# Air Quality Assessment Lakeshore Road East from Etobicoke Creek to East Avenue

**City of Mississauga**

SLR Project No: 241.30176.00000

June 8, 2023

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# 1. INTRODUCTION

SLR Consulting (Canada) Ltd., was retained by HDR Inc. on behalf of the City of Mississauga (City) to conduct an air quality assessment for a proposed Bus Rapid Transportation (BRT) system under the Transit Projects Assessment Process (TPAP) in Mississauga, Ontario. The Project also includes a realignment of 2 km of Lakeshore Road East from Etobicoke Creek to East Avenue. A context plan and an overview of the study area for the project is shown in **Figure 1.**

## 1.1 STUDY OBJECTIVES

The objective of the study is to assess the local air quality impacts associated with the BRT and Lakeshore Road realignment and includes an overview of construction impacts and a screening level assessment of greenhouse gases (GHG). To meet these objectives, the following scenarios were considered:

- **2021 No Build (NB) –** Assess the existing and future air quality conditions at representative receptors without the project in place. Predicted contaminant concentrations from the respective traffic levels were combined with hourly measured ambient concentrations to determine combined impacts.
- **2041 Future Build (FB) –** Assess the future air quality conditions with the proposed project in place. Predicted contaminant concentrations associated with traffic levels for the preferred alternative were combined with hourly measured ambient concentrations to determine combined impacts.

The modelling assessment considered guidance provided in MTO's Environmental Guide for Assessing and Mitigating Air Quality Impacts and Greenhouse Gas Emissions of Provincial Transportation Projects (AQ&GHG Guide; May 2020) and included vehicle emissions from Lakeshore Road East from East Avenue to 42/43 Street, along with arterial roads: East Avenue, Lakefront Promenade, Ogden Avenue, New Hydro Road, Haig Boulevard, Fergus Avenue, Dixie Road, 1515 Lakeshore Condo and, the BRT itself.


**Figure 1: Modelled Road Segments in Study Area**

## 1.2 CONTAMINANTS OF INTEREST

The contaminants of interest from vehicle emissions are based on the regularly assessed contaminants of interest for transportation assessments in Ontario, as determined by MTO and Ministry of Environment, Conservation and Parks (MECP). 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), MECP, Environment Canada (EC), Health Canada (HC), and 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 the selected contaminants are emitted during fuel combustion, while emissions from brake wear, tire wear, and breakdown of road dust include only the particulates. A summary of these contaminants is provided in **Table 1**.

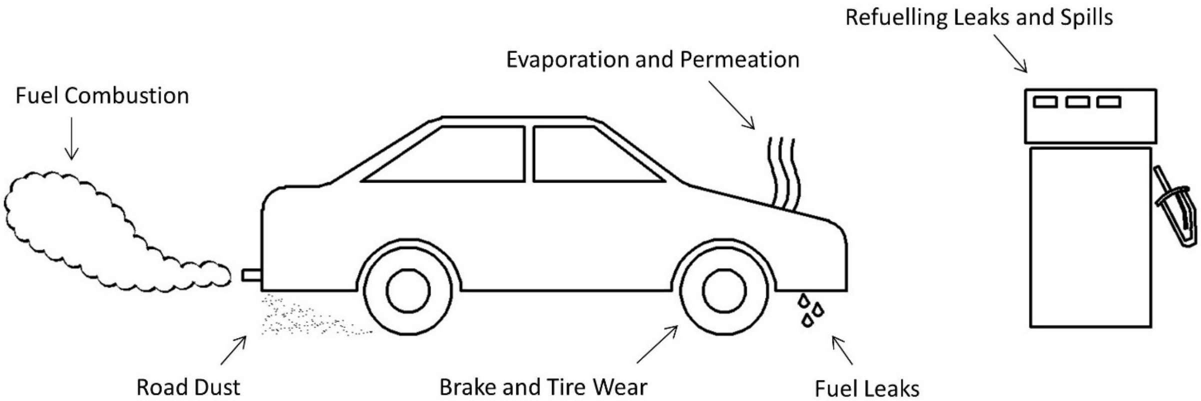



**Figure 2: Motor Vehicle Emission Sources**

**Table 1: Contaminants of Interest**

| Contaminants | | Volatile Organic Compounds (VOCs) | | Polycyclic Aromatic Hydrocarbon (PAH) | |
|---|---|---|---|---|---|
| Name | Symbol | Name | Symbol | Name | Symbol |
| Nitrogen Dioxide | $NO_2$ | Acetaldehyde | $C_2H_4O$ | Benzo(a)Pyrene | $C_{20}H_{12}$ |
| 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 | $CH_2O$ | | |

## 1.3 APPLICABLE GUIDELINES

To understand existing conditions in the study area, ambient background concentrations have been compared to guidelines established by government agencies and organizations. Relevant agencies and organizations in Ontario and Canada, and their applicable contaminant guidelines are:

- MECP Ambient Air Quality Criteria (AAQC).
- Health Canada/Environment Canada National Ambient Air Quality Objectives (NAAQOs).
- Canadian Council of Ministers of the Environment (CCME) Canadian Ambient Air Quality Standards (CAAQS).

Within the guidelines, the threshold value for each contaminant and its applicable averaging period were used to assess the maximum predicted impact at sensitive receptors derived from a combined result of ambient concentration and computer simulations. The contaminants of interest are compared against 1-hour, 8-hour, 24-hour, and annual averaging periods. The threshold values and averaging periods used in this assessment are presented in **Table 2**. It should be noted that the CAAQS for fine Particulate Matters less than two and a half micron in width ($PM_{2.5}$) is not based on the maximum 24-hour concentration value; $PM_{2.5}$ is assessed based on the annual 98th percentile value, averaged over 3 consecutive years.

**Table 2: Applicable Contaminant Guidelines**

| Contaminant | Averaging Period (hrs) | Threshold Value ($\mu g/m^3$) | Source |
|---|---|---|---|
| $NO_2$ | 1 | 400 | AAQC |
| | 24 | 200 | AAQC |
| | 1 | 79 (42 ppb)[1] | CAAQS (standard is to be phased-in in 2025) |
| | Annual | 23 (12 ppb)[2] | CAAQS (standard is to be phased-in in 2025) |
| CO | 1 | 36,200 | AAQC |
| | 8 | 15,700 | AAQC |
| $PM_{2.5}$ | 24 | 27[3] | CAAQS (standard is to be phased-in in 2020) |
| | Annual | 8.8[4] | CAAQS |
| $PM_{10}$ | 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 |

| Contaminant | Averaging Period (hrs) | Threshold Value ($\mu g/m^3$) | Source |
|---|---|---|---|
| Formaldehyde | 24 | 65 | AAQC |
| Benzo(a)Pyrene | 24 | 0.00005 | AAQC |
| | Annual | 0.00001 | AAQC |

[1] The 1-hour $NO_2$ CAAQs is based on the 3-year average of the annual 98$^{th}$ percentile of the $NO_2$ daily maximum 1-hour average concentrations
[2] The annual CAAQs is based on the average over a single calendar year of all the 1-hour average $NO_2$ concentrations
[3] The 24-hr $PM_{2.5}$ CAAQS is based on the 3-year average of the annual 98$^{th}$ percentile of the 24-hr average concentrations
[4] The annual $PM_{2.5}$ CAAQS is based on the average of the three highest annual average values over the study period

## 1.4 GENERAL ASSESSMENT METHODOLOGY

The worst-case contaminant concentrations due to motor vehicle emissions from the roadways were predicted at nearby receptors using dispersion modelling software on an hourly basis for a five-year period. Historical meteorological data from Billy Bishop Toronto City Airport for the period 2013-2017 was used. Five years were modelled to capture the worst-case meteorological conditions. Two emission scenarios were assessed: 2021 No Build (NB) and 2041 Future Build (FB).

Combined concentrations were determined by adding modelled and background (i.e., ambient data) concentrations together on an hourly basis. Background concentrations for all available contaminants were determined from MECP and NAPS (National Air Pollution Surveillance) stations nearest to the study area with applicable datasets.

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 occur infrequently and at only one receptor location.

# 2. BACKGROUND AMBIENT DATA

## 2.1 OVERVIEW

Background (ambient) conditions measure contaminant concentrations that are independent of emissions from the proposed project infrastructure. These concentrations consist of trans-boundary (macro-scale), regional (meso-scale), and local (micro-scale) emission sources and result from 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 (MECP, 2005). During smog episodes, the U.S. contribution to $PM_{2.5}$ can be as much as 90 percent near the southwest Ontario-U.S. border. The effects of U.S. air pollution in Ontario on a high $PM_{2.5}$ day and on an average $PM_{2.5}$ spring/summer day are illustrated in **Figure 3.**

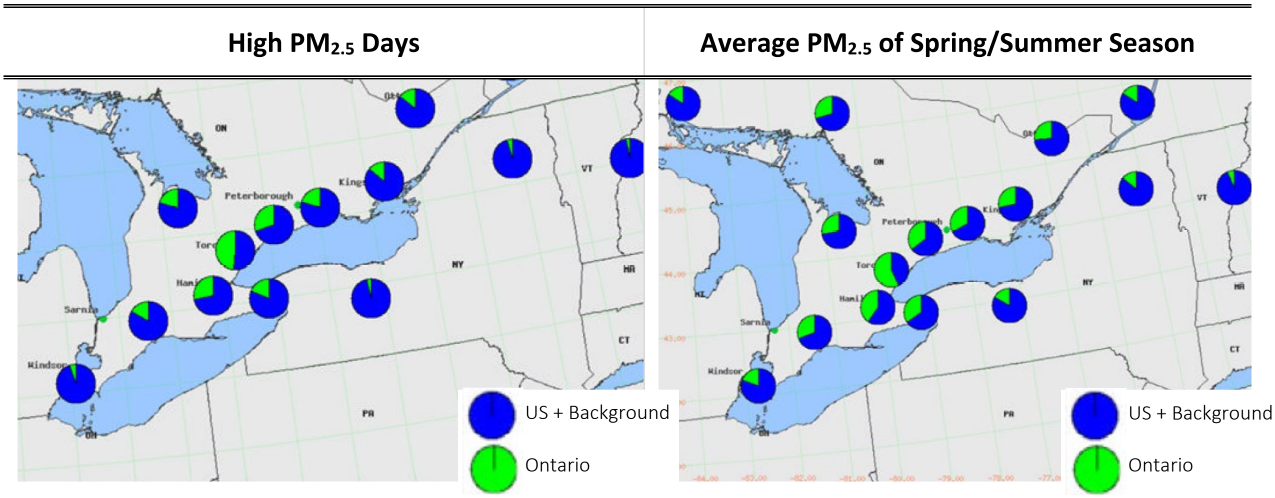



**Figure 3: Effect of Trans-Boundary Air Pollution (MECP, 2005)**

Air pollution is strongly influenced by weather systems (i.e., meteorology) that commonly 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 blowing from the southwest that can 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.

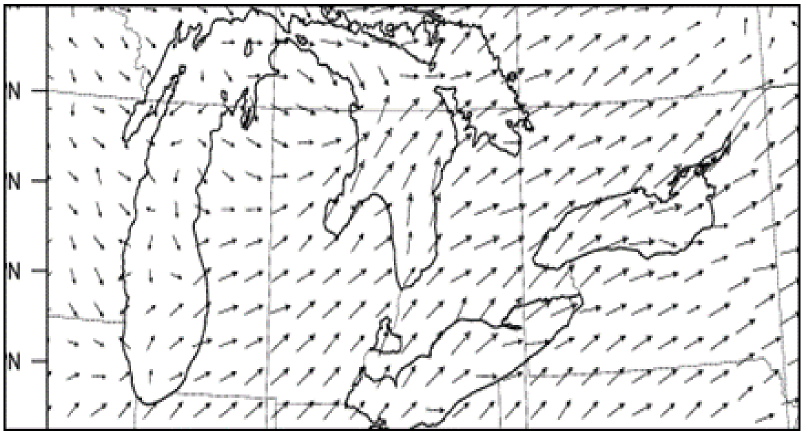



**Figure 4: Typical Wind Direction during an Ontario Smog Episode**

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

## 2.2 SELECTION OF RELEVANT AMBIENT MONITORING STATIONS

A review of MECP 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. The closest MECP station is located 9 km west of the site at 3359 Mississauga Rd. N., U of T Campus, in Mississauga. The closest NAPS station is located 5.5 km northeast at 461 Kipling Avenue Etobicoke South and 9 km north at Elmcrest Road, Etobicoke West, therefore these monitoring stations were used to summarize background concentrations in the study area. Note that CO is only monitored at the Toronto West Station, therefore this station was used only to assess background CO concentrations. Also note that Windsor is the only station in Ontario at which background Acrolein, Formaldehyde, and Acetaldehyde are measured in recent years. Only these contaminants were considered from the Windsor station; the remaining contaminants from the Windsor station were not considered given the stations' distance from the study area. The locations of the relevant ambient monitoring stations in relation to the study area are shown in Figure 5. Station information is presented in Table 3.

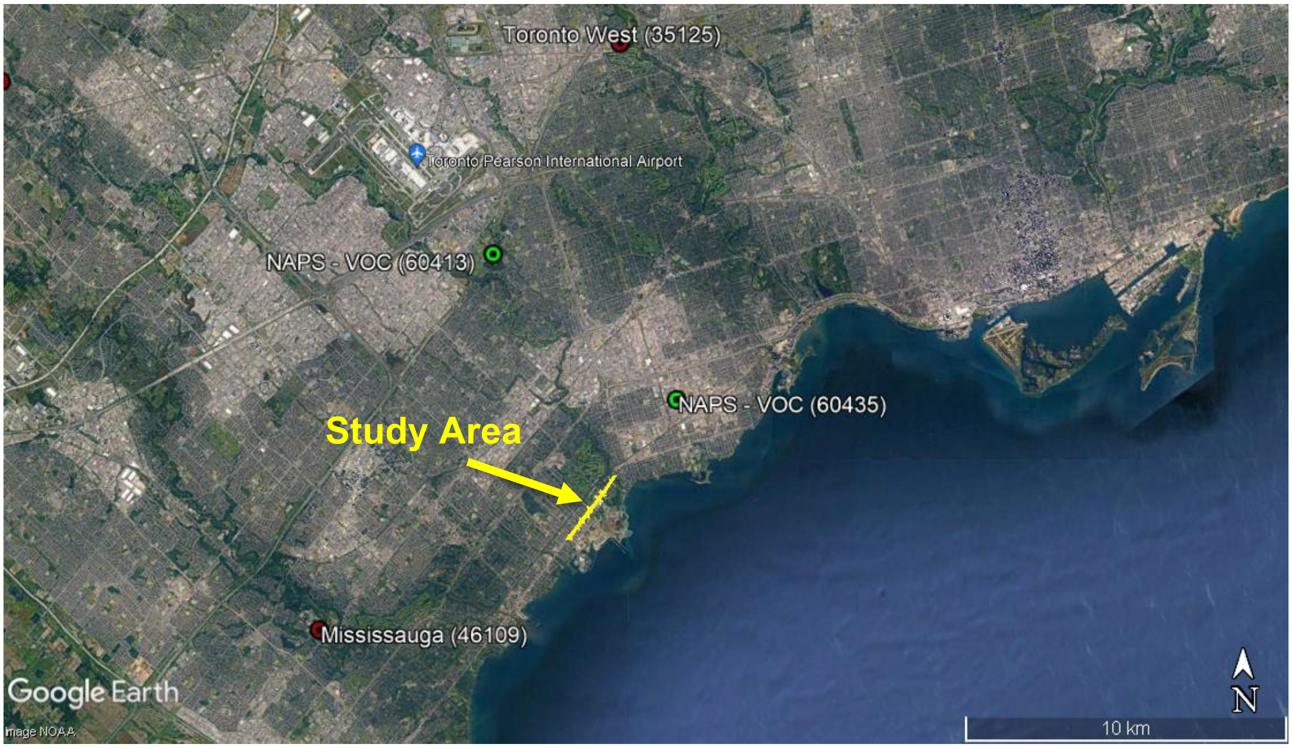



**Figure 5: Location of Ambient Monitoring Stations, Relevant to the Study Area**

**Table 3: Relevant MECP and NAPS Station Information**

| City/Town | Station ID | Location | Operator | Contaminant |
|---|---|---|---|---|
| Toronto West | 35125 | 125 Resources Rd | MECP | CO |
| Mississauga | 46109 | 3359 Mississauga Rd | MECP | $NO_2$\| $PM_{2.5}$ |
| Etobicoke West | 60413 | Elmcrest Road | NAPS | 1,3-Butadiene\|Benzene |
| Etobicoke South | 60435 | 461 Kipling Avenue | NAPS | 1,3-Butadiene\|Benzene |
| Windsor West | 60211 | College St/Prince St | NAPS | Formaldehyde \|Acetaldehyde \| Acrolein |

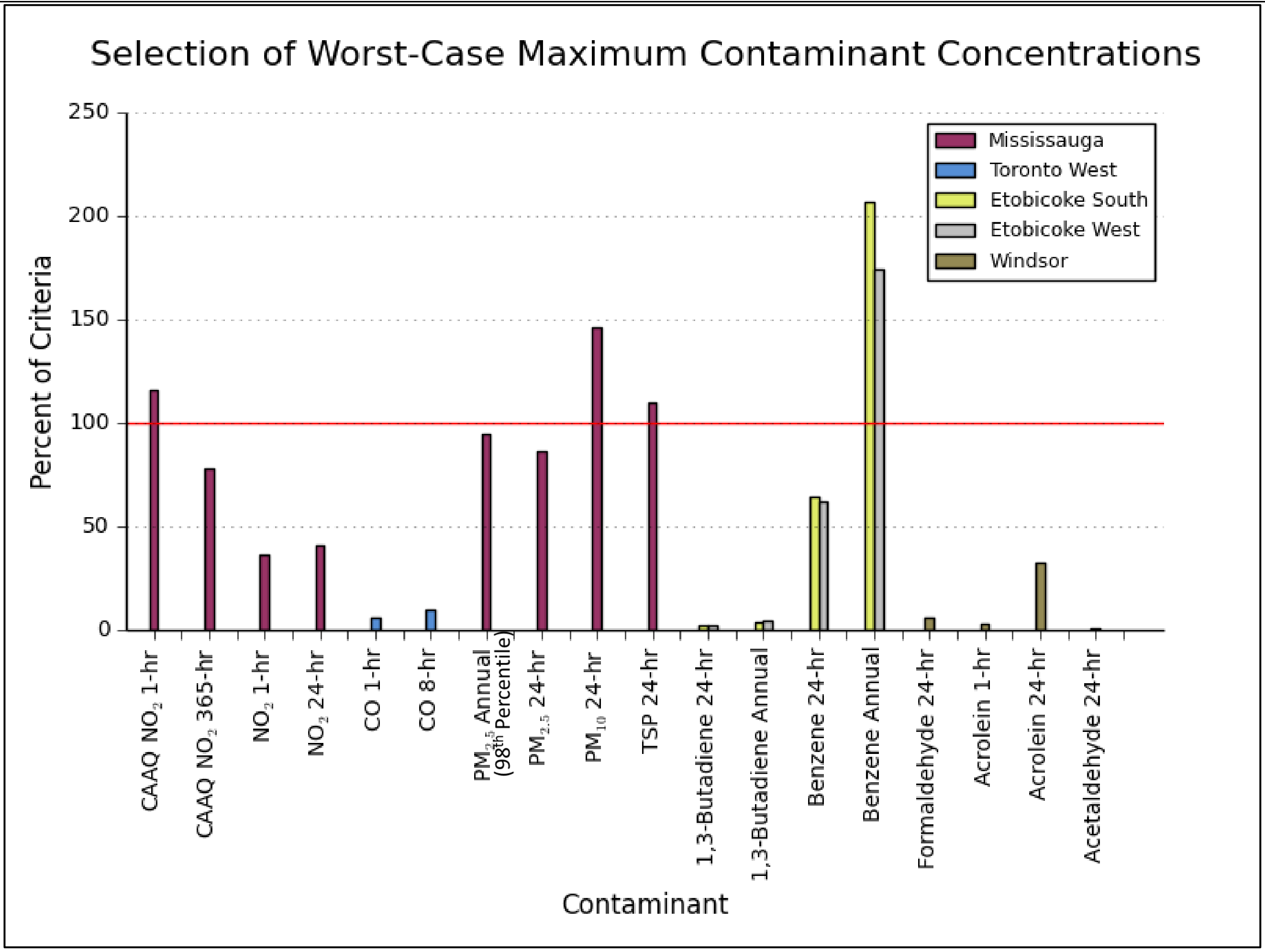
## 2.3 DETAILED ANALYSIS OF SELECTED WORST-CASE MONITORING STATIONS

Year 2013 to 2017 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 for the NAPS stations Volatile Organic Compounds (VOCs), formaldehyde, acetaldehyde and acrolein are only measured at the Windsor station and were not measured after 2010. Therefore 2006-2010 data was used for these VOCs. Five consecutive years of consistent ambient monitoring data is not available for benzo(a)pyrene and therefore background data has not been included in the cumulative analysis. Although background data was not directly used in the analysis for benzo(a)pyrene, a discussion of recorded data at the Toronto West station (Station ID 60438) is included in the presentation of results for this contaminant.

Note that $PM_{10}$ 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). 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 six days between measurements. When there was greater than six days between measurements, the $90^{th}$ percentile measured value for the year in question was applied for those days to determine combined concentrations. This method is conservative as it applies a concentration that is higher than 90% of the measured concentrations whenever data was not available.

Table 4 shows the selected monitoring station for the various contaminants considered in the assessment.

### Table 4: Selection of Background Monitoring Stations




Note: $PM_{10}$ and TSP are not measured in Ontario; therefore, background concentrations were estimated from $PM_{2.5}$ concentrations. Five consecutive years of consistent background data not available for benzo(a)pyrene.

| Contaminant | Worst-Case Station | Contaminant | Worst-Case Station |
|---|---|---|---|
| CAAQ $NO_2$ (1-Hr) | Mississauga | TSP | Mississauga |
| CAAQ $NO_2$ (ann) | Mississauga | 1,3-Butadiene (24-hr) | Etobicoke West |
| $NO_2$ (1-Hr) | Mississauga | 1,3-Butadiene (ann) | Etobicoke West |
| $NO_2$ (24-Hr) | Mississauga | Benzene (24-hr) | Etobicoke South |
| CO (1-Hr) | Toronto West | Benzene (ann) | Etobicoke South |
| CO (8-hr) | Toronto West | Formaldehyde | Windsor |
| $PM_{2.5}$ (24-hr) | Mississauga | Acrolein | Windsor |
| $PM_{2.5}$ (ann) | Mississauga | Acetaldehyde | Windsor |
| $PM_{10}$ | Mississauga | Benzo(a)pyrene | N/A |

A detailed statistical analysis of the selected worst-case background monitoring station for each of the contaminants was performed and is summarized in **Figure 6**. Presented is the average, 90th percentile, and maximum concentrations as a percentage of the guideline for each contaminant from the worst-case monitoring station determined above. Maximum ambient concentrations represent a single worst-case value. The 90th percentile concentration represents a reasonably worst-case background concentration, and the average concentration represents a typical background value. The 98th percentile concentration is shown for $PM_{2.5}$, as the guideline for $PM_{2.5}$ is based on 98th percentile concentrations.

Based on a review of ambient monitoring data from 2013-2017, background concentrations were generally below their respective guidelines. The exceptions are particulate matter and benzene, as well as the 1-hour and annual $NO_2$ CAAQS standards. In many cases the exceedances represent maximum concentrations and the $90^{th}$ percentile and/or average concentrations are below the guideline. It should be noted that $PM_{10}$ and TSP were calculated based on their relationship to $PM_{2.5}$. Background concentrations for benzo(a)pyrene were not included in the cumulative assessment but are discussed with the presentation of results.

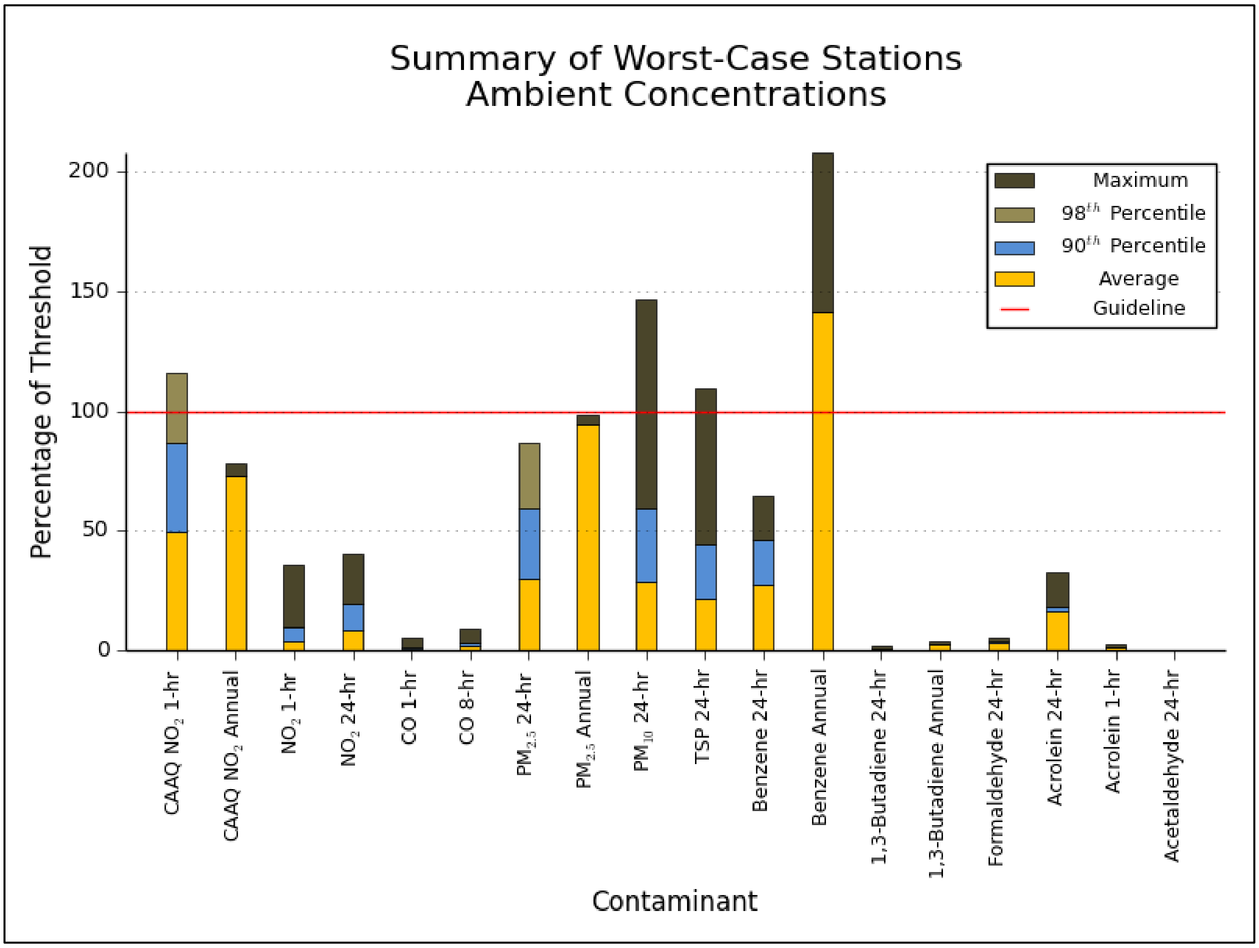



**Figure 6: Worst-Case Summary of Ambient Background Concentrations**

# 3. LOCAL AIR QUALITY ASSESSMENT

## 3.1 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.
- Childcare facilities.
- Educational facilities.
- Places of worship.
- Residential dwellings.

**Fifteen (15) sensitive receptor locations were selected to be representative of potential impacts within the study area. They are mostly residential houses around 50m north of Lakeshore Road, and thus the most likely impacted by the new BRT implementation shown in Figure 7**


Figure 7.

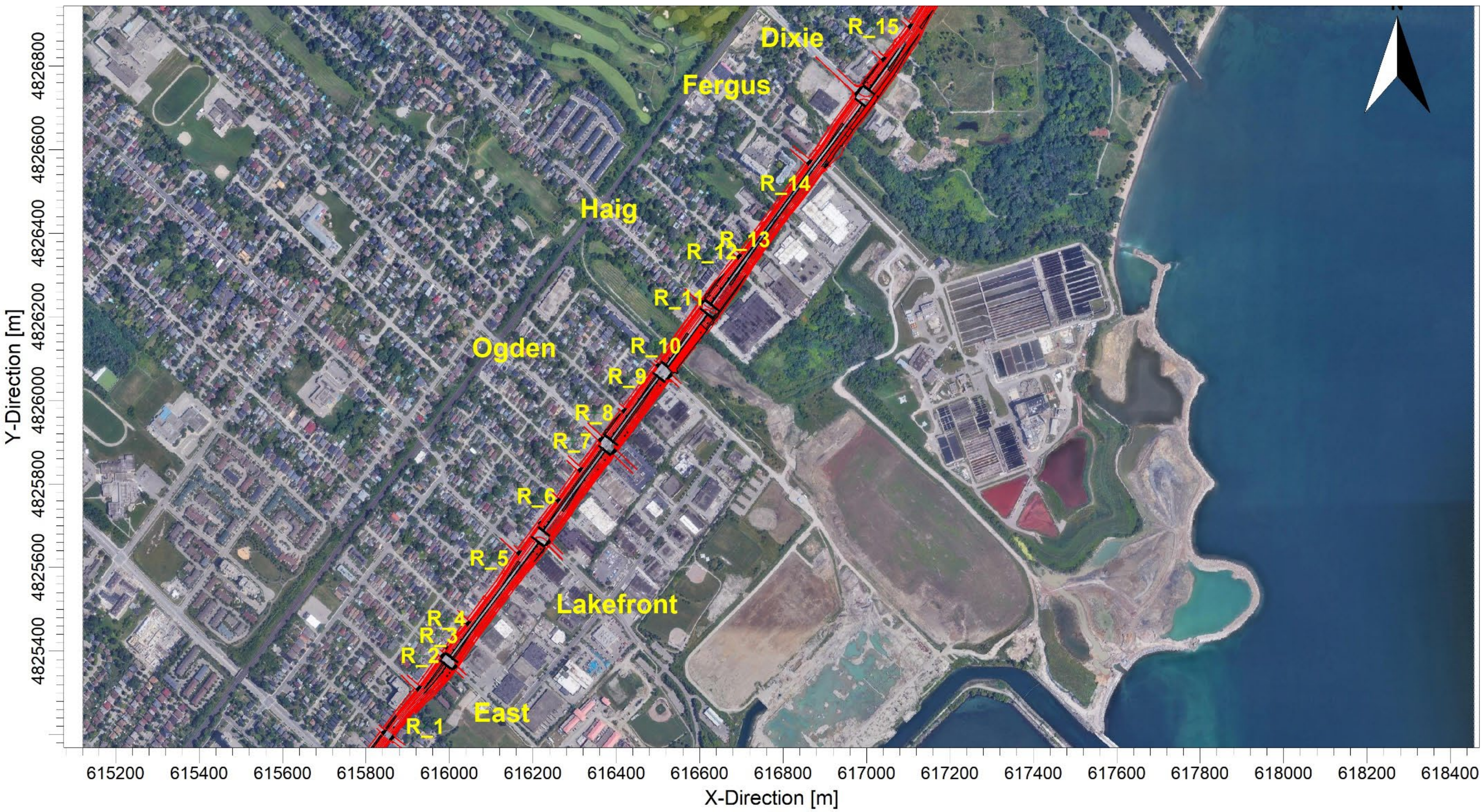



**Figure 7: Sensitive Receptor Locations**

## 3.2 ROAD TRAFFIC DATA

Traffic volumes for the 2021 No Build and 2041 Future Build scenarios for multiple roadways were provided by HDR Inc in the form of peak AM and PM traffic with percentage of commercial vehicles, day/night traffic split and the posted speeds. Red light timing for selected traffic intersection were incorporated as well. The Average Annual Daily Traffic (AADT) was derived using the average AM and PM Peak multiply by a factor of 10.42. The AADT volumes used in the assessment are shown in **Table 5** and **Table 6.**

**Table 5: 2021 Traffic Volumes (AADT – Vehicles/Day) Used in the Assessment**

| Roadway | Section | AADT | Day / Night Split [1] | Overall % Commercial Vehicles | Medium / Heavy Truck Split [2] | Posted or Used Speed (km/h) |
|---|---|---|---|---|---|---|
| Lakeshore Road East | West of East Ave. | 24643 | 90/10 | 4.72 | 2.36/2.36 | 50 |
| | East Ave. to Lakeshore Promenade | 23599 | 90/10 | 4.02 | 2.01/2.01 | 50 |
| | Lakefront Promenade to Ogden Avenue | 22643 | 90/10 | 3.97 | 1.98/1.98 | 50 |
| | Ogden Ave. to New Hydro Access Rd. | 21155 | 90/10 | 4.96 | 2.48/2.48 | 50 |
| | Haig Blvd. to Fergus Ave. | 22361 | 90/10 | 5.34 | 2.67/2.67 | 50 |
| | Fergus Ave. to Dixie Rd. | 23429 | 90/10 | 5.07 | 2.54/2.54 | 50 |
| | Dixie Rd. to 1515 Lakeshore Rd. East | 21551 | 90/10 | 5.05 | 2.53/2.53 | 50 |
| | 1515 Lakeshore Rd. East to 42/43 St. | 22150 | 90/10 | 4.82 | 2.41/2.41 | 50 |
| East Ave | North of Lakeshore Rd. East | 969 | 90/10 | 3.23 | 1.61/1.61 | 50 |
| | South of Lakeshore Rd. East | 2579 | 90/10 | 5.45 | 2.73/2.73 | 50 |
| Lakeshore Promenade | South of Lakeshore Rd. East | 1745 | 90/10 | 5.07 | 2.54/2.54 | 50 |
| Ogden Ave. | North of Lakeshore Rd. East | 3084 | 90/10 | 7.09 | 3.55/3.55 | 50 |
| | South of Lakeshore Rd. East | 281 | 90/10 | 20.37 | 10.19/10.19 | 50 |
| Haig Blvd. | North of Lakeshore Rd. East | 1990 | 90/10 | 19.11 | 9.55/9.55 | 50 |
| | South of Lakeshore Rd. East | 0 | 90/10 | 0.00 | 0/0 | 50 |

| Roadway | Section | AADT | Day / Night Split [1] | Overall % Commercial Vehicles | Medium / Heavy Truck Split [2] | Posted or Used Speed (km/h) |
|---|---|---|---|---|---|---|
| Fergus Ave. | North of Lakeshore Rd. East | 1292 | 90/10 | 8.87 | 4.44/4.44 | 50 |
| | South of Lakeshore Rd. East | 615 | 90/10 | 8.47 | 4.24/4.24 | 50 |
| Dixie Rd. | North of Lakeshore Rd. East | 9279 | 90/10 | 1.40 | 0.7/0.7 | 50 |
| | South of Lakeshore Rd. East | 94 | 90/10 | 11.11 | 5.56/5.56 | 50 |
| 1515 Lakeshore Rd. E. Condo | North of Lakeshore Rd. East | 1422 | 90/10 | 2.56 | 1.28/1.28 | 50 |

Notes: [1] XX / YY is percentage of vehicle traffic in the 16-hour daytime and 8-hour night-time periods, respectively.
[2] MM / HH is the percentage of medium trucks and heavy trucks used in the analysis, respectively.

## Table 6: 2041 Traffic Volumes (AADT – Vehicles/Day) Used in the Assessment

| Roadway | Section | AADT | Day / Night Split [1] | Overall % Commercial Vehicles | Medium / Heavy Truck Split [2] | Posted or Used Speed (km/h) |
|---|---|---|---|---|---|---|
| Lakeshore Road East | West of East Ave. | 39,492 | 90/10 | 3.52 | 1.76/1.76 | 50 |
| | East Ave. to Lakeshore Promenade | 37,944 | 90/10 | 3.34 | 1.67/1.67 | 50 |
| | Lakefront Promenade to Ogden Avenue | 33,838 | 90/10 | 3.78 | 1.89/1.89 | 50 |
| | Ogden Ave. to New Hydro Access Rd. | 34,538 | 90/10 | 4.41 | 2.21/2.21 | 50 |
| | New Hydro Access Rd. to Haig Blvd. | 32,226 | 90/10 | 4.46 | 2.23/2.23 | 50 |
| | Haig Blvd. to Fergus Ave. | 31,880 | 90/10 | 5.07 | 2.54/2.54 | 50 |
| | Fergus Ave. to Dixie Rd. | 31,340 | 90/10 | 5.07 | 2.54/2.54 | 50 |
| | Dixie Rd. to 1515 Lakeshore Rd. East | 26,176 | 90/10 | 5.71 | 2.86/2.86 | 50 |
| | 1515 Lakeshore Rd. East to 42/43 St. | 26,356 | 90/10 | 5.52 | 2.76/2.76 | 50 |
| East Ave | North of Lakeshore Rd. East | 970 | 90/10 | 5.38 | 2.69/2.69 | 50 |
| | South of Lakeshore Rd. East | 4,096 | 90/10 | 4.83 | 2.42/2.42 | 40 |

| Roadway | Section | AADT | Day / Night Split [1] | Overall % Commercial Vehicles | Medium / Heavy Truck Split [2] | Posted or Used Speed (km/h) |
|---|---|---|---|---|---|---|
| Lakeshore Promenade | South of Lakeshore Rd. East | 9,894 | 90/10 | 1.32 | 0.66/0.66 | 40 |
| Ogden Ave. | North of Lakeshore Rd. East | 7,440 | 90/10 | 4.06 | 2.03/2.03 | 50 |
| | South of Lakeshore Rd. East | 8,982 | 90/10 | 0.99 | 0.50/0.50 | 40 |
| New Hydro Access R. | North of Lakeshore Rd. East | 548 | 90/10 | 15.40 | 7.70/7.70 | 50 |
| | South of Lakeshore Rd. East | 9,820 | 90/10 | 0.00 | 0.00/0.00 | 40 |
| Haig Blvd. | North of Lakeshore Rd. East | 4,294 | 90/10 | 11.65 | 5.83/5.83 | 50 |
| | South of Lakeshore Rd. East | 6,564 | 90/10 | 0.00 | 0.00/0.00 | 40 |
| Fergus Ave. | North of Lakeshore Rd. East | 1,370 | 90/10 | 11.79 | 5.90/5.90 | 50 |
| | South of Lakeshore Rd. East | 614 | 90/10 | 11.86 | 5.93/5.93 | 40 |
| Dixie Rd. | North of Lakeshore Rd. East | 13,158 | 90/10 | 1.43 | 0.72/0.72 | 50 |
| | South of Lakeshore Rd. East | 94 | 90/10 | 22.22 | 11.11/11.11 | 40 |
| 1515 Lakeshore Rd. E. Condo | North of Lakeshore Rd. East | 1,422 | 90/10 | 4.40 | 2.20/2.20 | 50 |
| BRT | Entire Length on Lakeshore Rd. East | 272 | 90/10 | 100.00 | 100.00/0.00 | 50 |

Notes:
[1] XX / YY is percentage of vehicle traffic in the 16-hour daytime and 8-hour night-time periods, respectively.
[2] MM / HH is the percentage of medium trucks and heavy trucks used in the analysis, respectively.
* Medium trucks are Class 5 (2 Axle, 6 tire, Single Unit) to Class 10 (> 6 Axle, Single Trailer) based on FHWA vehicle classification
** Heavy trucks are Class 11 (< 6 Axle, Multi-trailer) to Class 10 (> 6 Axle Multi-trailer) based on FHWA vehicle classification

## 3.3 MEREOLOGICAL DATA

A five-year period (2013-2017) of hourly meteorological data was obtained from the Billy Bishop Toronto City Airport, while upper air data was obtained from Buffalo, New York, as recommended by the MECP for the study area. The combined data was processed to reflect conditions at the study area using the U.S. EPA's PCRAMMET software program which prepares meteorological data for use with the CAL3QHCR vehicle emission dispersion model. A wind frequency diagram (wind rose) is shown in **Figure 8**.

As can be seen in this figure, predominant winds are from the easterly and westerly directions.

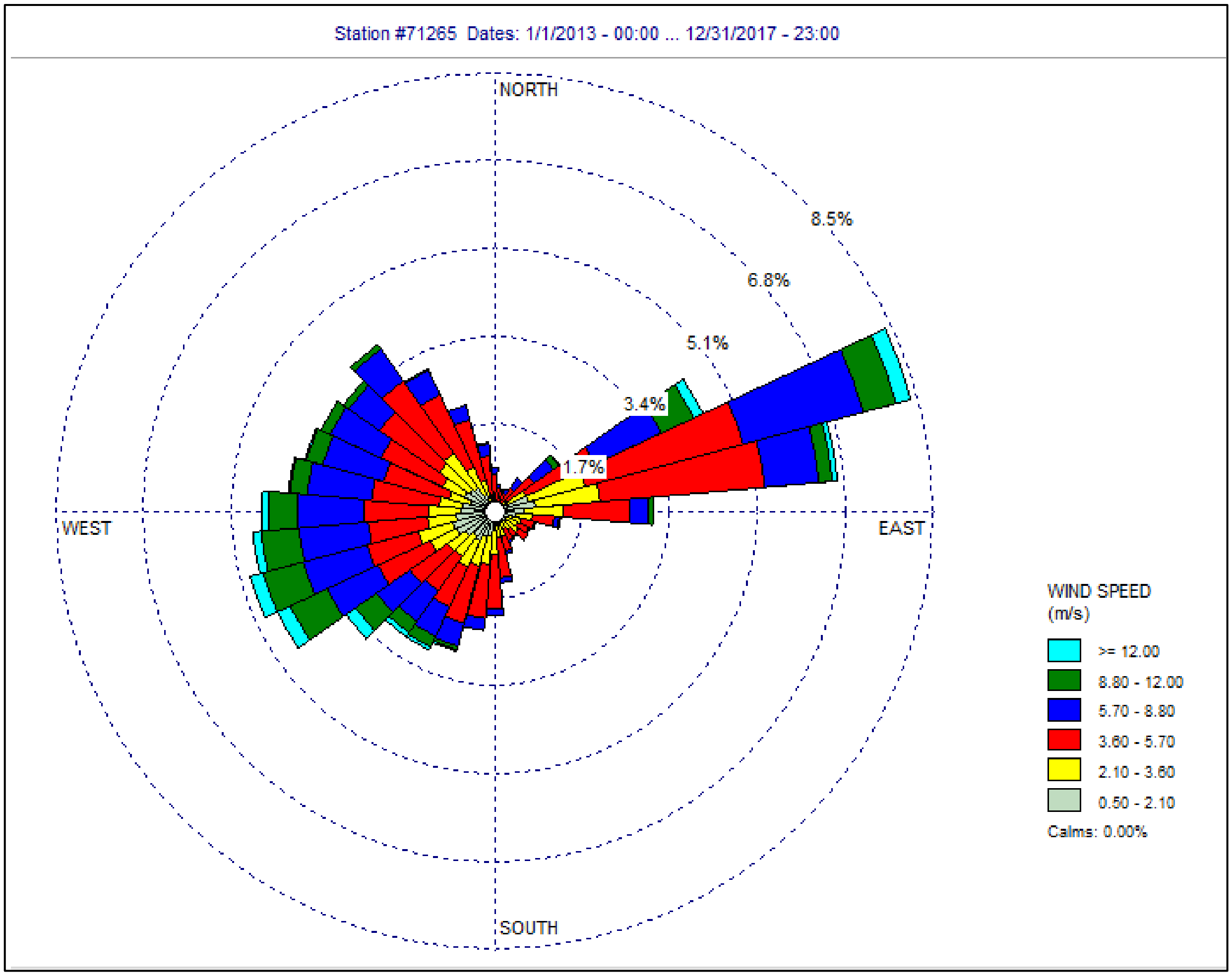



**Figure 8: Wind Frequency Diagram for Billy Bishop Toronto City Airport (2013-2017)**

## 3.4 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, vehicle fleet composition and speed. MOVES 2014b, released in December 2018, 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 outline above. Vehicle age was based on the U.S. EPA's default distribution. **Table 7** specifies the major inputs into MOVES. Do note by default, MOVES assumes there are no fully electric vehicles in the fleet as currently there isn't guidance or approved source on the present or projected fuel usage fraction for Ontario vehicles.

From the MOVES outputs, the highest monthly value for each contaminant was selected to represent a worst-case emission rate. The emission rates for each vehicle speed and contaminant modelled are shown in **Table 8** for the Existing and Future Build years, for a heavy/medium duty vehicle percentage of 2.5/2.5%, respectively. As shown in **Table 8**, emissions in the future year are generally predicted to decrease.

**Table 7: MOVES Input Parameters**

| Parameter | Input |
|---|---|
| Scale | Custom County Domain |
| Meteorology | Temperature and Relative Humidity were obtained from meteorological data from the Environment Canada Billy Bishop Toronto City Airport station for the years 2013 to 2017. |
| Years | 2021 and 2041 |
| 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 / Benzo(a)Pyrene / Equivalent $CO_2$<br>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. |

### Table 8: MOVES Output Emission Factors for Roadway Vehicles (g/VKT); Idle Emission Rates are grams per vehicle hour

| Year | Speed (Km/hr) | CO | $NO_X$ | Benzene | 1,3-Butadiene | Formaldehyde | Acetaldehyde | Acrolein | $PM_{2.5}$ | $PM_{10}$ | TSP[1] | Benzo(a)Pyrene |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2021 | 40 | 1.45 | 0.14 | 1.20E-03 | 5.35537E-05 | 8.58E-04 | 3.97E-04 | 4.7E-05 | 1.11E-02 | 5.28E-02 | 5.28E-02 | 1.80198E-06 |
| 2021 | 50 | 1.39 | 0.13 | 1.08E-03 | 4.67326E-05 | 7.56E-04 | 3.50E-04 | 4.14382E-05 | 9.38E-03 | 4.23E-02 | 4.21E-02 | 1.628E-06 |
| 2021 | Idle | 6.68 | 1.27 | 2.38E-02 | 2.02E-03 | 2.03E-02 | 1.06E-02 | 1.22E-03 | 1.00E-01 | 1.11E-01 | 1.11E-01 | 3.20E-05 |
| 2041 | 40 | 0.50 | 0.05 | 5.78E-04 | 1.25E-06 | 4.89E-04 | 1.77E-04 | 2.33E-05 | 8.51E-03 | 4.97E-02 | 5.00E-02 | 8.89E-07 |
| 2041 | 50 | 0.49 | 0.05 | 5.22E-04 | 1.07E-06 | 4.28E-04 | 1.56E-04 | 2.04E-05 | 7.08E-03 | 3.98E-02 | 3.96E-02 | 8.08E-07 |
| 2041 | Idle | 2.09 | 0.35 | 9.58E-03 | 2.23E-05 | 8.32E-03 | 2.98E-03 | 3.96E-04 | 3.32E-02 | 3.70E-02 | 3.70E-02 | 1.14E-05 |

[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.

## 3.5 RE-SUSPENDED PARTICULATE MATTER EMISSION RATES

A large portion of highway PM emissions comes from dust on the pavement which is re-suspended by vehicles travelling on the highway. 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 9**.

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

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

### Table 9: Re-suspended Particulate Matter Emission Factors

| Roadway AADT | K ($PM_{2.5}$/$PM_{10}$/TSP) | sL ($g/m^2$) | W (Tons) | E (g/VKT) | | |
|---|---|---|---|---|---|---|
| | | | | $PM_{2.5}$ | $PM_{10}$ | TSP |
| <500 | 0.25/1.0/5.24 | 0.6 | 3 | 0.31 | 1.25 | 6.56 |
| 500-5,000 | 0.25/1.0/5.24 | 0.2 | 3 | 0.11 | 0.46 | 2.41 |
| 5,000-10,000 | 0.25/1.0/5.24 | 0.06 | 3 | 0.04 | 0.15 | 0.81 |
| >10,000 | 0.25/1.0/5.24 | 0.03 | 3 | 0.02 | 0.08 | 0.43 |

## 3.6 AIR DISPERSION MODELLING USING CAL3QHCR

The U.S. EPA's CAL3QHCR dispersion model, based on the Gaussian plume equation, was specifically designed to predict air quality impacts from roadways using site specific meteorological data, vehicle emissions, traffic data, and signal data. The model input requirements include roadway geometry, sensitive receptor locations, meteorology, traffic volumes, and motor vehicle emission rates as well as some contaminant physical properties such as settling and deposition velocities. CAL3QHCR uses this information to calculate hourly concentrations which are then used to determine 1-hour, 8-hour, 24-hour, and annual averages for the contaminants of interest at the identified sensitive receptor locations. Table 10 provides the major inputs used in CAL3QHCR. The emission rates used in the model were the outputs from the MOVES and AP-42 models, weighted for the vehicle fleet distributions provided. The outputs of CAL3QHCR are presented in the results section.

**Table 10: CAL3QHCR Model Input Parameters**

| Parameter | Input |
|---|---|
| Free-Flow and Queue Link Traffic Data | Hourly traffic distributions were applied to the AADT traffic volumes in order to input traffic volumes in vehicles/hour.<br>Emission rates from the MOVES output were input in grams/VMT or grams per vehicle hour.<br>Signal timings for the traffic signal were input in seconds. |
| Meteorological Data | 2013-2017 data from Billy Bishop Toronto City Airport |
| Deposition Velocity | $PM_{2.5}$: 0.1 cm/s<br>$PM_{10}$: 0.5 cm/s<br>TSP: 0.15 cm/s<br>BaP, $NO_2$, CO and VOCs: 0 cm/s |
| Settling Velocity | $PM_{2.5}$: 0.02 cm/s<br>$PM_{10}$: 0.3 cm/s<br>TSP: 1.8 cm/s<br>BaP, CO, $NO_2$, and VOCs: 0 cm/s |
| Surface Roughness | The land type surrounding the project site is categorized as cultivated lands. Therefore, a surface roughness height of 72 cm was applied in the model. |
| Vehicle Emission Rate | Emission rates calculated in MOVES and AP-42 were input in g/VMT |

## 3.7 MODELLING RESULTS

Presented below on a contaminant-by-contaminant basis are the modelling results for the selected No Build (NB) and Future Build (FB) scenarios, based on 5-years of meteorological data. For each contaminant, combined concentrations are presented along with the relevant contribution due to the background and roadway. Results in this section are presented for the worst-case sensitive receptors for each contaminant, averaging period, and modelling scenario (see Table 11). Results for all modelled receptors can be provided upon request. It should be noted that the maximum combined concentration at any sensitive receptor often occurs infrequently and may only occur for one hour or day over the five-year period.

**Table 11: Worst-Case Sensitive Receptors for Each Scenario**

| Contaminant | Averaging Period | Sensitive Receptor | |
|---|---|---|---|
| | | 2021 NB | 2041 FB |
| CAAQ $NO_2$ | 1-hour | 14 | 7 |
| | Annual | 13 | 13 |
| $NO_2$ | 1-hour | 13 | 14 |
| | 24-hour | 13 | 14 |
| CO | 1-hour | 13 | 14 |
| | 8-hour | 13 | 14 |
| $PM_{2.5}$ | 24-hour | 13 | 8 |
| | Annual | 13 | 8 |
| $PM_{10}$ | 24-hour | 13 | 13 |
| TSP | 24-hour | 13 | 14 |
| 1,3-Butadiene | 24-hour | 3 | 2 |
| | Annual | 2 | 2 |
| Formaldehyde | 24-hour | 2 | 3 |
| Benzene | 24-hour | 3 | 2 |
| | Annual | 13 | 13 |
| Acrolein | 1-hour | 2 | 2 |
| | 24-hour | 2 | 2 |
| Acetaldehyde | 24-hour | 3 | 13 |
| Benzo(a)Pyrene | 24-hour | 3 | 3 |
| | Annual | 13 | 13 |

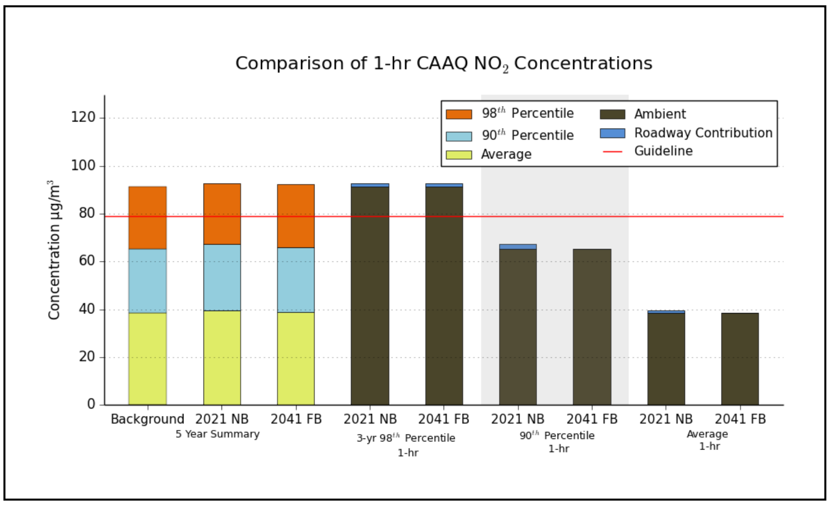
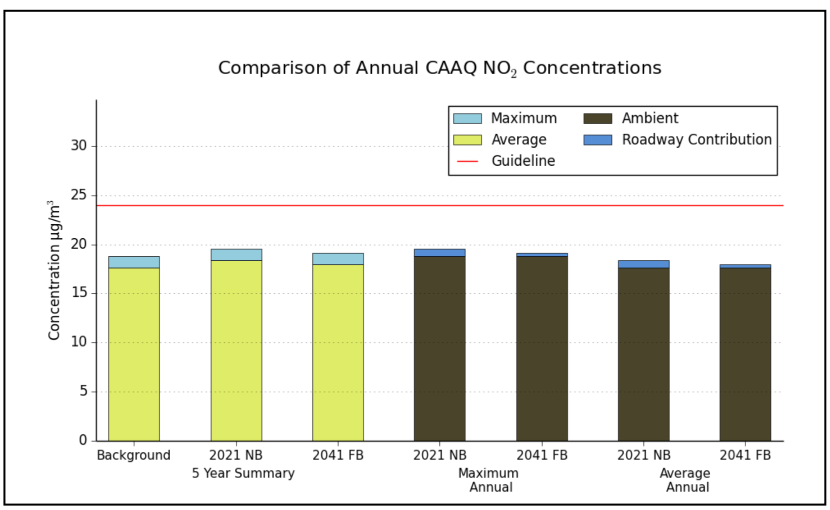
Coincidental hourly modelled roadway and background concentrations were added to derive the combined concentration for each hour over the 5-year period. Hourly combined concentrations were then used to determine contaminant concentrations based on the applicable averaging period. Statistical analysis in the form of maximum, 90th percentile, and average combined concentrations were calculated for the worst-case sensitive receptor for each contaminant and are presented below. The maximum combined concentration (or 3-year average annual 98$^{th}$ percentile concentration in the case of $PM_{2.5}$) was used to assess compliance with MECP guidelines or CAAQS. If excesses of the guideline were predicted, frequency analysis was undertaken to estimate the number of occurrences above the guideline. Predicted concentrations for benzo(a)pyrene did not include background concentrations; however, a discussion of recorded values at Toronto West station (Station ID 60438) is provided in the presentation of results for this contaminant. Below are the modelling results for the contaminants of interest. In addition to the "Statistical Analysis" presentation of results for all modelled scenarios, a supplemental breakdown of results for the "2041 FB" scenario is also provided.

### 3.7.1 NITROGEN DIOXIDE CAAQS

Table 12 presents the predicted combined concentrations for the worst-case sensitive receptor for 1-hour and annual $NO_2$ based on five years of meteorological data. The results conclude that:

- *The annual 98th percentile of daily maximum 1-hour $NO_2$ concentrations, averaged over three consecutive years exceeds the CAAQS for all modelled scenarios.*
- *The annual average concentrations are below the guideline for all modelled scenarios.*

**Table 12: Summary of Predicted CAAQ $NO_2$ Concentrations**

<table>
<tr><th>Statistical Analysis</th><th colspan="2">2041 FB</th></tr>
<tr><td rowspan="9">
</td><td colspan="2">% of CAAQS Guideline:</td></tr>
<tr><td>98th Percentile</td><td>117%</td></tr>
<tr><td>90th Percentile</td><td>82%</td></tr>
<tr><td>Average</td><td>49%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>98th Percentile</td><td>4%</td></tr>
<tr><td>90th Percentile</td><td>1%</td></tr>
<tr><td>Average</td><td>1%</td></tr>
<tr><td colspan="2">Maximum combined concentrations exceed the 1-hour CAAQ Guideline for all modelled scenarios. Note that the maximum background concentrations alone exceed the CAAQ's 1-hr objective of 79 µg/m³. Also note that this objective is based on the 3-year average of the annual 98th percentile of the NO2 daily-maximum 1-hour average concentrations.</td></tr>
<tr><td rowspan="8">
</td><td colspan="2">% of CAAQs Guideline:</td></tr>
<tr><td>Maximum</td><td>80%</td></tr>
<tr><td>Average</td><td>75%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>2%</td></tr>
<tr><td>Average</td><td>2%</td></tr>
<tr><td colspan="2">Maximum combined concentrations are below the annual CAAQ Guideline for all modelled scenarios.</td></tr>
</table>

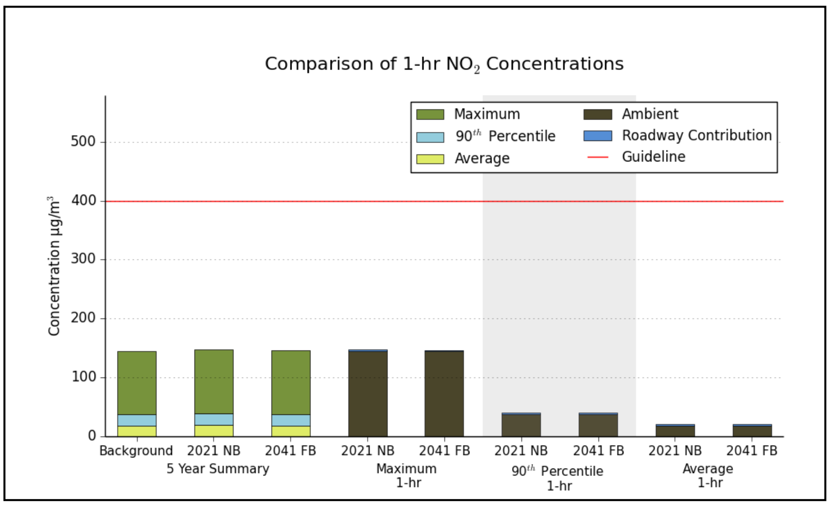
### 3.7.2 NITROGEN DIOXIDE

Table 13 presents the predicted combined concentrations for the worst-case sensitive receptor for 1-hour and 24-hour $NO_2$ based on five years of meteorological data. The results conclude that:

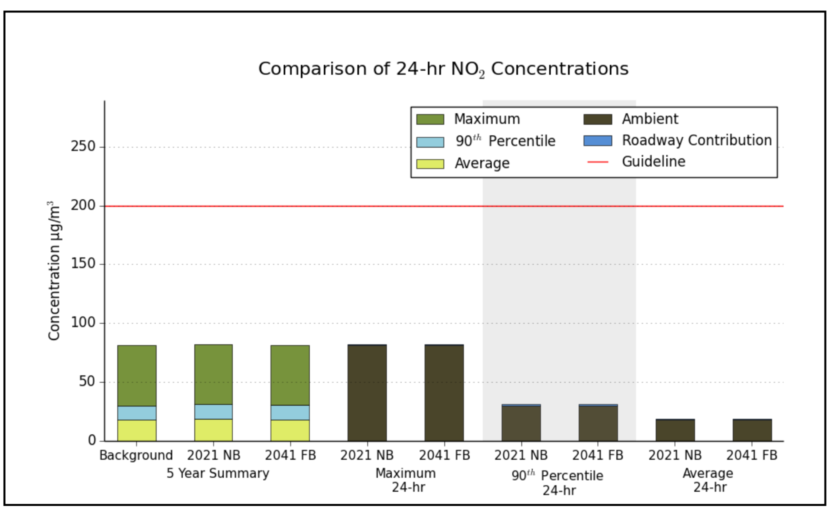
- *Both the maximum 1-hour and 24-hour $NO_2$ combined concentrations were below their respective MECP guidelines for all modelled scenarios.*

**Table 13: Summary of Predicted $NO_2$ Concentrations**

| Statistical Analysis | 2041 FB |
|---|---|




| % of MECP Guideline: | |
|---|---|
| Maximum | 36% |
| 90th Percentile | 9% |
| Average | 4% |
| **Roadway Contribution:** | |
| Maximum | 1% |
| 90th Percentile | 2% |
| Average | 2% |




| % of MECP Guideline: | |
|---|---|
| Maximum | 41% |
| 90th Percentile | 15% |
| Average | 9% |
| **Roadway Contribution:** | |
| Maximum | 1% |
| 90th Percentile | 1% |
| Average | 2% |

**Conclusions:**

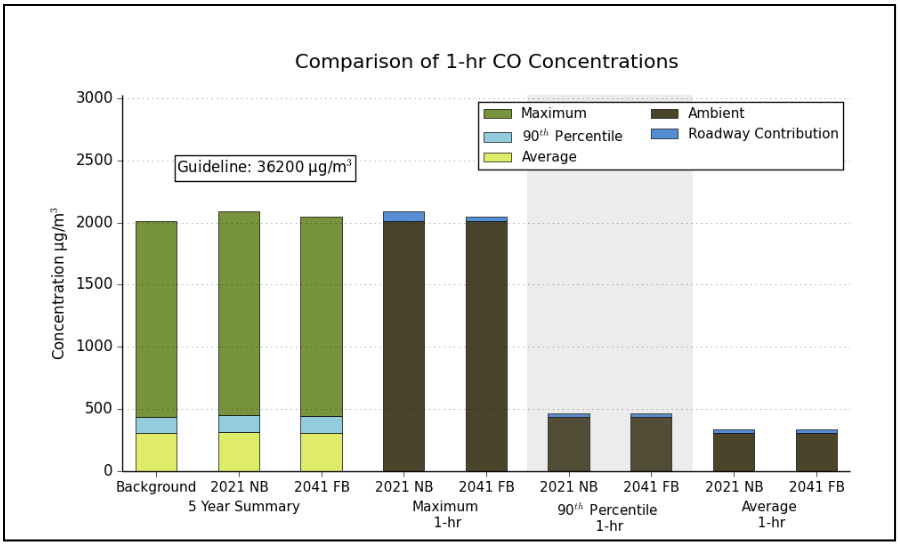
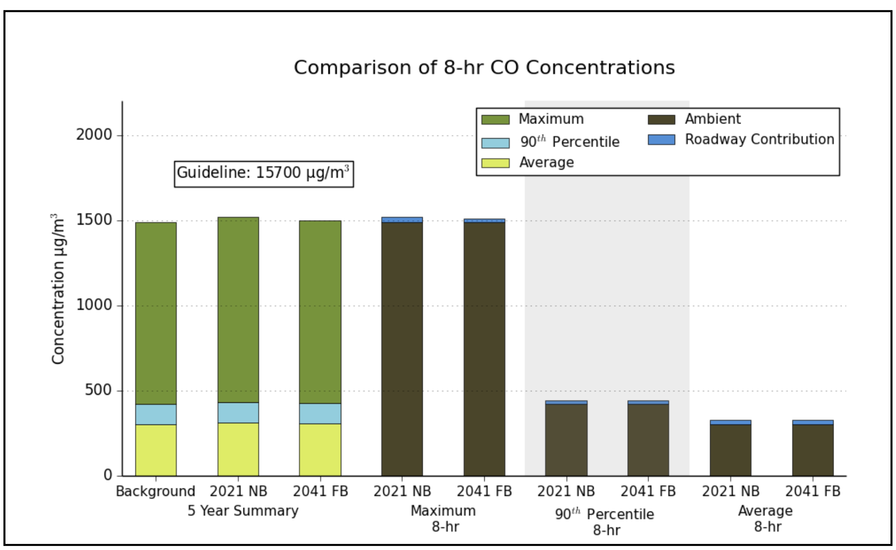
- All combined concentrations were below their respective MECP guidelines for all modelled scenarios.

### 3.7.3 CARBON MONOXIDE

**Table 14** presents the predicted combined concentrations for the worst-case sensitive receptor for 1-hour and 8-hour CO based on five years of meteorological data. The results conclude that:

- *Both the maximum 1-hour and 8-hour CO combined concentrations were well below their respective MECP guidelines for all modelled scenarios.*

**Table 14: Summary of Predicted CO Concentrations**

| Statistical Analysis | 2041 FB | |
|---|---|---|
|  | **% of MECP Guideline:** | |
| | Maximum | 6% |
| | $90^{th}$ Percentile | 1% |
| | Average | 1% |
| | **Roadway Contribution:** | |
| | Maximum | 2% |
| | $90^{th}$ Percentile | 1% |
| | Average | 1% |
|  | **% of MECP Guideline:** | |
| | Maximum | 10% |
| | $90^{th}$ Percentile | 2% |
| | Average | 2% |
| | **Roadway Contribution:** | |
| | Maximum | 2% |
| | 90th Percentile | 1% |
| | Average | 1% |





**Conclusions:**

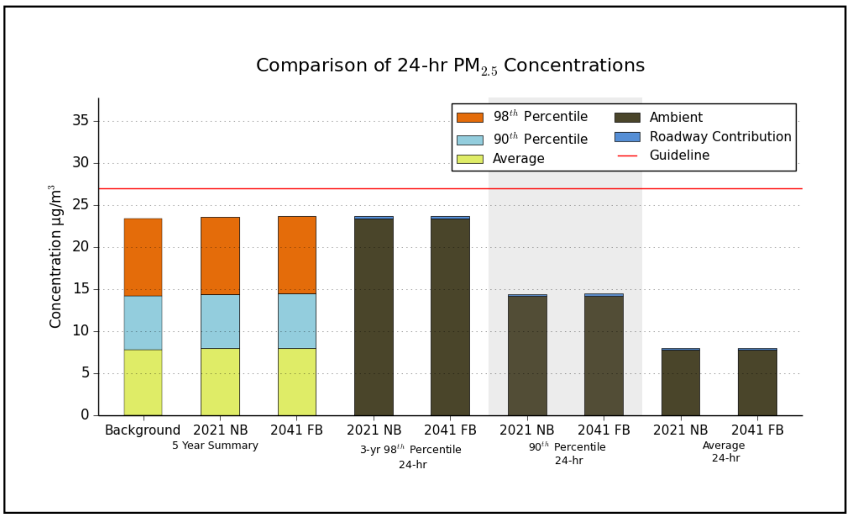
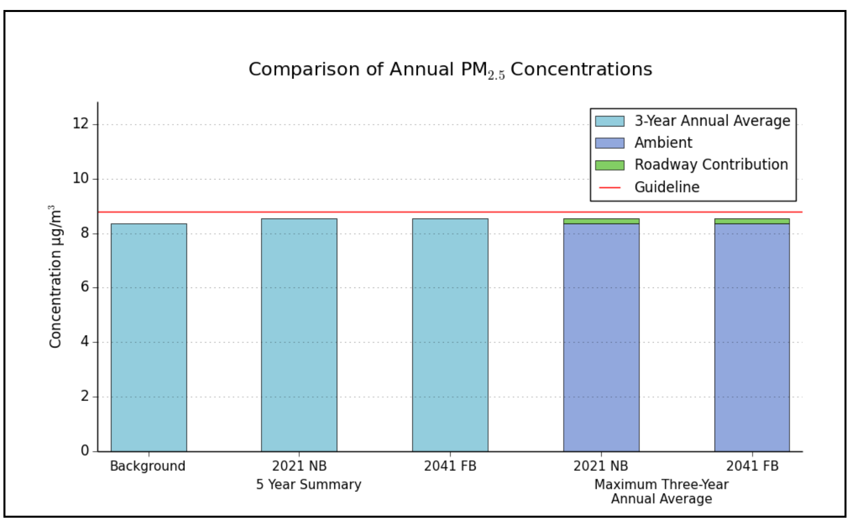
- All combined concentrations were below their respective MECP guidelines for all modelled scenarios.

### 3.7.4 FINE PARTICULATE MATTER ($PM_{2.5}$)

**Table 15** presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour and annual $PM_{2.5}$ based on five years of meteorological data. The results conclude that:

- *The average annual $98^{th}$ percentile 24-hour $PM_{2.5}$ combined concentrations, averaged over three consecutive years were below the CAAQS for all modelled scenarios.*
- *The three-year annual average concentrations were below the guideline for all modelled scenarios.*

**Table 15: Summary of Predicted $PM_{2.5}$ Concentrations**

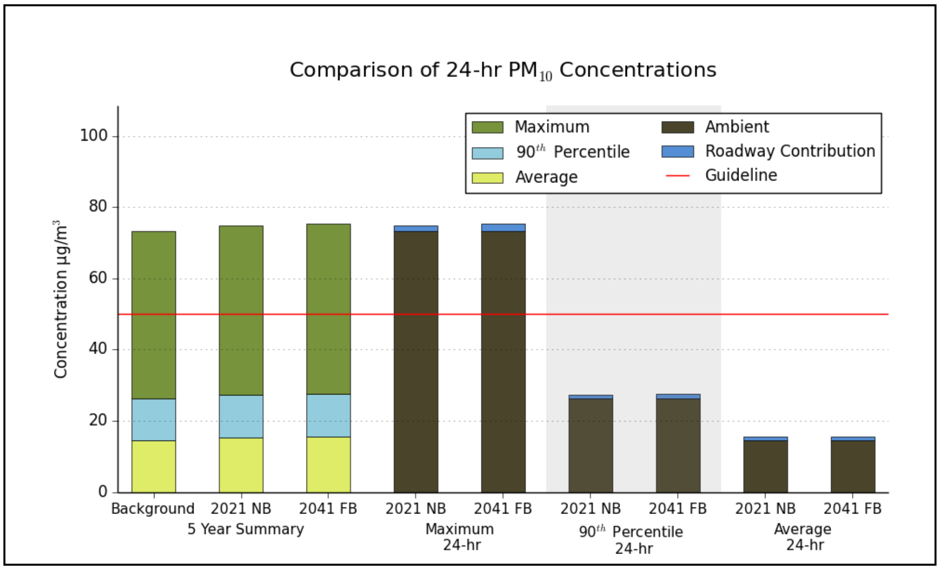
<table>
<tr><th>Statistical Analysis</th><th colspan="2">2041 FB</th></tr>
<tr><td rowspan="9">
</td><td colspan="2">% of CAAQs Guideline:</td></tr>
<tr><td>$98^{th}$ Percentile</td><td>88%</td></tr>
<tr><td>$90^{th}$ Percentile</td><td>53%</td></tr>
<tr><td>Average</td><td>30%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>$98^{th}$ Percentile</td><td>2%</td></tr>
<tr><td>$90^{th}$ Percentile</td><td>2%</td></tr>
<tr><td>Average</td><td>3%</td></tr>
<tr><td colspan="2">The $PM_{2.5}$ results were below the 3-year CAAQS for all modelled scenarios. For the 2041 FB scenario, the highest 3 year rolling average of the yearly $98^{th}$ percentile combined concentrations was calculated to be 22.69 µg/m$^3$ or 88% of the CAAQS.</td></tr>
<tr><td rowspan="5">
</td><td colspan="2">% of CAAQs Guideline:</td></tr>
<tr><td>Maximum 3-Year Annual Average</td><td>97%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum 3-Year Annual Average</td><td>2%</td></tr>
<tr><td colspan="2">The $PM_{2.5}$ results were below the 3-year CAAQS for all modelled scenarios.<br>For the 2041 FB scenario, the maximum 3-year annual average concentration was 8.5 µg/m$^3$ or 97% of the guideline.</td></tr>
</table>

### 3.7.5 COARSE PARTICULATE MATTER ($PM_{10}$)

Table 16 presents the predicted combined concentration for the worst-case sensitive receptor for 24-hour $PM_{10}$ based on five years of meteorological data. The results conclude that:

- *The maximum 24-hr $PM_{10}$ combined concentrations exceeded the MECP guideline for all modelled scenarios.*

**Table 16: Summary of Predicted $PM_{10}$ Concentrations**

| Statistical Analysis | 2041 FB | |
|---|---|---|
|  | % of MECP Guideline: | |
| | Maximum | 151% |
| | 90th Percentile | 55% |
| | Average | 31% |
| | Roadway Contribution: | |
| | Maximum | 3% |
| | 90th Percentile | 7% |
| | Average | 7% |



**Conclusions:**

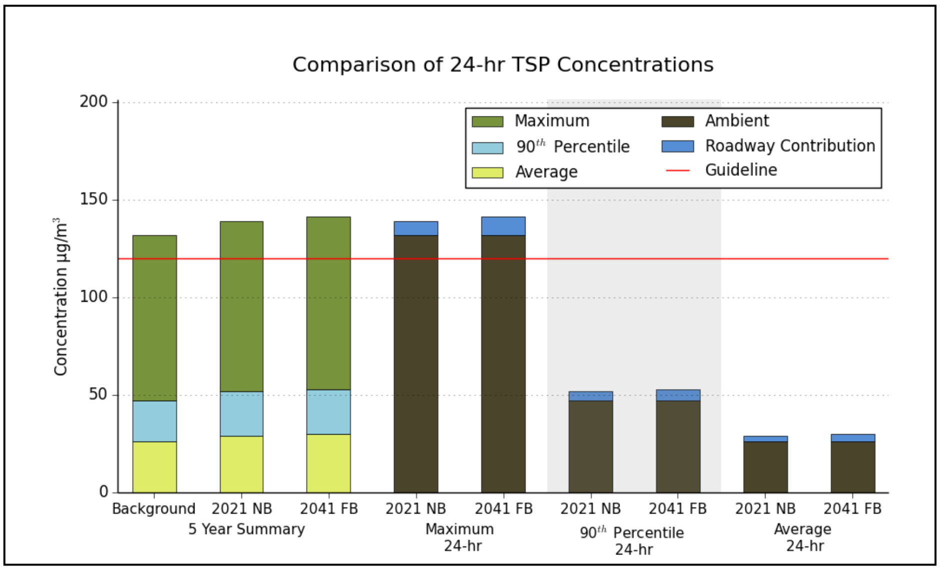
- The maximum combined concentrations of $PM_{10}$ were found to exceed the guideline of 50 µg/m$^3$. It should be noted, however, that background concentrations alone exceed the standard and that the roadway contribution is 3% of the maximum value (for the 2041 FB scenario).
- Frequency analysis was conducted to determine the frequency of exceedances over the 5-year period.
- A total of 11 days exceeded the guideline in the five-year period, for each of the modelled scenarios, which equates to less than 1% of the time.

### 3.7.6 TOTAL SUSPENDED PARTICULATE MATTER (TSP)

Table 17 presents the predicted combined concentration for the worst-case sensitive receptor for 24-hour TSP based on five years of meteorological data. The results conclude that:

- *The maximum 24-hr TSP combined concentrations exceed the MECP guideline for all modelled scenarios.*

**Table 17: Summary of Predicted TSP Concentrations**

| Statistical Analysis | 2041 FB | |
|---|---|---|
|  | **% of MECP Guideline:** | |
| | Maximum | 118% |
| | 90th Percentile | 44% |
| | Average | 24% |
| | **Roadway Contribution:** | |
| | Maximum | 7% |
| | 90th Percentile | 15% |
| | Average | 14% |

**Conclusions:**

- The TSP results show that the combined concentrations exceed the guideline for all modelled scenarios. It should be noted, however, that background concentrations alone account for 111% of the standard, and that the roadway contribution is 7% of the maximum value (for the 2041 FB scenario).
- Frequency analysis was conducted to determine the frequency of exceedances over the 5-year period.
- A total of 2 days exceeded the guideline in the five-year period, for each of the modelled scenarios, which equates to less than 1% of the time.

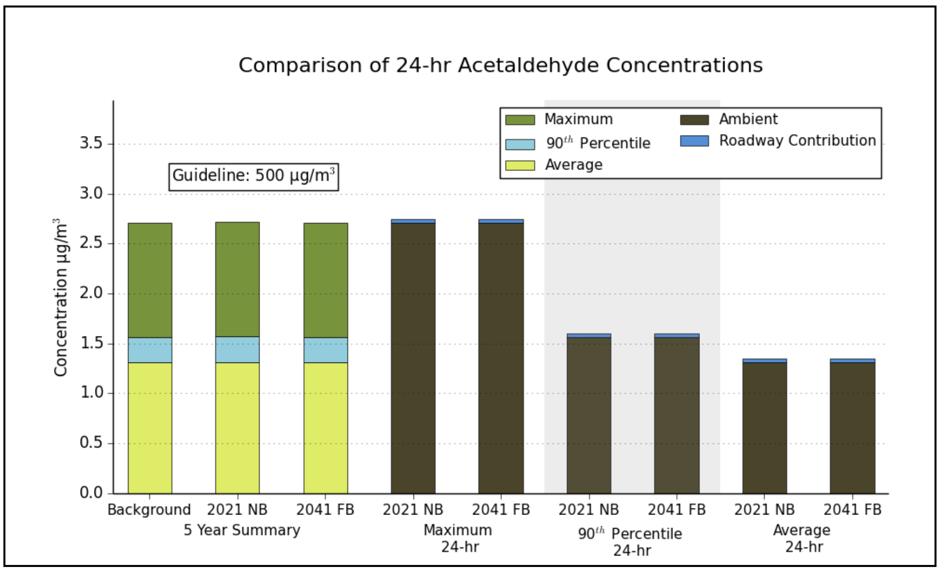
Ambient VOC concentrations are typically measured every 6 days in Ontario. In order to combine the ambient data to the modelled results, the measured concentrations were applied to the following 6 days when measurements were 6 days apart. When measurements were further than 6 days apart, the 90th percentile annual value was used to represent the missing data. This background data was added to the predicted hourly roadway concentrations at each receptor to obtain results for the VOCs.

### 3.7.7 ACETALDEHYDE

Table 18 presents the predicted combined concentration for the worst-case sensitive receptor for 24-hour acetaldehyde based on five years of meteorological data. The results conclude that:

- *The maximum 24-hour acetaldehyde combined concentrations were well below the respective MECP guideline for all modelled scenarios.*

**Table 18: Summary of Predicted Acetaldehyde Concentrations**

<table>
<tr><th>Statistical Analysis</th><th colspan="2">2041 FB</th></tr>
<tr><td rowspan="9">
</td><td colspan="2">% of MECP Guideline:</td></tr>
<tr><td>Maximum</td><td><1%</td></tr>
<tr><td>90th Percentile</td><td><1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td><1%</td></tr>
<tr><td>90th Percentile</td><td><1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td colspan="2"></td></tr>
</table>

**Conclusions:**

- All combined concentrations were below the respective MECP guideline for all modelled scenarios.

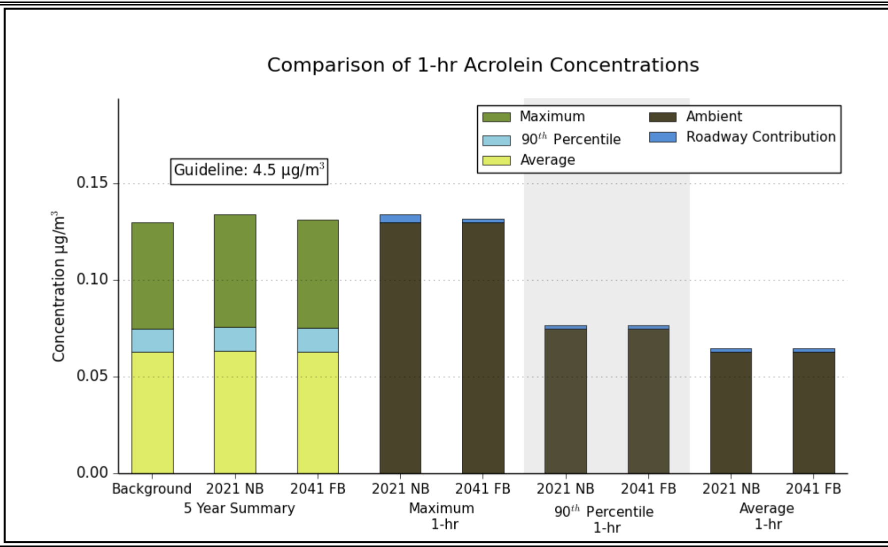
### 3.7.8 ACROLEIN

Table 19 presents the predicted combined concentrations for the worst-case sensitive receptor for 1-hour and 24-hour acrolein based on five years of meteorological data. The results conclude that:

- *The maximum 1-hour and 24-hour acrolein combined concentrations were below the respective MECP guidelines for all modelled scenarios.*

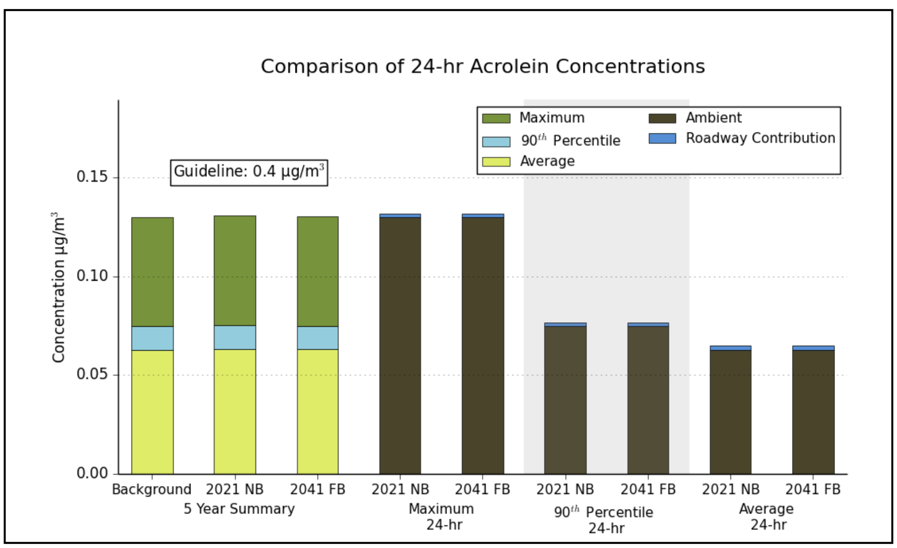
**Table 19: Summary of Predicted Acrolein Concentrations**

| Statistical Analysis | 2041 FB | |
|---|---|---|




| % of MECP Guideline: | |
|---|---|
| Maximum | 3% |
| 90th Percentile | 2% |
| Average | 1% |
| **Roadway Contribution:** | |
| Maximum | <1% |
| 90th Percentile | <1% |
| Average | 1% |

The combined concentrations were below the respective MECP 1-hr guideline for all modelled scenarios.




| % of MECP Guideline: | |
|---|---|
| Maximum | 33% |
| 90th Percentile | 19% |
| Average | 16% |
| **Roadway Contribution** | |
| Maximum | 1% |
| 90th Percentile | 1% |
| Average | 1% |

The combined concentrations were below the respective MECP 24-hr guideline for all modelled scenarios.

**Conclusions:**

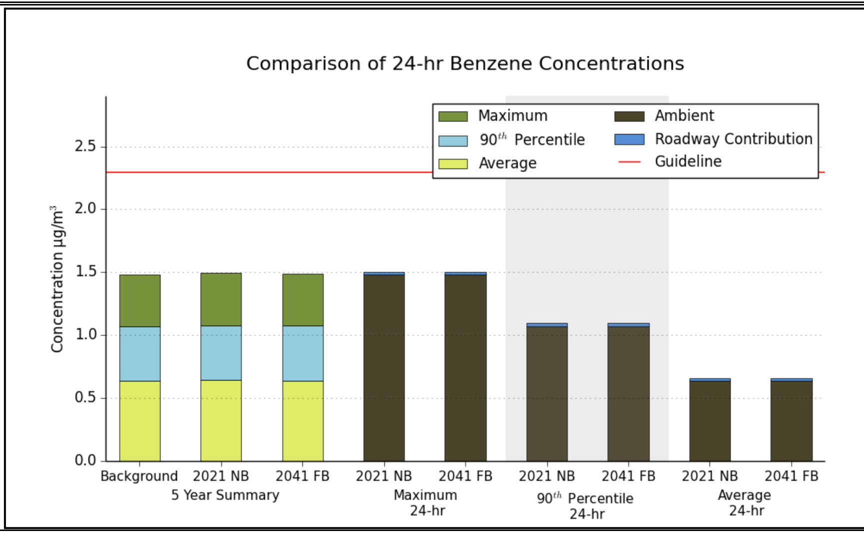
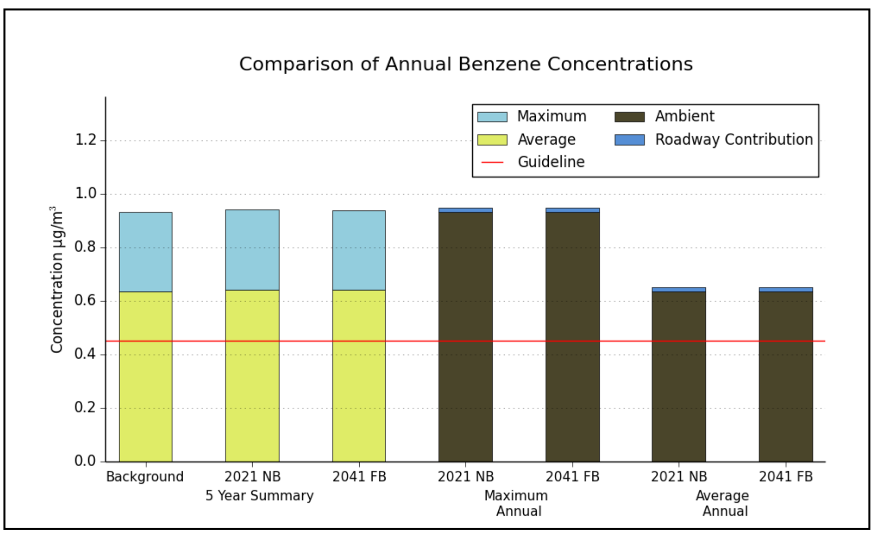
- All combined concentrations were below the respective MECP guidelines for all modelled scenarios.

### 3.7.9 BENZENE

Table 20 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour and annual benzene based on five years of meteorological data. The results conclude that:

- *The maximum 24-hour benzene combined concentrations were below the respective MECP guideline for all modelled scenarios.*
- *The annual benzene concentrations exceeded the guideline for all modelled scenarios.*

**Table 20: Summary of Predicted Benzene Concentrations**

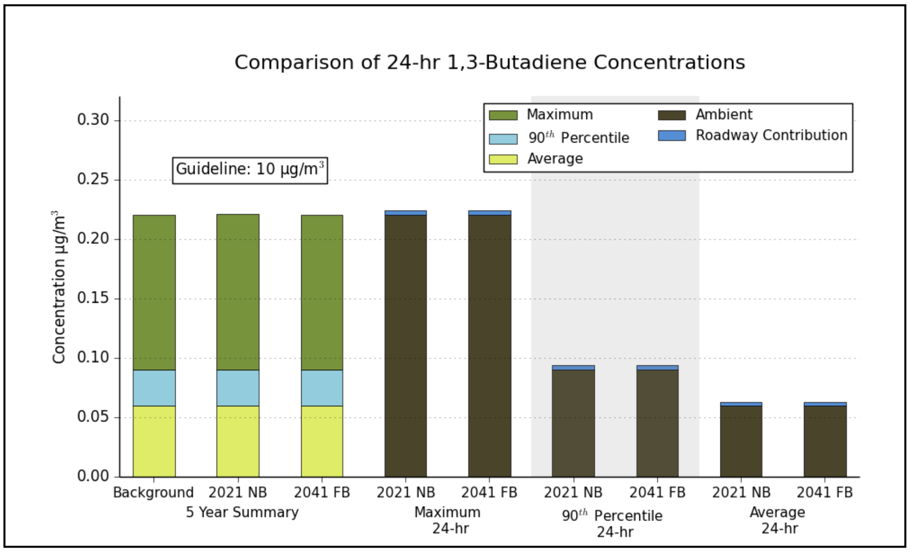
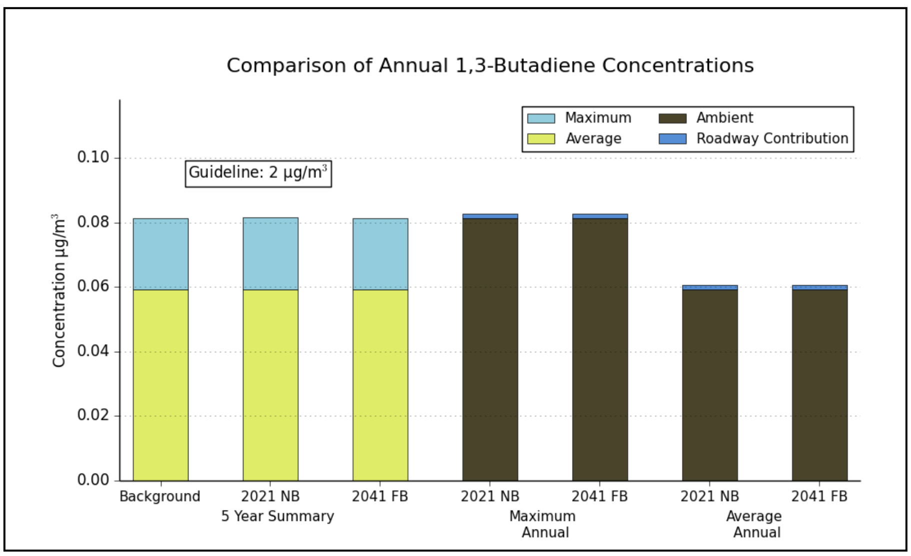
<table>
<tr><th>Statistical Analysis</th><th colspan="2">2041 FB</th></tr>
<tr><td rowspan="9">
</td><td colspan="2">% of MECP Guideline:</td></tr>
<tr><td>Maximum</td><td>65%</td></tr>
<tr><td>90th Percentile</td><td>47%</td></tr>
<tr><td>Average</td><td>28%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>1%</td></tr>
<tr><td>90th Percentile</td><td>1%</td></tr>
<tr><td>Average</td><td>1%</td></tr>
<tr><td colspan="2">Conclusions:<br>The combined concentrations were below the MECP 24-hr guideline for all modelled scenarios.</td></tr>
<tr><td rowspan="7">
</td><td colspan="2">% of MECP Guideline:</td></tr>
<tr><td>Maximum</td><td>208%</td></tr>
<tr><td>Average</td><td>142%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>1%</td></tr>
<tr><td>Average</td><td>1%</td></tr>
<tr><td colspan="2">Conclusions:<br>The combined concentrations exceeded the MECP annual guideline for all modelled scenarios. It should be noted that ambient concentrations were 200+% of the guideline and the roadway contribution to the maximum was 1% (for the 2041 FB scenario).</td></tr>
</table>

### 3.7.10 1,3-BUTADIENE

Table 21 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour and annual 1,3-butadiene based on five years of meteorological data. The results conclude that:

- *The maximum 24-hour and annual 1,3-butadiene combined concentrations were well below the respective MECP guidelines for all modelled scenarios.*

**Table 21: Summary of Predicted 1,3-Butadiene Concentrations**

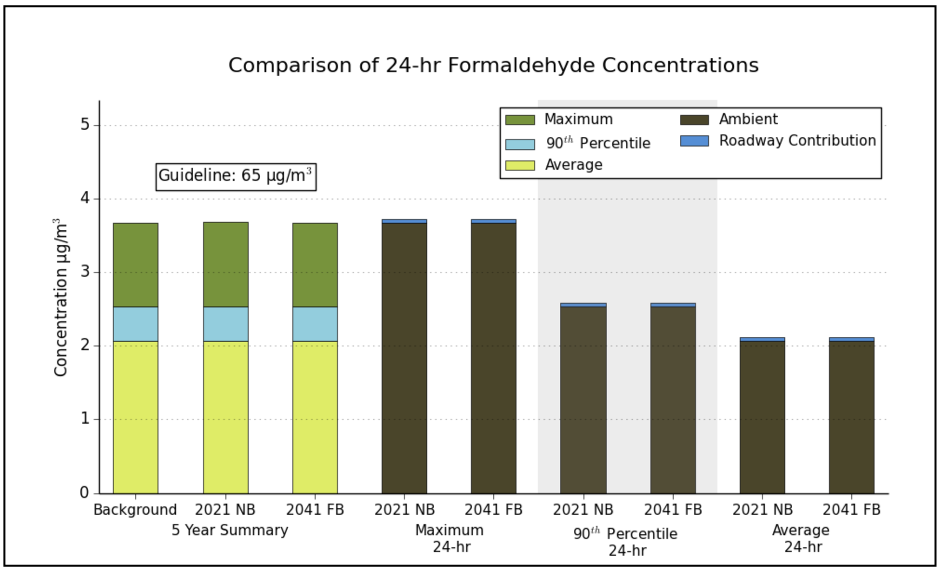
| Statistical Analysis | 2041 FB | |
|---|---|---|
|  | **% of MECP Guideline:** | |
| | Maximum | 2% |
| | 90th Percentile | <1% |
| | Average | <1% |
| | **Roadway Contribution:** | |
| | Maximum | <1% |
| | 90th Percentile | <1% |
| | Average | <1% |
| | Conclusions: The combined concentrations were below the respective MECP 24-hr guideline for all modelled scenarios. | |
|  | **% of MECP Guideline:** | |
| | Maximum | 4% |
| | Average | 3% |
| | **Roadway Contribution:** | |
| | Maximum | <1% |
| | Average | <1% |
| | Conclusions: The combined concentrations were below the respective MECP annual guideline for all modelled scenarios. | |

### 3.7.11 FORMALDEHYDE

Table 22 presents the predicted combined concentration for the worst-case sensitive receptor for 24-hour formaldehyde based on 5 years of meteorological data. The results conclude that:

- *The maximum 24-hour formaldehyde combined concentrations were below the respective MECP guideline for all modelled scenarios.*

**Table 22: Summary of Predicted Formaldehyde Concentrations**

| Statistical Analysis | 2041 FB | |
|---|---|---|
|  | **% of MECP Guideline:** | |
| | Maximum | 6% |
| | 90th Percentile | 4% |
| | Average | 3% |
| | **Roadway Contribution:** | |
| | Maximum | <1% |
| | 90th Percentile | <1% |
| | Average | <1% |



**Conclusions:**

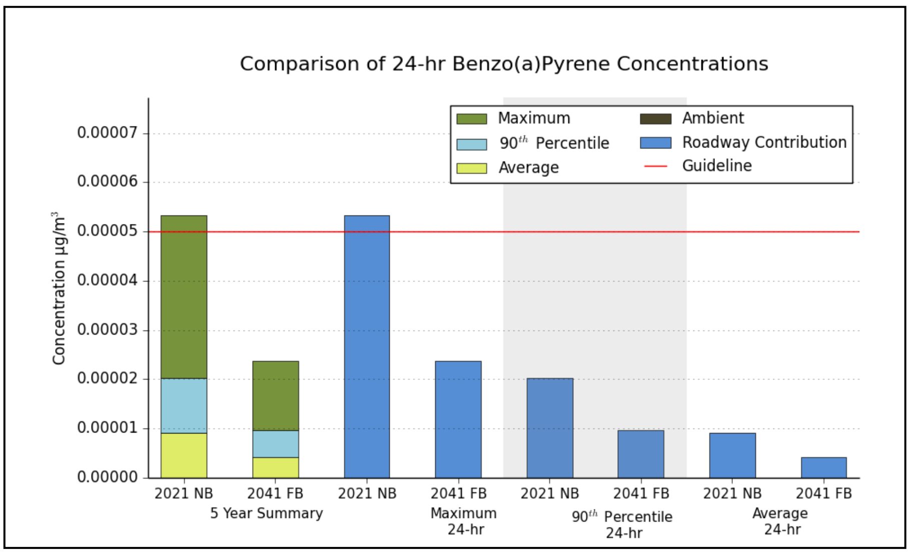
- All combined concentrations were below the respective MECP guideline for all modelled scenarios.

### 3.7.12 BENZO(A)PYRENE

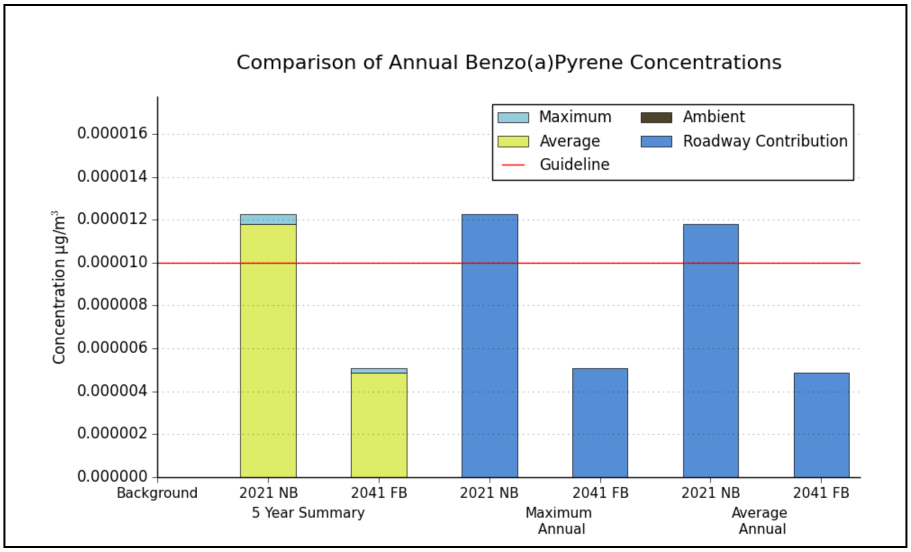
Table 23: Summary of Predicted Benzo(a)Pyrene Concentrations presents the predicted concentrations for the worst-case sensitive receptor for 24-hour and annual Benzo(a)pyrene based on five years of meteorological data. It is important to note that background concentrations are not included in the predicted concentrations. The results conclude that:

- *Excluding background concentrations, the maximum 24-hour and annual Benzo(a)Pyrene roadway concentrations were above the respective MECP guidelines for the 2021 NB scenario and were below the guidelines for the 2041 FB scenario. Background concentrations recorded at Toronto West station (2019, Station ID 60438) are well above the respective guidelines.*

**Table 23: Summary of Predicted Benzo(a)Pyrene Concentrations**




| Statistical Analysis | 2041 FB | |
|---|---|---|
| (chart above) | **% of MECP Guideline:** | |
| | Maximum | 48% |
| | 90th Percentile | 19% |
| | Average | 8% |
| | **2019 Background Concentrations as % of MECP Guideline** | |
| | Maximum | 329% |
| | 90th Percentile | 220% |
| | Average | 132% |
| | Conclusions: The maximum roadway concentrations were above the respective MECP 24-hr guideline for the 2021 NB modelled scenario and were below for the 2041 FB scenario. The maximum 2019 background concentration at Toronto West station was 0.00016 µg/m3 or 329% of the guideline. | |
| | **% of MECP Guideline:** | |
| | Maximum | 51% |
| | Average | 49% |
| | **2019 Background Concentrations as % of MECP Guideline** | |
| | Annual Average | 662% |

| Statistical Analysis | 2041 FB |
| --- | --- |
|  | **Conclusions:**<br>The maximum roadway concentrations were above the respective MECP annual guideline for the 2021 NB scenario but below the guidelines for the 2041 FB scenario. The 2019 annual average background concentration at Toronto West station was 0.00007 µg/m3 or 662% of the guideline. |



# GREENHOUSE GAS ASSESSMENT

In addition to the contaminants of interest assessed in the local air quality assessment, greenhouse gas (GHG) emissions were predicted from the project. Potential impacts were assessed by calculating the relative change in total emissions between the 2021 No Build and 2041 Future Build scenarios as well the total emission to the 2030 provincial and Canada-wide GHG targets. Total GHG emissions from the roadway were determined based on the length of the roadway, traffic volumes, and predicted emission rates.

From a GHG perspective, the contaminants of concern from motor vehicle emissions are carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($N_2O$). These GHGs can be further classified according to their Global Warming Potential. The Global Warming Potential is a multiplier developed for each GHG, which allows comparison of the ability of each GHG to trap heat in the atmosphere, relative to carbon dioxide. Using these multipliers, total GHG emissions can be classified as $CO_2$ equivalent emissions. For this assessment, the MOVES model was used to determine total $CO_2$ equivalent emission rates for the posted speed and heavy-duty vehicle percentage in the study area. **Table 24** summarizes key parameters for determining total GHG emissions from the project.

**Table 24: Summary of Road Traffic Volumes and Roadway Length**

| Roadways | Section | Two-Way AADT | | Length of Roadway (KMs) | | Medium/Heavy Duty Vehicle Percentage (%) | | $CO_2$ Equivalent Emission (tonnes) | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| | | 2021 | 2041 | 2021 | 2041 | 2021 | 2041 | 2021 | 2041 |
| Lakeshore Road East | West of East Ave. | 24643 | 39,492 | 0.10 | 0.10 | 2.36/2.36 | 1.76/1.76 | 218 | 250 |
| | East Ave. to Lakeshore Promenade | 23599 | 37,944 | 0.37 | 0.37 | 2.01/2.01 | 1.67/1.67 | 771 | 888 |
| | Lakefront Promenade to Ogden Avenue | 22643 | 33,838 | 0.27 | 0.27 | 1.98/1.98 | 1.89/1.89 | 540 | 578 |

| Roadways | Section | Two-Way AADT | | Length of Roadway (KMs) | | Medium/Heavy Duty Vehicle Percentage (%) | | $CO_2$ Equivalent Emission (tonnes) | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2021 | 2041 | 2021 | 2041 | 2021 | 2041 | 2021 | 2041 |
| | Ogden Ave. to New Hydro Access Rd. | 21155 | 34,538 | 0.22 | 0.22 | 2.48/2.48 | 2.21/2.21 | 411 | 480 |
| | New Hydro Access Rd. to Haig Blvd. | | 32,226 | 0.19 | 0.19 | | 2.23/2.23 | 347 | 379 |
| | Haig Blvd. to Fergus Ave. | 22361 | 31,880 | 0.43 | 0.43 | 2.67/2.67 | 2.54/2.54 | 843 | 861 |
| | Fergus Ave. to Dixie Rd. | 23429 | 31,340 | 0.20 | 0.20 | 2.54/2.54 | 2.54/2.54 | 414 | 396 |
| | Dixie Rd. to 1515 Lakeshore Rd. East | 21551 | 26,176 | 0.49 | 0.49 | 2.53/2.53 | 2.86/2.86 | 933 | 811 |
| | 1515 Lakeshore Rd. East to 42/43 St. | 22150 | 26,356 | 0.24 | 0.24 | 2.41/2.41 | 2.76/2.76 | 464 | 395 |
| East Ave | North of Lakeshore Rd. East | 969 | 970 | 0.10 | 0.10 | 1.61/1.61 | 2.69/2.69 | 9 | 6 |
| | South of Lakeshore Rd. East | 2579 | 4,096 | 0.10 | 0.10 | 2.73/2.73 | 2.42/2.42 | 23 | 28 |
| Lakefront Promenade | South of Lakeshore Rd. East | 1745 | 9,894 | 0.10 | 0.10 | 2.54/2.54 | 0.66/0.66 | 15 | 63 |
| Ogden Ave. | North of Lakeshore Rd. East | 3084 | 7,440 | 0.10 | 0.10 | 3.55/3.55 | 2.03/2.03 | 31 | 52 |
| | South of Lakeshore Rd. East | 281 | 8,982 | 0.10 | 0.10 | 10.19/10.19 | 0.50/0.50 | 3 | 52 |
| New Hydro Access R. | North of Lakeshore Rd. East | N/A | 548 | N/A | 0.10 | N/A | 7.70/7.70 | N/A | 0 |
| | South of Lakeshore Rd. East | N/A | 9,820 | N/A | 0.10 | N/A | 0.00/0.00 | N/A | 56 |
| Haig Blvd. | North of Lakeshore Rd. East | 1990 | 4,294 | 0.10 | 0.10 | 9.55/9.55 | 5.83/5.83 | 24 | 32 |
| | South of Lakeshore Rd. East | 0 | 6,564 | 0.10 | 0.10 | 0.00/0.00 | 0.00/0.00 | 0 | 38 |
| Fergus Ave. | North of Lakeshore Rd. East | 1292 | 1,370 | 0.10 | 0.10 | 4.44/4.44 | 5.90/5.90 | 13 | 10 |
| | South of Lakeshore Rd. East | 615 | 614 | 0.10 | 0.10 | 4.24/4.24 | 5.93/5.93 | 5 | 5 |
| Dixie Rd. | North of Lakeshore Rd. East | 9279 | 13,158 | 0.10 | 0.10 | 0.72/0.72 | 0.72/0.72 | 93 | 83 |
| | South of Lakeshore Rd. East | 94 | 94 | 0.10 | 0.10 | 5.56/5.56 | 11.11/11.11 | 1 | 1 |
| 1515 Lakeshore Rd. E. Condo | North of Lakeshore Rd. East | 1422 | 1,422 | 0.10 | 0.10 | 1.28/1.28 | 2.20/2.20 | 13 | 9 |
| BRT | Entire Length on Lakeshore Rd. East | N/A | 272 | 0.10 | 0.10 | N/A | 100.00/0.00 | 0 | 29 |

The total predicted annual GHG emissions are shown in **Table 25**. Also shown is the percent change in total GHG emissions from the 2021 NB scenario. The change is the culmination of increased traffic volume on existing roadways, change in vehicle composition, and reduced emission per vehicle km travelled, as well as additional vehicles on new roadways.

**Table 25: Changes in Predicted GHG Emissions**

| Roadway | $CO_2$ Equivalent Emission (tonnes) | | Incremental Increase/Decrease (tonnes) | Changes in Emission from 2021 (%) |
|---|---|---|---|---|
| | 2021 | 2041 | | |
| Total | 5,170 | 5,500 | 330 | 6% |

Table 26 shows the incremental change in GHG equivalent emissions as percentages of various targets.

**Table 26: Incremental Change of GHG Equivalent Emissions Compare to Targets**

| | $CO_2$ Equivalent |
|---|---|
| Incremental Change | 330 tonnes |
| Comparison to Canada-wide Target | 0.00006% |
| Comparison to Ontario-wide Target | 0.0003% |
| Comparison to Transportation Target | 0.0002% |
| **Canada-Wide 2030 GHG Target[1]** | **517,000,000 tonnes** |
| **Ontario-Wide 2030 GHG Target[2]** | **102,350,000 tonnes** |
| **Transportation Sector GHG 2030 Target[3]** | **164,000,000 tonnes** |

# 4. AIR QUALITY IMPACTS DURING CONSTRUCTION

During construction of the roadway, dust is the primary contaminant of concern. Other contaminants including $NO_x$ and VOC's may be emitted from equipment used during construction activities. Due to the temporary nature of construction activities, there are no air quality criteria specific to construction activities. However, the Environment Canada "Best Practices for the Reduction of Air Emissions from Construction and Demolition Activities" document provides several mitigation measures for reducing emissions during construction activities. Mitigation techniques discussed in the document include material wetting or use of non-chloride dust suppressants to reduce dust, use of wind barriers and limiting exposed areas which may be a source of dust, and equipment washing. It is recommended that these best management practices be followed during construction of the roadway to reduce any air quality impacts that may occur.

[1] Environment and Climate Change Canada (2018) Canadian Environmental Sustainability Indicators: Progress towards Canada's greenhouse gas emissions reduction target. Available at: www.canada.ca/en/environment-climate-change/services/environmentalindicators/progress-towards-canada-greenhouse-gas-emissions-reduction-target.html.

[2] Ontario Climate Change Strategy. Available at: https://www.ontario.ca/page/climate-change-strategy

[3] CANADA'S SECOND BIENNIAL REPORT ON CLIMATE CHANGE. Available at https://www.canada.ca/en/environment-climate-change/services/climate-change/greenhouse-gas-emissions/second-biennial-report.html

# 5. CONCLUSIONS

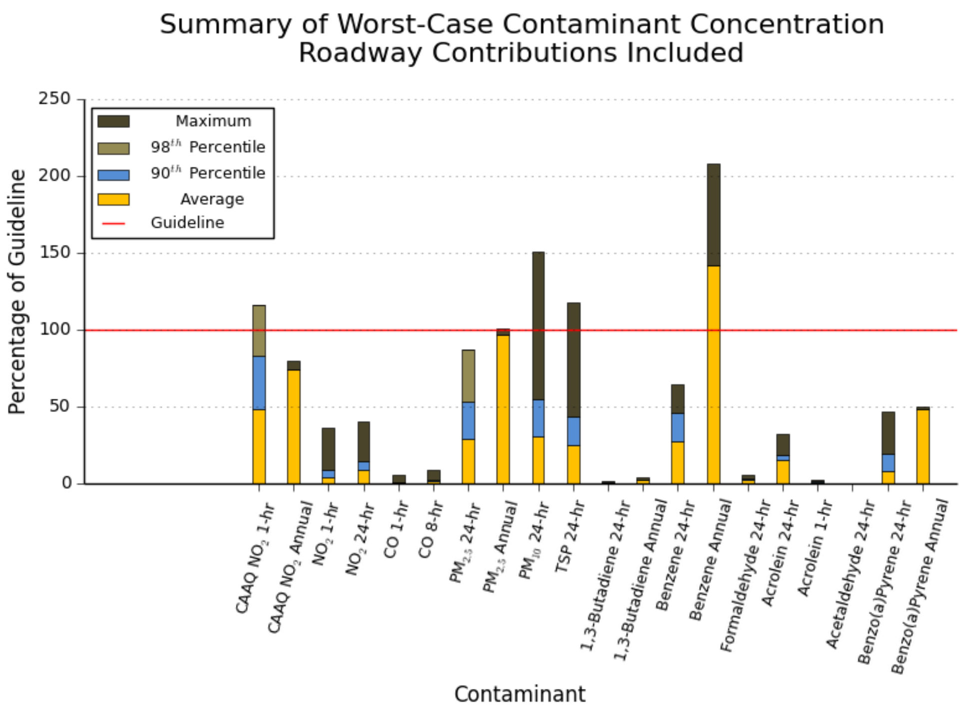
Presented in **Table 27** is a summary of the worst-case modelling results for the 2041 Future Build scenario based on 5-years of meteorological data. For each contaminant, combined concentrations are presented as a percentage of the applicable guideline.

The maximum combined concentrations for the 2041 Future Build were all below their respective MECP guidelines or CAAQS, except for the 1-hr $NO_2$ CAAQ, 24-hr $PM_{10}$, 24-hr TSP, and annual benzene. Note that background concentrations exceeded the guideline for all of these contaminant averaging periods.

The roadway contributions to the total concentrations were found to be small, as outlined in **Table 12** through **Table 23.**

## Table 27: Worst-Case Summary of Predicted Combined Contaminant Concentrations for the 2041 Future Build

### 5 Year Statistical Summary




**Notes:** The $PM_{2.5}$ results are in compliance with the CAAQS; the highest 3 year rolling average of the yearly 98th percentile combined concentrations were calculated to be 23.91 µg/m$^3$ or 89% of the CAAQS. Background concentrations not included for benzo(a)pyrene.

### % of Guideline

| 2041 FB | |
|---|---|
| CAAQ $NO_2$ (1-hr) | 117% |
| CAAQ $NO_2$ (Annual) | 80% |
| $NO_2$ (1-hr) | 36% |
| $NO_2$ (24-hr) | 41% |
| CO (1-hr) | 6% |
| CO (8-hr) | 10% |
| $PM_{2.5}$ (24-hr See Note) | 88% |
| $PM_{2.5}$ (Annual) | 97% |
| $PM_{10}$ | 151% |
| TSP | 118% |
| Acetaldehyde | <1% |
| Acrolein (1-hr) | 3% |
| Acrolein (24-hr) | 33% |
| Benzene (24-hr) | 68% |
| Benzene (Annual) | 208% |
| 1,3-Butadiene (24-hr) | 2% |
| 1,3-Butadiene (Annual) | 4% |
| Formaldehyde | 6% |
| Benzo(a)Pyrene (24-hr) | 48% |
| Benzo(a)Pyrene (Annual) | 51% |

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