Appendix N

Air Quality Assessment

Local Air Quality Assessment
Mavis Road – Class EA
From Courtneypark Drive West to the North City Limit
Regional Municipality of Peel, Ontario

Novus Reference No. 15-0367 Version No. 2 (FINAL) May 29, 2017

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1.0 Introduction

Novus Environmental Inc. (Novus) was retained by WSP/MMM Group to conduct an air quality assessment for the Mavis Road Class EA between Courtneypark Drive West and the northern City limit. The project includes widening the roadway to six lanes, mainly through widening towards the centre line. This report assesses the impacts of the roadway widening at nearby sensitive receptors. The study area is approximately 3 km in length and is shown in orange in **Figure 1**.

Figure 1: Study Area Showing the Proposed Roadway Widening (In Orange)

1.1 Study Objectives

The main objective of the study was to assess the local air quality impacts due to the proposed widening of Mavis Road to six lanes between Courtneypark Drive West and the northern City limit. 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 scenarios were considered:

- **2015 Existing** – Assess the existing air quality conditions at representative receptors. Predicted contaminant concentrations from the existing roadway were combined with hourly measured ambient concentrations to determine the combined impact.

- **2041 Future Build** – Assess the future air quality conditions for the proposed roadway improvements. Predicted contaminant concentrations from the proposed roadway improvements 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 and Climate Change (MOECC). Motor vehicle emissions have largely been determined by scientists and engineers with United States and Canadian government agencies such as the U.S. Environmental Protection Agency (EPA), the MOECC, Environment Canada (EC), Health Canada (HC), and the MTO. These contaminants are emitted due to fuel combustion, brake wear, tire wear, the breakdown of dust on the roadway, fuel leaks, evaporation and permeation, and refuelling leaks and spills as illustrated in **Figure 2**. Note that emissions related to refuelling leaks and spills are not applicable to motor vehicle emissions from roadway travel. Instead, these emissions contribute to the overall background levels of the applicable contaminants. All of the selected contaminants are emitted during fuel combustion, 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**.

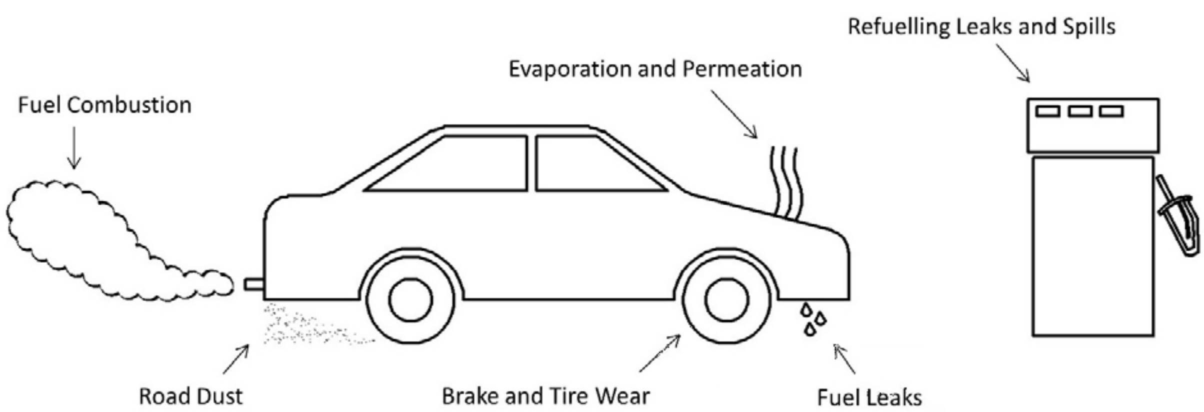


Figure 2: Motor Vehicle Emission Sources

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:

- MOECC Ambient Air Quality Criteria (AAQC);
- Health Canada/Environment Canada National Ambient Air Quality Objectives (NAAQOs); and
- 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 for $PM_{2.5}$ is not based on the maximum 24-hour concentration value; $PM_{2.5}$ is assessed based on the annual 98th percentile value, averaged over 3 consecutive years.

Table 2: Applicable Contaminant Guidelines

Contaminant	Averaging Period (hrs)	Threshold Value ($\mu g/m^3$)	Source
NO_2	1	400	AAQC
	24	200	AAQC
CO	1	36,200	AAQC
	8	15,700	AAQC
$PM_{2.5}$	24	27[1]	CAAQS (27 $\mu g/m^3$ standard is to be phased-in in 2020)
	Annual	8.8[2]	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 23-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. 2011-2015 historical meteorological data from Toronto Pearson Airport was used. Five years were modelled in order to capture the worst-case meteorological conditions. Two emissions scenarios were assessed: 2015 Existing, and 2041 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 MOECC 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 2015 Existing and 2041 Future Build scenarios are presented in **Section 3.8**.

2.0 Background Ambient Data

2.1 Overview

Background (ambient) conditions are measured contaminant concentrations that are 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 (MOECC, 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**.

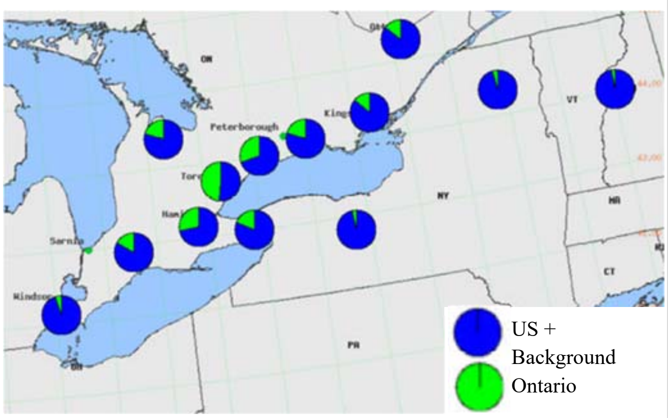
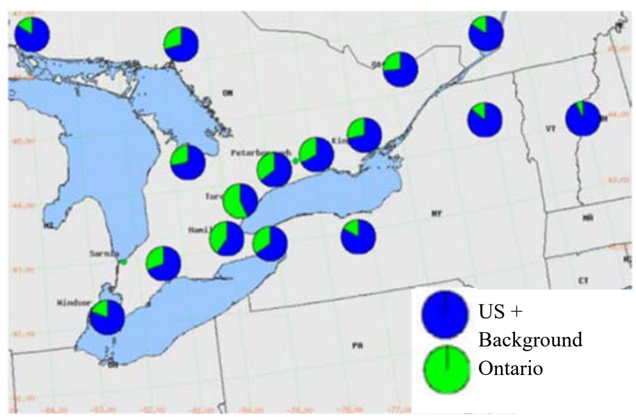
High $PM_{2.5}$ Days	Average $PM_{2.5}$ of Spring/Summer Season
	

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

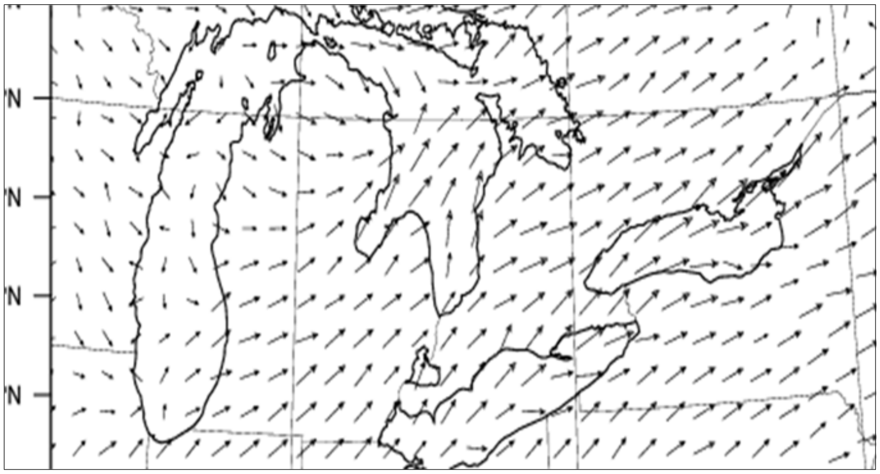


Figure 4: Typical Wind Direction during an Ontario Smog Episode

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 MOECC 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 MOECC and NAPS ambient monitoring stations in Ontario was undertaken to identify the monitoring stations that are in relative proximity to the study area and that would be representative of background contaminant concentrations in the study area. Four MOECC (Brampton, Mississauga, Oakville and Toronto West) and five NAPS (Brampton, Etobicoke North, Etobicoke South, Toronto Downtown and Windsor) stations were selected for the analysis. 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**.

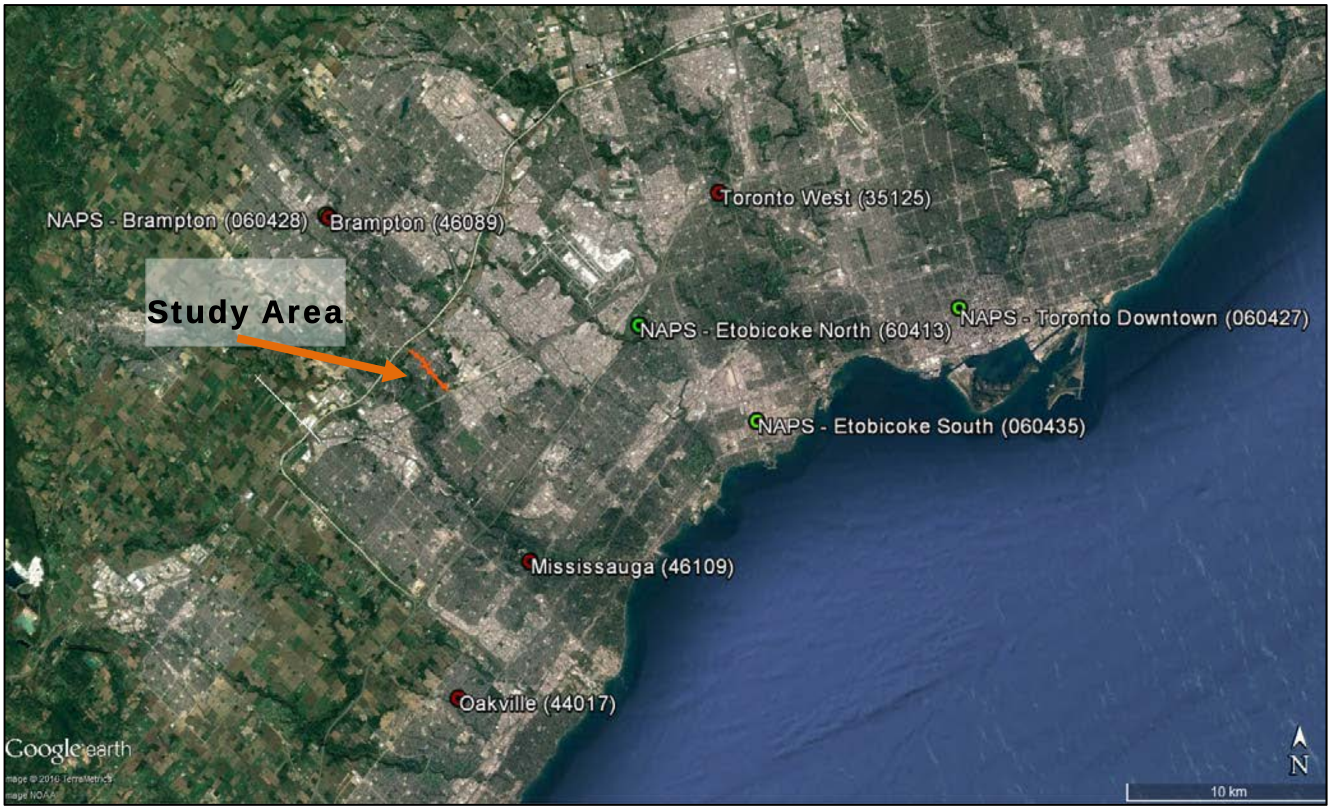


Figure 5: Relevant MOECC (shown in red) and NAPS (shown in green) Monitoring Stations; Windsor NAPS Station Not Shown; Study Area in Orange

Table 3: Relevant MOECC and NAPS Station Information

City/Town	Station ID	Location	Operator	Contaminants
Brampton	46089	525 Main St N	MOECC	NO_2|$PM_{2.5}$
Mississauga	46109	3359 Mississauga Rd. N.	MOECC	NO_2|$PM_{2.5}$
Oakville	44017	Eight Line/Glenashton Dr.	MOECC	NO_2|$PM_{2.5}$
Toronto West	35125	125 Resources Rd	MOECC	NO_2|CO|$PM_{2.5}$
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		1,3-Butadiene|Benzene
Toronto Downtown	60427	223 College St	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.

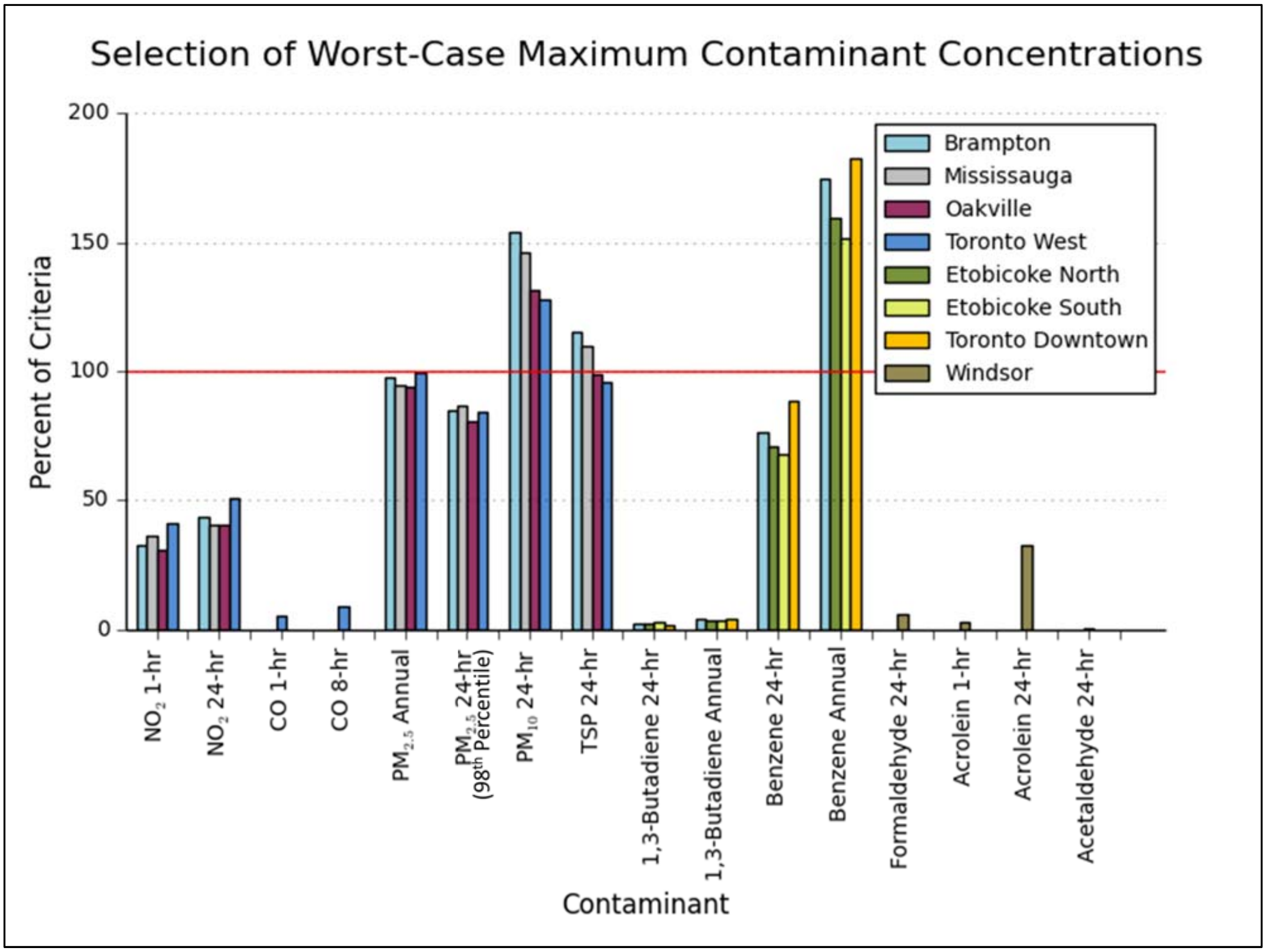
2.3 Selection of Worst-Case Monitoring Stations

Year 2011 to 2015 hourly ambient monitoring data from the selected stations were statistically summarized for the desired averaging periods: 1-hour, 8-hour, 24-hour, and annual. Note that VOC monitoring data for 2015 is not yet publicly available. 2010-2014 data was used for benzene and 1,3-butadiene. Formaldehyde, acetaldehyde and acrolein are only recently measured at the Windsor station, and were not measured in 2014. Therefore 2009-2013 data was used for these VOCs. For consistency with the combined effects analysis (using 2011-2015 meteorological data to predict roadway concentrations), the actual date of measured VOC data within 2011-2015 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 90^{th} percentile measured value for the year in question was applied for those days in order to determine combined concentrations. This method is conservative as it applies the 10^{th} percentile highest 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. **Table 4** 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 West	1,3-Butadiene (24-hr)	Etobicoke South
NO_2 (24-Hr)	Toronto West	1,3-Butadiene (ann)	Brampton
CO (1-Hr)	Toronto West	Benzene (24-hr)	Toronto Downtown
CO (8-hr)	Toronto West	Benzene (ann)	Toronto Downtown
$PM_{2.5}$ (24-hr)	Mississauga	Formaldehyde	Windsor
$PM_{2.5}$ (ann)	Toronto West	Acrolein	Windsor
Pm_{10}	Brampton	Acetaldehyde	Windsor
TSP	Brampton		

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 represents 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 2011-2015, all background concentrations were below their respective guidelines with the exception of 24-hour PM_{10}, 24-hour TSP, and annual benzene. It should be noted that PM_{10} and TSP were calculated based on their relationship to $PM_{2.5}$. The annual $PM_{2.5}$ average concentration was 100% of the guideline.

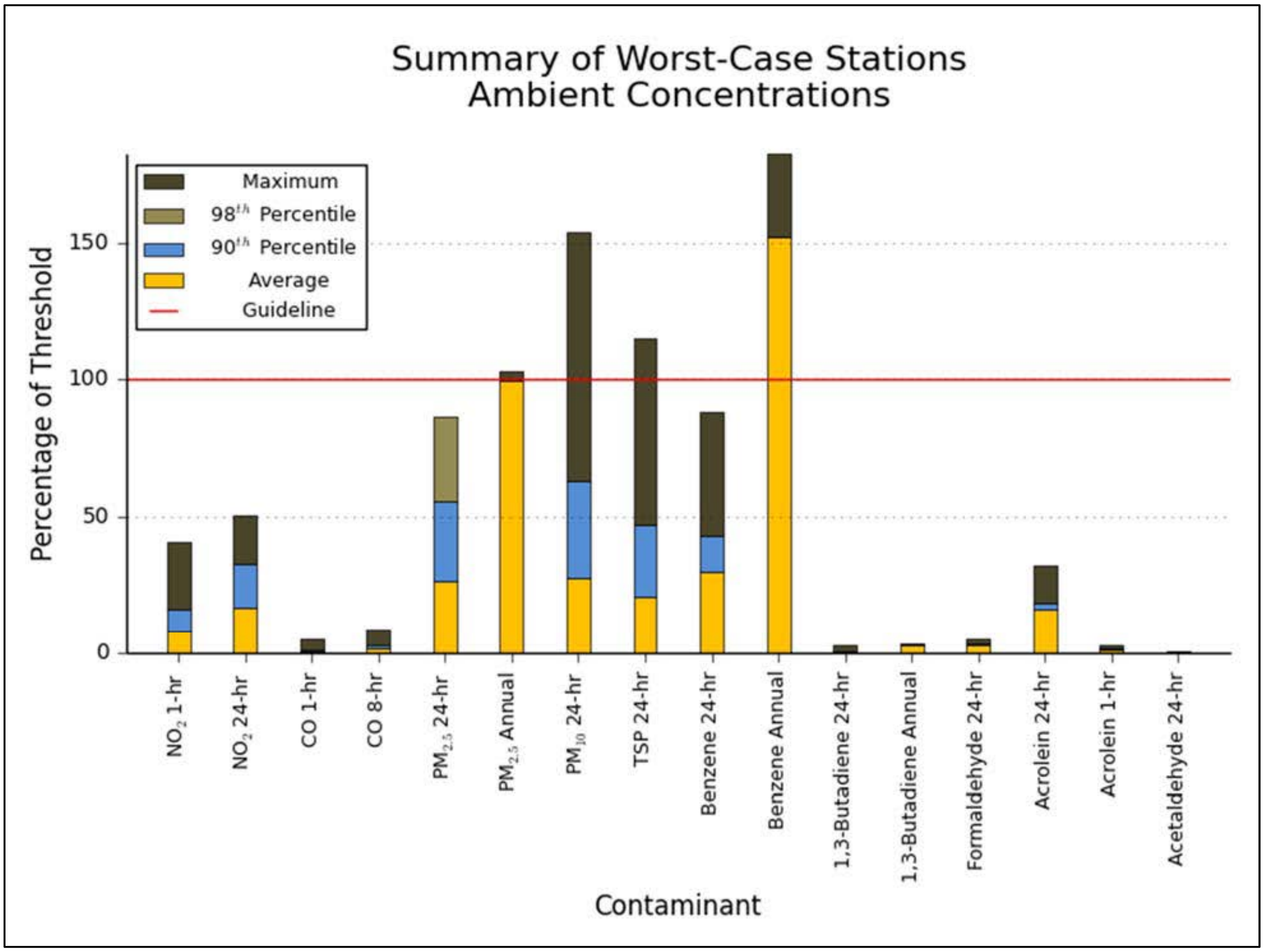


Figure 6: Summary of Background Conditions Applied in the Assessment

3.0 Local Air Quality Assessment

3.1 Overview

The worst-case impacts due to roadway vehicle emissions were assessed for two scenarios: 2015 Existing (or No Build/NB) and 2041 Future Build (FB). The two scenarios include the following activities:

2015 Existing (NB):

- Existing traffic volumes on Mavis Road and arterial roads for the existing alignment.

2041 Future Build (FB):

- Projected vehicle volumes on Mavis Road and arterial roads for the proposed widened 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.

Fifty-eight sensitive receptors were evaluated to represent worst-case impacts surrounding the project area. All receptors represented residential and school locations surrounding the roadway. The receptor locations are identified in **Figure 7** through **Figure 9**.

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-R16 Locations Within the Study Area (Courtneypark Drive West to Western Skies Way)

Figure 8: Receptors R12-R15 and R17-R39 Locations Within the Study Area (Western Skies Way to Derry Road W)

Figure 9: Receptors R36-R58 Locations Within the Study Area (Derry Road W to Northern City Limit)

3.3 Road Traffic Data

Traffic volumes for Mavis Road and the intersecting roadways within the study area were provided by WSP Group/MMM in the form of Annual Average Daily Traffic (AADT) volumes for the 2015 Existing and 2041 Future Build scenarios. The AADTs were provided as directionally divided volumes for all roadways in the study area. The traffic volumes used in the assessment are provided in **Table 5** and **Table 6**. Also provided were hourly traffic volumes for three sections on Mavis Road for a single day in 2013 and a single day in 2014. These measurements were averaged to determine hourly traffic distributions for Mavis Road northbound and southbound. The average of all data (both directions) was used for the hourly distribution on the arterial roads. The hourly vehicle distributions used in the assessment are provided in **Table 7**. Estimated heavy duty vehicle percentages were also provided, with an average of 5% throughout the study area. This value was used in the modelling for both Mavis Road and the arterial roads. Lastly, signal timing was provided by WSP Group/MMM for all traffic lights within the study area.

Table 5: 2015 Traffic Volumes (AADT) Used in the Assessment

Roadway	2015 Existing AADT		Speed (km/hr)
	Northbound /Eastbound	Southbound /Westbound	
Mavis Road from Hwy 401 WB off-ramp to Courtneypark Dr W/Sombrero Way	23,140	29,210	70 km/hr
Mavis Road from Courtneypark Dr W/Sombrero Way to Western Skies Way/Craig Carrier Court	21,790	24,660	
Mavis Road from Western Skies Way/Craig Carrier Court to Novo Star Drive/Crawford Mill Ave	20,500	23,200	
Mavis Road from Novo Star Dr/Crawford Mill Ave to Derry Rd	18,970	21,480	
Mavis Road from Derry Rd to Kaiser Dr/Envoy Dr	19,200	19,050	
Mavis Road from Kaiser Dr/Envoy Dr to Twain Ave/Knotty Pine Grove	20,050	19,900	
Mavis Road from North of Kaiser Dr/Envoy Dr	19,950	19,800	
Courtneypark Dr W	9,270	14,630	50 km/hr
Sombrero Way	7,410	6,990	
Western Skies Way	1,325	1,325	
Craig Carrier Court	1,600	1,600	
Novo Star Dr	2,700	2,700	40 km/hr
Crawford Mill Ave	3,975	3,975	
Derry Rd W East of Mavis	20,080	19,770	70 km/hr
Derry Rd W West of Mavis	20,310	18,540	
Kaiser Dr	2,075	2,075	50 km/hr
Envoy Dr	3,125	3,125	
Twain Ave	3,550	3,550	
Knotty Pine Grove	2,725	2,725	

Table 6: 2041 Traffic Volumes (AADT) Used in the Assessment

Roadway	2041 Future Build AADT		Speed (km/hr)
	Northbound /Eastbound	Southbound /Westbound	
Mavis Road from Hwy 401 WB off-ramp to Courtneypark Dr W/Sombrero Way	30,140	38,060	70 km/hr
Mavis Road from Courtneypark Dr W/Sombrero Way to Western Skies Way/Craig Carrier Court	28,050	31,750	
Mavis Road from Western Skies Way/Craig Carrier Court to Novo Star Drive/Crawford Mill Ave	26,760	30,290	
Mavis Road from Novo Star Dr/Crawford Mill Ave to Derry Rd	25,260	28,590	
Mavis Road from Derry Rd to Kaiser Dr/Envoy Dr	25,830	25,620	
Mavis Road from Kaiser Dr/Envoy Dr to Twain Ave/Knotty Pine Grove	26,660	26,440	
Mavis Road from North of Kaiser Dr/Envoy Dr	26,580	26,370	
Courtneypark Dr W	10,180	16,070	50 km/hr
Sombrero Way	8,030	7,570	
Western Skies Way	1,325	1,325	
Craig Carrier Court	1,600	1,600	
Novo Star Dr	2,700	2,700	40 km/hr
Crawford Mill Ave	3,975	3,975	
Derry Rd W East of Mavis	22,090	21,760	70 km/hr
Derry Rd W West of Mavis	22,330	20,370	
Kaiser Dr	2,075	2,075	50 km/hr
Envoy Dr	3,125	3,125	
Twain Ave	3,550	3,550	
Knotty Pine Grove	2,725	2,725	

Table 7: Hourly Vehicle Distribution

Hour	Mavis Rd Northbound	Mavis Road Southbound	Arterial Roads
1	1.9%	0.8%	1.4%
2	1.0%	0.4%	0.7%
3	0.7%	0.3%	0.5%
4	0.4%	0.4%	0.4%
5	0.4%	0.8%	0.6%
6	0.7%	2.6%	1.6%
7	2.1%	6.9%	4.5%
8	4.0%	8.5%	6.3%
9	4.6%	8.9%	6.7%
10	3.2%	6.3%	4.7%
11	2.9%	4.5%	3.7%
12	3.6%	4.4%	4.0%
13	4.5%	4.6%	4.6%
14	4.7%	4.6%	4.6%
15	5.6%	5.0%	5.3%
16	7.8%	5.7%	6.7%
17	8.8%	6.3%	7.6%
18	9.6%	6.3%	8.0%
19	8.2%	5.5%	6.8%
20	6.2%	4.6%	5.4%
21	5.9%	4.0%	5.0%
22	5.2%	3.4%	4.3%
23	4.2%	3.0%	3.6%
24	3.8%	2.0%	2.9%
TOTAL	100%	100%	100%

3.4 Meteorological Data

2011-2015 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 MOECC 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 10**. As can be seen in this figure, predominant winds are from the south-westerly through northerly directions.

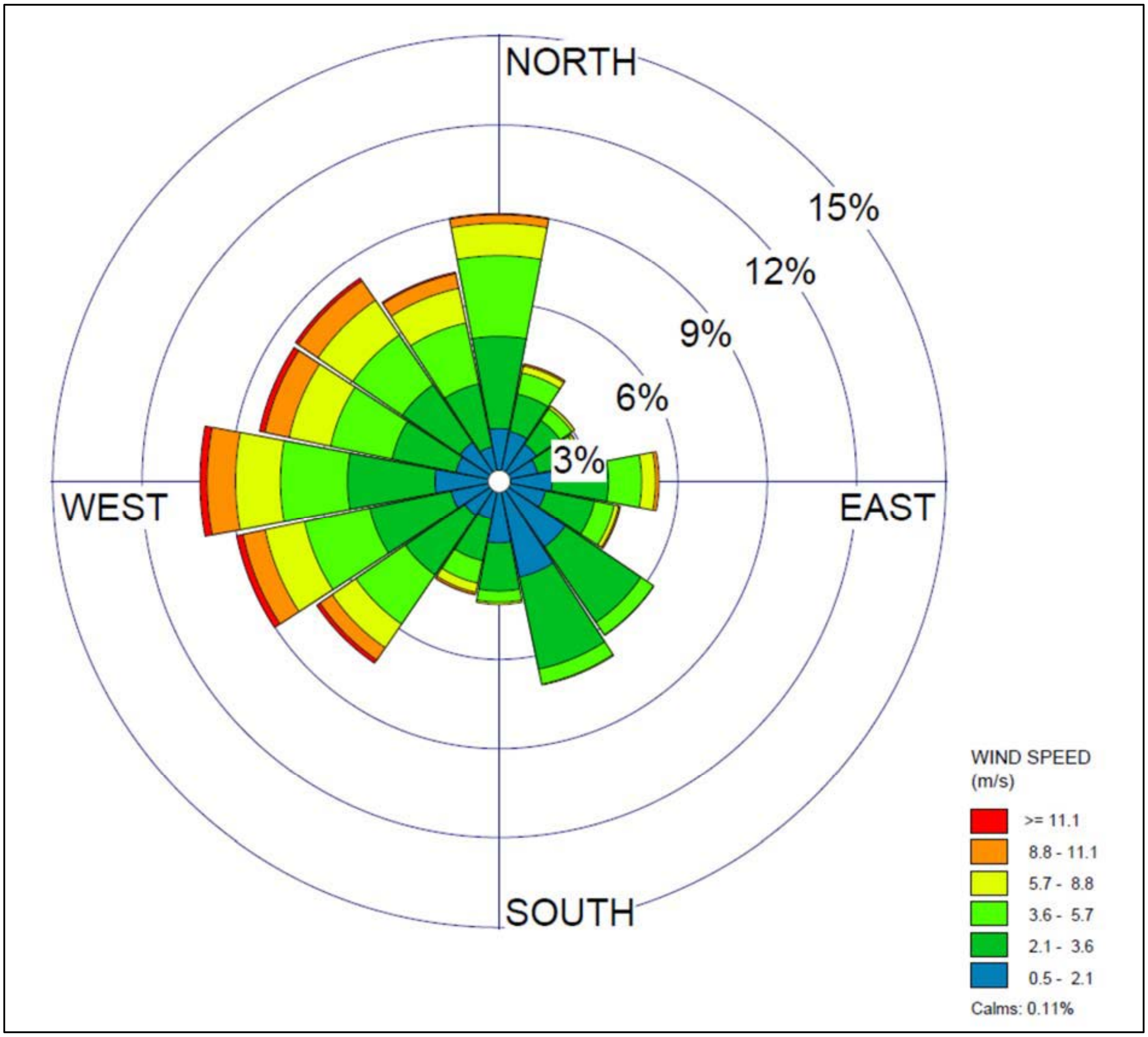


Figure 10: Wind Frequency Diagram for Toronto Pearson International Airport (2011-2015)

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 WSP

Group/MMM. Vehicle age was based on the U.S. EPA's default distribution. **Table 8** specifies the major inputs into MOVES.

Table 8: 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 2011 to 2015.
Years	2015 (Existing) and 2041 (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 speed modelled for a 5% heavy duty vehicle percentage are shown in **Table 9**. As shown in **Table 9**, emissions in the future year for all contaminants are predicted to decrease.

Table 9: 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
2015	70 km/hr	0.39	2.71	0.018	0.044	0.044	0.0011	0.00011	0.003	0.000243	0.0018
	50 km/hr	0.42	3.32	0.025	0.076	0.076	0.0014	0.00014	0.004	0.000321	0.0023
	40 km/hr	0.45	3.51	0.029	0.094	0.094	0.0016	0.00016	0.004	0.000369	0.0026
	Idle	3.46	17.27	0.187	0.207	0.207	0.0271	0.00259	0.060	0.007279	0.0416
2041	70 km/hr	0.05	0.78	0.006	0.030	0.030	0.0002	0.00002	0.001	0.000001	0.0004
	50 km/hr	0.05	0.86	0.010	0.059	0.059	0.0002	0.00003	0.001	0.000001	0.0005
	40 km/hr	0.05	0.87	0.012	0.075	0.075	0.0002	0.00003	0.001	0.000001	0.0006
	Idle	0.25	2.11	0.027	0.030	0.030	0.0023	0.00029	0.007	0.000015	0.0064

[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 10**.

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

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 10: 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	0.0176	0.070	0.368

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 11** 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 11: 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	2011-2015 data from Pearson International Airport
Deposition Velocity	$PM_{2.5}$: 0.01 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 2015 Existing and 2041 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 12**), which were identified as the maximum combined concentration for the 2041 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 12: Worst-Case Sensitive Receptors for 2041 Future Build Scenario

Contaminant	Averaging Period	Sensitive Receptor
NO_2	1-hour	R8
	24-hour	R8
CO	1-hour	R8
	8-hour	R8
$PM_{2.5}$	24-hour	R27
	Annual	R49
PM_{10}	24-hour	R26
TSP	24-hour	R26
Acetaldehyde	24-hour	R36
Acrolein	1-hour	R36
	24-hour	R36
Benzene	24-hour	R36
	Annual	R8
1,3-Butadiene	24-hour	R8
	Annual	R8
Formaldehyde	24-hour	R3

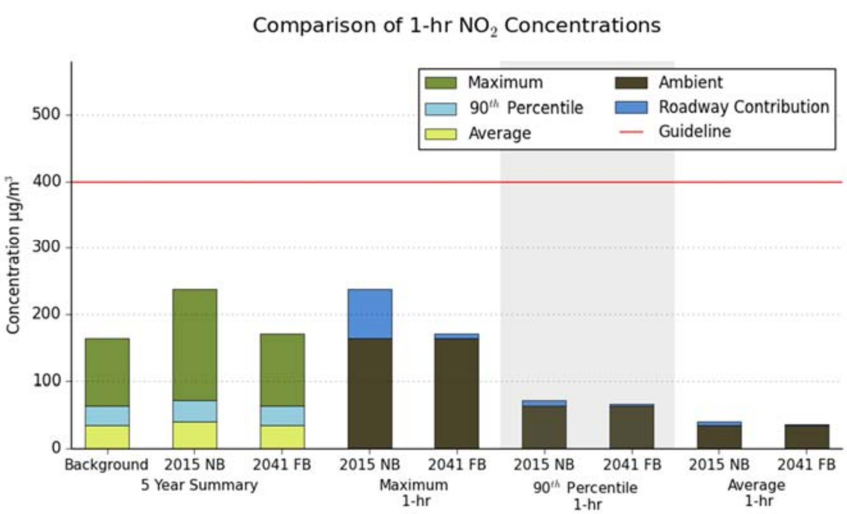
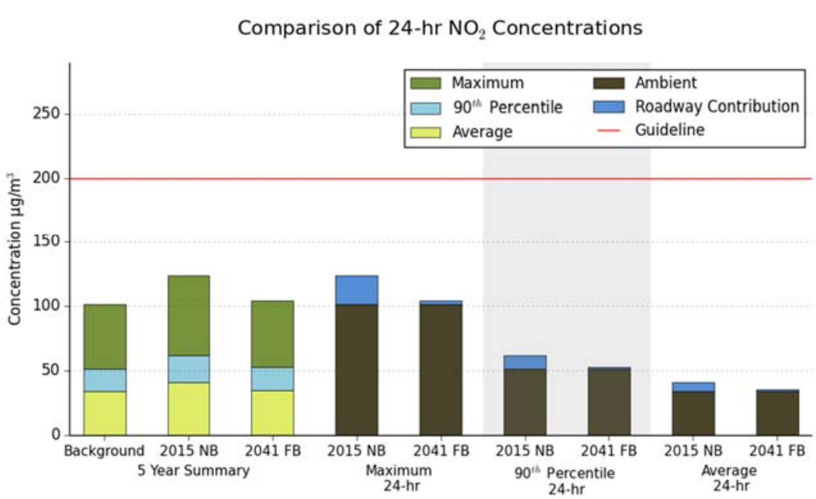
Coincidental hourly modelled roadway and background concentrations were added to derive the combined concentration for each hour over the 5-year period. Hourly combined concentrations were then used to determine contaminant concentrations based on the applicable averaging period. Statistical analysis 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 MOECC 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 13 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 that:

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

Table 13: Summary of Predicted NO_2 Concentrations

Statistical Analysis	2041 FB	
	**% of MOECC Guideline:**	
	Maximum	43%
	90th Percentile	16%
	Average	9%
	Roadway Contribution:	
	Maximum	5%
	90th Percentile	2%
	Average	3%
	**% of MOECC Guideline:**	
	Maximum	52%
	90th Percentile	26%
	Average	17%
	Roadway Contribution:	
	Maximum	3%
	90th Percentile	2%
	Average	3%

Conclusions:

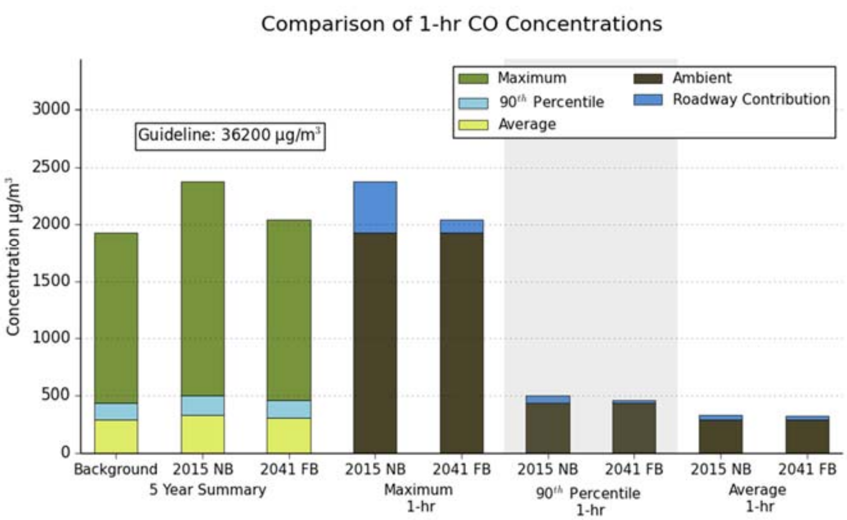
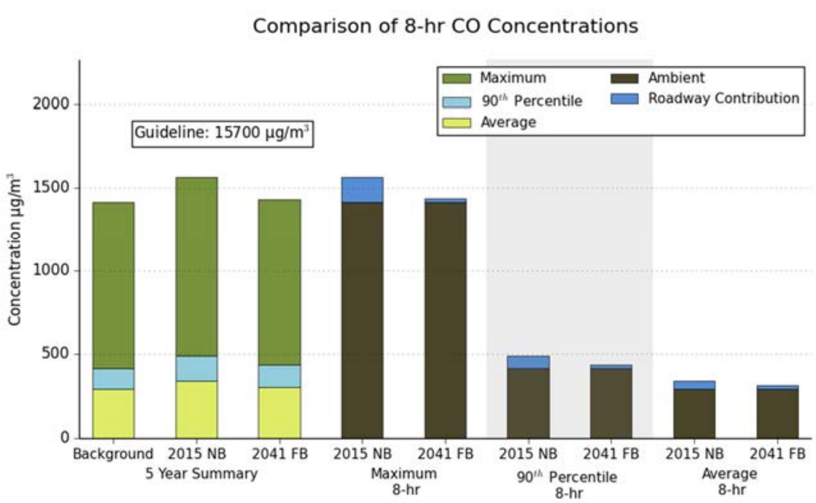
- All combined concentrations were below their respective MOECC guidelines.
- The contribution from the roadway to the combined concentrations was 5% or less.

Carbon Monoxide

Table 14 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 MOECC guidelines.*

Table 14: Summary of Predicted CO Concentrations

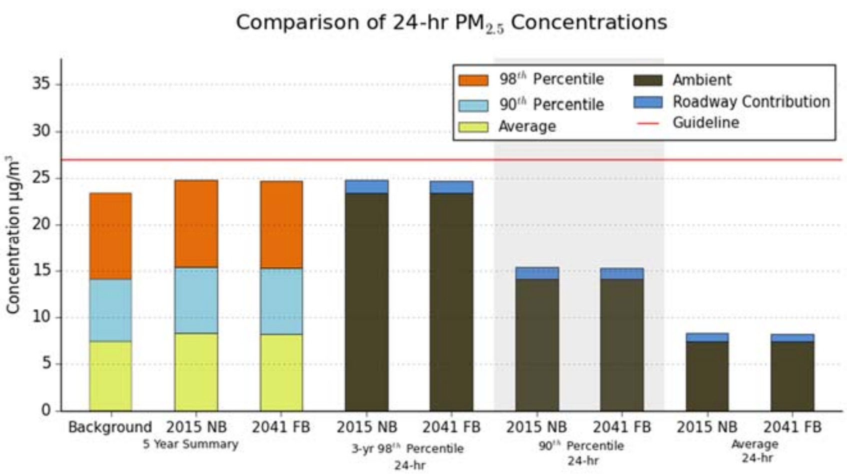
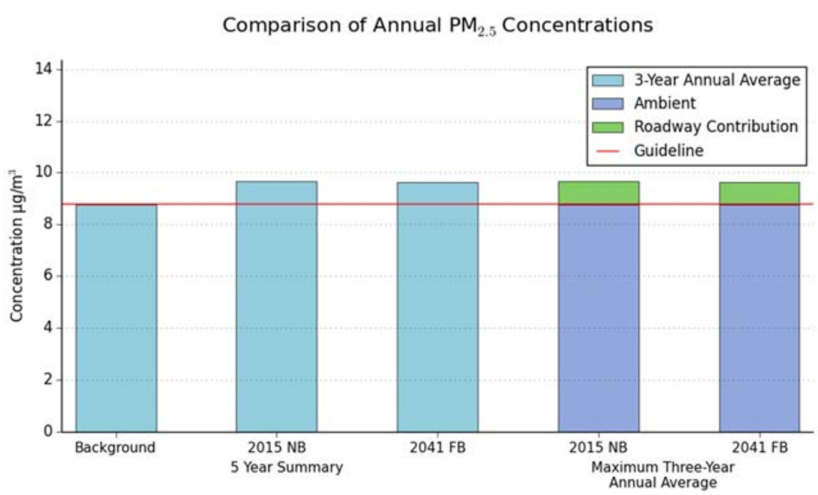
<table>
<tr><th>Statistical Analysis</th><th colspan="2">2041 FB</th></tr>
<tr><td rowspan="9"></td><td colspan="2">% of MOECC Guideline:</td></tr>
<tr><td>Maximum</td><td>6%</td></tr>
<tr><td>90th Percentile</td><td>1%</td></tr>
<tr><td>Average</td><td>1%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>6%</td></tr>
<tr><td>90th Percentile</td><td>6%</td></tr>
<tr><td>Average</td><td>5%</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td rowspan="9"></td><td colspan="2">% of MOECC Guideline:</td></tr>
<tr><td>Maximum</td><td>9%</td></tr>
<tr><td>90th Percentile</td><td>3%</td></tr>
<tr><td>Average</td><td>2%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>6%</td></tr>
<tr><td>90th Percentile</td><td>5%</td></tr>
<tr><td>Average</td><td>4%</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="3">Conclusions:
• All combined concentrations were below their respective MOECC guidelines.
• The contribution from the roadway to the combined concentrations was 6% or less.</td></tr>
</table>

Fine Particulate Matter ($PM_{2.5}$)

Table 15 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour and annual $PM_{2.5}$ based on 5 years of meteorological data. The results conclude that:

- *The average annual 98th percentile 24-hour $PM_{2.5}$ combined concentration, averaged over three consecutive years was below the CAAQS.*
- *The three-year annual average exceeded the guideline with a 9% contribution from the roadway*

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

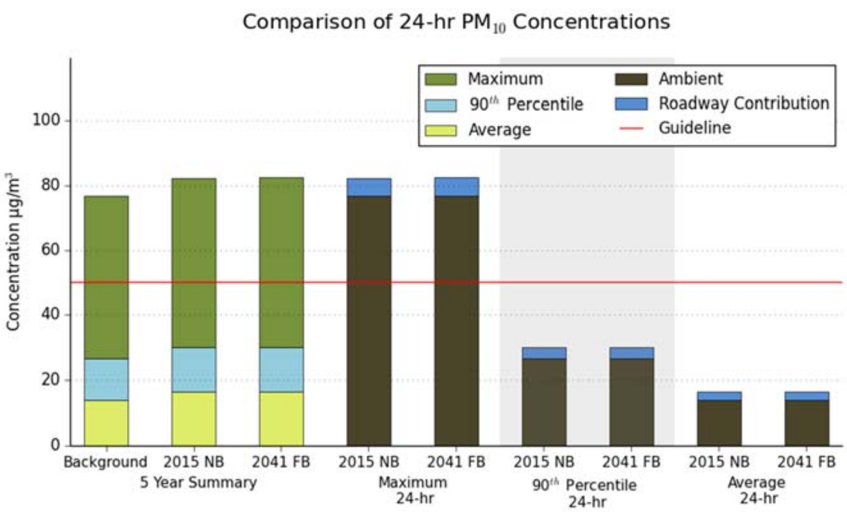
<table>
<tr><th>Statistical Analysis</th><th colspan="2">2041 FB</th></tr>
<tr><td rowspan="9">
</td><td colspan="2">% of MOECC Guideline:</td></tr>
<tr><td>98th Percentile</td><td>91%</td></tr>
<tr><td>90th Percentile</td><td>57%</td></tr>
<tr><td>Average</td><td>30%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>98th Percentile</td><td>8%</td></tr>
<tr><td>90th Percentile</td><td>9%</td></tr>
<tr><td>Average</td><td>10%</td></tr>
<tr><td colspan="2">The PM2.5 results were below the 3-year CAAQS. The highest 3 year rolling average of the yearly 98th percentile combined concentrations was calculated to be 24.65 µg/m³ or 91% of the CAAQS.</td></tr>
<tr><td rowspan="5">
</td><td colspan="2">% of MOECC Guideline:</td></tr>
<tr><td>3-Year Annual Average</td><td>109%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>3-Year Annual Average</td><td>9%</td></tr>
<tr><td colspan="2">The PM2.5 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 100% of the guideline. And that there was no change between the 2015 Existing and 2041 Future Build Scenarios</td></tr>
</table>

Coarse Particulate Matter (PM_{10})

Table 16 presents the predicted combined concentrations 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 concentrations exceeded the MOECC guideline.*

Table 16: Summary of Predicted PM_{10} Concentrations

Statistical Analysis	2041 FB	
	**% of MOECC Guideline:**	
	Maximum	165%
	90th Percentile	60%
	Average	30%
	Roadway Contribution:	
	Maximum	7%
	90th Percentile	16%
	Average	18%

Conclusions:

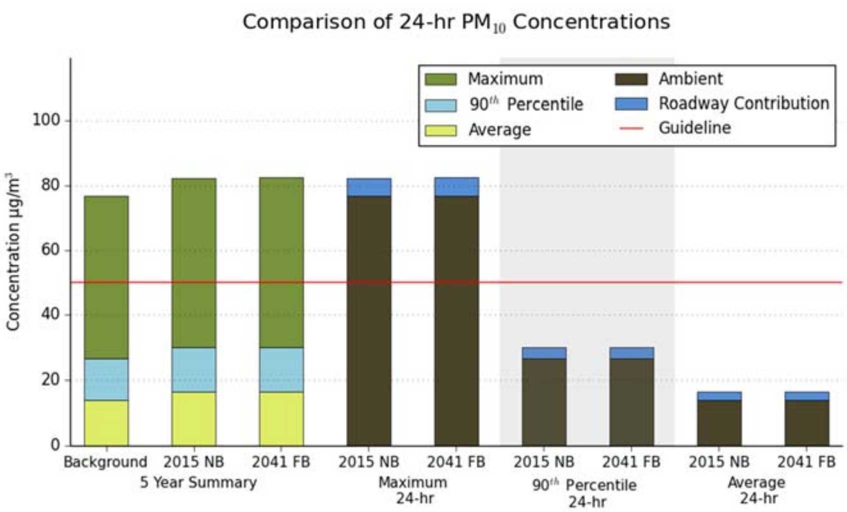
- The combined concentrations of PM_{10} surrounding the study area exceed the standard of 50 µg/m^3. It should be noted, however, that background concentrations alone exceeded the standard and that the roadway contribution is 7% of the maximum value.
- Frequency analysis was conducted to show that elevated concentrations were not frequent over a 5-year period.
- Frequency analysis showed that no additional exceedances are expected due to the roadway over the five-year period between 2015 Existing and 2041 Future Build.
- A total of 21 days exceeded the guideline in the five year period in both scenarios, which equates to approximately 1%.

Total Suspended Particulate Matter (TSP)

Table 17 presents the predicted combined concentrations 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 concentrations exceeded the MOECC guideline.*

Table 17: Summary of Predicted TSP Concentrations

Statistical Analysis	2041 FB	
	**% of MOECC Guideline:**	
	Maximum	138%
	90^{th} Percentile	55%
	Average	32%
	Roadway Contribution:	
	Maximum	16%
	90^{th} Percentile	37%
	Average	30%

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 16% of the maximum value.
- Frequency analysis was conducted to show that elevated concentrations were not frequent over a 5-year period.
- Frequency analysis showed that 3 additional exceedances are expected due to the roadway over the five-year period between 2015 Existing and 2041 Future Build.
- A total of 6 days exceeded the guideline in the Existing Scenario and 9 days exceeded in the Future Build Scenario, which equates to less than 1%.

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.

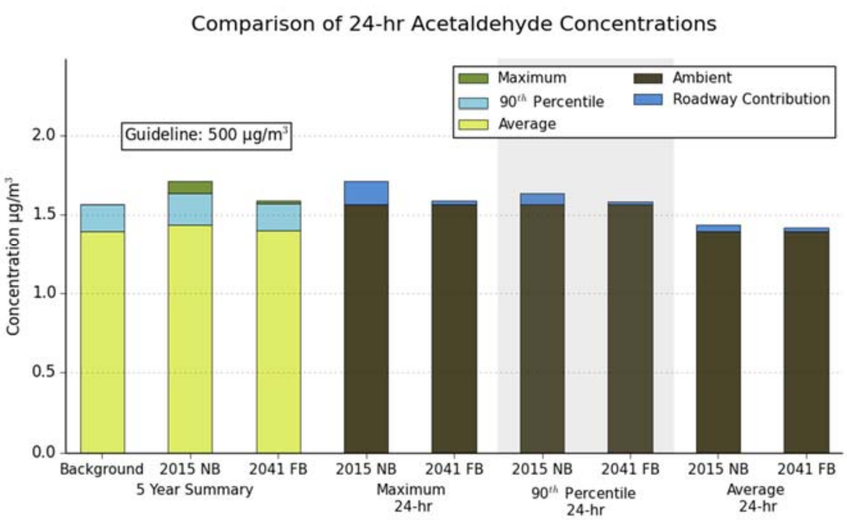
Acetaldehyde

Table 18 presents the predicted combined concentrations 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 MOECC guideline.*

Table 18: Summary of Predicted Acetaldehyde Concentrations

Statistical Analysis	2041 FB



% of MOECC Guideline:	
Maximum	<1%
90th Percentile	<1%
Average	<1%
Roadway Contribution:	
Maximum	2%
90th Percentile	<1%
Average	<1%

Conclusions:
- All combined concentrations were below their respective MOECC guidelines.
- The contribution from the roadway to the combined concentrations was 2% or less.

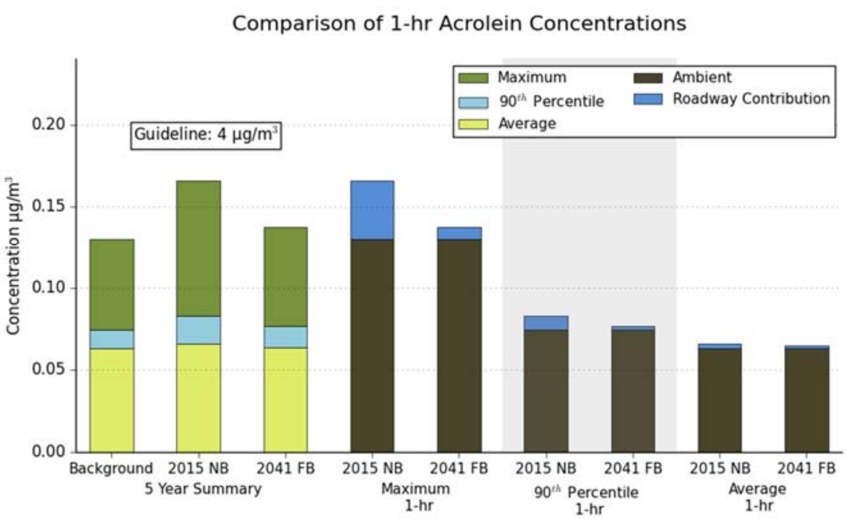
Acrolein

Table 19 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 concentration were below the respective MOECC guideline.*

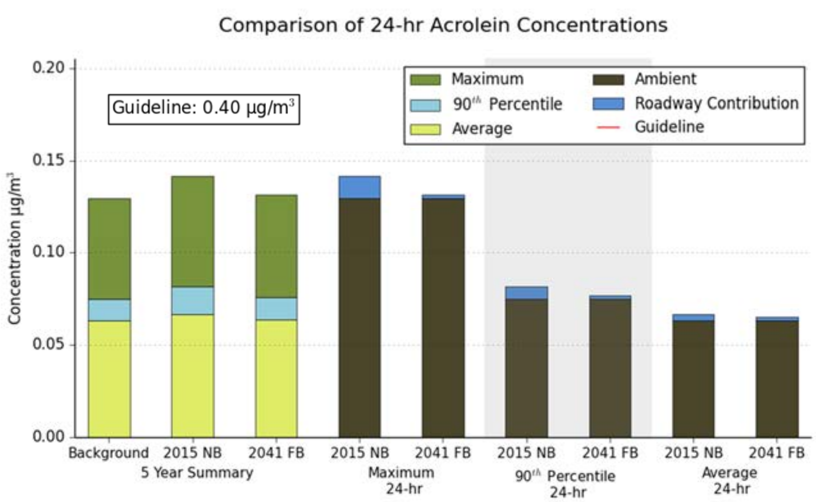
Table 19: Summary of Predicted Acrolein Concentrations

Statistical Analysis	2041 FB



% of MOECC Guideline:	
Maximum	3%
90th Percentile	2%
Average	1%
Roadway Contribution:	
Maximum	5%
90th Percentile	1%
Average	1%

Conclusions:
The combined concentrations were below the respective MOECC guidelines. The contribution from the roadway was 5% or less.



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

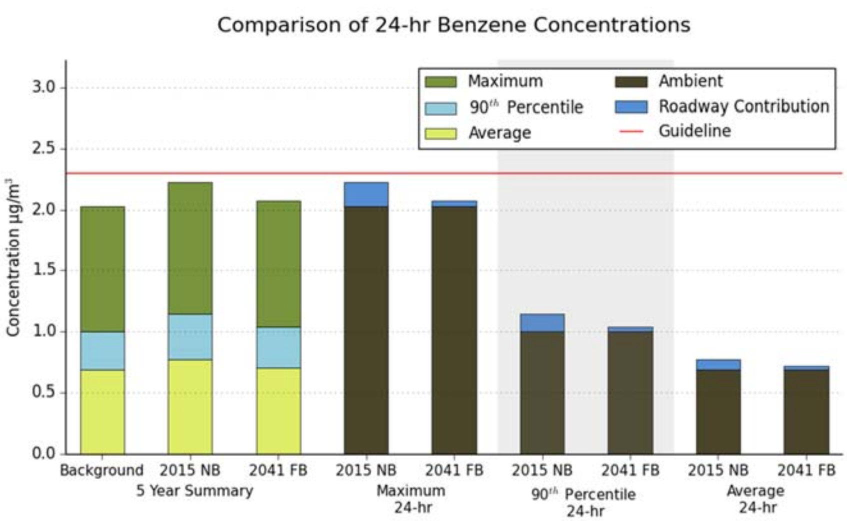
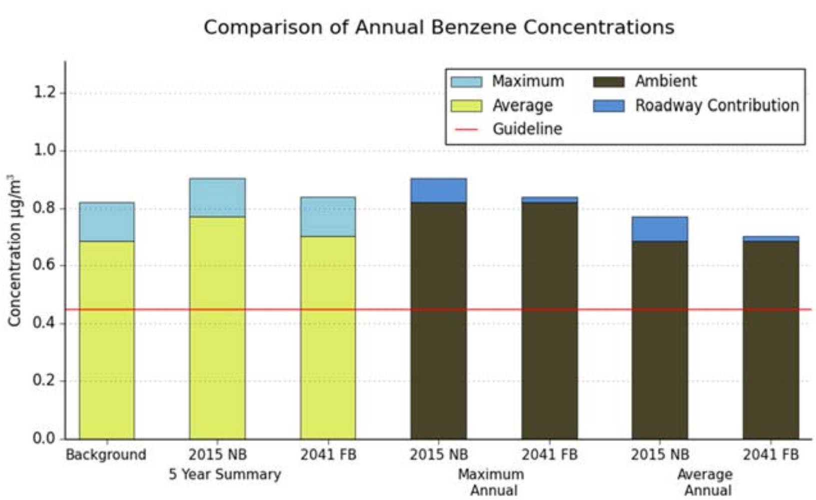
Conclusions:
The combined concentrations were below the respective MOECC guidelines. The contribution from the roadway was 1% or less.

Benzene

Table 20 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 MOECC guideline.*
- *The annual benzene concentrations exceeded the guidline due to ambient concentrations. The roadway contributino to the annual average was 3%.*

Table 20: Summary of Predicted Benzene Concentrations

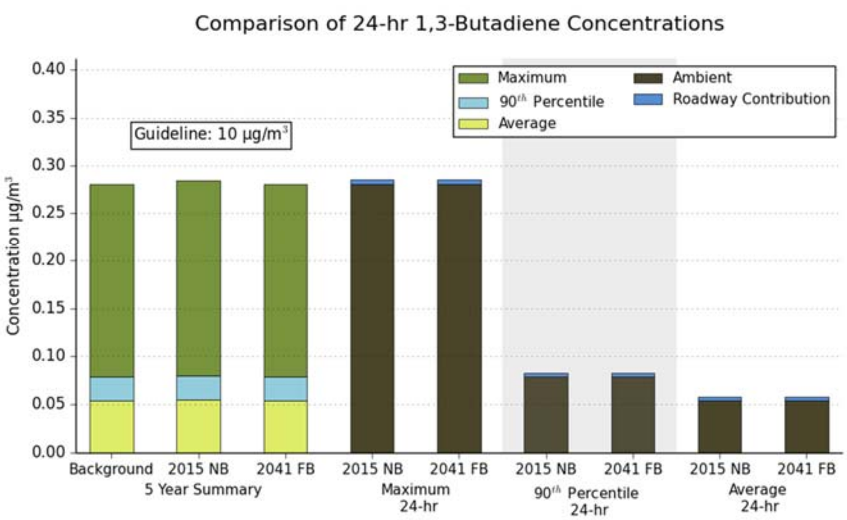
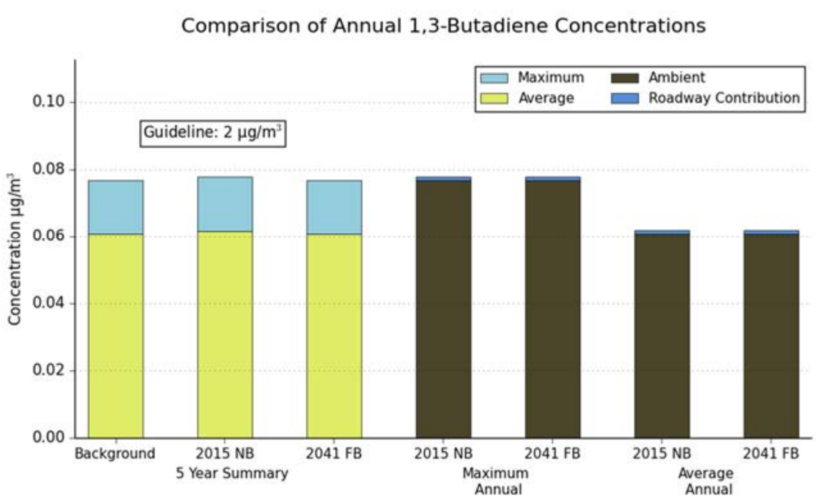
Statistical Analysis	2041 FB	
	**% of MOECC Guideline:**	
	Maximum	90%
	90th Percentile	45%
	Average	31%
	Roadway Contribution:	
	Maximum	2%
	90th Percentile	2%
	Average	3%
	Conclusions: The combined concentrations were below the respective MOECC guidelines. The contribution from the roadway was 3%.	
	**% of MOECC Guideline:**	
	Maximum	186%
	Average	156%
	Roadway Contribution:	
	Maximum	2%
	Average	3%
	Conclusions: The combined concentration exceeded the MOECC guideline. It should be noted that ambient concentrations were 186% of the guideline and the roadway contribution to the maximum was 2%.	

1,3-Butadiene

Table 21 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour and annual 1,3-butadiene based on 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 MOECC guidelines.*

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

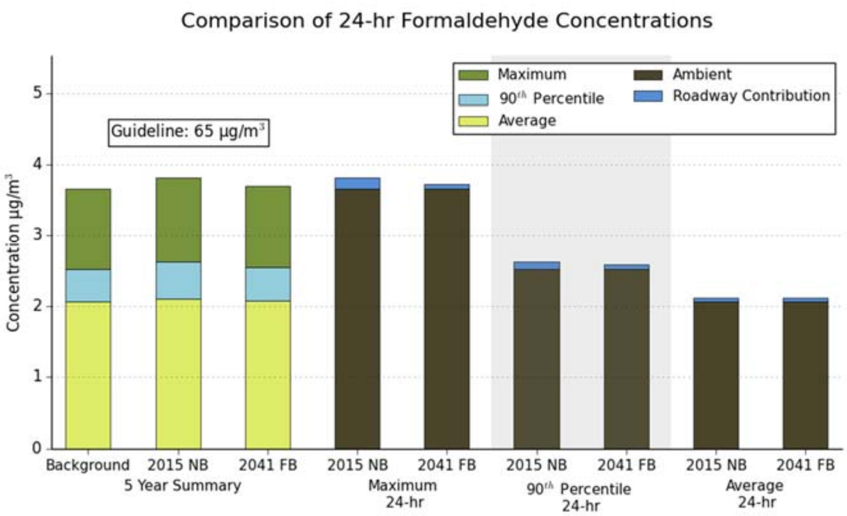
Statistical Analysis	2041 FB	
	**% of MOECC Guideline:**	
	Maximum	3%
	90th Percentile	<1%
	Average	1%
	Roadway Contribution:	
	Maximum	<1%
	90th Percentile	<1%
	Average	<1%
	Conclusions: The combined concentrations were below the respective MOECC guidelines. The contribution from the roadway was less than 1%.	
	**% of MOECC Guideline:**	
	Maximum	4%
	Average	3%
	Roadway Contribution:	
	Maximum	<1%
	Average	<1%
	Conclusions: The combined concentrations were below the respective MOECC guidelines. The contribution from the roadway was less than 1%.	

Formaldehyde

Table 22 presents the predicted combined concentrations 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 MOECC guideline.*

Table 22: Summary of Predicted Formaldehyde Concentrations

Statistical Analysis	2041 FB	
	**% of MOECC 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 MOECC guidelines.
- The contribution from the roadway to the combined concentrations was 1% or less.

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 calculating the relative change in total emissions between the 2015 Existing and 2041 Future Build scenarios. Total GHG emissions 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 Mavis Road. **Table 23** summarizes the length of the roadway, traffic volumes, and emission rates used to determine total GHG emissions on Mavis Road for the 2015 Existing and 2041 Future Build scenarios.

Table 23: Summary of Mavis Road Traffic Volumes, Roadway Length and Emission Rates

Roadway	2015 Two-Way AADT	2041 Two-Way AADT	Length of Roadway (Miles)	Heavy Duty Vehicle Percentage (%)	Posted Speed (km/hr)	2015 CO_2 Equivalent Emission Rate (g/VMT)	2041 CO_2 Equivalent Emission Rate (g/VMT)
Mavis Road from Hwy 401 WB off-ramp to Courtneypark Dr W/Sombrero Way	52,350	68,200	0.20	5%	70	375	224
Mavis Road from Courtneypark Dr W/Sombrero Way to Western Skies Way/Craig Carrier Court	46,450	59,800	0.38	5%	70	375	224
Mavis Road from Western Skies Way/Craig Carrier Court to Novo Star Drive/Crawford Mill Ave	43,700	57,050	0.23	5%	70	375	224
Mavis Road from Novo Star Dr/Crawford Mill Ave to Derry Rd	40,450	53,850	0.22	5%	70	375	224
Mavis Road from Derry Rd to Kaiser Dr/Envoy Dr	38,250	51,450	0.23	5%	70	375	224
Mavis Road from Kaiser Dr/Envoy Dr to Twain Ave/Knotty Pine Grove	39,950	53,100	0.20	5%	70	375	224
Mavis Road from North of Kaiser Dr/Envoy Dr	39,750	52,950	0.31	5%	70	375	224

The total predicted annual GHG emission for the 2015 Existing and 2041 Future Build scenarios are shown in **Table 24**. Also shown is the percent change in total GHG emissions between the scenarios. The results show that due to increases in traffic volumes and decreases in future emission rates, total GHG emissions will be reduced in all sections of the study area. Overall, there is a 21% reduction in GHG emissions between the 2015 Existing and 2041 Future Build scenarios.

Table 24: Predicted GHG Emissions

Roadway	2015 Total CO_2 Equivalent (tonnes/year)	2041 Total CO_2 Equivalent (tonnes/year)	Change in Emissions (%)
Mavis Road from Hwy 401 WB off-ramp to Courtneypark Dr W/Sombrero Way	1447	1128	-22%
Mavis Road from Courtneypark Dr W/Sombrero Way to Western Skies Way/Craig Carrier Court	2429	1871	-23%
Mavis Road from Western Skies Way/Craig Carrier Court to Novo Star Drive/Crawford Mill Ave	1356	1060	-22%
Mavis Road from Novo Star Dr/Crawford Mill Ave to Derry Rd	1204	959	-20%
Mavis Road from Derry Rd to Kaiser Dr/Envoy Dr	1187	956	-20%
Mavis Road from Kaiser Dr/Envoy Dr to Twain Ave/Knotty Pine Grove	1121	892	-20%
Mavis Road from North of Kaiser Dr/Envoy Dr	1690	1347	-20%
TOTAL MAVIS ROAD	10433	8212	-21%

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. It is recommended that these best management practices be followed during construction of the roadway to reduce any air quality impacts that may occur.

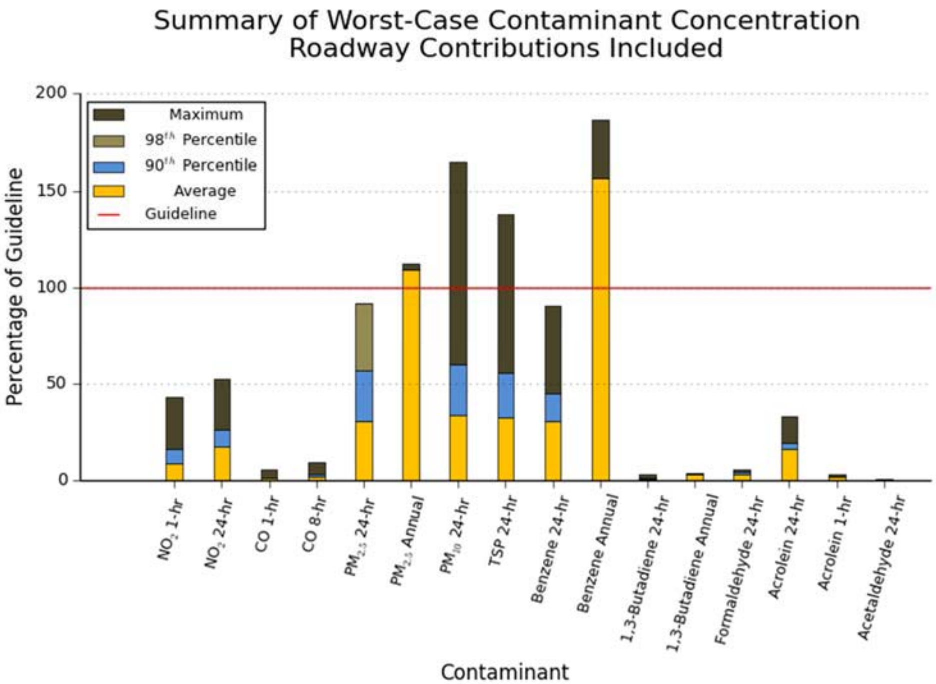
6.0 Conclusions and Recommendations

The potential impact of the proposed project infrastructure on local air quality has been assessed and the results are summarized in **Table 25**. 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 MOECC guidelines or CAAQS, with the exception of annual $PM_{2.5}$, PM_{10}, TSP and annual benzene. Note that for each of these contaminants, background concentrations alone were 100% of the guideline or more.*
- *Frequency Analysis determined that there were no additional days on which exceedances of PM_{10} occurred and only 6 additional days for TSP between the 2015 Existing and 2041 Future Build scenarios, which is less than 1% of the time.*
- *Overall, maximum predicted concentrations are similar between the 2015 Existing and 2041 Future Build scenarios, with little or no increase occurring as a result of the project.*
- *Mitigation measures are not warranted, due to the small number of days which are expected to exceed the guideline.*
- *Total GHG emissions were predicted to decrease in the study area. Overall, there was a 21% decrease in total GHG emissions predicted between the Existing and Future Build scenarios.*

Table 25: Summary of 2041 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 24.65 µg/m³ or 91% of the CAAQS.

% of Guideline

2041 Future Build	
NO_2 (1-hr)	43%
NO_2 (24-hr)	52%
CO (1-hr)	6%
CO (8-hr)	9%
$PM_{2.5}$ (24-hr See Note)	91%
$PM_{2.5}$ (Annual)	112%
PM_{10}	165%
TSP	138%
Acetaldehyde	<1%
Acrolein (1-hr)	3%
Acrolein (24-hr)	33%
Benzene (24-hr)	90%
Benzene (Annual)	186%
1,3-Butadiene (24-hr)	3%
1,3-Butadiene (Annual)	4%
Formaldehyde	6%

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Appendix A
Receptor Specific Modelling Results

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This section shows the maximum results predicted by the air dispersion modelling at each receptor within the study area for the 2015 Existing and 2041 Future Build scenarios. **Figure A1** shows the location of the receptors within the study area.

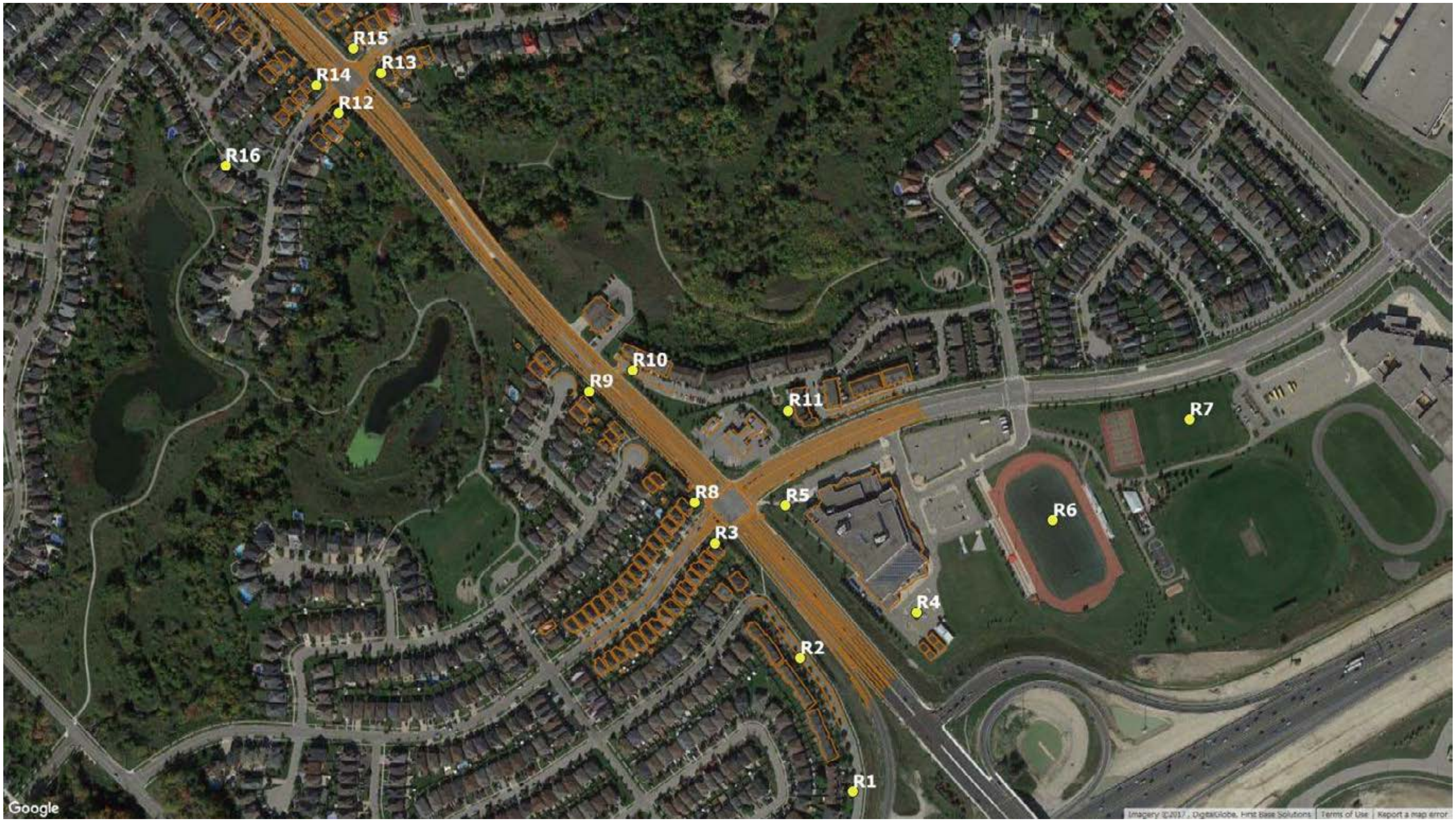


Figure A1: Receptor R1-R16 Locations within the Study Area

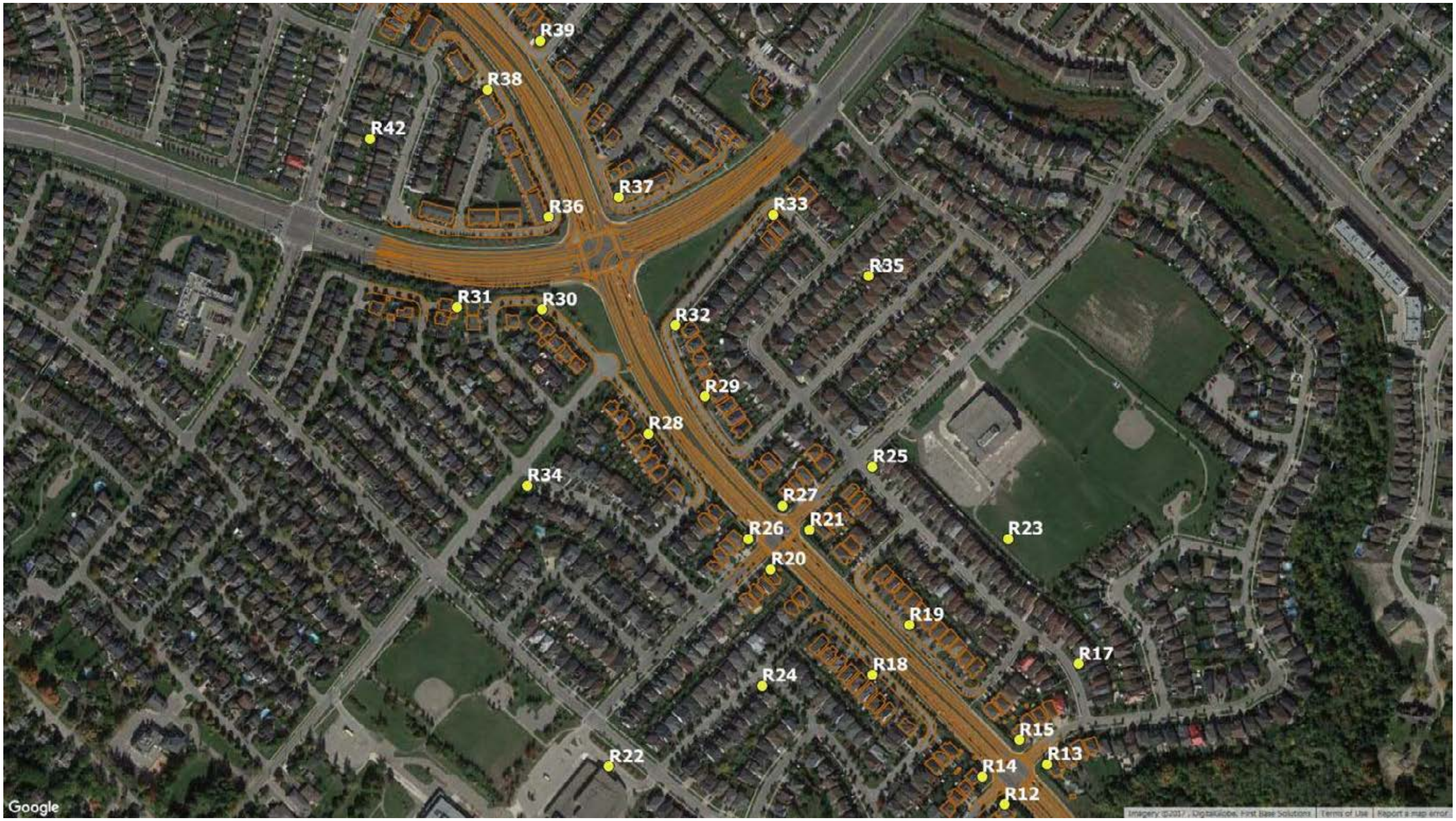


Figure A2: Receptor R12-R15, R17-R39 Locations within the Study Area

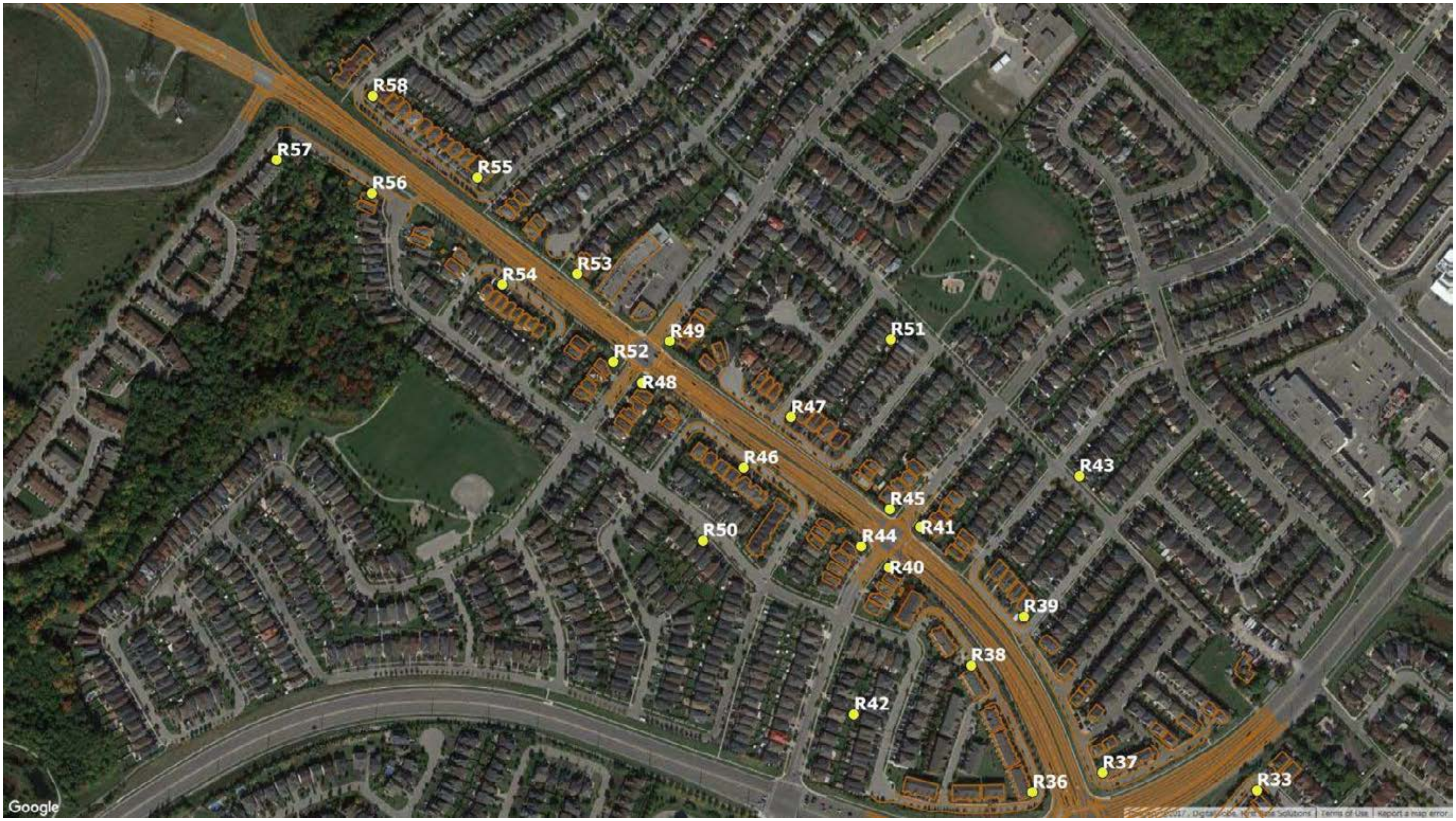
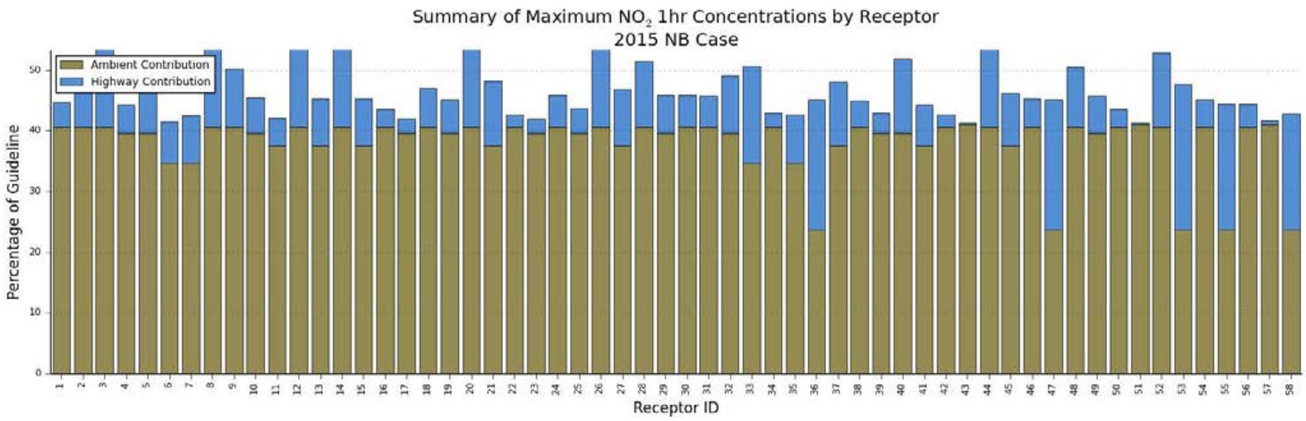


Figure A3: Receptor R36-R58 Locations within the Study Area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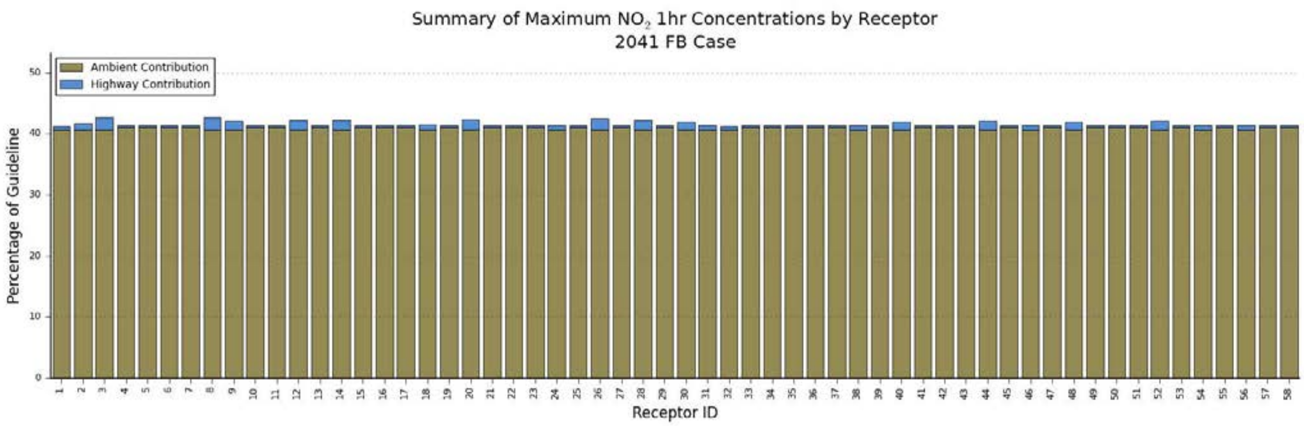
Highway Contribution
Percentage of Guideline
Receptor ID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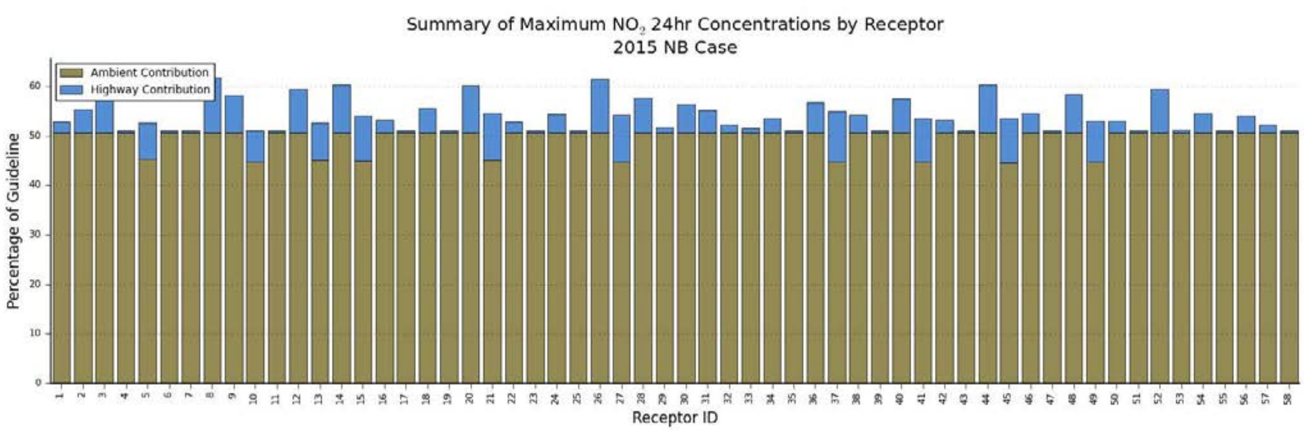
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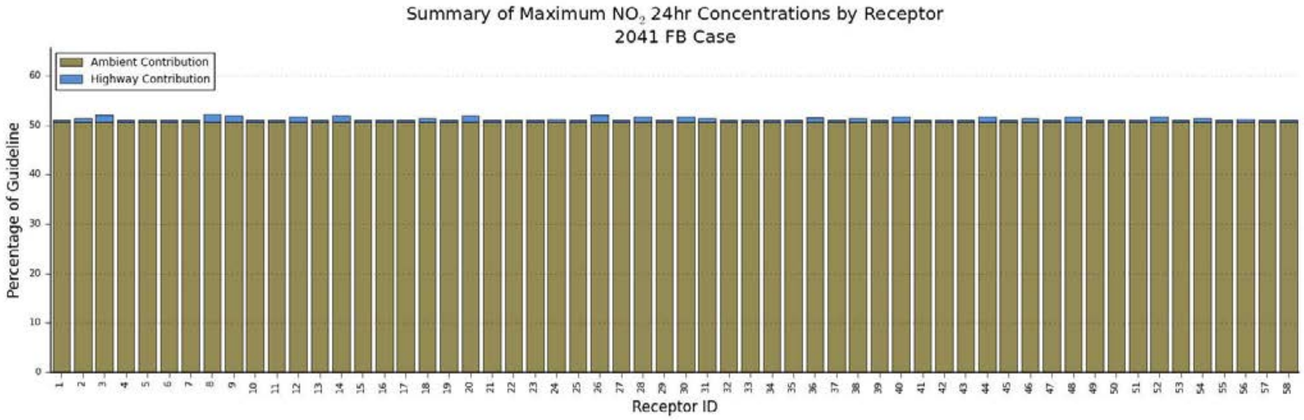
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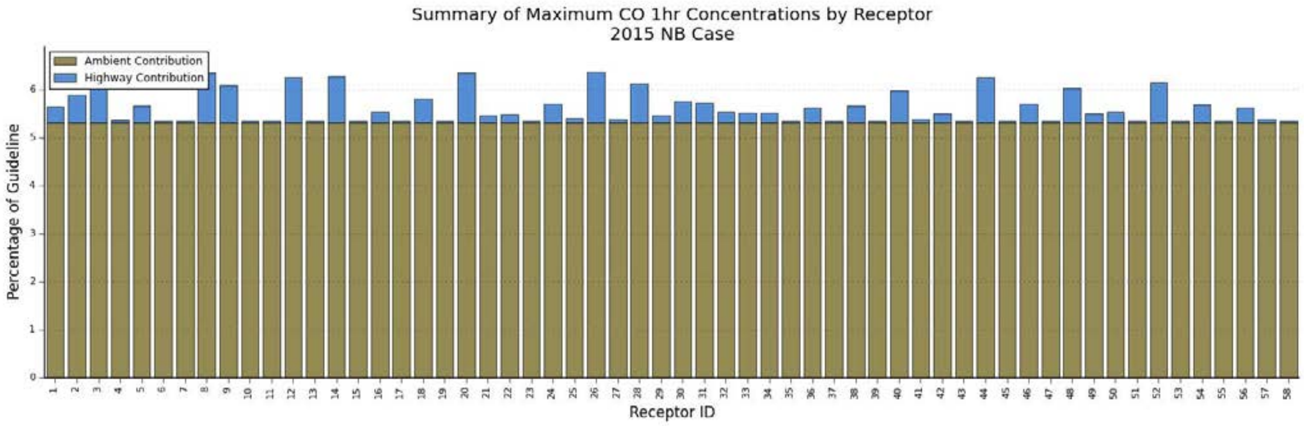
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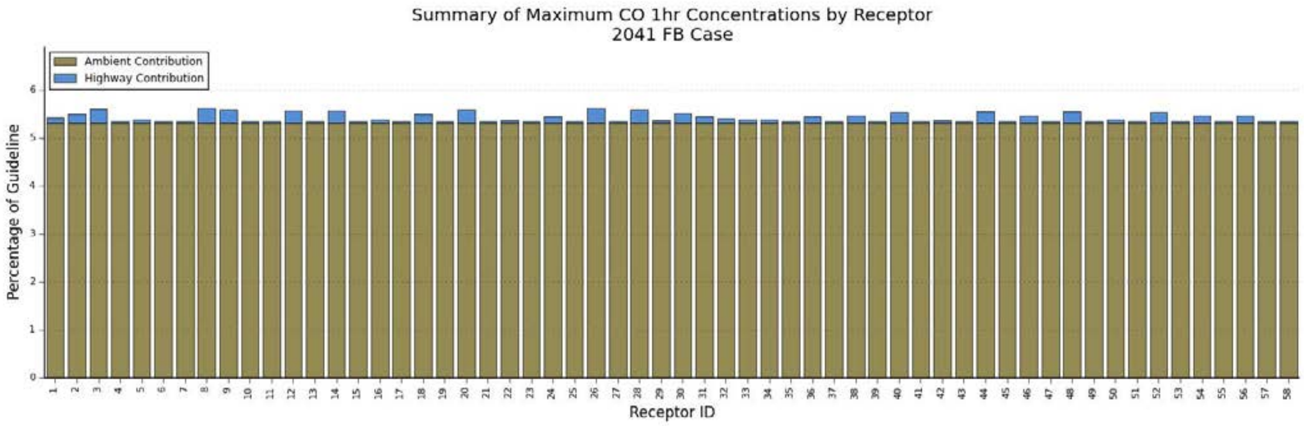
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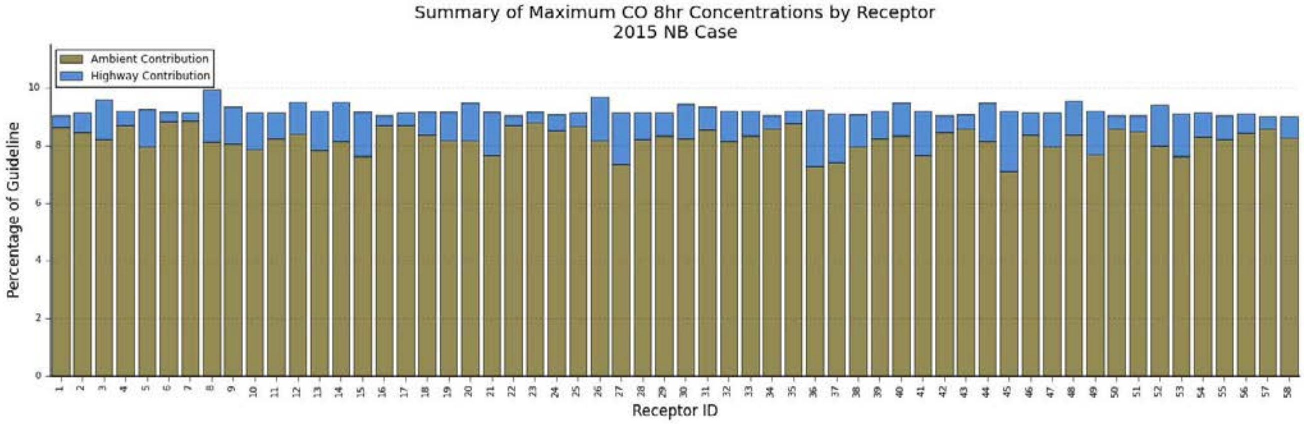
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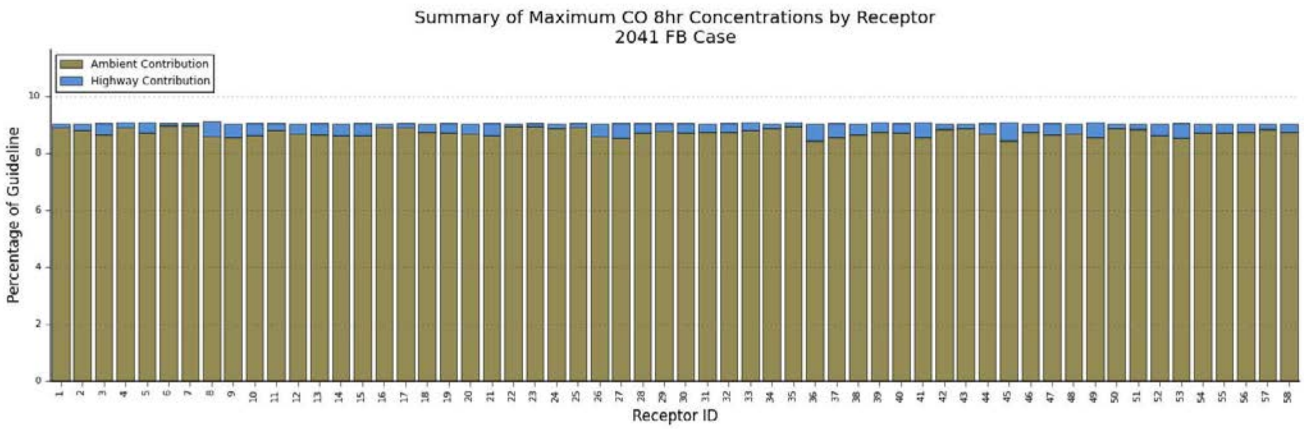
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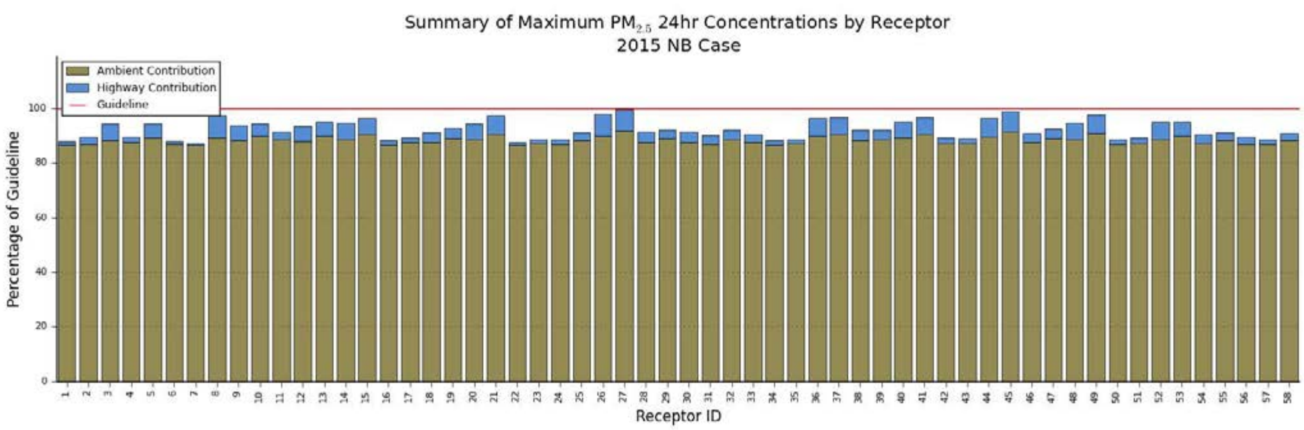
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Percentage of Guideline
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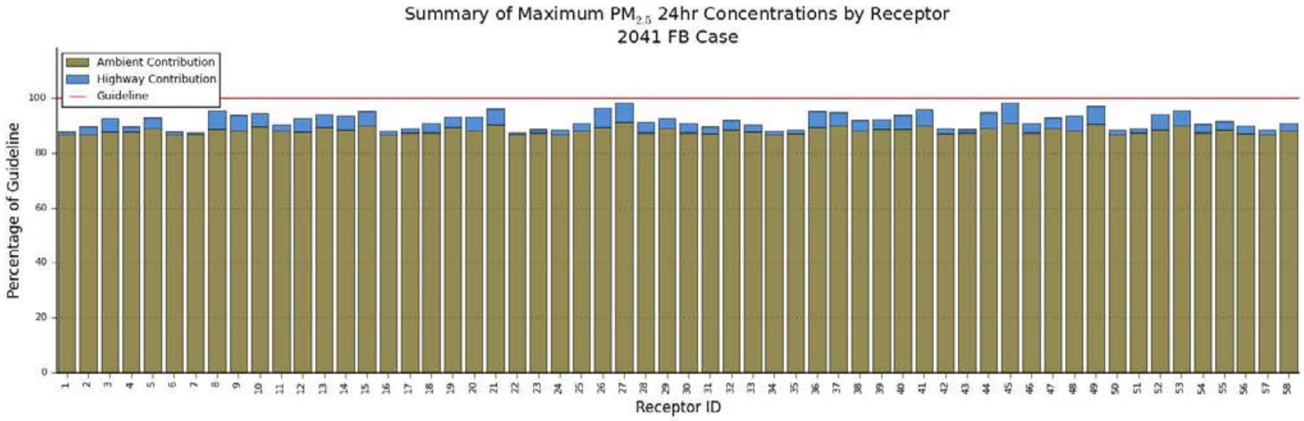
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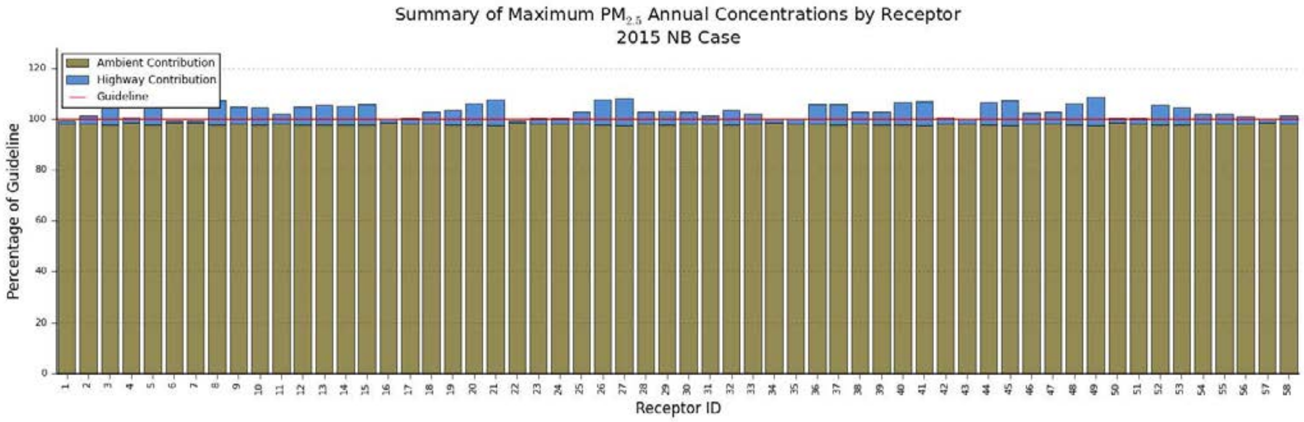
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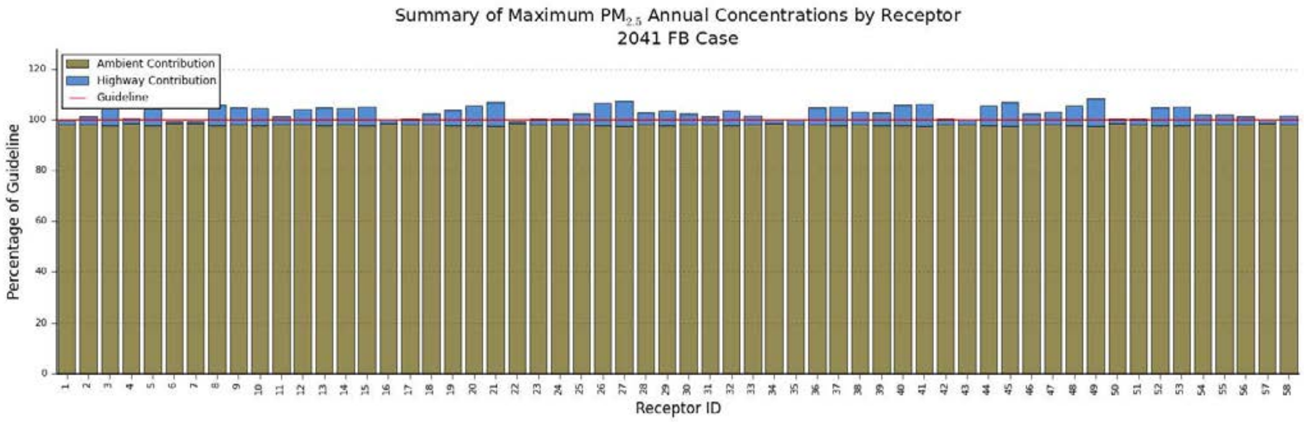
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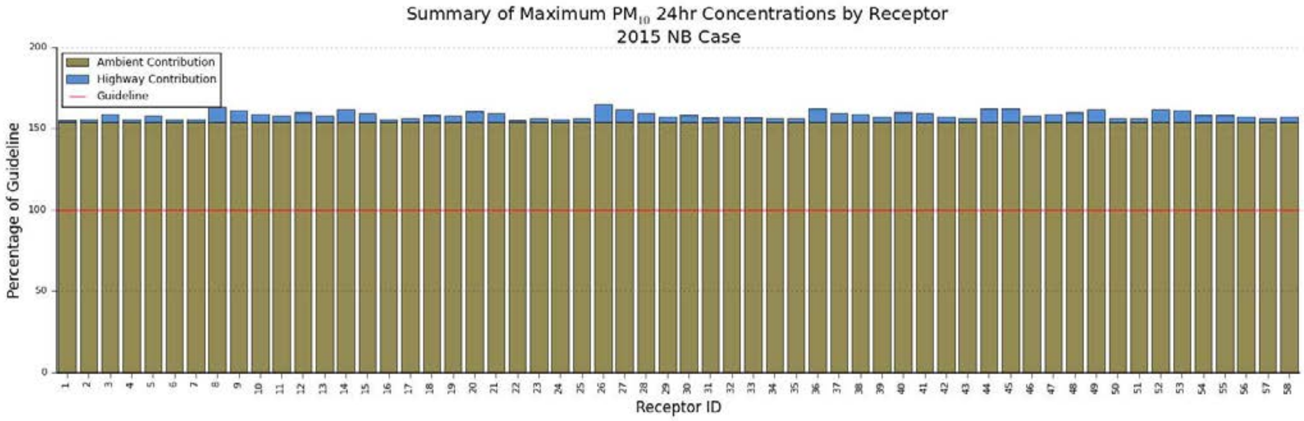
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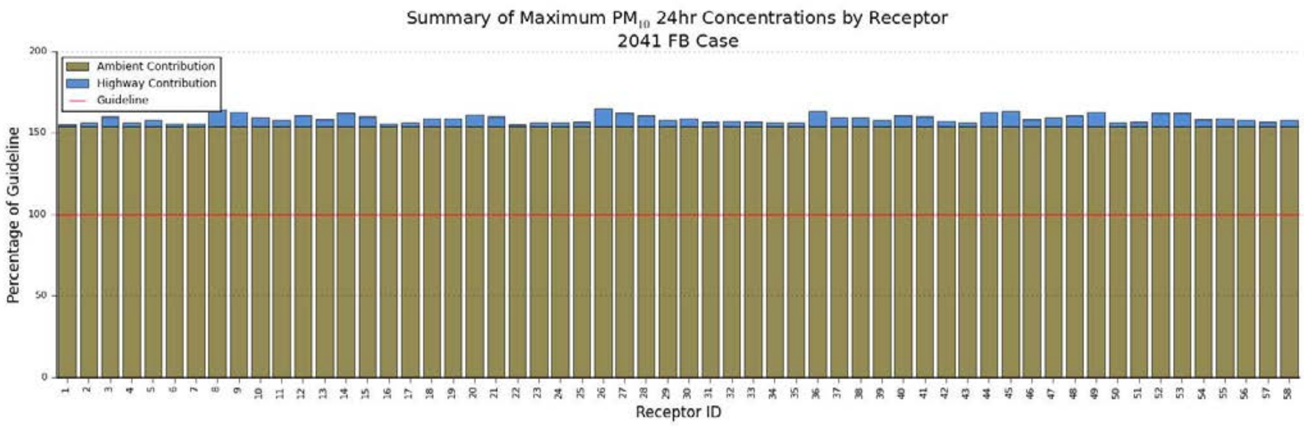
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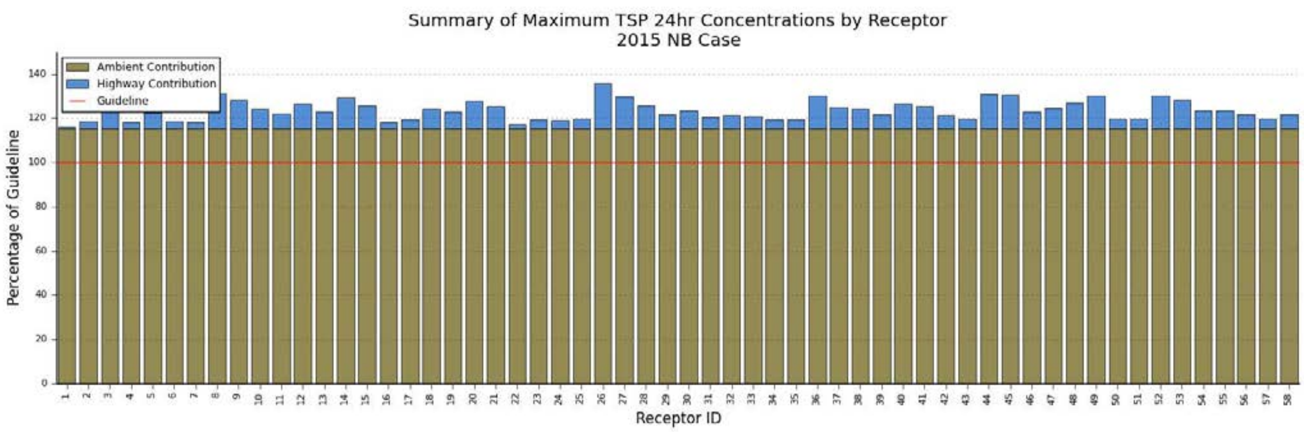
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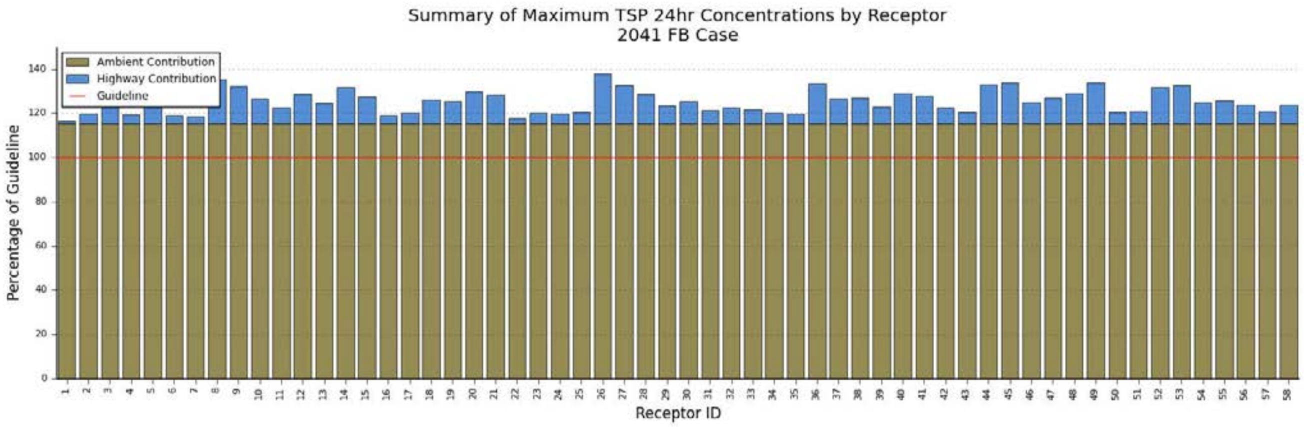
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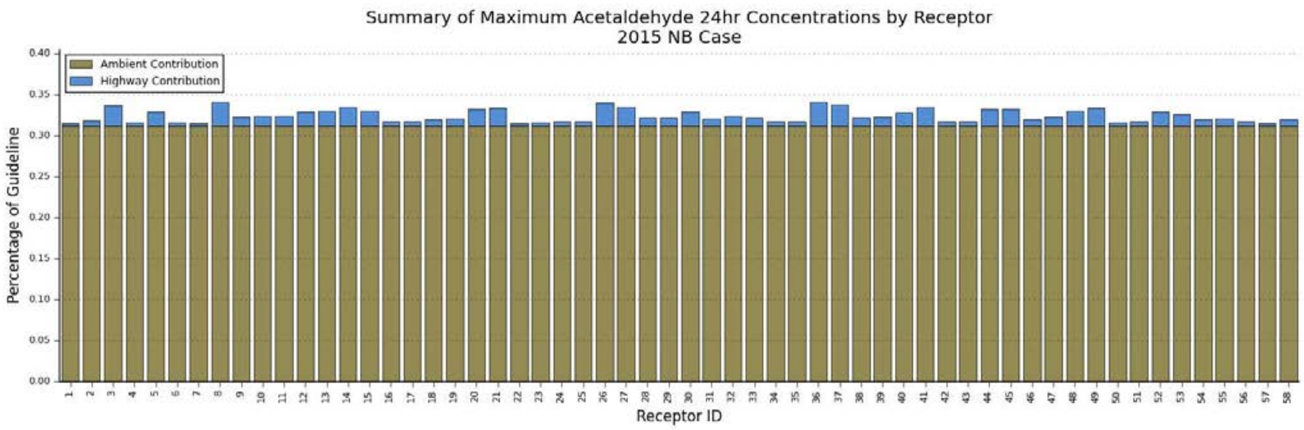
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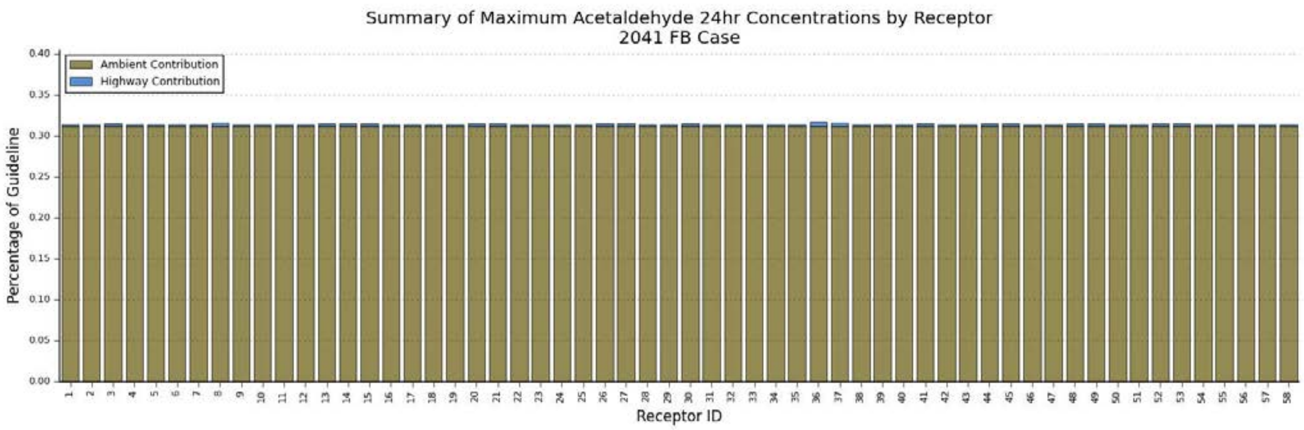
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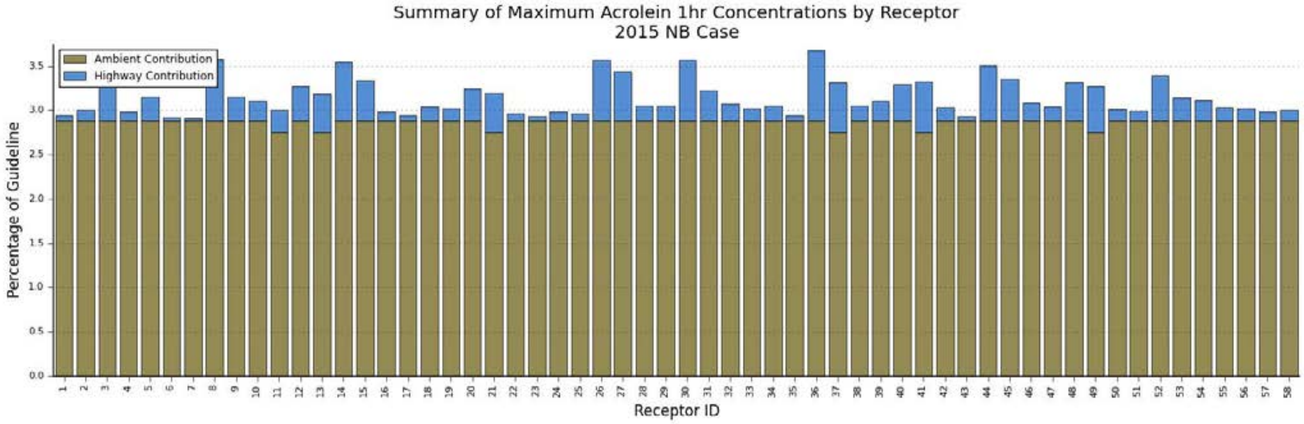
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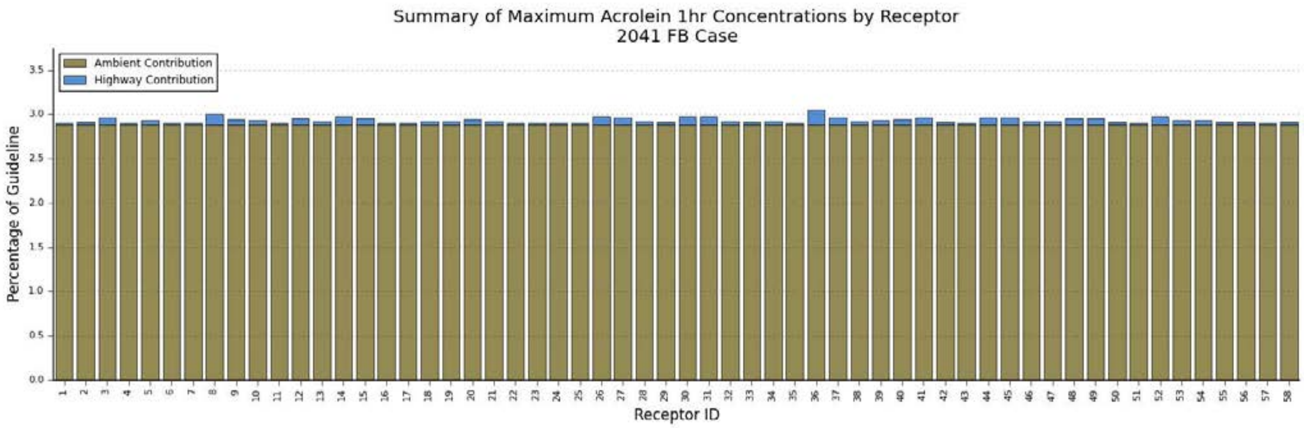
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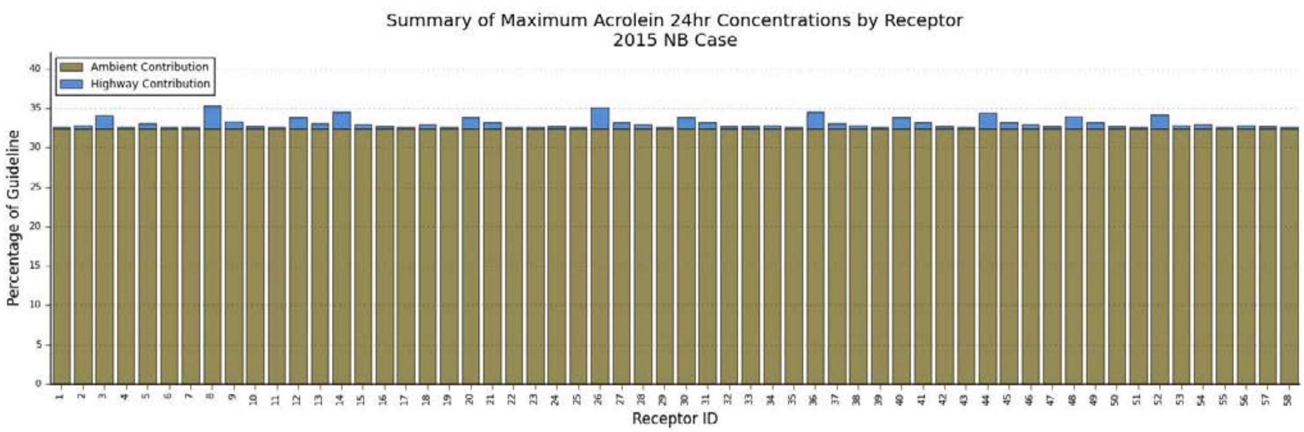
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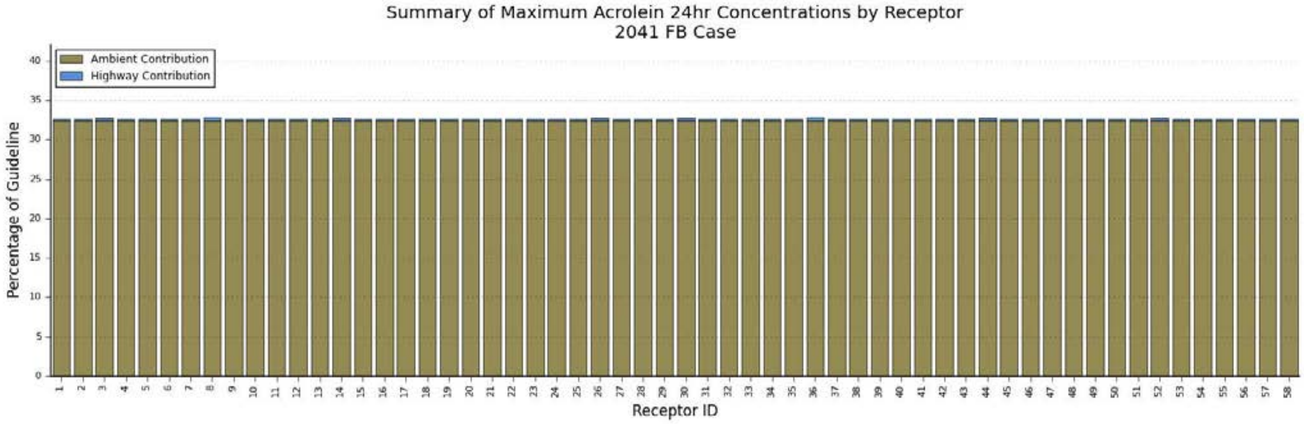
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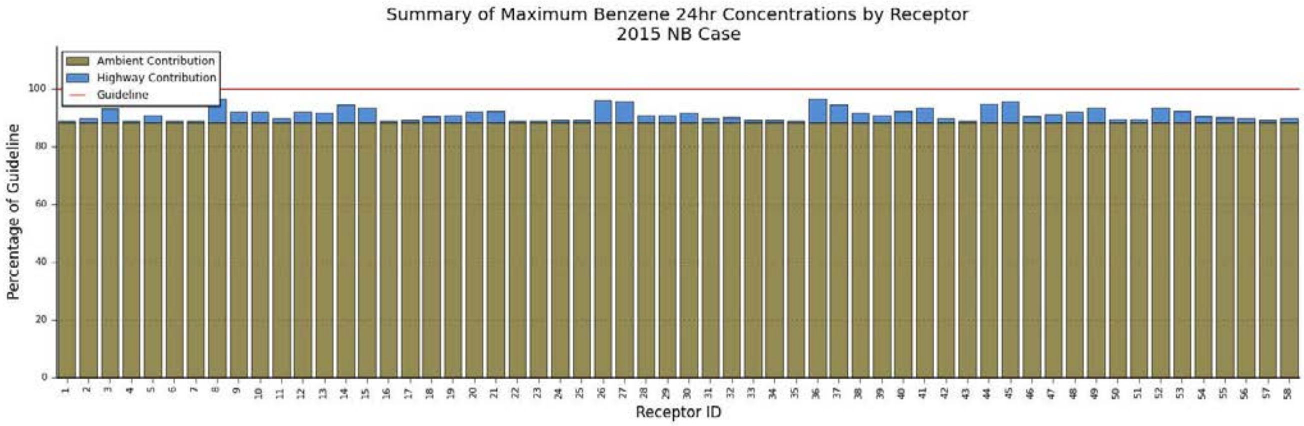
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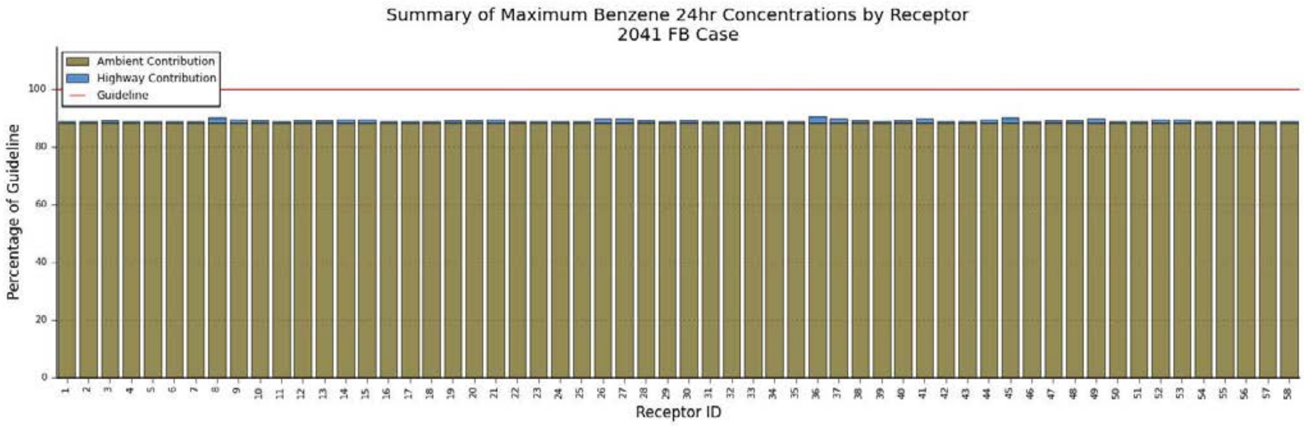
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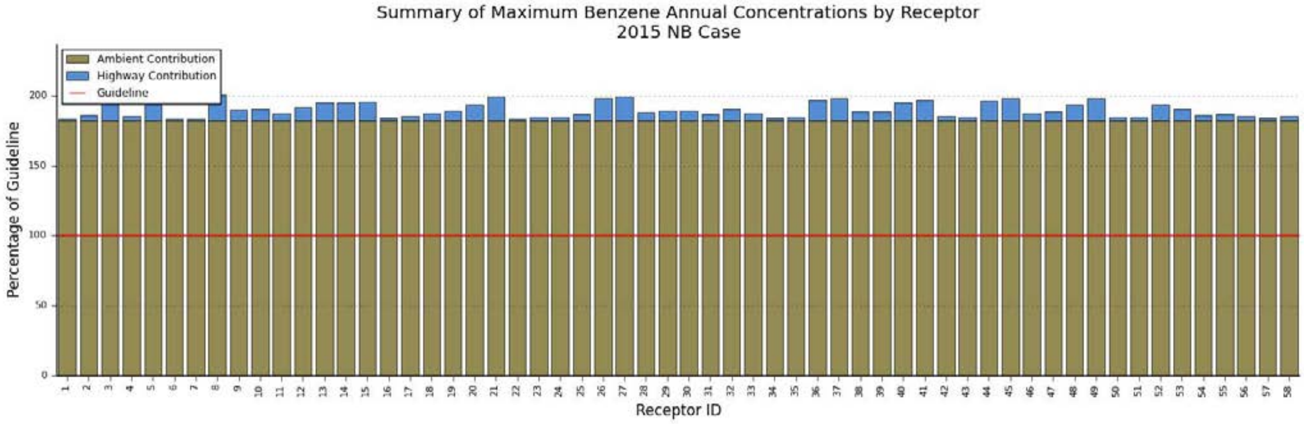
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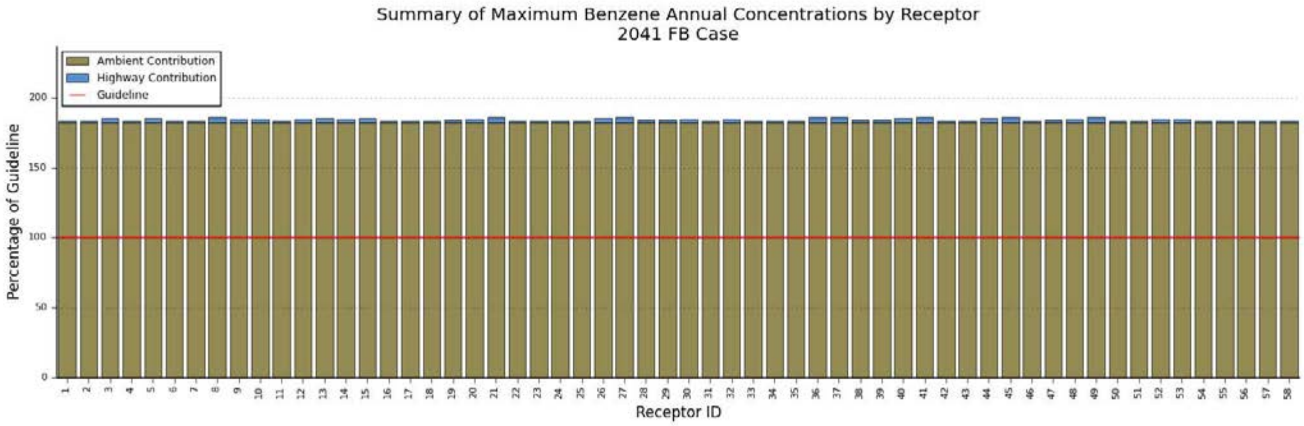
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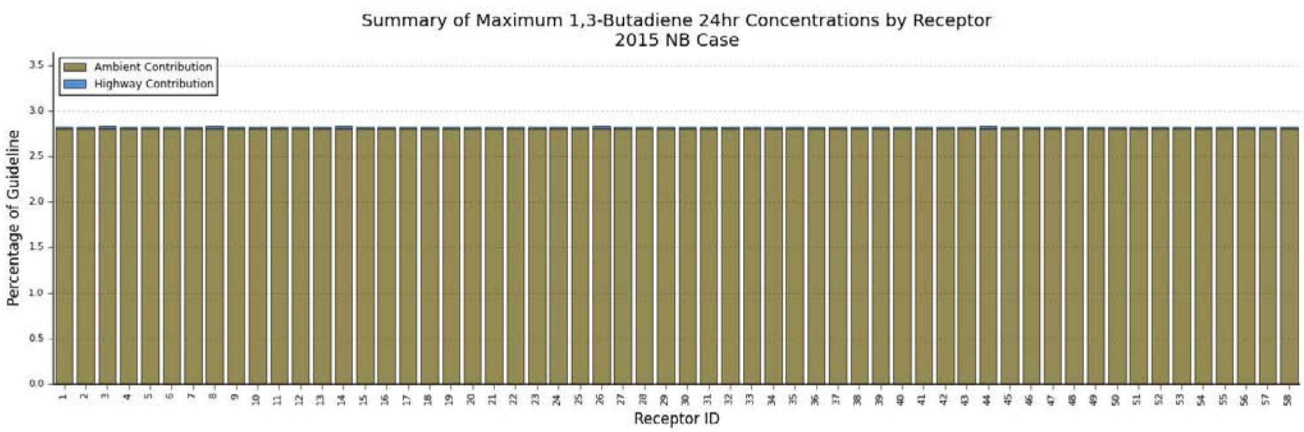
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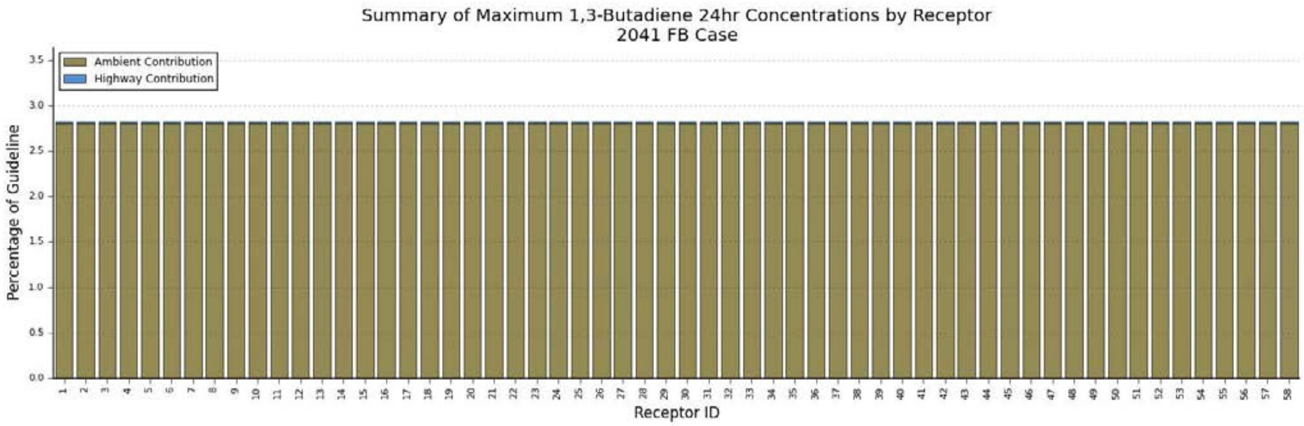
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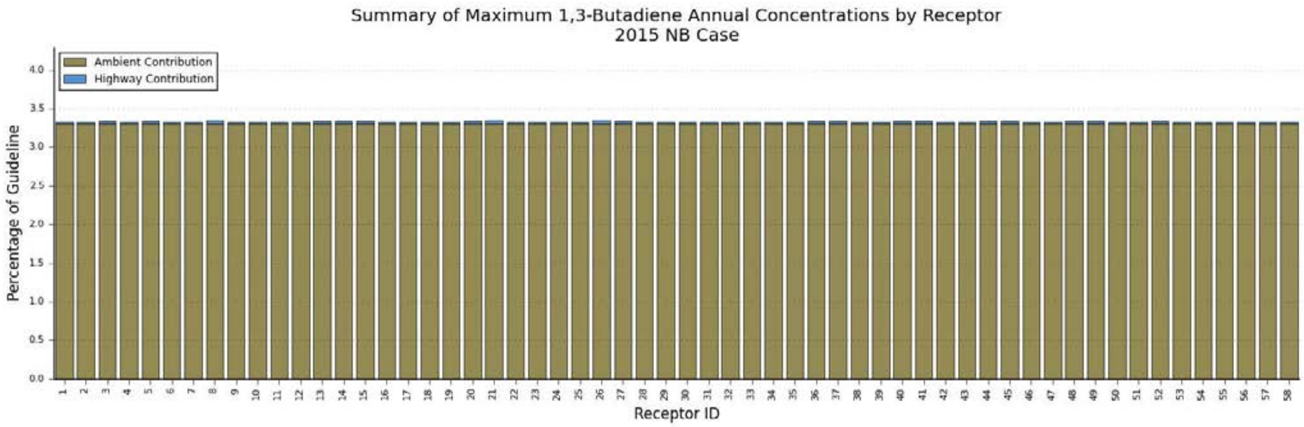
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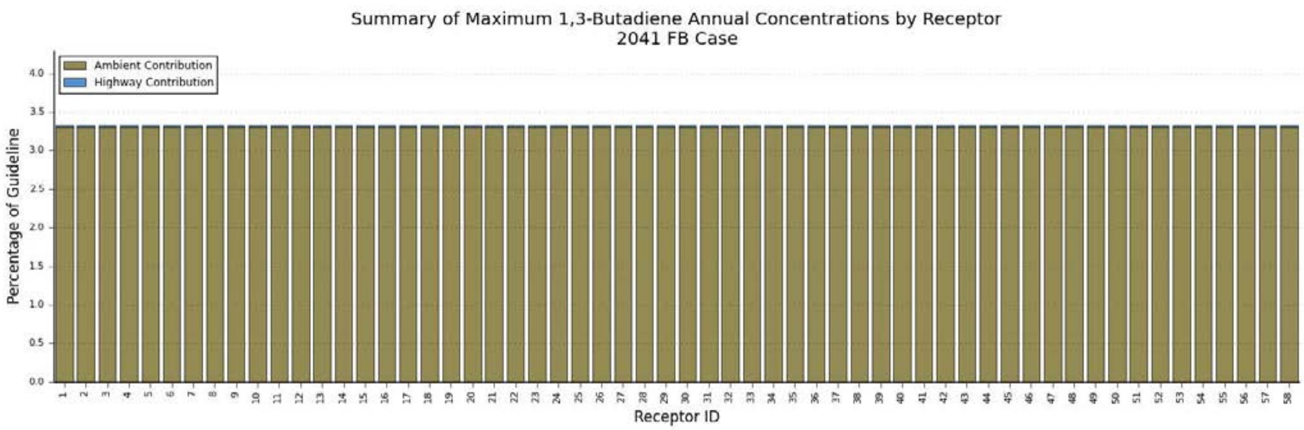
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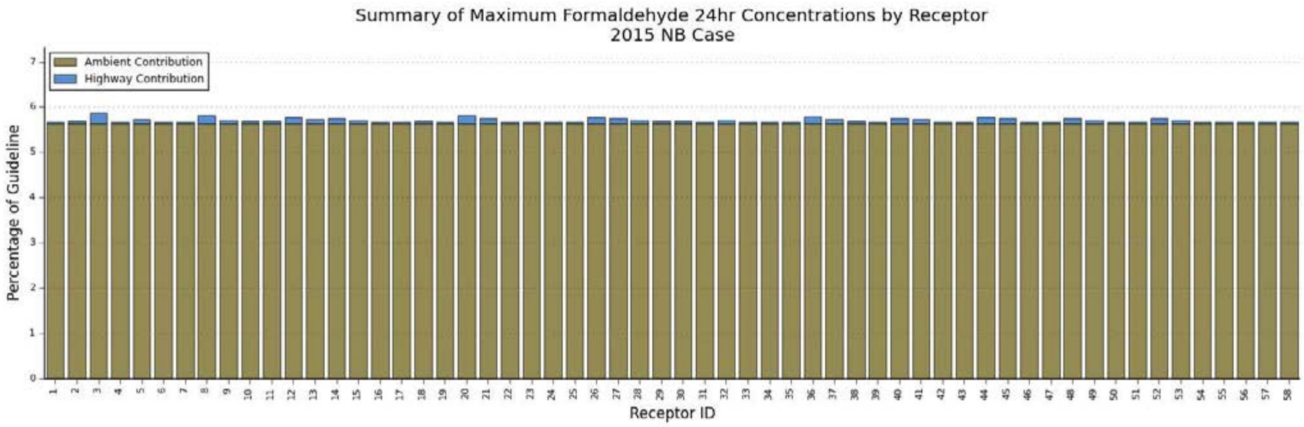
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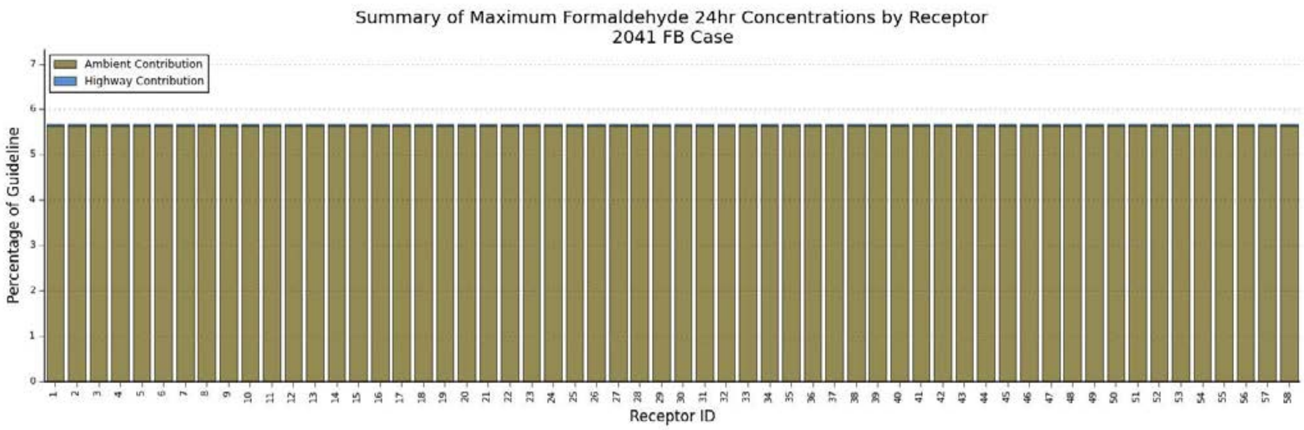
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Highway Contribution
Percentage of Guideline
Receptor ID

ENVIRONMENTAL

Local Air Quality Assessment
Mavis Road North – Class EA
From the North City Limit (Mississauga) to Ray Lawson Boulevard
Regional Municipality of Peel, Ontario

Novus Reference No. 15-0367 Version No. 2 (FINAL) May 29, 2017

NOVUS PROJECT TEAM:

Engineer:	Jenny Vesely, P.Eng.
Senior Engineer:	Jason Slusarczyk, P. Eng.
Project Manager/Specialist:	Scott Shayko, Hon. B. Comm., B.Sc.

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1.0 Introduction

Novus Environmental Inc. (Novus) was retained by WSP/MMM Group to conduct an air quality assessment for the Mavis Road Class EA between the Mississauga northern City limit and Ray Lawson Boulevard. Novus previously conducted an air quality assessment for the widening of Mavis Road between Courtneypark Drive West and the northern City limit, which is summarized in our report dated February 8, 2017. This assessment is an extension of the southern Mavis Road project and includes widening the roadway to six lanes between the northern City limit and Ray Lawson Boulevard. This report assesses the impacts of the roadway widening at nearby sensitive receptors. The study area is approximately 1 km in length and is shown in orange in **Figure 1**.

Figure 1: Study Area Showing the Proposed Roadway Widening (In Orange)

1.1 Study Objectives

The main objective of the study was to assess the local air quality impacts due to the proposed widening of Mavis Road to six lanes between the northern City limit and Ray Lawson Boulevard. 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 scenarios were considered:

- **2015 Existing** – Assess the existing air quality conditions at representative receptors. Predicted contaminant concentrations from the existing roadway were combined with hourly measured ambient concentrations to determine the combined impact.
- **2041 Future Build** – Assess the future air quality conditions for the proposed roadway improvements. Predicted contaminant concentrations from the proposed roadway improvements 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 and Climate Change (MOECC). Motor vehicle emissions have largely been determined by scientists and engineers with United States and Canadian government agencies such as the U.S. Environmental Protection Agency (EPA), the MOECC, Environment Canada (EC), Health Canada (HC), and the MTO. These contaminants are emitted due to fuel combustion, brake wear, tire wear, the breakdown of dust on the roadway, fuel leaks, evaporation and permeation, and refuelling leaks and spills as illustrated in **Figure 2**. Note that emissions related to refuelling leaks and spills are not applicable to motor vehicle emissions from roadway travel. Instead, these emissions contribute to the overall background levels of the applicable contaminants. All of the selected contaminants are emitted during fuel combustion, 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**.

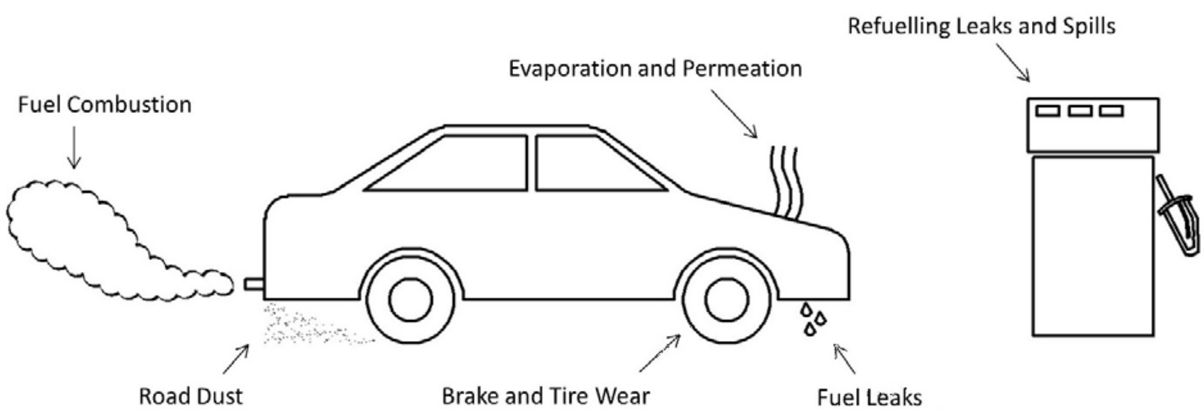


Figure 2: Motor Vehicle Emission Sources

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:

- MOECC Ambient Air Quality Criteria (AAQC);
- Health Canada/Environment Canada National Ambient Air Quality Objectives (NAAQOs); and
- 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 for $PM_{2.5}$ is not based on the maximum 24-hour concentration value; $PM_{2.5}$ is assessed based on the annual 98^{th} percentile value, averaged over 3 consecutive years.

Table 2: Applicable Contaminant Guidelines

Contaminant	Averaging Period (hrs)	Threshold Value ($\mu g/m^3$)	Source
NO_2	1	400	AAQC
	24	200	AAQC
CO	1	36,200	AAQC
	8	15,700	AAQC
$PM_{2.5}$	24	27[1]	CAAQS (27 $\mu g/m^3$ standard is to be phased-in in 2020)
	Annual	8.8[2]	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 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. 2011-2015 historical meteorological data from Toronto Pearson Airport was used. Five years were modelled in order to capture the worst-case meteorological conditions. Two emissions scenarios were assessed: 2015 Existing, and 2041 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 MOECC 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 2015 Existing and 2041 Future Build scenarios are presented in **Section 3.8**.

2.0 Background Ambient Data

2.1 Overview

Background (ambient) conditions are measured contaminant concentrations that are 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 (MOECC, 2005). During smog episodes, the U.S. contribution to $PM_{2.5}$ can be as much as 90 percent near the southwest Ontario-U.S. border. The effects of U.S. air pollution in Ontario on a high $PM_{2.5}$ day and on an average $PM_{2.5}$ spring/summer day are illustrated in **Figure 3**.

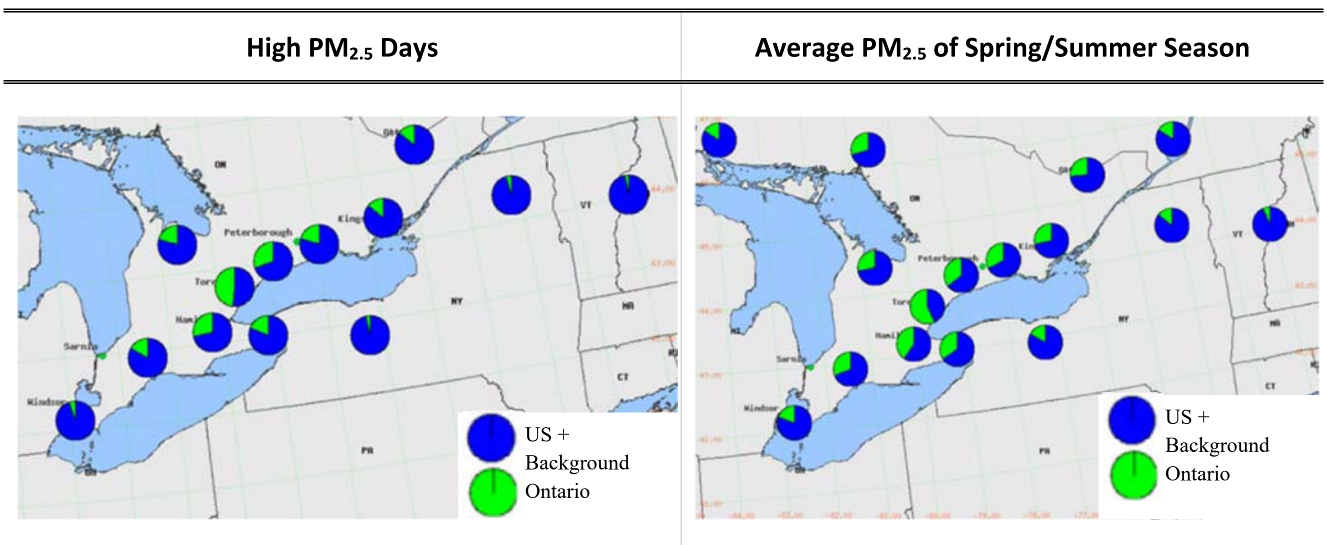


Figure 3: Effect of Trans-Boundary Air Pollution (MOECC, 2005)

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.

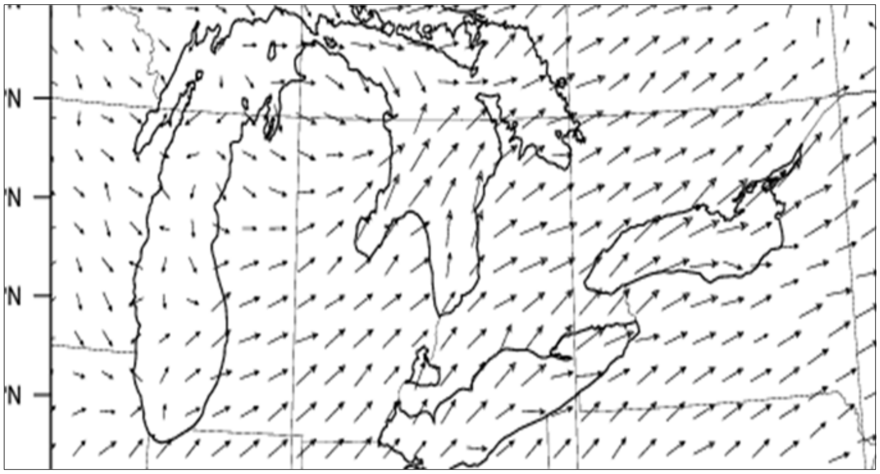


Figure 4: Typical Wind Direction during an Ontario Smog Episode

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 MOECC 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 MOECC and NAPS ambient monitoring stations in Ontario was undertaken to identify the monitoring stations that are in relative proximity to the study area and that would be representative of background contaminant concentrations in the study area. Four MOECC (Brampton, Mississauga, Oakville and Toronto West) and five NAPS (Brampton, Etobicoke North, Etobicoke South, Toronto Downtown and Windsor) stations were selected for the analysis. 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**.

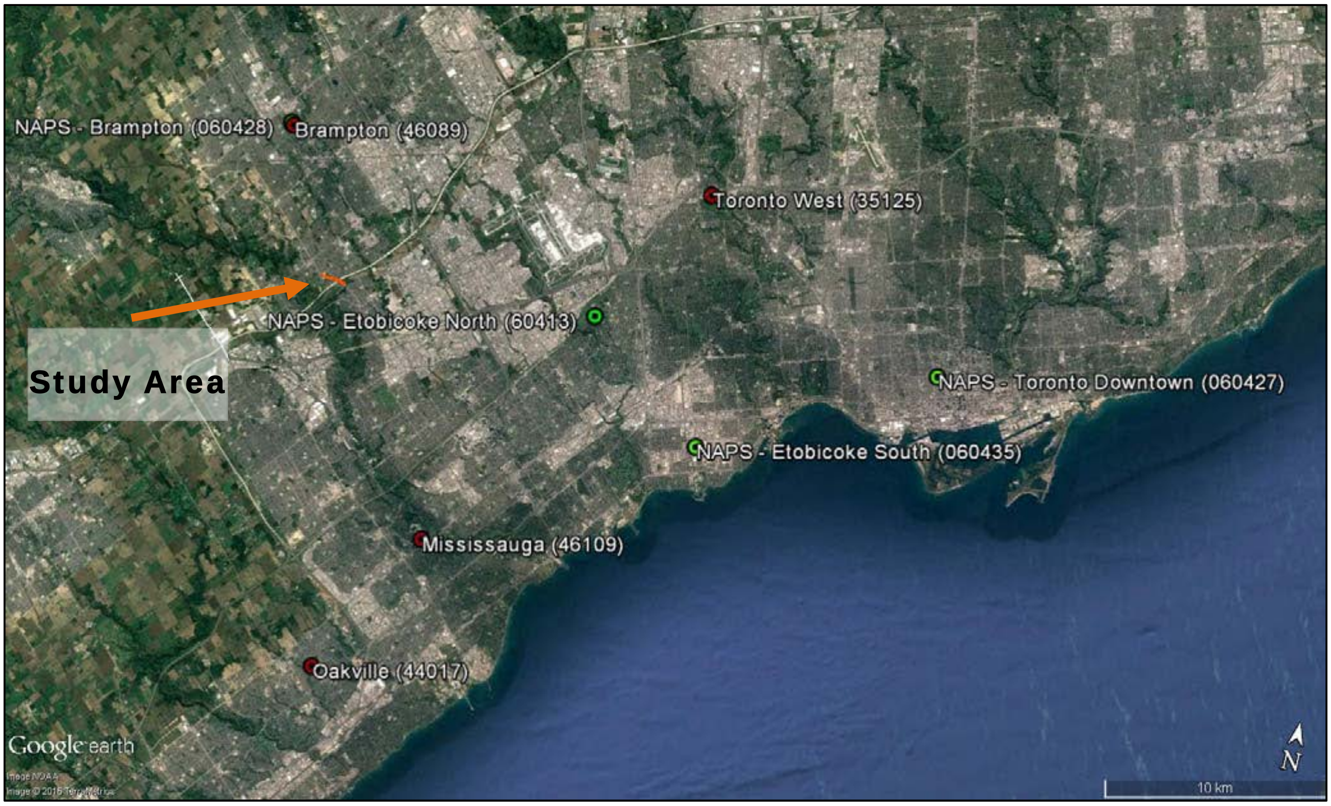


Figure 5: Relevant MOECC (shown in red) and NAPS (shown in green) Monitoring Stations; Windsor NAPS Station Not Shown; Study Area in Orange

Table 3: Relevant MOECC and NAPS Station Information

City/Town	Station ID	Location	Operator	Contaminants
Brampton	46089	525 Main St N	MOECC	NO_2|$PM_{2.5}$
Mississauga	46109	3359 Mississauga Rd. N.	MOECC	NO_2|$PM_{2.5}$
Oakville	44017	Eight Line/Glenashton Dr.	MOECC	NO_2|$PM_{2.5}$
Toronto West	35125	125 Resources Rd	MOECC	NO_2|CO|$PM_{2.5}$
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		1,3-Butadiene|Benzene
Toronto Downtown	60427	223 College St	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.

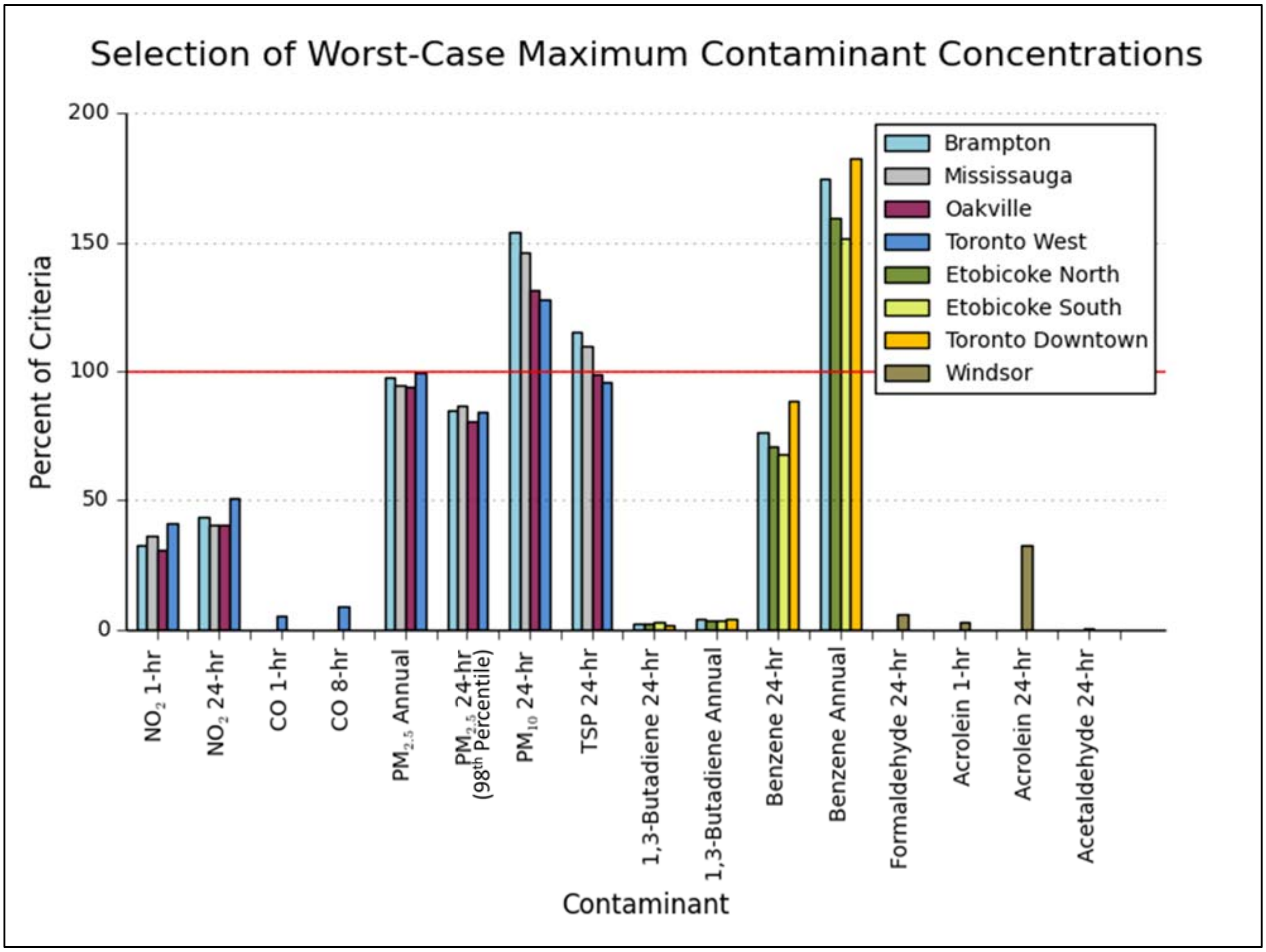
2.3 Selection of Worst-Case Monitoring Stations

Year 2011 to 2015 hourly ambient monitoring data from the selected stations were statistically summarized for the desired averaging periods: 1-hour, 8-hour, 24-hour, and annual. Note that VOC monitoring data for 2015 is not yet publicly available. 2010-2014 data was used for benzene and 1,3-butadiene. Formaldehyde, acetaldehyde and acrolein are only recently measured at the Windsor station, and were not measured in 2014. Therefore 2009-2013 data was used for these VOCs. For consistency with the combined effects analysis (using 2011-2015 meteorological data to predict roadway concentrations), the actual date of measured VOC data within 2011-2015 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 90^{th} percentile measured value for the year in question was applied for those days in order to determine combined concentrations. This method is conservative as it applies the 10^{th} percentile highest 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. **Table 4** 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 West	1,3-Butadiene (24-hr)	Etobicoke South
NO_2 (24-Hr)	Toronto West	1,3-Butadiene (ann)	Brampton
CO (1-Hr)	Toronto West	Benzene (24-hr)	Toronto Downtown
CO (8-hr)	Toronto West	Benzene (ann)	Toronto Downtown
$PM_{2.5}$ (24-hr)	Mississauga	Formaldehyde	Windsor
$PM_{2.5}$ (ann)	Toronto West	Acrolein	Windsor
Pm_{10}	Brampton	Acetaldehyde	Windsor
TSP	Brampton		

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 represents 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 2011-2015, all background concentrations were below their respective guidelines with the exception of 24-hour PM_{10}, 24-hour TSP, and annual benzene. It should be noted that PM_{10} and TSP were calculated based on their relationship to $PM_{2.5}$. It should also be noted that annual PM2.5 CAAQS is based on the average of the three highest annual average values over the study period, and not the maximum (shown in brown below). The annual $PM_{2.5}$ average concentration was 100% of the guideline.

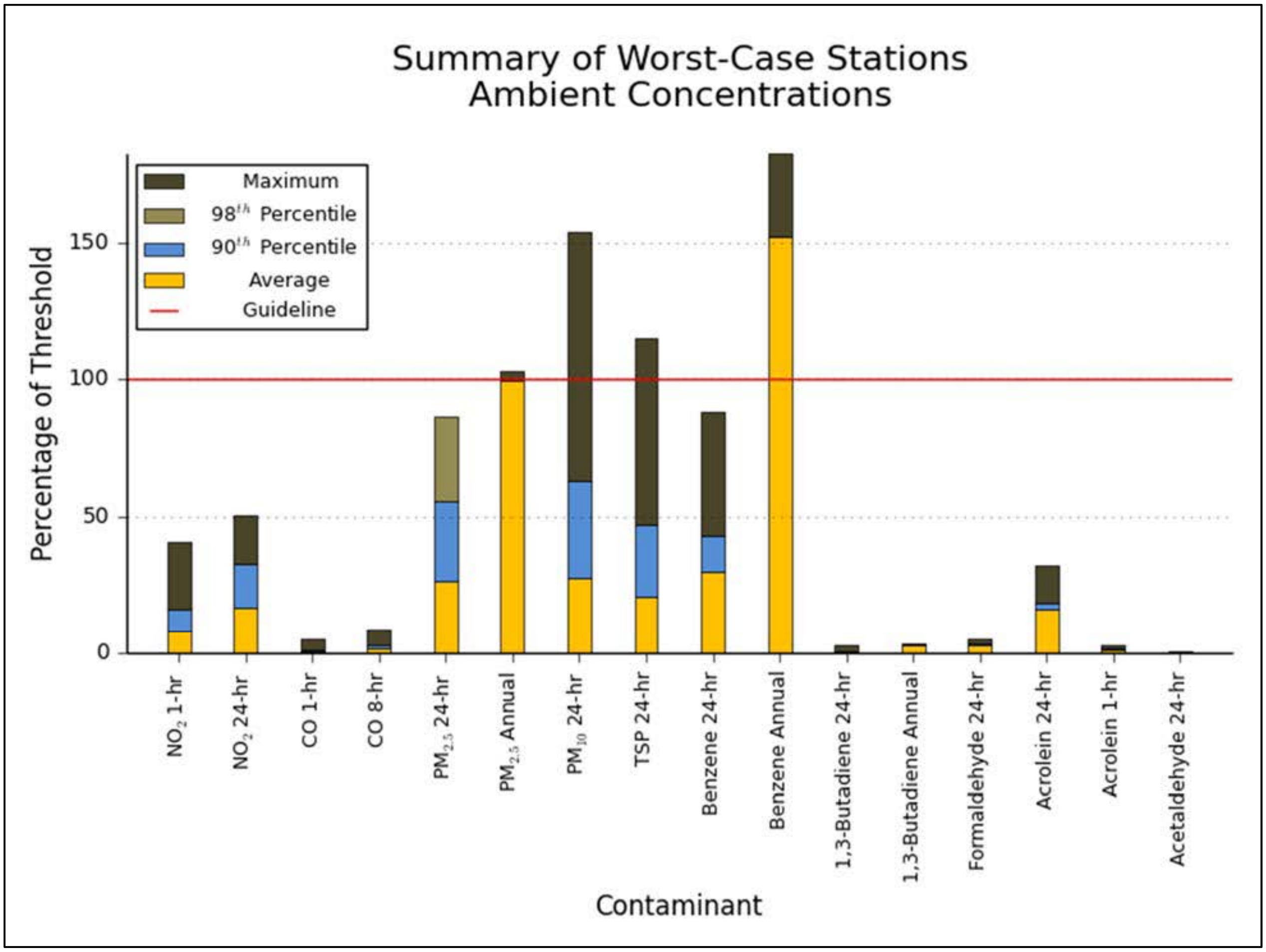


Figure 6: Summary of Background Conditions Applied in the Assessment

3.0 Local Air Quality Assessment

3.1 Overview

The worst-case impacts due to roadway vehicle emissions were assessed for two scenarios: 2015 Existing (or No Build/NB) and 2041 Future Build (FB). The two scenarios include the following activities:

2015 Existing (NB):

- Existing traffic volumes on Mavis Road and arterial roads for the existing alignment. Note that the existing configuration considers the 4-lane alignment of Mavis Road.

2041 Future Build (FB):

- Projected vehicle volumes on Mavis Road and arterial roads for the proposed widened alignment to 6-lanes.

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.

Seventeen sensitive receptors were evaluated to represent worst-case impacts surrounding the project area. All receptors represented residential locations surrounding the roadway. 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.

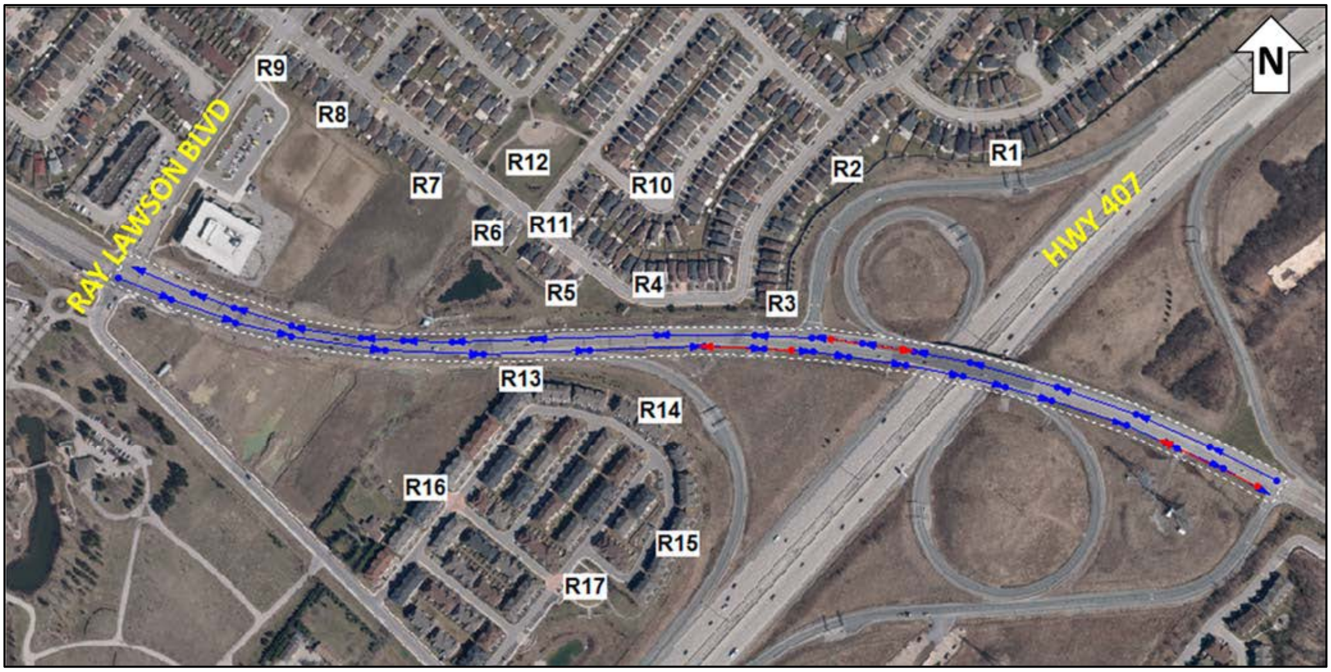


Figure 7: Receptor Locations Within the Study Area

3.3 Road Traffic Data

Traffic volumes for Mavis Road were provided by WSP/MMM Group in the form of Annual Average Daily Traffic (AADT) volumes for the 2015 Existing and 2041 Future Build scenarios. The AADTs were provided as directionally divided volumes for Mavis Road. The traffic volumes used in the assessment are provided in **Table 5** and **Table 6**. Also provided were hourly traffic volumes for three sections on Mavis Road for a single day in 2013 and a single day in 2014. These measurements were averaged to determine hourly traffic distributions for Mavis Road northbound and southbound. The hourly vehicle distributions used in the assessment are provided in **Table 7**. Estimated heavy duty vehicle percentages were also provided, with a maximum of approximately 2% throughout the study area. This value was used in the modelling to be conservative. Lastly, signal timing was provided by WSP/MMM Group for all traffic lights within the study area.

Table 5: 2015 Traffic Volumes (AADT) Used in the Assessment

Roadway	2015 Existing AADT		Speed (km/hr)
	Northbound	Southbound	
Mavis Road from Hwy 407 EB Off-Ramp to Highway 407 WB Off-Ramp	20,810	20,640	70 km/hr
North of Highway 407 WB Off-Ramp	21,160	20,990	

Table 6: 2041 Traffic Volumes (AADT) Used in the Assessment

Roadway	2015 Existing AADT		Speed (km/hr)
	Northbound	Southbound	
Mavis Road from Hwy 407 EB Off-Ramp to Highway 407 WB Off-Ramp	27,640	27,410	70 km/hr
North of Highway 407 WB Off-Ramp	28,090	27,860	

Table 7: Hourly Vehicle Distribution

Hour	Mavis Rd Northbound	Mavis Road Southbound	Arterial Roads
1	1.9%	0.8%	1.4%
2	1.0%	0.4%	0.7%
3	0.7%	0.3%	0.5%
4	0.4%	0.4%	0.4%
5	0.4%	0.8%	0.6%
6	0.7%	2.6%	1.6%
7	2.1%	6.9%	4.5%
8	4.0%	8.5%	6.3%
9	4.6%	8.9%	6.7%
10	3.2%	6.3%	4.7%
11	2.9%	4.5%	3.7%
12	3.6%	4.4%	4.0%
13	4.5%	4.6%	4.6%
14	4.7%	4.6%	4.6%
15	5.6%	5.0%	5.3%
16	7.8%	5.7%	6.7%
17	8.8%	6.3%	7.6%
18	9.6%	6.3%	8.0%
19	8.2%	5.5%	6.8%
20	6.2%	4.6%	5.4%
21	5.9%	4.0%	5.0%
22	5.2%	3.4%	4.3%
23	4.2%	3.0%	3.6%
24	3.8%	2.0%	2.9%
TOTAL	100%	100%	100%

3.4 Meteorological Data

2011-2015 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 MOECC for the study area. The combined data was processed to reflect conditions at the study area using the U.S. EPA's PCRAMMET software program which prepares meteorological data for use with the CAL3QHCR vehicle emission dispersion model. A wind frequency diagram (wind rose) is shown in **Figure 8**. As can be seen in this figure, predominant winds are from the south-westerly through northerly directions.

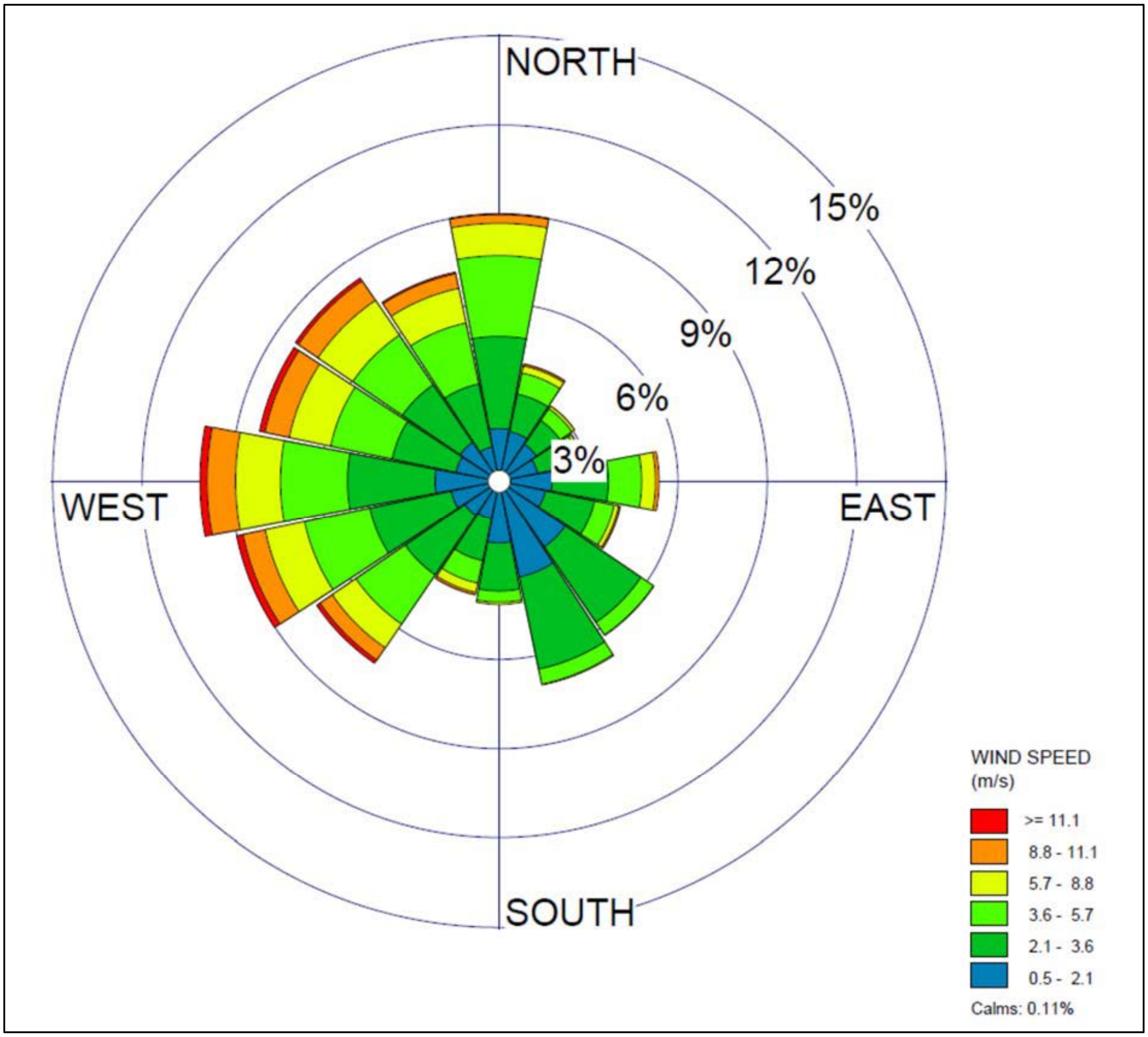


Figure 8: Wind Frequency Diagram for Toronto Pearson International Airport (2011-2015)

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

WSP/MMM Group. Vehicle age was based on the U.S. EPA's default distribution. **Table 8** specifies the major inputs into MOVES.

Table 8: 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 2011 to 2015.
Years	2015 (Existing) and 2041 (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 speed modelled for a 2% heavy duty vehicle percentage are shown in **Table 9**. As shown in **Table 9**, emissions in the future year for all contaminants are predicted to decrease.

Table 9: 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
2015	70 km/hr	0.35	2.68	0.02	0.04	0.04	0.0009	0.00008	0.003	0.000230	0.0014
	Idle	2.87	17.09	0.14	0.15	0.15	0.0229	0.00183	0.059	0.006931	0.0321
2041	70 km/hr	0.04	0.78	0.01	0.03	0.03	0.0001	0.00002	0.001	0.000001	0.0003
	Idle	0.17	2.10	0.02	0.03	0.03	0.0018	0.00022	0.007	0.000009	0.0047

[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 10**.

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

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 10: 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	0.0176	0.070	0.368

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 11** 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 11: 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	2011-2015 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 2015 Existing and 2041 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 12**), which were identified as the maximum combined concentration for the 2041 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 12: Worst-Case Sensitive Receptors for 2041 Future Build Scenario

Contaminant	Averaging Period	Sensitive Receptor
NO_2	1-hour	R13
	24-hour	R13
CO	1-hour	R13
	8-hour	R13
$PM_{2.5}$	24-hour	R3
	Annual	R3
PM_{10}	24-hour	R3
TSP	24-hour	R3
Acetaldehyde	24-hour	R3
Acrolein	1-hour	R13
	24-hour	R3
Benzene	24-hour	R3
	Annual	R3
1,3-Butadiene	24-hour	R3
	Annual	R3
Formaldehyde	24-hour	R3

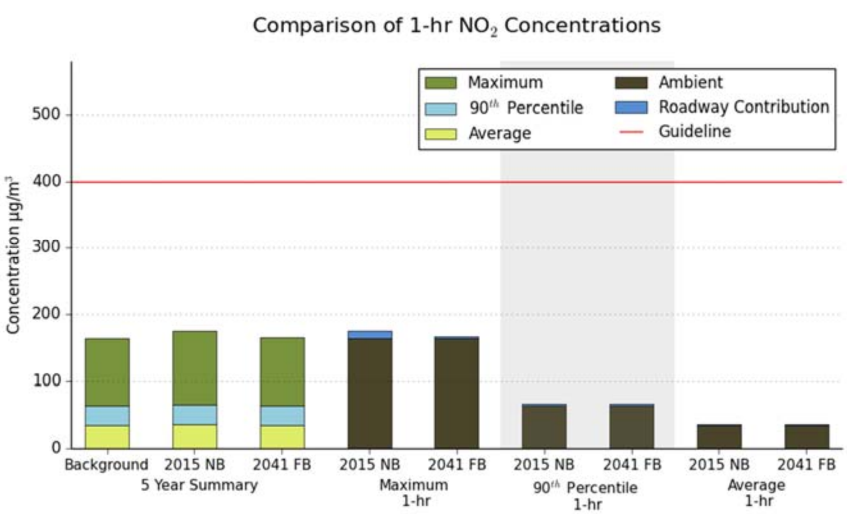
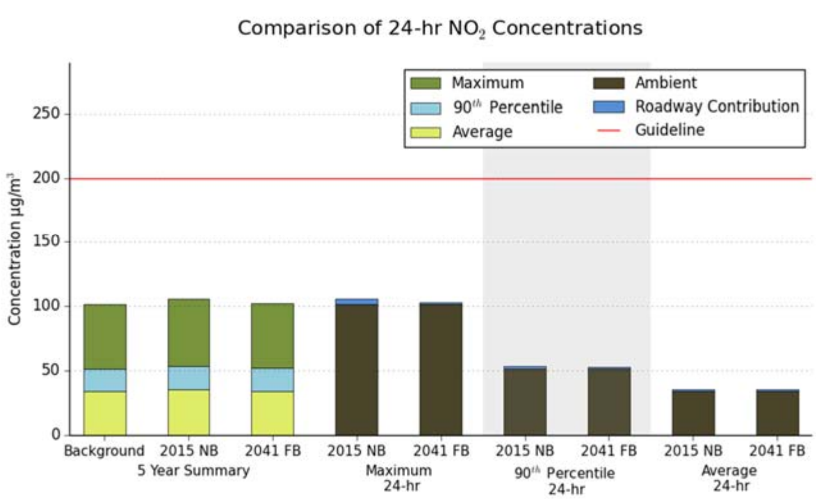
Coincidental hourly modelled roadway and background concentrations were added to derive the combined concentration for each hour over the 5-year period. Hourly combined concentrations were then used to determine contaminant concentrations based on the applicable averaging period. Statistical analysis 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 MOECC 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 13 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 that:

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

Table 13: Summary of Predicted NO_2 Concentrations

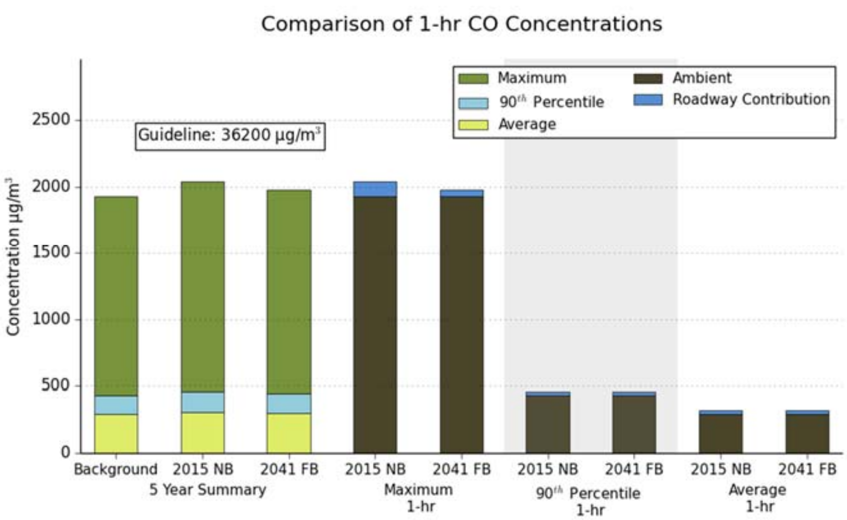
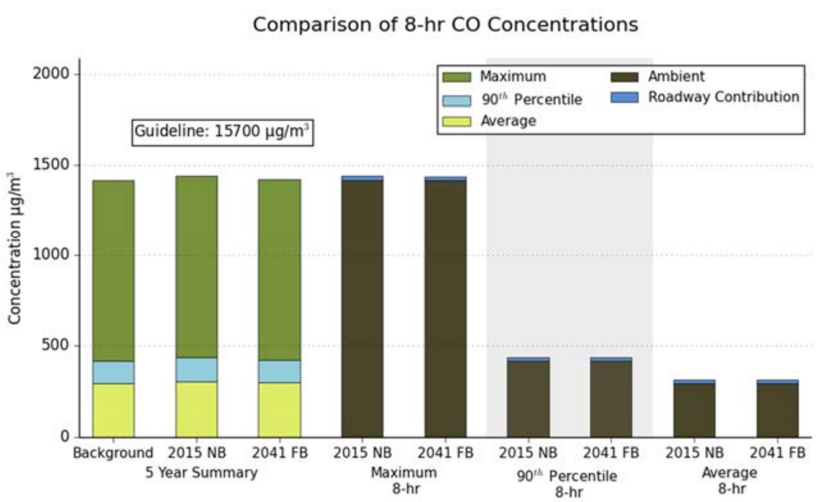
<table>
<tr><th>Statistical Analysis</th><th colspan="2">2041 FB</th></tr>
<tr><td rowspan="8">
</td><td colspan="2">% of MOECC Guideline:</td></tr>
<tr><td>Maximum</td><td>41%</td></tr>
<tr><td>90th Percentile</td><td>16%</td></tr>
<tr><td>Average</td><td>9%</td></tr>
<tr><td colspan="2">Roadway Contribution:</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 rowspan="8">
</td><td colspan="2">% of MOECC Guideline:</td></tr>
<tr><td>Maximum</td><td>51%</td></tr>
<tr><td>90th Percentile</td><td>26%</td></tr>
<tr><td>Average</td><td>17%</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="3">Conclusions:
• All combined concentrations were below their respective MOECC guidelines.
• The contribution from the roadway to the combined concentrations was 1% or less.</td></tr>
</table>

Carbon Monoxide

Table 14 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 MOECC guidelines.*

Table 14: Summary of Predicted CO Concentrations

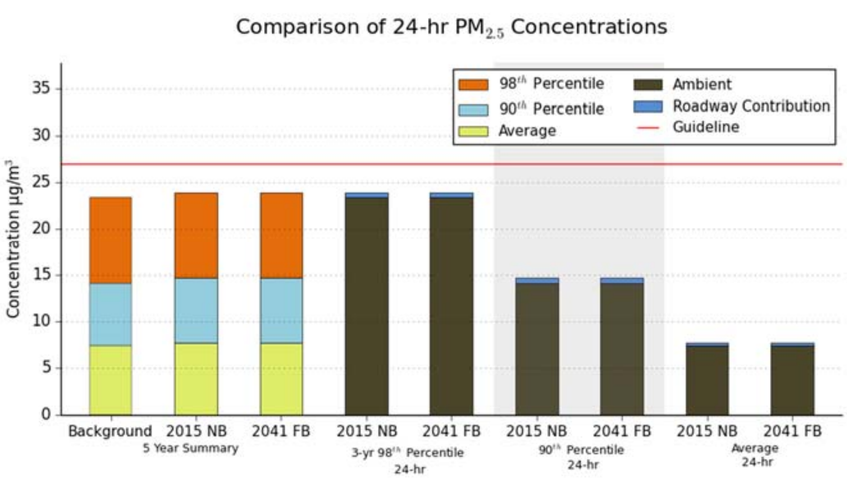
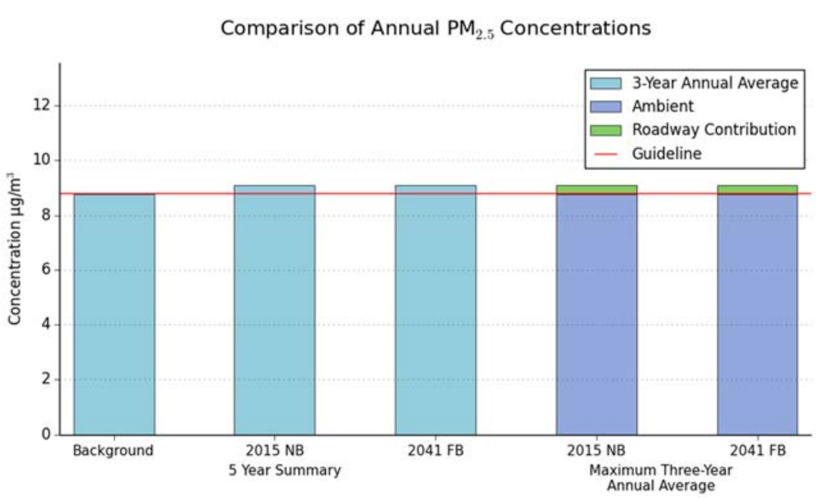
<table>
<tr><th>Statistical Analysis</th><th colspan="2">2041 FB</th></tr>
<tr><td rowspan="9">
</td><td colspan="2">% of MOECC Guideline:</td></tr>
<tr><td>Maximum</td><td>5%</td></tr>
<tr><td>90th Percentile</td><td>1%</td></tr>
<tr><td>Average</td><td>1%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>3%</td></tr>
<tr><td>90th Percentile</td><td>2%</td></tr>
<tr><td>Average</td><td>2%</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td rowspan="9">
</td><td colspan="2">% of MOECC Guideline:</td></tr>
<tr><td>Maximum</td><td>9%</td></tr>
<tr><td>90th Percentile</td><td>3%</td></tr>
<tr><td>Average</td><td>2%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td>3%</td></tr>
<tr><td>90th Percentile</td><td>2%</td></tr>
<tr><td>Average</td><td>2%</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="3">Conclusions:
• All combined concentrations were below their respective MOECC guidelines.
• The contribution from the roadway to the combined concentrations was 3% or less.</td></tr>
</table>

Fine Particulate Matter ($PM_{2.5}$)

Table 15 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour and annual $PM_{2.5}$ based on 5 years of meteorological data. The results conclude that:

- *The average annual 98th percentile 24-hour $PM_{2.5}$ combined concentration, averaged over three consecutive years was below the CAAQS.*
- *The three-year annual average exceeded the guideline with a 4% contribution from the roadway*

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

<table>
<tr><th>Statistical Analysis</th><th colspan="2">2041 FB</th></tr>
<tr><td rowspan="9">
</td><td colspan="2">% of MOECC Guideline:</td></tr>
<tr><td>98th Percentile</td><td>89%</td></tr>
<tr><td>90th Percentile</td><td>54%</td></tr>
<tr><td>Average</td><td>29%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>98th Percentile</td><td>4%</td></tr>
<tr><td>90th Percentile</td><td>3%</td></tr>
<tr><td>Average</td><td>5%</td></tr>
<tr><td colspan="2">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 23.92 µg/m³ or 89% of the CAAQS.</td></tr>
<tr><td rowspan="5">
</td><td colspan="2">% of MOECC Guideline:</td></tr>
<tr><td>3-Year Annual Average</td><td>103%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>3-Year Annual Average</td><td>4%</td></tr>
<tr><td colspan="2">The $PM_{2.5}$ results were above the 3-year CAAQS. The maximum 3-year annual average concentration was 103% of the guideline. It should be noted that ambient concentrations alone were 100% of the guideline and that there was no change between the 2015 Existing and 2041 Future Build Scenarios</td></tr>
</table>

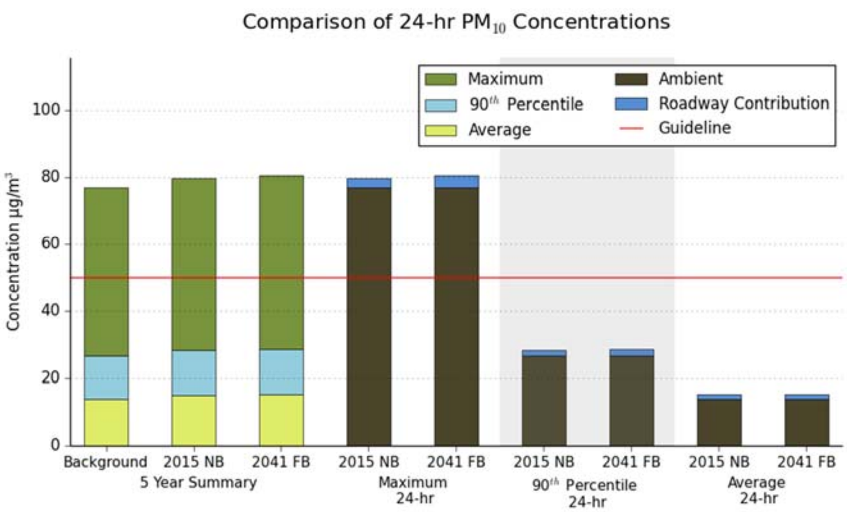
Coarse Particulate Matter (PM_{10})

Table 16 presents the predicted combined concentrations 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 concentrations exceeded the MOECC guideline.*

Table 16: Summary of Predicted PM_{10} Concentrations

Statistical Analysis | **2041 FB**



2041 FB	
% of MOECC Guideline:	
Maximum	161%
90th Percentile	57%
Average	30%
Roadway Contribution:	
Maximum	4%
90th Percentile	9%
Average	10%

Conclusions:

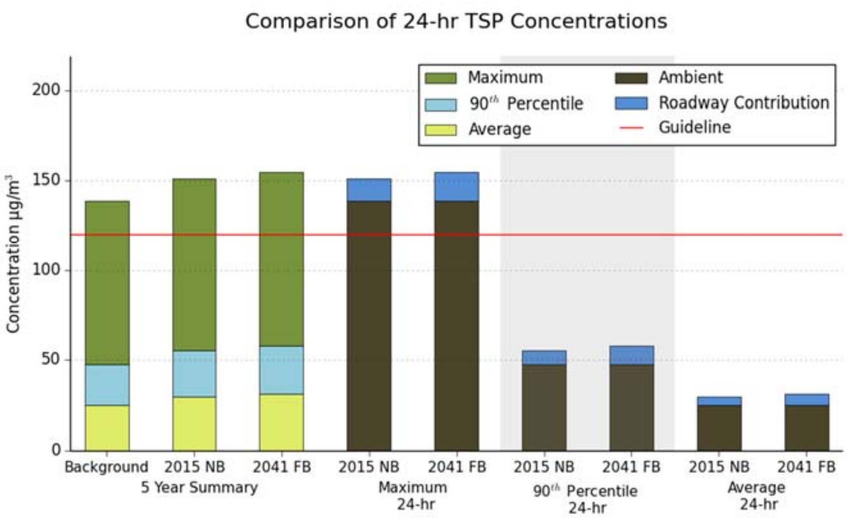
- The combined concentrations of PM_{10} surrounding the study area exceed the standard of 50 µg/m^3. It should be noted, however, that background concentrations alone exceeded the standard and that the roadway contribution is 4% of the maximum value.
- Frequency analysis was conducted to show that elevated concentrations were not frequent over a 5-year period.
- Frequency analysis showed that only one additional exceedance is expected due to the roadway over the five-year period between 2015 Existing and 2041 Future Build.
- A total of 15 days exceeded the guideline in the five year period in the Future Build scenario, which equates to approximately 1% of the time.

Total Suspended Particulate Matter (TSP)

Table 17 presents the predicted combined concentrations 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 concentrations exceeded the MOECC guideline.*

Table 17: Summary of Predicted TSP Concentrations

Statistical Analysis	2041 FB	
	**% of MOECC Guideline:**	
	Maximum	129%
	90^{th} Percentile	48%
	Average	26%
	Roadway Contribution:	
	Maximum	11%
	90^{th} Percentile	24%
	Average	20%

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 11% of the maximum value.
- Frequency analysis was conducted to show that elevated concentrations were not frequent over a 5-year period.
- Frequency analysis showed that 1 additional exceedance is expected due to the roadway over the five-year period between 2015 Existing and 2041 Future Build.
- A total of 5 days exceeded the guideline in the Future Build Scenario, which equates to less than 1% of the time.

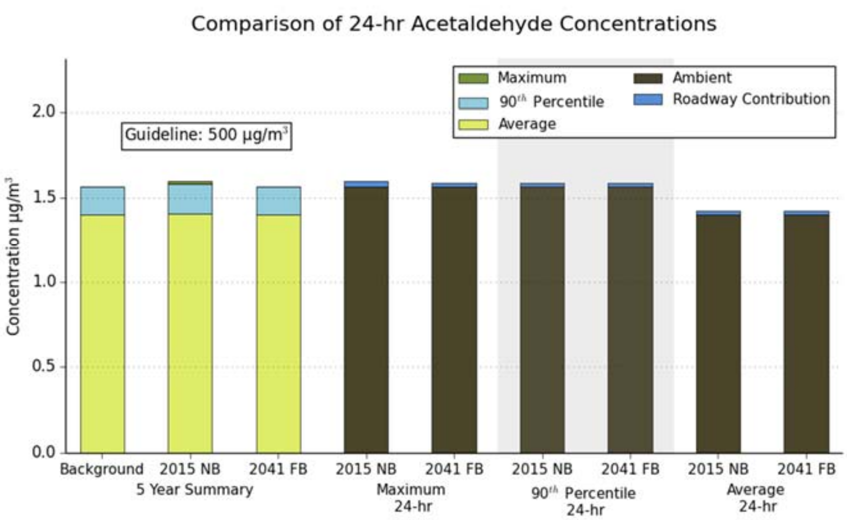
Ambient VOC concentrations are typically measured every 6 days in Ontario. In order to combine the ambient data to the modelled results, the measured concentrations were applied to the following 6 days when measurements were 6 days apart. When measurements were further than 6 days apart, the 90th percentile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

Acetaldehyde

Table 18 presents the predicted combined concentrations 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 MOECC guideline.*

Table 18: Summary of Predicted Acetaldehyde Concentrations

<table>
<tr><th>Statistical Analysis</th><th colspan="2">2041 FB</th></tr>
<tr><td rowspan="9">
</td><td colspan="2">% of MOECC Guideline:</td></tr>
<tr><td>Maximum</td><td><1%</td></tr>
<tr><td>90th Percentile</td><td><1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td><1%</td></tr>
<tr><td>90th Percentile</td><td><1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td colspan="2"></td></tr>
<tr><td colspan="3">Conclusions:
• All combined concentrations were below their respective MOECC guidelines.
• The contribution from the roadway to the combined concentrations was than 1%.</td></tr>
</table>

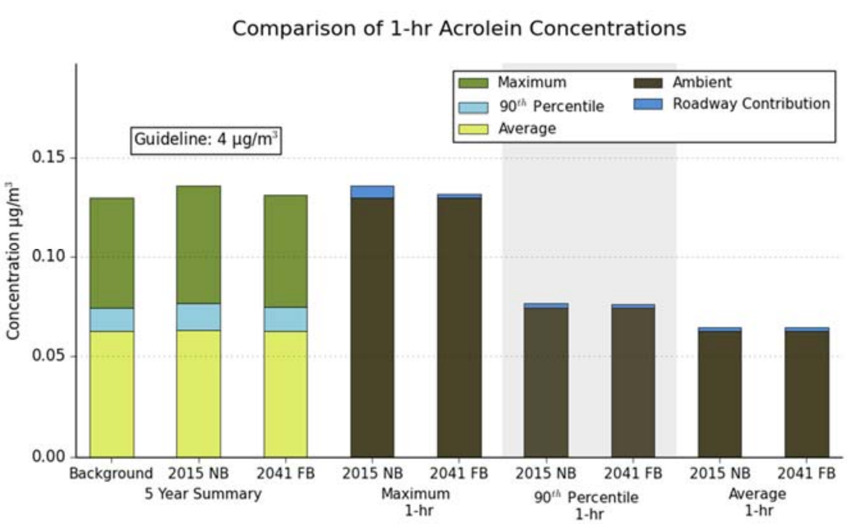
Acrolein

Table 19 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 concentration were below the respective MOECC guideline.*

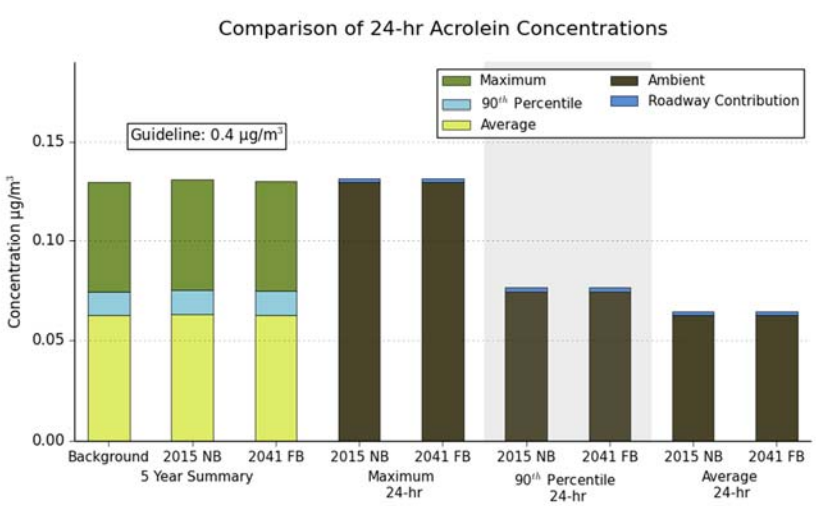
Table 19: Summary of Predicted Acrolein Concentrations

Statistical Analysis	2041 FB



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

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



% of MOECC 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 MOECC guidelines. The contribution from the roadway was less than 1%.

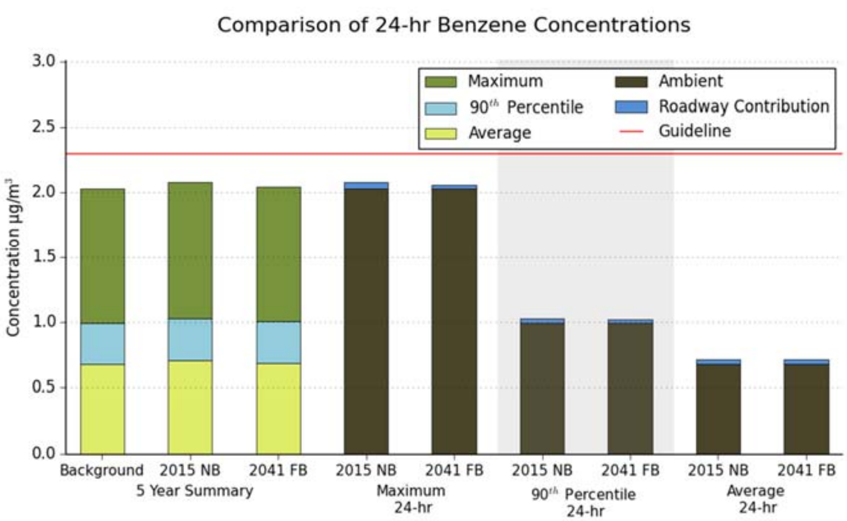
Benzene

Table 20 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 MOECC guideline.*
- *The annual benzene concentrations exceeded the guidline due to ambient concentrations. The roadway contributino to the annual average was 1%.*

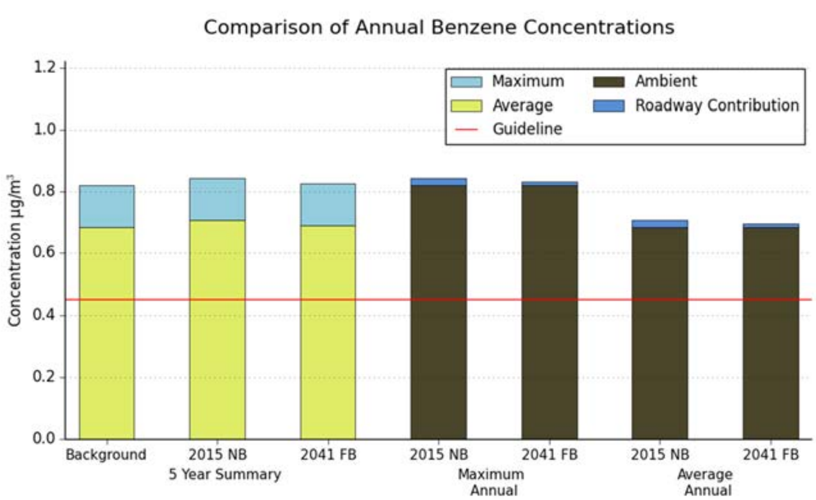
Table 20: Summary of Predicted Benzene Concentrations

Statistical Analysis	2041 FB	



% of MOECC Guideline:	
Maximum	89%
90th Percentile	44%
Average	30%
Roadway Contribution:	
Maximum	1%
90th Percentile	1%
Average	1%

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



% of MOECC Guideline:	
Maximum	184%
Average	154%
Roadway Contribution:	
Maximum	1%
Average	1%

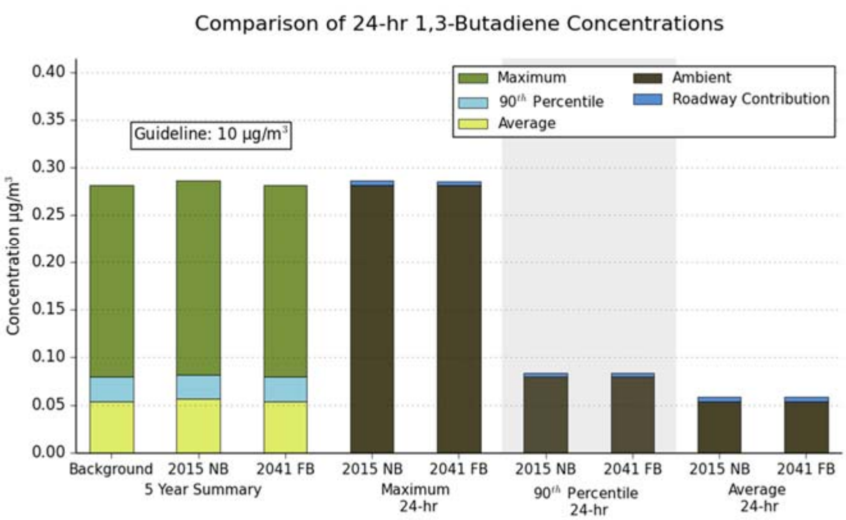
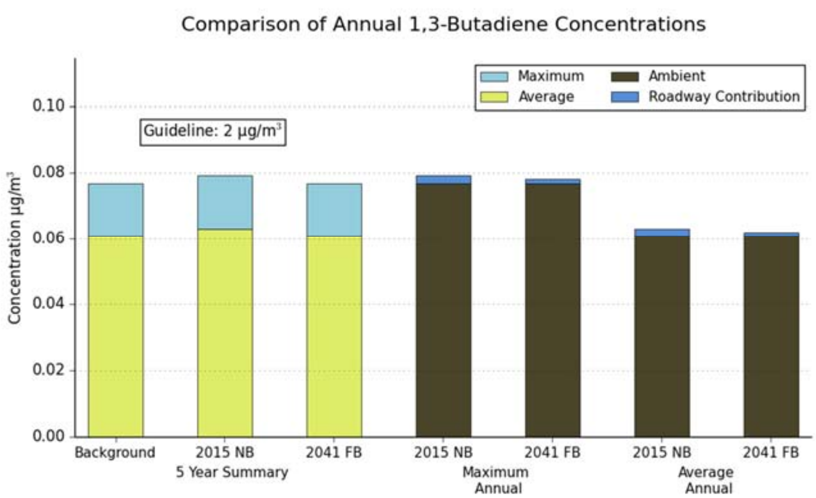
Conclusions:
The combined concentration exceeded the MOECC guideline. It should be noted that ambient concentrations were 182% of the guideline and the roadway contribution to the maximum was just over 1%.

1,3-Butadiene

Table 21 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour and annual 1,3-butadiene based on 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 MOECC guidelines.*

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

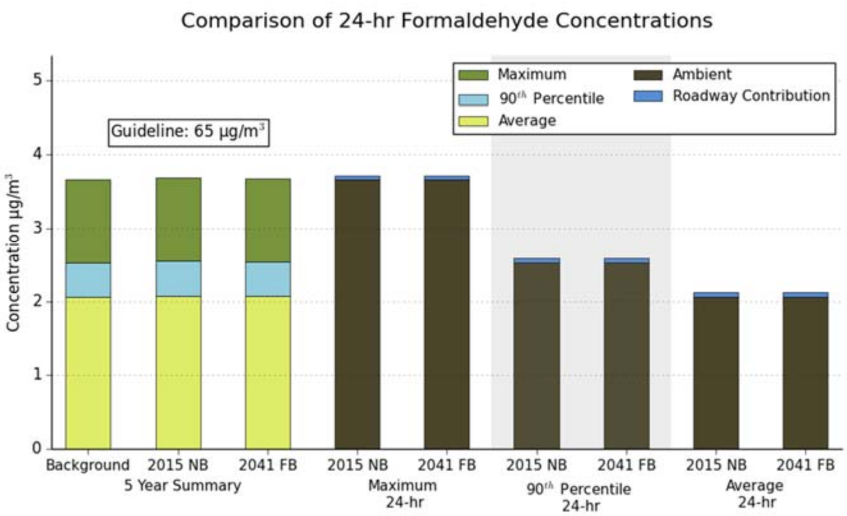
<table>
<tr><th>Statistical Analysis</th><th colspan="2">2041 FB</th></tr>
<tr><td rowspan="9">
</td><td colspan="2">% of MOECC Guideline:</td></tr>
<tr><td>Maximum</td><td>3%</td></tr>
<tr><td>90th Percentile</td><td>1%</td></tr>
<tr><td>Average</td><td>1%</td></tr>
<tr><td colspan="2">Roadway Contribution:</td></tr>
<tr><td>Maximum</td><td><1%</td></tr>
<tr><td>90th Percentile</td><td><1%</td></tr>
<tr><td>Average</td><td><1%</td></tr>
<tr><td colspan="2">Conclusions:
The combined concentrations were below the respective MOECC guidelines. The contribution from the roadway was less than 1%.</td></tr>
<tr><td rowspan="7">
</td><td colspan="2">% of MOECC Guideline:</td></tr>
<tr><td>Maximum</td><td>4%</td></tr>
<tr><td>Average</td><td>3%</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 concentrations were below the respective MOECC guidelines. The contribution from the roadway was less than 1%.</td></tr>
</table>

Formaldehyde

Table 22 presents the predicted combined concentrations 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 MOECC guideline.*

Table 22: Summary of Predicted Formaldehyde Concentrations

Statistical Analysis	2041 FB	
	**% of MOECC 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 MOECC guidelines.
- The contribution from the roadway to the combined concentrations 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 calculating the relative change in total emissions between the 2015 Existing and 2041 Future Build scenarios. Total GHG emissions 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 Mavis Road. **Table 23** summarizes the length of the roadway, traffic volumes, and emission rates used to determine total GHG emissions on Mavis Road for the 2015 Existing and 2041 Future Build scenarios.

Table 23: Summary of Mavis Road Traffic Volumes, Roadway Length and Emission Rates

Roadway	2015 Two-Way AADT	2041 Two-Way AADT	Length of Roadway (Miles)	Heavy Duty Vehicle Percentage (%)	Posted Speed (km/hr)	2015 CO_2 Equivalent Emission Rate (g/VMT)	2041 CO_2 Equivalent Emission Rate (g/VMT)
Mavis Road from Hwy 407 EB Off-Ramp to Highway 407 WB Off-Ramp	41,450	52,950	0.29	2%	70	364	213
North of Highway 407 WB Off-Ramp	42,150	55,050	0.42	2%	70	364	213

The total predicted annual GHG emission for the 2015 Existing and 2041 Future Build scenarios are shown in **Table 24**. Also shown is the percent change in total GHG emissions between the scenarios. The results show that due to increases in traffic volumes and decreases in future emission rates, total GHG emissions will be reduced in the study area. Overall, there is a 24% reduction in GHG emissions between the 2015 Existing and 2041 Future Build scenarios.

Table 24: Predicted GHG Emissions

Roadway	2015 Total CO_2 Equivalent (tonnes/year)	2041 Total CO_2 Equivalent (tonnes/year)	Change in Emissions (%)
Mavis Road from Hwy 407 EB Off-Ramp to Highway 407 WB Off-Ramp	1,622	1,213	-25%
North of Highway 407 WB Off-Ramp	2,344	1,792	-24%
TOTAL MAVIS ROAD	**3,966**	**3,005**	**-24%**

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. It is recommended that these best management practices be followed during construction of the roadway to reduce any air quality impacts that may occur.

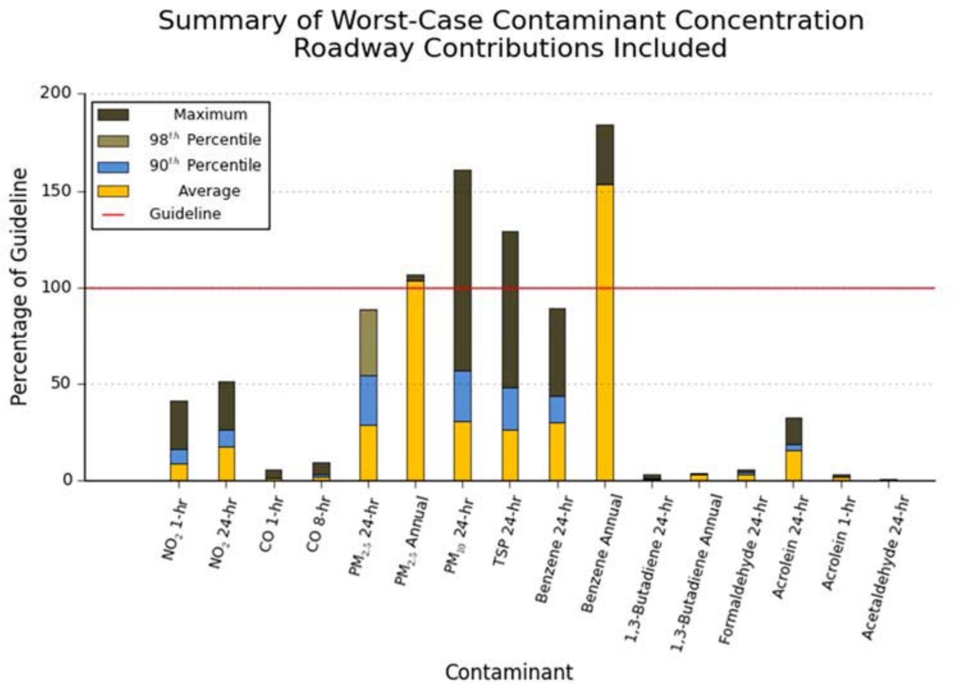
6.0 Conclusions and Recommendations

The potential impact of the proposed project infrastructure on local air quality has been assessed and the results are summarized in **Table 25**. 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 MOECC guidelines or CAAQS, with the exception of annual $PM_{2.5}$, PM_{10}, TSP and annual benzene. Note that for each of these contaminants, background concentrations alone were 100% of the guideline or more.*
- *Frequency Analysis determined that there was only 1 additional day on which exceedances of PM_{10} and TSP occurred between the 2015 Existing and 2041 Future Build scenarios, which is less than 1% of the time.*
- *Overall, maximum predicted concentrations are similar between the 2015 Existing and 2041 Future Build scenarios, with little or no increase occurring as a result of the project.*
- *Mitigation measures are not warranted, due to the small number of days which are expected to exceed the guideline.*
- *Total GHG emissions were predicted to decrease in the study area. Overall, there was a 24% decrease in total GHG emissions predicted between the Existing and Future Build scenarios.*

Table 25: Summary of 2041 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 23.9 µg/m³ or 88% of the CAAQS.

% of Guideline

2041 Future Build	
NO_2 (1-hr)	41%
NO_2 (24-hr)	51%
CO (1-hr)	5%
CO (8-hr)	9%
$PM_{2.5}$ (24-hr See Note)	89%
$PM_{2.5}$ (Annual)	103%
PM_{10}	161%
TSP	129%
Acetaldehyde	<1%
Acrolein (1-hr)	3%
Acrolein (24-hr)	33%
Benzene (24-hr)	89%
Benzene (Annual)	184%
1,3-Butadiene (24-hr)	3%
1,3-Butadiene (Annual)	4%
Formaldehyde	6%

7.0 References

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Appendix A
Receptor Specific Modelling Results

This section shows the maximum results predicted by the air dispersion modelling at each receptor within the study area for the 2015 Existing and 2041 Future Build scenarios. **Figure A1** shows the location of the receptors within the study area.

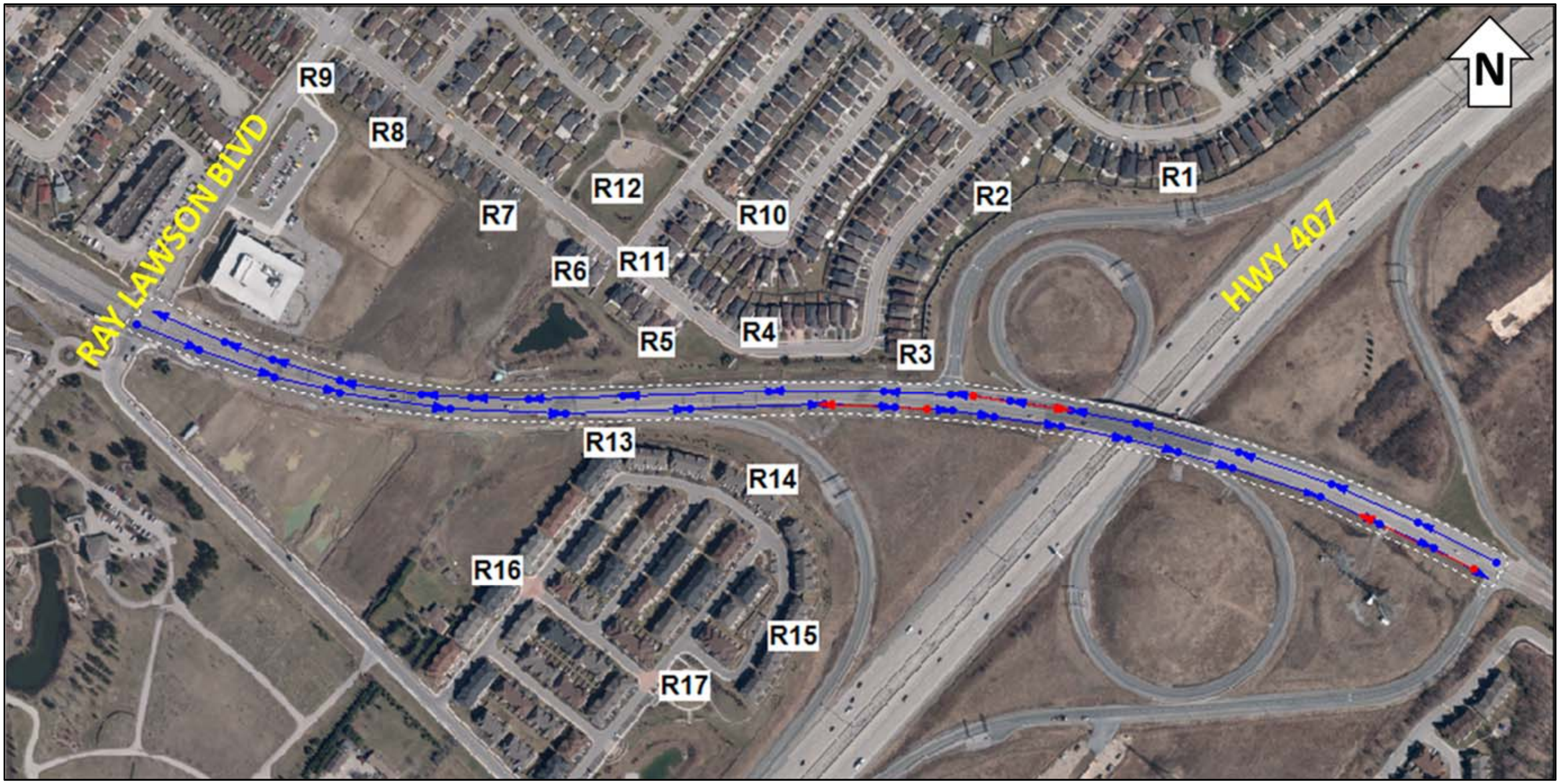
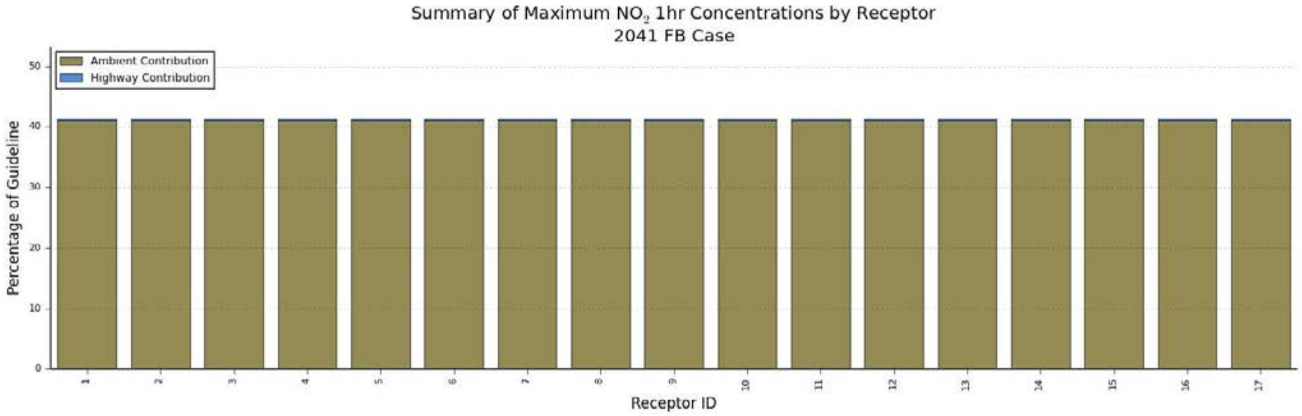
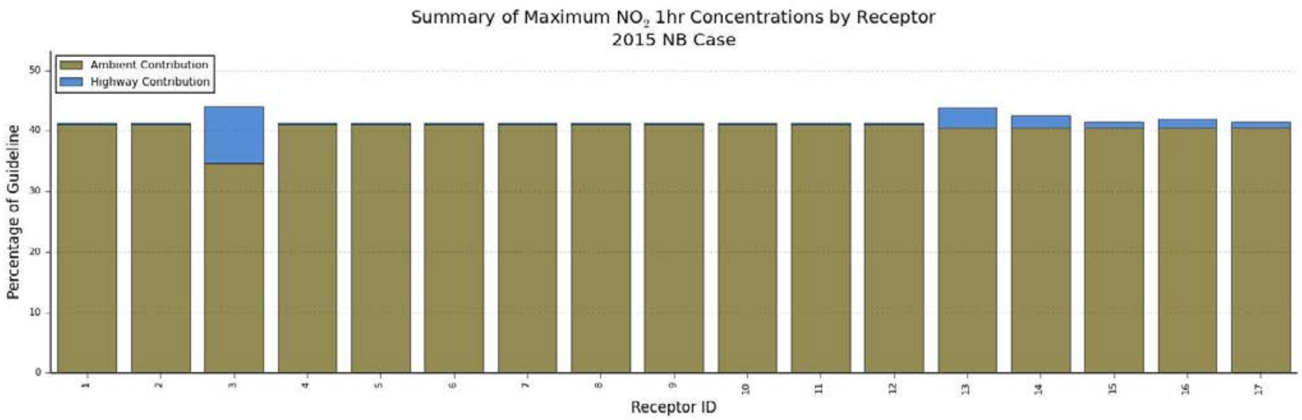
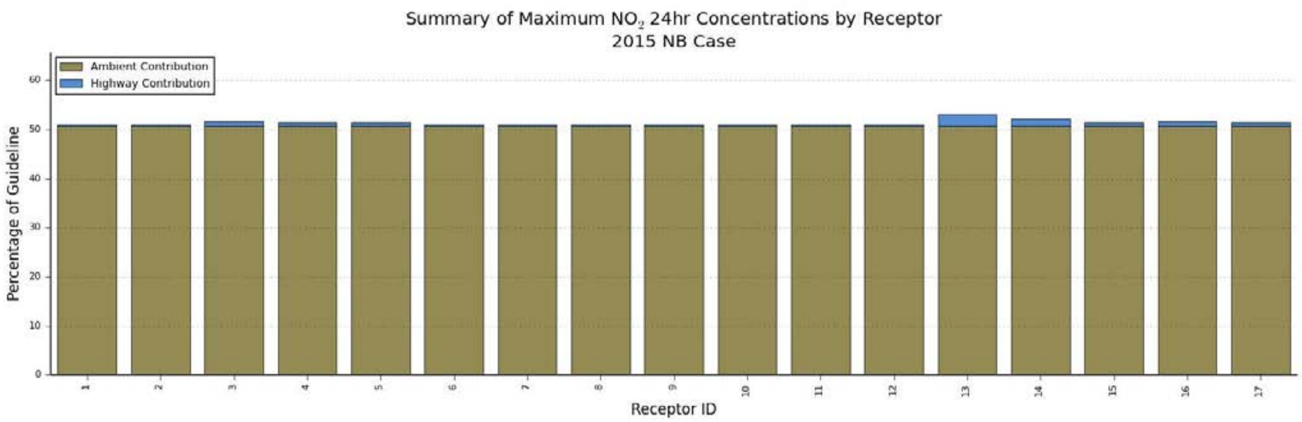
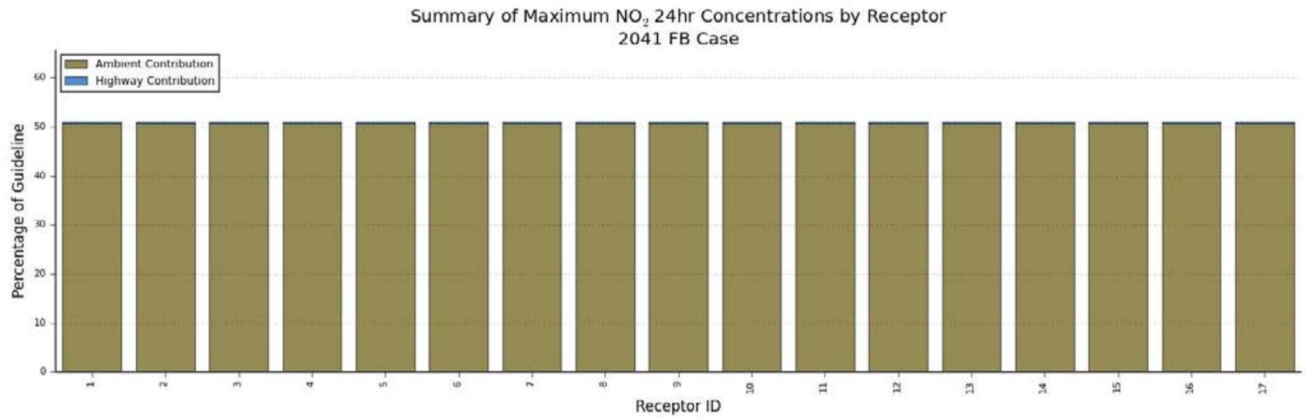


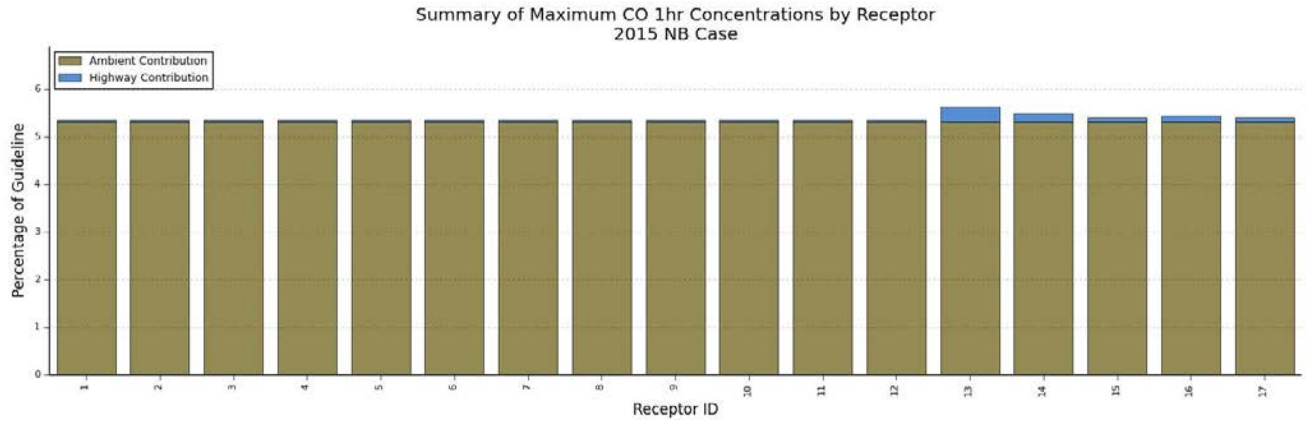
Figure A1: Receptor Locations within the Study Area

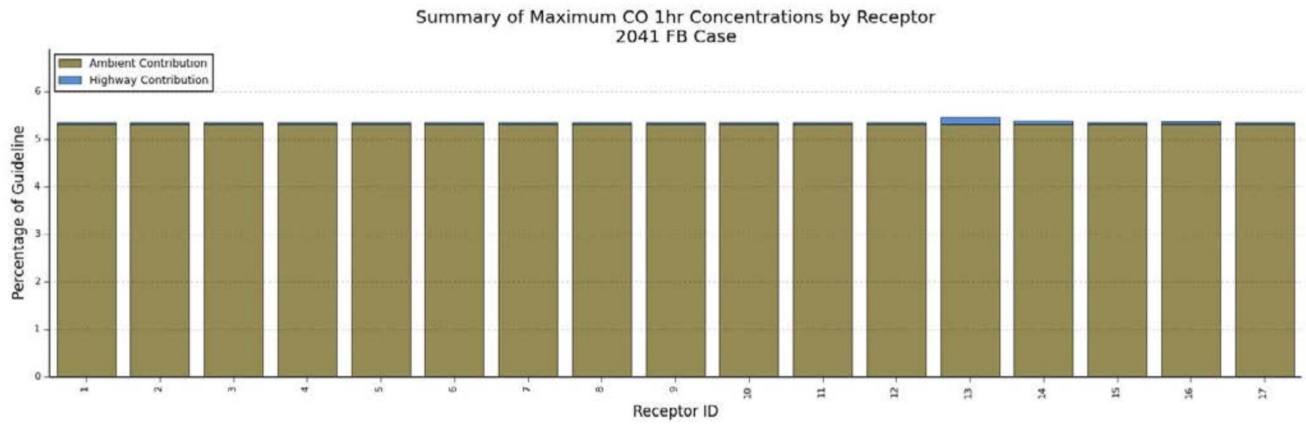

Summary of Maximum NO_2 1hr Concentrations by Receptor
2041 FB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum NO_2 1hr Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID

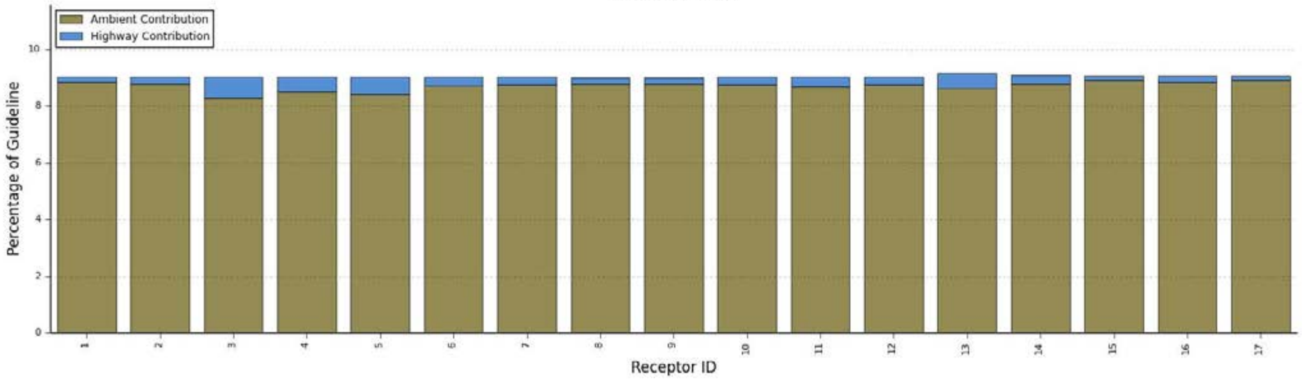

Summary of Maximum NO_2 24hr Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum NO_2 24hr Concentrations by Receptor
2041 FB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID

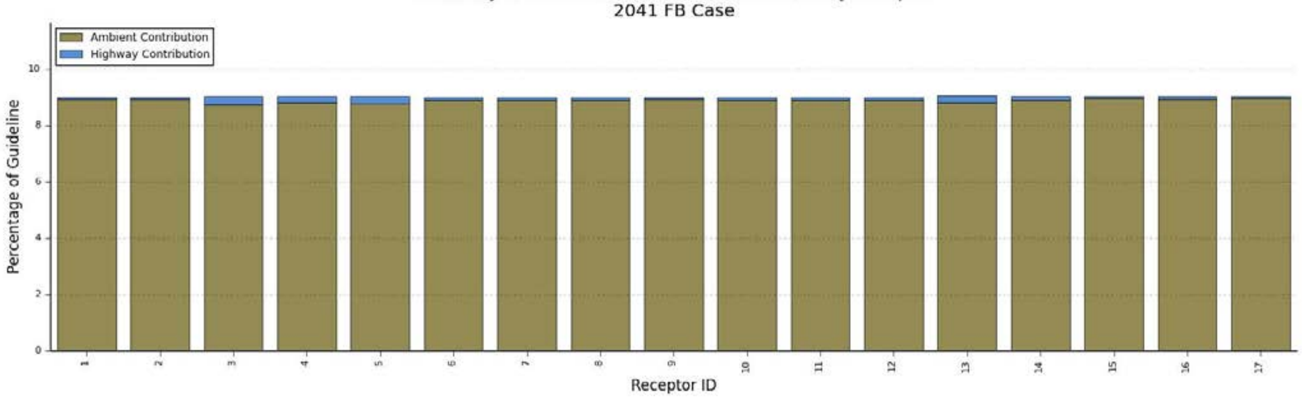

Summary of Maximum CO 1hr Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum CO 1hr Concentrations by Receptor
2041 FB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID

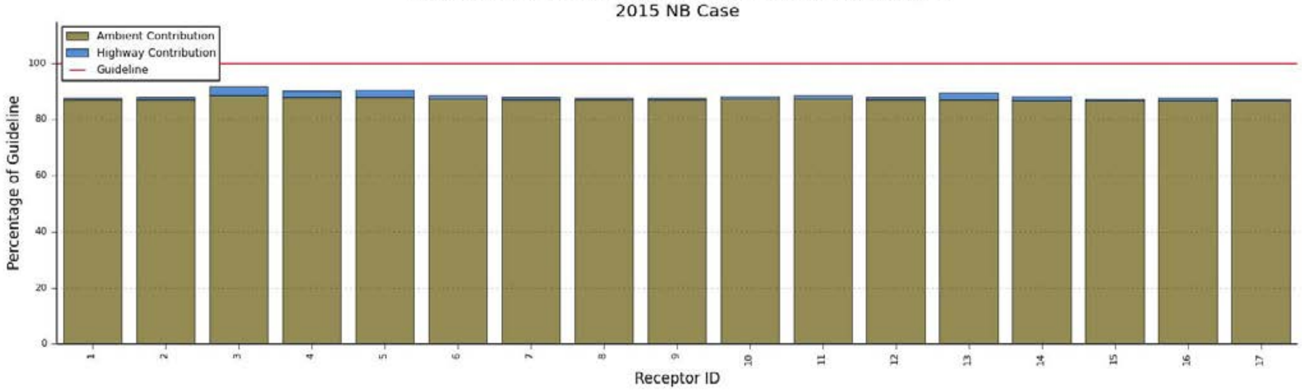
Summary of Maximum CO 8hr Concentrations by Receptor
2015 NB Case

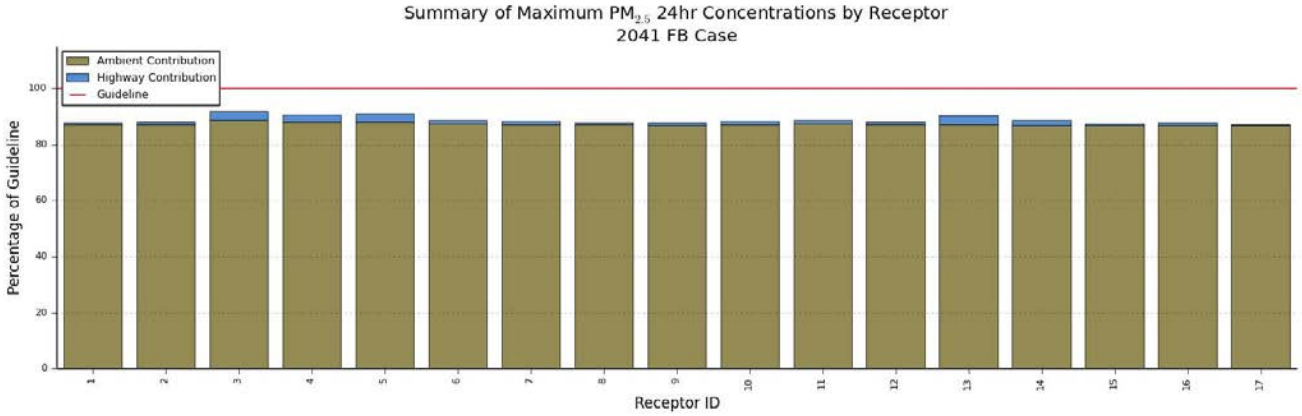


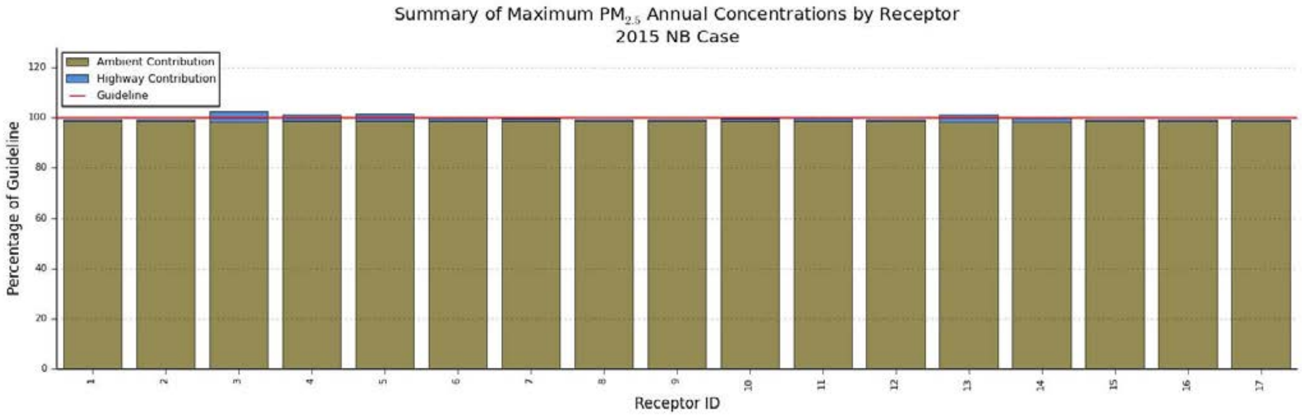
Summary of Maximum CO 8hr Concentrations by Receptor
2041 FB Case

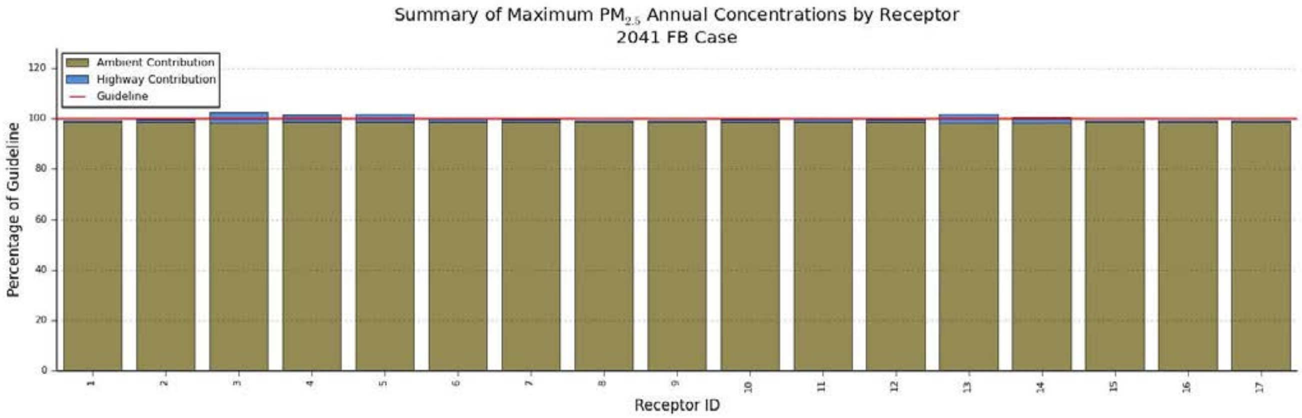


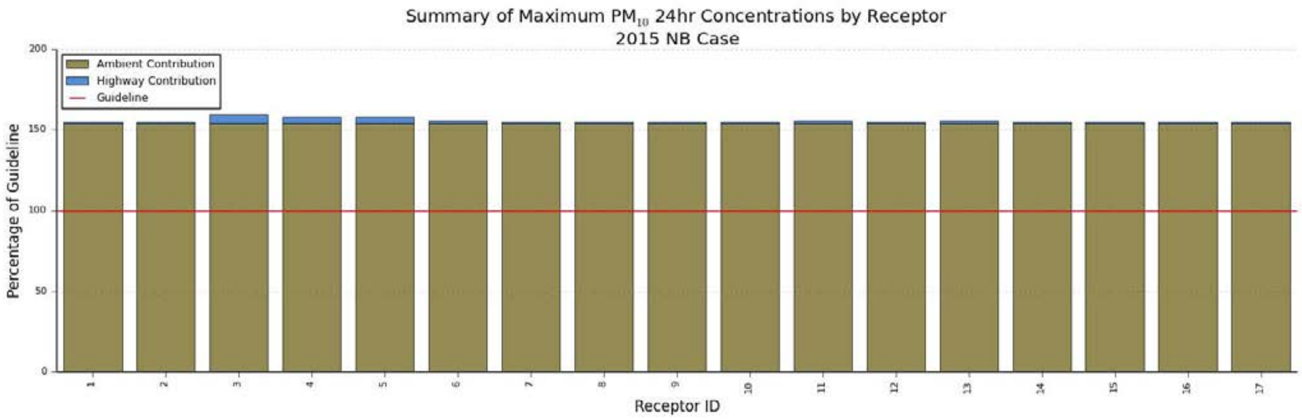
Summary of Maximum $PM_{2.5}$ 24hr Concentrations by Receptor
2015 NB Case

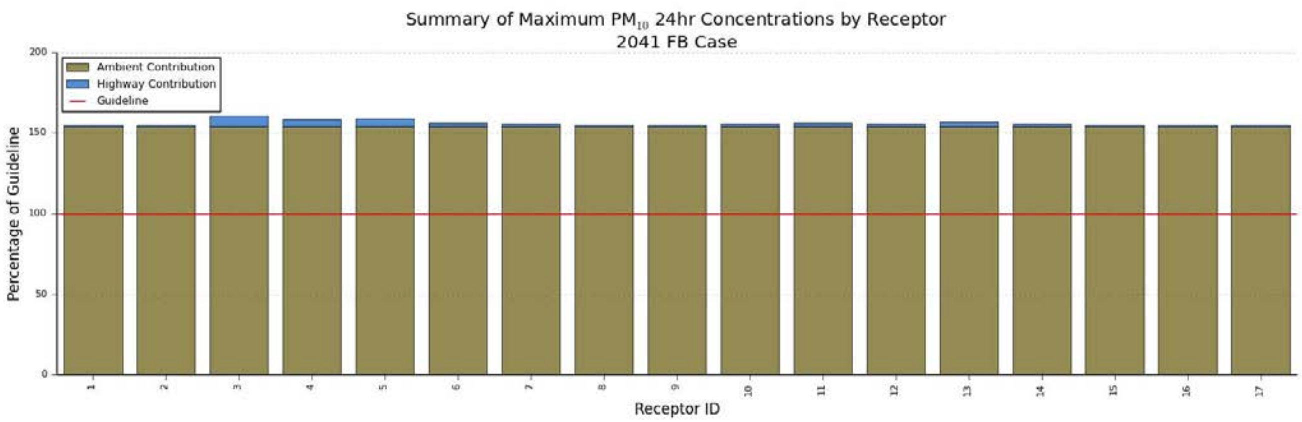


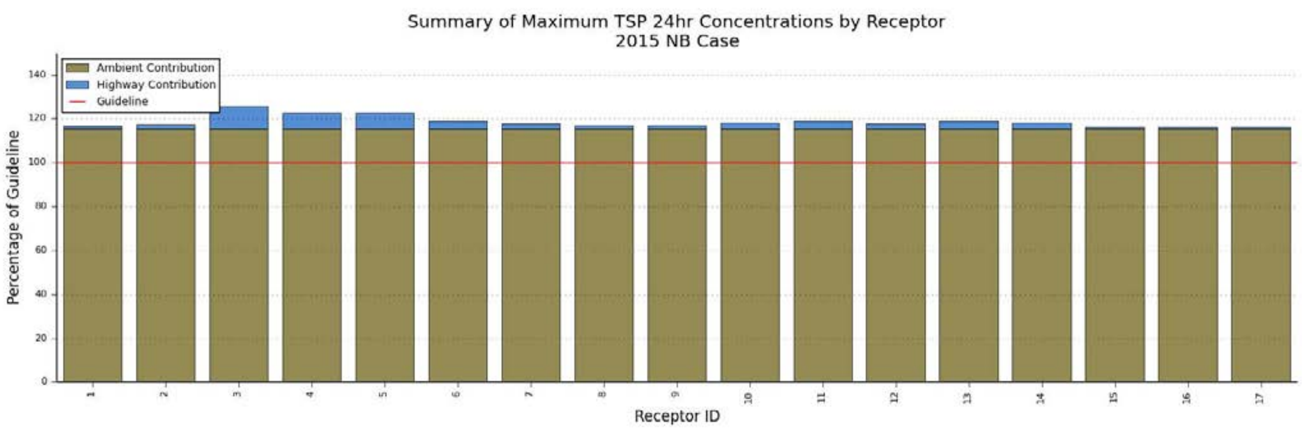

Summary of Maximum $PM_{2.5}$ 24hr Concentrations by Receptor
2041 FB Case
Ambient Contribution
Highway Contribution
Guideline
Percentage of Guideline
Receptor ID

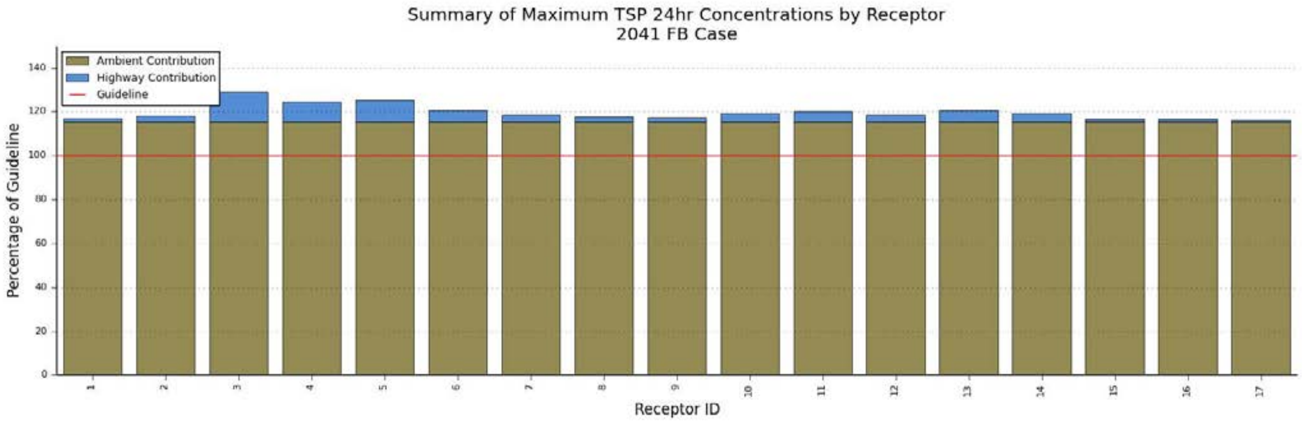

Summary of Maximum $PM_{2.5}$ Annual Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Guideline
Percentage of Guideline
Receptor ID

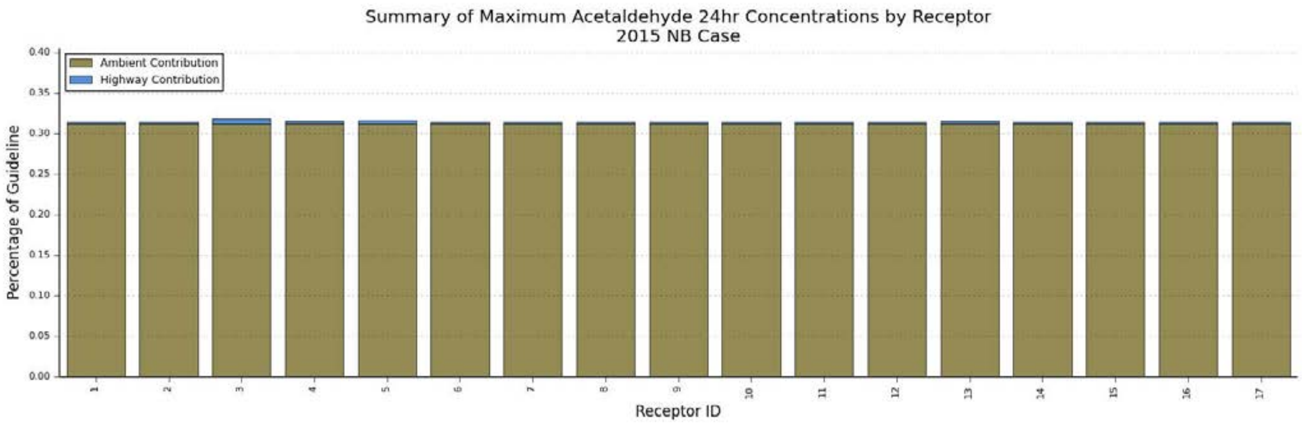

Summary of Maximum $PM_{2.5}$ Annual Concentrations by Receptor
2041 FB Case
Ambient Contribution
Highway Contribution
Guideline
Percentage of Guideline
Receptor ID

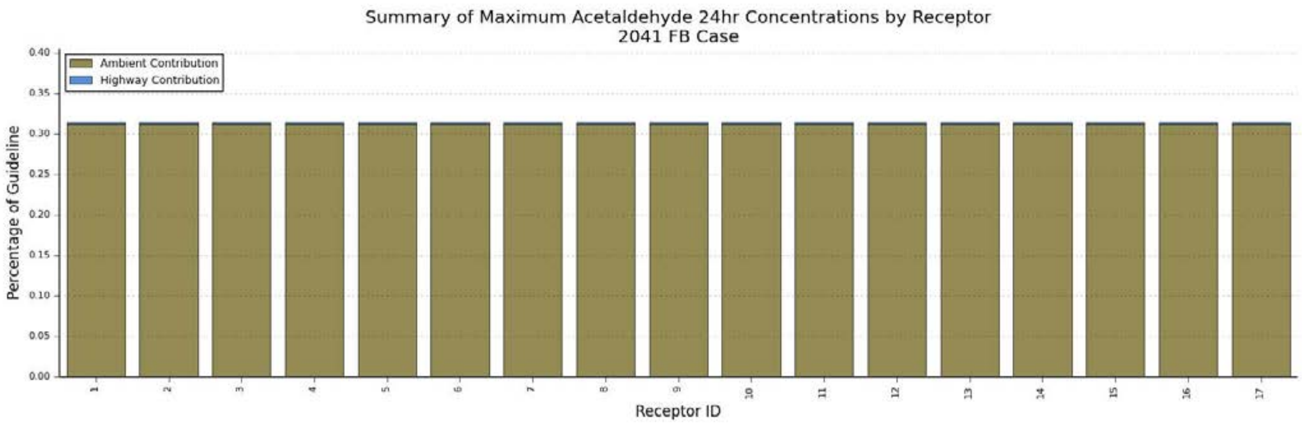

Summary of Maximum PM_{10} 24hr Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Guideline
Percentage of Guideline
Receptor ID

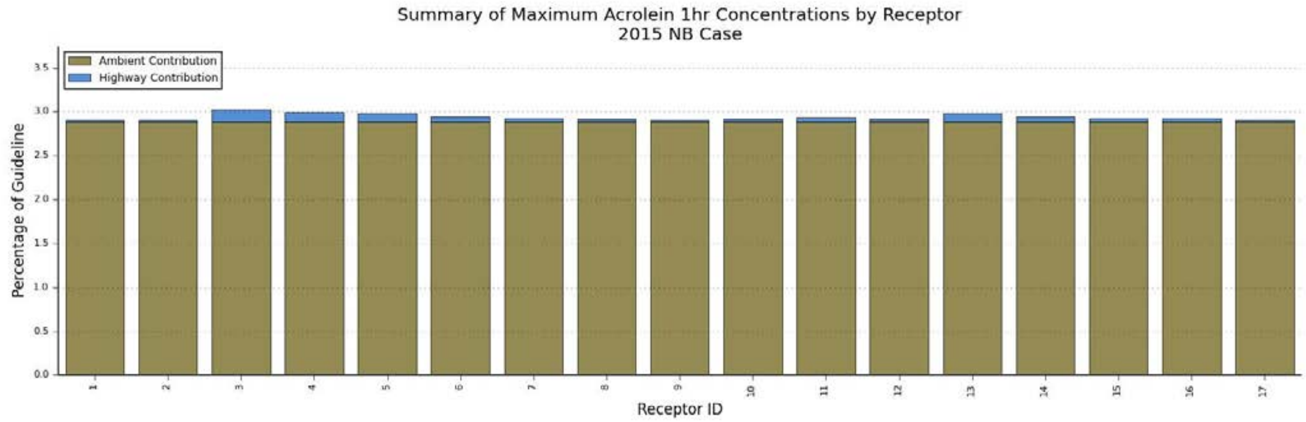

Summary of Maximum PM_{10} 24hr Concentrations by Receptor
2041 FB Case
Ambient Contribution
Highway Contribution
Guideline
Percentage of Guideline
Receptor ID

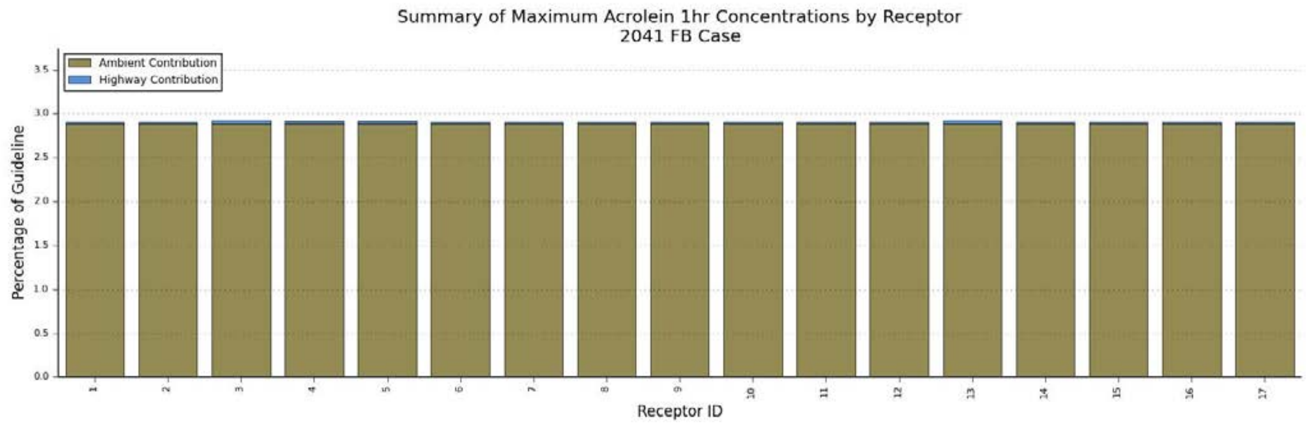

Summary of Maximum TSP 24hr Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Guideline
Percentage of Guideline
Receptor ID

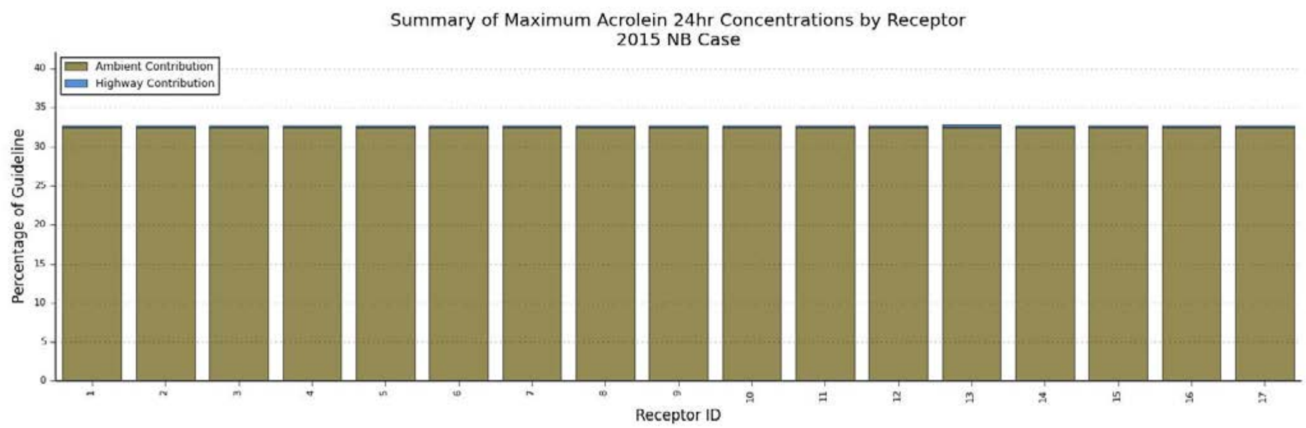

Summary of Maximum TSP 24hr Concentrations by Receptor
2041 FB Case
Ambient Contribution
Highway Contribution
Guideline
Percentage of Guideline
Receptor ID


Summary of Maximum Acetaldehyde 24hr Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum Acetaldehyde 24hr Concentrations by Receptor
2041 FB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum Acrolein 1hr Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17


Summary of Maximum Acrolein 1hr Concentrations by Receptor
2041 FB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17


Summary of Maximum Acrolein 24hr Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID
0
5
10
15
20
25
30
35
40
1
2
3
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5
6
7
8
9
10
11
12
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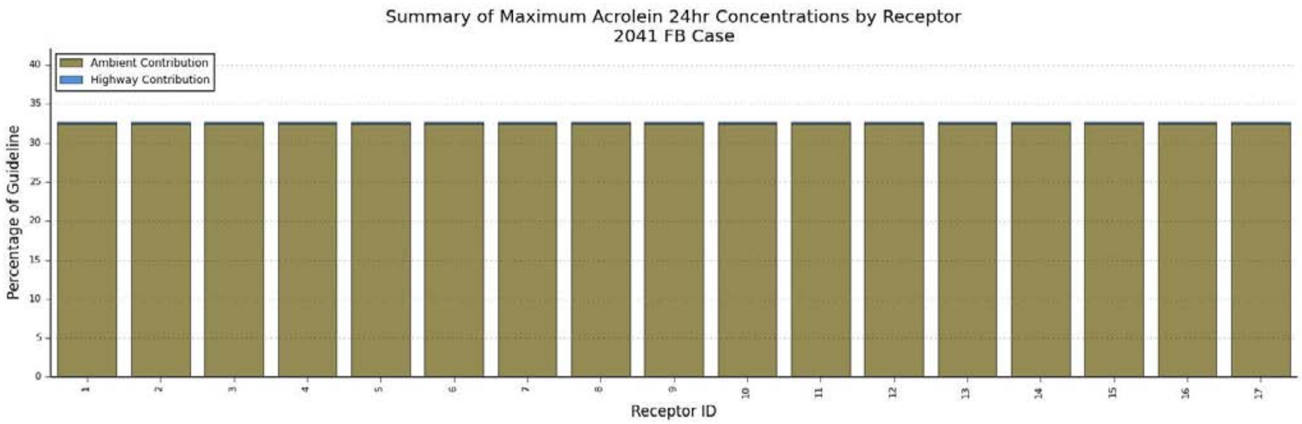
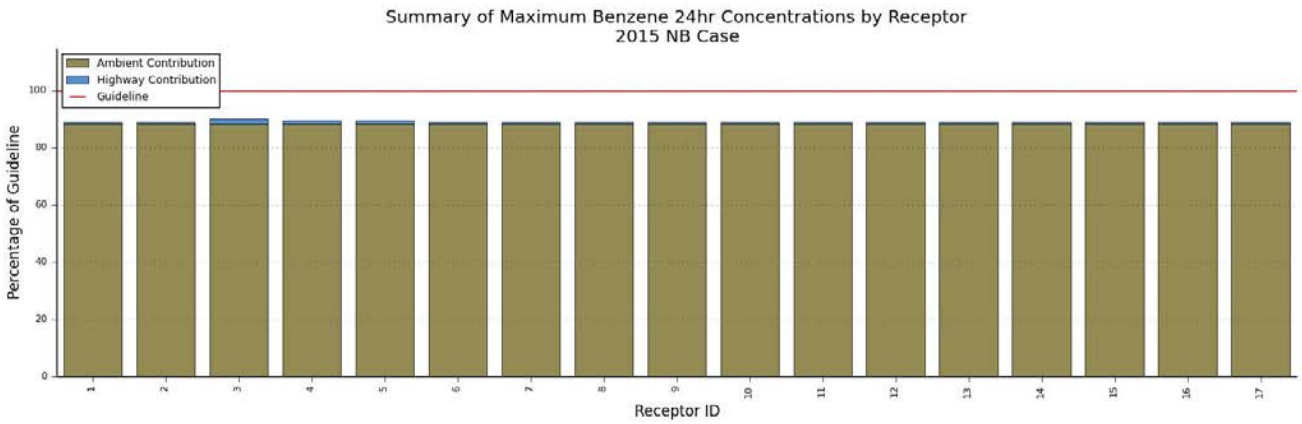
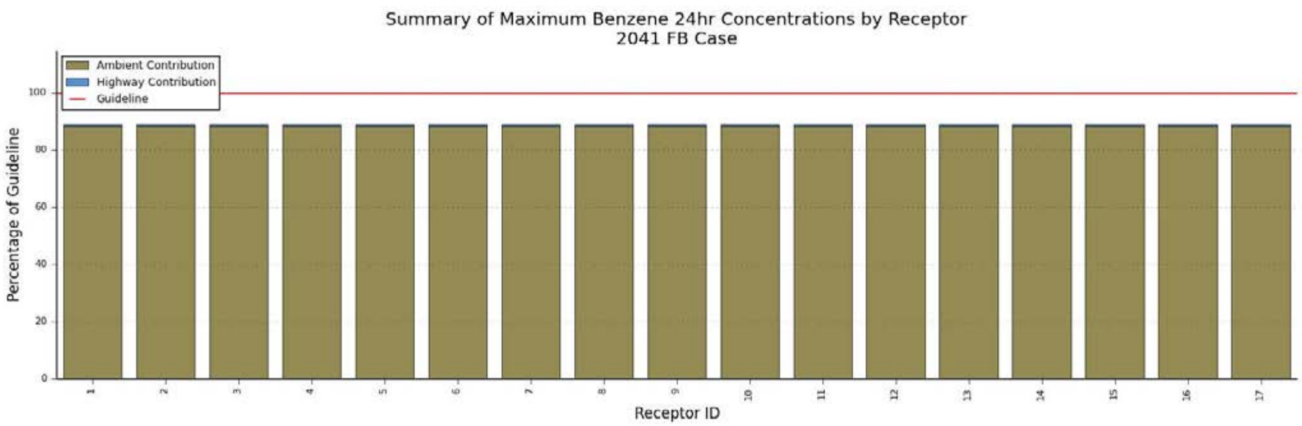
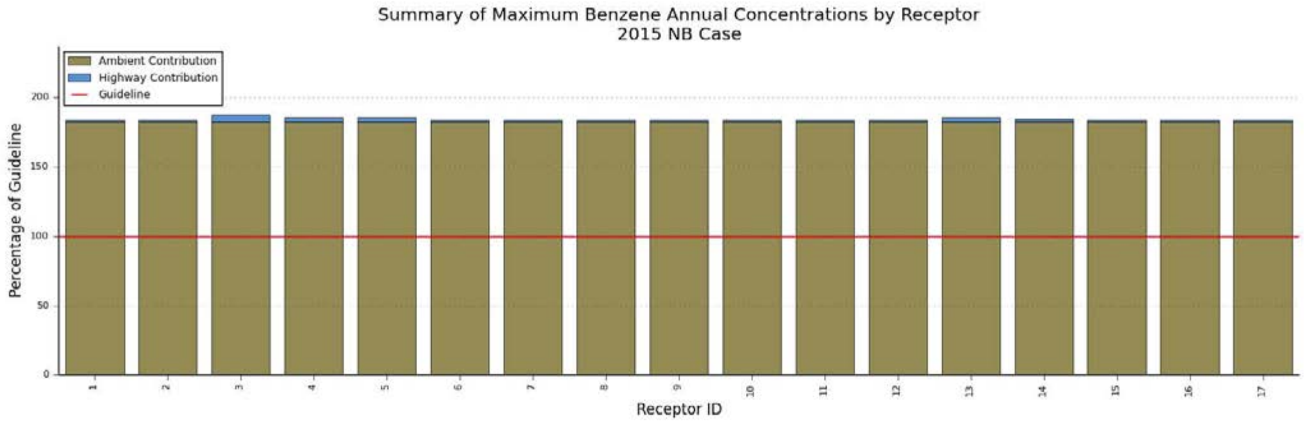
14
15
16
17


Summary of Maximum Acrolein 24hr Concentrations by Receptor
2041 FB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum Benzene 24hr Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Guideline
Percentage of Guideline
Receptor ID


Summary of Maximum Benzene 24hr Concentrations by Receptor
2041 FB Case
Ambient Contribution
Highway Contribution
Guideline
Percentage of Guideline
Receptor ID


Summary of Maximum Benzene Annual Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Guideline
Percentage of Guideline
0
50
100
150
200
1
2
3
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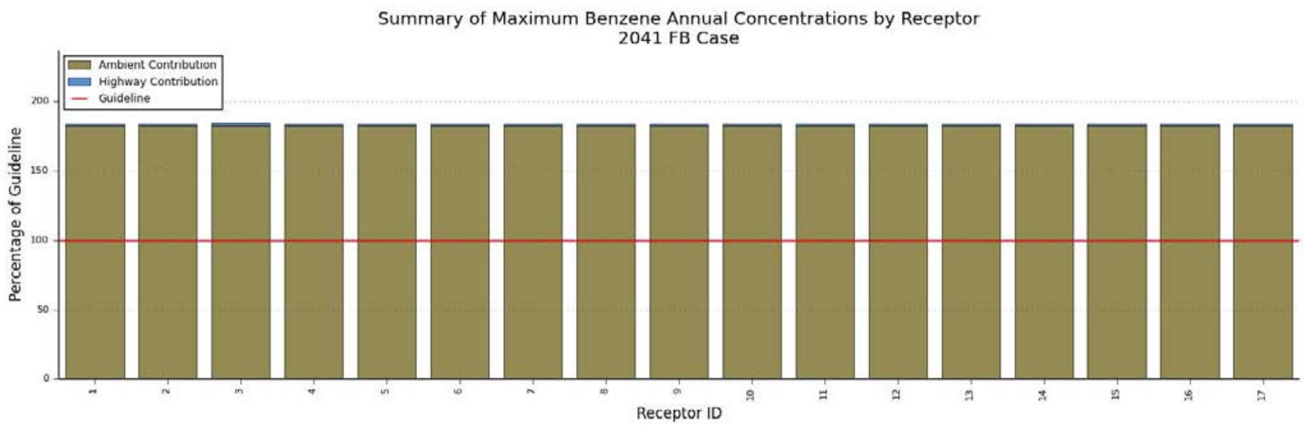
5
6
7
8
9
10
11
12
13
14
15
16
17
Receptor ID


Summary of Maximum Benzene Annual Concentrations by Receptor
2041 FB Case
Ambient Contribution
Highway Contribution
Guideline
Percentage of Guideline
0
50
100
150
200
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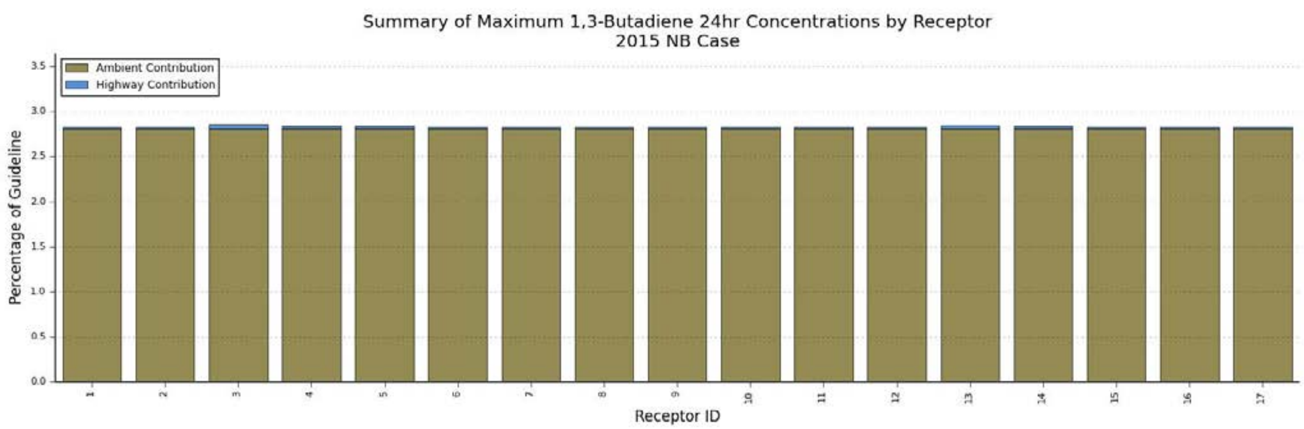
17
Receptor ID


Summary of Maximum 1,3-Butadiene 24hr Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
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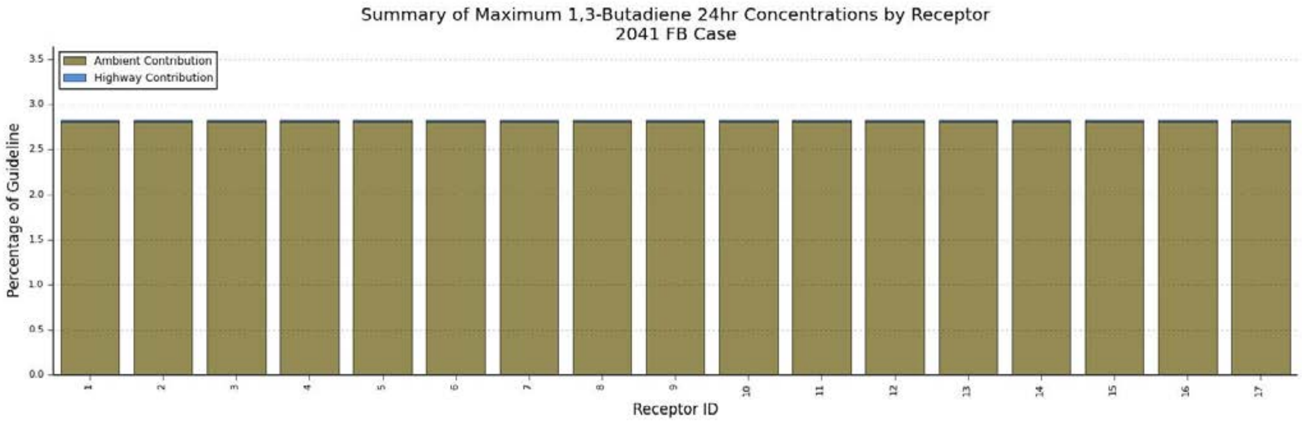
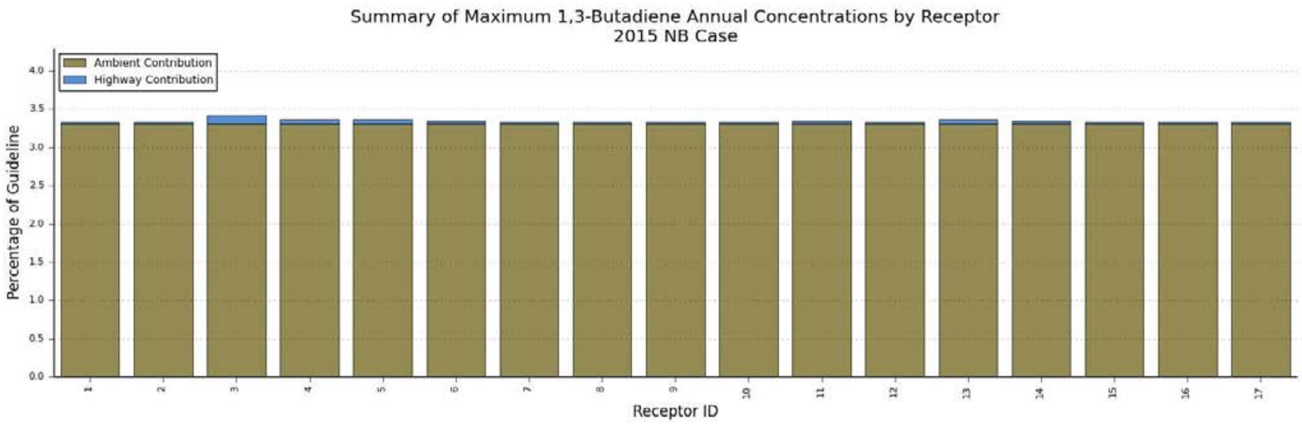
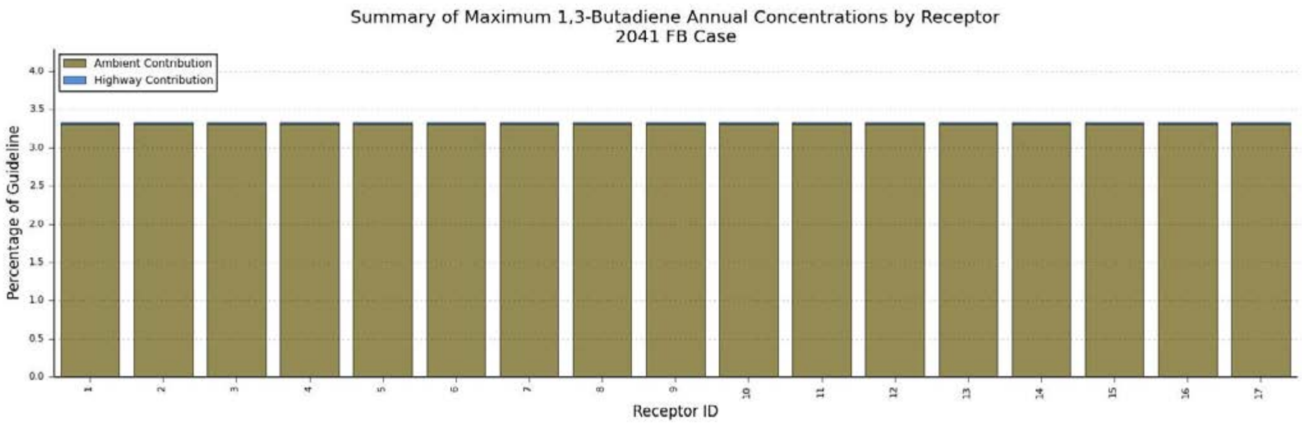
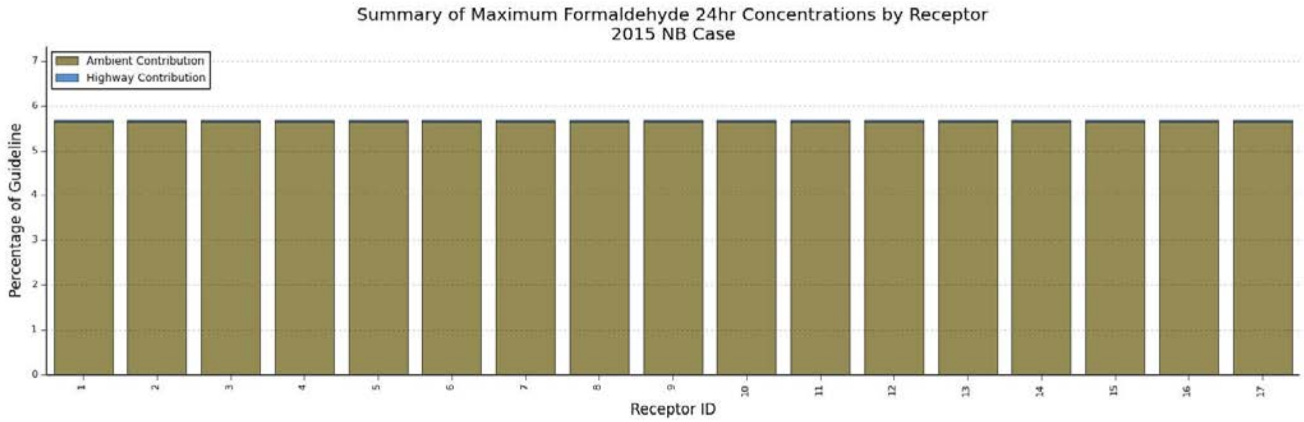
Receptor ID


Summary of Maximum 1,3-Butadiene 24hr Concentrations by Receptor
2041 FB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum 1,3-Butadiene Annual Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum 1,3-Butadiene Annual Concentrations by Receptor
2041 FB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum Formaldehyde 24hr Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID
0
1
2
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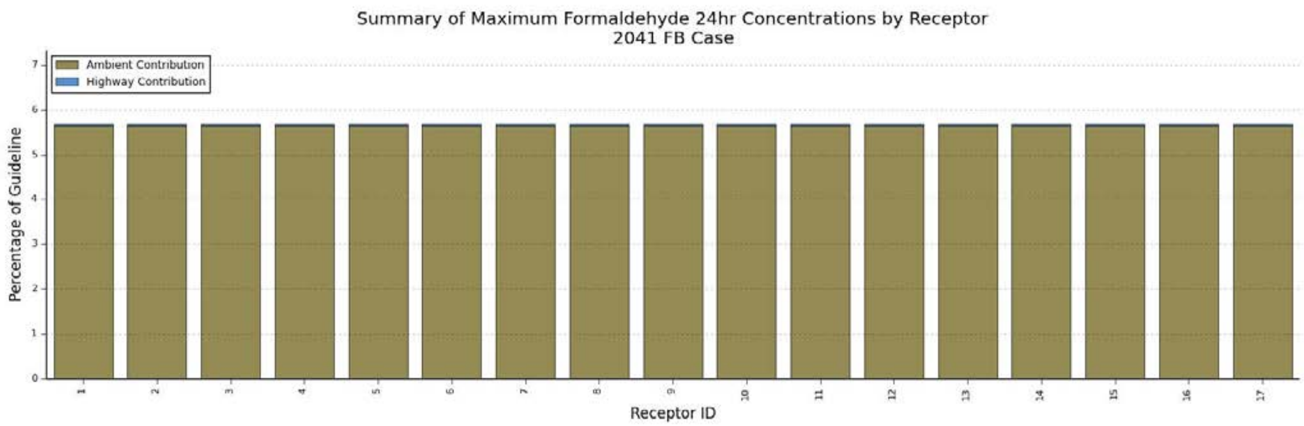
Summary of Maximum Formaldehyde 24hr Concentrations by Receptor
2041 FB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID
0
1
2
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4
5
6
7
1
2
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