, Linc/Red Hill Intersection Area, Gourley, Rymal/Paradise, Meadowlands, Ancaster and Waterdown comprise a band surrounding the central City core and are distinguished in this this study by having mainly better air quality than the rest of the city. Figure 30 repeats Figure 12 to show this effect, with four of the seven neighbourhoods actually having better air quality when the winds are from the north east. Obviously these neighbourhoods are sufficiently far away from the industrial areas and the downtown core that emissions from those areas have a negligible impact. However, localized impacts from the highways are probably having some effect (Linc/Red Hill). Rymal/Mud could be impacted by Upper Centennial.

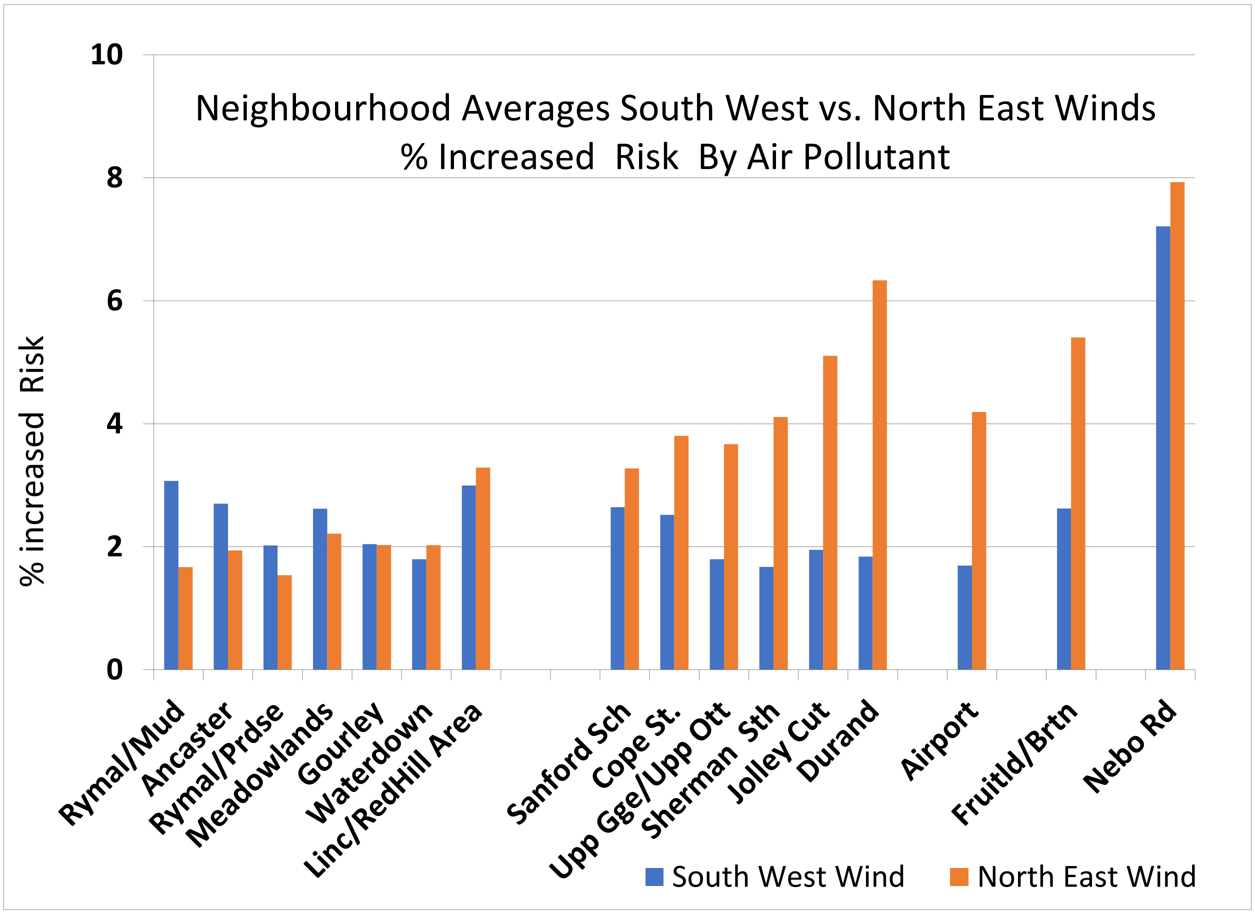


Figure 30 – Phase 2, Neighbourhood Average Risk Percent Comparison of Winds from South West and North East

Figures 31, 32, 33, 34, 35, 36 and 37 show the risk breakdown by pollutant for each of south west and north east winds for these areas. The higher risk levels for Rymal/Mud and others are due, in order, to $PM_{2.5}$, PM_{10} and Nitrogen Dioxide (NO2) with a trace of Sulphur Dioxide (SO2), all of which may indicate diesel traffic related emissions (direct emissions plus road dust resuspension).

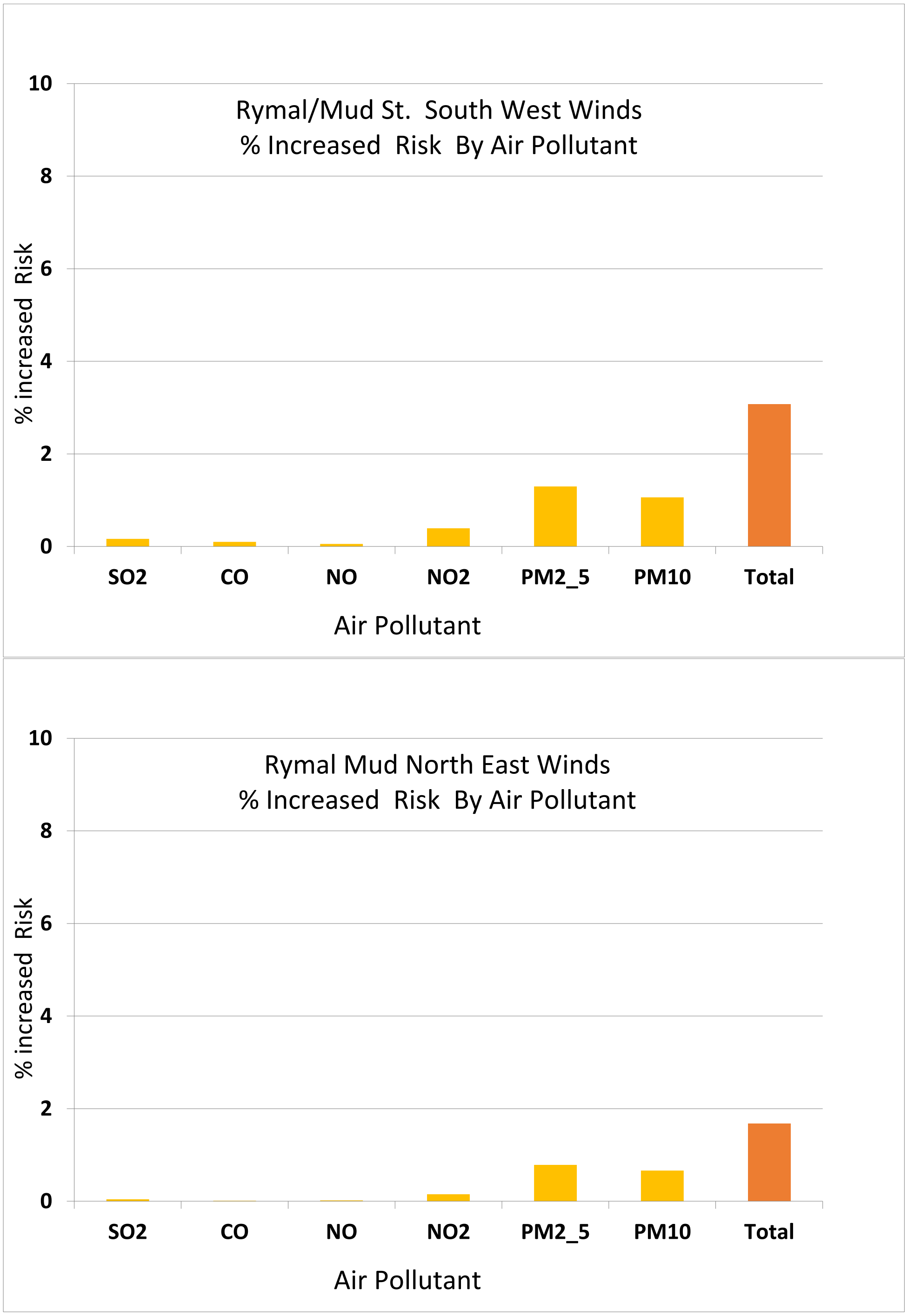


Figure 31 – Rymal/Mud Percent Increased Early Mortality Risk by Air Pollutant: South West Winds (Top Panel) and North East Winds (Bottom Panel).

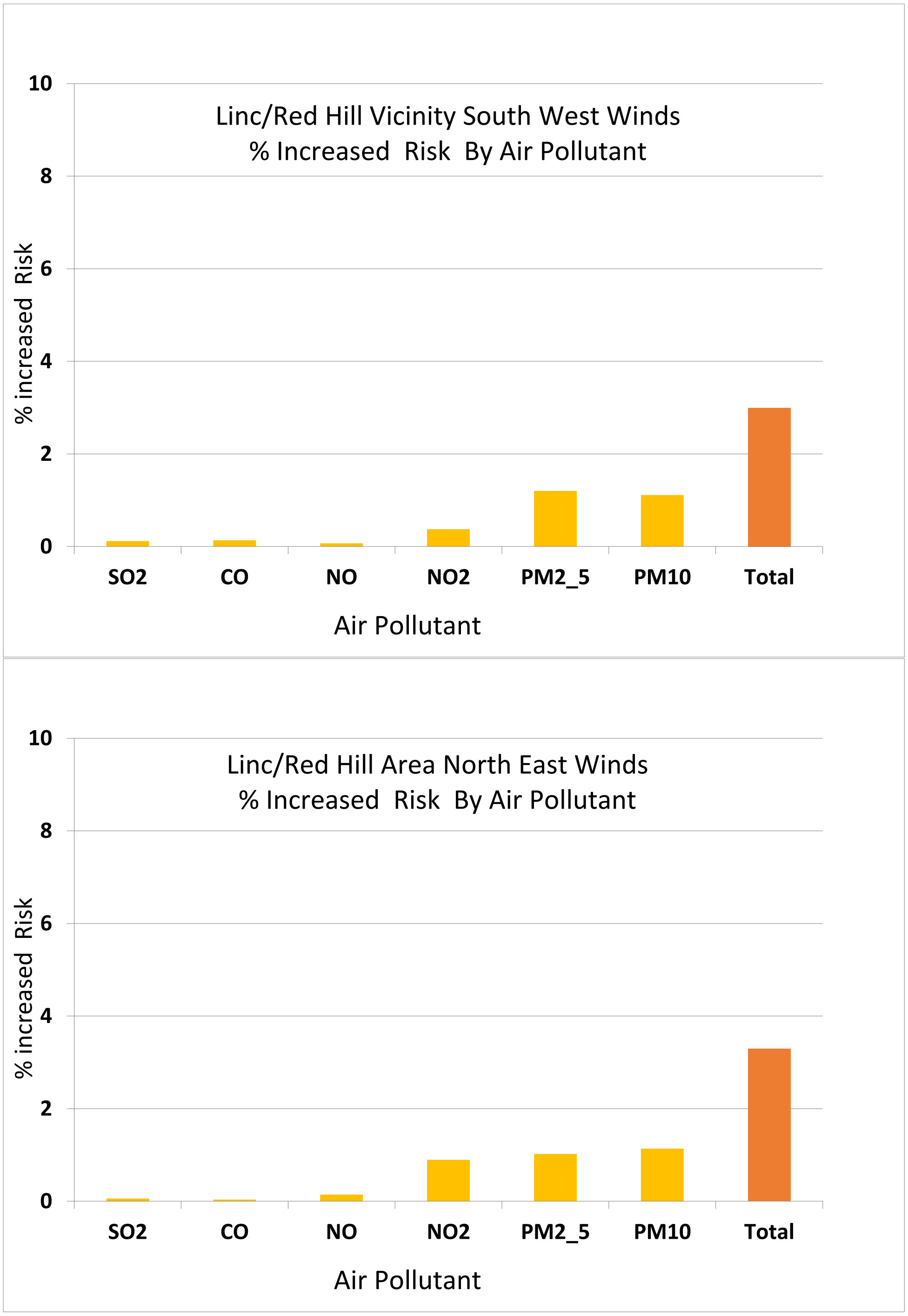
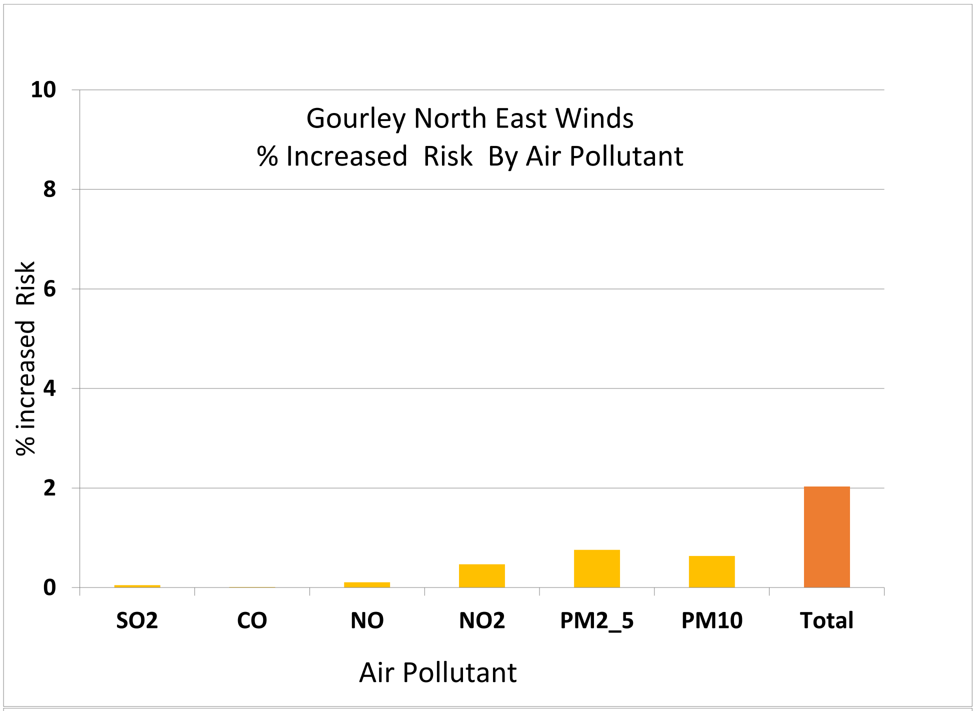


Figure 32 – Linc/Red Hill Area Percent Increased Early Mortality Risk by Air Pollutant: South West Winds (Top Panel) and North East Winds (Bottom Panel).



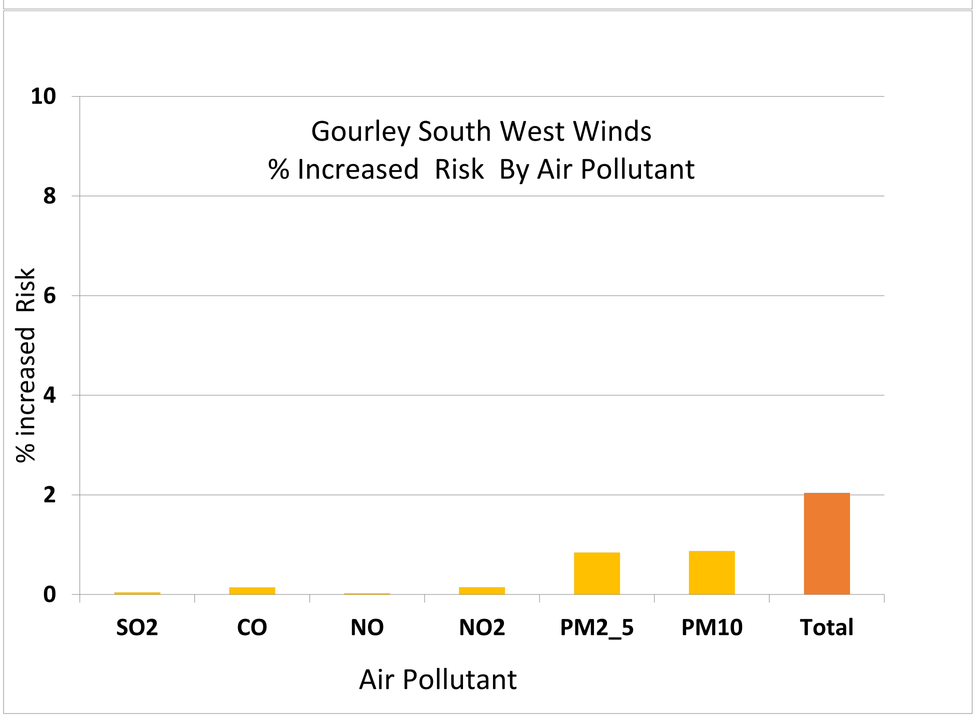


Figure 33 – Gourley Percent Increased Early Mortality Risk by Air Pollutant: South West Winds (Top Panel) and North East Winds (Bottom Panel).

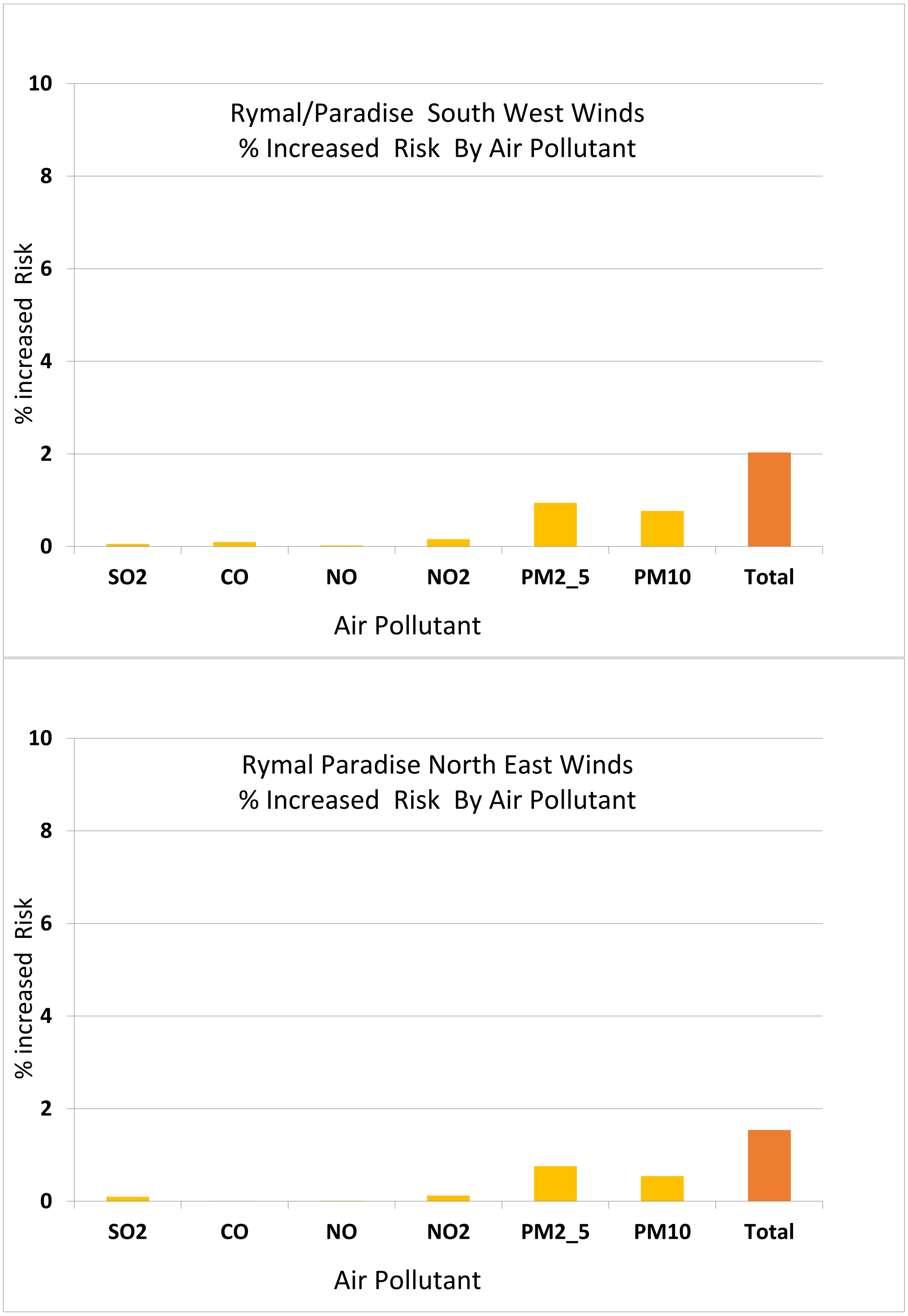


Figure 34 – Rymal/Paradise Percent Increased Early Mortality Risk by Air Pollutant: South West Winds (Top Panel) and North East Winds (Bottom Panel).

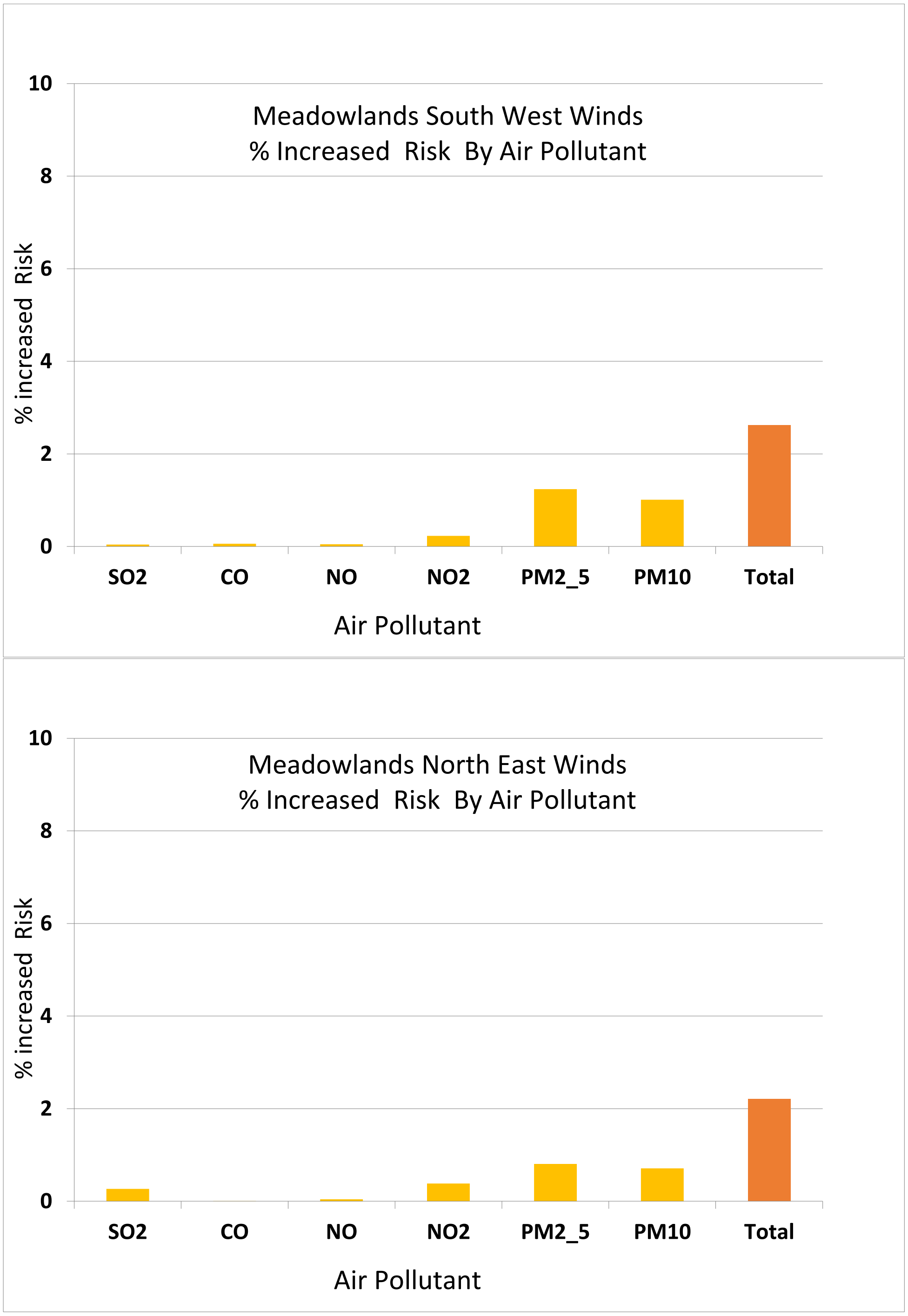


Figure 35 – Rymal/Mud Percent Increased Early Mortality Risk by Air Pollutant: South West Winds (Top Panel) and North East Winds (Bottom Panel).

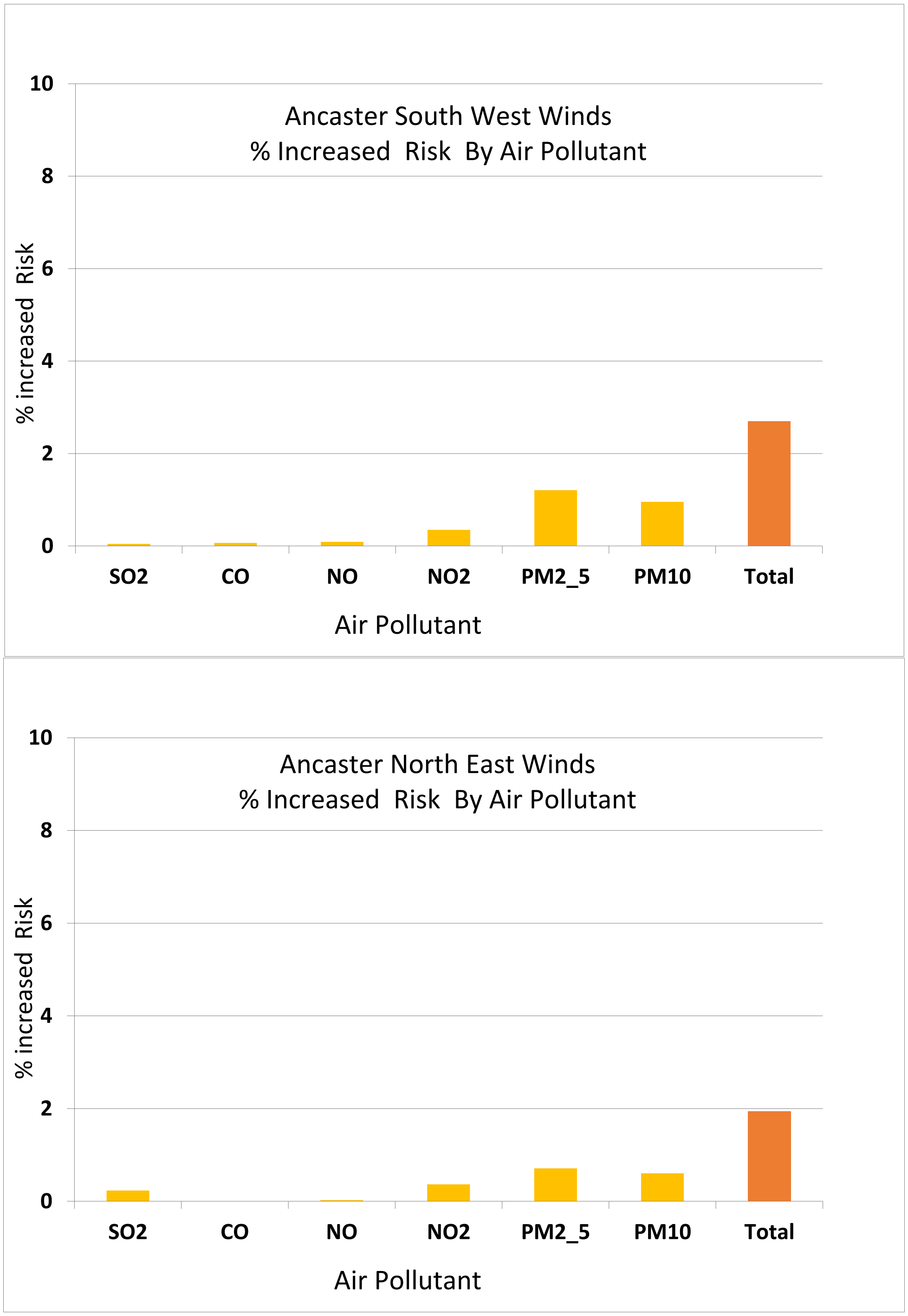


Figure 36 – Ancaster Percent Increased Early Mortality Risk by Air Pollutant: South West Winds (Top Panel) and North East Winds (Bottom Panel).

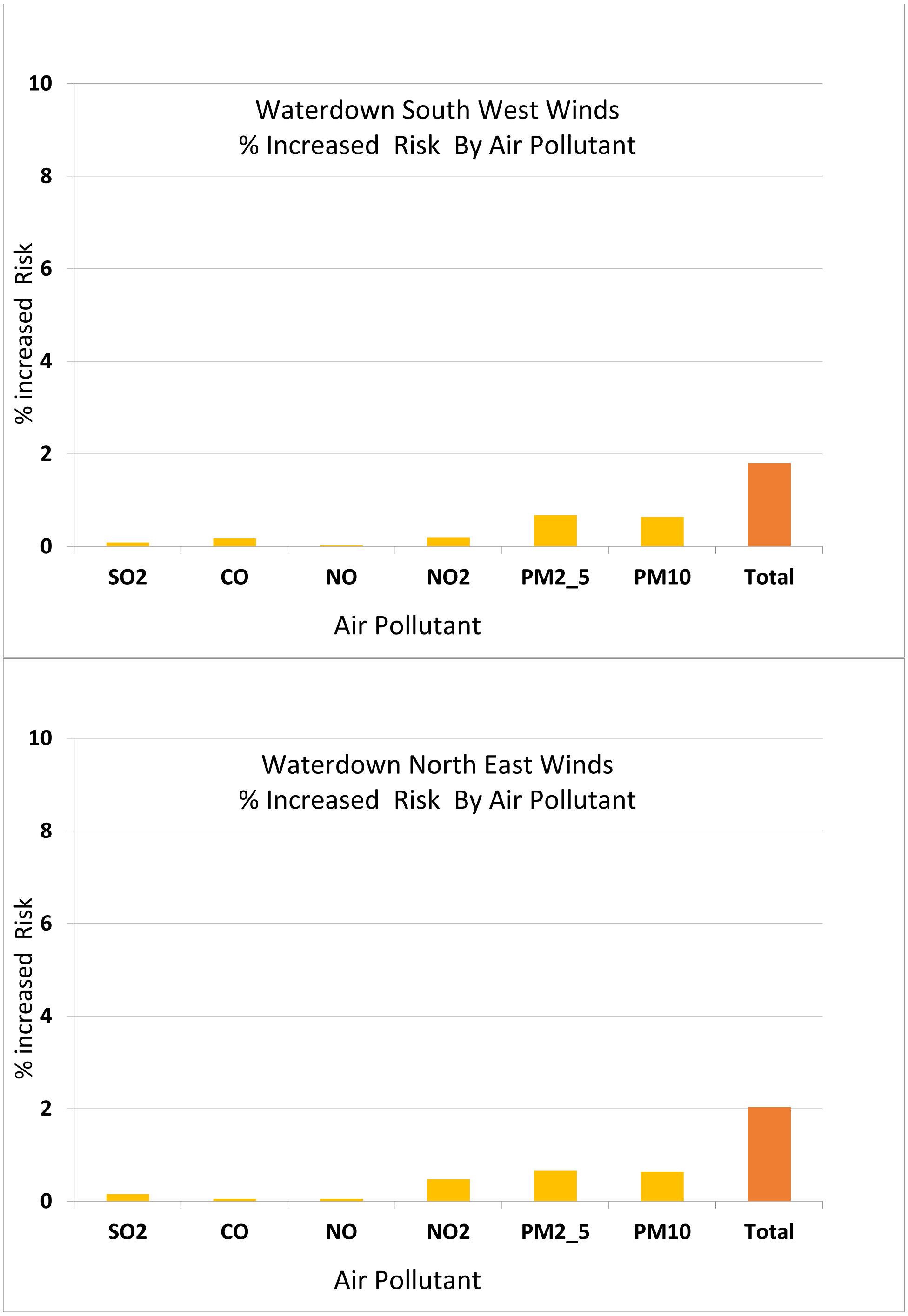


Figure 37 – Waterdown Percent Increased Early Mortality Risk by Air Pollutant: South West Winds (Top Panel) and North East Winds (Bottom Panel).

3.2.9 Air Quality Risk Estimates – Ward 6 – Additional requests section.

Ward 6 Councillor Tom Jackson requested additional mobile monitoring on behalf of his constituents (Mrs. Kate Fraser and group) who had prepared a list of areas of concern. A special presentation was made to the Ward 6 Neighbourhood Association meeting to discuss the results. For clarity, this section covers these requests to the degree that they have not been addressed in the main body of the report. The Rymal Road area was already covered under the City wide monitoring program and Nebo Road has been covered in Section 5.2.3.

The request list included:

- Kenilworth Access traffic circle on Mountain Brow and Mountain Brow Blvd
- School buses in the area of Sherwood Secondary School and the French School
- Intersection of Upper Ottawa and Fennell Ave
- Intersection of Mohawk Rd. and Upper Ottawa
- Intersection of Upper Gage and Fennell Ave
- Intersection of Upper Gage and Mohawk Rd
- Rymal Rd. and Nebo Rd. area.

Figure 38 shows the school buses outside Sherwood Secondary School.

Figure 38 – School buses outside Sherwood Secondary School

Figure 39 shows the results of the Ward 6 monitoring, separated by wind direction. City wide averages for south west and north east winds are included for comparison.

Similar to the city-wide monitoring program, in most cases there were higher levels of air pollutants during winds from the north east.

For the monitoring outside the school, there were no significant differences between air pollution levels either near the school buses or for different wind directions. However it should be noted that the bus operators turned off their engines promptly upon arrival. It is possible that this responsible behaviour could be due to either school requests or the visible presence of the Ministry of Environment and Climate Change Monitoring van nearby.

For the road intersections, south west winds showed about the same lower values, but the Fennell intersections showed markedly higher levels for north east winds, possibly because they are impacted by some downtown sources.

Mountain Brow Boulevard had very clean air under south west winds (1.3% increased risk) with higher levels (2.5% increased risk) for north east winds, probably due to impacts from downtown/industry but still well below city averages. Kenilworth Access/Traffic Circle had a somewhat unusual pattern in that south west wind conditions were higher at 3.3% compared to north east at 2.6%. It may well be that for south west winds, traffic emissions can accumulate on the Access, while for north east winds these emissions may be blown away.

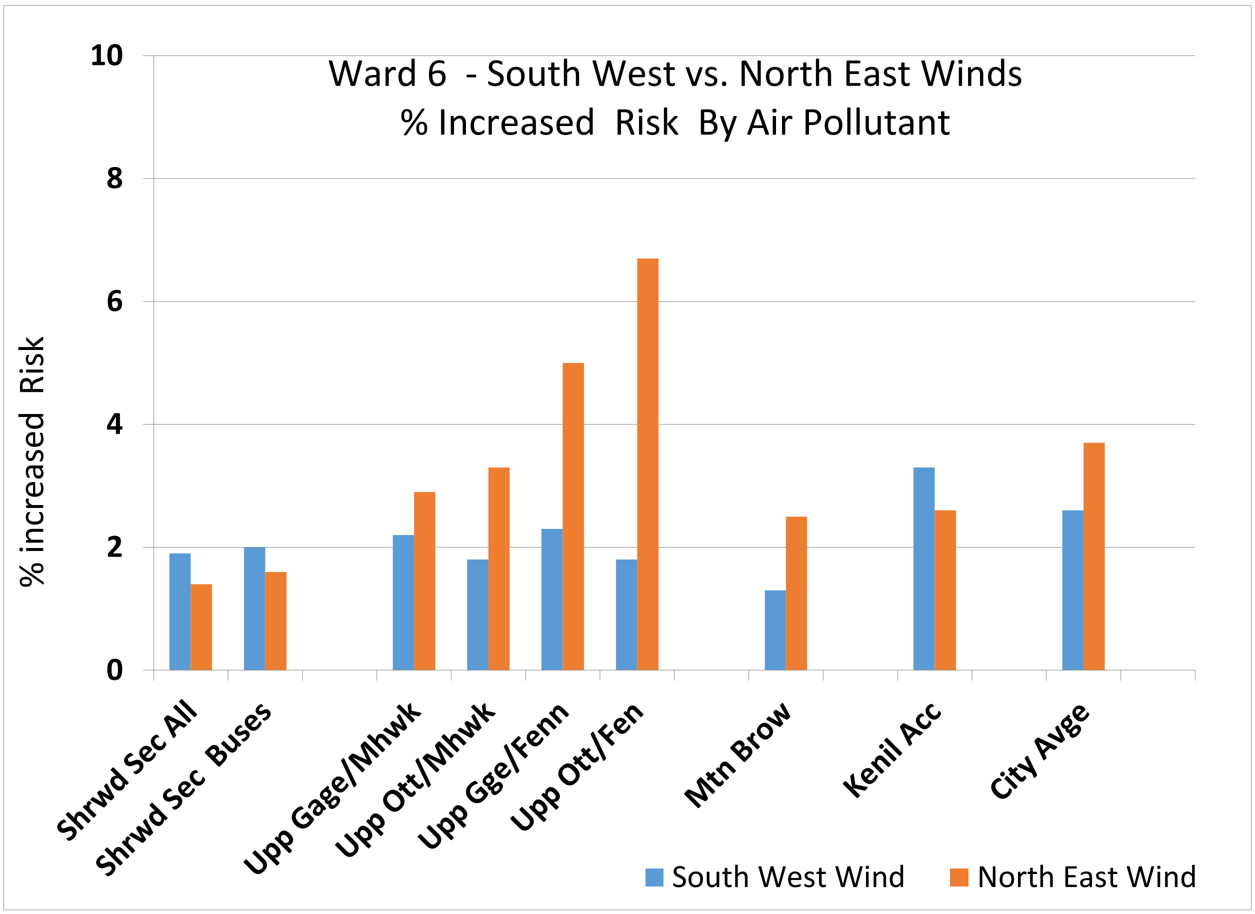


Figure 39 – Ward 6 Additional Monitoring

4. Summary and Conclusions

Phase 1 of this mobile air monitoring project was intended to address five neighbourhoods only. Consultation with a number of stakeholders, including neighbourhood associations, led to a much larger than anticipated target list of twenty six neighbourhoods.

A community grant program, supported by ArcelorMittal Dofasco allowed eleven of the twenty six locations to be completed in Phase 1. The Phase 1 report can be found on the Clean Air Hamilton website at:
http://www.cleanair.hamilton.ca/downloads/Hamilton%20neighbourhoods%20%202011.pdf

This Phase 2 report addresses the remaining fifteen neighbourhoods, along with additional special requests. The additions included specific locations in Hamilton's Ward 6 (Councillor Tom Jackson) as well as Nebo Rd. for a total of seventeen neighbourhoods.

This study was supported by Hamilton Public Health Services and conducted in partnership with the Ontario Ministry of Environment and Climate Change

Mobile air monitoring techniques were used to evaluate levels of Carbon Monoxide (CO), Oxides of Nitrogen (NO, NO2 and NOX), Sulphur Dioxide (SO2), Inhalable Particulate PM_{10} (particulate matter less than 10 microns aerodynamic diameter) and Respirable Particulate $PM_{2.5}$ (particulate matter less than 2.5 microns aerodynamic diameter). A GPS monitor was used to specify monitoring locations and GIS (Geographic Information System) techniques were used to map and evaluate the data.

An innovative data evaluation technique was developed for this program. Health effects (additional mortality risk percentages) due to air pollution were calculated for each neighborhood 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. These total values were then further structured into values for each individual pollutant, indicating the particular problems in each neighborhood.

Risk values were calculated on the basis of acute mortality risk data from the Hamilton Public Health Services/Clean Air Hamilton study on this topic. It should be cautioned that percentage increased mortality risk estimates should only be used as a general indication of, and surrogate for, a broader suite of health impacts, both respiratory and cardiovascular effects, rather than exact counts of death or illness. Intuitively, one would expect that, for air pollution, respiratory health impacts would dominate, however cardiovascular effects are equally important.

The majority of air pollution impacts in this study were due to Particulate Matter (PM) and Oxides of Nitrogen (NOx), with additional contributions from Sulphur Dioxide (SO2) in some areas when winds were from the north east.

Winds blow from the south west approximately 60% of the time and from the north east 20% of the time. Most of the remaining winds come from the north or north west. For simplicity in this report, data for all data for winds from the westerly direction were consolidated and were called south west. One exception to this was the Fruitland/Barton area where west or northwest winds might indicate industrial impacts.

Three general patterns emerged.

1. For winds from the south west (prevailing wind direction) air quality was generally better, with risk levels being somewhat higher closer to downtown and the north central industrial area.

2. For winds from the north east, much higher pollution levels were measured for areas nearer the downtown core and industrial areas, decreasing greatly the farther from these emission sources (with some exceptions).

3. For areas farthest from the downtown/industrial emissions, the band of neighbourhoods around the edge of the City, there was overall better air quality with little difference between south west and north east wind conditions, or else there were actually lower values during north east winds.

These data indicate that both vehicular and industrial emissions are still important contributors to air pollution levels in Hamilton, particularly under north east wind conditions.

The exceptions to the above patterns were:

- Nebo Rd. in the south west of the City was specifically measured at the request of Councillor Jackson’s constituents (Mrs. Kate Fraser and group) and showed high particulate levels regardless of wind direction.

- The Barton/Fruitland area in Stoney Creek, in the east of the City, showed unexpectedly high particulate levels during north east winds (i.e., away from downtown area inputs), particularly in the Jones Rd. location. Sulphur dioxide levels also contributed.

- Cope St., in the north of the City, beside the north east heavy industry, would have been expected to show higher levels during north east winds, but did not in fact do so.

Each of these areas could be studied more closely in the future, either by additional mobile monitoring or by using Public Health Services moveable monitoring stations, the AirPointers.

Of the seventeen neighbourhoods monitored, all showed some air pollution impacts. Overall risk averages for all these neighbourhoods were 2.6% for south west winds and 4.1% for north east winds increased mortality risk. For south west winds, individual neighbourhoods ranged from

1.3% (Mountain Brow) to 7.2% (Nebo Rd.) increased mortality risk. For north east winds the range was 1.5% (Rymal/Paradise) to 7.9% (Nebo Rd.).

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