REPORT

Quantitative Air Quality Assessment To Support the Environmental Assessment of Airport Road Improvements

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by HDR Inc. to complete a quantitative air quality assessment in support of a Municipal Class Environmental Assessment (EA) – Schedule C for the proposed improvements to Airport Road (the Project) in the City of Brampton (the City), Region of Peel (the Region), Ontario. The air quality assessment was prepared to provide an assessment of the air quality impacts resulting from the proposed Project. The air quality impacts will be compared to relevant federal and provincial standards and guidelines. Using the available background air quality data, the assessment was prepared to discuss the existing background air quality in the vicinity of the proposed Project and the potential impacts of the proposed Project on local air quality.

The factual data, interpretations and preliminary recommendations contained in this report pertain to a specific project as described in the report and are not applicable to any other project or site location. This report should be read in conjunction with *"Important Information and Limitations of This Report"* in Appendix A, following the text of this report. The reader's attention is specifically drawn to this information, as it is essential for the proper use and interpretation of this report.

2.0 PROJECT DESCRIPTION

As part of the Region's 2012 Updated Long Range Transportation Plan (LRTP), the Region is considering road improvements along an approximately 1.5 km corridor of Airport Road between Countryside Drive and Braydon Boulevard/Stonecrest Drive in the City of Brampton. The project includes widening of the existing four lanes of traffic to six lanes in addition to modifications to the streetscape and continuous active transportation facilities.

3.0 METHODOLOGY

The assessment was conducted as per the general guidance provided in the Ministry of the Environment, Conservation, and Parks (MECP) Central Region Draft Document "Traffic Related Air Pollution: Mitigation Strategies and Municipal Class Environmental Assessment Air Quality Impact Assessment Protocol", (MECP, 2017a, "MECP Central Region Draft Guidance").

As part of pre-consultation with the MECP, it was identified that a partial Air Quality Impact Assessment was recommended for this study, following the "hot spot methodology" identified in the MECP Central Region Draft Guidance. The relevant hot spot area was identified based on the following criteria

- Traffic volumes;
- Critical receptors, identified as parks, schools, child care facilities, child family programs, long term care facilities, and recreational facilities within 300 m of either side of the roadway;
- Sensitive receptors, identified as residences within 300 m of either side of the roadway; and
- Areas of road curvature or significant change in slope/grade (i.e. grade separation).

The stretch of Airport Road between Eagle Plains Drive and Braydon Boulevard was ultimately selected as the Hot Spot Area for future modelling as it has the largest number of critical receptors within 300 m of Airport Road and a high volume of sensitive receptors adjacent to both sides of the road.

The hot spot location and study area for this proposed Project is shown in Figure 1.

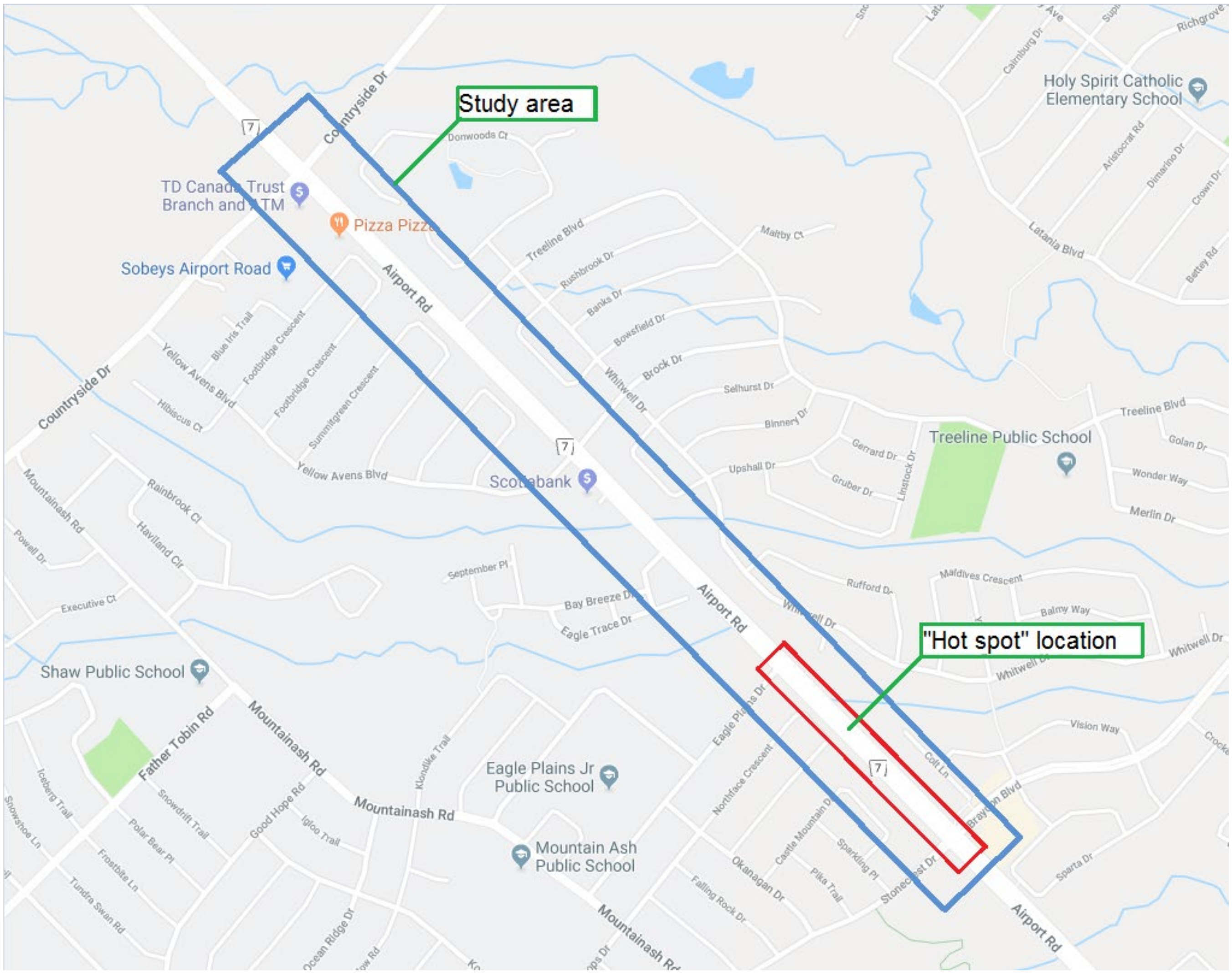

Figure 1: Proposed Project Study Area

This air quality assessment follows the partial AQIA methodology described in the MECP Central Region Draft Guidance and includes two main tasks, namely characterizing the existing conditions and assessing the net effects of the proposed Project on air quality. The Assessment considers the "maximum worst case" potential emissions for both the current and future scenarios.

4.0 BACKGROUND AIR QUALITY

The background air quality in the area around the proposed Project has been described by considering existing sources of emission and regional concentrations, based on publicly available monitoring data. The background air quality represents the existing conditions of air quality before the operation of the proposed Project. Sources include roadways, long range transboundary air pollution, small regional sources and large industrial sources.

This section details the selection of compounds considered in the assessment, applicable guidelines for this assessment, selection of the monitoring stations, and comparison of the selected data to the ambient air quality criteria (AAQCs).

4.1 Indicator Compounds

The assessment of background air quality focused on some criteria air contaminants (CACs), compounds that are expected to be released from mobile sources, such as specific volatile organic compounds (VOCs) for which relevant air quality criteria exist, and which are generally accepted as indicative of changing air quality. These compounds are emitted from fuel combustion from vehicles travelling on roadways. The indicator compounds for this project include:

- carbon monoxide (CO);
- nitrogen oxides, expressed as nitrogen dioxide (NO_2);
- suspended particulate matter[1] (SPM);
- particulate matter with a diameter of less than 10 microns (PM_{10});
- particulate matter with a diameter of less than 2.5 microns ($PM_{2.5}$); and
- selected volatile organic compounds (VOCs): acetaldehyde, acrolein, benzene, 1-3 butadiene, and formaldehyde.

4.2 Applicable Guidelines

The air quality criteria used for assessing the air quality effects of the proposed Project include Ontario criteria, and federal standards and objectives where provincial guidelines are not available. The Ministry of the Environment, Conservation, and Parks (MECP) has issued guidelines related to ambient air concentrations, which are summarized in *Ontario's Ambient Air Quality Criteria* (MECP, 2018a). There are two sets of federal objectives and criteria: the Canadian Ambient Air Quality Standards (CAAQS) and the National Ambient Air Quality Objectives (NAAQO).

The NAAQO are benchmarks that can be used to facilitate air quality management on a regional scale and provide goals for outdoor air quality that protect public health, the environment, or aesthetic properties of the environment (CCME, 1999). The federal government has established the following levels of NAAQO (Health Canada, 1994):

[1] SPM can also be referred to as total suspended particulate or TSP

- The maximum desirable level defines the long-term goal for air quality and provides a basis for an anti-degradation policy for unpolluted parts of the country and for the continuing development of control technology.
- The maximum acceptable level is intended to provide adequate protection against adverse effects on soil, water, vegetation, materials, animals, visibility, personal comfort, and well-being.

The CAAQS have been developed under the *Canadian Environmental Protection Act* and include new standards for SO_2 to be implemented by 2020 and 2025.

A summary of the applicable Ontario and federal standards, objectives and criteria are listed in Table 1, along with the selected project criteria, which were selected to be the most stringent.

Table 1: Ontario and Canadian Regulatory Air Quality Objectives and Criteria

Substance	Averaging Period	Ontario Ambient Air Quality Criteria[a]	Canadian Ambient Air Quality Criteria[b]	National Ambient Air Quality Standards and Objectives[c]		Project Criteria
				Desirable	Acceptable	
CO (µg/m³)	1-hour	36,200	—	15,000	35,000	36,200
	8-hour	15,700	—	6,000	15,000	15,700
NO_2 (µg/m³)	1-hour	400	113[d] (60 ppb)	—	400	113/400
	24-hour	200	—	—	200	200
	Annual	—	32[e] (17 ppb)	60	100	32
SPM (µg/m³)	24-hour	120	—	—	120	120
	Annual	60	—	60	—	60
PM_{10} (µg/m³)	24-hour	50	—	—	—	50
$PM_{2.5}$ (µg/m³)	24-hour	30	28/27	—	—	27
	Annual	—	8.8	—	—	8.8
Acrolein (µg/m³)	1-hour	4.5	—	—	—	4.5
	24-hour	0.4	—	—	—	0.4
Acetaldehyde (µg/m³)	24-hour	500	—	—	—	500
1,3-Butadiene (µg/m³)	24-hour	10	—	—	—	10
	Annual	2	—	—	—	2
Benzene (µg/m³)	24-hour	2.3	—	—	—	2.3

Substance	Averaging Period	Ontario Ambient Air Quality Criteria(a)	Canadian Ambient Air Quality Criteria(b)	National Ambient Air Quality Standards and Objectives(c)		Project Criteria
				Desirable	Acceptable	
Formaldehyde (µg/m³)	Annual	0.45	—	—	—	0.45
	24-hour	65	—	—	—	65

Notes:
(a) MECP 2019
(b) CAAQS published in the Canada Gazette Volume 147, No. 21 - May 25, 2013. Final standard phase in date of 2020 used.
(c) CCME 1999
(d) CAAQS published in the Canada Gazette Volume 151, No. 43 – October 28, 2017, effective from 2020. Standards provided as parts per billion (ppb) were converted to µg/m³ using a reference temperature of 25°C and pressure of 1 atmosphere (atm). The 1 hour standard is based on the three-year average of the 98th percentile of the daily maximum 1-hour average concentration. The annual standard is based on the average over a single calendar year of all 1-hour average concentrations.

(d) — = No guideline available.

Note: 1-hour CAAQS for NO_2 are based on the three-year average of the 98th percentile of the daily maximum 1-hour average concentration, which is not readily provided by the air quality dispersion models for transportation sources. As a result, the Ontario AAQC is also provided for comparison.

4.3 Project Location

The proposed Project is located in a residential area, as a result, there are no industrial facilities within a 1 km radius of the proposed Project that reported to Environment and Climate Change Canada's (ECCC) National Pollutant Reporting Inventory for 2017 (ECCC, 2019). The closest facilities that reported emissions in 2017 are located approximately 4.9 km away from the proposed Project.

The main source of emissions close to the Project is anticipated to be road sources, including Bovaird Drive East/Castlemore Road, Sandalwood Parkway East, Goreway Drive and Torbram Road, which are major arterial roads located within 2 km of the project.

4.4 Monitoring Data

In Ontario, regional air quality is monitored through a network of air quality monitoring stations operated by the MECP and ECCC National Air Pollution Surveillance (NAPS) Network. These stations are operated under strict quality assurance and quality control procedures. Existing air quality was characterized using background air concentrations from local monitoring data sources.

The proposed Project is located close to Stonecrest Drive/Braydon Boulevard (to the south), Countryside Drive (to the north), Torbram Road (to the west) and Goreway Drive (to the east). The areas to the east, south and west of the proposed Project are mainly residential with some open green space. The project ends at Countryside Drive, with a rural area directly to the northeast of it and a residential neighbourhood to the northwest.

There are no stations directly located in the proposed Project Study Area. The closest relevant station that monitors the required substances is the Brampton station, located at 525 Main Street North/Peel Manor. This station is located in an urban residential area with only a few industrial sources which may influence it, more than 1.5 km away. It is also adjacent to three major arterial roads; as a result it was considered representative of the study area due to its location, upwind of the proposed Project and similarities in nearby land use and traffic air pollution sources.

Data for the most recent five-year period (2012 to 2016) with complete and quality assured data by ECCC was used for this assessment.

VOC data for the Brampton station is available for the period of 2011 to 2015 but does not include acetaldehyde, formaldehyde or acrolein. These VOCs are not part of ECCC's typical suite of VOCs, therefore data is not available for many stations across Ontario. Data for these Indicator Compounds was therefore taken from the station located at 200 College Street in Toronto, however, data was only available for 2014-2016.

There are no stations in the vicinity of the proposed Project that monitor CO. Due to decreasing trends in CO levels in the province over the past ten years (MECP, 2018a), there are few stations that currently monitor these compounds. The Mississauga station is the closest station to the study area with monitoring data for CO. It is located on the University of Toronto – Mississauga campus bordered by Mississauga Road to the west and Dundas Street West to the south, with surrounding land use consisting of residential area and green space/parks. This is similar to the proposed Project Study Area. There are several sources of VOCs and particulates upwind of this station, but industrial sources of CO are at least 10 km away therefore data for these Indicator Compounds was taken from this station.

Selected station details are provided in Table 2, below.

Table 2: Ambient Air Quality Monitoring Parameters

Station Name	NAPS Station ID	Available Data[a]								Distance from Project [km]	Direction from the Project
		CO	NO_2	NO	SO_2	SPM[(a)]	PM_{10}[(a)]	$PM_{2.5}$	VOCs		
Brampton	60428	—	Y	Y	—	—	—	Y	Y[(b)]	9	Southwest
200 College	60439	—	—	—	—	—	—	—	Y[(c)]	30	Southeast
Mississauga	60434	Y	—	—	Y	—	—	—	—	26	South

Notes:
"—" Station not used for obtaining compound data.
(a) SPM and PM10 data was calculated using the following ratios; $PM_{2.5} = 0.54 \times PM_{10}$, $PM_{2.5} = 0.3 \times SPM$ (Lall et al., 2004).
(b) Does not include acetaldehyde, acrolein, or formaldehyde
(c) Does not include benzene or 1,3-butadiene

For analyzing monitoring data, the 90th percentile of the available monitoring data is typically considered a conservative estimate of background air quality (CEA Agency and CNSC, 2009). As a result, the 90th percentile of the measured concentrations have been used to represent background air quality for parameters with shorter averaging periods (i.e., 1-hour, 8-hour, and 24-hour). Annual background concentrations were calculated based on the mean of the available data. A summary of the background air quality concentrations for all compounds is provided below in Table 3 with further discussion in the following sections.

Table 3: Summary of Air Quality Monitoring Data

Indicator Compound	Averaging Period	Background Air Quality Concentration [µg/m³]	Project Criteria [µg/m³]	% of Project Criteria
CO	1-hour	343.57	36,200	1%
	8-hour	443.78	15,700	3%
O_3	1-hour	86.35	N/A	N/A
	8-hour	102.96	N/A	N/A
NO_2	1-hour	43.26	113/400	38%/11%
	24-hour	36.97	200	18%
	Annual	18.73	32	59%
SPM	24-hour	47.79	120	40%
	Annual	25.62	60	43%
PM_{10}	24-hour	26.76	50	54%
$PM_{2.5}$	24-hour	14.34	27	53%
	Annual	7.68	8.8	87%
Acetaldehyde (µg/m³)	24-hour	1.72	500	<1%
Acrolein (µg/m³)	1-hour	—	4.5	—
	24-hour	0.07	0.4	18%
Benzene (µg/m³)	24-hour	0.88	2.3	38%
	Annual	0.55	0.45	121%
1,3-Butadiene (µg/m³)	24-hour	0.09	10	1%
	Annual	0.05	2	2%

Indicator Compound	Averaging Period	Background Air Quality Concentration [µg/m³]	Project Criteria [µg/m³]	% of Project Criteria
Formaldehyde (µg/m³)	24-hour	3.19	65	5%

Notes:
(a) All values are based on 90th percentile with the exception of annual averages.
(b) "–" no data available
(c) N/A - not applicable for this assessment

Emission sources of indicator compounds in the proposed Project Study Area are accounted for in the existing air quality, including local traffic, industrial, commercial, and residential sources.

4.4.1 CO Concentrations

Carbon monoxide is a colourless, odourless, tasteless gas, and at high concentrations can cause adverse health effects. It is produced primarily from the incomplete combustion of fossil fuels, as well as natural sources. The monitoring data assessed indicates that the measured concentrations for the 1-hour or 8-hour CO were below the Ontario AAQC and are presented below (Figure 2).

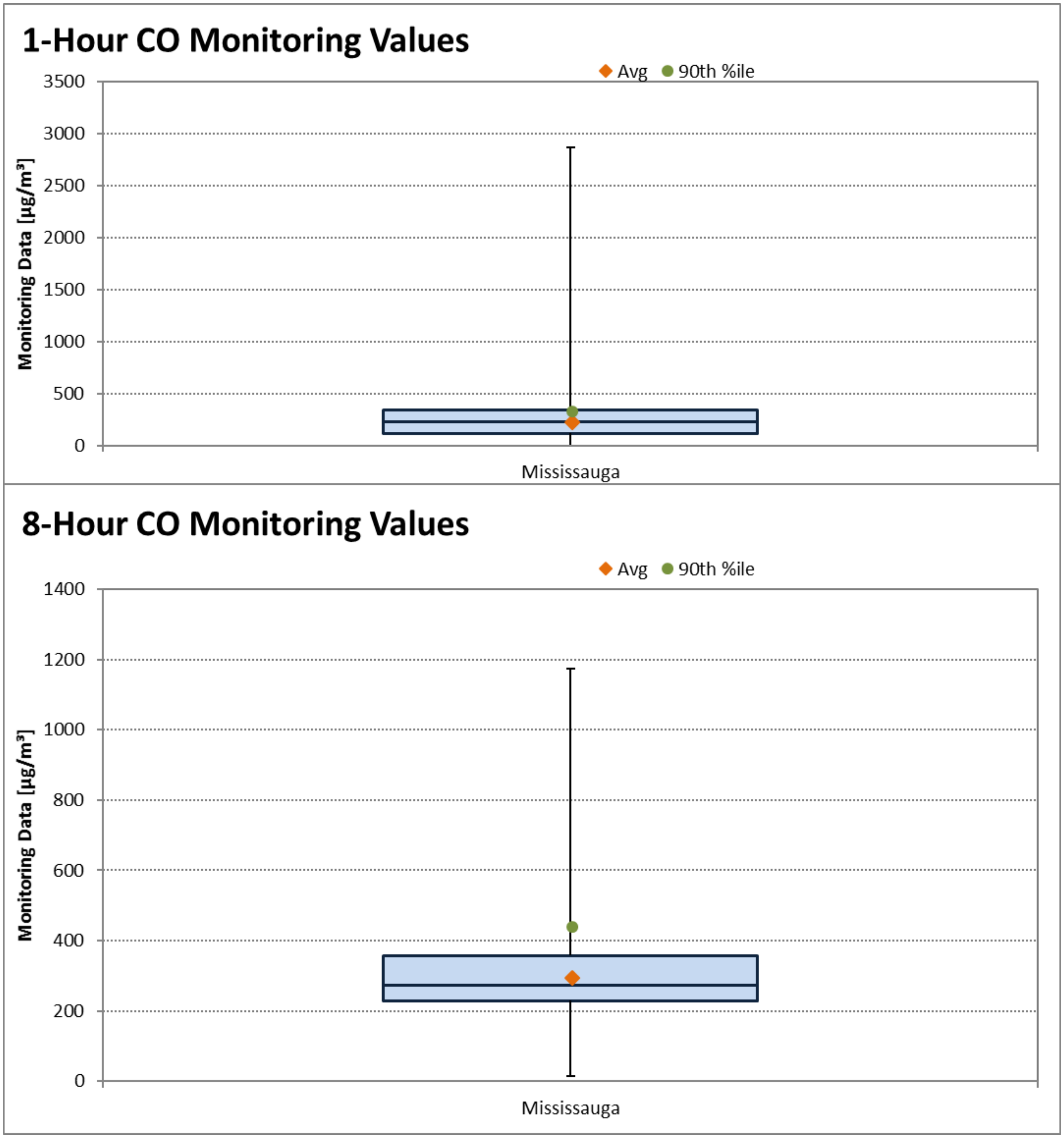

Figure 2: Measured 1-hour and 8-hour Carbon Monoxide (CO) Concentrations at the Mississauga Station

4.4.2 NO_X and NO_2 Concentrations

NO_X is emitted in two primary forms: nitric oxide (NO) and NO_2. NO reacts with ozone in the atmosphere to create NO_2. The primary source of NO_X in the region is the combustion of fossil fuels. Emissions of NO_X result from the operation of stationary equipment such as incinerators, boilers, and generators, as well as the operation of mobile sources such as vehicles, haul trucks, and other equipment.

The presence of NO_2 in the atmosphere has known health effects (e.g., lung irritation) and environmental effects (e.g., acid precipitation, ground-level ozone formation) (MECP 2018a). As a result, regulatory guideline levels are based on NO_2 emissions and concentrations. The annual mean concentrations of NO_2 in Ontario have decreased by 30% from 2007 to 2016 (MECP 2018a). The monitoring data assessed shows the 1-hour or 24-hour Ontario AAQC for NO_2 recorded (Figure 3) were below the Ontario AAQC.

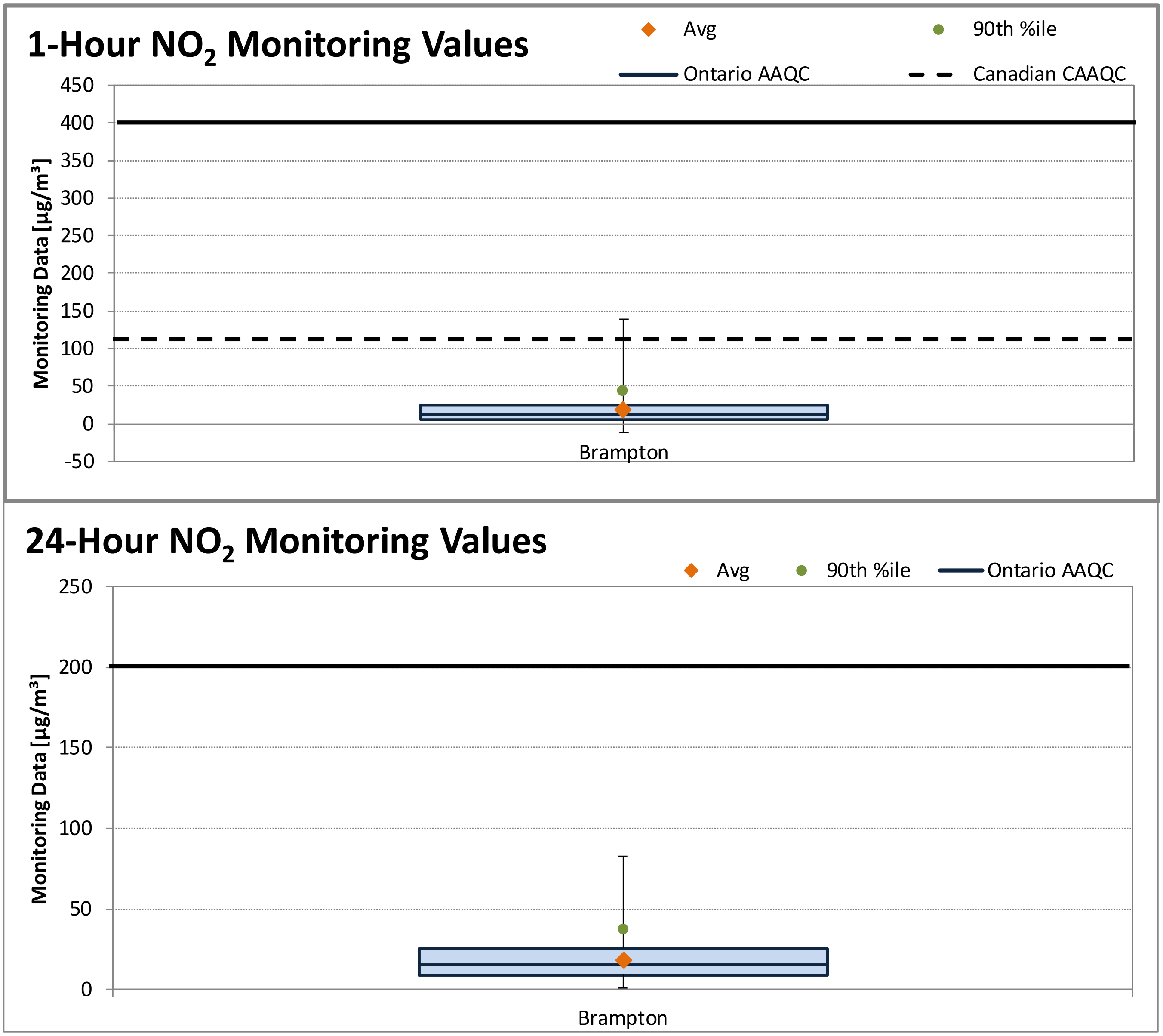

Figure 3: Measured 1-hour and 24-hour Nitrogen Dioxide (NO_2) Concentrations at the Brampton Station

4.4.3 O_3 Concentrations

Ground-level ozone is formed when NO_x and VOCs react in the presence of sunlight. Ground-level ozone concentrations are included in this assessment as they may be required to calculate the concentrations of NO_2 as described in the Ozone Limiting Method (OLM).

4.4.4 Particulate Matter (SPM, PM_{10} and $PM_{2.5}$)

Particulate emissions occur due to anthropogenic activities, such as agricultural, industrial and transportation sources, as well as natural sources. Particulate matter is classified based on its aerodynamic particle size, primarily due to the different health effects that can be associated with the particles of different diameters. Fine particulate matter ($PM_{2.5}$) is of primary concern related as they can penetrate deep into the respiratory system and may results in health impacts. In Ontario, these emissions have been demonstrating a steady decline over time, decreasing by approximately 16% from 2007 to 2016 (MECP, 2018b). As presented in Figure 4 for 24-hour $PM_{2.5}$, measurements meet the Ontario AAQC value of 30 µg/m³ and the CAAQC of 27 µg/m³.

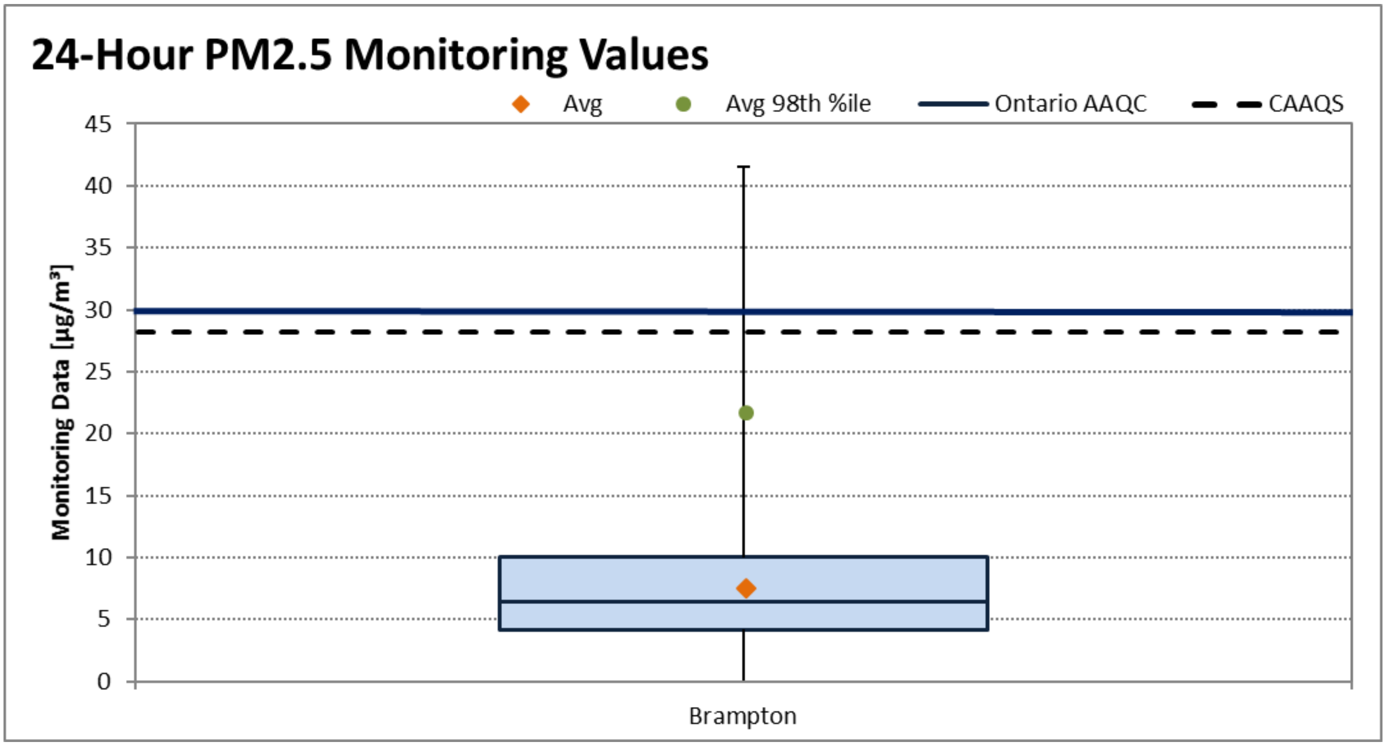

Figure 4: Measured 24-hour $PM_{2.5}$ Concentrations at the Brampton Station

No local monitoring data was available for SPM and PM_{10}, however, the background SPM and PM_{10} concentrations can be estimated from the available $PM_{2.5}$ monitoring data. Fine particulate matter (i.e., $PM_{2.5}$) is a subset of PM_{10}, and PM_{10} is a subset of SPM. Therefore, it is reasonable to assume that the ambient concentrations of SPM will be greater than corresponding PM_{10} levels, and PM_{10} concentrations will be greater than the corresponding levels of $PM_{2.5}$. The mean levels of $PM_{2.5}$ in Canadian locations are found to be about 54% of the PM_{10} concentrations and about 30% of the SPM concentrations (Lall et al., 2004). By applying this ratio, it was possible to estimate the background SPM and PM_{10} concentrations for the region.

Larger particles (i.e., SPM) can result in nuisance effects, such as soiling or visibility and, therefore, must be taken into consideration as part of the study. All derived SPM and PM_{10} values are below the relevant AAQC and NAAQOs.

4.4.5 VOC Concentrations

Volatile organic compounds are primary precursors to the formation of ground level ozone and aerosols which are the main components of smog, known to have adverse effects on human health and the environment (ECCC 2015a). Ontario's major sources of VOCs includes transportation and general solvent use (MECP 2015). The primary VOCs associated with traffic include acetaldehyde, acrolein benzene, 1,3-butadiene, and formaldehyde. Benzene and 1,3- butadiene are routinely measured at the Brampton Station every 6 days and therefore a statistical analysis of these compounds is provided below.

Benzene is mainly released from vehicle exhausts due to fuel combustion (ECCC 2015b). Similarly, 1,3-butadiene is typically a product of incomplete combustion, released into the atmosphere from transportation vehicle exhausts or fuel/biomass combustion in non-transportation sources (ECCC, 2015c). 1,3-butadiene may also be released from industrial facilities. The presence of both benzene and 1,3-butadiene in the atmosphere have known health and environmental effects.

The monitoring data for 1,3-butadiene indicates that the measured values for the 24-hour (Figure 5) or annual AAQC were below the criteria.

From the monitoring data assessed, benzene values were below the 24-hour AAQC (Figure 6); however, the annual benzene concentration was exceeded every year, where the average annual benzene concentration was 120% of the AAQC. It should be noted, however, that annual monitored benzene concentrations exceed the AAQC across the Greater Toronto Area at all monitoring stations for which data is publicly available. Additionally, as data is recorded only every 6 days, the annual average serves as an indicator only.

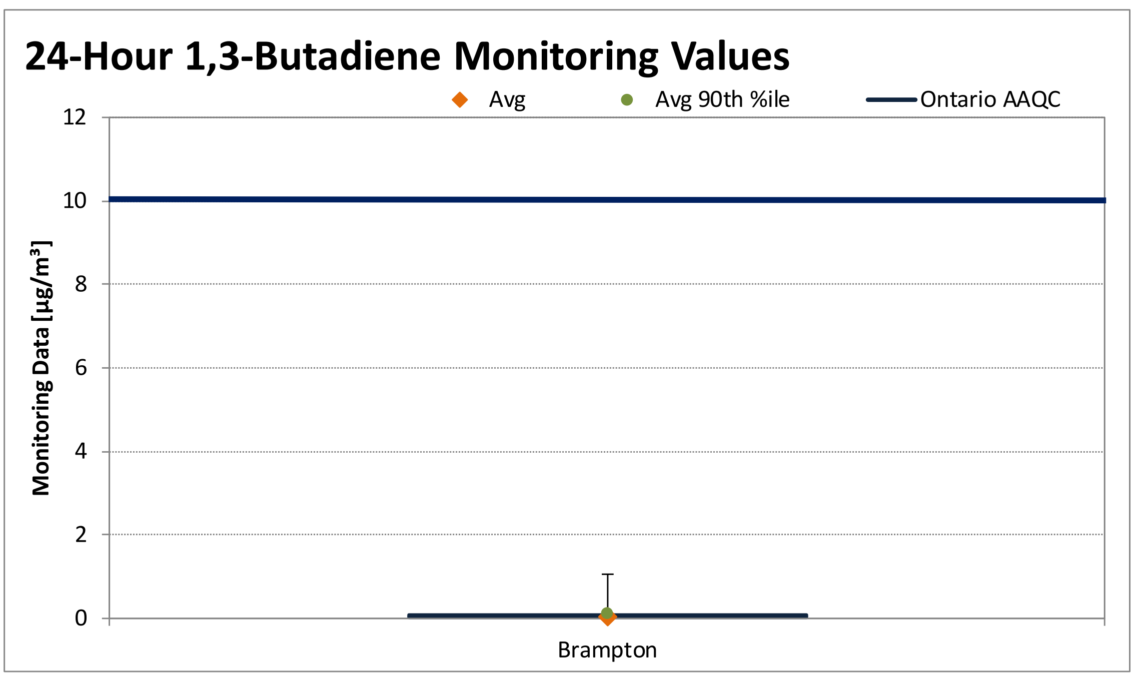

Figure 5: Measured 1,3-Butadiene at the Brampton Station

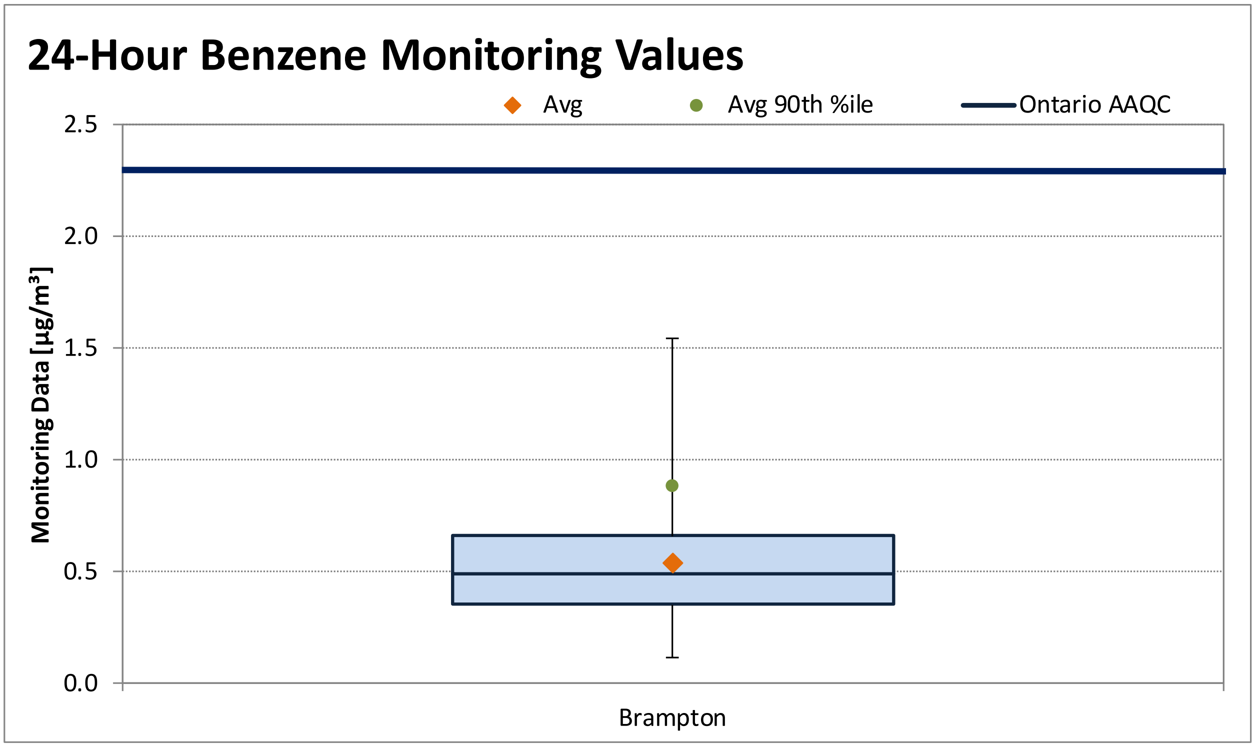

Figure 6: Measured Benzene at the Brampton Station

Limited data is available for acetaldehyde, acrolein, and formaldehyde, as these indicator compounds are only monitored at 2 stations across Ontario and have only been monitored since August 2015, on a sporadic basis. The monitoring data for all three indicator compounds shows that monitored values were observed to be significantly below the AAQC.

5.0 PROJECT EMISSIONS

The proposed Project involves road improvements along an approximately 1.5 km corridor of Airport Road from between Countryside Drive and Braydon Boulevard/Stonecrest Drive in the City of Brampton. The project includes widening of the existing four lanes of traffic to six lanes. Emission rates for both the project construction and operation is discussed in the following sections.

5.1 Construction Emissions

Construction activities have the potential to create temporary, localized effects on air quality in the immediate vicinity of the proposed Project. Emissions from construction are primarily comprised of fugitive dust and combustion products from the movement and operation of construction equipment and vehicles.

These emissions, in turn, may create a nuisance or disturbance effect for local residents and land users during the construction phase. Mitigation measures to reduce potential nuisance effects of dust and air emissions include the following:

- Regular maintenance of equipment used on site to minimize exhaust;
- Use of effective dust suppression techniques, such as on-site watering, as necessary;
- Reducing speed limits on unpaved areas for mobile equipment;
- Optimization of material transfer operations, including reducing distance for material transfers, if possible.

5.2 Operation Emissions

Worst case impacts from roadway vehicle emissions were assessed for three different scenarios:

1. 2011 Conditions – Historical Traffic Volumes on Airport Road for the current alignment
2. 2031 Future No-Build – Projected Traffic Volumes on Airport Road without the Project
3. 2031 Future Build – Projected Traffic Volumes on Airport Road when the proposed Project is in the mature state of development

Annual Average Daily Traffic (AADT) data was provided for the Project. The Project AADT for the study area is shown in Table 4 below.

Table 4: Project Traffic Volumes for Study Area (South to North)

Year	Starting Point	Finishing Point	Project AADT	Posted Vehicle Speed [km/hour]	Day/Night Split [%]	Medium/heavy Truck Split [%}
2011	Stonecrest Dr./Braydon Blvd.	Countryside Dr.	20,000	70	N/A	N/A
2031 – No Build	Stonecrest Dr./Braydon Blvd.	Countryside Dr.	36,000	70	90%/10%	4%/4%
2031 - Build	Stonecrest Dr./Braydon Blvd.	Countryside Dr.	42,000	70	90%/10%	4%/4%

Emission rates from roads are typically estimated by multiplying emission factors by corresponding fleet size and kilometers of distance travelled. The US EPA Motor Vehicle Emission Simulator (MOVES), version 2014b model. This sources emission factor model is one of the MECP and Ontario Ministry of Transportation (MTO) and MECP recommended models for calculating emission factors for roads. Model inputs to MOVES are summarised below

Table 5: Inputs to MOVES model

MOVES Parameter	Input
Scale	Model Type: On-road Domain/Scale: Project
Year of Evaluation	2011, 2031
Month	January, July (Worst case selected)
Road Type	urban, unrestricted access
Fuels	Diesel/gasoline
Source Use Types	Passenger Car/Light Commercial Truck/Combination Long Haul Truck
Pollutants	NO_2, CO, $PM_{2.5}$, PM_{10}, Acetaldehyde, Acrolein, Benzene, 1,3-butadiene, Formaldehyde, Equivalent CO_2
Meteorology	Temperature and Relative Humidity taken from Pearson Airport
Vehicle Age Distribution	MOVES Default for respective year of assessment
Vehicle Fleet Characteristics	92% Passenger car 4% Light Commercial Truck 4% Combination long Haul Truck
Link Information	See Table 4

Emissions from the re-entrainment of the road dust from vehicles travelling on paved roads were calculated using the U.S. EPA AP-42 emission factors from Chapter 13.2.1 – Paved Roads (January 2011). The following predictive emissions equation was used to calculate the fugitive dust emission factor for paved roads:

$$\mathrm{EF} = (\mathrm{k}(\mathrm{sL})^{0.91} \times (\mathrm{W})^{1.02})$$

Where:

EF =particulate emission factor (having units matching the units of k),

k =particle size multiplier for particle size range and units of interest (see Table 6), sL =road surface silt loading (g/m^2) assumed to be 0.03 (as per U.S. EPA AP-42 Section 13.2.1-2, silt loading for public roadways with an AADT of over 10,000),

W =average weight (tons) of the vehicles traveling the road, assumed to be 3 tons or 2.7 tonnes

Table 6: Particle Size Assumptions for Paved Road Dust

Size Range	K (g/VKT)
SPM	3.23
PM_{10}	0.62
$PM_{2.5}$	0.15

The following is a sample calculation for SPM for the predictive emission factor for vehicles that will travel along the main site access road. It was estimated that the vehicles have an average weight of 3 tons.

$$\mathrm{EF} = (3.23\ \times (0.03)^{0.91} \times (2.7)^{1.02})$$

$$\mathrm{EF} = 0.41\ \mathrm{g/VKT}$$

The emission factors of PM_{10} and $PM_{2.5}$ were calculated as presented above.

Emissions from the re-entrainment of road dust were added to the emission rates from MOVES. The traffic data from the proposed Project presented in Table 4, above, was used with the emission factor outputs from the MOVES model to calculate the annual emissions for the proposed Project.

Emission Factors used in the Project are presented in Table 7, below:

Table 7: Project Emission Factors

Contaminant	2011 Historical Operation Emission Factors		2031 Future Emission Factors	
	g/VKT	g/hr/vehicle - Idling	g/VKT	g/hr/vehicle - Idling
NOx	0.56	7.29	0.06	0.46
CO	3.37	38.24	0.70	0.65
SPM[1]	0.41	0.14	0.41	0.05
PM_{10}	0.090	0.14	0.081	0.05
$PM_{2.5}$	0.030	0.12	0.022	0.05
Acetaldehyde	0.0008	0.022	0.0001	0.002

Contaminant	2011 Historical Operation Emission Factors		2031 Future Emission Factors	
	g/VKT	g/hr/vehicle - Idling	g/VKT	g/hr/vehicle - Idling
Acrolein	0.00012	0.0034	0.00002	0.0004
Benzene	0.0049	0.14	0.0002	0.0014
1,3-Butadiene	0.0006	0.018	0.000004	0.00010
Formaldehyde	0.0021	0.060	0.0003	0.006

Note:
[1]Conservatively assumed that tailpipe SPM emissions are the same as tailpipe PM_{10} emissions.

6.0 AIR DISPERSION MODELLING

The estimated environmental effects for the air quality indicators were evaluated based on the results of the MOVES model, using the CAL3QHCR dispersion model for paved roads. The CAL3HQCR model is suited to predict concentrations for roadway dispersion and is the preferred model for the credible worst-case analysis method as identified in Ontario Ministry of Transportation's Environmental Guide for Assessing and Mitigating the Air Quality Impacts and Greenhouse Gas Emissions of Provincial Transportation Projects (MTO Guide, MTO 2012). The CAL3QHCR model was selected for air dispersion modelling analysis for the paved road emissions for the Project, given that the majority of air emissions are traffic related.

6.1 Dispersion Modelling Inputs

This section summarizes the dispersion modelling inputs for the CAL3QHCR model. To predict ambient air concentrations from roads with the aid of CAL3QHCR model, site geometry inputs are required to parameterize the sources of emissions as well as their transport. The CAL3QHCR dispersion model also requires input data for vehicle emission rates, receptor locations, and meteorological conditions.

6.1.1 Site Geometry

The CAL3QHCR can process up to 120 links. A link is defined as a straight-line segment and can be specified as either a free flow or a queue link. For this Project, all links used in the dispersion modelling of the hot spot are free flow links as there is no data for traffic lights within the hot spot. A free flow link is defined as a straight segment of roadway with a constant width, height, traffic volume, travel speed, and vehicle emission factor. The location of the link is specified by its start and end point coordinates, X1, Y1 and X2, Y2.

Link width or mixing zone width (W) is defined as the width of the travelled roadway (lanes of moving traffic only), plus 3 m on each side of the roadway to account for the dispersion of the plume generated by the wake of moving vehicles. For the Project, the road will be widened from 4 lanes to 6 lanes, as a result, this was accounted for in the mixing zone width for the two different scenarios. Link height (H) can be elevated or depressed, but is limited within 10 m for elevated, and -10 m for depressed. For the Project, all the links are assumed to be at grade (i.e., a link height of 0 m has been assumed). Two free-flow links have been defined for the Project to represent the emissions from two-way travel through the Project study area (Table 8).

All the modelling objects have been defined using UTM projection (NAD83, Zone 17). In order for easy tracking in the modelling input and output files, the UTM coordinates have been subtracted by 600,000 m (easting) and 4,840,000 m (northing).

Table 8: Modelled Links – Free Flow

Link ID	X1 (m)	Y1 (m)	X2 (m)	Y2 (m)	Length (m)	Height (m)	Mixing Zone Width - 2011 (m)	Mixing Zone Width – 2031 No Build (m)	Mixing Zone Width – 2031 Build (m)
Airport Rd NB	1782	7421	1489	7713	415	0	13	13	17
Airport Rd SB	1489	7713	1782	7421	415	0	13	13	17

One Queue link was also used to represent queuing traffic heading Southbound towards Braydon Boulevard (Table 9). Data for the queue link is provided below.

Table 9: Modelled Links - Queue Links

Link ID	X1 (m)	Y1 (m)	X2 (m)	Y2 (m)	Number of Lanes
SB queue to Braydon Boulevard	1668	7526	1763	7432	4

6.1.2 Receptors

CAL3QHCR can process up to 60 receptor locations at selected heights. Studies by the US EPA have found that roadways generally influence air quality within a few hundred metres downwind from a heavily travelled road. The actual distance varies by location, time of day, year and prevailing meteorology, topography and traffic patterns (US EPA, 2014). Concentrations will dissipate rapidly from the road source; therefore, it is expected that this Project will have a negligible impact on regional air quality. As outlined in the MECP Central Region Draft Guidance, sensitive and critical receptors within 300 m of the study area should be identified and assessed. Sensitive receptors may include residences and critical receptors may include healthcare facilities, long term care facilities, child care facilities, camp grounds, schools, community centres, daycares, recreational centres and sports facilities or outdoor public recreational areas.

Critical receptors within 300 m of the study area include one school facility and two recreational sites. These receptors were placed at the point of the property closest to the Project. As the study area is in a suburban residential area characterized by neighbourhoods of single-family detached housing, sensitive receptors were too numerous to identify individually. Therefore, a line of receptors was created along each side of the road, defined by points spaced 20 m apart, to represent sensitive receptors. All receptors were modelled at a height of 1.8 m to represent an average breathing height, according to the CAL3QHC guidance document (U.S. EPA, 1995). The CAL3QHCR critical receptor inputs are presented in the following table. The locations of critical and sensitive receptors are depicted in Figure 7. The two lines of sensitive receptors are identified in green.

Table 10: CAL3QHCR Critical Receptor Data

I.D.	Description	X (m)	Y (m)	Height (m)
S1	School	1297	7521	1.8
REC1	Recreational site	1436	7725	1.8
REC2	Recreational site	1775	7388	1.8

Figure 7: Airport Road Critical and Sensitive Receptors

6.1.3 Meteorological Conditions

CAL3QHCR requires five years of consecutive meteorological data which includes hourly wind flow vector, wind speed, ambient temperature, stability class, and urban mixing height. As the emissions are ground based, the maximum downwind concentrations typically occur under low wind speeds and stable conditions. The Toronto Surface Station (ID 61587) was used in the assessment, using a five-year data set from January 1st, 2011 to December 31st, 2015.

Additional parameters including surface roughness length, deposition velocity, and settling velocity. The surface roughness length was set to 108 cm based on recommended values for High Intensity Residential Areas (U.S. EPA, 1995). Following the MTO Guide, the settling velocities for $PM_{2.5}$ and PM_{10} are set to be at 0.02 and 0.3 centimetres per second (cm/s), respectively. The deposition velocities for $PM_{2.5}$ and PM_{10} are set to be at 0.1 and 0.5 cm/s, respectively. The MTO Guide does not have recommended values for SPM. For this analysis, the settling and deposition velocities for SPM are conservatively set to be the same as those of PM_{10}.

6.1.4 Emission Inputs

Emission sources for the Project have been defined using free flow and queue links. In addition to the link information, the emission rates for each contaminant (grams per kilometer [g/km]) and traffic volume (vehicles/hour) were estimated using information from the traffic study and the outputs from MOVES results. For the 2011 modelling scenario the day/night traffic split was unknown, therefore modelling assumed constant traffic volumes through all 24 hours of the day. In the future (2031) no-build and build scenarios the daytime and nighttime traffic proportions were used to vary emissions throughout the day with daytime traffic (90% of AADT) occurring from 7am to 11pm daily and night time traffic (10% of AADT) occurring between 11pm and 7am. There is little fluctuation in road width or alignment over the 415 m hot spot area, therefore only two free flow segments were modelled with traffic either northbound or southbound. Emissions from idling were taken the MOVES output and used to describe queuing at intersections.

6.1.5 Conversions of NOx to NO2

Emissions of NOx were used as inputs to the CAL3QHCR model. Ambient predictions of nitrogen dioxide (NO_2), can be calculated from modelled NOx values using the Ozone Limiting Method (OLM). The OLM consists of comparing the maximum modelled NOx concentration to the background ozone concentration to assess the limiting factor to NO_2 (Cole et al. 1979). The following equations present the methodology:

If background $[O_3]$ >0.90 [NOx], total conversion: $[NO_2]$ = [NOx]

If background $[O_3]$ <0.90 [NOx], NO2 is limited by O_3: $[NO_2] = [O_3] + 0.10$ [NOx]

For the air quality assessment, all NO_2 concentrations were calculated assuming total conversion of NOx since background ozone values at these averaging periods were above 0.90 [NOx].

6.1.6 Summary of Dispersion Modelling Inputs

A summary of the modelling inputs to CAL3QHCR, as described in the sections above is provided below:

Table 11: Summary of CAL3QHCR Inputs

Parameter	Description
Run Averaging Time (minutes)	60
Roughness Length (cm)	108
Settling Velocity (cm/s)	$PM_{2.5}$: 0.02 PM_{10}: 0.3 SPM: 0.3 All other contaminants: 0

Parameter	Description
Deposition velocity (cm/s)	$PM_{2.5}$: 0.1 PM_{10}: 0.5 SPM: 0.5 All other contaminants: 0
Number of Receptors	48 – 3 critical and 45 sensitive
Output Unit	Meters
Meteorological Data	Toronto (2011-2015)
Pollutant Type	“PM” was selected for all contaminants except Carbon monoxide, for which “CO” was selected
Number of Links	2 (See Tables 7 and 8 for geometry details)
Emission Rates	Emission rates were calculated using MOBILE6.2C
Traffic Data	Daytime (90%) and Nighttime (10%) traffic distributions were applied to the future no-build and build AADT traffic volumes in Table 4 in order to input traffic volumes in vehicles per hour (day/night traffic split was unknown for the 2011 scenario, therefore modelling for that scenario assumed constant traffic volumes throughout day/night)

6.2 Dispersion Modelling Results

CAL3QHCR predicts the maximum 24-hour and annual concentrations for most of the indicator compounds and the maximum 1-hour and 8-hour concentration for CO. In cases where a standard and/or guideline has an averaging period that CAL3QHCR is not designed to predict (e.g. ½-hr), a conversion to the appropriate averaging period was completed using the MECP recommended conversion factors, as documented in the MECP Air Dispersion Modelling Guideline for Ontario (MECP, 2017b). The actual predicted maximum concentrations at ground level are those from the CAL3QHCR model outputs divided by the relevant inflation factors.

The CAL3QHCR output presents the resulting maximum concentrations at each sensitive and critical receptor. The maximum concentrations predicted at any of the receptors, are presented in Tables 12, 13 and 14 below and compared to the relevant Project Criteria.

Table 12: 2011 Historical Conditions Predicted Concentrations

Indicator Compound	Averaging Period	Project Criteria [µg/m³]	Roadway predicted Concentration [µg/m³]	% of Project Criteria	Brampton Concentration [µg/m³][(1)]	Cumulative Concentration [µg/m³]	% of Project Criteria
CO[(2)]	1-Hour	36,200	310.58	1%	343.57	654.15	2%
	8-Hour	15,700	183.87	1%	443.78	627.65	4%
NO_2	1-Hour	400	56.95	14%	43.26	100.21	25%
		113	56.95	50%	43.26	100.21	89%
	24-Hour	200	18.95	9%	36.97	55.92	28%
	Annual	32	4.03	13%	18.73	22.76	71%
SPM	24-Hour	120	7.27	6%	47.79	55.06	46%
	Annual	60	2.02	3.4%	25.62	27.64	46%
PM_{10}	24-Hour	50	1.66	3%	26.76	28.43	57%
$PM_{2.5}$	24-Hour	27	0.63	2%	14.34	14.97	55%
	Annual	8.8	0.16	2%	7.68	7.84	89%
Acrolein (µg/m³)[(3)]	1-Hour	4.5	0.00	0.1%	—	0.00	0.1%
	24-Hour	0.4	0.00	0%	0.07	0.07	18%
Acetaldehyde (µg/m³)[(3)]	24-Hour	500	0.04	0.01%	1.72	1.77	0.4%
1,3-Butadiene (µg/m³)	24-Hour	10	0.04	0%	0.09	0.13	1%
	Annual	2	0.01	0%	0.05	0.05	3%
Benzene (µg/m³)	24-hour	2.3	0.30	13%	0.88	1.18	51%
	Annual	0.45	0.05	12%	0.55	0.60	133%
Formaldehyde (µg/m³)[(3)]	24-Hour	65	0.13	0.2%	3.19	3.32	5%

Notes:

(1)Unless otherwise stated.

(2)Background concentration data obtained from the Mississauga station.

(3)Background concentration data obtained from the College station.

Table 13: 2031 Future No-Build Dispersion Modelling Results

Indicator Compound	Averaging Period	Project Criteria [µg/m³]	Roadway predicted Concentration [µg/m³]	% of Project Criteria	Brampton Concentration [µg/m³](1)	Cumulative Concentration [µg/m³]	% of Project Criteria
CO(2)	1-Hour	36,200	63.58	0.2%	343.57	407.15	1%
	8-Hour	15,700	43.88	0.3%	443.78	487.66	3%
NO_2	1-Hour	400	7.33	2%	43.26	50.59	13%
		113	7.33	6%	43.26	50.59	45%
	24-Hour	200	2.68	1%	36.97	39.64	20%
	Annual	32	0.54	2%	18.73	19.26	60%
SPM	24-Hour	120	12.79	11%	47.79	60.58	50%
	Annual	60	3.33	5.6%	25.62	28.95	48%
PM_{10}	24-Hour	50	2.53	5%	26.76	29.29	59%
$PM_{2.5}$	24-Hour	27	0.76	3%	14.34	15.10	56%
	Annual	8.8	0.18	2%	7.68	7.87	89%
Acrolein (µg/m³)(3)	1-Hour	4.5	0.444	9.9%	—	0.44	9.9%
	24-Hour	0.4	0.143	35.70%	0.07	0.21	53%
Acetaldehyde (µg/m³)(3)	24-Hour	500	0.003	0.001%	1.72	1.73	0.3%
1,3-Butadiene (µg/m³)	24-Hour	10	0.0004	0.004%	0.09	0.09	1%
	Annual	2	0.0001	0.003%	0.05	0.05	2%
Benzene (µg/m³)	24-hour	2.3	0.006	0.3%	0.88	0.89	39%
	Annual	0.45	0.002	0.4%	0.55	0.55	121%
Formaldehyde (µg/m³)(3)	24-Hour	65	0.0003	0.001%	3.19	3.19	5%

Notes:
(1)Unless otherwise stated.
(2)Background concentration data obtained from the Mississauga station.
(3)Background concentration data obtained from the College station.

Table 14: 2031 Future Build Dispersion Modelling Results

Indicator Compound	Averaging Period	Project Criteria [µg/m³]	Roadway predicted Concentration [µg/m³]	% of Project Criteria	Brampton Concentration [µg/m³][(1)]	Cumulative Concentration [µg/m³]	% of Project Criteria
CO[(2)]	1-Hour	36,200	79.74	0.2%	343.57	423.31	1%
	8-Hour	15,700	57.28	0.4%	443.78	501.06	3%
NO_2	1-Hour	400	8.46	2%	43.26	51.73	13%
		113	8.46	7%	43.26	51.73	46%
	24-Hour	200	3.31	2%	36.97	40.28	20%
	Annual	32	0.68	2%	18.73	19.41	61%
SPM	24-Hour	120	16.28	14%	47.79	64.07	53%
	Annual	60	4.33	7%	25.62	29.95	50%
PM_{10}	24-Hour	50	3.22	6%	26.76	29.98	60%
$PM_{2.5}$	24-Hour	25	0.97	4%	14.34	15.30	61%
	Annual	8.8	0.24	3%	7.68	7.92	90%
Acrolein (µg/m³)[(3)]	1-Hour	4.5	0.005	0.1%	—	0.00	0.1%
	24-Hour	0.4	0.001	0.4%	0.07	0.07	18%
Acetaldehyde (µg/m³)[(3)]	24-Hour	500	0.004	0.001%	1.72	1.73	0.3%
1,3-Butadiene (µg/m³)	24-Hour	10	0.0004	0.004%	0.09	0.09	1%
	Annual	2	0.0001	0.003%	0.05	0.05	2%
Benzene (µg/m³)	24-hour	2.3	0.007	0.3%	0.88	0.89	39%
	Annual	0.45	0.002	0%	0.55	0.55	122%
Formaldehyde (µg/m³)[(3)]	24-Hour	65	0.034	0.1%	3.19	3.23	5%

Notes:

(1) Unless otherwise stated.

(2) Background concentration data obtained from the Mississauga station.

(3) Background concentration data obtained from the College station.

Overall, the results of the air quality assessment show that predicted concentrations of all indicator compounds from the road are below the relevant project criteria. Projected future traffic volumes will contribute to increases in particulate concentrations from the roadway, regardless of whether the project is built. For all other indicator compounds, improvements to combustion engine emissions over time appear to contribute to reductions in CO, NO_2 and VOCs relative to 2011 historical emissions, although the magnitude of reduction is less with the Project (Future Build) due to anticipated increases to AADT volumes. For the comparison between the 2031 no building and project scenarios, the Project results in a small increase in all contaminants, although the change is less than 30%. A comparison of the results from each scenario is presented in Table 15, below.

Table 15: Comparison of Future No-Build and Build Predicted Concentrations

Indicator Compound	Averaging Period	2031 - Future No-Build	2031 - Future Build	% Change (Build vs. No-Build)
		Predicted Concentrations	Predicted Concentrations	
CO	1-Hour	63.58	79.74	25%
	8-Hour	43.88	57.28	31%
NO_2	1-Hour	7.33	8.46	16%
	24-Hour	2.68	3.31	24%
	Annual	0.54	0.68	27%
SPM	24-Hour	12.79	16.28	27%
	Annual	3.33	4.33	30%
PM_{10}	24-Hour	2.53	3.22	27%
$PM_{2.5}$	24-Hour	0.76	0.97	27%
	Annual	0.18	0.24	30%
Acrolein (µg/m³)	1-Hour	0.004	0.005	2%
	24-Hour	0.001	0.001	3%
Acetaldehyde (µg/m³)	24-Hour	0.003	0.004	9%
1,3-Butadiene (µg/m³)	24-Hour	0.0004	0.0004	3%
	Annual	0.0001	0.0001	7%
Benzene (µg/m³)	24-hour	0.006	0.007	9%

Indicator Compound	Averaging Period	2031 - Future No-Build	2031 - Future Build	% Change (Build vs. No-Build)
		Predicted Concentrations	Predicted Concentrations	
	Annual	0.0017	0.0018	6%
Formaldehyde (µg/m^3)	24-Hour	0.033	0.034	1%

Background air quality concentrations were added to the predicted concentrations from Airport Road for both modelled scenarios. With the addition of the background concentrations, the concentrations of all Indicator Compounds (except for annual, benzene) are within the Ontario AAQC and CAAQS. The cumulative concentrations of annual averaged benzene exceed the relevant Project Criteria, however, the majority of these concentrations are due to existing background emissions which already include the existing road, as it is already in existence. Airport Road contributes less than 1% of annual benzene concentrations for both the 2031 no-build and 2031- Build scenarios.

7.0 REGIONAL IMPACTS – GREENHOUSE GASES

In addition to the indicator compounds, emissions of greenhouse gases, specifically carbon dioxide were also assessed for the Project. Potential impacts were assessed by reviewing the total CO_2 emissions for the three different scenarios and comparing them to identify the relative change. Total GHG emissions from the different scenarios are provided below in Table 16, the results indicate that overall the Project is expected to result in a slight increase in GHG emissions, although emissions from the project are insignificant compared to Ontario total transportation sector emissions, contributing less than 0.1%.

Table 16: Comparison of CO_2 Emissions to Provincial Totals

Scenario	Annual CO2 Emissions [MT/year]
2011 Historical Conditions	0.006
2031 Future No-Build	0.010
2031 Future Build	0.012
Ontario Provincial Total for Transportation Sector[1]	56.6

Note:
1. Based on 2012 data taken from Ontario's Climate Change Update 2014 (MECP, 2014)

8.0 CONCLUSIONS

A partial air quality impact assessment was completed to assess the impact of widening 1.5 km stretch of Airport Road between Countryside Drive and Braydon Boulevard/Stonecrest Drive in the City of Brampton. The Project includes widening of the existing four lanes of traffic to six lanes. The air quality assessment focussed on a “hot spot” section of the 1.5 km corridor between Eagle Plains Drive and Braydon Boulevard. This area was identified as a hotspot as it has the largest number of critical receptors within 300 m of Airport Road and a high volume of sensitive receptors adjacent to both sides of the road.

Three different scenarios were included in the assessment: 2011 base case emissions based on current road alignment and historical traffic volumes; 2031 emissions based on current road alignment and projected future traffic growth; and 2031 emissions based on projected future traffic growth and future road alignment. Emission rates were calculated using the US EPA MOVES model and dispersion modelling was completed using CAL3QHCR.

The results of the air quality impact assessment indicate that the proposed project will result in increases in predicted concentrations of all indicator compounds, at receptors closest to Airport Road, relative to predicted future conditions without the project. However, when results are compared to the Project Criteria, predicted concentrations of all relevant compounds are below the relevant criteria.

A cumulative assessment was completed using background air quality data taken from local monitoring stations. The background air quality was added to the predicted concentrations from the road and used to provide an estimate of cumulative air quality. The results of this assessment indicate that cumulative concentrations are below the relevant ambient air quality criteria for all indicator compounds with the exception of benzene on an annual averaging period. For this indicator compound, the background air quality concentration is already close to or above the relevant ambient air quality criteria and the road itself contributes less than 1% of the total concentration.

The proposed Project aims to minimize the air quality impact associated with the projected increased traffic for the Study Area through improved traffic flows within the local vicinity of the proposed Project and reduced queuing times at other roads surrounding the proposed Project. Emissions from the proposed Project within the Study Area do not represent a significant contribution to local air quality. As a result, the proposed Project is necessary to help alleviate congestion and the proposed Project will minimize the air quality impact.

Overall, the proposed Project itself is therefore anticipated to be a relatively minor source of emissions, and the impact on overall air quality in the region is expected to be negligible.

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APPENDIX A

Limitations

IMPORTANT INFORMATION AND LIMITATIONS OF THIS REPORT

Standard of Care: Golder Associates Ltd. (Golder) has prepared this report in a manner consistent with that level of care and skill ordinarily exercised by members of the engineering and science professions currently practising under similar conditions in the jurisdiction in which the services are provided, subject to the time limits and physical constraints applicable to this report. No other warranty, expressed or implied is made.

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Unless otherwise stated, the suggestions, recommendations and opinions given in this report are intended only for the guidance of the Client in the design of the specific project. The extent and detail of investigations, including the number of test holes, necessary to determine all of the relevant conditions which may affect construction costs would normally be greater than has been carried out for design purposes. Contractors bidding on, or undertaking the work, should rely on their own investigations, as well as their own interpretations of the factual data presented in the report, as to how subsurface conditions may affect their work, including but not limited to proposed construction techniques, schedule, safety and equipment capabilities.

Soil, Rock and Ground Water Conditions: Classification and identification of soils, rocks, and geologic units have been based on commonly accepted methods employed in the practice of geotechnical engineering and related disciplines. Classification and identification of the type and condition of these materials or units involves judgment, and boundaries between different soil, rock or geologic types or units may be transitional rather than abrupt. Accordingly, Golder does not warrant or guarantee the exactness of the descriptions.

Special risks occur whenever engineering or related disciplines are applied to identify subsurface conditions and even a comprehensive investigation, sampling and testing program may fail to detect all or certain subsurface conditions. The environmental, geologic, geotechnical, geochemical and hydrogeologic conditions that Golder interprets to exist between and beyond sampling points may differ from those that actually exist. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site or on adjacent properties. The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at the site, unless otherwise specifically stated and identified in the report. The presence or implication(s) of possible surface and/or subsurface contamination resulting from previous activities or uses of the site and/or resulting from the introduction onto the site of materials from off-site sources are outside the terms of reference for this project and have not been investigated or addressed.

Soil and groundwater conditions shown in the factual data and described in the report are the observed conditions at the time of their determination or measurement. Unless otherwise noted, those conditions form the basis of the recommendations in the report. Groundwater conditions may vary between and beyond reported locations and can be affected by annual, seasonal and meteorological conditions. The condition of the soil, rock and groundwater may be significantly altered by construction activities (traffic, excavation, groundwater level lowering, pile driving, blasting, etc.) on the site or on adjacent sites. Excavation may expose the soils to changes due to wetting, drying or frost. Unless otherwise indicated the soil must be protected from these changes during construction.

Sample Disposal: Golder will dispose of all uncontaminated soil and/or rock samples 90 days following issue of this report or, upon written request of the Client, will store uncontaminated samples and materials at the Client’s expense. In the event that actual contaminated soils, fills or groundwater are encountered or are inferred to be present, all contaminated samples shall remain the property and responsibility of the Client for proper disposal.

Follow-Up and Construction Services: All details of the design were not known at the time of submission of Golder’s report. Golder should be retained to review the final design, project plans and documents prior to construction, to confirm that they are consistent with the intent of Golder’s report.

During construction, Golder should be retained to perform sufficient and timely observations of encountered conditions to confirm and document that the subsurface conditions do not materially differ from those interpreted conditions considered in the preparation of Golder’s report and to confirm and document that construction activities do not adversely affect the suggestions, recommendations and opinions contained in Golder’s report. Adequate field review, observation and testing during construction are necessary for Golder to be able to provide letters of assurance, in accordance with the requirements of many regulatory authorities. In cases where this recommendation is not followed, Golder’s responsibility is limited to interpreting accurately the information encountered at the borehole locations, at the time of their initial determination or measurement during the preparation of the Report.

Changed Conditions and Drainage: Where conditions encountered at the site differ significantly from those anticipated in this report, either due to natural variability of subsurface conditions or construction activities, it is a condition of this report that Golder be notified of any changes and be provided with an opportunity to review or revise the recommendations within this report. Recognition of changed soil and rock conditions requires experience and it is recommended that Golder be employed to visit the site with sufficient frequency to detect if conditions have changed significantly.

Drainage of subsurface water is commonly required either for temporary or permanent installations for the project. Improper design or construction of drainage or dewatering can have serious consequences. Golder takes no responsibility for the effects of drainage unless specifically involved in the detailed design and construction monitoring of the system.

APPENDIX B

Example Model Input File

```
'AIRPORT ROAD TWO WAY ROAD'  60. 108.  0. 0.  48  1 0
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 61587 11  61587 11
 1 1 'U'
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'NB REC 4'       1555      7702      1.8
'NB REC 5'       1568      7689      1.8
'NB REC 6'       1581      7676      1.8
'NB REC 7'       1594      7663      1.8
'NB REC 8'       1607      7650      1.8
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'NB REC 14'      1685      7572      1.8
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'NB REC 18'      1737      7520      1.8
'NB REC 19'      1750      7507      1.8
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'NB REC 21'      1776      7481      1.8
'NB REC 22'      1789      7468      1.8
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'SB REC 21'      1748      7410      1.8
'SB REC 22'      1762      7396      1.8
'S1'           1297      7521      1.8
'REC1'         1441      7728      1.8
'REC2'         1775      7388      1.8

2 'P'
1 1 1 1 1 1 1
'AIRPORT ROAD HOT SPOT'      3
   1  1
'Airport Rd NB    ' 'AG'    1782.   7421.   1489.   7713.   0.   17.
   2  1
'Airport Rd SB     ' 'AG'    1489.   7713.   1782.   7421.   0.   17.
   3  2
'SB queue to Braydon  '         'AG'        1668.   7526.   1763.   7432.   0.   14.  4.

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  2  525.   5.54E-02
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  2  525.   5.54E-02
  3  90.  40.  3.  525.   4.56E-01  1600.  1.  3.
3  0
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  2  525.   5.54E-02
  3  90.  40.  3.  525.   4.56E-01  1600.  1.  3.
4  0
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  2  525.   5.54E-02
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5  0
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  2  525.   5.54E-02
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  2  525.   5.54E-02
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  2  2363.   5.54E-02
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  2  2363.   5.54E-02
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18  0
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23  0
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  2  2363.   5.54E-02
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  2  525.   5.54E-02
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