Appendix B-3

Local Air Quality Assessment

Local Air Quality Assessment
Scarborough Subway Extension
Toronto, Ontario

Novus Reference No. 14-0231 Version No. 1 (FINAL) August 2, 2017

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1.0 Introduction

Novus Environmental Inc. (Novus) was retained by AECOM to conduct an air quality assessment for the new bus terminal associated with the Scarborough Subway Extension at the Scarborough Town Centre in Toronto, Ontario. This report assesses the impacts of idling buses at the new terminals.

1.1 Study Area

The City of Toronto and the Toronto Transit Commission (TTC) are currently planning to extend the Bloor-Danforth Subway Line (Line 2) to better serve the Scarborough area. The current plan includes extending Line 2 east to Scarborough Town Centre, and adding a new bus terminal here to serve the subway extension and local bus routes. This study focuses on the air quality impacts of idling buses at the preferred design of the new bus terminal. The Scarborough Town Centre bus terminal will be located along Triton Road, west of McCowan Road and just south of the Scarborough Town Centre mall and movie theatre complex. The location of the proposed bus terminal is shown in **Figure 1**.

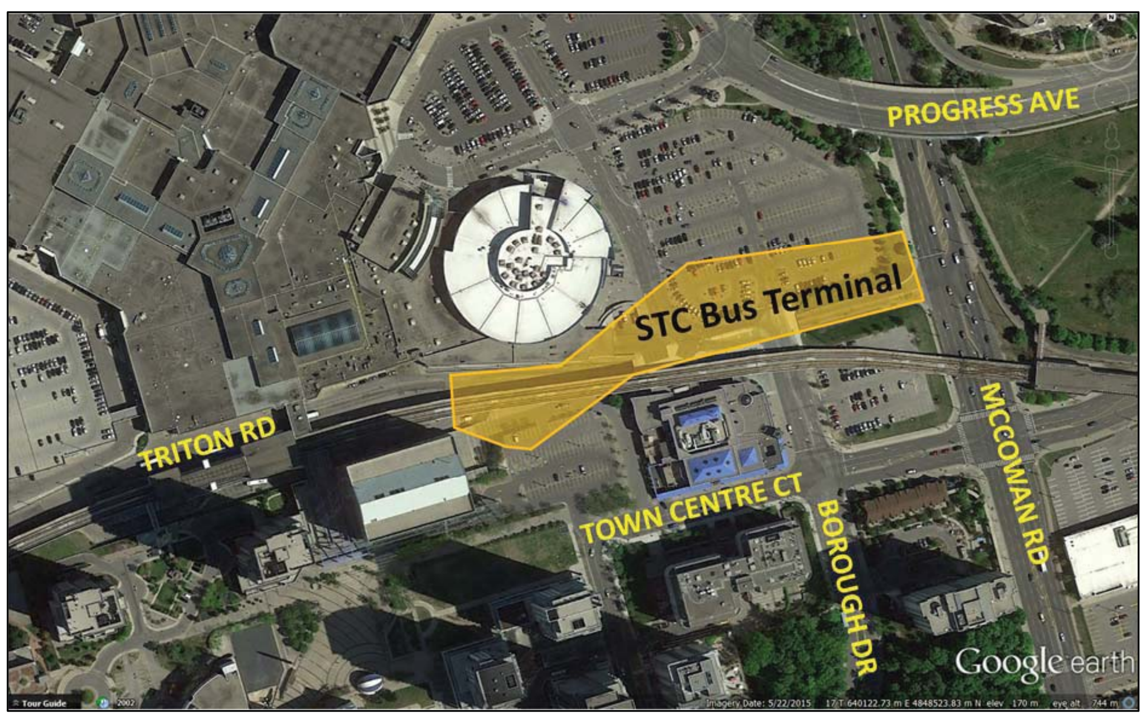


Figure 1: Location of Brimley Bus Terminal

1.2 Study Objectives

The objective of the study is to assess the local air quality impacts of the new bus terminal. The objective was assessed as follows:

- **2014 Existing –** Assess the existing conditions at representative receptors. Predicted contaminant concentrations from the nearby roadways were combined with maximum measured ambient concentrations to determine the overall impact.
- **2031 Future No-Build** – Assess the future conditions without the project. Predicted contaminant concentrations from the nearby roadways for future traffic volumes were combined with maximum measured ambient concentrations to determine the overall impact.
- **2031 Future Build –** The bus terminal with future traffic volumes for nearby roadways. Predicted roadway and bus terminal concentrations were combined with maximum measured ambient concentrations to determine the overall impact at representative receptors.

1.3 Contaminants of Interest

The contaminants of interest for this study have been chosen based on the regularly assessed contaminants of interest for transportation assessments in Ontario, as determined by the Ministry of Transportation Ontario (MTO) and Ministry of the Environment and Climate Change (MOECC). Motor vehicle emissions have largely been determined by scientists and engineers with United States and Canadian government agencies such as the U.S. Environmental Protection Agency (EPA), the MOECC, Environment Canada (EC), Health Canada (HC), and the MTO. These contaminants are emitted due to fuel combustion, brake wear, tire wear, the breakdown of dust on the roadway, fuel leaks, evaporation and permeation, and refuelling leaks and spills as illustrated in **Figure 2**. Note that emissions related to refuelling leaks and spills are not applicable to motor vehicle emissions from roadway travel. Instead, these emissions contribute to the overall background levels of the applicable contaminants. All of the selected contaminants are emitted during fuel combustion, and the contaminants emitted from brake wear, tire wear, and breakdown of road dust are emitted as particulates. A summary of these contaminants are provided in **Table 1**.

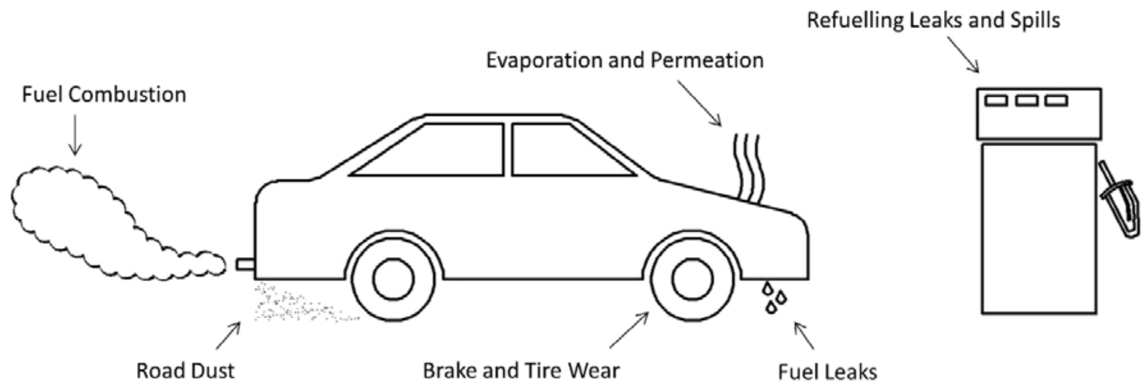


Figure 2: Motor Vehicle Emission Sources

Table 1: Contaminants of Interest

Contaminants		Volatile Organic Compounds (VOCs)	
Name	**Symbol**	**Name**	**Symbol**
Nitrogen Dioxide	NO_2	Acetaldehyde	HCHO
Carbon Monoxide	CO	Acrolein	C_3H_4O
Fine Particulate Matter (<2.5 microns in diameter)	$PM_{2.5}$	Benzene	C_6H_6
Coarse Particulate Matter (<10 microns in diameter)	PM_{10}	1,3-Butadiene	C_4H_6
Total Suspended Particulate Matter (<44 microns in diameter)	TSP	Formaldehyde	CCHO

1.4 Applicable Guidelines

In order to assess the impact of the project, the predicted effects at sensitive receptors were compared to guidelines established by government agencies and organizations. Relevant agencies and organizations in Canada and their applicable contaminant guidelines are:

- MOECC Ambient Air Quality Criteria (AAQC); and
- Canadian Council of Ministers of the Environment (CCME) Canada Wide Standards (CWSs).

Within the guidelines, the threshold value for each contaminant and its applicable averaging period was used to assess the maximum predicted effect at sensitive receptors derived from computer simulations. The contaminants of interest are compared against 1-, 8-, 24-hour, and annual averaging periods. The threshold values and averaging periods used in this assessment are presented in **Table 2** below. It should be noted that the 24-hr CWS for $PM_{2.5}$ is not based on the maximum threshold value; 24-hr $PM_{2.5}$ is assessed based on the annual 98th percentile

value, averaged over 3 consecutive years. Annual $PM_{2.5}$ is assessed based on the average of the three highest consecutive annual average values over the study period.

Table 2: Applicable Contaminant Guidelines

Contaminant	Averaging Period (hrs)	Threshold Value (µg/m³)	Source
NO_2	1	400	AAQC
	24	200	AAQC
CO	1	36,200	AAQC
	8	15,700	AAQC
$PM_{2.5}$	24	27[1]	CWS (27 µg/m³ standard is to be phased in in 2020)
	Annual	8.8[2]	CWS
PM_{10}	24	50	Interim AAQC
TSP	24	120	AAQC
Acetaldehyde	24	500	AAQC
Acrolein	24	0.4	AAQC
	1	4.5	AAQC
Benzene	Annual	0.45	AAQC
	24	2.3	AAQC
1,3-Butadiene	24	10	AAQC
	Annual	2	AAQC
Formaldehyde	24	65	AAQC

[1] The CWS is based on the annual 98th percentile concentration, averaged over three consecutive years
[2] The annual CWS is based on the average of the three highest annual average values over the study period

1.5 General Assessment Methodology

The worst-case contaminant concentrations due to idling bus emissions and motor vehicle emissions from the roadways were predicted at nearby receptors using dispersion modelling software on an hourly basis for a five-year period. Pre-processed meteorological data approved by the MOECC for 1996-2000 for Toronto Pearson Airport was used. Five years were modelled in order to capture the worst-case meteorological conditions. Three emissions scenarios were assessed, 2014 Existing, 2031 Future No-Build 2031 Future Build.

Combined concentrations were determined by adding the worst-case modelled concentration to the maximum background (i.e., ambient data) together. This method is conservative as it is unlikely that the maximum impacts from the bus terminal and nearby roadways would occur at the same time as maximum background concentrations. The results represent the worst-case predicted impacts. Background concentrations for all available contaminants were determined from MOECC and NAPS (National Air Pollution Surveillance) datasets for the most representative locations; typically the 'representative locations' are stations within a close proximity to the study area.

Maximum 1-hour, 8-hour, 24-hour, and annual predicted combined concentrations were determined for comparison with the applicable guidelines using emission and dispersion models published by the U.S. Environmental Protection Agency (EPA). The worst-case predicted impacts are presented in this report, however, it is important to note that the worst-case impacts may only occur at one receptor for a short duration.

Local background concentrations are presented in **Section 2.0**. Impacts due to the roadway for existing, future no-build and future-build scenarios are presented in **Section 3.8**.

2.0 Background Ambient Data

2.1 Overview

Background (ambient) conditions are measured contaminant concentrations that are exclusive of emissions from the existing or proposed project infrastructure. These emissions are typically the result of trans-boundary (macro-scale), regional (meso-scale), and local (micro-scale) emission sources and result due to both primary and secondary formation. Primary contaminants are emitted directly by the source and secondary contaminants are formed by complex chemical reactions in the atmosphere. Secondary pollution is generally formed over great distances in the presence of sunlight and heat and most noticeably results in the formation of fine particulate matter ($PM_{2.5}$) and ground-level ozone (O_3), also considered smog.

In Ontario, a significant amount of smog originates from emission sources in the United States which is the major contributor during smog events which usually occur in the summer season (MOECC, 2005). During smog episodes, the U.S. contribution to $PM_{2.5}$ can be as much as 90 percent near the southwest U.S. border. The effect of U.S. air pollution in Ontario on a high $PM_{2.5}$ day and on an average $PM_{2.5}$ spring/summer day is illustrated in **Figure 3**.

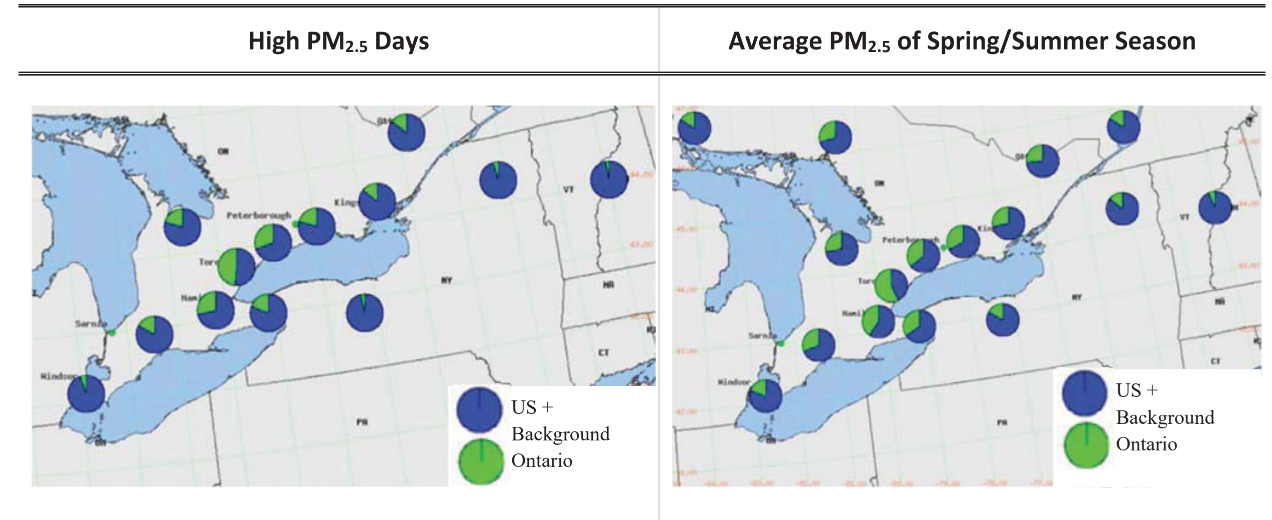


Figure 3: Effect of Trans-Boundary Air Pollution (MOECC, 2005)

Air pollution is strongly influenced by weather systems (i.e., meteorology) that typically move out of central Canada into the mid-west of the U.S. then eastward to the Atlantic coast. This weather system generally produces winds with a southerly component that travel over major emission sources in the U.S. and result in the transport of pollution into Ontario. This phenomenon is demonstrated in the following figure and is based on a computer simulation from the Weather Research and Forecasting (WRF) Model.

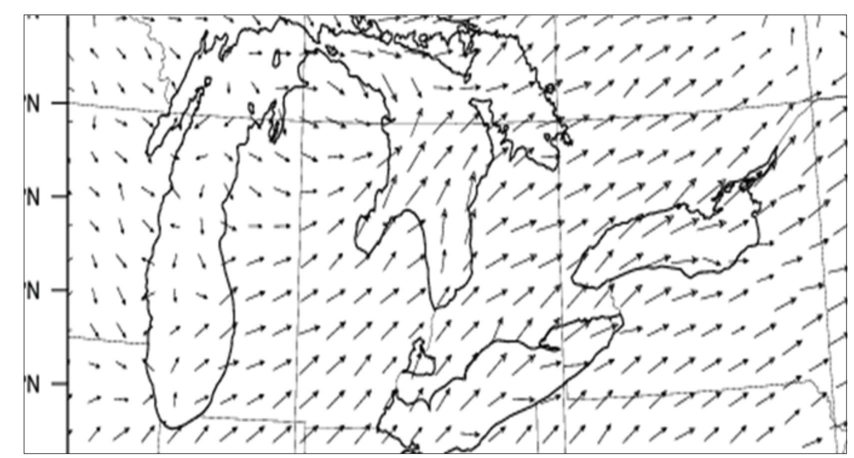


Figure 4: Typical Wind Direction during a Smog Episode

As discussed, understanding the composition of background air pollution and its influences is important in determining the potential impacts of a project, considering that the majority of the combined concentrations are typically due to existing elevated ambient background levels. In this assessment, background conditions were characterized utilizing existing ambient monitoring data from MOECC and NAPS Network stations and added to the modelled predictions in order to conservatively estimate the combined concentration.

2.2 Selection of Relevant Ambient Monitoring Stations

A review of MOECC and NAPS ambient monitoring stations in Ontario was undertaken to identify the monitoring stations that are in relative proximity to the study area and that would be representative of background contaminant concentrations in the study area. Four MOECC (Toronto Downtown, Toronto East, Toronto North and Toronto West) and five NAPS (Toronto Downtown, Etobicoke North, Etobicoke South, Newmarket and Windsor) stations were determined to be representative. Note that Windsor is the only station in Ontario at which background acrolein, acetaldehyde, and formaldehyde concentrations are measured for recent years. The locations of the nearby ambient monitoring stations are shown in **Figure 5**. Station information is presented in **Table 3**.

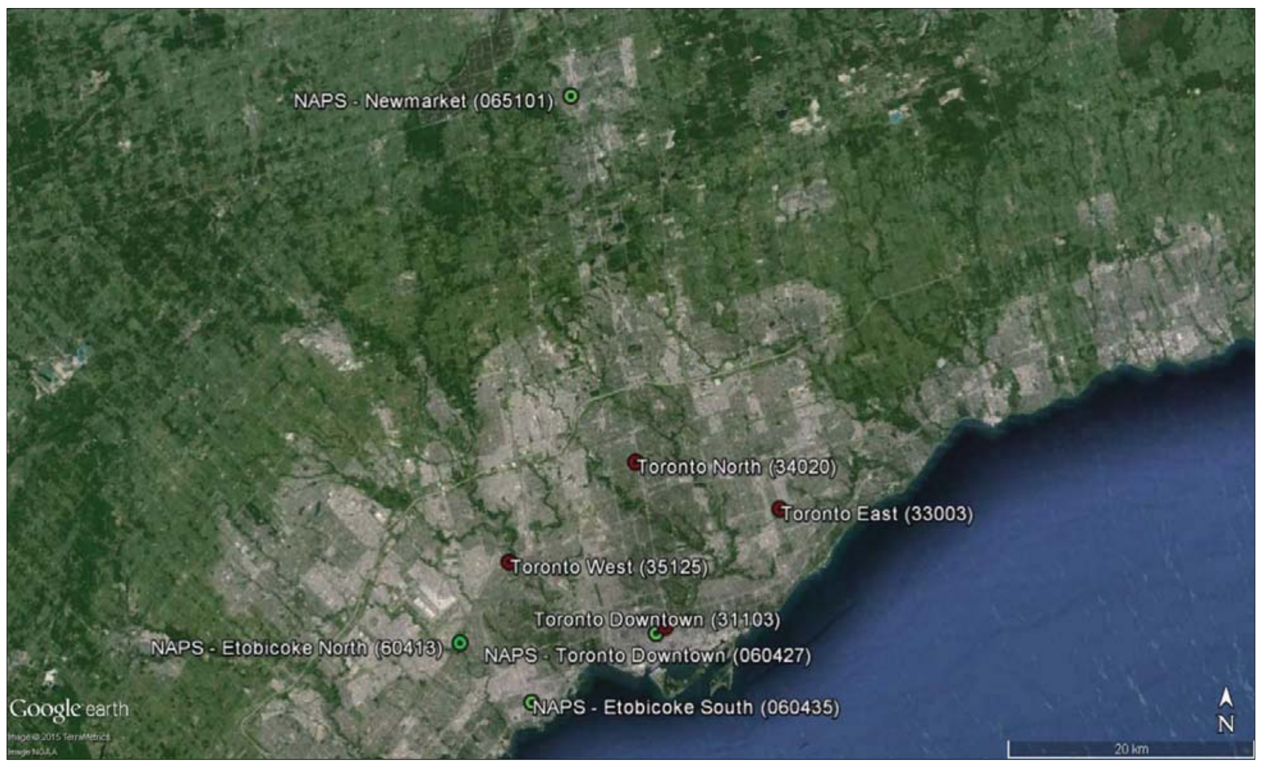


Figure 5: Nearby MOECC (shown in red) and NAPS (shown in green) Monitoring Stations; Windsor and Egbert NAPS Stations Not Shown

Table 3: Relevant MOECC and NAPS Station Information

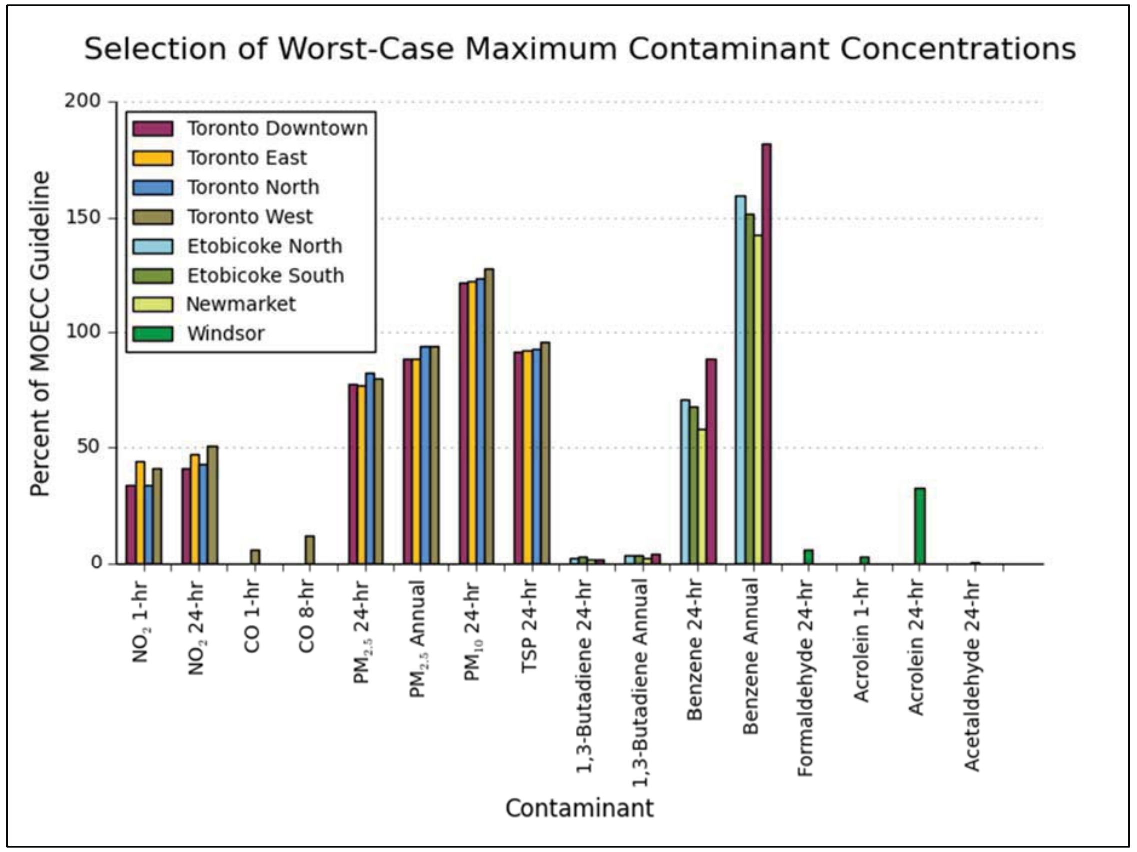
City/Town	Station ID	Location	Operator	Contaminants
Toronto Downtown	31103	Bay St/Wellesley St W	MOECC	NO_2 | $PM_{2.5}$
Toronto East	33003	Kennedy Rd/Lawrence Ave E	MOECC	NO_2 | $PM_{2.5}$
Toronto North	34020	Hendon Ave/Yonge St	MOECC	NO_2 | $PM_{2.5}$
Toronto West	35125	125 Resources Rd	MOECC	NO_2 | $PM_{2.5}$ | CO
Toronto Downtown	60427	223 College St	NAPS	Benzene | 1,3-Butadiene
Etobicoke North	60413	Elmcrest Rd	NAPS	Benzene | 1,3-Butadiene
Etobicoke South	60435	461 Kipling Ave	NAPS	Benzene | 1,3-Butadiene
Newmarket	65101	Newmarket	NAPS	Benzene | 1,3-Butadiene
Windsor	60211	College/Prince	NAPS	Formaldehyde |Acetaldehyde | Acrolein

Since there are several monitoring stations which could be used to represent the study area, a comparison was performed for the available data on a contaminant basis, to determine the worst-case representative background concentration (see **Section 2.3**). Selecting the worst-case ambient data will result in a conservative combined assessment.

2.3 Selection of Worst-Case Monitoring Stations

Year 2010 to 2014 hourly ambient monitoring data from the selected stations were statistically summarized for the desired averaging periods, 1-hour, 8-hour, 24-hour, and annual. Note that VOC monitoring data for 2014 is not yet publically available. 2009-2013 data was used for VOC's. The station with the highest maximum value over the five-year period for each contaminant and averaging period was selected to represent background concentrations in the study area. The maximum concentration represents an absolute worst-case background scenario. Ambient VOC data is not monitored hourly, but is typically measured every six days. To combine this dataset with the hourly modelled concentrations, each measured six-day value was applied to all hours between measurement dates, when there were 6 days between measurements. When there was greater than 6 days between measurements, the 90^{th} percentile measured value for the year in question was applied for those days in order to determine combined concentrations. This method is conservative in determining combined impacts as it assumed the 10^{th} percentile highest concentrations whenever data was not available. **Table 4** shows a comparison of the relevant stations for each contaminant of interest, and the selection of the worst-case station.

Table 4: Comparison of Background Concentrations



Note: PM_{10} and TSP are not measured in Ontario; therefore, background concentrations were estimated by applying a $PM_{2.5}/PM_{10}$ ratio of 0.54 and a $PM_{2.5}$/TSP ratio of 0.3 (Lall et al., 2004).

Contaminant	Worst-Case Station	Contaminant	Worst-Case Station
NO_2 (1-Hr)	Toronto East	1,3-Butadiene (24-hr)	Etobicoke South
NO_2 (24-Hr)	Toronto West	1,3-Butadiene (ann)	Toronto Downtown
CO (1-Hr)	Toronto West	Benzene (24-hr)	Toronto Downtown
CO (8-hr)	Toronto West	Benzene (ann)	Toronto Downtown
$PM_{2.5}$ (24-hr)	Toronto North	Formaldehyde	Windsor
$PM_{2.5}$ (ann)	Toronto West	Acrolein	Windsor
PM_{10}	Toronto West	Acetaldehyde	Windsor
TSP	Toronto West		

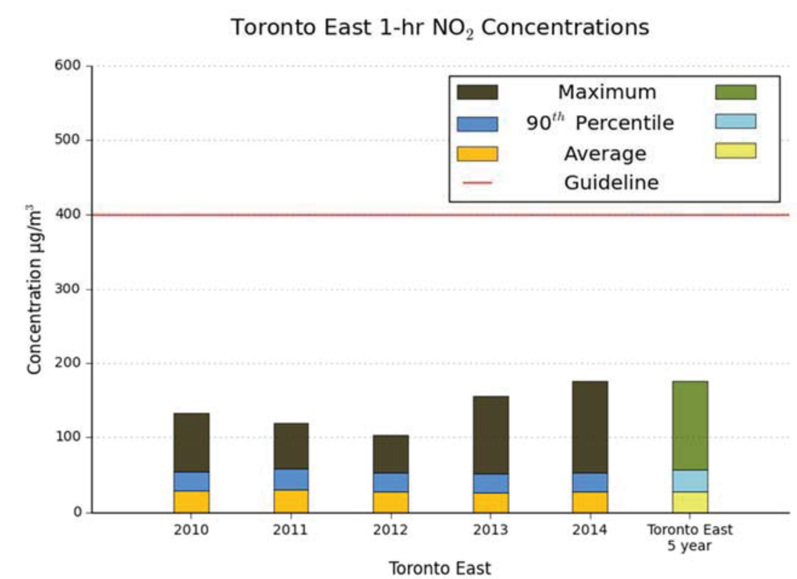
2.4 Detailed Analysis of Selected Worst-case Monitoring Stations

A detailed statistical analysis of the selected worst-case background monitoring station for each of the contaminants is presented below, summarized for average, 90^{th} percentile and maximum concentrations. Maximum ambient concentrations represented a worst-case day. The 90^{th} percentile concentration represents a day with reasonably worst-case background

concentrations, and the average concentration represents a typical day. Each site is presented on a yearly basis and for the five-year period. Where measurements exceeded the guideline, frequency analysis was performed.

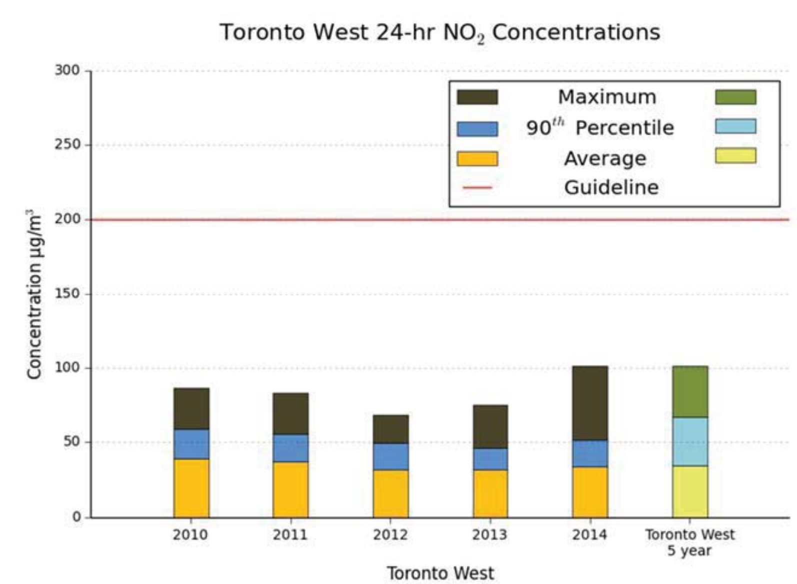
Table 5: Summary of Background NO_2

Statistical Analysis | **Five-Year Summary**



Statistic	% of Guideline
Maximum	44%
90^{th} Percentile	14%
Average	7%

Conclusion:
A review of five years of ambient monitoring data from the Toronto East Station indicated that background concentrations are well below the Guideline on a 1-hour basis.

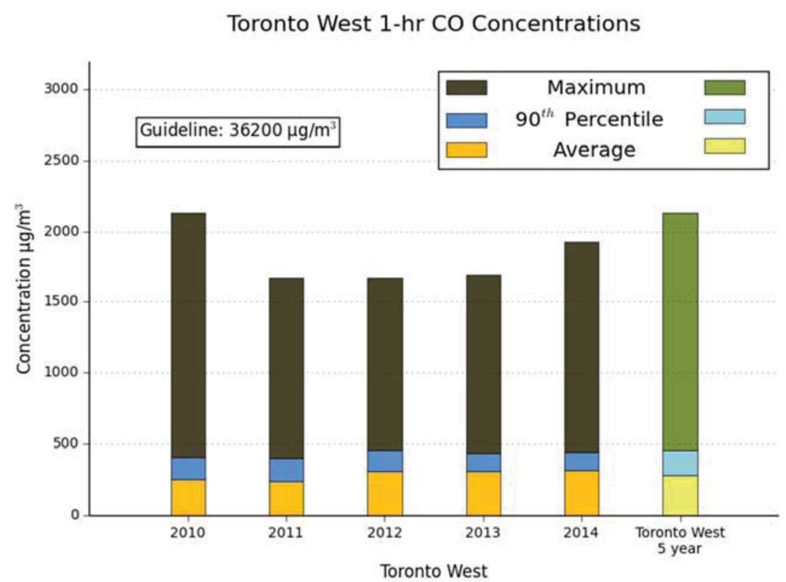


Statistic	% of Guideline
Maximum	51%
90^{th} Percentile	26%
Average	18%

Conclusion:
A review of five years of ambient monitoring data from the Toronto West Station indicated that background concentrations are well below the Guideline on a 24-hour basis.

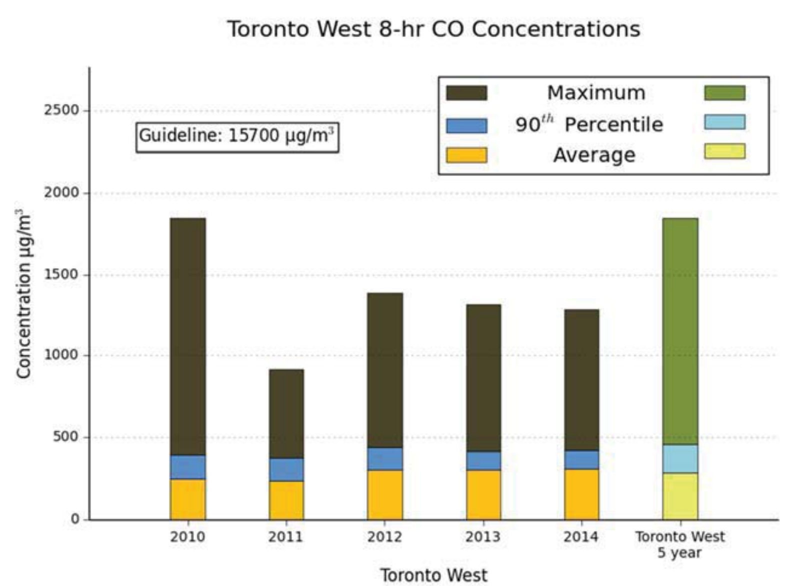
Table 6: Summary of Background CO

Statistical Analysis	Five-Year Summary



Statistic	% of Guideline
Maximum	6%
90th Percentile	1%
Average	1%

Conclusion:
A review of five years of ambient monitoring data from the Toronto West Station indicated that background concentrations are well below the Guideline on a 1-hour basis.

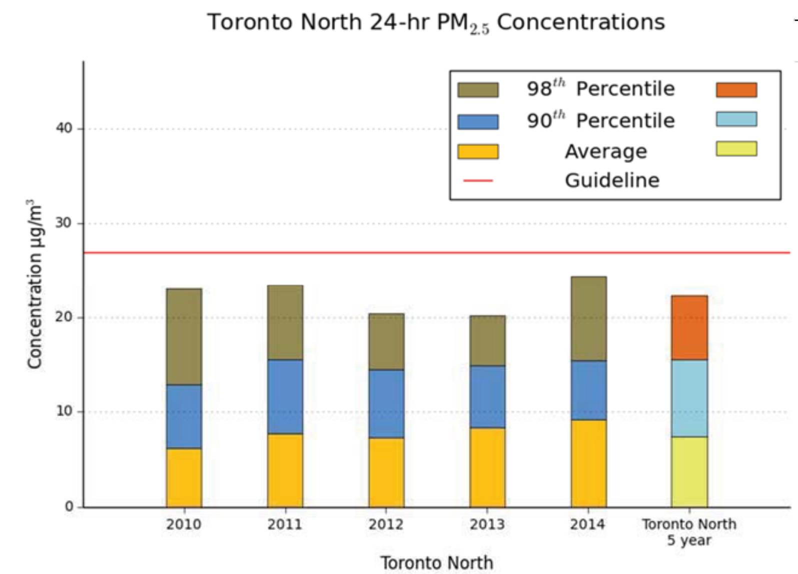


Statistic	% of Guideline
Maximum	12%
90th Percentile	3%
Average	2%

Conclusion:
A review of five years of ambient monitoring data from the Toronto West Station indicated that background concentrations are well below the Guideline on an 8-hour basis.

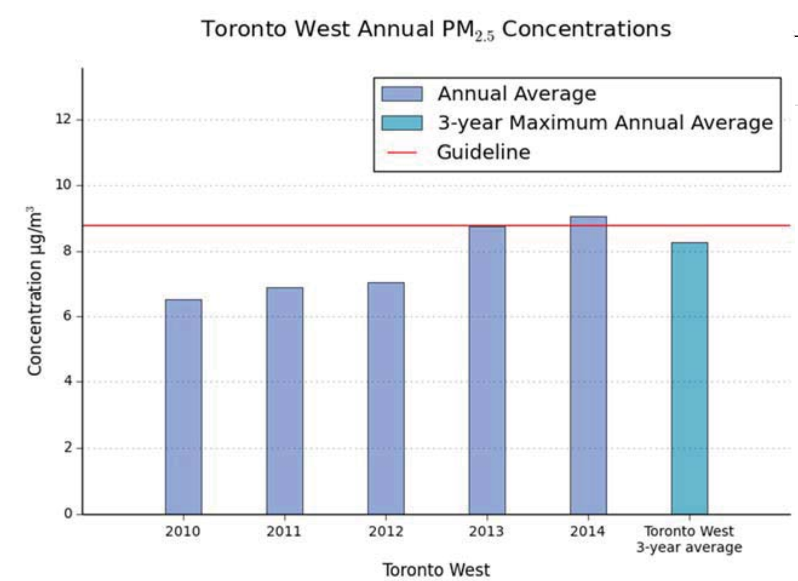
Table 7: Summary of Background $PM_{2.5}$

Statistical Analysis	Five-Year Summary



Statistic	% of Guideline
98th Percentile	83%

Conclusion:
The guideline for $PM_{2.5}$ is based on the 98th percentile value averaged over three consecutive years. A review of five years of ambient monitoring data from the Toronto North Station indicated that the highest 3-year average of 22.34 µg/m³ from 2010 to 2012 is 83% of the guideline.

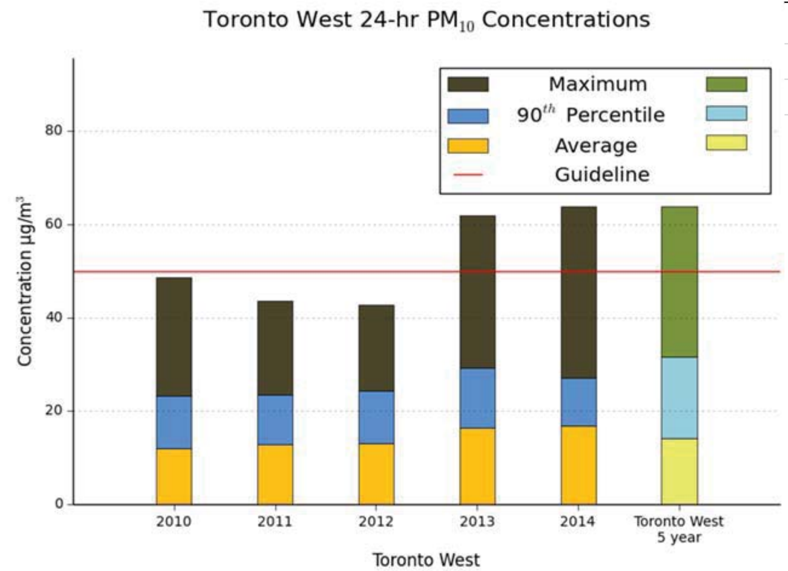


Statistic	% of Guideline
3-year Maximum Annual Average	8.29

Conclusion:
The annual guideline for $PM_{2.5}$ is based on the three-year maximum annual average. A review of five years of ambient monitoring data from the Toronto West Station indicated that the highest 3-year average of 8.29 µg/m³ from 2012 to 2014 is 94% of the guideline.

Table 8: Summary of Background PM_{10}

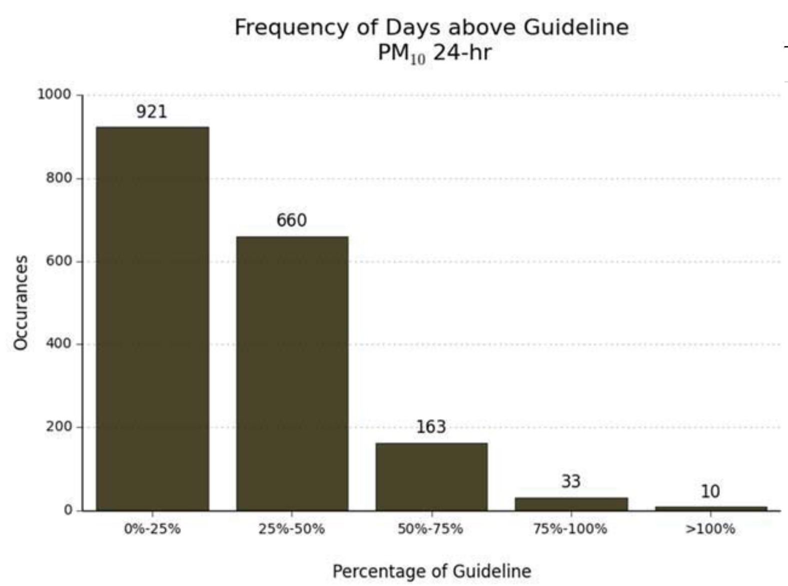
Statistical Analysis | **Five-Year Summary**



Statistic	% of Guideline
Maximum	128%
90th Percentile	52%
Average	28%

Conclusion:
A review of five years of PM_{10} data calculated from $PM_{2.5}$ ambient monitoring data from the Toronto West Station indicated that the estimated maximum background concentration exceeded the guideline on a 24-hour basis. Therefore, frequency analysis was conducted to determine the number of days the estimated background exceeded the guideline (see below).

Note: PM_{10} is not monitored in Ontario; therefore, background concentrations were estimated by applying a $PM_{2.5}/PM_{10}$ ratio of 0.54. Lall et al. (2004)

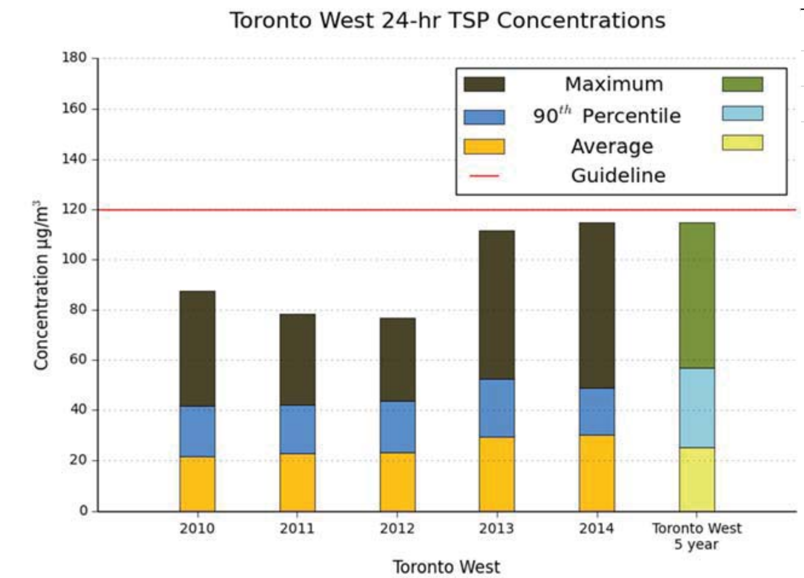


Number of Days Measured	Number of Days > Guideline
1,787	10

Conclusion:
Frequency analysis determined that 24-hr concentrations exceeded the guideline on an infrequent basis. Measured concentrations exceeded the guideline 10 days over the 5-year period. This means that the background concentration exceeded the guideline less than 1% of the time over the 5-year period.

Table 9: Summary of Background TSP

Statistical Analysis | **Five-Year Summary**



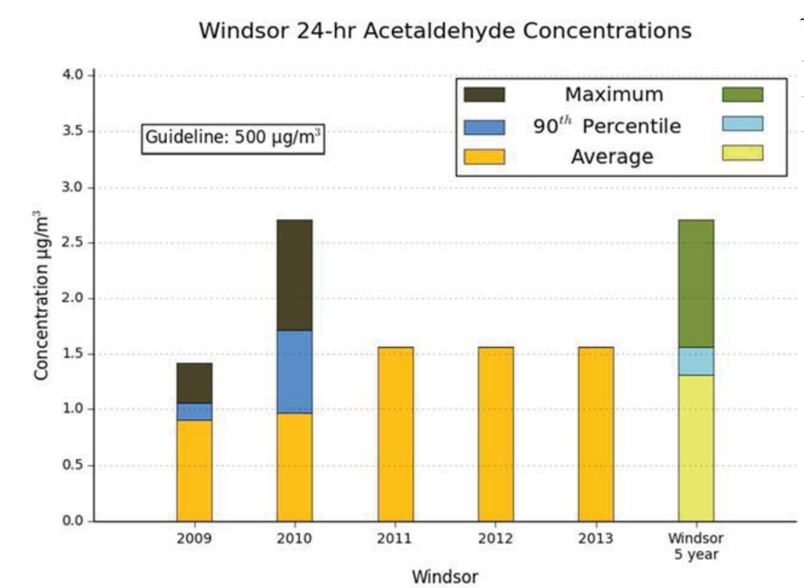
Statistic	% of Guideline
Maximum	96%
90th Percentile	39%
Average	21%

Conclusion:
A review of five years of TSP data calculated from $PM_{2.5}$ ambient monitoring data from the Toronto West Station indicated that the estimated maximum background concentration did not exceed the guideline on a 24-hour basis.

Note: TSP is not monitored in Ontario; therefore, background concentrations were estimated by applying a $PM_{2.5}$/TSP ratio of 0.3. Lall et al. (2004)

Table 10: Summary of Background Acetaldehyde

Statistical Analysis | **Five-Year Summary**

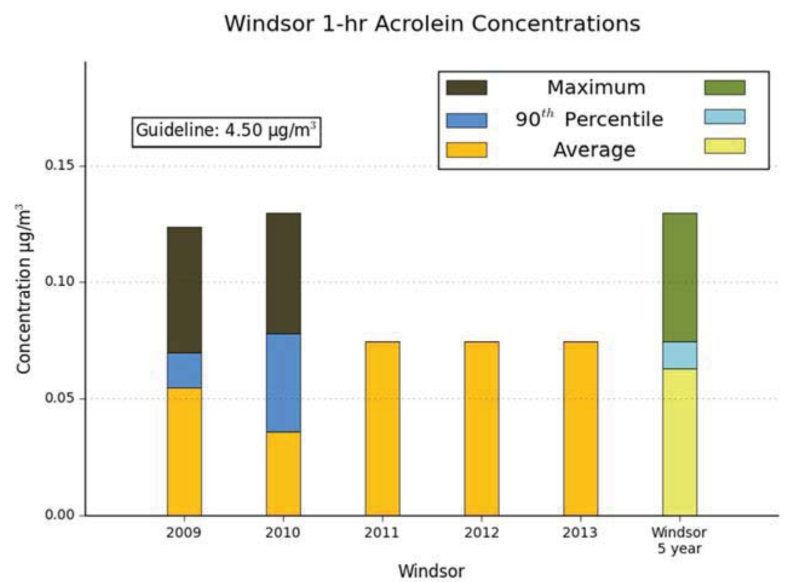


Statistic	% of Guideline
Maximum	1%
90th Percentile	<1%
Average	<1%

Conclusion:
A review of five years of ambient monitoring data from the Windsor Station indicated that the maximum background concentration was well below the guideline.

Table 11: Summary of Background Acrolein

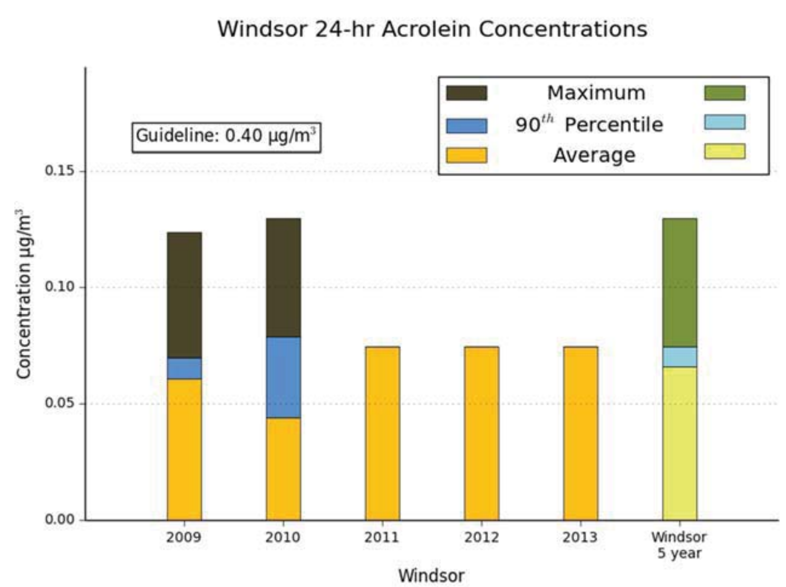
Statistical Analysis	Five-Year Summary



Statistic	% of Guideline
Maximum	3%
90th Percentile	2%
Average	1%

Conclusion:

A review of five years of ambient monitoring data from the Windsor Station indicated that background concentrations are well below the Guideline on a 1-hour basis.



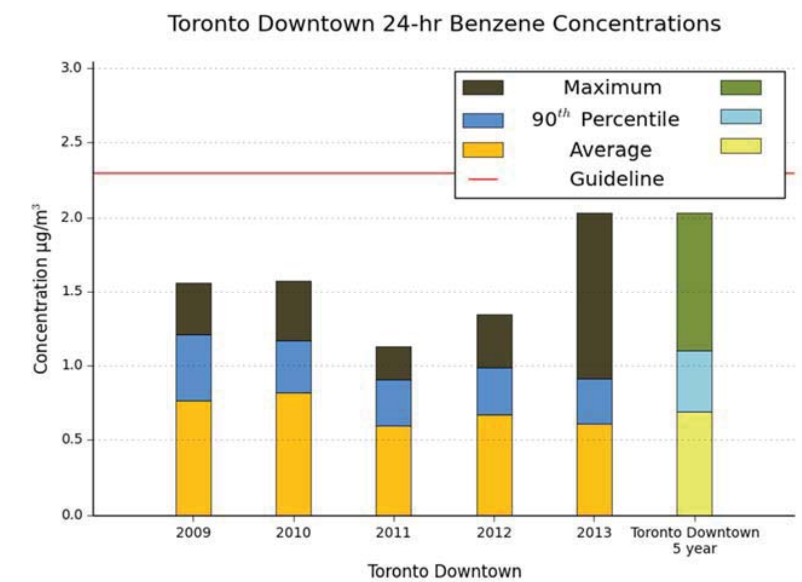
Statistic	% of Guideline
Maximum	32%
90th Percentile	19%
Average	16%

Conclusion:

A review of five years of ambient monitoring data from the Windsor Station indicated that background concentrations are well below the Guideline on a 24-hour basis.

Table 12: Summary of Background Benzene

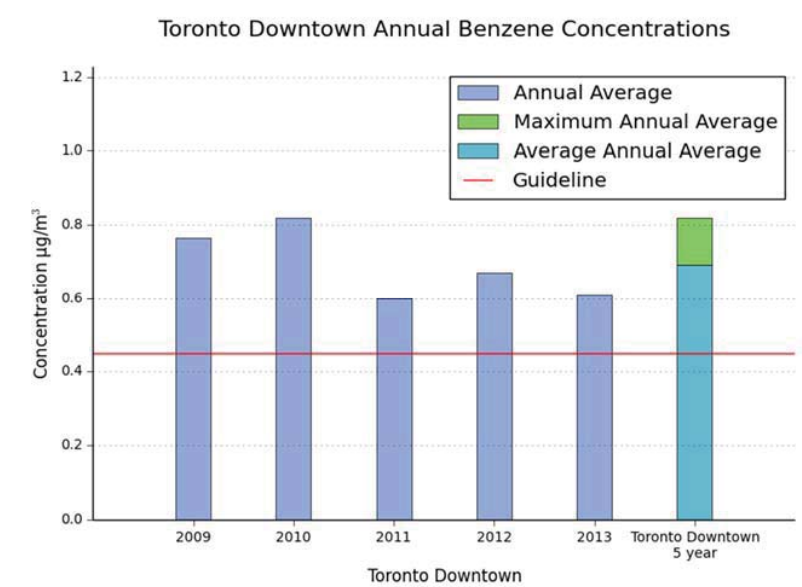
Statistical Analysis	Five-Year Summary



Statistic	% of Guideline
Maximum	88%
90th Percentile	48%
Average	30%

Conclusion:

A review of five years of ambient monitoring data from the Toronto Downtown Station indicated that background concentrations were 88% of the 24-hour standard.



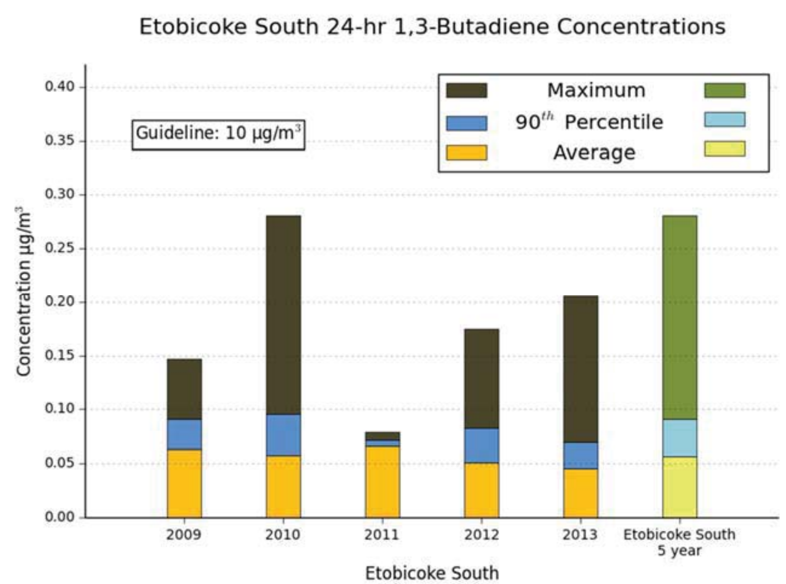
Statistic	% of Guideline
Maximum Annual Average	182%
Average Annual Average	154%

Conclusion:

A review of five years of ambient monitoring data from the Toronto Downtown Station indicated that maximum background concentrations were 182% of the annual standard. Average background concentrations over the five-year period were 154% of the standard.

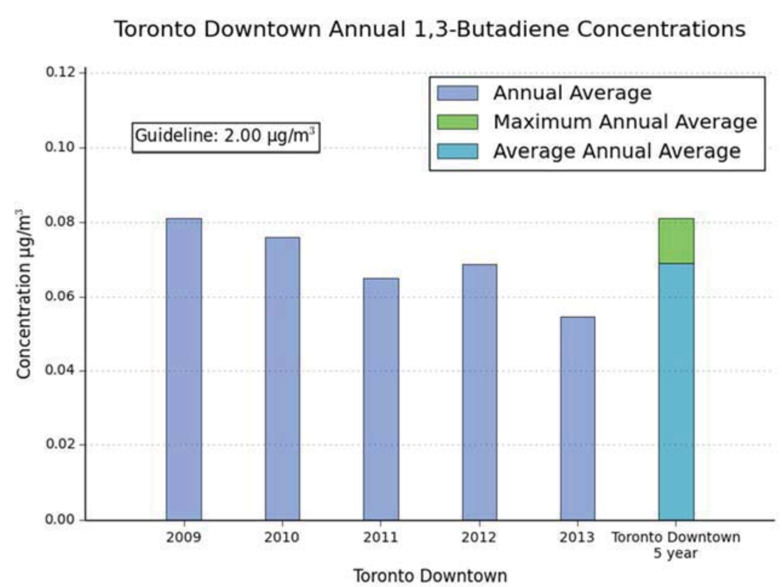
Table 13: Summary of Background 1,3-Butadiene

Statistical Analysis	Five-Year Summary



Statistic	% of Guideline
Maximum	3%
90th Percentile	1%
Average	1%

Conclusion:
A review of five years of ambient monitoring data from the Etobicoke South Station indicated that background concentrations were well below the 24-hour standard.

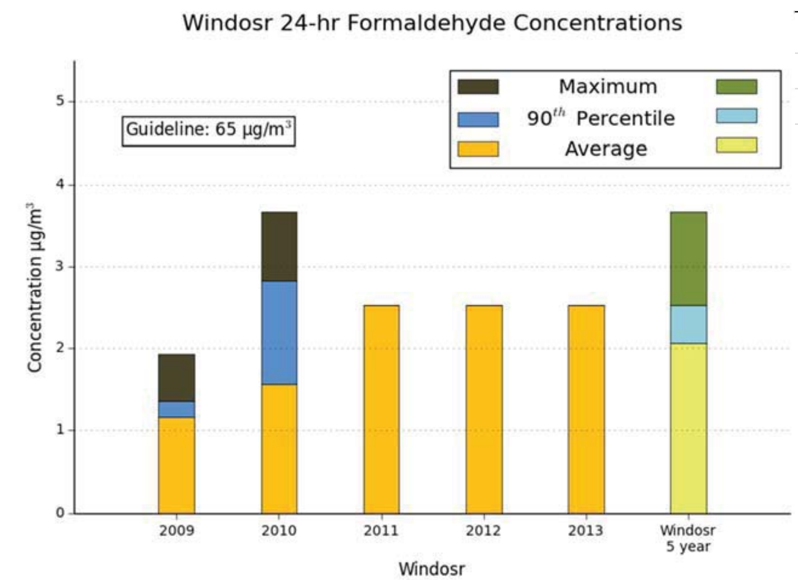


Statistic	% of Guideline
Maximum Annual Average	4%
Average Annual Average	3%

Conclusion:
A review of five years of ambient monitoring data from the Toronto Downtown Station indicated that background concentrations were 3% of the annual standard.

Table 14: Summary of Background Formaldehyde

Statistical Analysis	Five-Year Summary



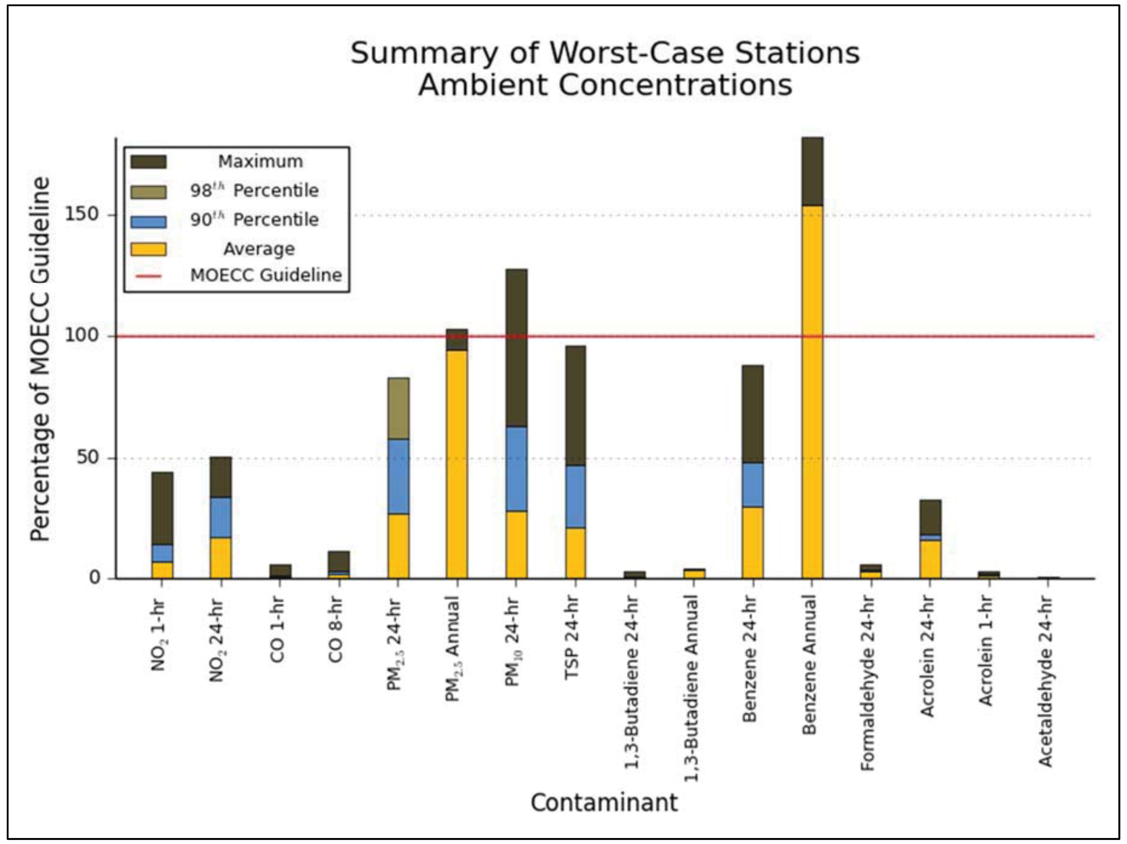
Statistic	% of Guideline
Maximum	6%
90th Percentile	4%
Average	3%

Conclusion:
A review of five years of ambient monitoring data from the Windsor Station indicated that the maximum background concentration was well below the guideline.

2.5 Summary of Background Conditions

Based on a review ambient monitoring data from 2010-2014, all contaminants were below their respective guidelines with the exception of PM_{10} and benzene. It should be noted that PM_{10} and TSP were calculated based on their relationship to $PM_{2.5}$.

A summary of the background concentrations as a percentage of their respective guidelines or CWS is presented in **Figure 6**.



Note: The $PM_{2.5}$ annual guideline is based on the three-year maximum annual average. The three-year maximum average is 94% of the guideline.

Figure 6: Summary of Background Conditions

3.0 Local Air Quality Assessment

3.1 Overview

The worst-case impacts due to vehicle and bus emissions were assessed for three scenarios: 2014 Existing, 2031 Future No-Build and 2031 Future Build. The three scenarios include the following activities:

2014 Existing:
- Existing vehicle and bus counts on nearby roadways.

2031 Future No-Build:
- Projected vehicle volumes including buses on nearby roadways

2031 Future Build:
- Projected vehicle volumes including buses on nearby roadways
- Idling buses at the proposed bus terminal

The assessment was performed using U.S. EPA approved models to determine vehicle emission rates and air dispersion. Worst-case impacts at representative sensitive receptor locations were predicted. The details of the assessment are discussed below.

3.2 Location of Sensitive Receptors within the Study Area

Land uses which are defined as sensitive receptors for evaluating potential air quality effects are:

- Health care facilities;
- Senior citizens' residences or long-term care facilities;
- Child care facilities;
- Educational facilities;
- Places of worship; and
- Residential dwellings.

25 sensitive receptors were modelled to represent worst-case impacts surrounding the bus terminal site. All identified sensitive receptors represent residential properties. R1 through R11 and R14-R15 represent high-rise residential buildings, for which receptors were modelled above grade as well as at grade-level to represent any operable windows. R12-R13 and R16 through R25 represent one-to-two storey houses, therefore, only grade level receptors were considered.

Representative worst-case impacts were predicted by the dispersion model at the sensitive receptors closest to the roadway. This is due to the fact that contaminant concentrations disperse significantly with downwind distance from the motor vehicles resulting in reduced contaminant concentrations. At approximately 500 m from the roadway, contaminant concentrations from motor vehicles generally become indistinguishable from background levels. The maximum predicted contaminant concentrations at the closest sensitive receptors will usually occur during weather events which produce calm to light winds (< 3 m/s). During weather events with higher wind speeds, the contaminant concentrations disperse much more quickly.

Figure 7: Receptor Locations Within The Study Area

3.3 Road Traffic Data

Traffic volumes from the City of Toronto for roadways surrounding the bus terminal were provided by AECOM in the form of both hourly counts and peak turning movements for the years 2008-2014. The hourly counts resulted in a higher daily traffic volumes, and were therefore used in the modelling to be conservative. The resulting annual average daily traffic (AADT) volumes are shown in **Table 15**. Based on available traffic volumes, roadway traffic was modelled on McCowan Road, Progress Avenue and Ellesmere Road.

The hourly vehicle distribution was determined for each roadway by taking the average of the existing hourly counts provided for the roadways considered in the assessment. The peak turning movements provided included the breakdown of trucks and buses. From these counts, a heavy-duty vehicle percentage of 5%, with buses comprising 2.3% of traffic volumes was determined.

A growth rate of 2% was provided by AECOM for all roadways. This growth rate was used to determine traffic volumes for the project years: 2014 and 2031. All roadways considered in the study area have a posted speed limit of 60 km/hr.

Table 15: Traffic Volumes (AADT) and Heavy Duty Vehicle Percentages Used in the Assessment

Roadway	2014 Existing AADT	2031 Future AADT
McCowan Road	45,080	62,123
Progress Avenue	11,255	15,760
Ellesmere Road	33,139	46,403

3.4 Bus Schedules

For the bus terminal, the number of routes and AM peak bus counts were provided by AECOM. Detailed schedule information was not available for the Scarborough Town Centre terminal at this time, however, a detailed daily schedule was available for the Sheppard East Station. Therefore, the average ratio of AM Peak Volumes to other time periods for the Sheppard Terminal was used to scale the AM Peak Volumes at the Scarborough Town Centre terminal and determine an hourly bus schedule. The TTC idling policy ensures that each bus will idle for no more than 3 minutes. Therefore, a 3 minute idling time for each bus at each station was used in the modelling. The hourly schedule for the bus terminal is shown in **Table 16**.

Table 16: Hourly Bus Volumes for Each Terminal

Hour	Number of Buses At the Terminal
0:00	99
1:00	99
2:00	99
3:00	0
4:00	0
5:00	0
6:00	171
7:00	171
8:00	171
9:00	116
10:00	116
11:00	116
12:00	116
13:00	116
14:00	116
15:00	163
16:00	163
17:00	163
18:00	163
19:00	114
20:00	114
21:00	114
22:00	99
23:00	99

3.5 Meteorological Data

The preprocessed meteorological data for the years 1996-2000 was used in the model. This data is recommended by the MOECC for projects the Toronto region. The surface data is obtained from Toronto Pearson Airport and the upper air station data is obtained from the Buffalo monitoring station. The urban dataset was used for this project. The preprocessed meteorological data is AERMOD ready. A wind frequency diagram (wind rose) is shown in **Figure 8**. As can be seen in this figure, predominant winds are from the westerly and north-westerly directions.

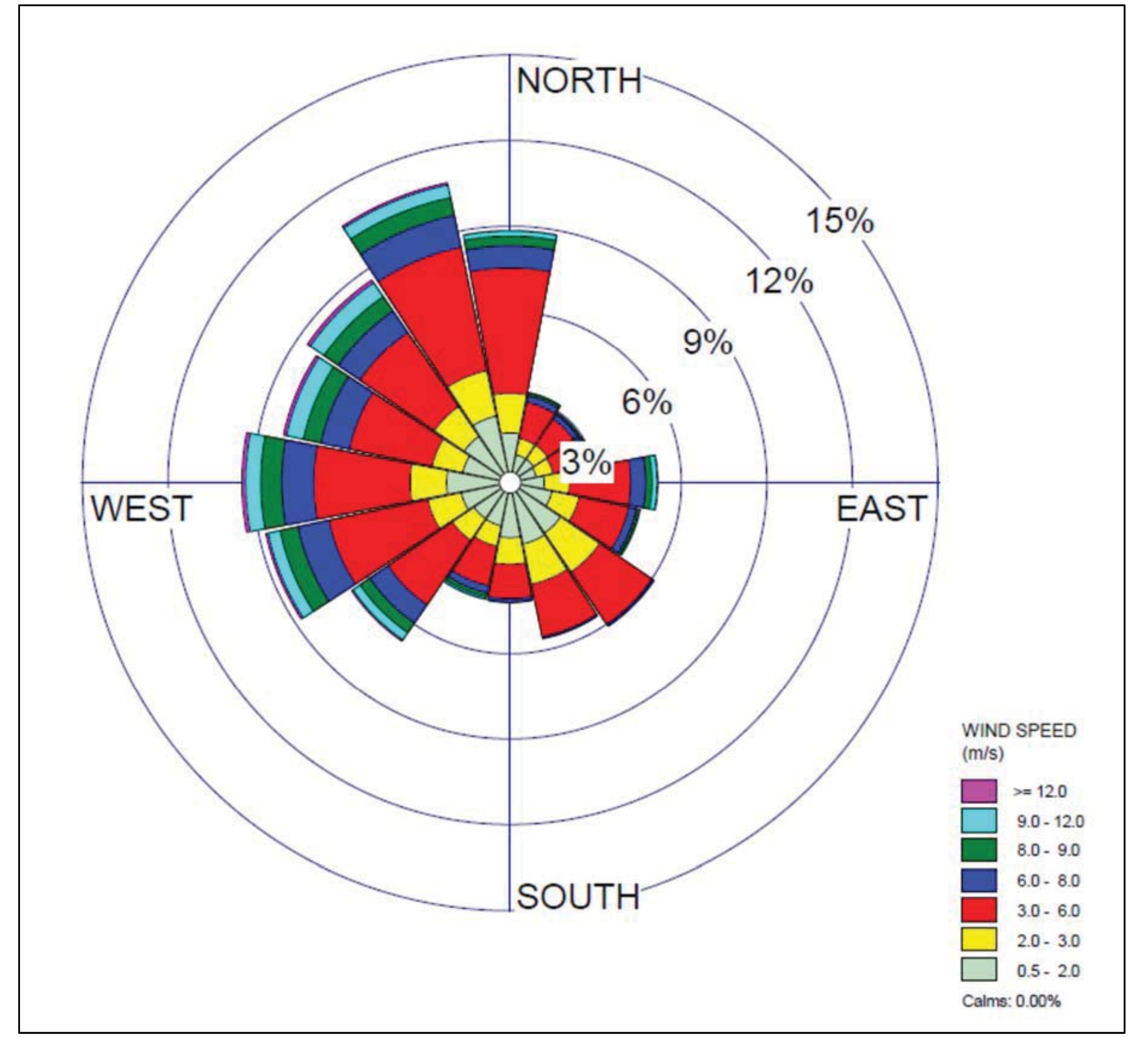


Figure 8: Wind Frequency Diagram for Pearson International Airport

3.6 Motor Vehicle Emission Rates

The U.S. EPA's Motor Vehicle Emission Simulator (MOVES) model provides estimates of current and future emission rates from motor vehicles based on a variety of factors such as local meteorology and vehicle fleet composition. MOVES 2014, released in October 2014, is the U.S. EPA's tool for estimating vehicle emissions due to the combustion of fuel, brake and tire wear, fuel evaporation, permeation and refuelling leaks. The model is based on "an analysis of millions of emission test results and considerable advances in the Agency's understanding of vehicle emissions and accounts for changes in emissions due to proposed standards and regulations". For this project, MOVES was used to estimate vehicle emissions based on vehicle type, road type, model year, and vehicle speed. Emission rates were estimated based on the heavy duty vehicle percentages determined from the turning movement peak hour counts. Emission rates were determined for the surrounding roadways and for buses alone idling at the terminals. Vehicle age was determined based on the U.S. EPA's default distribution. For the buses, an average age of 9 years with a linear distribution was recommended by the TTC. **Table 17** specifies the major inputs into MOVES.

Table 17: MOVES Input Parameters

Parameter	Input
Scale	Custom County Domain
Meteorology	Temperature and Relative Humidity were obtained from meteorological data from Pearson International Airport.
Years	2014, 2031
Geographical Bounds	Custom County Domain
Fuels	Compressed Natural Gas / Diesel Fuels / Gasoline Fuels
Source Use Types	Combination Long-haul Truck / Combination Short-haul Truck / Intercity Bus / Light Commercial Truck / Motor Home / Motorcycle / Passenger Car / Passenger Truck / Refuse Truck / School Bus / Single Unit Long-haul Truck / Single Unit Short-haul Truck / Transit Bus
Road Type	Urban Unrestricted Access
Contaminants and Processes	NO_2 / CO / $PM_{2.5}$ / PM_{10} / Acetaldehyde / Acrolein / Benzene / 1,3-Butadiene / Formaldehyde. TSP can't be directly modelled by MOVES. However, the U.S. EPA has determined, based on emissions test results, that >97% of tailpipe particulate matter is PM_{10} or less. Therefore, the PM_{10} exhaust emission rate was used for TSP.
Vehicle Age Distribution	MOVES defaults based on years selected for the roadway.

From the MOVES outputs, the highest monthly value was selected to represent a worst-case emission rate. The emission rates for each speed modelled for a 5% heavy duty vehicle percentage, with buses comprising 2.3% are shown in **Table 18**.

Table 18: MOVES Output Emission Factors for Roadway Vehicles (g/VMT)

Year	Speed	NO_2	CO	$PM_{2.5}$	PM_{10}	TSP[1]	Acetaldehyde	Acrolein	Benzene	1,3-Butadiene	Formaldehyde
2014	60 km/hr	0.059	2.99	0.027	0.07	0.07	0.0018	0.0002	0.0037	0.0004	0.003
2031		0.018	1.08	0.01	0.06	0.06	0.0002	0.00003	0.0009	0.000002	0.0006

1 – Note that TSP can't be directly modelled by MOVES. However, the U.S. EPA has determined, based on emissions test results, that >97% of tailpipe particulate matter is PM_{10} or less. Therefore, the PM_{10} exhaust emission rate was used for TSP.

At the transit station, only emissions from idling buses were considered. Emissions from buses travelling on the roadways were included in the emission rate for roadways based on the existing bus counts provided in the peak turning movement counts. It is assumed that with the bus terminals in place, the number of buses on the roadways will remain similar to the existing scenario. Emissions for idling transit buses for the future-build year are provided in **Table 19**.

Table 19: MOVES Output Emission Factors for Idling Buses (g/hour)

Year	Speed	NO_2	CO	$PM_{2.5}$	PM_{10}	TSP[1]	Acetaldehyde	Acrolein	Benzene	1,3-Butadiene	Formaldehyde
2031	Idle	3.40	2.03	0.13	0.14	0.14	0.024	0.0035	0.0045	0.00028	0.075

1 – Note that TSP can't be directly modelled by MOVES. However, the U.S. EPA has determined, based on emissions test results, that >97% of tailpipe particulate matter is PM_{10} or less. Therefore, the PM_{10} exhaust emission rate was used for TSP.

3.7 Re-suspended Particulate Matter Emission Rates

A large portion of roadway particulate matter emissions comes from dust on the pavement which is re-suspended by vehicles travelling on the roadway. These emissions are estimated using empirically derived values presented by the U.S. EPA in their AP-42 report. The emissions factors for re-suspended PM were estimated by using the following equation from U.S. EPA's Document AP-42 report, Chapter 13.2.1.3 and are summarized in **Table 20**.

$$E = k(sL)^{0.91} * (W)^{1.02}$$

Where: E = the particulate emission factor
k = the particulate size multiplier
sL = silt loading
W = average vehicle weight (Assumed 3 Tons based on Toyota fleet data and U.S. EPA vehicle weight and distribution)

Table 20: Re-suspended Particulate Matter Emission Factors

Roadway AADT	K ($PM_{2.5}/PM_{10}$/TSP)	sL (g/m^2)	W (Tons)	E (g/VMT)		
				$PM_{2.5}$	PM_{10}	TSP
<500	0.25/1.0/5.24	0.6	3	0.503	2.015	10.561
500-5,000	0.25/1.0/5.24	0.2	3	0.185	0.741	3.886
5,000-10,000	0.25/1.0/5.24	0.06	3	0.061	0.247	1.299
>10,000	0.25/1.0/5.24	0.03	3	0.033	0.132	0.691

3.8 Air Dispersion Modelling Using AERMOD

The U.S. EPA's AERMOD dispersion model, based on the Gaussian plume equation was used to predict air quality impacts from the new bus terminals. The model inputs include local topography, sensitive receptor locations, meteorology, emission rates and exhaust parameters. AERMOD uses this information to calculate hourly, 8-hour, 24-hour and annual averages for the contaminants of interest at the identified sensitive receptor locations. The line-area source type, meant for modelling roadways, was used in this assessment. The emission rates used in the model were the outputs from the MOVES and AP-42 models, weighted for the heavy duty vehicle and bus distribution.

3.9 Modelling Results

Presented below are the modelling results for the existing, Future No-Build and Future Build scenarios. Worst-case predicted concentrations were determined by combining the maximum predicted concentration (at any sensitive receptor) with the maximum background concentration. Note that this methodology results in conservative worst-case concentrations as the maximum concentration from the roadway and bus terminal likely does not occur at the same time as the maximum background concentration.

The worst-case predicted concentrations for the Existing, Future No-Build and Future Build scenarios are shown in **Table 21** and **Table 22**. Note that the worst-case predicted concentrations occurred at R25, on the south side of Ellesmere Road just east of McCowan Road for all contaminants and for all scenarios. Shown is the combined concentration as a percentage of the guideline, the roadway and bus contributions to the maximum combined concentration for each scenario. Idling buses are only included in the Future Build Scenario. Results are shown only for the worst-case sensitive receptor; predicted concentrations at all other receptor locations are below those shown in **Table 21** and **Table 22**.

Table 21: Worst-Case Combined Results for the Existing Scenario

		Background	Existing Scenario		
Contaminant	Averaging Period	Percentage of Guideline	Combined Concentration (% of Guideline)	Background Contribution to Maximum	Roadway Contribution to Maximum
Acetaldehyde	24-hr	0.5%	0.6%	95.7%	4.3%
Acrolein	1-hr	2.9%	3.8%	75.1%	24.9%
	24-hr	32.4%	35.9%	90.4%	9.6%
Benzene	24-hr	88.3%	99.4%	88.8%	11.2%
	Annual	181.9%	193.1%	94.2%	5.8%
1,3-Butadiene	24-hr	2.8%	3.1%	91.5%	8.5%
	Annual	4.1%	4.3%	94.1%	5.9%
CO	1-hr	5.9%	7.7%	76.6%	23.4%
	8-hr	11.8%	14.0%	84.2%	15.8%
Formaldehyde	24-hr	5.6%	6.0%	94.5%	5.5%
NO_2	1-hr	44.0%	72.2%	61.0%	39.0%
	24-hr	50.6%	68.8%	73.7%	26.3%
$PM_{2.5}$	24-hr	82.7%	98.3%	84.2%	15.8%
	Annual	94.2%	103.5%	91.0%	9.0%
PM_{10}	24-hr	127.8%	156.5%	81.6%	18.4%
TSP	24-hr	95.8%	148%	65%	35%

Table 22: Worst-Case Combined Results for the Future No-Build and Future Build Scenarios

		Future No-Build Scenario			Future Build Scenario			
Contaminant	Averaging Period	Combined Concentration (% of Guideline)	Background Contribution to Maximum	Roadway Contribution to Maximum	Combined Concentration (% of Guideline)	Background Contribution to Maximum	Roadway Contribution to Maximum	Bus Terminal Contribution to Maximum
Acetaldehyde	24-hr	0.5%	99.2%	0.8%	1%	99.1%	0.9%	0.02%
Acrolein	1-hr	3.1%	93.3%	6.7%	3%	92.9%	6.7%	0.4%
	24-hr	33.2%	97.7%	2.3%	33%	97.7%	2.3%	0.1%
Benzene	24-hr	92.2%	95.7%	4.3%	92%	95.7%	4.3%	0.004%
	Annual	185.8%	97.9%	2.1%	186%	97.9%	2.1%	0.004%
1,3-Butadiene	24-hr	2.8%	99.9%	0.1%	3%	99.9%	0.1%	0%
	Annual	4.1%	100.0%	0.0%	4%	100.0%	0.0%	0.01%
CO	1-hr	6.8%	86.6%	13.4%	7%	86.6%	13.4%	0.01%
	8-hr	12.9%	91.4%	8.6%	13%	91.4%	8.6%	0.003%
Formaldehyde	24-hr	5.7%	98.4%	1.6%	6%	98.3%	1.6%	0.04%
NO_2	1-hr	49.9%	88.2%	11.8%	50%	87.5%	11.8%	0.7%
	24-hr	54.4%	93.0%	7.0%	55%	92.9%	7.0%	0.1%
$PM_{2.5}$	24-hr	98.3%	84.2%	15.8%	98%	84.1%	15.9%	0.01%
	Annual	103.5%	91.0%	9.0%	104%	91.0%	9.0%	0.002%
PM_{10}	24-hr	164.4%	77.7%	22.3%	164%	77.7%	22.3%	0.003%
TSP	24-hr	167%	57%	43%	167%	57.2%	42.8%	0.001%

In all scenarios, background concentrations alone are a major contributor to the worst-case combined concentration for all pollutants. For annual benzene and 24-hour PM_{10}, the background concentrations alone exceed the guideline. The $PM_{2.5}$ background concentrations are 83% and 94% of the 24-hr and annual guidelines, respectively and the TSP background concentration alone is 96% of the guideline. Background concentrations are based on the worst-case measured concentrations monitored in the study area.

In the Existing Scenario (**Table 21**), the worst-case combined concentration is below the guideline for all contaminants except for benzene and the particulates ($PM_{2.5}$, PM_{10}, TSP). For these contaminants, background concentrations contribute 80% or more to the worst-case concentration, with the exception of TSP. For TSP, the background contribution to the maximum is 65%. Overall, the contribution from the existing roadways to the worst-case combined concentration is less than the background contribution for all pollutants.

In the Future No-Build Scenario (**Table 22**), the worst-case combined concentration is below the guideline for all contaminants except for annual benzene and the particulates. Similarly to the Existing Scenario, the contribution of background concentration to the worst-case concentration is greater than 75% for all pollutants except for TSP. For TSP, background concentrations contribute 57% to the maximum. The majority of TSP emissions from the roadway are due to silt loading. Overall, for the majority of pollutants the background concentrations are the major contributor to worst-case concentrations.

The results for the Future Build Scenario (**Table 22**) show that the worst-case combined concentration is below the guideline for all contaminants except for annual benzene and all of the particulates ($PM_{2.5}$, PM_{10} and TSP). As noted above, for annual benzene and 24-hour PM_{10}, the background concentrations alone exceed the guideline. The $PM_{2.5}$ and TSP background concentrations alone are greater than 80% of their guidelines. The contribution of nearby roadways to the maximum concentration is less than 20% for all contaminants with the exception of PM_{10} and TSP. The contribution of the bus terminal to the maximum concentration is less than 1% for all pollutants, showing that existing roadway emissions dominate worst-case predicted concentrations in the study area. It is also important to note that the difference between the worst-case concentration between the Future No-Build and Future Build Scenarios is 1% or less for all contaminants. These results show that the impact of the bus terminal is minimal, and overall impacts between the Future Build and Future No-Build scenarios are similar.

4.0 Conclusions and Recommendations

The potential effects of the proposed project infrastructure on local air quality have been assessed. The following conclusions and recommendations are a result of this assessment.

- *The maximum combined concentrations for the future build scenario were all below their respective MOECC guidelines or CWS, with the exception of $PM_{2.5}$, PM_{10}, TSP, and annual benzene. For annual benzene and PM_{10}, background concentrations alone exceeded the guidelines.*
- *The contribution of the bus terminal to the worst-case concentration was less than 1% for all contaminants and averaging periods.*
- *The difference in maximum predicted concentrations between the Future No-Build and Future Build scenarios is very small, showing that the air quality impacts from the Scarborough Town Centre Bus Terminal on the surrounding area are minimal.*
- *Mitigation measures are not warranted.*

5.0 References

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