Air quality at congested border crossings: a preliminary assessment using routinely collected data

Summary Report to the North American Commission for Environmental Cooperation

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Introduction

The work described in this report builds upon existing North American Commission for Environmental Cooperation (CEC) supported activities related to air quality impacts associated with transport along trade corridors. The goal of the proposed work was to evaluate the current availability of data to assess community exposures related to emissions at congested border crossings. The overall objective of this work was to estimate the potential public health impacts of exposure to air pollutants from vehicle emissions at selected congested border crossing points. As an initial component of this process we conducted a preliminary analysis of existing data with specific aims to:

- Define major border crossings with large potential population exposures
- Use census data and GIS to estimate populations in close proximity to crossings
- Assess availability of routine network monitoring data, for individual crossings
- Assess availability of sufficiently time-resolved vehicle count / waiting time data for individual crossings
- Conduct a preliminary analysis of the relationship between vehicle count and air monitoring data (pending the availability of adequate data)

Methods

Using the two main criteria of high volume border crossing and proximity to densely populated urban areas, the border sites studied were narrowed to the following seven crossings:

Detroit-Windsor (the Ambassador Bridge, and Detroit Windsor Tunnel)

Buffalo-Fort Erie

San Diego-Tijuana (Otay Mesa, and San Ysidro)

El Paso-Ciudad Juarez

Laredo-Nuevo Laredo

Nogales-Nogales

Vancouver-Seattle (Peace Arch).

Following preliminary inquiries to local air pollution authorities and Canada and U.S. Customs and after an initial review of available air monitoring data and U.S., Canadian and Mexican census data, it was decided to focus this initial assessment on the Detroit-Windsor and Buffalo – Fort Erie border crossings.

To narrow the scope of the initial analysis we elected to focus on the following pollutants: PM_{10}, $PM_{2.5}$, NO/NO_2/NOx, and CO for the time period of January 1, 2000 to December 31, 2001 to conduct a preliminary analysis of the relationship between vehicle count and air monitoring data. These pollutants were selected because they are associated with the heavy-duty vehicle emissions and for their potential health concern either directly or indirectly as precursors to other pollutants.

In gathering both the air pollution data and the vehicle count data we incorporated the same basic method. Air pollution data from all monitors located within 10 km of the specific border crossing of interest was requested from State and Provincial agencies that operate the relevant monitoring networks. For Canada, national, as well as provincial, network data were obtained from Environment Canada (Table 1). We requested hourly air pollution data for the two years Jan. 1, 2000 – Dec 31, 2001. A sample data request sheet is attached (Appendix 1). The vehicle count data was not as readily obtainable. In

order to gather the vehicle data, we contacted individuals associated with U.S. and/or Canadian customs as well as state and provincial authorities. Additionally, several border crossings, namely the Ambassador Bridge, the Detroit Windsor Tunnel, and the Peace Bridge, are privately owned and operated and the operators were contacted directly. A summary of the data that were successfully obtained is presented in Table 1.

While we successfully collected hourly air pollution data, the vehicle data was available only on a daily basis and for a more limited time period. The air pollution and vehicle data was also analyzed by calculating the yearly average for each day of the week and/or each hour of the day to examine average patterns throughout the course of a week or a day. For instance, all the CO measurements collected on all Mondays throughout an entire year were averaged, to produce one average for Monday Co concentrations for a specific year. All the analysis for air pollution focused on pollutant, by year, by border crossing, and monitoring site. In this way, we were able to compare results across border crossings, years, pollutants, or monitoring sites.

For the purposes of this report, we focus on the air quality measurements in the vicinity of the Detroit-Windsor and Buffalo-Fort Erie border crossings as the most complete data sets were available for these crossings. Locations of the relevant monitoring sites are shown in Figures 1 and 2.

Table 1: Border Crossing Site Information. [#]Data available for tunnel only.

Site ID	Border	X	Y	Pollutants	Distance to Crossing (km)	Data Source	Corresponding Vehicle Data
60203	Windsor	42.33806	-82.9272	NO/NO2/NOx	Amb: 12.2, Tunnel: 9.3	Tom Dann: 613-991-9459	2000/2001[#]
60204	Windsor	42.31667	-83.0439	CO, NO/NO2/NOx	Amb: 3.0, Tunnel: 0.5	"	2000/2001[#]
60211	Windsor	42.29222	-83.0731	All	Amb: 2.4, Tunnel: 4.6	"	2000/2001[#]
145103	Buffalo	42.99292	-78.7714	PM2.5, NO/NO2/NOx	14.3	Tim Ross: tdross@gw.dec.state.my.us	2000/2001
140118	Buffalo	42.87684	-78.8099	PM2.5, CO, NO/NO2/NOx	8.1	"	2000/2001
140214	Buffalo	42.82778	-78.8499	PM2.5	9.5	"	2000/2001
26-125-0001	Detroit, Oak Park	42.2747	-83.11	PM2.5, CO	Amb: 19.0, Tunnel: 19.4	Debbie Sherrod: 517-373-6254	2000/2001[#]
26-163-0001	Detroit, Allen Park	42.1342	-83.1233	PM10, PM2.5, CO	Amb: 14.5, Tunnel: 17.5	"	2000/2001[#]
26-163-0016	Detroit, Linwood	42.2127	-83.0549	NO/NO2/NOx	Amb: 5.5, Tunnel: 6.0	"	2000/2001[#]
26-163-0019	Detroit, Mile Rd.	42.2551	-83.0003	NO/NO2/NOx	Amb: 14.5, Tunnel: 12.3	"	2000/2001[#]
26-163-0036	Detroit, Wyandotte	42.1103	-83.0947	PM2.5	Amb: 16.0, Tunnel: 18.5	"	2000/2001[#]
481410037	El Paso (UTEP)	31.76833	106.5014	PM10, PM2.5	InMex:2.6, InUS: 2.8	Benedicto Villamin: BVILLAMI@tnrcc.state.tx.us	N/A
481410055	El Paso (Ascarate Park)	31.74667	106.4028	PM10	InMex: 1.8, InUS: 2.0	"	N/A
481410053	El Paso (Sun Metro)	31.75861	106.5011	PM2.5	InMex: 8.0, InUS: 7.6	"	N/A
484790017	Laredo	27.50167	99.50306	PM2.5	0.5	"	N/A

Figure 1. Buffalo-Fort Erie Roads and Monitoring Sites

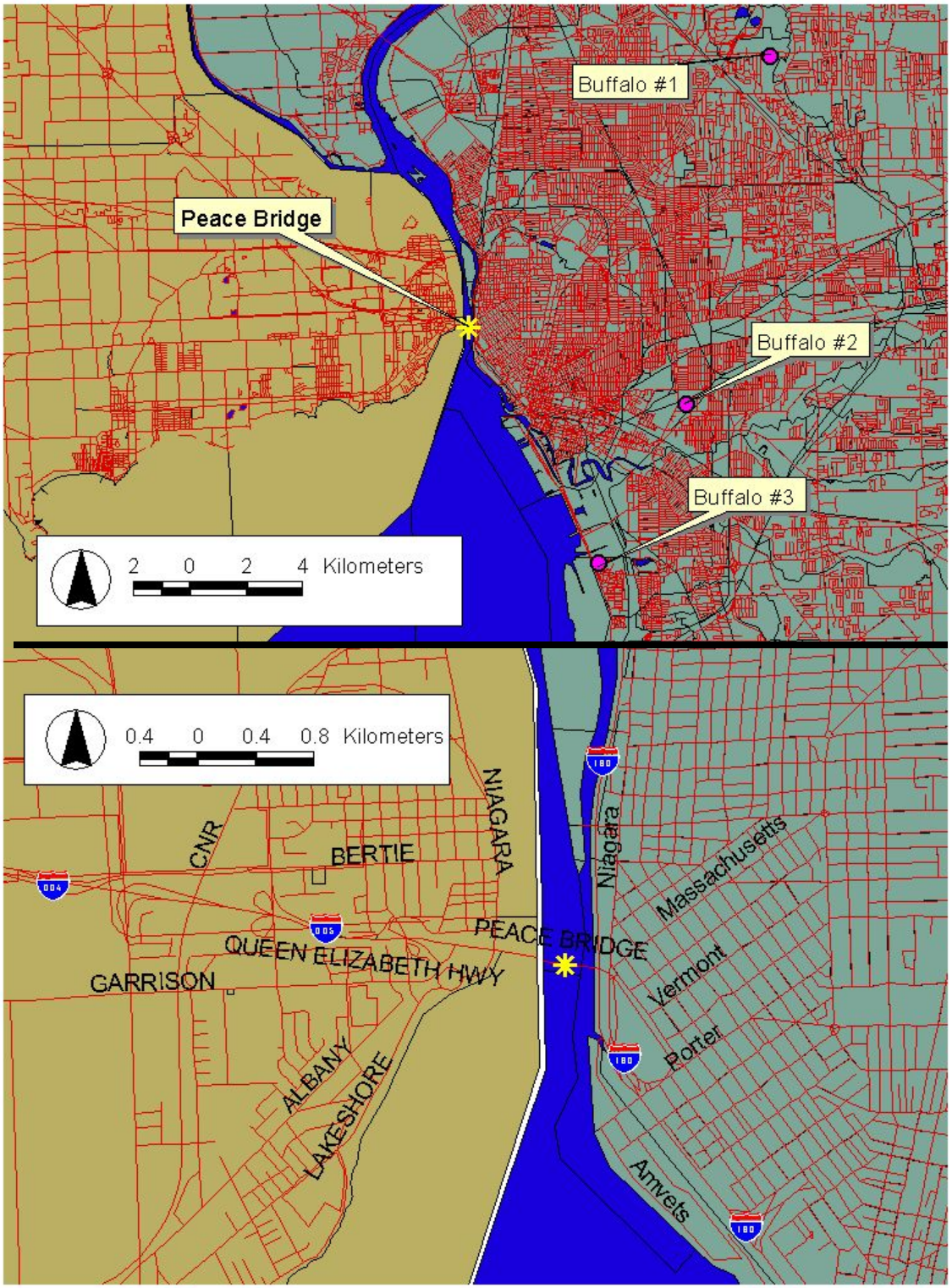
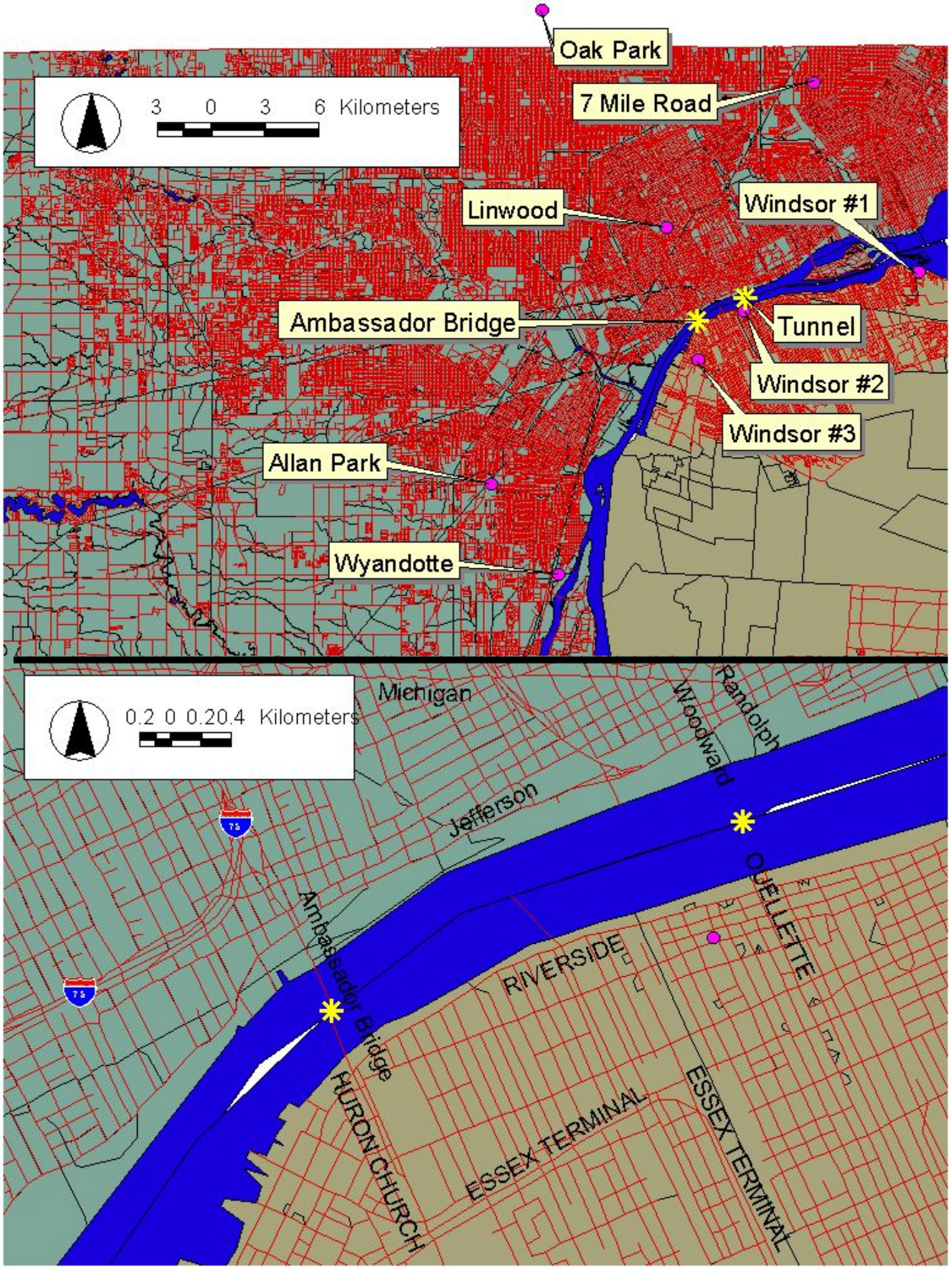


Figure 2. Detroit-Windsor Major Roads and Monitoring Sites



ASCII and digital cartographic data for Canada were obtained from the 1996 census collection held by the UBC data library. Files were received in .txt and .e00 formats, respectively, and were converted to .dbf and .shp files for compatibility with ESRI's (Environmental Systems Research Institute) Arc/View software. Data for the United States was downloaded from ESRI's online TIGER '95 (Topographically Integrated Geographic Encoding & Referencing system developed by the US census bureau) server. Geographic and attribute data for each county were received in .shp format, and were imported directly into Arc/View. Very limited data for Mexico were available through Columbia University's CIESIN (Centre for International Earth Science Information Network), and these were downloaded to provide coarse information about Mexican geography and population around the border crossings of interest. Files were received in .e00 format. From communications with GIS professionals in Mexico and the US it is probable that data better suited to the purposes of this study could be obtained in the future.

All data were received unprojected in lat/long co-ordinates referenced to the NAD-27 datum. Arc/View (version 3.2) was used display data collected from the sources listed above, as well as information concerning the locations of the border crossings, and all ambient air quality monitors in the surrounding areas. Crossing identifiers were manually located directly on the borderlines, using information from other maps in conjunction with the available digital street network files. Where one or more air quality monitors were located within 20 km of the crossing, a new theme was created and these stations were located using lat/long co-ordinates provided by the monitoring organizations. All maps were projected to UTM-27 after these features had been added.

In order to most accurately estimate the number of people potentially affected by border crossing traffic, population data with the highest available resolution were used. Block-face data were used for Canada, which assign a population value to the centre of each street network block, as shown by the black dots in the left-hand image on the following page. Census block data were used for the USA, which assign a single population value to the area enclosed by the surrounding streets. These areas are quite small in densely

populated regions, but they increase in size as population density decreases. Several census blocks (coloured according to their population value) are shown in the right-hand image in Figure 3.

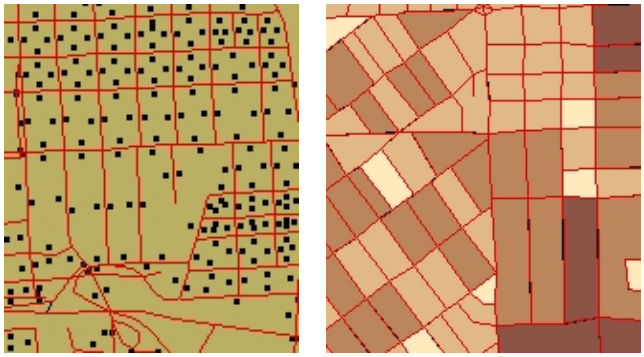


Figure 3. Canadian block-face population data compared to American census block population data.

Arc/View was used to make several population estimates for each border crossing. The number of persons residing within 1, 2, 5, and 10 kilometre radii of each crossing were estimated, as well as persons living within a 1 km buffer of a 2 km stretch of any main road leading to/away from the crossing. Each of these conditions was generated as a theme in Arc/View, which was used to select all population data contained by that theme. In the case of the case of the census block data (for the USA) all polygons having their centroid contained by the theme were selected. This is demonstrated by Figure 4, where the population living within a 1 km buffer of streets leading in to the Detroit-Windsor Tunnel is highlighted in yellow.

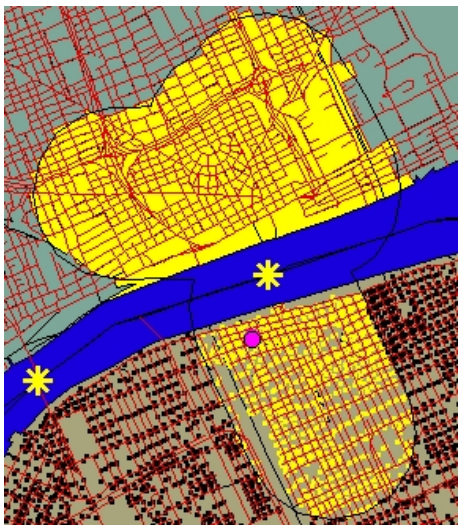


Figure 4. Population within 1 km buffer zone of streets leading into the Detroit-Windsor Tunnel

Results

Table 2 presents estimated numbers of people residing in areas close to the selected border crossings. Although the populations in close proximity to the border crossings themselves are quite small, when lead-in roads are considered, it is evident that large numbers of people are potentially exposed to emissions related to transportation at the border crossings. Both the Detroit-Windsor and Buffalo-Fort Erie border crossings have more than 35,000 people living within 1 km of the crossing or major lead-in roads.

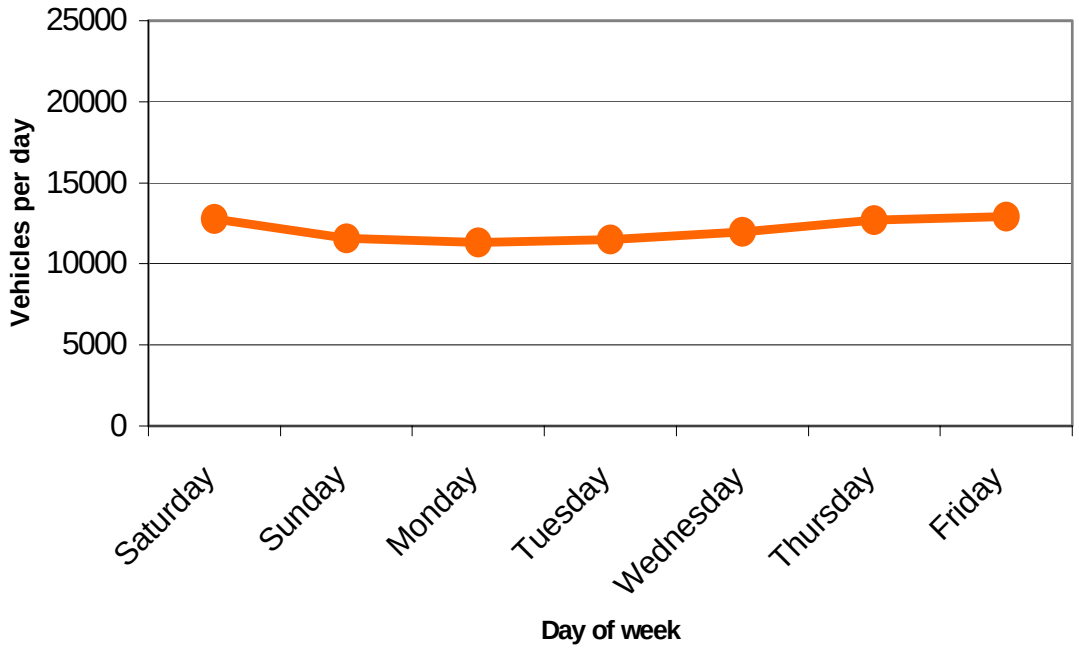
Table 2: Estimated Population Data

	R = 1 km	1 km buffer on lead-in roads	1 km buffer on lead-in roads + R = 2 km	R = 2km	R = 5 km	R = 10 km
Ambassador Bridge	3738	41125	47375	29257	171630	620647
Detroit/Windsor Tunnel	3728	36483	47373	33957	170946	591902
Peace Bridge	6655	38335	49698	37998	135516	421813
Peace Arch	705	5670	5768	2885	31475	76761
El Paso (Texas side only; from point centred between the two crossings)	6670	NA	NA	18594	62660	185531
Laredo (Texas side only)	4177	17013	21752	17069	94388	128511
San Ysidro (California side only)	777	26563	26837	8145	52836	190534
Otay Mesa (California side only)	<100	<100	<100	<100	4160	22760
Nogales (New Mexico side only)	4654	6826	9020	8874	16071	21621

Vehicle count data were only obtained from two of the major order crossings, and only one of these (Buffalo – Fort Erie) provided data that were segregated by vehicle type. Vehicle count data were also obtained from the Peace Arch border crossing between British Columbia and Washington, although there were no air monitoring sites within 10 km of this crossing and relatively few people located in close proximity to this border. Figures 5 and 6 display the available vehicle count data as yearly average values for each day of the week. While the Detroit-Windsor vehicle counts were relatively consistent for

all days of the week, there were a distinct differences in weekend and weekday vehicle counts at the Buffalo – Fort Erie crossing. At this crossing, total vehicle counts were similar for all days, but there were sharp weekend increases in car counts and corresponding decreases in truck counts. This suggested that some relationship between vehicle counts and air quality might be measurable for this location. Although similar data describing differential vehicle counts were not obtained for other crossings it is likely that other transit corridors that encounter high levels of commercial truck traffic might have similar weekly patterns, indicating a potential source of temporal variability that could be exploited in future studies.

Figure 5. Vehicle count (total vehicles) data (bi-directional) for Detroit-Windsor tunnel in year 2000.



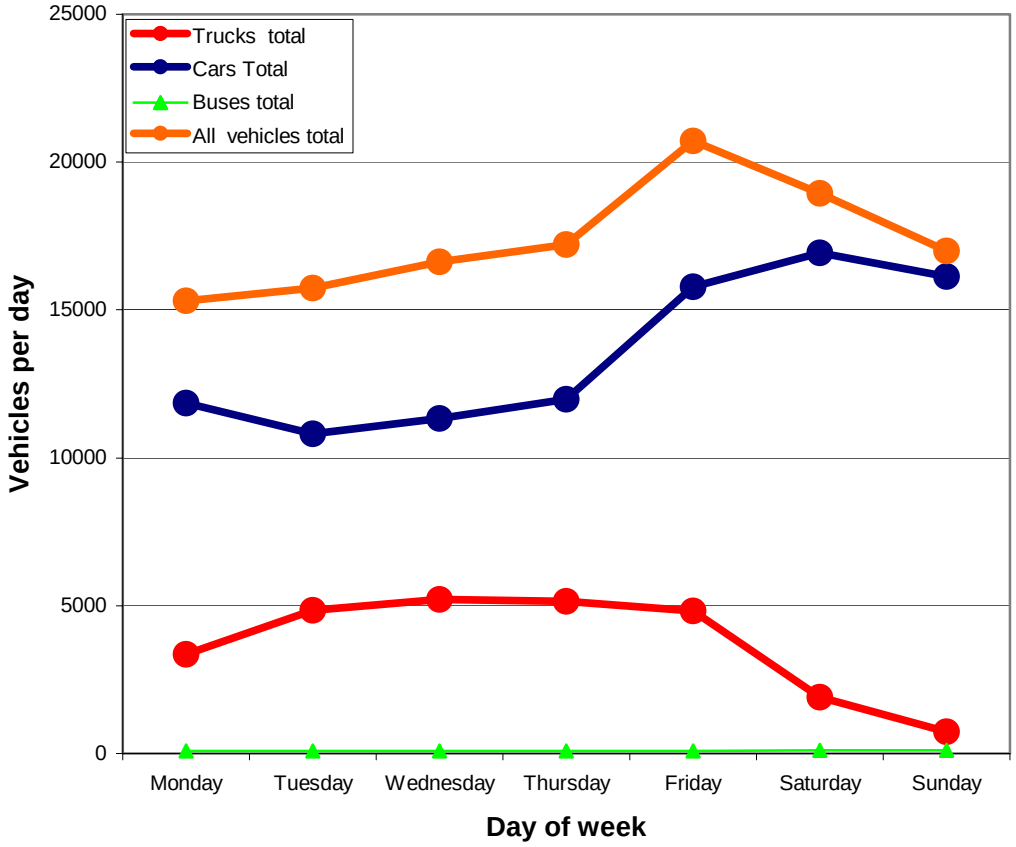


Figure 6. Vehicle count data (bi-directional), by vehicle type, for Buffalo-Fort Erie border crossing, year 2000.

Air quality data were summarized into daily averages for each day of the week, in order to assess the possibility of evaluating weekday and weekend differences in vehicle counts with corresponding air quality data. Similarly, we averaged data for each hour of the day over all 365 days per year to generate average temporal plots of hourly air pollution concentrations. Examples are presented in Figures 7 - 13 below in order to illustrate the following general trends that were observed. i) For all monitoring locations clear diurnal

profiles were observed for CO, NO/NO2, PM10 and PM2.5 with a distinct morning rush hour peak (Figures 7-13. ii) NO and CO, the two measured pollutants that are primary emissions, indicated the clearest morning rush-hour peak and appear to be the best indicators of traffic-related emissions of the measured pollutants (Figures 7,8,10,11,13). iii) Weekday peak rush-hour concentrations were significantly higher than weekend concentrations for CO, NO/NO2, PM10 and PM2.5 (Figures 7-12). iv) Although relevant data (multiple sampling sites for the same pollutants with different proximities to the border crossing) were only available for NO and the Detroit-Windsor border crossing, there is a general effect of proximity to the Ambassador Bridge on increasing concentrations of NO more monitoring sites closest to the bridge (Figure 13). There were similar patterns observed over both years in which data were available (Figures 7-8).

Figure 7. Buffalo Daily Pollutant Average 2000 for CO (site 140118)

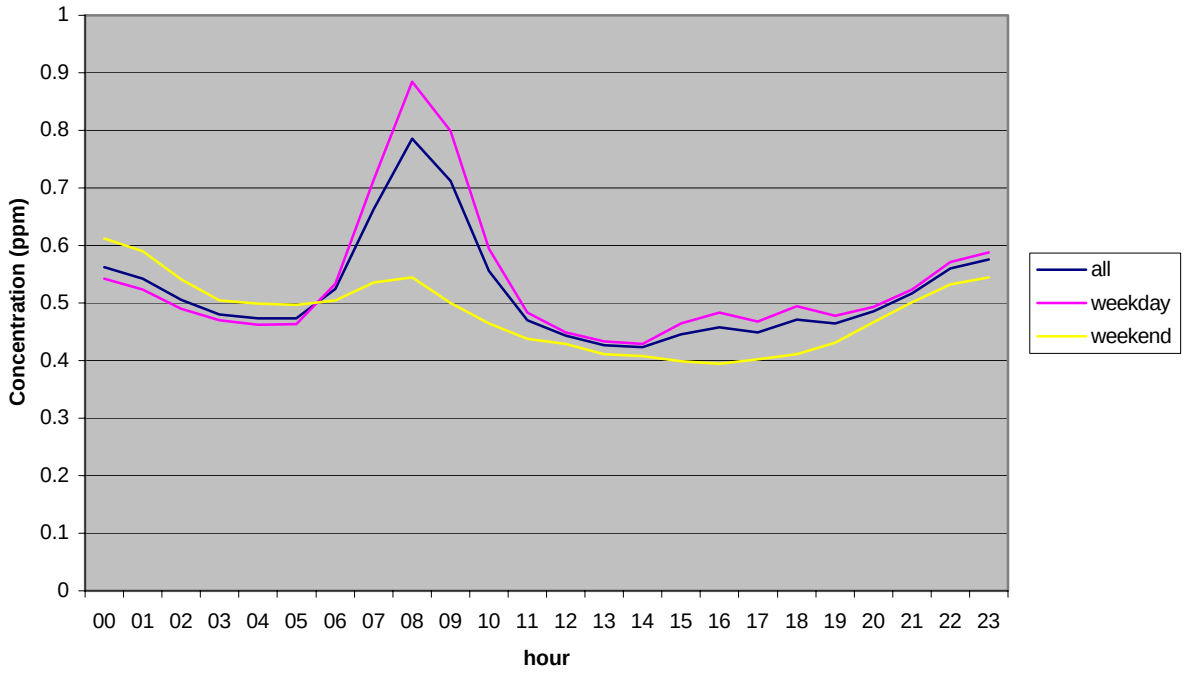


Figure 8. Buffalo Daily Pollutant Average 2001 for CO (site 140118)

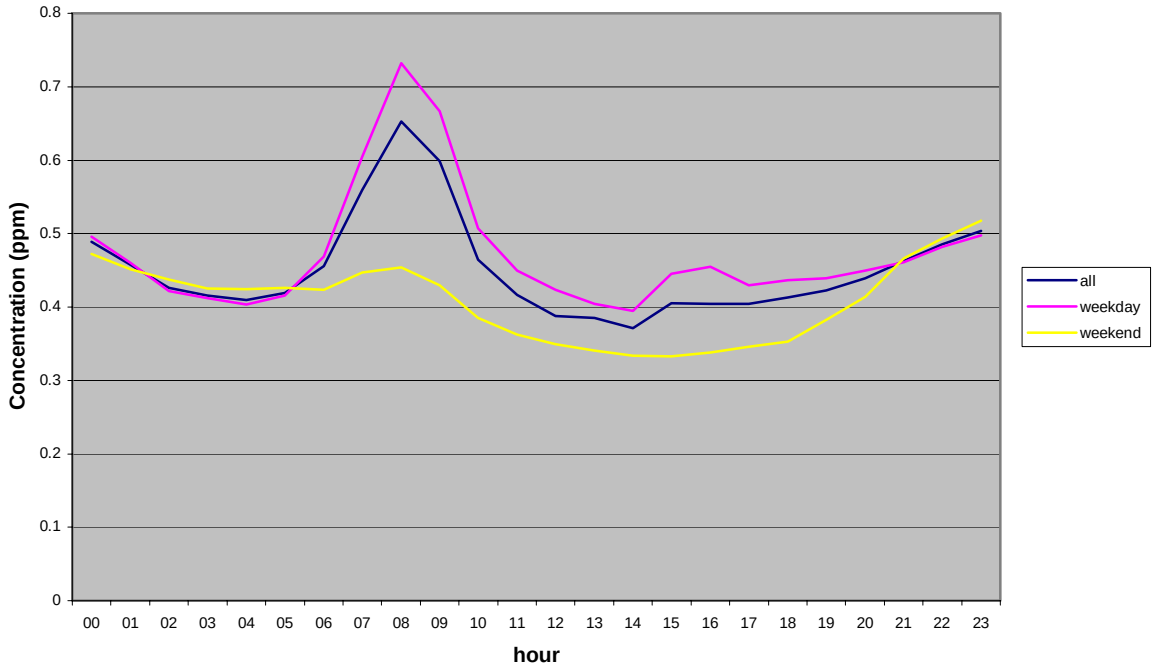


Figure 9. Windsor daily pollutant averages for PM10 (site 60211), 2000.

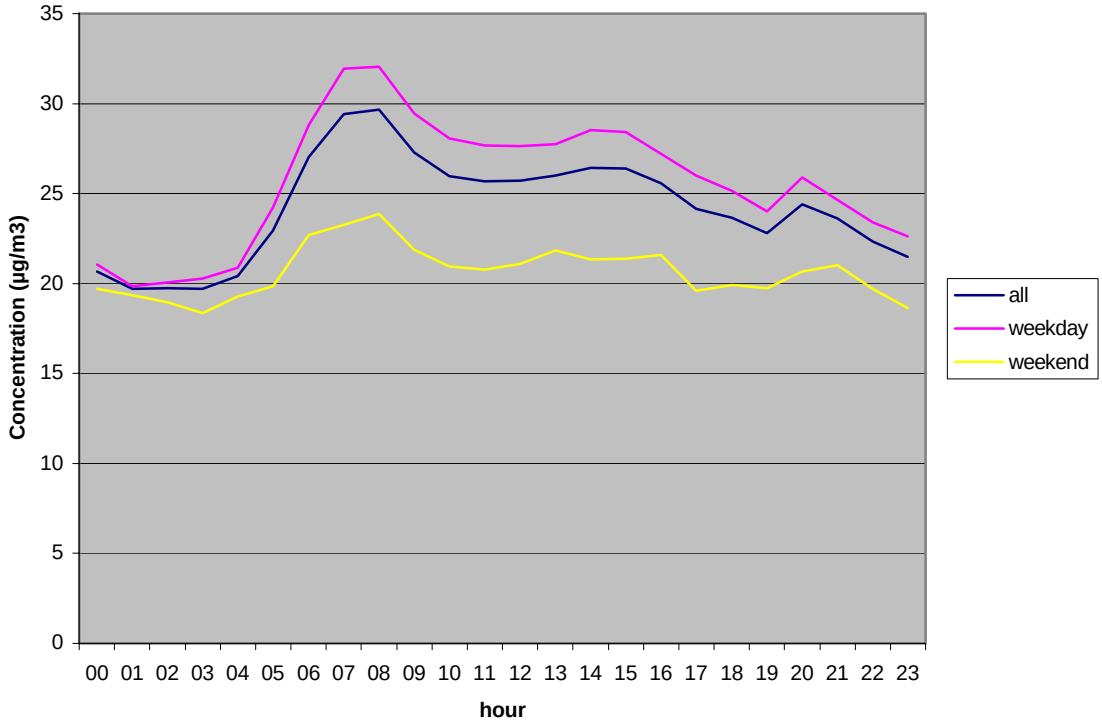


Figure 10. Windsor daily pollutant averages for NO (site 60211), 2000.

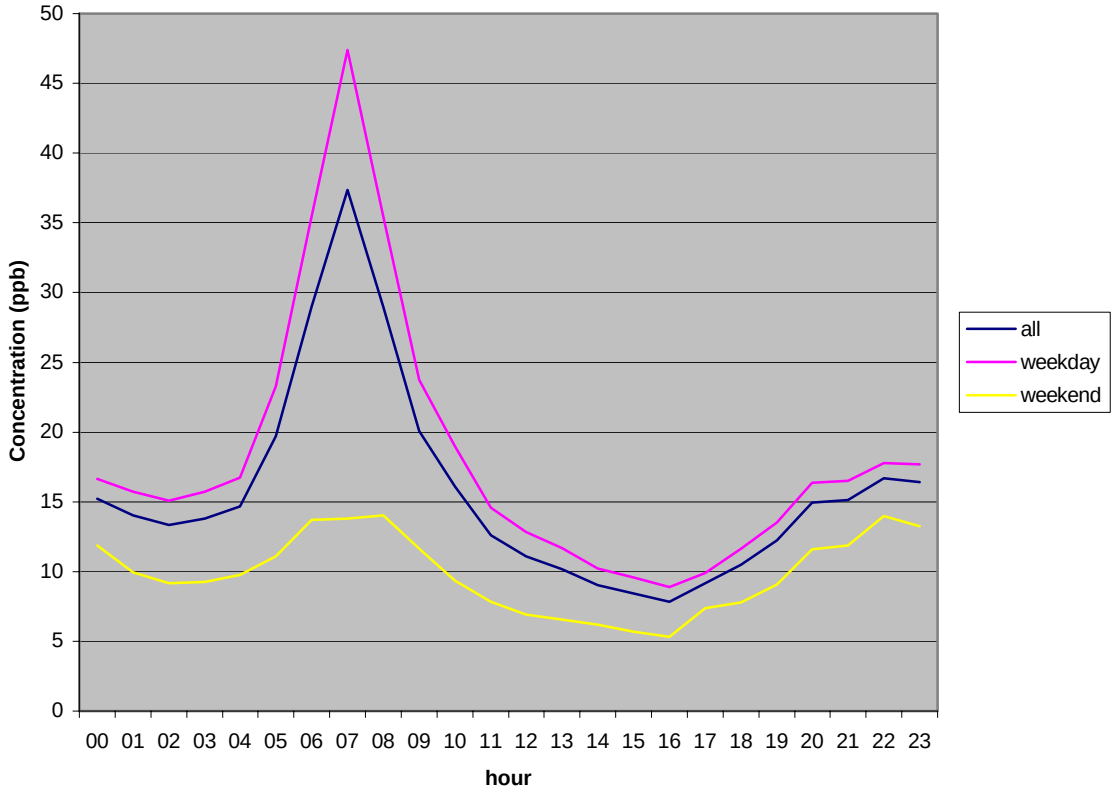


Figure 11. Buffalo daily pollutant averages for NO (2001) Site 140118.

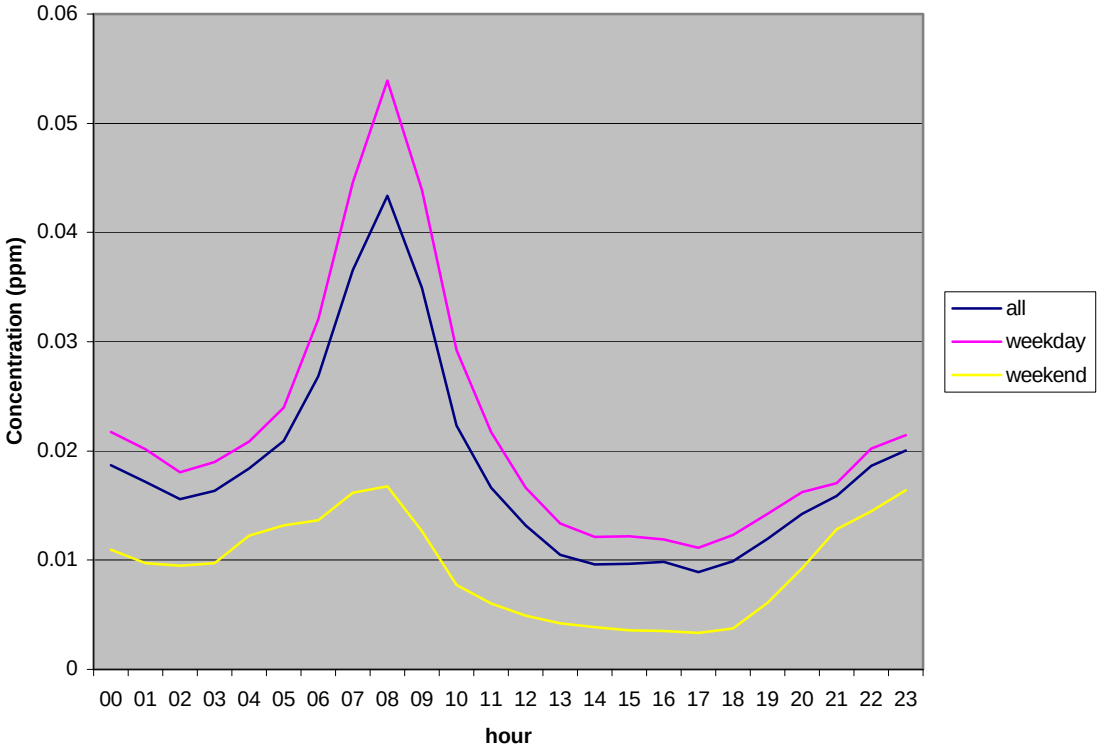
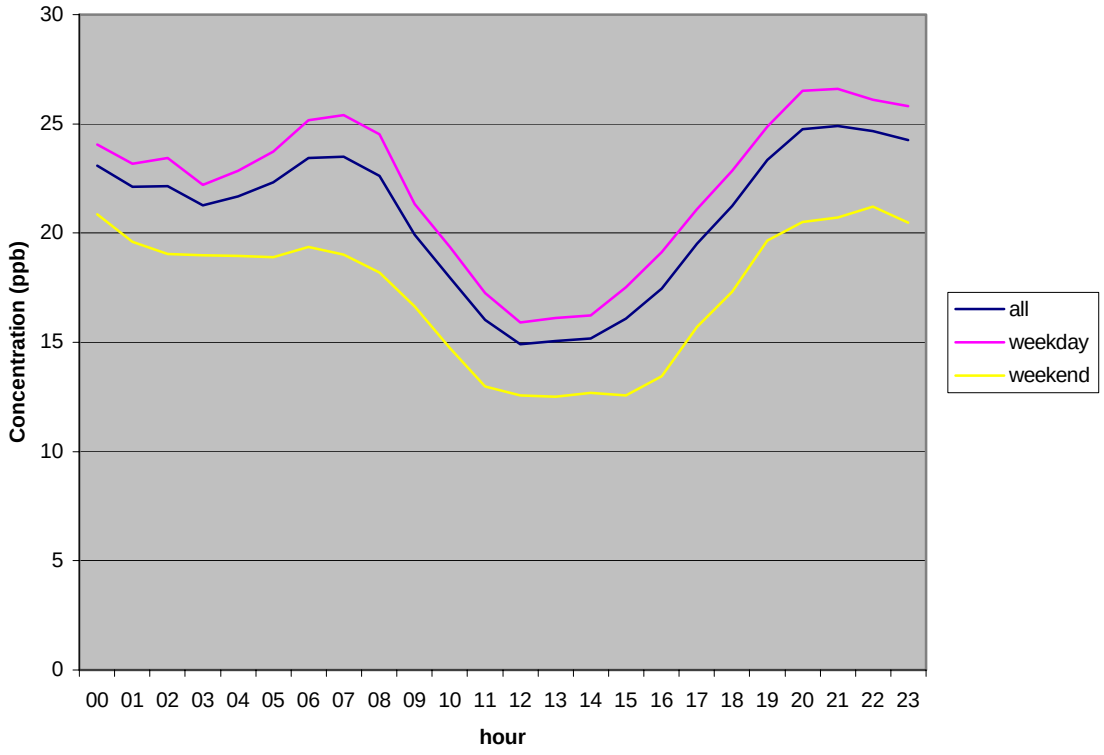


Figure 12. Windsor daily pollutant averages for NO2 (site 60211), 2000.



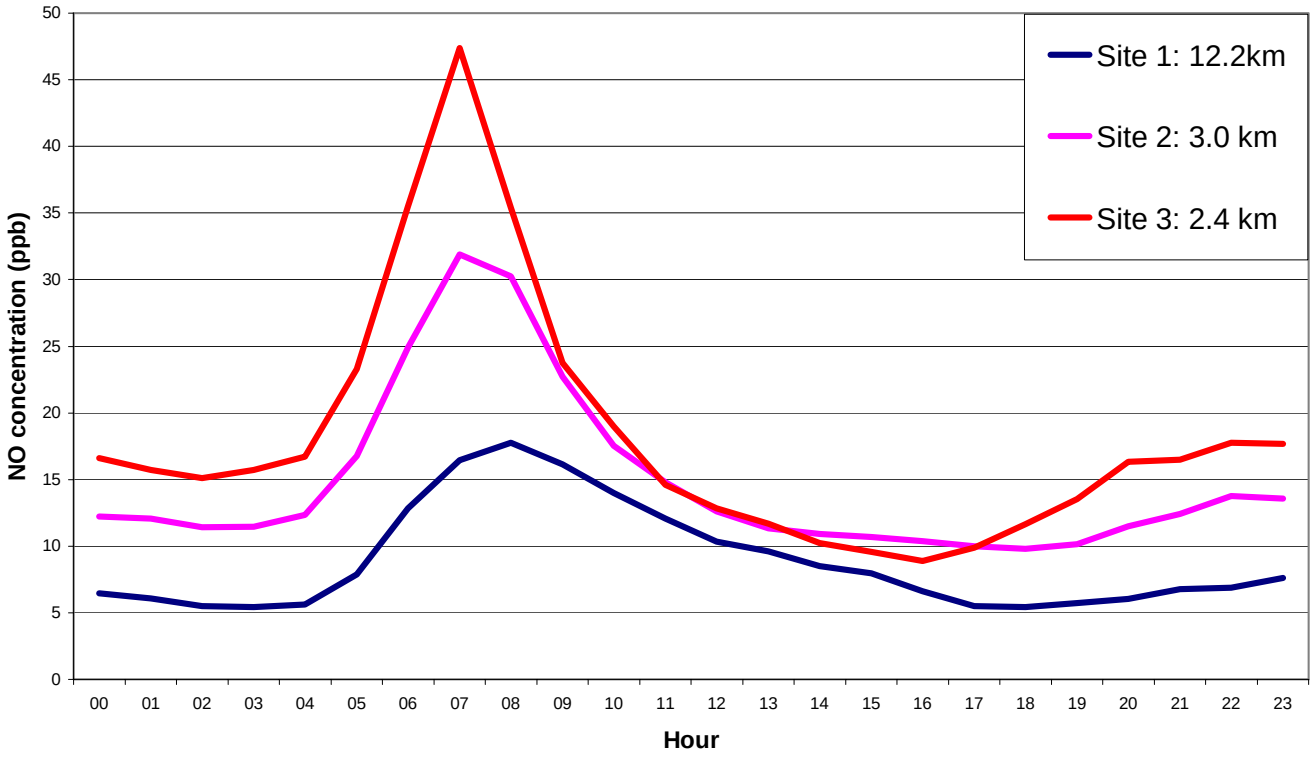


Figure 13. Windsor NO and distance from Ambassador Bridge (2000)

Given the limitation in the available vehicle count data, analysis of the relationships between air pollutant concentrations and vehicle counts were only attempted for Buffalo. Figures 14 – 27 display measured air pollutant concentrations stratified by quintiles of car and truck counts for each of the two years of the study period. While there are no clear relationships between car counts and any of the measured pollutants, there are trends evident between truck counts and NO/NO_2 and to as slight degree with CO and $PM_{2.5}$.

Figure 14

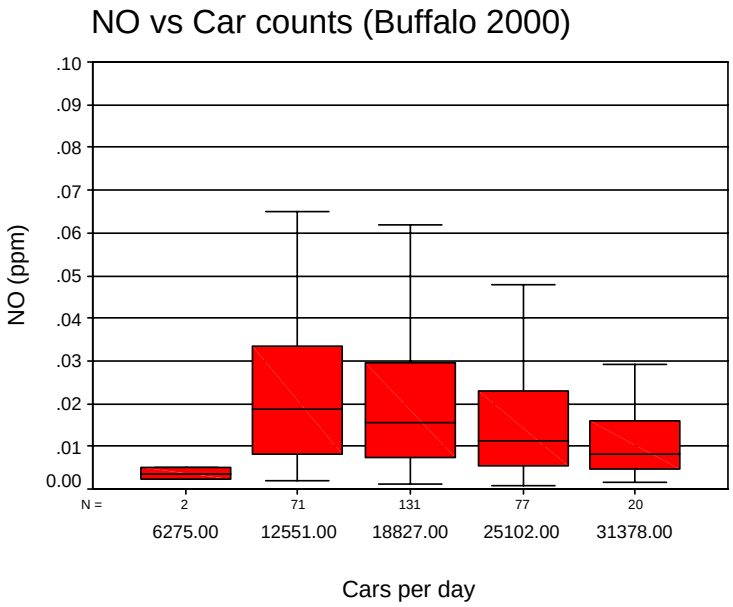


Figure 15

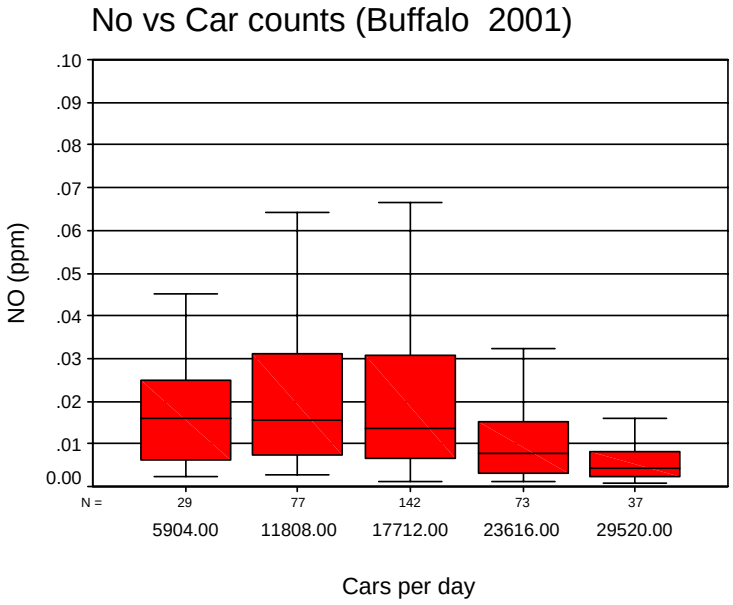


Figure 16

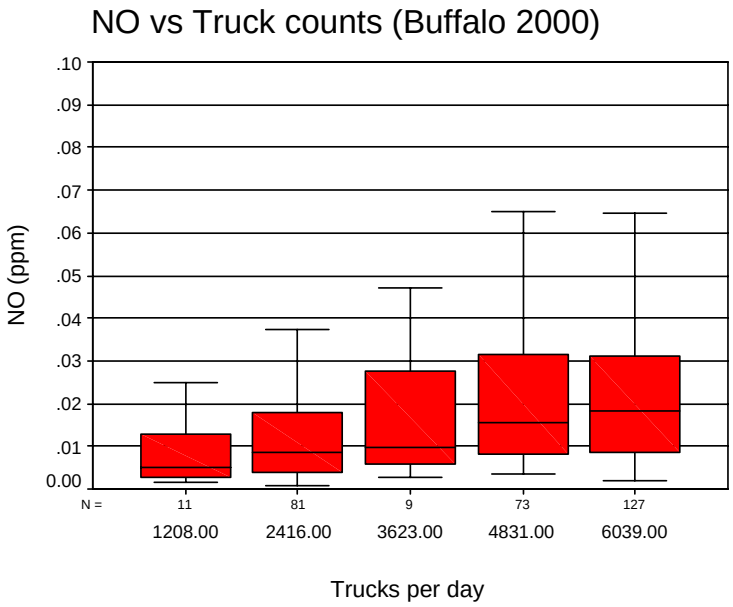


Figure 17

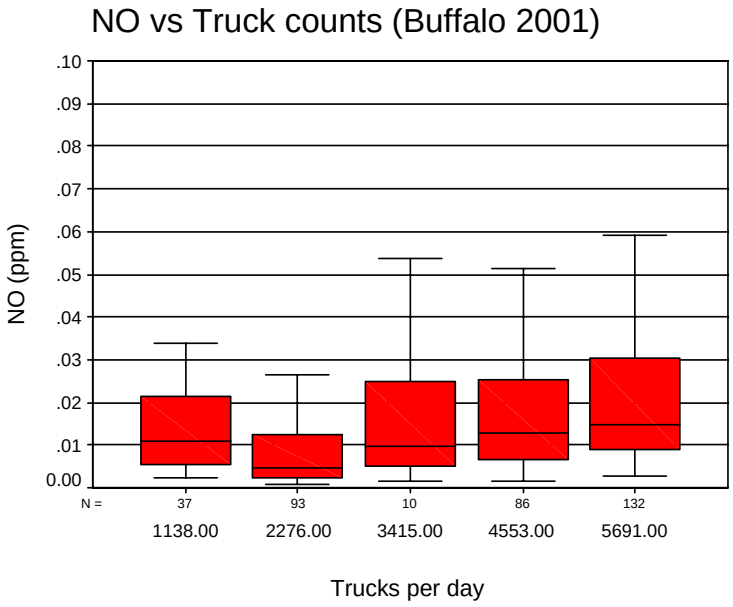


Figure 18

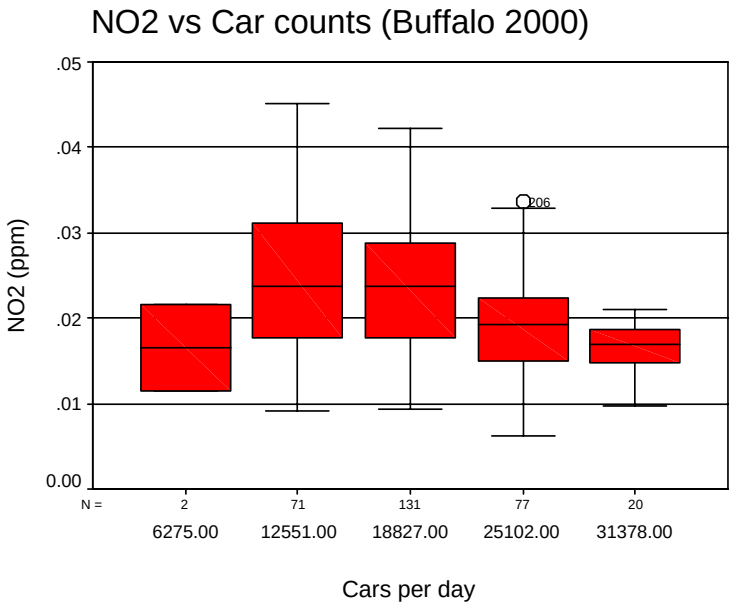


Figure 19

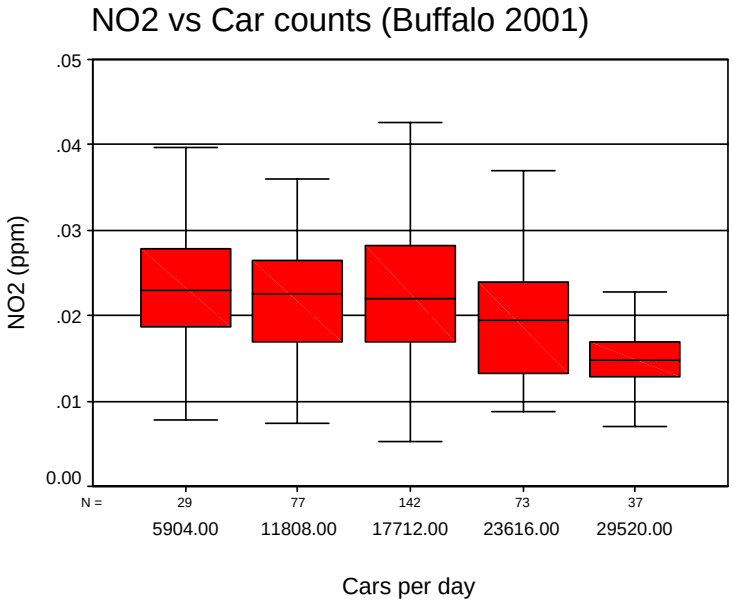


Figure 20

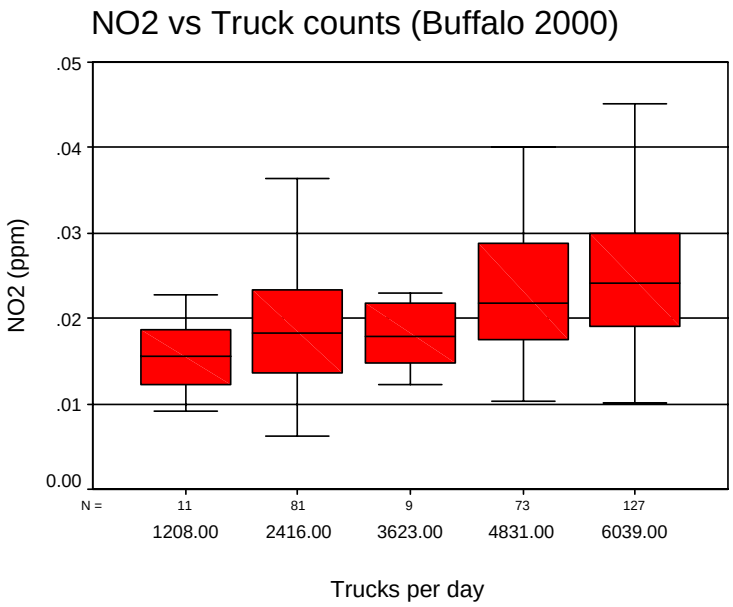


Figure 21

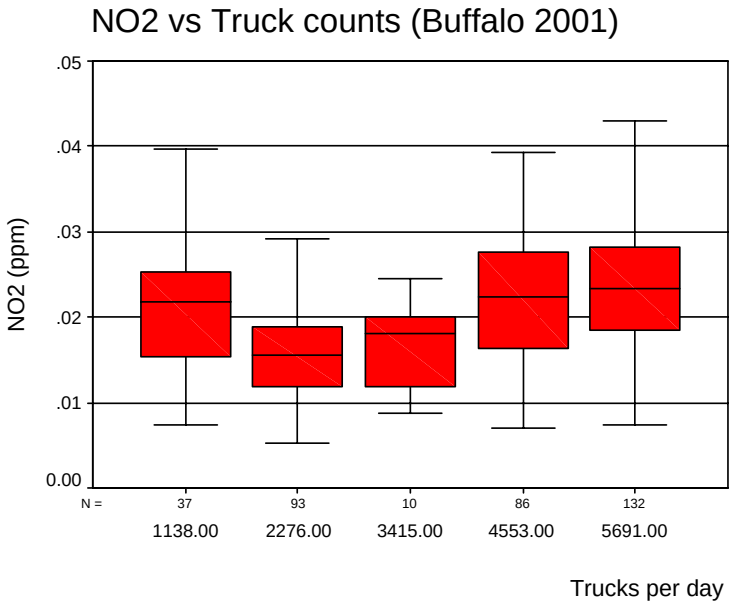


Figure 22

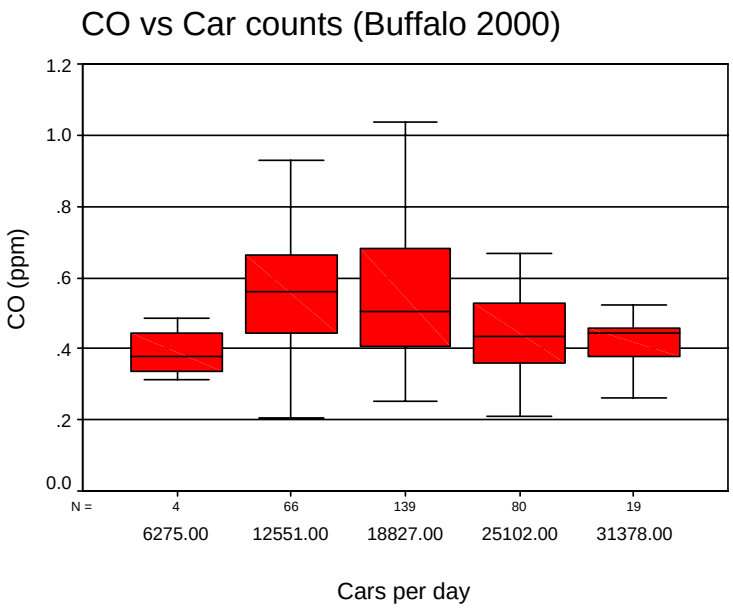


Figure 23

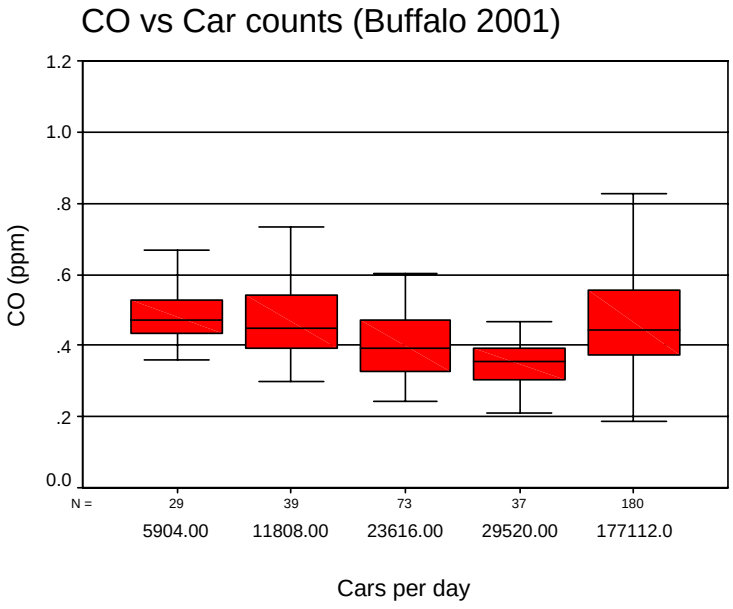


Figure 24

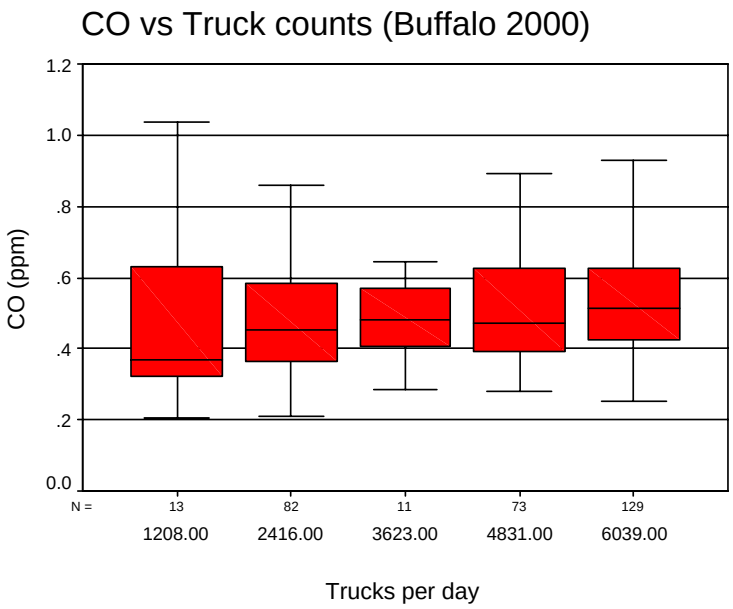


Figure 25

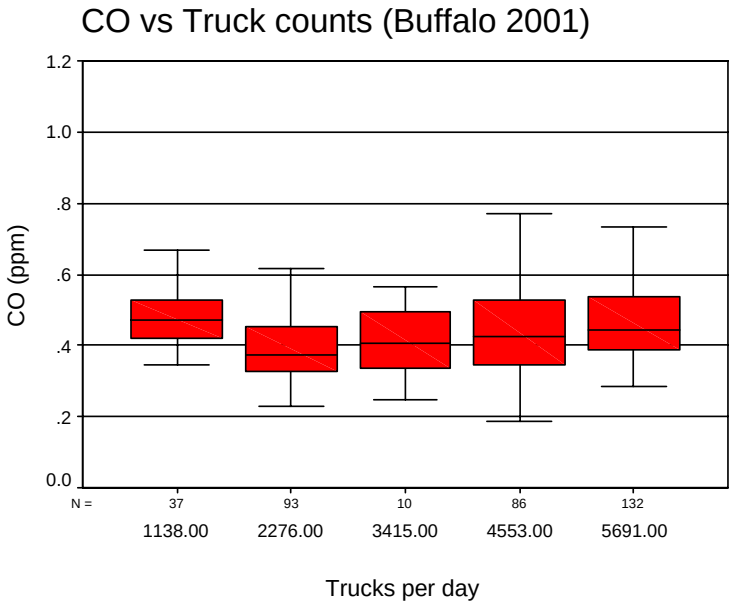


Figure 26

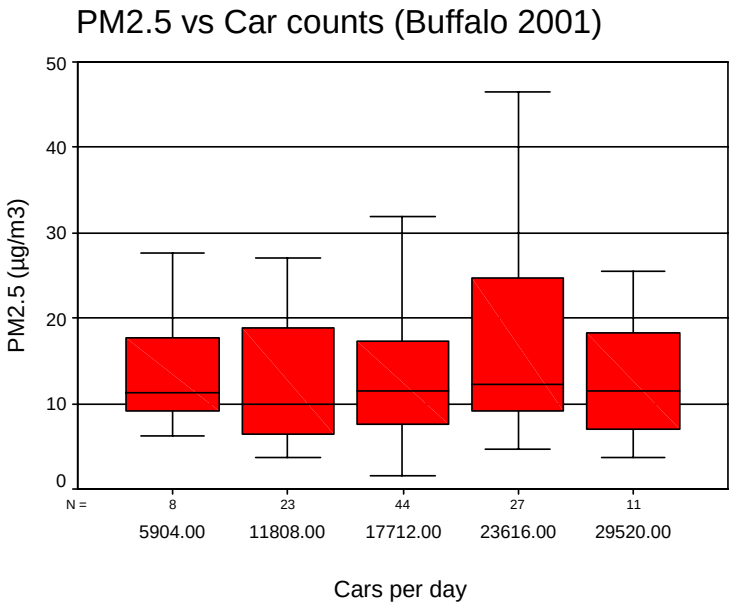
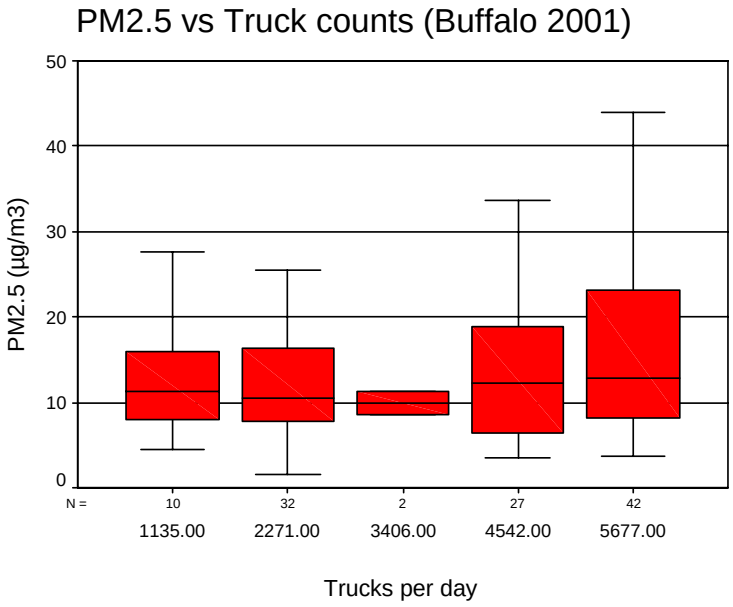


Figure 27



Conclusions

In general the results of this preliminary analysis were disappointing. Routinely collected air monitoring data were not useful in identifying border crossings as major sources of air pollutants, largely due to a lack of sites in close proximity to major crossings and transit corridor and to the limited number of pollutants that are routinely monitored. In addition, our inability to obtain vehicle count data reduced the utility of these preliminary analyses. Despite these limitations, several broad conclusions can be made. Large numbers of people are potentially affected by air pollution associated with transportation at major border crossings. At several of the border crossings, as many as 35,000 people live within 1 km of the crossing itself or major roads leading to the crossing. Unfortunately, there were very limited monitoring locations in close proximity to the crossings. Future exposure assessment or epidemiological studies will require enhanced monitoring sites that are located much closer to the crossings or the major lead-in roads. Vehicle count data were difficult to obtain, in part due to the private operation of several of the major border crossings and the lack of standardized traffic counting measurements. In addition, there were no available data on wait times. Substantial wait times would lead to increased idling emissions, especially from trucks, and are likely to be important factors in the determination of overall air quality impacts. Finally, this very basic analysis did indicate some weak evidence of impacts of the border crossings on local air quality although it was difficult to distinguish these from the typical urban air pollution profile observed in most locations.

Appendix 1

Air Quality at Congested Border Crossings

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This project is a joint initiative of The University of British Columbia and the North American Coalition for Environmental Cooperation (CEC). The goal of the proposed work is to assess the current availability of data to assess community exposures related to emissions at congested border crossings and to develop methodologies for future assessments of exposure and health impacts in potentially affected communities.

Specific Objectives

1. To collect available (hourly) air quality data (from routine network monitoring stations) for PM10, PM2.5, NO/NO2/NOx, and CO for monitoring sites in closest proximity to border crossings. The study period will be January 1, 2000 – December 31, 2001. The proposed border crossings of interested are:

    Detroit-Windsor (bridge and tunnel)
    Buffalo-Fort Erie
    San Diego-Tijuana (Otay Mesa, and San Ysidro)
    El Paso-Ciudad Juarez
    Laredo-Nuevo Laredo
    Nogales-Nogales

These crossings were chosen based on the criteria of having large numbers of light/heavy duty vehicles crossing the border, as well as being located near densely populated areas.

2. For the border crossings listed above, to collect available hourly or daily vehicle count data segregated by light/heavy duty vehicles.

3. To assess the size of the population potentially exposed to air pollutants from the specific border crossings by GIS buffer calculations and to identify potential areas of concern with respect to population exposure.