APPENDIX C9

Air Quality

Local Air Quality Assessment
Class Environmental Assessment for Kirby Road Extension Municipal Class EA, City of Vaughan

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1.0 Introduction

Novus Environmental Inc. (Novus) was retained by Rizmi Holdings Ltd. to conduct an air quality assessment as part of the Municipal Class Environmental Assessment for the Kirby Road Extension between Dufferin Street and Bathurst Street in Vaughan, Ontario. The project includes two kilometers of a new 4-lane roadway with that will connect the current Kirby Road west of Dufferin Street to Gamble Road east of Bathurst Street. This report assesses the impacts of the new roadway at nearby sensitive receptors, as well as at the proposed residential development located at the southeast corner of Dufferin Street and Kirby Road. The study area is approximately 2 km in length and is shown in orange in **The remainder** of this report considers the assessment of Alignment 5.

Figure 1.

Note that this assessment considers the roadway alignment plans provided to Novus in October 2018, known as Alignment 5. The roadway alignment was recently modified in 2019, with the new alignment referred to as Aignment 5A. The new alignment includes shifting a small portion of the roadway to the south. The proposed shift begins approximately 300 metres east of the Kirby Road/Dufferin Street intersection and ends approximately 900 metres west of the Kirby Road/Bathurst Street intersection. At these distances, the proposed shift is not expected to affect any of the study findings near these intersections, where worst-case impacts are predicted to occur. Further details regarding the change in roadway alignment are discussed in **Section 6.0**. The remainder of this report considers the assessment of Alignment 5.

Figure 1: Study Area Showing the Proposed Alignment 5 (In Orange)

1.1 Study Objectives

The main objective of the study was to assess the local air quality impacts due to the proposed extension of Kirby Road, between Dufferin Street and Bathurst Street. The study also included an assessment of total greenhouse (GHG) emissions due to the project, and an overview of construction impacts. To meet these objectives, the following scenario was considered:

- **2031 Future Build** – Assessment of the future air quality conditions for the proposed roadway. Predicted contaminant concentrations from the proposed roadway were combined with hourly measured ambient concentrations to determine the combined impact.

1.2 Contaminants of Interest

The contaminants of interest for this study have been chosen based on the regularly assessed contaminants of interest for transportation assessments in Ontario, as determined by the Ministry of Transportation Ontario (MTO) and Ministry of the Environment, 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), the MECP, Environment Canada (EC), Health Canada (HC), and the MTO. These contaminants are emitted due to fuel combustion, brake wear, tire wear, the breakdown of dust on the roadway, fuel leaks, evaporation and permeation, and refuelling leaks and spills as illustrated in **Figure 2**. Note that emissions related to refuelling leaks and spills are not applicable to motor vehicle emissions from roadway travel. Instead, these emissions contribute to the overall background levels of the applicable contaminants. All of the selected contaminants are emitted during fuel combustion, 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**.

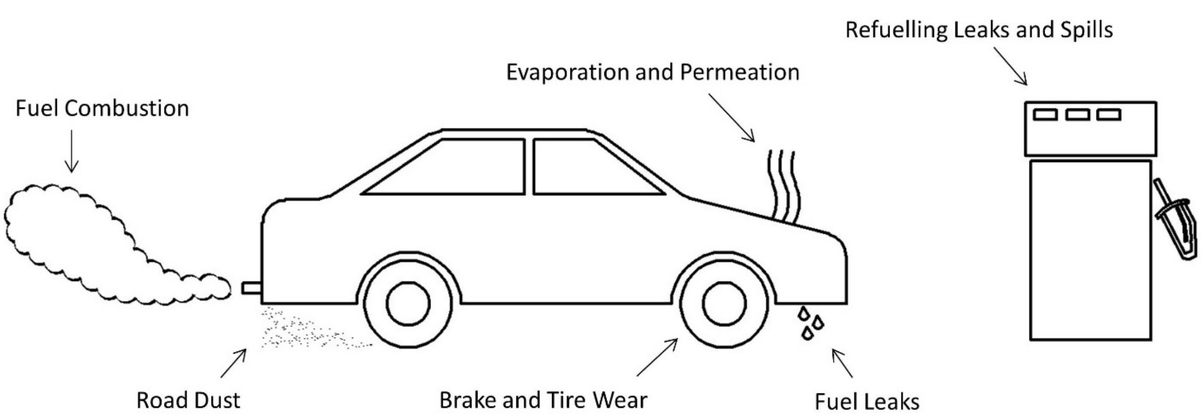


Figure 2: Motor Vehicle Emission Sources

Table 1: Contaminants of Interest

Contaminants		Volatile Organic Compounds (VOCs)	
Name	**Symbol**	**Name**	**Symbol**
Nitrogen Dioxide	NO_2	Acetaldehyde	C_2H_4O
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

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

- MECP Ambient Air Quality Criteria (AAQC);
- 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 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 standards are based on different averaging methods, as noted at the bottom of **Table 2**. It should also be noted that the 1-hour and annual CAAQs for NO_2 have been included in **Table 2** for comparative purposes, but are not included in the detailed analysis, as per the most recent direction by the MECP. The $PM_{2.5}$ standard was adopted previously by the MECP and is assessed against.

Table 2: Applicable Contaminant Guidelines

Contaminant	Averaging Period (hrs)	Threshold Value (µg/m³)	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
Formaldehyde	24	65	AAQC

[1] The 1-hour NO_2 CAAQs is based on the 3-year average of the annual 98th percentile of the NO_2 daily-maximum 1-hour average concentrations
[2] 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 annual 98th percentile concentration, averaged over three consecutive years
[2] 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. 2012-2016 historical meteorological data from Toronto Pearson Airport was used. Five years were modelled in order to capture the worst-case meteorological conditions. One emission scenario was assessed: 2031 Future Build.

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.

Local background concentrations are presented in **Section 2.0**. Impacts due to the roadway for the 2031 Future Build scenario are presented in **Section 3.8**.

2.0 Background Ambient Data

2.1 Overview

Background (ambient) conditions are measured 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**.

High $PM_{2.5}$ Days	Average $PM_{2.5}$ of Spring/Summer Season

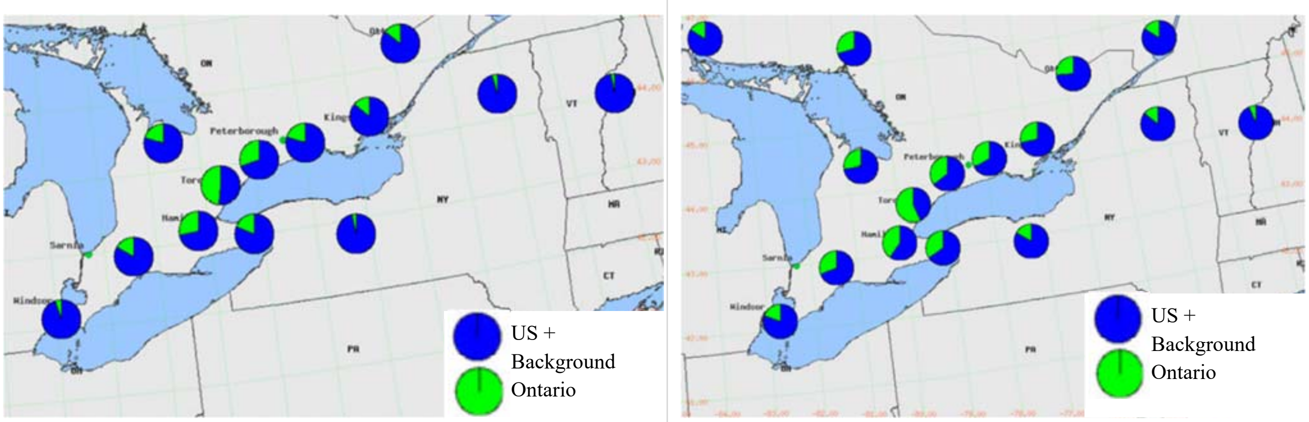


Figure 3: Effect of Trans-Boundary Air Pollution (MECP, 2005)

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.

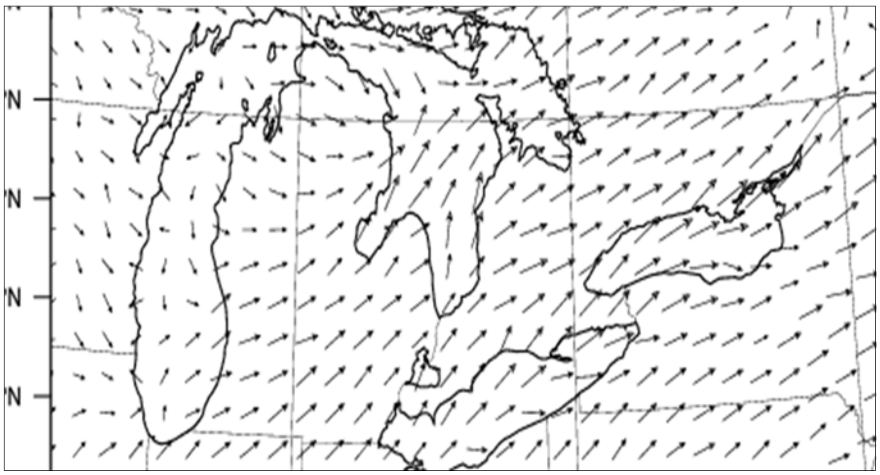


Figure 4: Typical Wind Direction during an Ontario Smog Episode

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 utilizing existing ambient monitoring data from MECP and NAPS Network stations and added to the modelled predictions in order 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. Four MECP (Newmarket, Toronto North, Toronto East and Toronto West) and five NAPS (Newmarket, Etobicoke South, Etobicoke North, Brampton and Windsor) stations were selected for the analysis. 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: Relevant MECP (shown in red) and NAPS (shown in green) Monitoring Stations; NAPS Station Not Shown; Study Area in Orange

Table 3: Relevant MECP and NAPS Station Information

City/Town	Station ID	Location	Operator	Contaminants
Newmarket	48006	Eagle St. W./Mc Caffrey Rd	MECP	NO_2 | $PM_{2.5}$
Toronto East	33003	Kennedy Rd./Lawrence Ave. E.	MECP	NO_2 | $PM_{2.5}$
Toronto North	34020	Hendon Ave./Young St.	MECP	NO_2 | $PM_{2.5}$
Toronto West	35125	125 Resources Rd	MECP	CO | NO_2 | $PM_{2.5}$
Newmarket	65101	Eagle St. W./Mc Caffrey Rd	NAPS	1,3-Butadiene | Benzene
Brampton	60428	525 Main St	NAPS	1,3-Butadiene | Benzene
Etobicoke North	60413	Elmcrest Road	NAPS	1,3-Butadiene | Benzene
Etobicoke South	60435	461 Kipling Ave	NAPS	1,3-Butadiene | Benzene
Windsor	60211	College St/Prince St	NAPS	Formaldehyde | Acetaldehyde | Acrolein

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

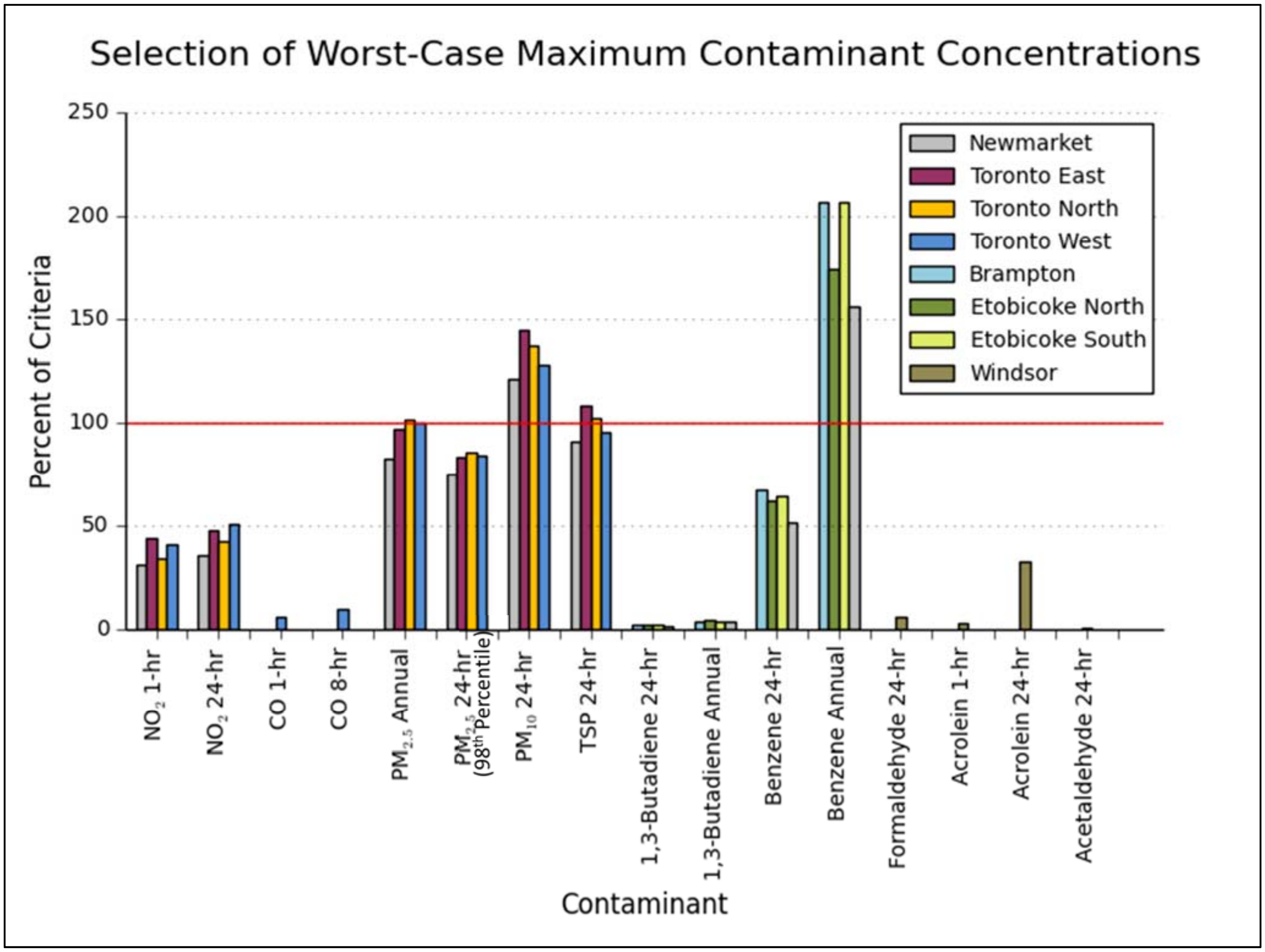
2.3 Selection of Worst-Case Monitoring Stations

Year 2012 to 2016 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 at the Etobicoke North and Brampton NAPS stations, minimal data was available in 2016, therefore, 2011-2015 data was used for these stations. Formaldehyde, acetaldehyde and acrolein are only recently measured at the Windsor station, and were not measured after 2013. Therefore 2009-2013 data was used for these VOCs. For consistency with the combined effects analysis (using 2012-2016 meteorological data to predict roadway concentrations), the actual date of measured VOC data within dataset was used when possible.

The station with the highest maximum value over the five-year period for each contaminant and averaging period was selected to represent background concentrations in the study area. The maximum concentration represents an absolute worst-case background scenario. 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 6 days between measurements. When there was greater than 6 days between measurements, the 90th percentile measured value for the year in question was applied for those days in order 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.

Following the above methodology, the worst-case concentrations for each contaminant and averaging period were summarized for each of the selected monitoring stations. The station with the highest concentration, for each contaminant and averaging period, was selected for the analysis. Error! Not a valid bookmark self-reference. shows a comparison of the contaminant concentrations from each station and the selection of the worst-case station.

Table 4: Comparison and Selection of Background Concentrations



Note: PM_{10} and TSP are not measured in Ontario; therefore, background concentrations were estimated from $PM_{2.5}$ concentrations

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

Note that the NO_2 1-hr and annual CAAQS are not shown in the graph above; the maximum 1-hr concentration at the Toronto East station is 176 µg/m^3 or 222% of the CAAQS and the maximum annual concentration at the Toronto West station is 33.78 µg/m^3 or 147% of the

CAAQS. As the CAAQS are new standards which don't come into effect until 2025, they have been included in this assessment for comparison purposes only. The one-hour standard has not been assessed based on the 3-year average of the annual 98th percentile of the NO_2 daily-maximum 1-hour average concentrations, and the annual averaging period has not been assessed for NO_2. This is in accordance with guidance from the MECP.

2.4 Detailed Analysis of Selected Worst-case Monitoring Stations

A detailed statistical analysis of the selected worst-case background monitoring station for each of the contaminants 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 worst-case day. The 90th percentile concentration represents a day with reasonably worst-case background concentrations, and the average concentration represents a typical day. 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 2012-2016, all background concentrations were below their respective guidelines with the exception of 24-hour PM_{10}, 24-hour TSP, and annual $PM_{2.5}$ and benzene. It should be noted that PM_{10} and TSP were calculated based on their relationship to $PM_{2.5}$.

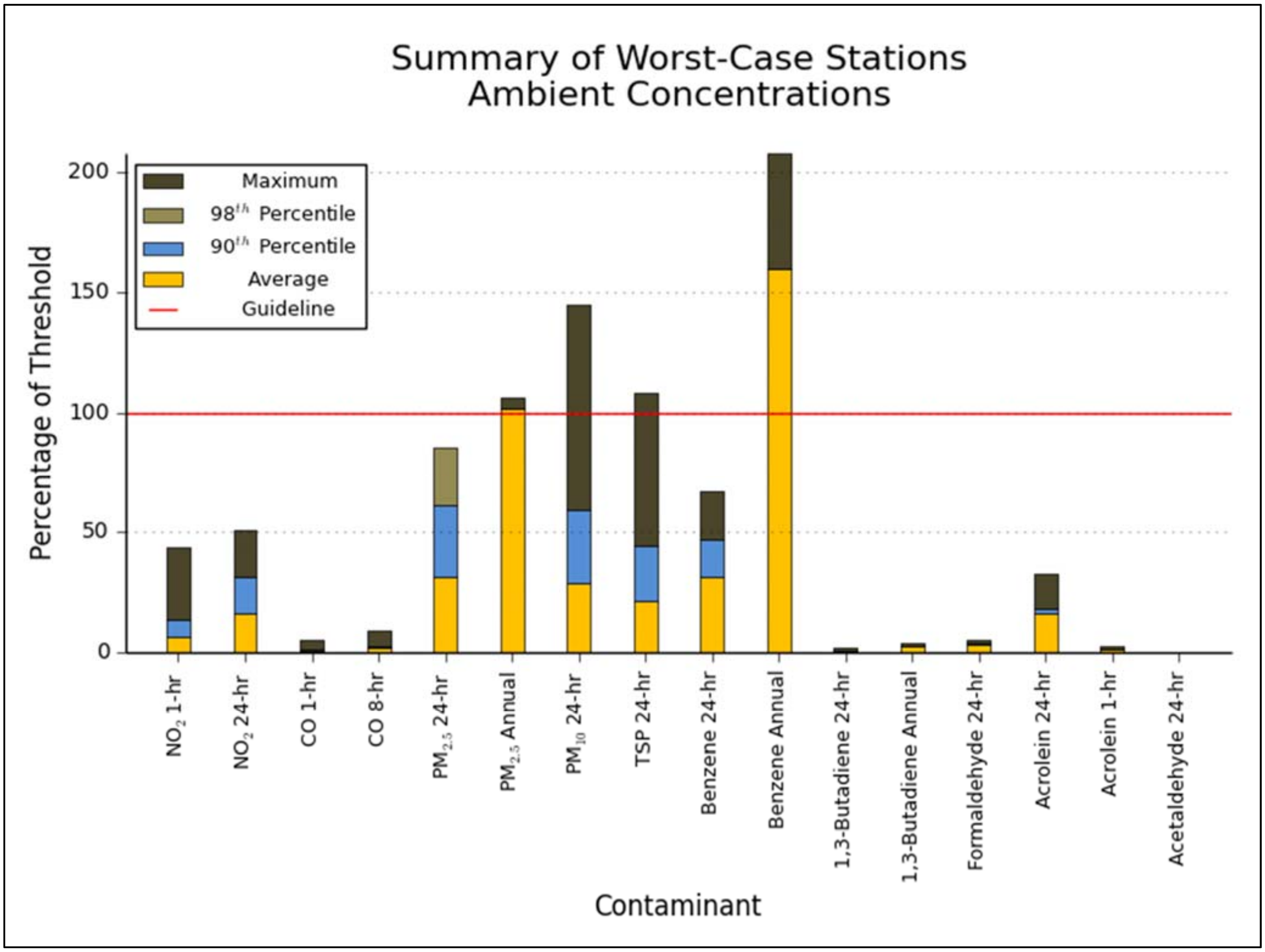


Figure 6: Summary of Background Conditions Applied in the Assessment

3.0 Local Air Quality Assessment

3.1 Overview

The worst-case impacts due to roadway vehicle emissions were assessed for the 2031 Future Build (FB) scenario. The scenario includes the following activities:

2031 Future Build (FB):

- Projected vehicle volumes on the new Kirby Road and arterial roads for the proposed alignment.

The assessment was performed using U.S. EPA approved vehicle emission and air dispersion models to predict worst-case impacts at representative sensitive receptor locations. The assessment was conducted in accordance with the MTO *Environmental Guide for Assessing* *and Mitigating the Air Quality Impacts and Greenhouse Gas Emissions of Provincial Transportation Projects*. The details of the assessment are discussed below.

3.2 Location of Sensitive Receptors within the Study Area

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

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

Ten sensitive receptors were evaluated to represent worst-case impacts surrounding the project area. All receptors represent the nearest existing residential properties, as well as the proposed residential development at the southeast corner of Dufferin Street and Kirby Road. We understand an application for approval of this new subdivision has been submitted to the City of Vaughan. Therefore, it was included as a sensitive receptor in the air quality assessment, in the case that it gets approved. The receptor locations are identified in **Figure 7**.

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

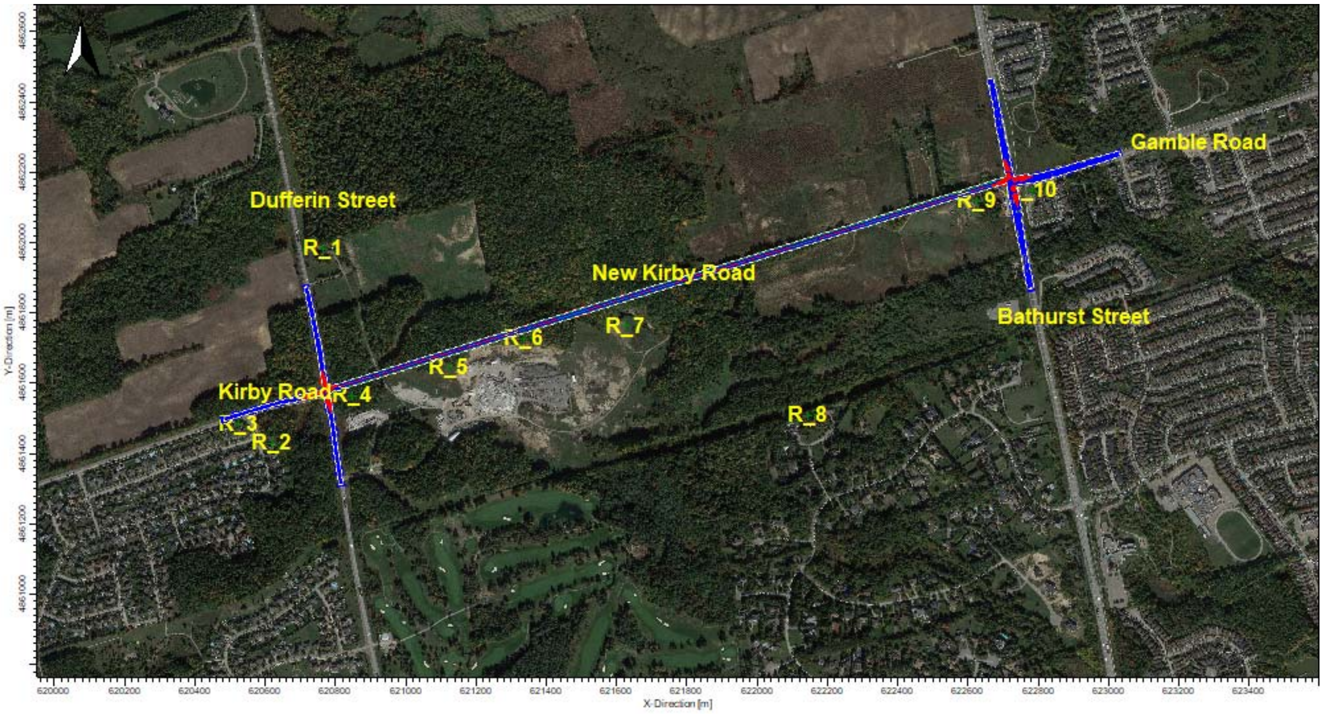


Figure 7: Receptors R1-R10 Locations Within the Study Area (New Kirby Road Extension)

3.3 Road Traffic Data

Traffic data used in this assessment was taken from the *Kirby Road EA Need and Justification Report*, prepared by Poulous & Chung Limited. Traffic data in this report was was provided in the form of Forecast 2031 Am/PM Peak Hour Volumes (with and without GTA West). Annual Average Daily Traffic (AADT) volumes were determine from the PM peak hour volumes, assuming peak hour is 10% of daily traffic. The AADT volumes used in the assessment are shown in **Table 5**. A heavy duty vehicle percentage of 20% for the new roadway was also provided. It was assumed this would be 10% medium and 10% heavy duty vehicles, to be conservative. Since hourly traffic volumes are not available, as it is a new roadway, the US EPA standard off-network and urban weekday hourly distribution was used. This hourly distribution is shown in **Table 6**. Lastly, signal timing was provided by Schaeffers Consulting Engineers for all traffic lights within the study area.

Table 5: 2031 Traffic Volumes (AADT) Used in the Assessment

Roadway	FB 2031 AADT	Speed (km/hr)
Dufferin St. North of Kirby Rd.	10,520	70
Dufferin St. South of Kirby Rd.	11,260	60
Bathurst St. North of Kirby Rd./Gamble Rd.	34,080	70
Bathurst St. South of Kirby Rd./Gamble Rd.	34,710	70
Kirby Rd. West of Dufferin St.	21,360	60
Kirby Rd. Dufferin St. to Bathurst St.	23,670	60
Gamble Rd. East of Bathurst St.	22,750	60

Table 6: US EPA Off-Network, Urban, Weekday, Hourly Vehicle Distribution

Hour	MON	TUE	WED	THU	FRI	SAT	SUN
1	0.9%	0.9%	0.9%	0.9%	0.9%	2.2%	2.2%
2	0.6%	0.6%	0.6%	0.6%	0.6%	1.4%	1.4%
3	0.5%	0.5%	0.5%	0.5%	0.5%	1.0%	1.0%
4	0.4%	0.4%	0.4%	0.4%	0.4%	0.8%	0.8%
5	0.6%	0.6%	0.6%	0.6%	0.6%	0.7%	0.7%
6	1.9%	1.9%	1.9%	1.9%	1.9%	1.0%	1.0%
7	4.6%	4.6%	4.6%	4.6%	4.6%	1.9%	1.9%
8	6.9%	6.9%	6.9%	6.9%	6.9%	2.6%	2.6%
9	6.1%	6.1%	6.1%	6.1%	6.1%	3.8%	3.8%
10	5.0%	5.0%	5.0%	5.0%	5.0%	4.8%	4.8%
11	5.1%	5.1%	5.1%	5.1%	5.1%	5.9%	5.9%
12	5.4%	5.4%	5.4%	5.4%	5.4%	6.5%	6.5%
13	5.8%	5.8%	5.8%	5.8%	5.8%	7.1%	7.1%
14	5.9%	5.9%	5.9%	5.9%	5.9%	7.1%	7.1%
15	6.2%	6.2%	6.2%	6.2%	6.2%	7.1%	7.1%
16	7.1%	7.1%	7.1%	7.1%	7.1%	7.2%	7.2%
17	7.7%	7.7%	7.7%	7.7%	7.7%	7.1%	7.1%
18	7.9%	7.9%	7.9%	7.9%	7.9%	6.8%	6.8%
19	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%	6.0%
20	4.4%	4.4%	4.4%	4.4%	4.4%	5.2%	5.2%
21	3.5%	3.5%	3.5%	3.5%	3.5%	4.3%	4.3%
22	3.1%	3.1%	3.1%	3.1%	3.1%	3.9%	3.9%
23	2.5%	2.5%	2.5%	2.5%	2.5%	3.2%	3.2%
24	1.9%	1.9%	1.9%	1.9%	1.9%	2.4%	2.4%

3.4 Meteorological Data

2012-2016 hourly meteorological data was obtained from the Pearson International Airport in Toronto and 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: Wind Frequency Diagram for Toronto Pearson International Airport (2012-2016)

13. As can be seen in this figure, predominant winds are from the south-westerly through northerly directions.

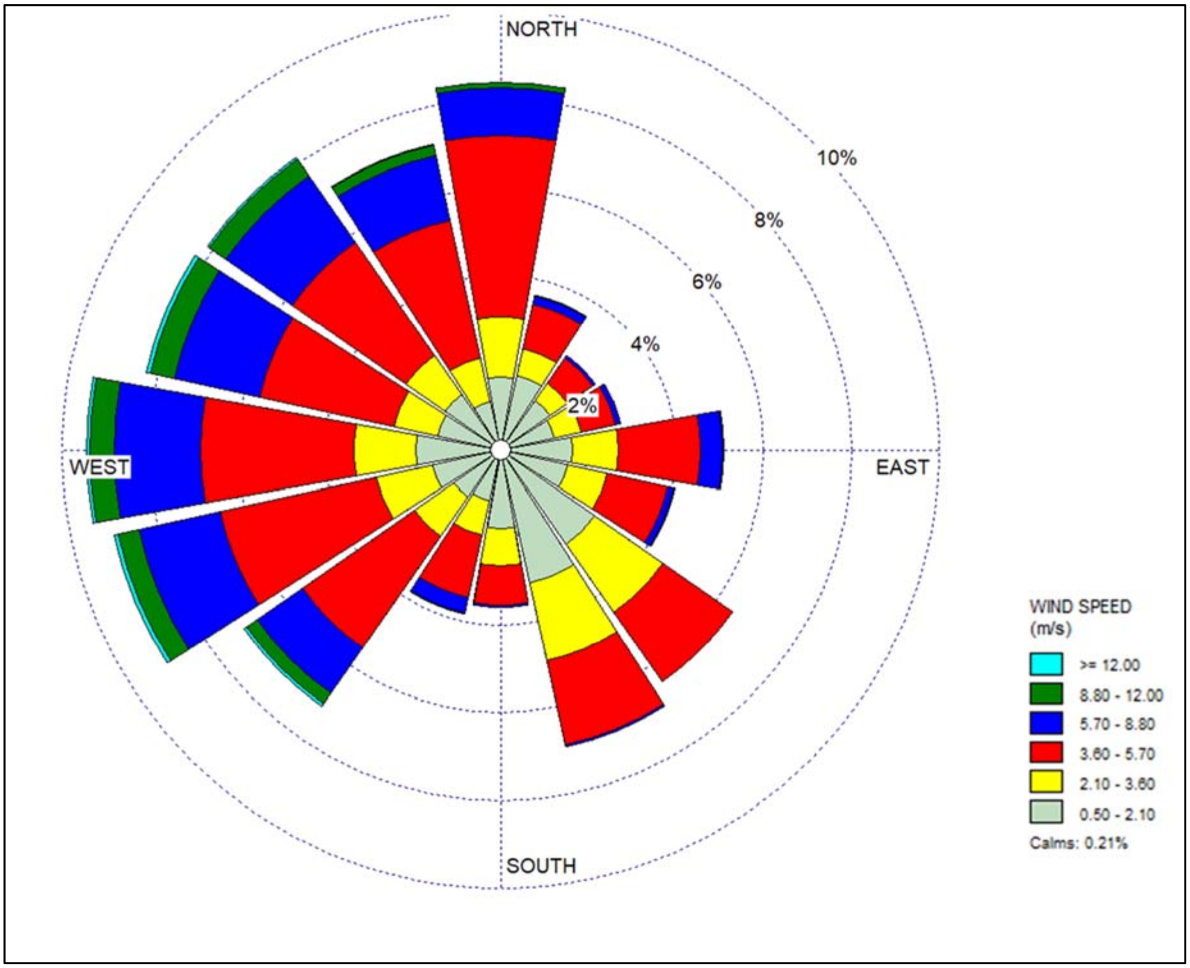


Figure 8: Wind Frequency Diagram for Toronto Pearson International Airport (2012-2016)

3.5 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 2014a, released in November 2015, is the U.S. EPA's latest 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 provided by Poulos & Chung Vehicle age was based on the U.S. EPA’s default distribution. **Table 7** specifies the major inputs into MOVES.

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 Toronto INTL A station for the years 2012to 2016.
Years	2031 (Future Build)
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/Equivalent CO_2 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 PM10 exhaust emission rate was used for TSP.
Vehicle Age Distribution	MOVES defaults based on years selected for the roadway.

From the MOVES outputs, the highest monthly value 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 Future Build year.

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

Year	Speed	NO_x	CO	$PM_{2.5}$	PM_{10}	TSP[1]	Acetaldehyde	Acrolein	Benzene	1,3-Butadiene	Formaldehyde
2031	Idle	1.39	2.75	0.083	0.091	0.091	0.0087	0.0013	0.0117	0.0002	0.0252
	60 km/h	0.217	1.17	0.0063	0.007	0.007	0.0006	0.0001	0.0010	0.00001	0.0017
	70 km/h	0.205	1.06	0.0057	0.006	0.006	0.0005	0.0001	0.0009	0.00001	0.0014

[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.

3.6 Re-suspended Particulate Matter Emission Rates

A large portion of roadway particulate matter emissions comes from dust on the pavement which is re-suspended by vehicles travelling on the roadway. These emissions are estimated using empirically derived values presented by the U.S. EPA in their AP-42 report. The emissions factors for re-suspended PM were estimated by using the following equation from U.S. EPA's Document AP-42 report, Chapter 13.2.1.3 and are summarized in **Table 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/VMT)		
				PM2.5	PM10	TSP
<500	0.25/1.0/5.24	0.6	3	0.503	2.015	10.561
500-5,000	0.25/1.0/5.24	0.2	3	0.185	0.741	3.886
5,000-10,000	0.25/1.0/5.24	0.06	3	0.061	0.247	1.299
>10,000	0.25/1.0/5.24	0.03	3	0.03299	0.13195	0.6914

3.7 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. Emission rates from the MOVES output were input in grams/VMT or grams per vehicle hour. Signal timings for the traffic signal were input in seconds.
Meteorological Data	2012-2016 data from Pearson International Airport
Deposition Velocity	$PM_{2.5}$: 0.1 cm/s PM_{10}: 0.5 cm/s TSP: 0.15 cm/s NO_2, CO and VOCs: 0 cm/s
Settling Velocity	$PM_{2.5}$: 0.02 cm/s PM_{10}: 0.3 cm/s TSP: 1.8 cm/s CO, NO_2, and VOCs: 0 cm/s
Surface Roughness	The land type surrounding the project site is categorized as 'low intensity residential'. The average surface roughness height for low intensity residential for all seasons of 52 cm was applied in the model.
Vehicle Emission Rate	Emission rates calculated in MOVES and AP-42 were input in g/VMT

3.8 Modelling Results

Presented below are the modelling results for the 2031 Future Build 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 and averaging period (see **Table 11**), which were identified as the maximum combined concentration for the 2031 Future Build scenario. Results for all modelled receptors are provided in **Appendix A.** 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 5-year period.

Table 11: Worst-Case Sensitive Receptors for 2031 Future Build Scenario

Contaminant	Averaging Period	Sensitive Receptor
NO_2	1-hour	10
	24-hour	9
CO	1-hour	10
	8-hour	10
$PM_{2.5}$	24-hour	10
	Annual	10
PM_{10}	24-hour	10
TSP	24-hour	9
Acetaldehyde	24-hour	10
Acrolein	1-hour	3
	24-hour	9
Benzene	24-hour	9
	Annual	10
1,3-Butadiene	24-hour	9
	Annual	10
Formaldehyde	24-hour	10

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, 90^{th} 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 in order to estimate the number of occurrences above the guideline. Provided below are the modelling results for the contaminants of interest.

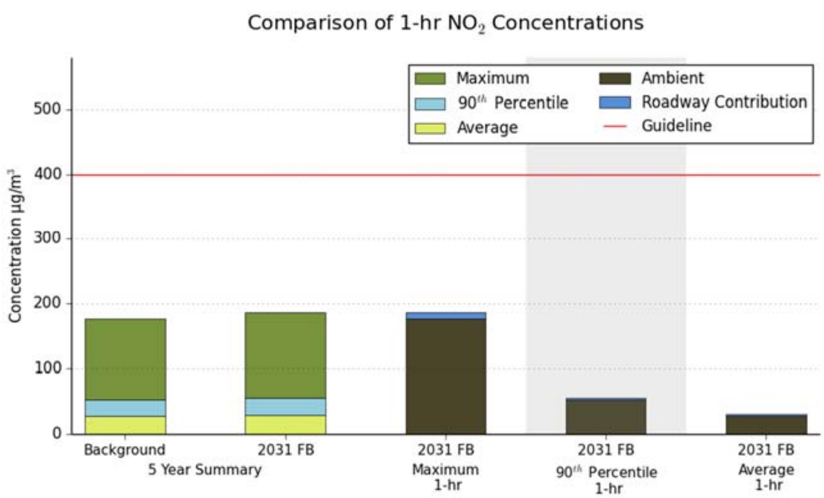
Nitrogen Dioxide

Table 12 presents the predicted combined concentrations for the worst-case sensitive receptor for 1-hour and 24-hour NO_2 based on 5 years of meteorological data. The results conclude:

- *Both the maximum 1-hour and 24-hour NO_2 combined concentrations were below their respective MECP guidelines.*

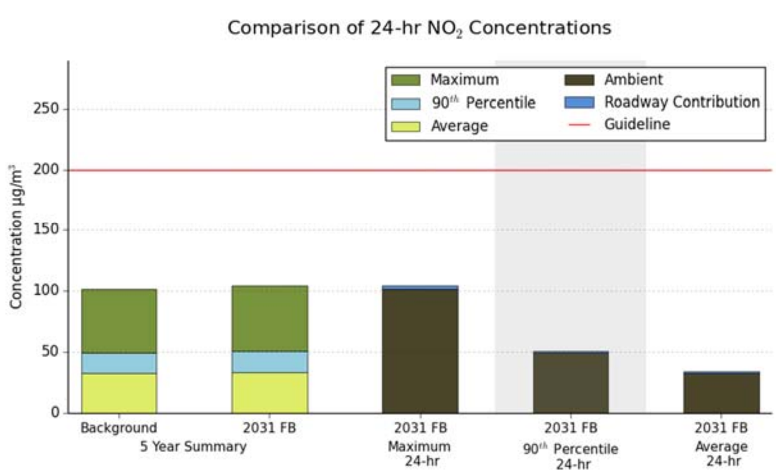
Table 12: Summary of Predicted NO_2 Concentrations

Statistical Analysis	2031 FB	



% of MECP Guideline:	
Maximum	46%
90th Percentile	14%
Average	7%
Roadway Contribution:	
Maximum	5%
90th Percentile	5%
Average	7%

All combined concentrations are below the 1-hour MECP Guideline. Maximum background concentrations alone exceed the CAAQS 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 NO_2 daily-maximum 1-hour average concentrations, which is not included in the analysis.



% of MECP Guideline:	
Maximum	52%
90th Percentile	25%
Average	17%
Roadway Contribution:	
Maximum	3%
90th Percentile	3%
Average	3%

Conclusions:

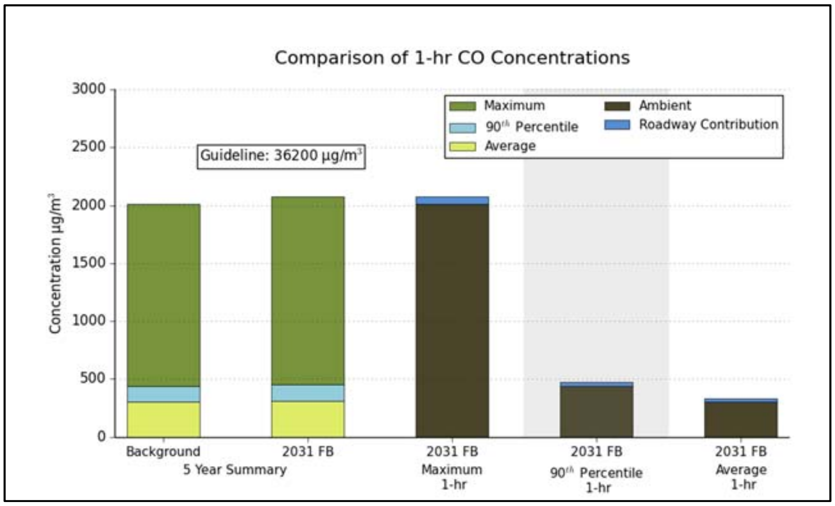
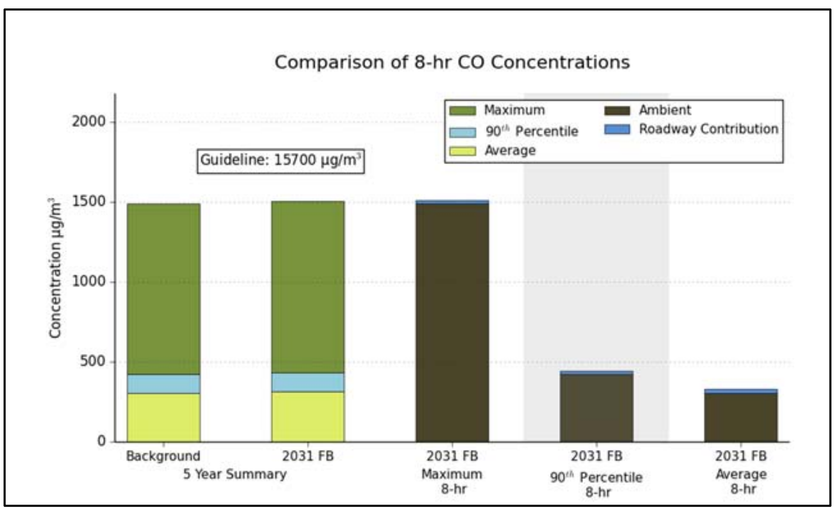
- All combined concentrations were below their respective MECP guidelines.
- The contribution from the roadway to the combined concentrations was 7% or less.
- The annual average for NO_2 has not been assessed, however, the background concentrations alone exceed the CAAQS annual objective of 23 µg/m³.

Carbon Monoxide

Table 13 presents the predicted combined concentrations for the worst-case sensitive receptor for 1-hour and 8-hour CO based on 5 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.*

Table 13: Summary of Predicted CO Concentrations

Statistical Analysis	2031 FB	
	**% of MECP Guideline:**	
	Maximum	6%
	90th Percentile	1%
	Average	1%
	Roadway Contribution:	
	Maximum	3%
	90th Percentile	2%
	Average	3%
	**% of MECP Guideline:**	
	Maximum	10%
	90th Percentile	3%
	Average	2%
	Roadway Contribution:	
	Maximum	4%
	90th Percentile	2%
	Average	3%

Conclusions:

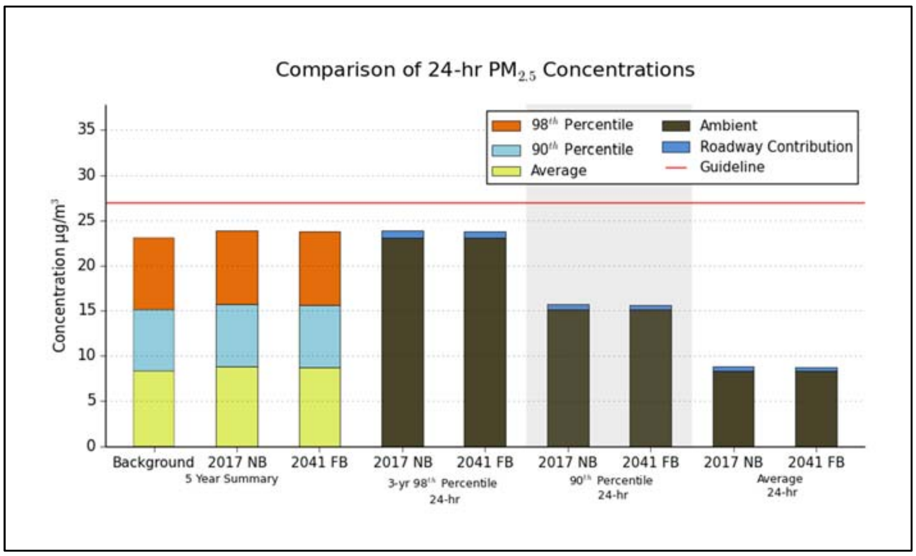
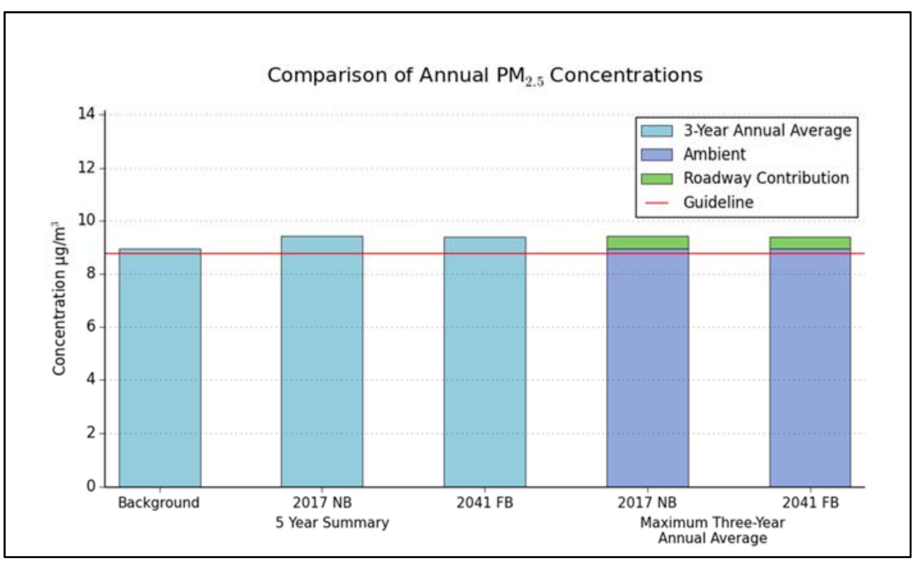
- All combined concentrations were below their respective MECP guidelines.
- The contribution from the roadway to the combined concentrations was 4% or less.

Fine Particulate Matter ($PM_{2.5}$)

Table 14 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour and annual $PM_{2.5}$ based on 5 years of meteorological data. The results conclude that:

- *The average annual 98th percentile 24-hour $PM_{2.5}$ combined concentrations, averaged over three consecutive years was below the CAAQS.*
- *The three-year annual average concentration exceeded the guideline with a 3% contribution from the roadway*

Table 14: Summary of Predicted $PM_{2.5}$ Concentrations

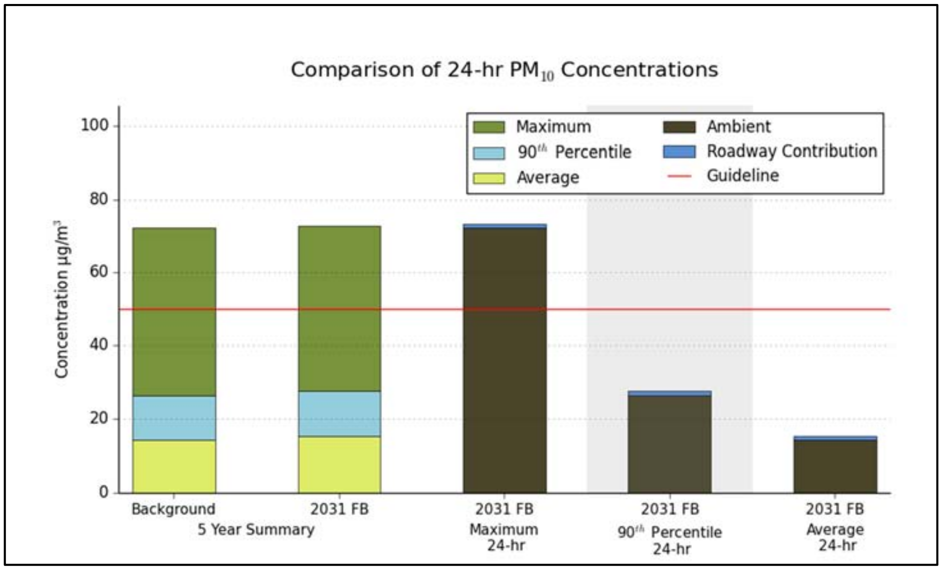
Statistical Analysis	2031 FB	
	**% of CAAQs Guideline:**	
	98th Percentile	86%
	90th Percentile	57%
	Average	32%
	Roadway Contribution:	
	98th Percentile	4%
	90th Percentile	2%
	Average	6%
	The $PM_{2.5}$ results were below the 3-year CAAQS. The highest 3 year rolling average of the yearly 98th percentile combined concentrations was calculated to be 23.35 µg/m³ or 86% of the CAAQS.	
	**% of CAAQs Guideline:**	
	3-Year Annual Average	109%
	Roadway Contribution:	
	3-Year Annual Average	3%
	The $PM_{2.5}$ results were above the 3-year CAAQS. The maximum 3-year annual average concentration was 109% of the guideline. It should be noted that ambient concentrations alone were 105% of the guideline.	

Coarse Particulate Matter (PM_{10})

Table 15 presents the predicted combined concentration for the worst-case sensitive receptor for 24-hour PM_{10} based on 5 years of meteorological data. The results conclude that:

- *The maximum 24-hr PM_{10} combined concentration exceeded the MECP guideline.*

Table 15: Summary of Predicted PM_{10} Concentrations



Statistical Analysis	2031 FB	
	% of MECP Guideline:	
	Maximum	146%
	90^{th} Percentile	55%
	Average	31%
	Roadway Contribution:	
	Maximum	1%
	90^{th} Percentile	5%
	Average	7%

Conclusions:

- The combined concentrations of PM_{10} surrounding the study area exceed the standard of 50 µg/m^3. It should be noted, however, that background concentrations alone exceeded the standard and that the roadway contribution is 1% of the maximum value.
- Frequency analysis was conducted to determine the frequency of exceedances over the 5-year period.
- A total of 15 days exceeded the guideline in the five-year period, which equates to less than 1% of the time.
- Frequency analysis showed that no additional exceedances are expected due to the roadway over the five-year period, when comparing the background concentrations and the 2031 Future Build scenario.

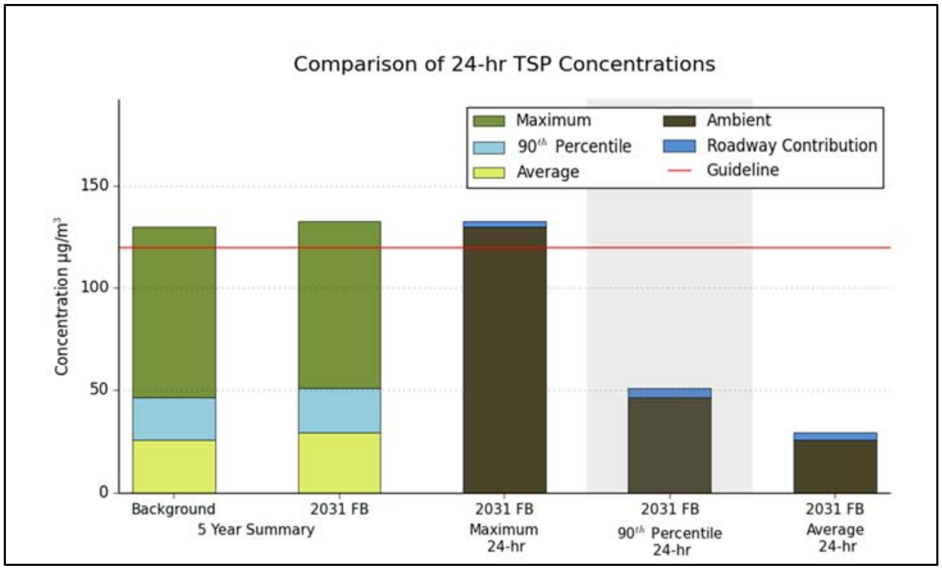
Total Suspended Particulate Matter (TSP)

Table 16 presents the predicted combined concentration for the worst-case sensitive receptor for 24-hour TSP based on 5 years of meteorological data. The results conclude that:

- *The maximum 24-hr TSP combined concentration exceeded the MECP guideline.*

Table 16: Summary of Predicted TSP Concentrations

Statistical Analysis | **2031 FB**



2031 FB	
% of MECP Guideline:	
Maximum	111%
90th Percentile	42%
Average	24%
Roadway Contribution:	
Maximum	2%
90th Percentile	9%
Average	13%

Conclusions:

- The TSP results show that the combined concentrations exceed the guideline. It should be noted, however, that background concentrations alone exceeded the standard and that the roadway contribution is 2% of the maximum value.
- Frequency analysis was conducted to determine the frequency of exceedances over the 5-year period.
- 1 day exceeded the guideline in the five-year period in, which equates to less than 1%.
- Frequency analysis showed that no additional exceedances are expected due to the roadway over the five-year period , when comparing the background concentrations and the 2031 Future Build scenario.

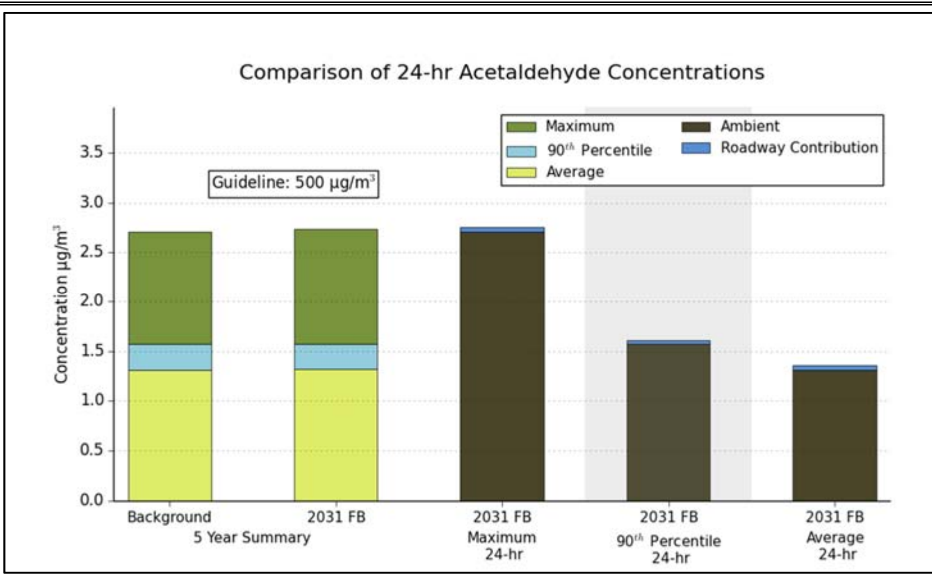
Ambient VOC concentrations are typically measured every 6 days in Ontario. In order to combine the ambient data to the modelled results, the measured concentrations were applied to the following 6 days when measurements were 6 days apart. When measurements were further than 6 days apart, the 90th percentile 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.

Acetaldehyde

Table 17 presents the predicted combined concentration for the worst-case sensitive receptor for 24-hour acetaldehyde based on 5 years of meteorological data. The results conclude that:

- *The maximum 24-hour acetaldehyde combined concentration was well below the respective MECP guideline.*

Table 17: Summary of Predicted Acetaldehyde Concentrations



Statistical Analysis	2031 FB	
(chart above)	**% of MECP Guideline:**	
	Maximum	<1%
	90th Percentile	<1%
	Average	<1%
	Roadway Contribution:	
	Maximum	<1%
	90th Percentile	<1%
	Average	<1%

Conclusions:

- All combined concentrations were below their respective MECP guidelines.
- The contribution from the roadway to the combined concentrations was less than 1%.

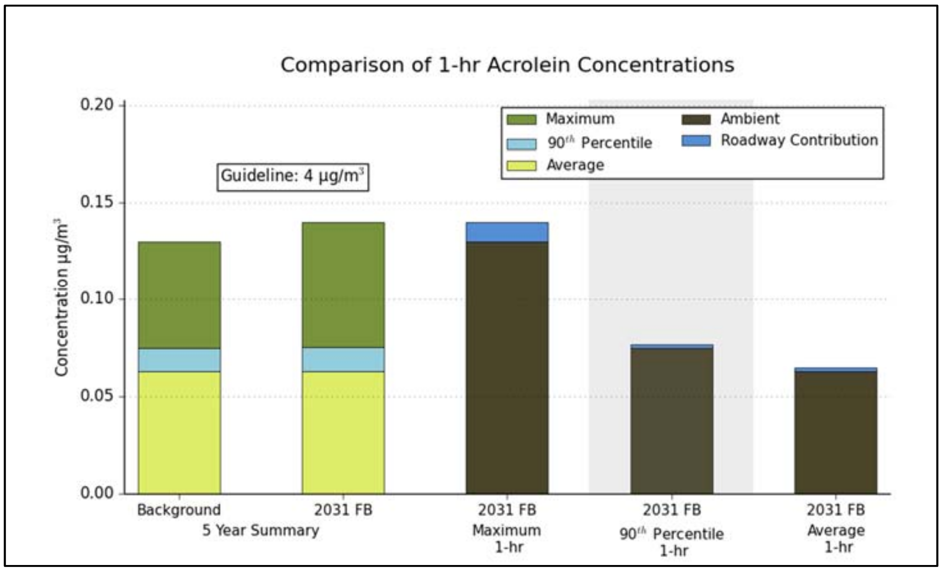
Acrolein

Table 18 presents the predicted combined concentrations for the worst-case sensitive receptor for 1-hour and 24-hour acrolein based on 5 years of meteorological data. The results conclude that:

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

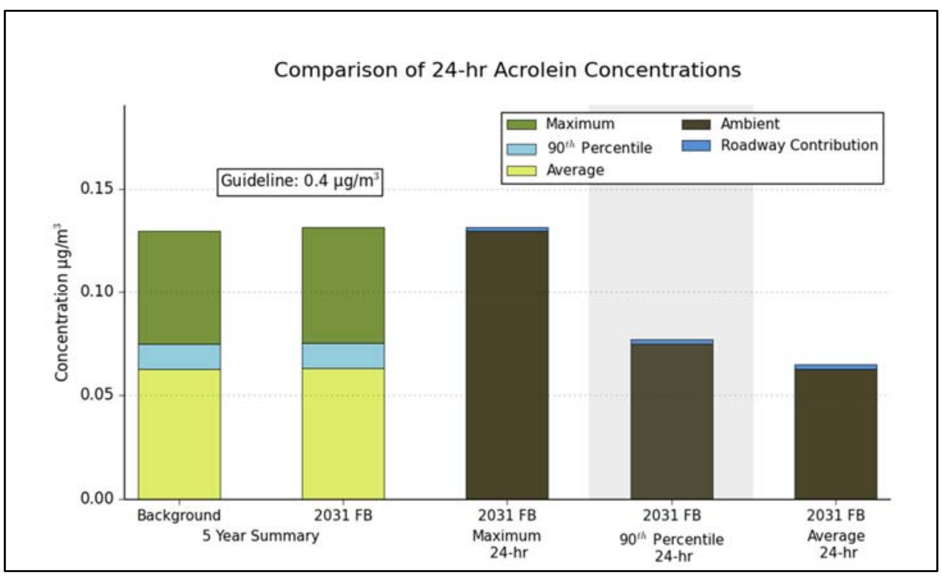
Table 18: Summary of Predicted Acrolein Concentrations

Statistical Analysis	2031 FB



% of MECP Guideline:	
Maximum	3%
90th Percentile	2%
Average	1%
Roadway Contribution:	
Maximum	7%
90th Percentile	<1%
Average	<1%

Conclusions:
The combined concentrations were below the respective MECP guidelines. The contribution from the roadway was 7% or less.



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

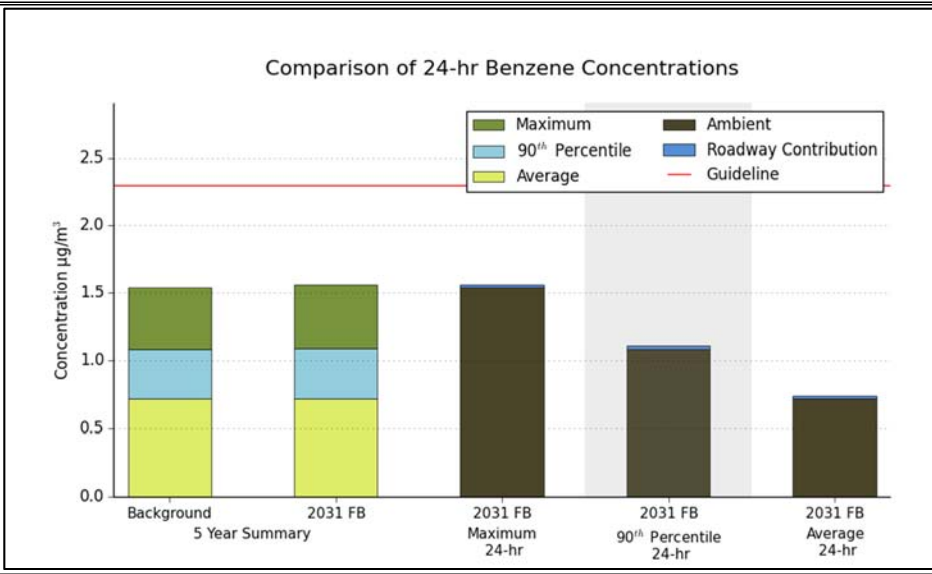
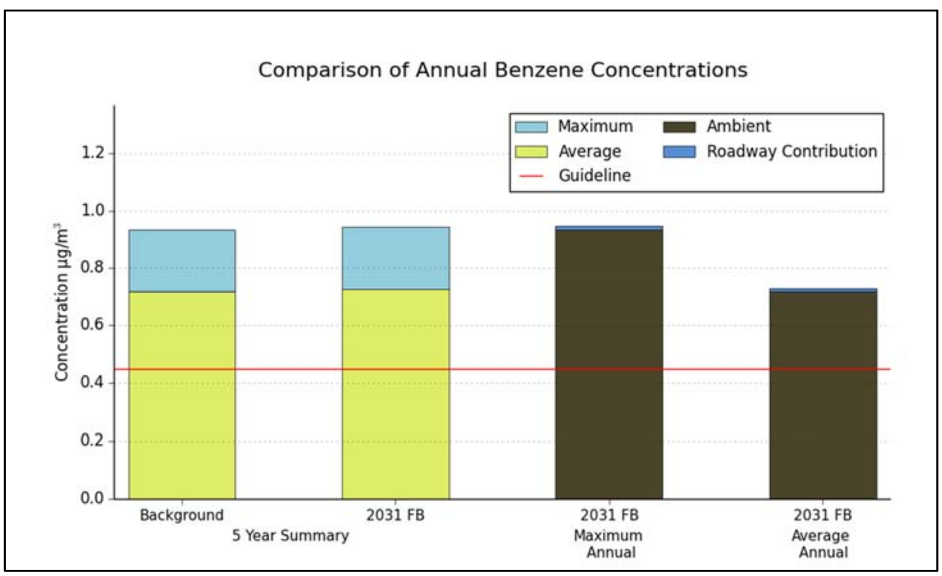
Conclusions:
The combined concentrations were below the respective MECP guidelines. The contribution from the roadway was 1% or less.

Benzene

Table 19 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour and annual benzene based on 5 years of meteorological data. The results conclude that:

- *The maximum 24-hour benzene combined concentration was below the respective MECP guideline.*
- *The annual benzene concentration exceeded the guidline due to ambient concentrations. The roadway contribution to the maximum annual average was 1%.*

Table 19: Summary of Predicted Benzene Concentrations

<table>
<tr><th>Statistical Analysis</th><th colspan="2">2031 FB</th></tr>
<tr><td rowspan="9">
</td><td colspan="2">% of MECP Guideline:</td></tr>
<tr><td>Maximum</td><td>69%</td></tr>
<tr><td>90th Percentile</td><td>47%</td></tr>
<tr><td>Average</td><td>31%</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:
The combined concentrations were below the respective MECP guidelines. The contribution from the roadway was 1% or less.</td></tr>
<tr><td rowspan="7">
</td><td colspan="2">% of MECP Guideline:</td></tr>
<tr><td>Maximum</td><td>209%</td></tr>
<tr><td>Average</td><td>161%</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:
The combined concentration exceeded the MECP guideline. It should be noted that ambient concentrations were 207% of the guideline and the roadway contribution to the maximum was 1%.</td></tr>
</table>

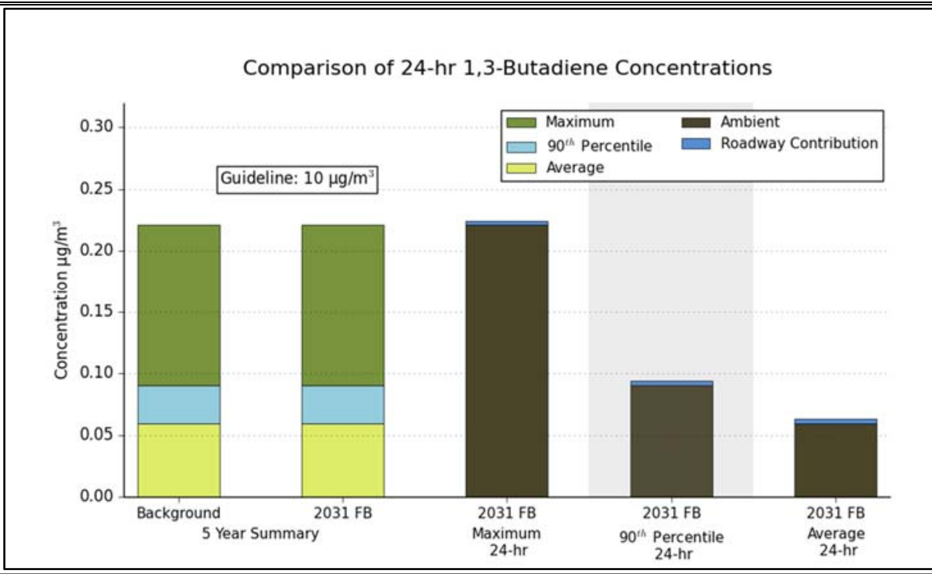
1,3-Butadiene

Table 20 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour and annual 1,3-butadiene based on 5 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.*

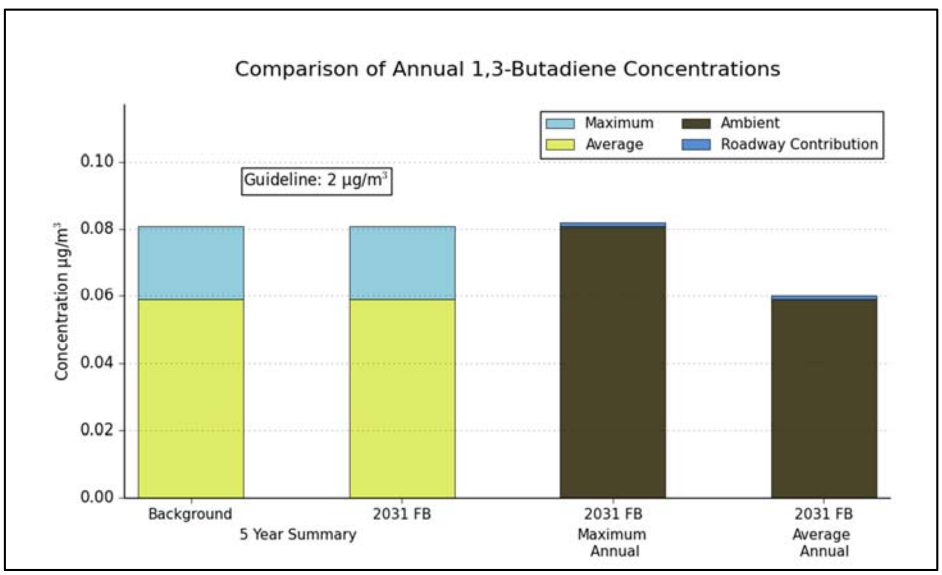
Table 20: Summary of Predicted 1,3-Butadiene Concentrations

Statistical Analysis	2031 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 guidelines. The contribution from the roadway was less than 1%.



% of MECP Guideline:	
Maximum	4%
Average	3%
Roadway Contribution:	
Maximum	<1%
Average	<1%

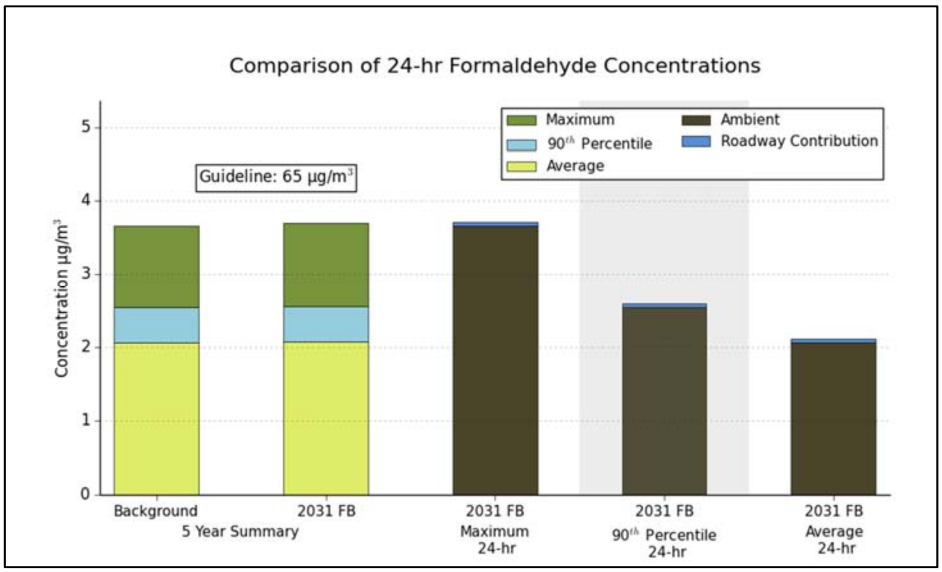
Conclusions:
The combined concentrations were below the respective MECP guidelines. The contribution from the roadway was less than 1%.

Formaldehyde

Table 21 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 concentration was below the respective MECP guideline.*

Table 21: Summary of Predicted Formaldehyde Concentrations

Statistical Analysis	2031 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 their respective MECP guideline.
- The contribution from the roadway to the combined concentration was less than 1%.

4.0 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 comparing the relative total emissions predicted from the Kirby Road extension in the 2031 Future Build scenario 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 on New Kirby Road Extension. **Table 22** summarizes the length of the roadway, traffic volumes, and emission rates used to determine total GHG emissions on New Kirby Road Extension 2031 Future Build scenario.

Table 22: Summary of New Kirby Road Extension Traffic Volumes, Roadway Length and Emission Rates

Roadway	2031 Two-Way AADT	Length of Roadway (Miles)	Heavy Duty Vehicle Percentage (%)	Medium Duty Vehicle Percentage (%)	Posted Speed (km/hr)	2031 CO_2 Equivalent Emission Rate (g/VMT)
New Kirby Road Extension	23,670	1.24	10%	10%	60	418

The total predicted annual GHG emission for the 2031 Future Build scenario is shown in **Table 23**. GHG emissions represent 0.004% of the provincial target and 0.0009% of the Canada-wide target. The contribution of GHG emissions from the project is small in comparison to these provincial and national targets.

Table 23: Predicted GHG Emissions

Source	Total CO_2 Equivalent (tonnes/year)
New Kirby Road Extension	4,485
Comparison to Canada-wide Target	0.00087%
Comparison to Ontario-wide Target	0.0044%
Comparison to Transportation Target	0.0035%
Canada-Wide 2030 GHG Target[1]	**517,000,000**
Ontario-Wide 2030 GHG Target[2]	**102,350,000**
Transportation Sector GHG 2030 Target[3]	**130,000,000**

[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

5.0 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 chemical suppressants to reduce dust, use of wind barriers, and limiting exposed areas which may be a source of dust and equipment washing. Note that the MECP recommends that non-chloride dust suppressants be applied. It is recommended that these best management practices be followed during construction of the roadway to reduce any air quality impacts that may occur.

6.0 Updated Roadway Alignment

As discussed in **Section 1.0**, the preferred roadway alignment was recently modified in 2019, with the new alignment referred to as Alignment 5A. **Figure 9** shows the new roadway Alignment 5A (multi-coloured), with the previously assessed Alignment 5 shown in blue. Also shown in **Figure 9** are the receptor locations included in the assessment. The change in alignment includes shifting a portion of the road to the south; however, near the intersections of Kirby Road with Dufferin Street and Bathurst Street, the alignment remains the same. As can be seen in **Figure 9**, the change in alignment only affects receptors R5, R6 and R7. These receptors were included to represent a proposed residential development in this area, however, the plans for the residential development are not yet confirmed or approved. Therefore, receptors R5, R6 and R7 were placed at representative distances of 30m, 15m and 65m south of the roadway, respectively.

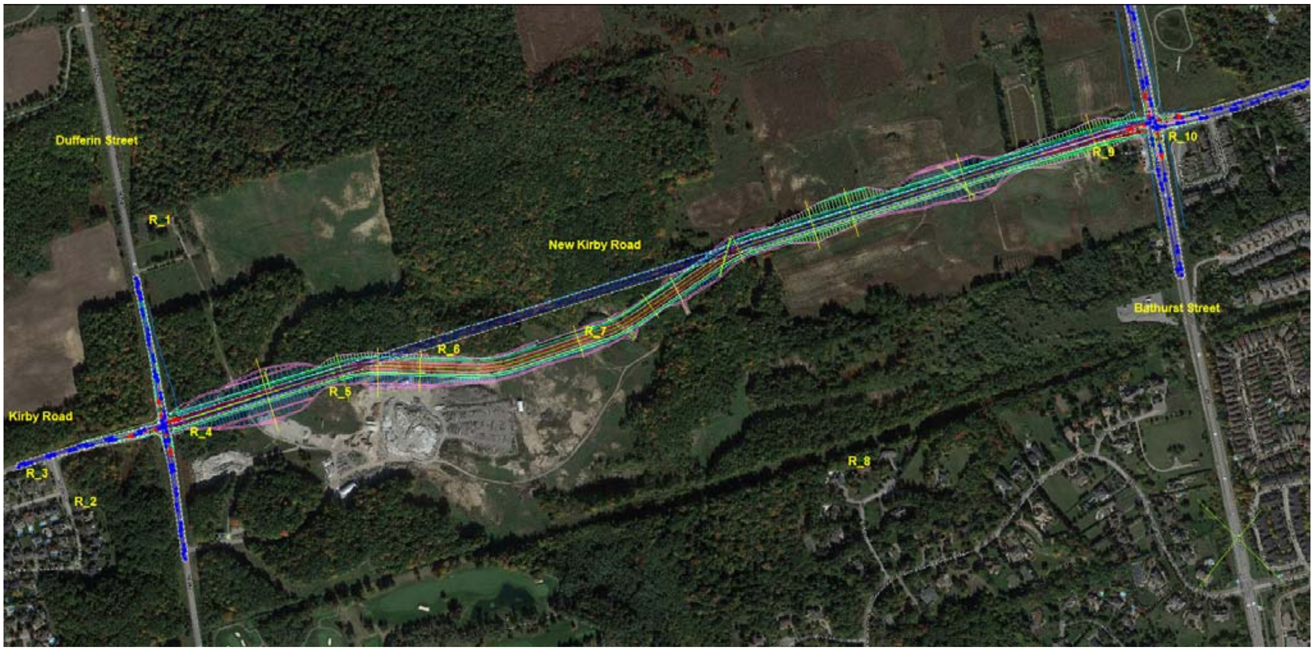


Figure 9: Updated Roadway Alignment

Furthermore, with the re-alignment of Kirby Road to Alignment 5A, the plans for the new residential subdivision will also be updated. Plans for the new subdivision are currently unavailable. It is expected that residences will remain a minimum distance of 15m south of the roadway, as modelled in the original assessment. Therefore, the results of the original assessment predicted at location R6 would remain representative of worst-case predicted impacts at the proposed subdivision, provided that a separation distance of 15m to the roadway is maintained. In addition, worst-case impacts in the assessment were predicted at locations R9 and R10, near the intersection of Kirby Road and Bathurst Street. Worst-case results were predicted at these locations due to the higher traffic volumes on Bathurst Street; these receptor locations are expected to remain the worst-case results for the revised alignment. Therefore, the worst-case results presented in the above assessment are expected to remain the same for the modified roadway Alignment 5A.

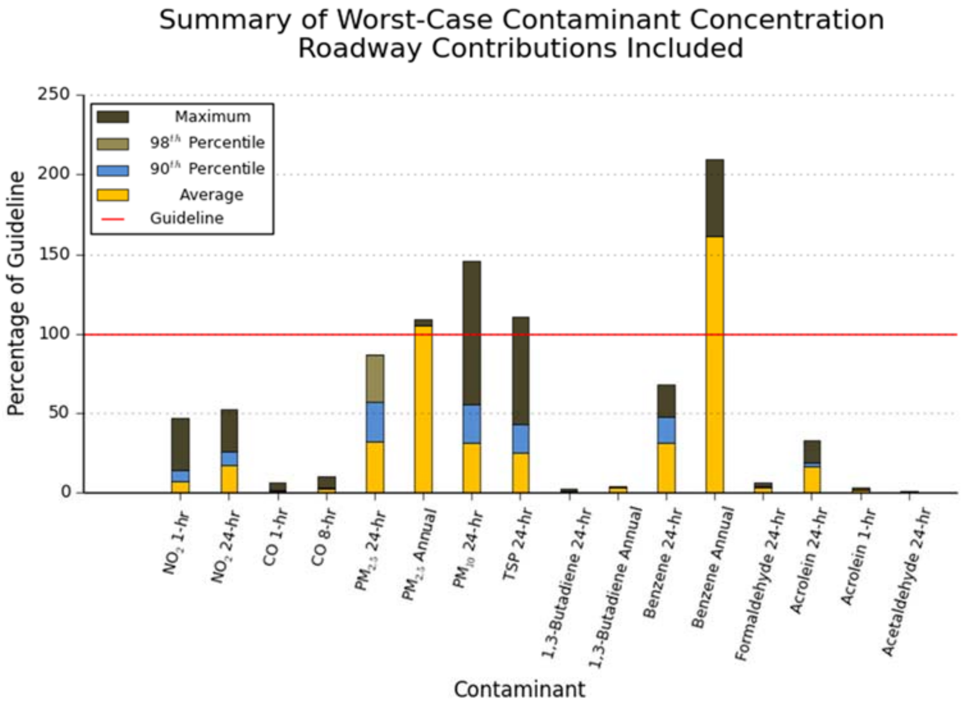
7.0 Conclusions and Recommendations

The potential impact of the proposed project infrastructure on local air quality has been assessed and the results are summarized in **Table 24**. An assessment of GHG emissions was also conducted. The following conclusions and recommendations are a result of this assessment.

- *The maximum combined concentrations for the future build scenario were all below their respective MECP guidelines or CAAQS, with the exception of annual $PM_{2.5}$, 24-hr PM_{10}, 24-hr TSP and annual benzene. Note that for each of these contaminants, background concentrations alone exceeded the guideline.*
- *Frequency Analysis determined that there were no additional days on which exceedances of PM_{10} or TSP occurred in 2031 Future Build scenarios in comparison to background concentrations. For both PM_{10} and TSP, exceedances of the guideline occurred less than 1% of the time.*
- *Mitigation measures are not warranted, due to the small number of days which are expected to exceed the guideline.*
- *Total GHG emissions in the study area were predicted to be negligible compared to the provincial and Canada-wide targets. Overall, the contributions from the roadway account for less than 0.004% of the province target and sector target.*

Table 24: Summary of 2031 Future Build Results

5 Year Statistical Summary



Note: The $PM_{2.5}$ results are in compliance with the CAAQS. The highest 3 year rolling average of the yearly 98th percentile combined concentrations was calculated to be 23.35 µg/m³ or 86% of the CAAQS.

% of Guideline	
2031 Future Build	
NO_2 (1-hr)	46%
NO_2 (24-hr)	52%
CO (1-hr)	6%
CO (8-hr)	10%
$PM_{2.5}$ (24-hr See Note)	86%
$PM_{2.5}$ (Annual)	109%
PM_{10}	145%
TSP	110%
Acetaldehyde	<1%
Acrolein (1-hr)	3%
Acrolein (24-hr)	33%
Benzene (24-hr)	68%
Benzene (Annual)	209%
1,3-Butadiene (24-hr)	2%
1,3-Butadiene (Annual)	4%
Formaldehyde	6%

8.0 References

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Appendix A
Receptor Specific Modelling Results

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for 2-sided printing purposes

This section shows the maximum results predicted by the air dispersion modelling at each receptor within the study area for the 2031 Future Build scenarios. **Figures A1** show the location of the evaluated receptors within the study area.

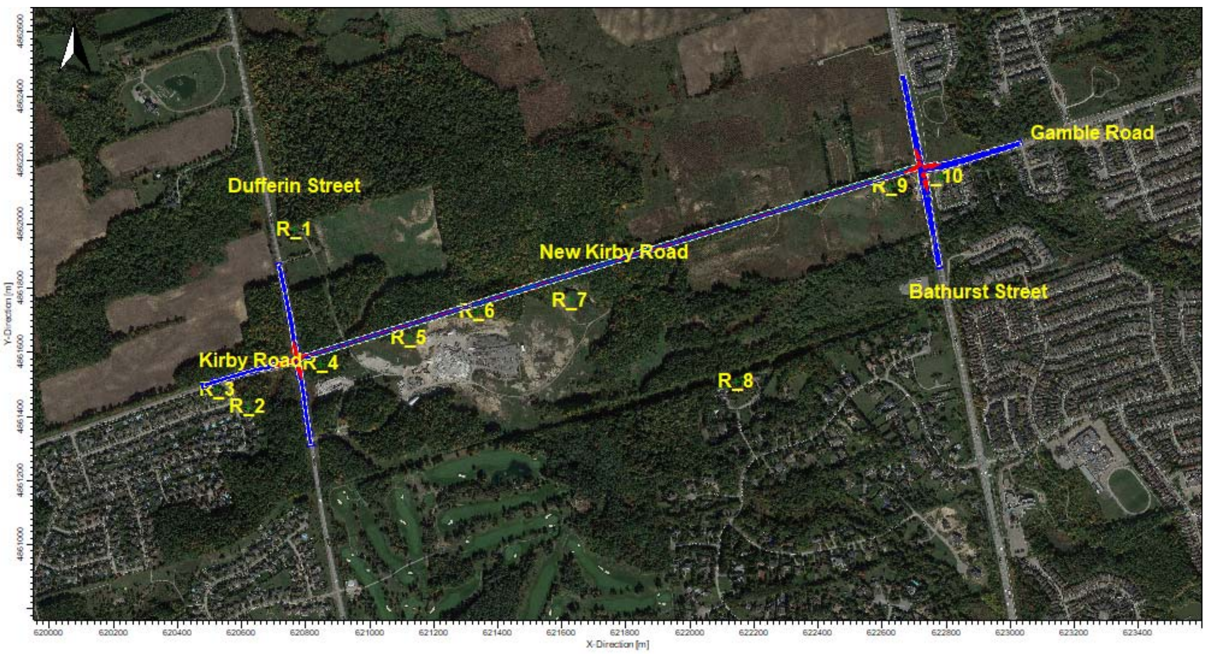
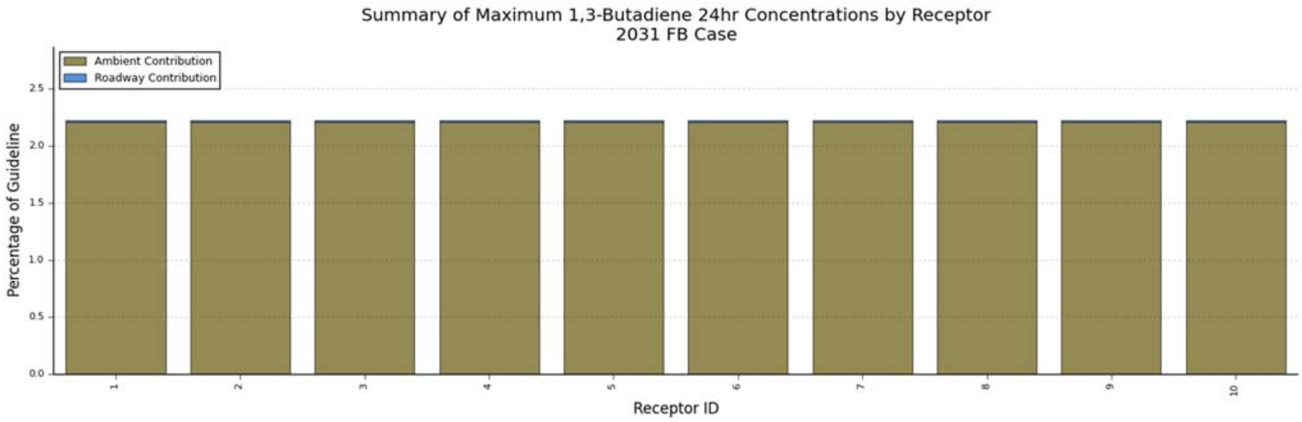
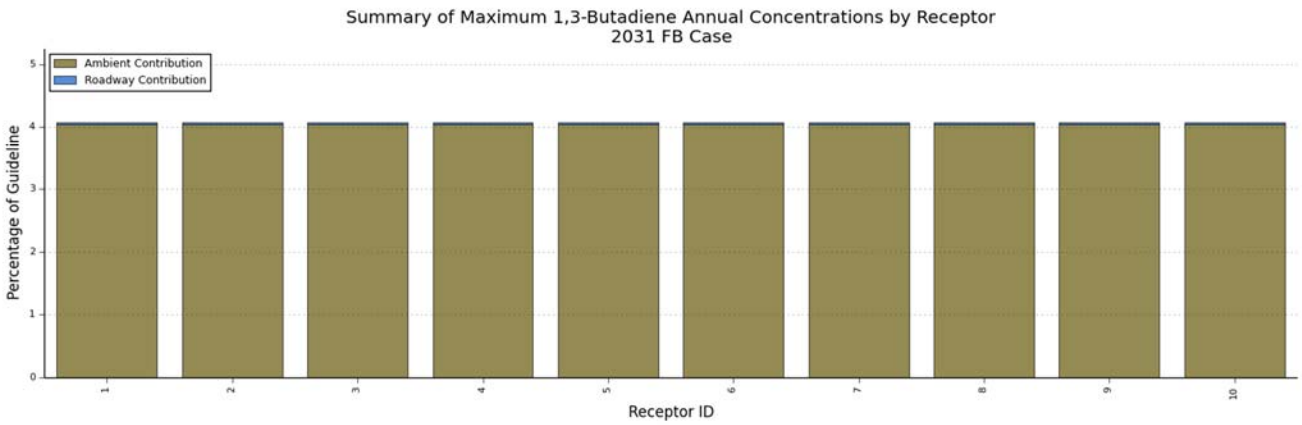
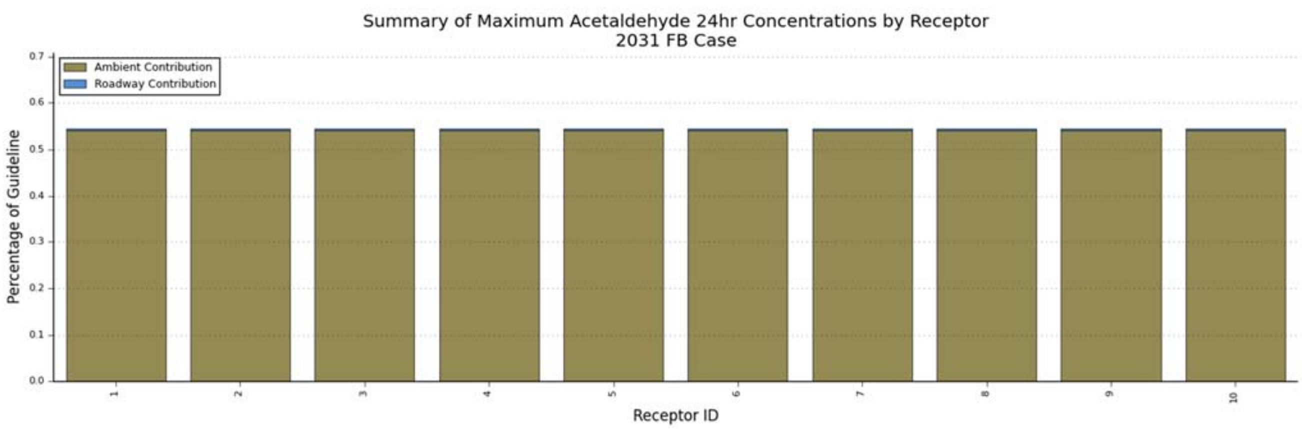
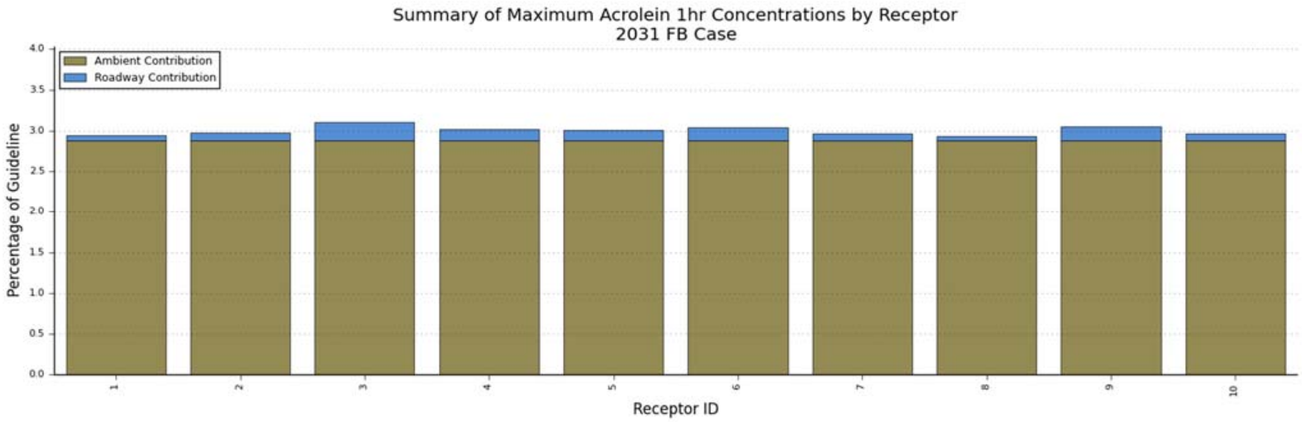


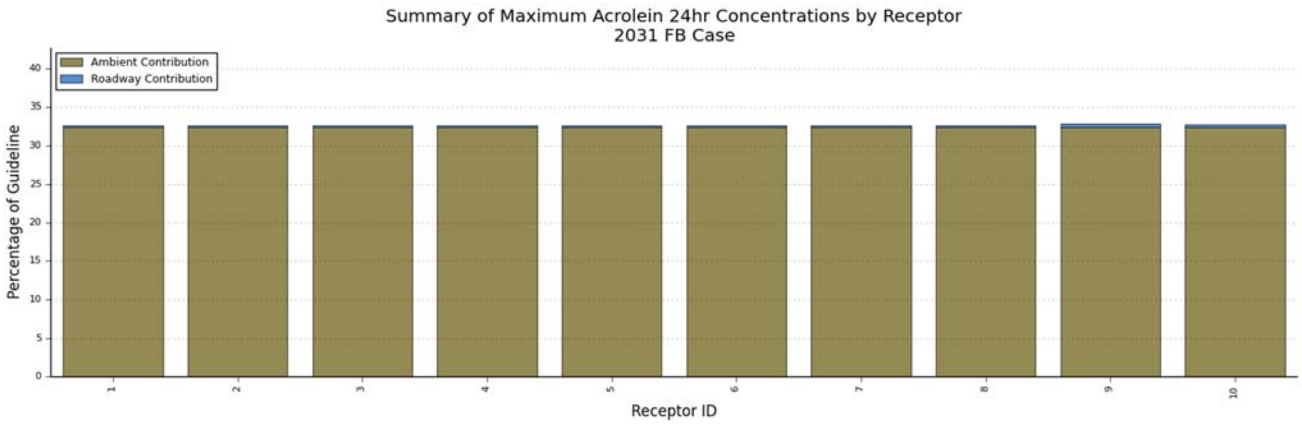
Figure A1: Receptor R1-R10 Locations within the Study Area

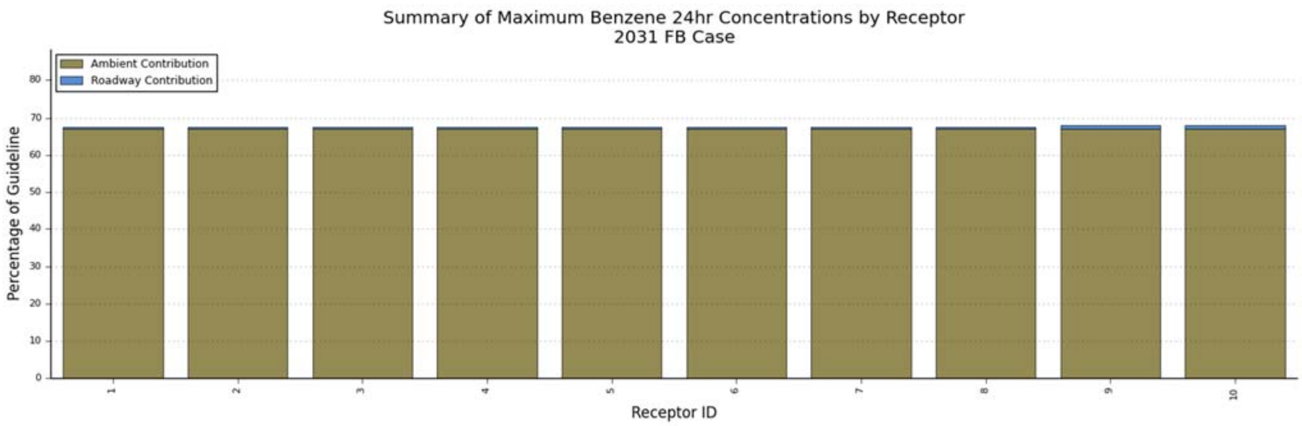

Summary of Maximum 1,3-Butadiene 24hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID

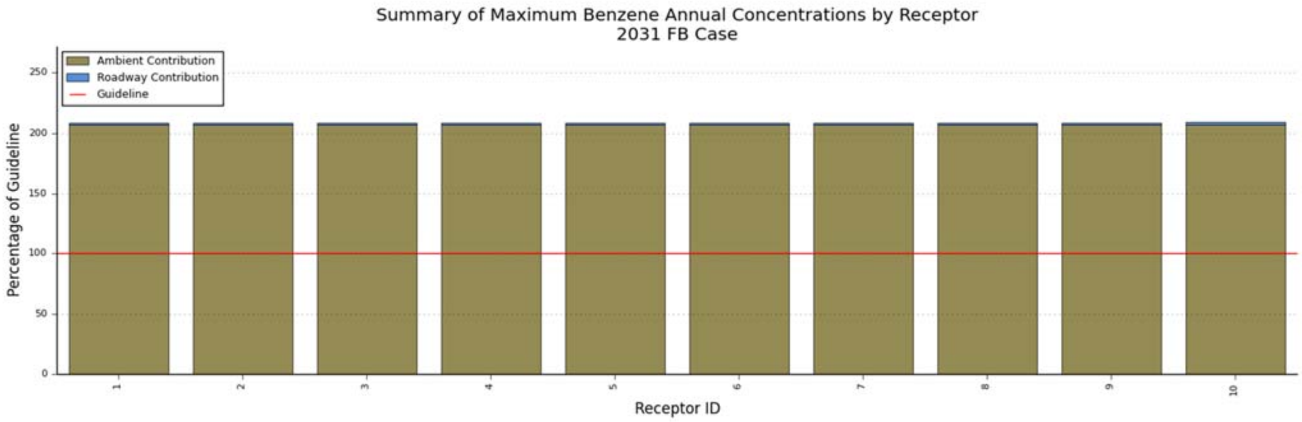

Summary of Maximum 1,3-Butadiene Annual Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID

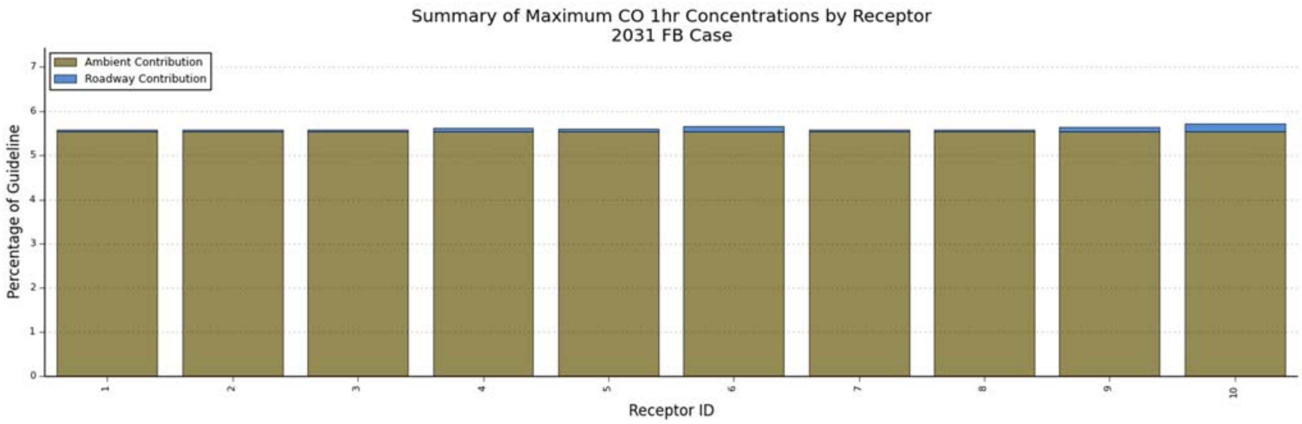

Summary of Maximum Acetaldehyde 24hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID

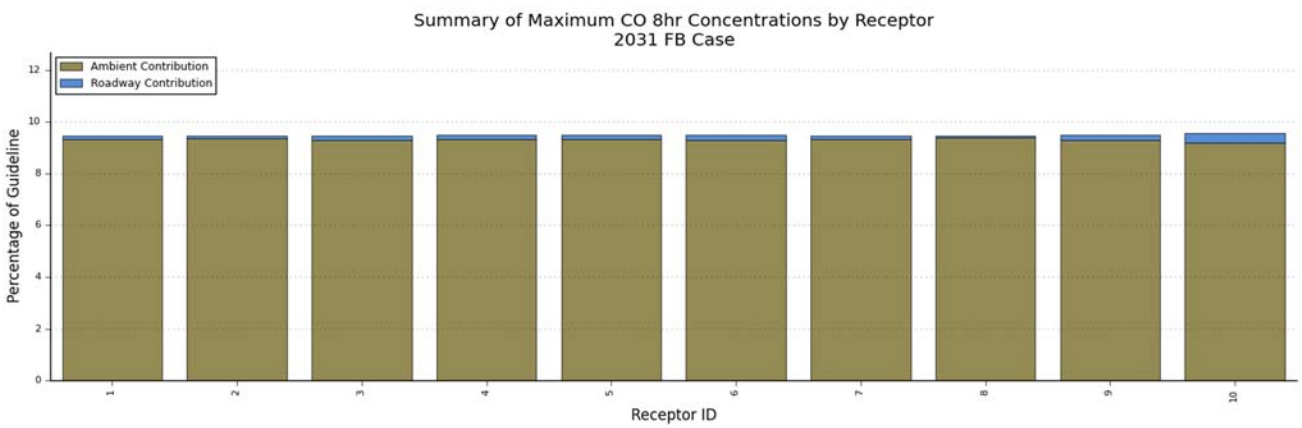

Summary of Maximum Acrolein 1hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID

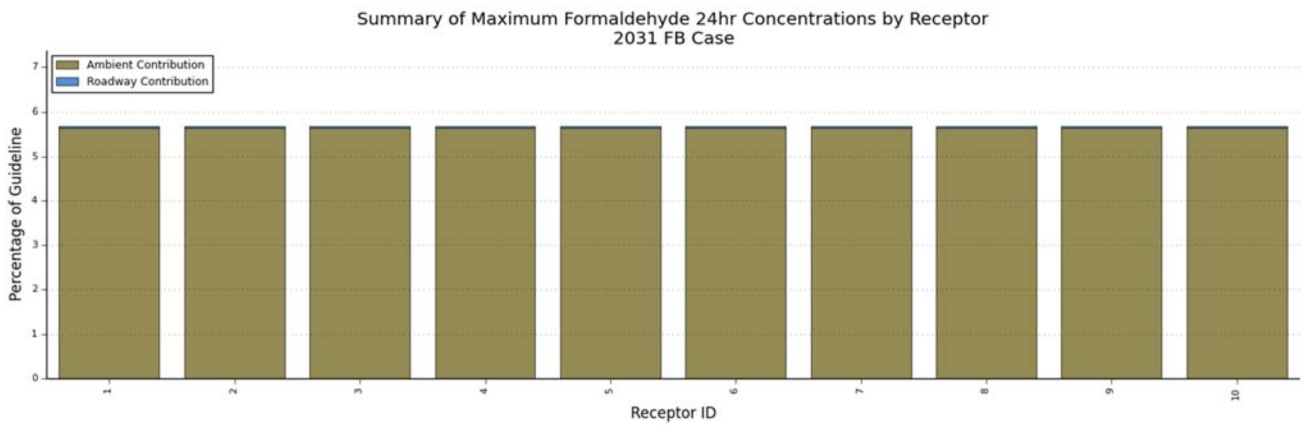

Summary of Maximum Acrolein 24hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID

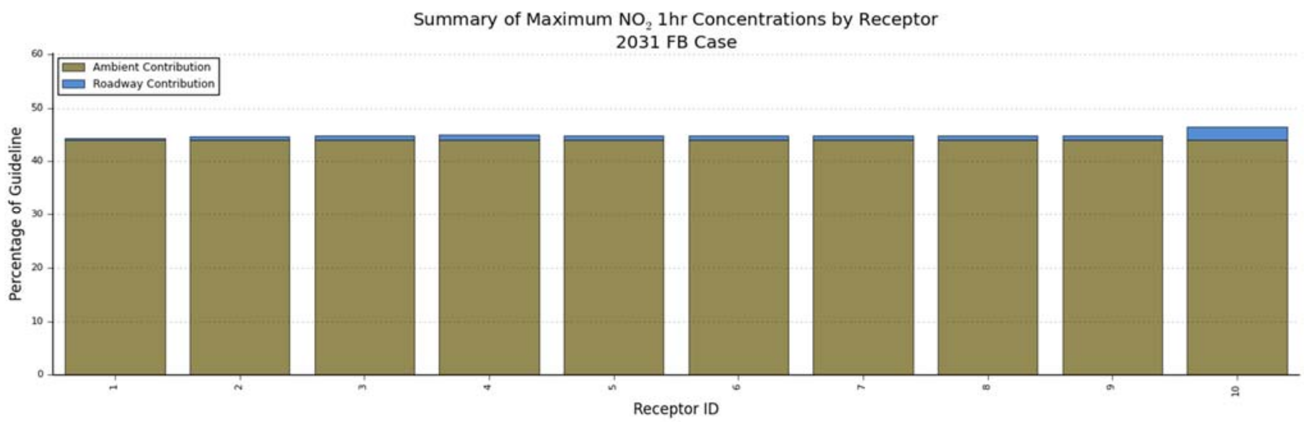

Summary of Maximum Benzene 24hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum Benzene Annual Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID


Summary of Maximum CO 1hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum CO 8hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum Formaldehyde 24hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum NO_2 1hr Concentrations by Receptor
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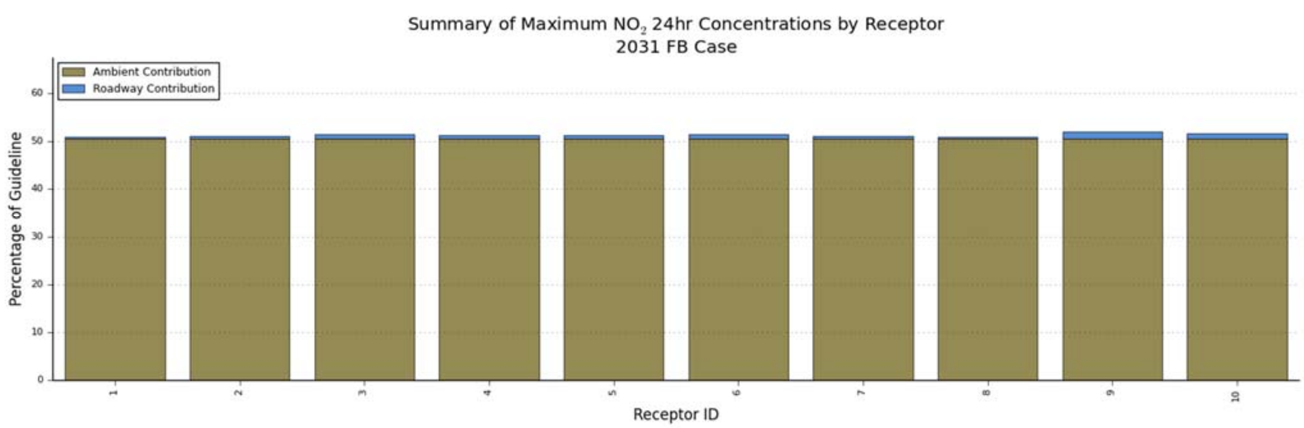
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID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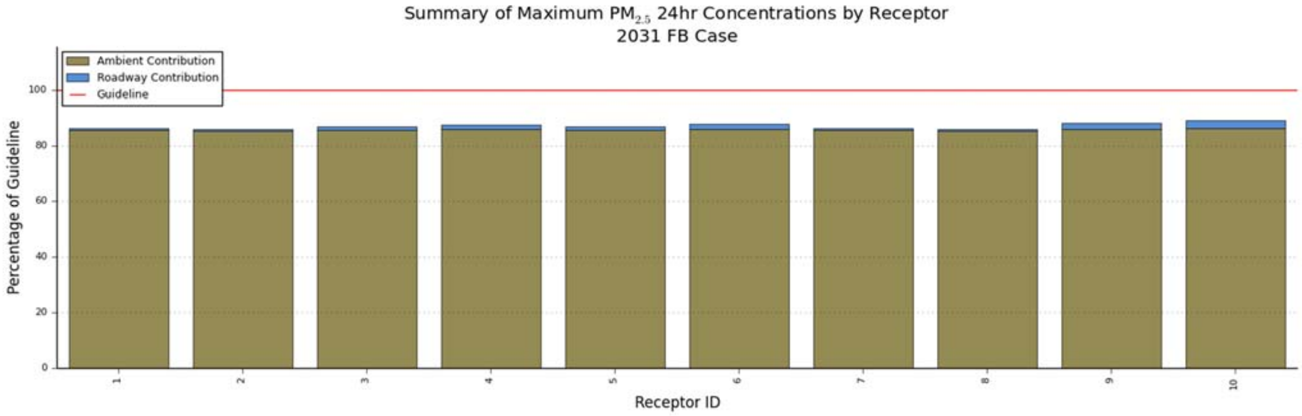
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum $PM_{2.5}$ 24hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID
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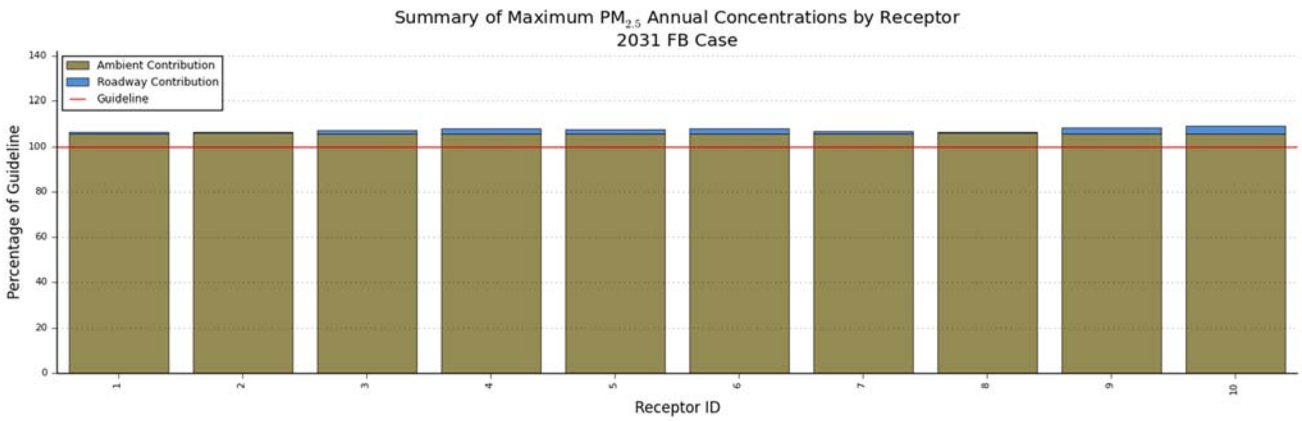
6
7
8
9
10


Summary of Maximum $PM_{2.5}$ Annual Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID
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6
7
8
9
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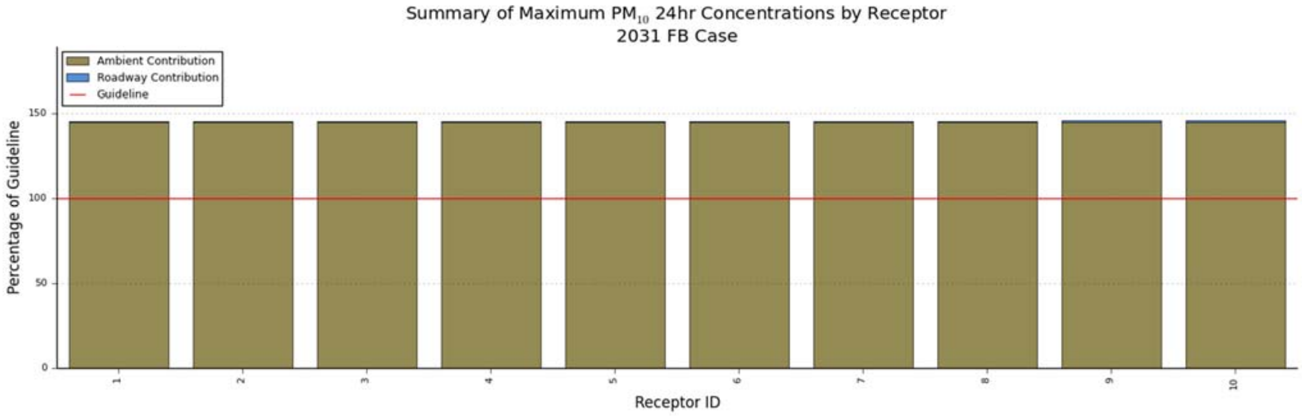
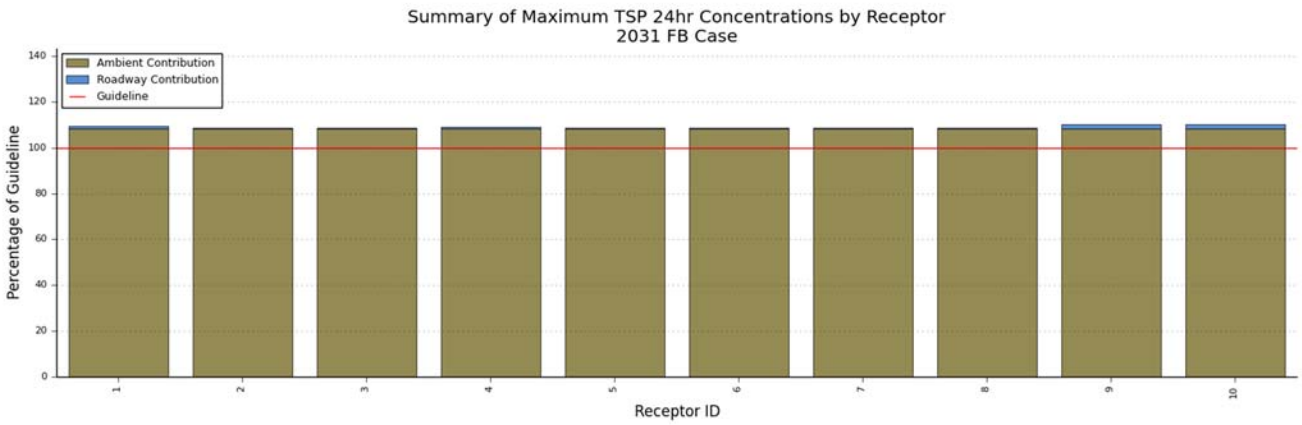

Summary of Maximum PM10 24hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID


Summary of Maximum TSP 24hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID