Local Air Quality Assessment
Trafalgar Road from Steeles Avenue to Highway 7
Town of Halton Hills, Ontario

Novus Reference No. 13-0251 Version No. Final February 12, 2016

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1.0 Introduction

Novus Environmental Inc. (Novus) was retained by MMM Group Limited (MMM) to conduct an air quality assessment for the proposed widening of Trafalgar Road between Steeles Avenue and Highway 7 in the Regional Municipality of Halton. This report assesses the impacts of increased traffic volumes and adjusted roadway alignment due to the widening of the roadway from 2 to 4 lanes. The study area is approximately 13 km in length and is shown in **Figure 1**, with the section of Trafalgar Road highlighted in orange.

Figure 1: Study Area Showing the Subject Roadway

1.1 Background

Halton Region is carrying out a class Environmental Assessment (Class EA) Study to undertake road improvements to the Trafalgar Road corridor from Steeles Avenue to Highway 7 in the Town of Halton Hills. The study area is approximately 13 km in length. The surroundings of Trafalgar Road within the study area changes from rural in the south to semi-urban in the north, towards Georgetown. Trafalgar Road serves both local and inter-regional travel, agricultural equipment, and goods movement. Within the study area, Trafalgar Road is crossed by both the CN and Metrolinx railway corridors as well at the Black Creek water course. The project involves widening the roadway from two lanes to four lanes to accommodate increased traffic volumes, as well as provision of active transportation facilities to support cyclists and pedestrians..

1.2 Study Objectives

The objective of the study is to assess the local air quality impacts of widening the roadway from two lanes to four lanes. These objectives were assessed as follows:

- **2015 Existing –** Assess the impact of the existing roadway traffic volumes and alignment at representative receptors. Predicted contaminant concentrations from the roadway were combined with measured ambient concentrations to determine the overall impact.
- **2031 Future Build –** The widened roadway was modelled with future traffic volumes. Predicted roadway concentrations and measured ambient concentrations were combined to determine the overall impact at representative receptors.

1.3 Contaminants of Interest

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

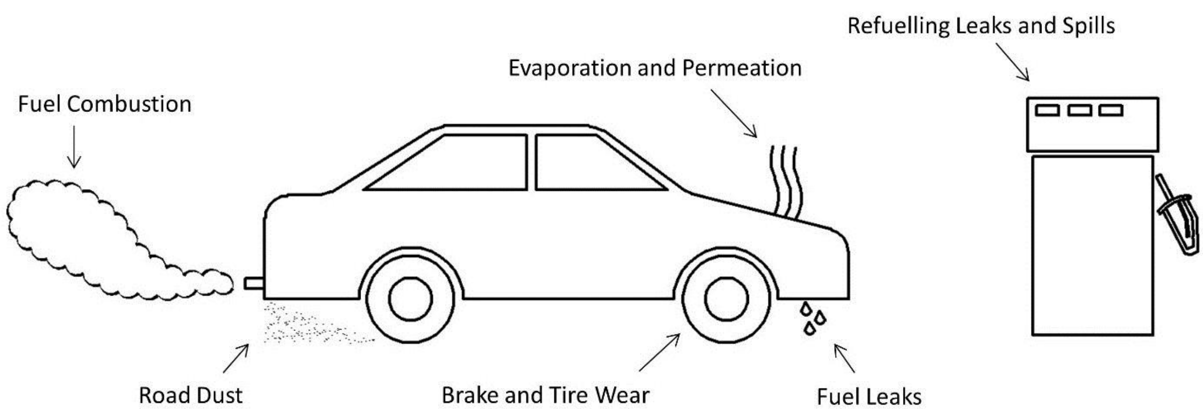


Figure 2: Motor Vehicle Emission Sources

Table 1: Contaminants of Interest

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

1.4 Applicable Guidelines

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

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

Within the guidelines, the threshold value for each contaminant and its applicable averaging period was used to assess the maximum predicted effect at sensitive receptors derived from computer simulations. The contaminants of interest are compared against 1-, 8-, 24-hour, and annual averaging periods. The threshold values and averaging periods used in this assessment are presented in **Table 2**. It should be noted that the CWS for $PM_{2.5}$ is not based on the maximum threshold value; $PM_{2.5}$ is assessed based on the annual 98th percentile value, averaged over 3 consecutive years. The annual standard for $PM_{2.5}$ is based on the 3-year average of the annual average concentrations. The annual standards for 1,3-Butadiene and Benzene are simply based on the single year average.

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]	CWS (27 $\mu g/m^3$ standard is to be phased in in 2020)
	Annual	8.8[2]	CWS
PM_{10}	24	50	Interim AAQC
TSP	24	120	AAQC
Acetaldehyde	24	500	AAQC
Acrolein	1	4.5	AAQC
	24	0.4	AAQC
Benzene	24	2.3	AAQC
	Annual	0.45	AAQC
1,3-Butadiene	24	10	AAQC
	Annual	2	AAQC
Formaldehyde	24	65	AAQC

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

1.5 General Assessment Methodology

The worst-case contaminant concentrations due to motor vehicle emissions from the roadway were predicted at nearby receptors using dispersion modelling software on an hourly basis for a five-year period. 2010-2014 historical meteorological data from 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 2031 ‘Future Build’.

Combined concentrations were determined by adding modelled and background (i.e., ambient data) together on an hourly basis. Background concentrations for all available contaminants were determined from MOECC and NAPS (National Air Pollution Surveillance) measured data for the most representative locations; typically the ‘representative locations’ are measurement stations within a close proximity to the study area.

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

Local background concentrations are presented in **Section 2.0**. Impacts due to the roadway for Existing and Future Build scenarios are presented in **Section 3.8**.

2.0 Background Ambient Data

2.1 Overview

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

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

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

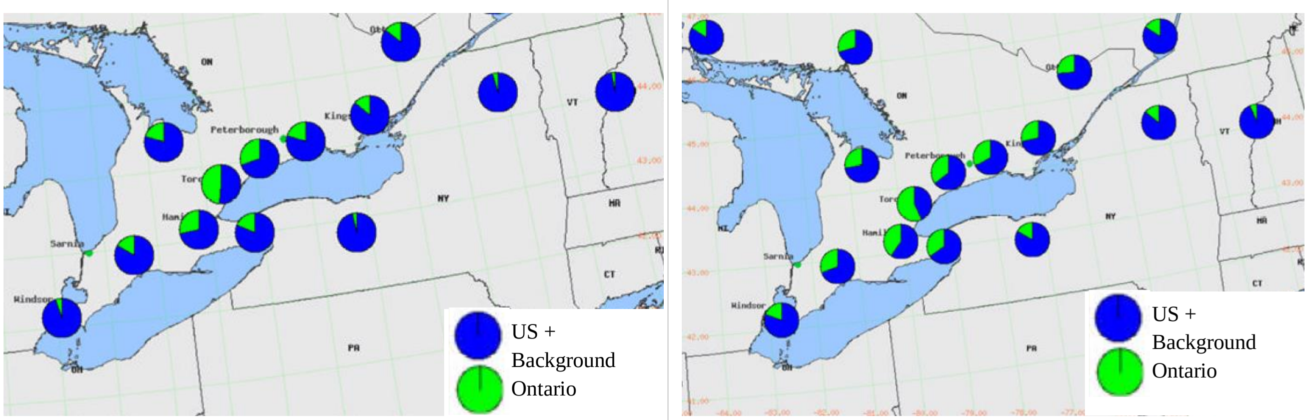


Figure 3: Effect of Trans-Boundary Air Pollution (MOECC, 2005)

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

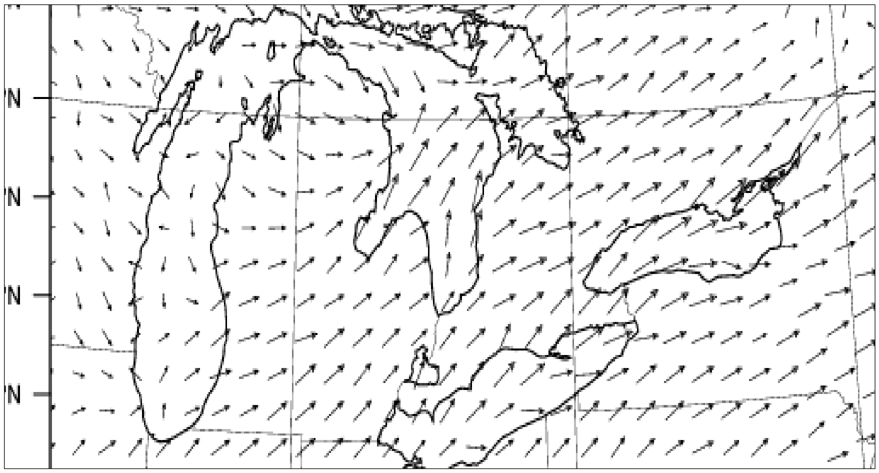


Figure 4: Typical Wind Direction during a Smog Episode

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

2.2 Selection of Relevant Ambient Monitoring Stations

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

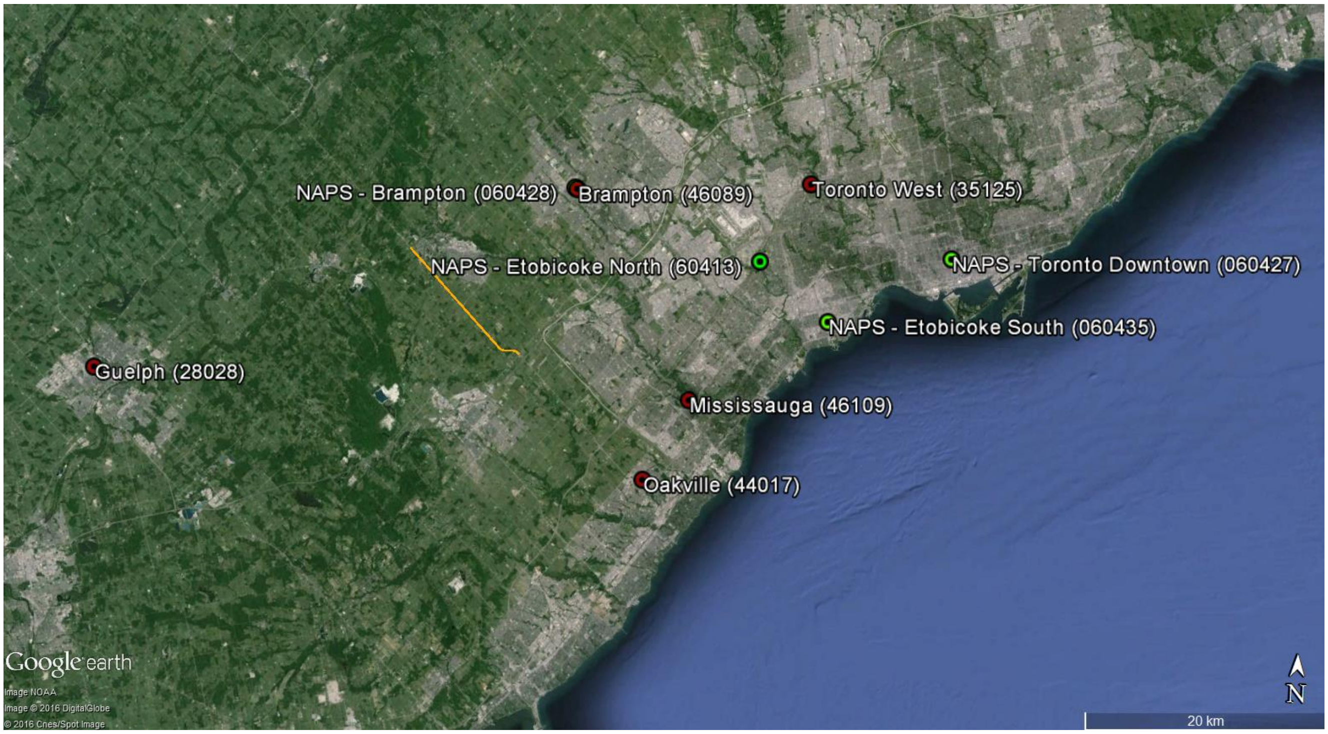


Figure 5: Relevant MOECC (shown in red) and NAPS (shown in green) Monitoring Stations; Windsor NAPS Station Not Shown

Table 3: Relevant MOECC and NAPS Station Information

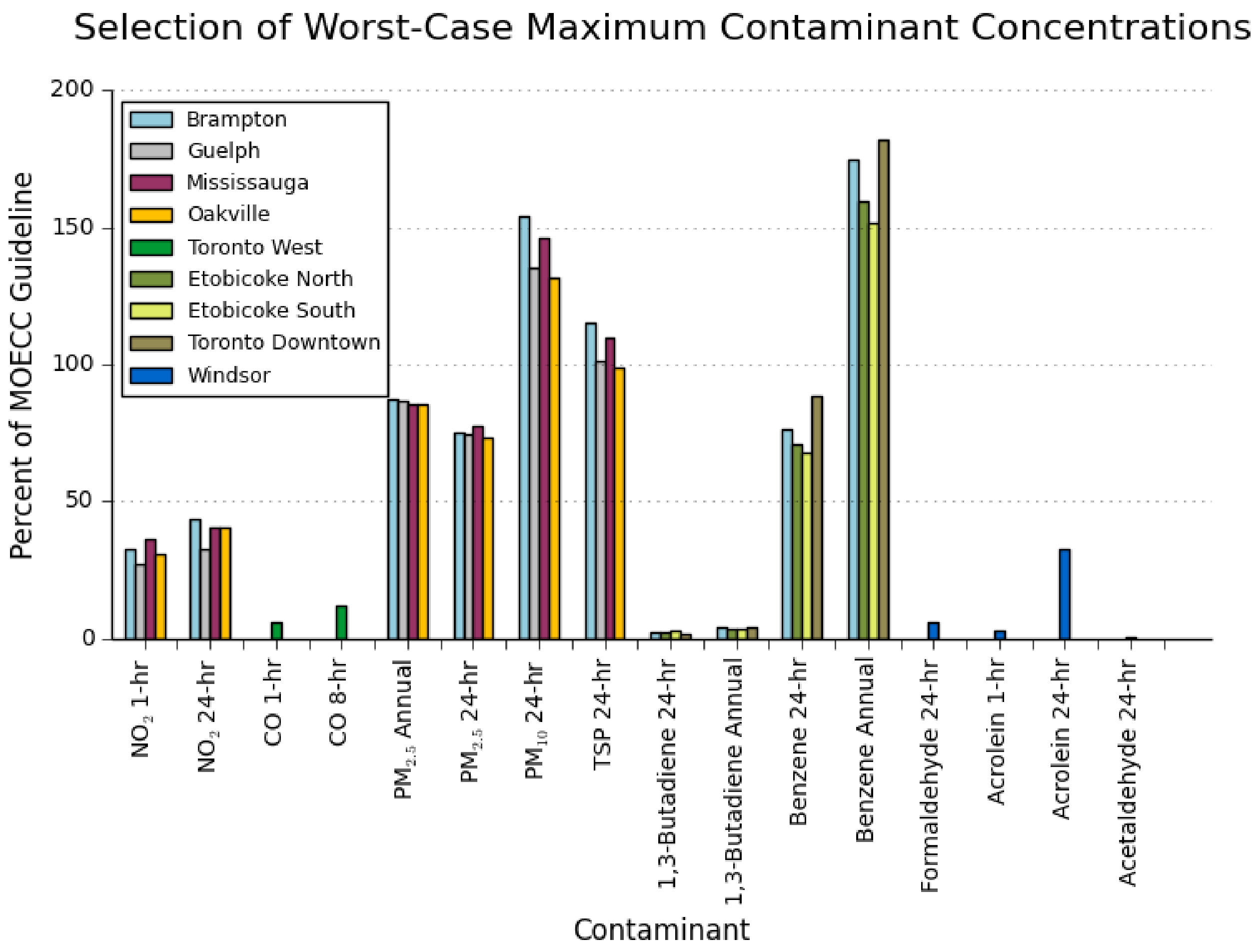
City/Town	Station ID	Location	Operator	Contaminants
Guelph	28028	Exhibition St./Clark St. W.	MOECC	NO_2 | $PM_{2.5}$
Oakville	44017	Eighth Line/Glenashton Dr.	MOECC	NO_2 | $PM_{2.5}$
Mississauga	46109	3359 Mississauga Rd. N.	MOECC	NO_2 | $PM_{2.5}$
Brampton	46089	525 Main St. N.	MOECC	NO_2 | $PM_{2.5}$
Toronto West	35125	125 Resources Rd	MOECC	CO
Brampton	60428	525 Main St. N.	NAPS	Benzene | 1,3-Butadiene
Etobicoke North	60413	Elmcrest Road	NAPS	Benzene | 1,3-Butadiene
Etobicoke South	60435	461 Kipling Ave	NAPS	Benzene | 1,3-Butadiene
Toronto Downtown	60427	223 College St.	NAPS	Benzene | 1,3-Butadiene
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 2010 to 2014 hourly ambient monitoring data from the selected stations were statistically summarized for the desired averaging periods: 1-hour, 8-hour, 24-hour, and annual. Note that VOC monitoring data for 2014 is not yet publically available. 2009-2013 data was used for VOC's. The station with the highest maximum value over the five-year period for each contaminant and averaging period was selected to represent background concentrations in the study area. The maximum concentration represents an absolute worst-case background scenario. Ambient VOC data is not monitored hourly, but is typically measured every six days. To combine this dataset with the hourly modelled concentrations, each measured six-day value was applied to all hours between measurement dates, when there were 6 days between measurements. When there was greater than 6 days between measurements, the 90th percentile measured value for the year in question was applied for those days in order to determine combined concentrations. This method is conservative in determining combined impacts as it assumed the 10th percentile highest concentrations whenever data was not available. **Table 4** shows a comparison of the relevant stations for each contaminant of interest, and the selection of the worst-case station.

Table 4: Comparison of Background Concentrations



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

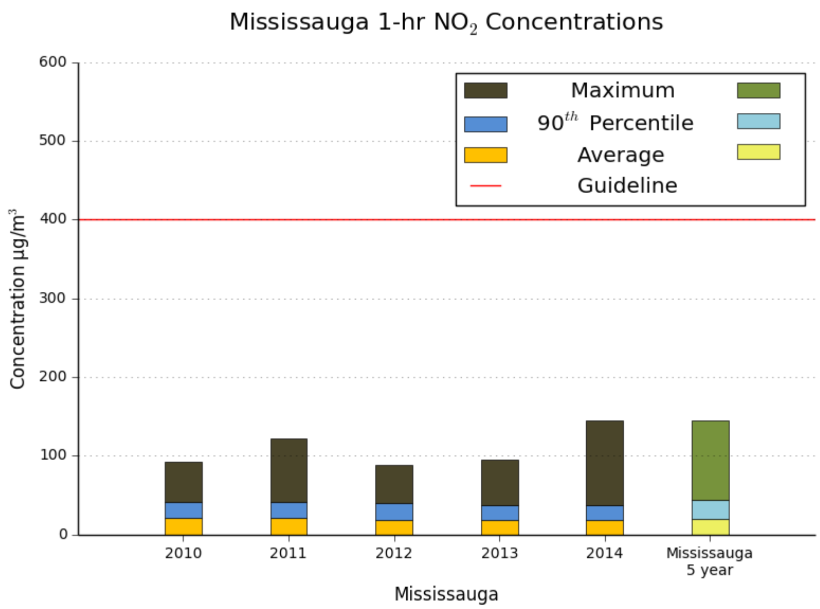
Contaminant	Worst-Case Station	Contaminant	Worst-Case Station
NO_2 (1-Hr)	Mississauga	1,3-Butadiene (24-hr)	Etobicoke South
NO_2 (24-Hr)	Brampton	1,3-Butadiene (ann)	Toronto Downtown
CO (1-Hr)	Toronto West	Benzene (24-hr)	Toronto Downtown
CO (8-hr)	Toronto West	Benzene (ann)	Toronto Downtown
$PM_{2.5}$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

2.4 Detailed Analysis of Selected Worst-case Monitoring Stations

A detailed statistical analysis of the selected worst-case background monitoring station for each of the contaminants is presented below, summarized for average, 90th percentile, and maximum concentrations. Maximum ambient concentrations represented 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. Each site is presented on a yearly basis and for the five-year period. Where measurements exceeded the guideline, frequency analysis was performed.

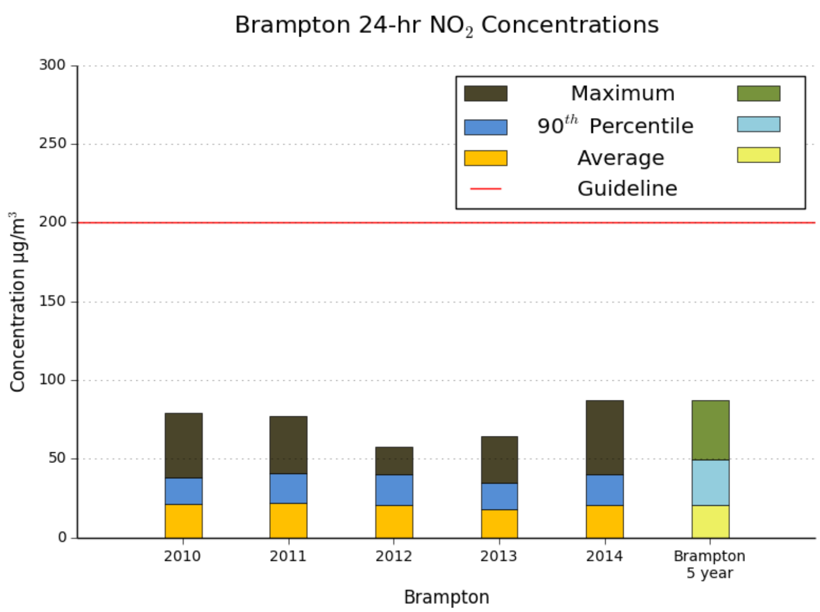
Table 5: Summary of Background NO_2

Statistical Analysis | **Five-Year Summary**



Statistic	% of Guideline
Maximum	36%
90th Percentile	10%
Average	5%

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

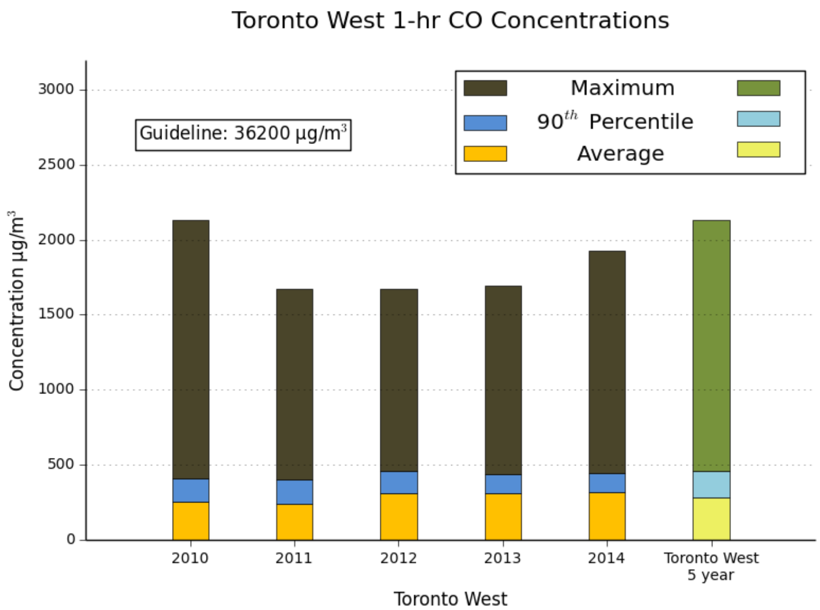


Statistic	% of Guideline
Maximum	43%
90th Percentile	20%
Average	10%

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

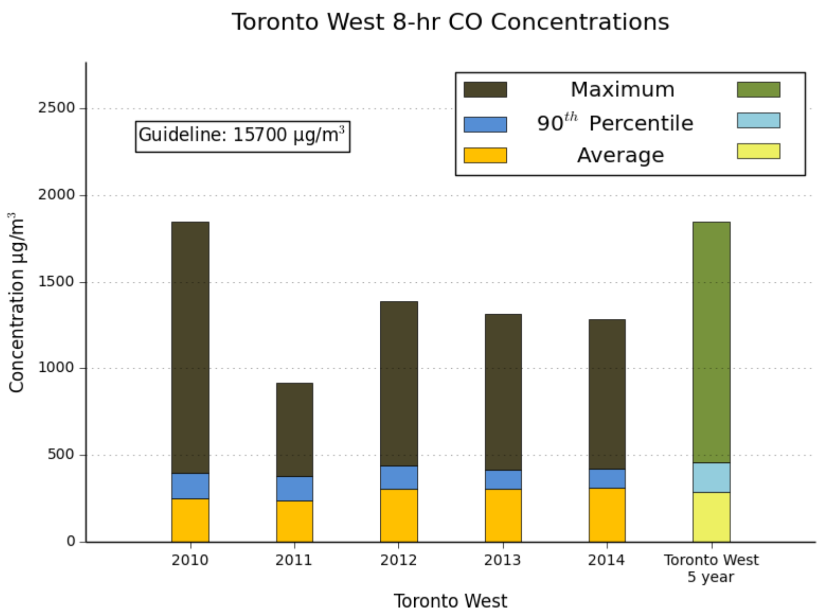
Table 6: Summary of Background CO

Statistical Analysis | **Five-Year Summary**



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

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

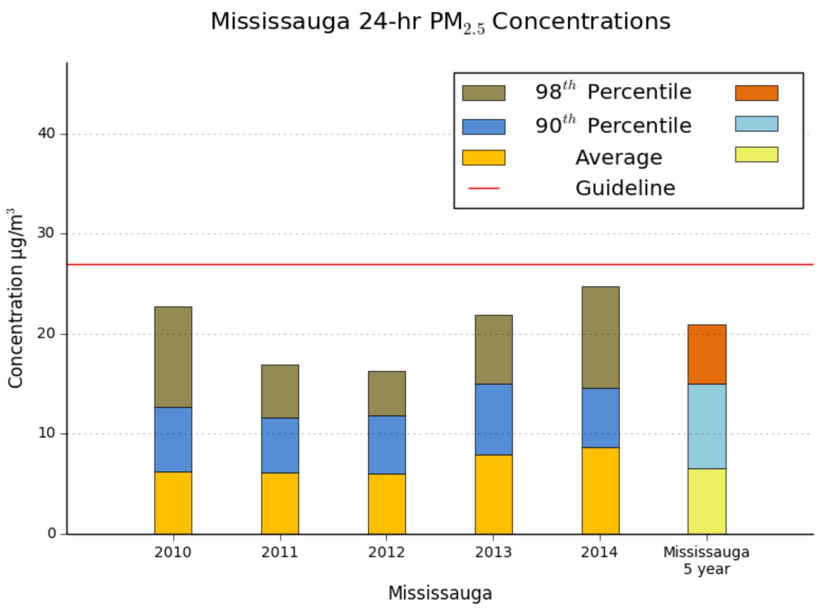


Statistic	% of Guideline
Maximum	12%
90th Percentile	3%
Average	2%

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

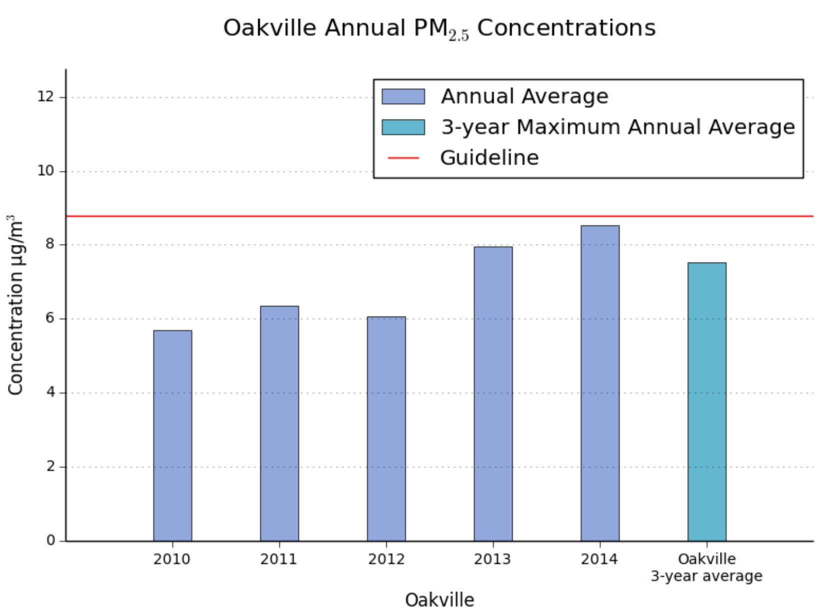
Table 7: Summary of Background $PM_{2.5}$

Statistical Analysis	Five-Year Summary



Statistic	% of Guideline
98th Percentile	78%

Conclusion:
The guideline for $PM_{2.5}$ is based on the 98th percentile value averaged over three consecutive years. A review of five years of ambient monitoring data from the Mississauga Station indicated that the highest 3-year average of 20.9 µg/m³ from 2012 to 2014 was 78% of the guideline.

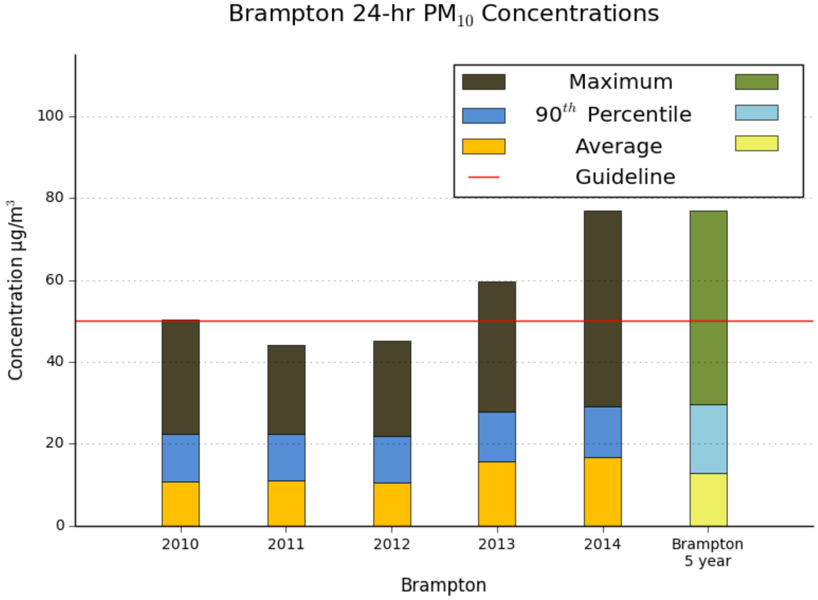


Statistic	% of Guideline
3-year Maximum Annual Average	85%

Conclusion:
The annual guideline for $PM_{2.5}$ is based on the three-year maximum annual average. A review of five years of ambient monitoring data from the Oakville Station indicated that the highest 3-year average of 7.5 µg/m³ from 2012 to 2014 was 85% of the guideline.

Table 8: Summary of Background PM_{10}

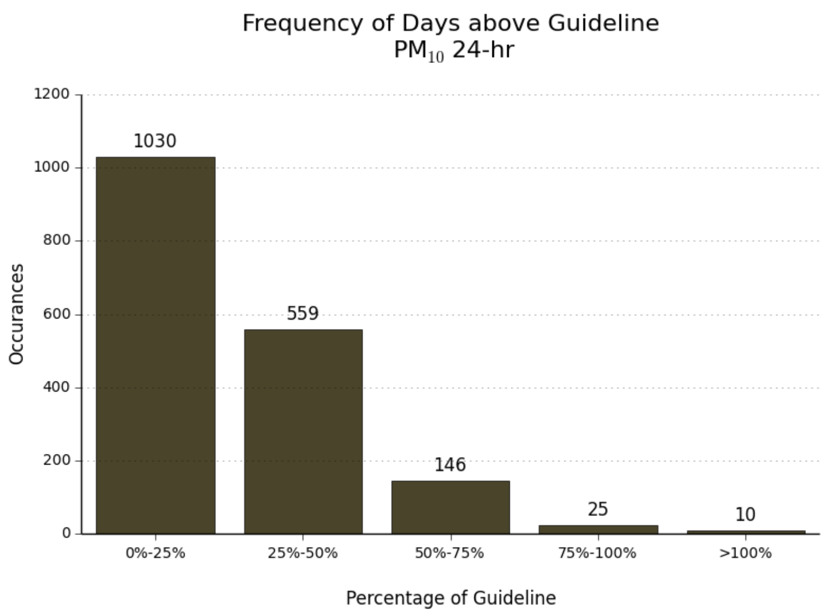
Statistical Analysis	Five-Year Summary



Statistic	% of Guideline
Maximum	154%
90th Percentile	50%
Average	26%

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

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

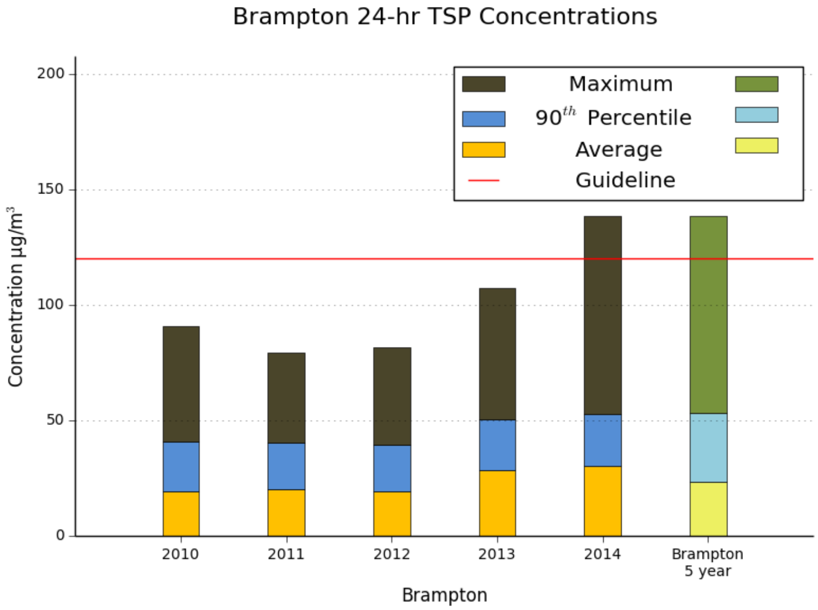


Number of Days Measured	Number of Days > Guideline
1,770	10

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

Table 9: Summary of Background TSP

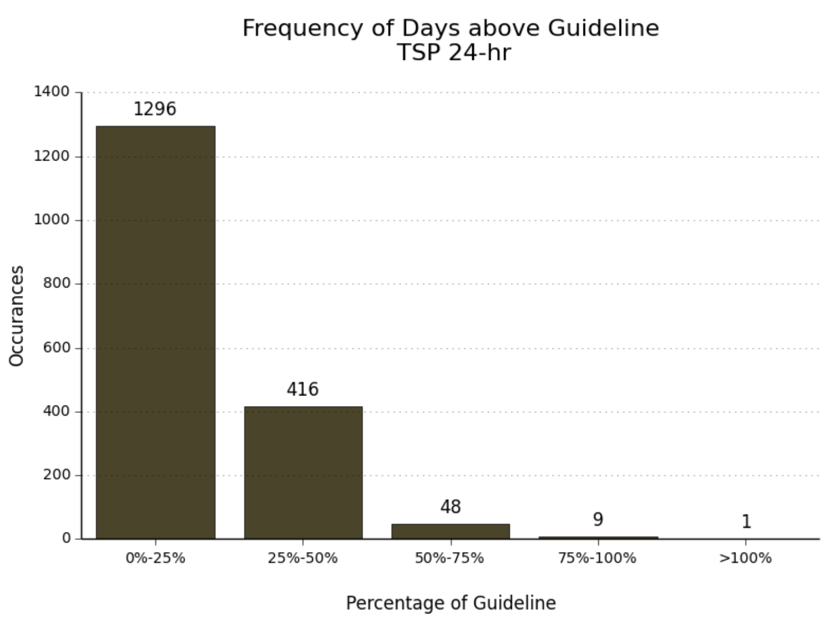
Statistical Analysis	Five-Year Summary



Statistic	% of Guideline
Maximum	115%
90th Percentile	38%
Average	19%

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

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

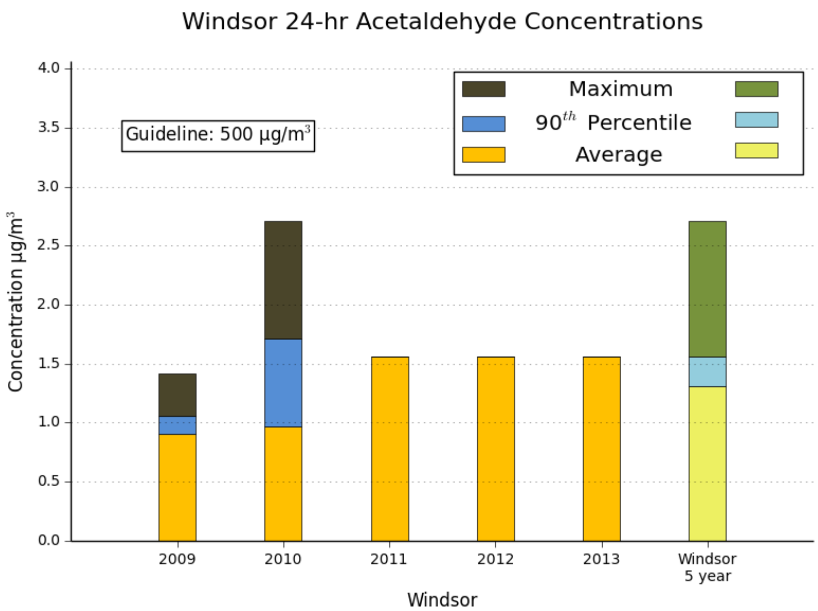


Number of Days Measured	Number of Days > Guideline
1,770	1

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

Table 10: Summary of Background Acetaldehyde

Statistical Analysis	Five-Year Summary



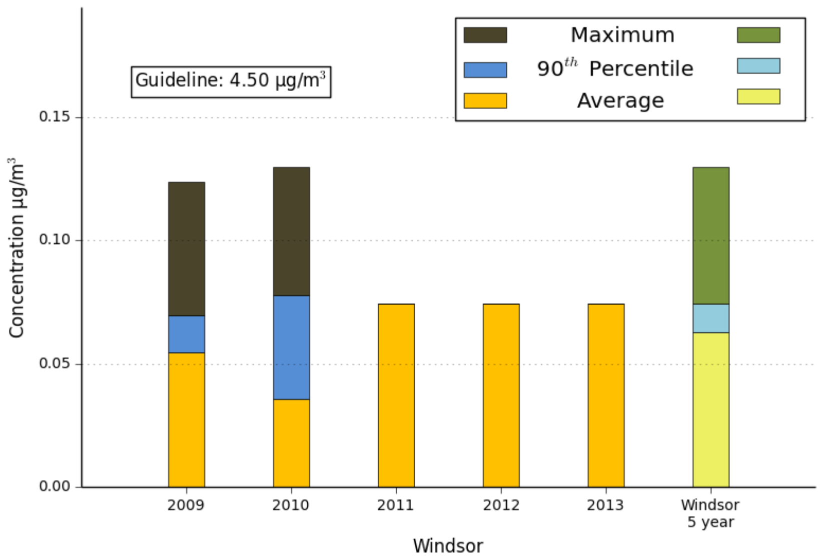
Statistic	% of Guideline
Maximum	1%
90th Percentile	<1%
Average	<1%

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

Table 11: Summary of Background Acrolein

Statistical Analysis	Five-Year Summary

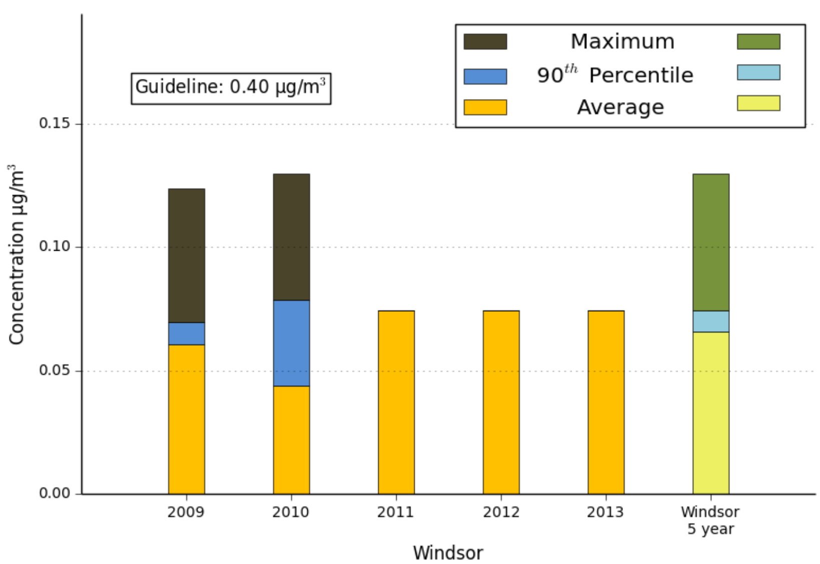
Windsor 1-hr Acrolein Concentrations



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

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

Windsor 24-hr Acrolein Concentrations

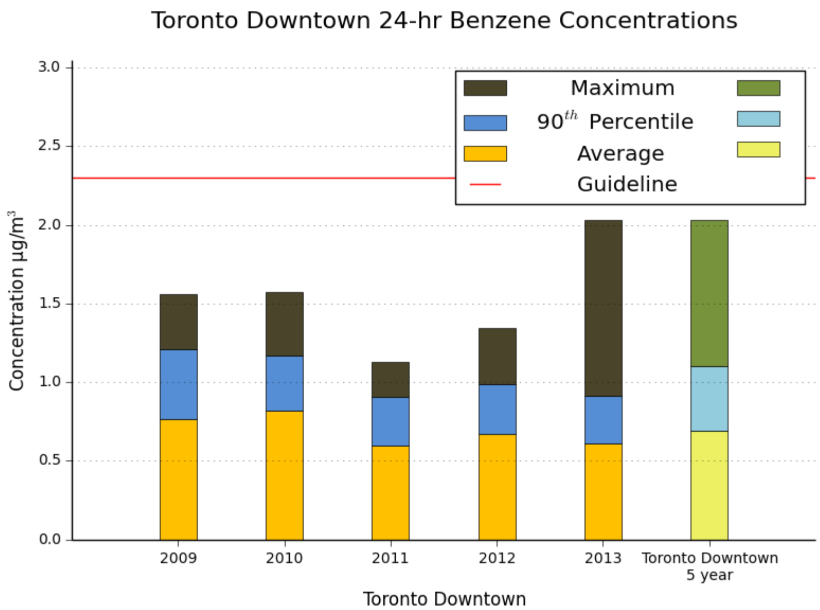


Statistic	% of Guideline
Maximum	32%
90th Percentile	19%
Average	16%

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

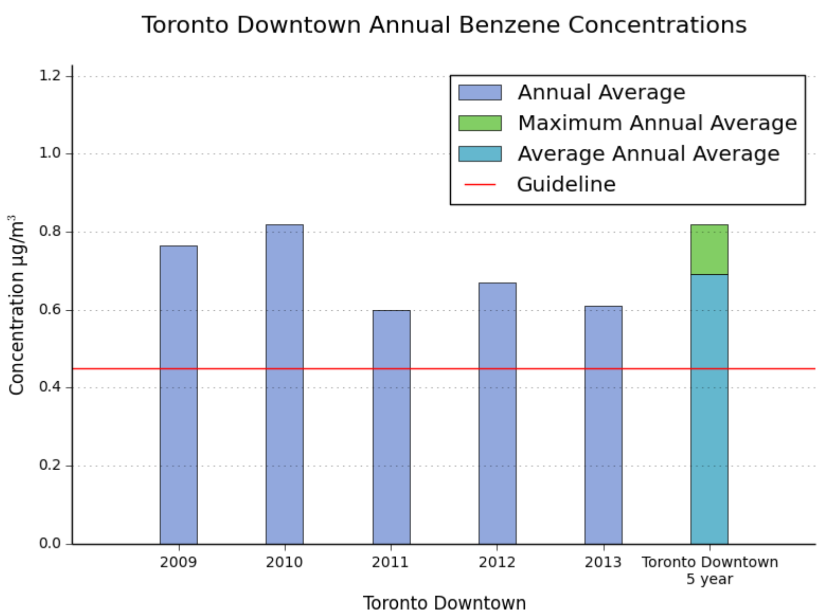
Table 12: Summary of Background Benzene

Statistical Analysis	Five-Year Summary



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

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

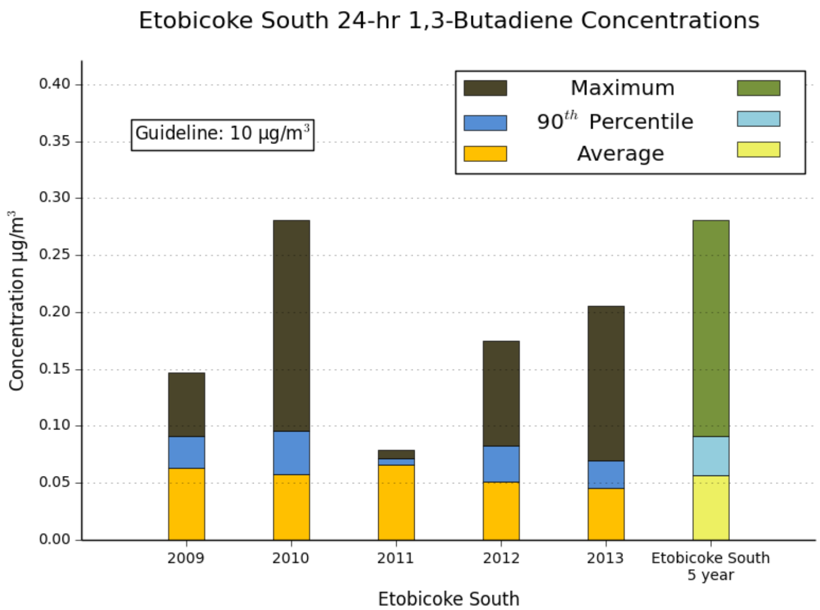


Statistic	% of Guideline
Maximum Annual Average	182%
Average Annual Average	154%

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

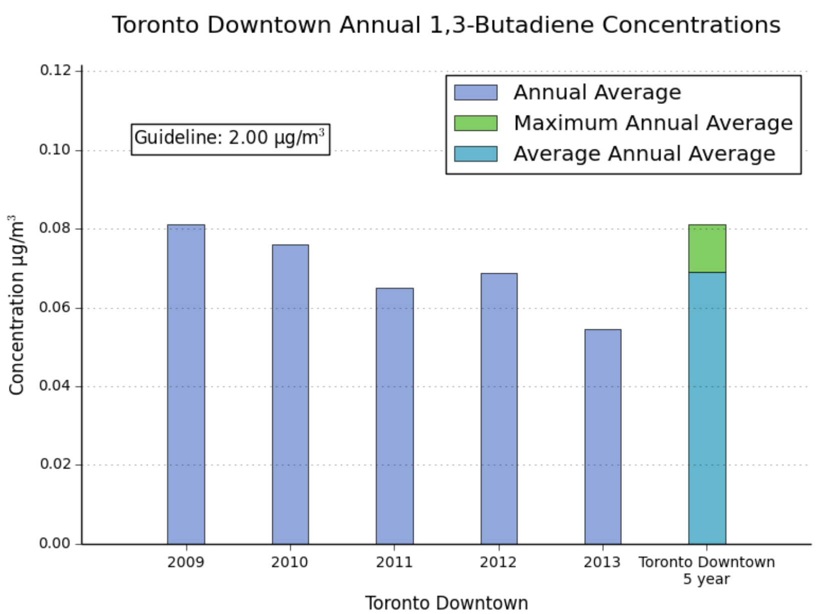
Table 13: Summary of Background 1,3-Butadiene

Statistical Analysis	Five-Year Summary



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

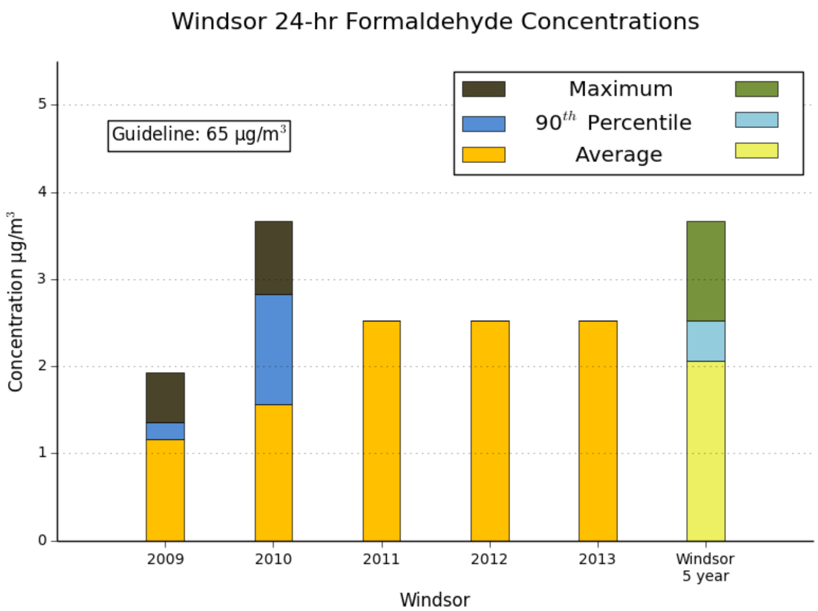
Conclusion:
A review of five years of ambient monitoring data from the Etobicoke South Station indicated that background concentrations were well below the 24-hour standard.



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

Conclusion:
A review of five years of ambient monitoring data from the Toronto Downtown Station indicated that maximum background concentrations were 4% of the annual standard and average concentrations were 3 % of the standard.

Table 14: Summary of Background Formaldehyde

Statistical Analysis	Five-Year Summary	
	**Statistic**	**% of Guideline**
	Maximum	6%
	90th Percentile	4%
	Average	3%

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

2.5 Summary of Background Conditions

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

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

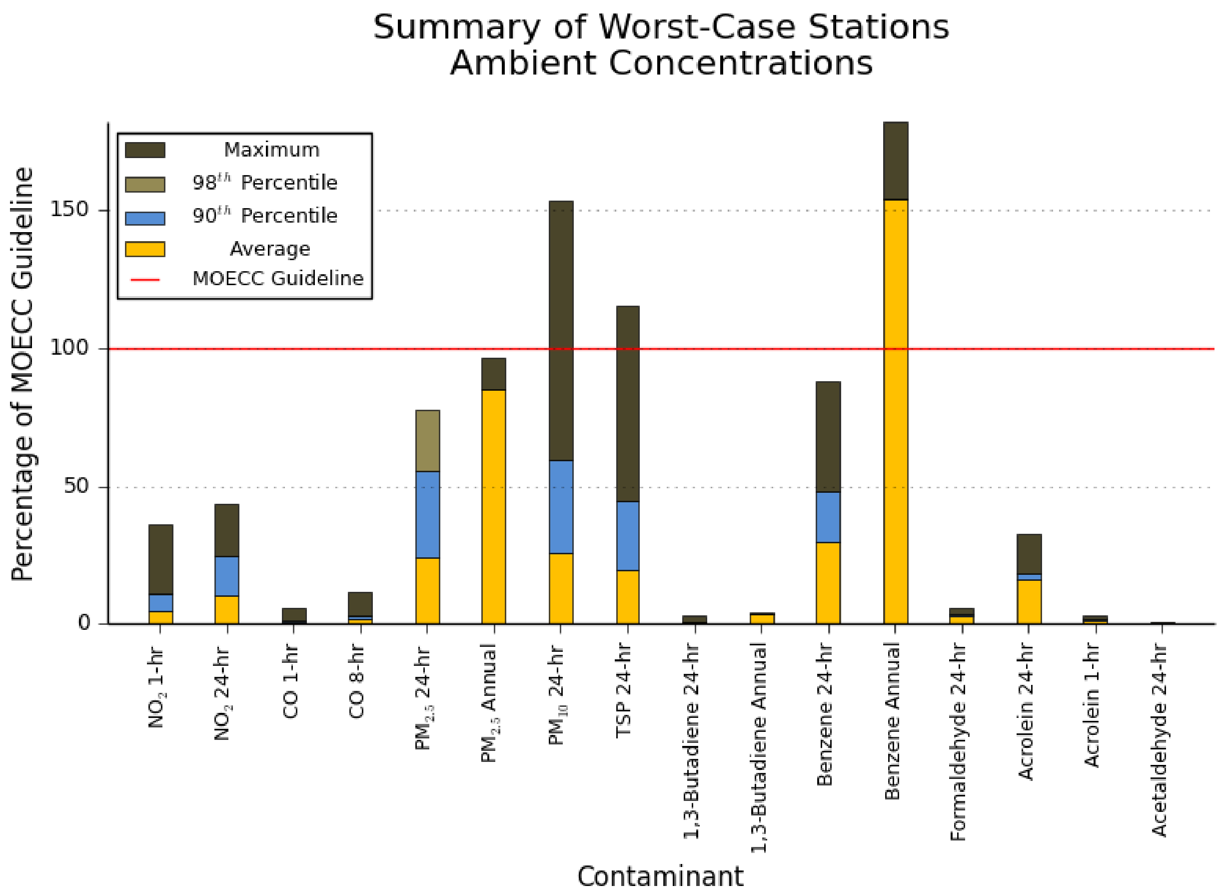


Figure 6: Summary of Background Conditions

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 and 2031 Future Build. The two scenarios include the following activities:

2015 Existing:

- Existing vehicle counts and roadway alignment

2031 Future Build:

- Projected vehicle volumes on Trafalgar Road considering population growth and the new roadway alignment
- Roadway widening to four lanes

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

3.2 Location of Sensitive Receptors within the Study Area

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

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

73 sensitive receptors were modelled to represent worst-case impacts surrounding the project area. Three schools and two churches were included in the model. The remaining receptors chosen were residences. The receptor locations on mapping are identified in **Figure 7** through **Figure 9**, with the new Trafalgar Road alignment shown in pink. Note close ups showing the locations of each receptor are shown in **Appendix A**.

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

Figure 7: Location of R1-R22 (Steeles Ave to South of 10 Side Road)

Figure 8: Location of R23-R42 (South of 10 Side Road to 15 Side Road)

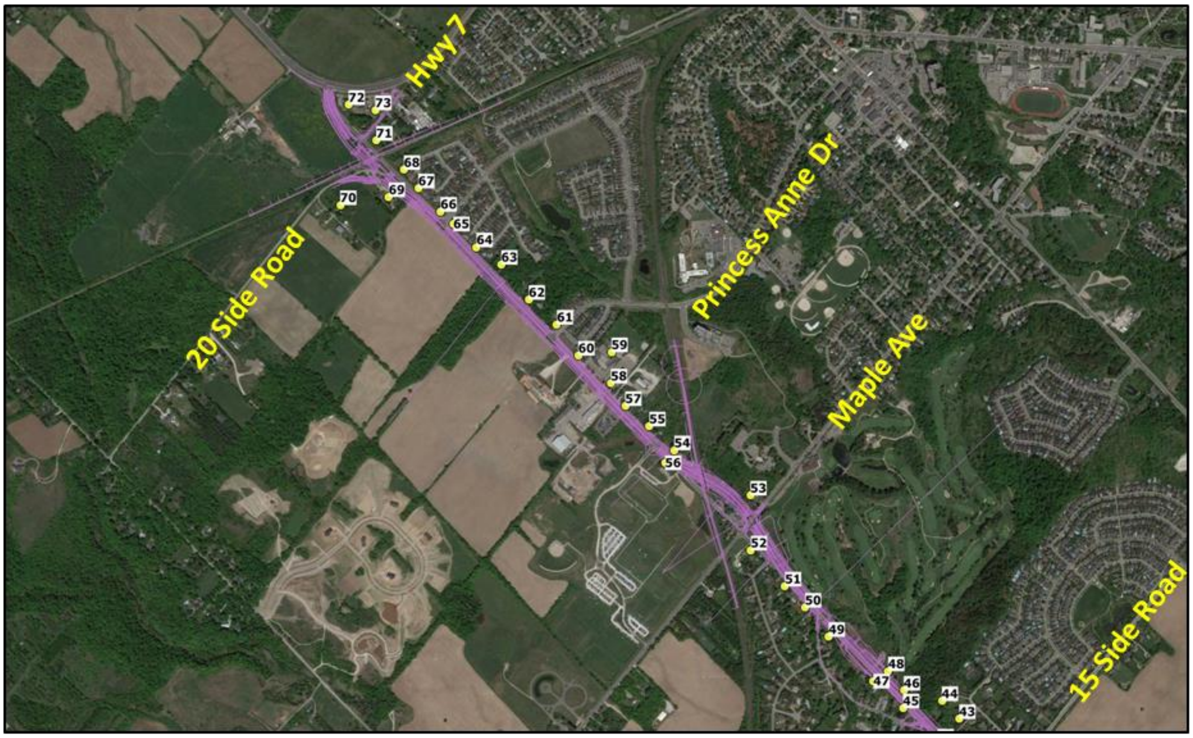


Figure 9: Location of R43-R73 (15 Side Road to Highway 7)

3.3 Road Traffic Data

Traffic volumes for Trafalgar Road were provided by MMM in the form of estimated 24-hour volumes, based on traffic data provided by Halton Region. The traffic volumes used in the assessment are provided in **Table 15**. MMM also provided a 5% heavy-duty vehicle percentage, based on the Halton Region hourly vehicle counts. The hourly counts in the study area were also used to determine the hourly vehicle distribution for the project, presented in **Table 16**.

The study area contains seven traffic signals at the intersections of Steeles Avenue, 5 Side Road, 10 Side Road, 15 Side Road, 17 Side Road (Maple Avenue), Princess Anne Drive and Highway 7. Signal timing information was provided by MMM.

Table 15: Traffic Volumes (AADT) Used in the Assessment

Roadway	2015 Existing 24-hr Volume	2031 Future Build 24-hr Volume	Speed (km/hr)
south of 5 Side Road	13707	20348	70/80
north of 5 Side Road	18458	27401	80
north of 10 Side Road	16599	21739	80
200m south of Maple Avenue	17668	23138	60
north of Maple Avenue (north of CN Rail Tracks)	11102	14541	60
Between 20 Side Road and Hwy 7	9783	12812	70

Table 16: Hourly Vehicle Distribution

Hour	Vehicle Percentage
1	0.6%
2	0.2%
3	0.3%
4	0.3%
5	0.6%
6	2.7%
7	5.8%
8	8.0%
9	7.8%
10	5.6%
11	4.7%
12	4.6%
13	4.8%
14	4.4%
15	4.9%
16	6.8%
17	8.1%
18	8.4%
19	6.7%
20	4.5%
21	3.4%
22	3.2%
23	2.2%
24	1.4%

3.4 Meteorological Data

2010-2014 hourly meteorological data was obtained from the Pearson Airport and upper air data was obtained from Buffalo Airport as recommended by the MOECC. 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 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 west to northerly directions.

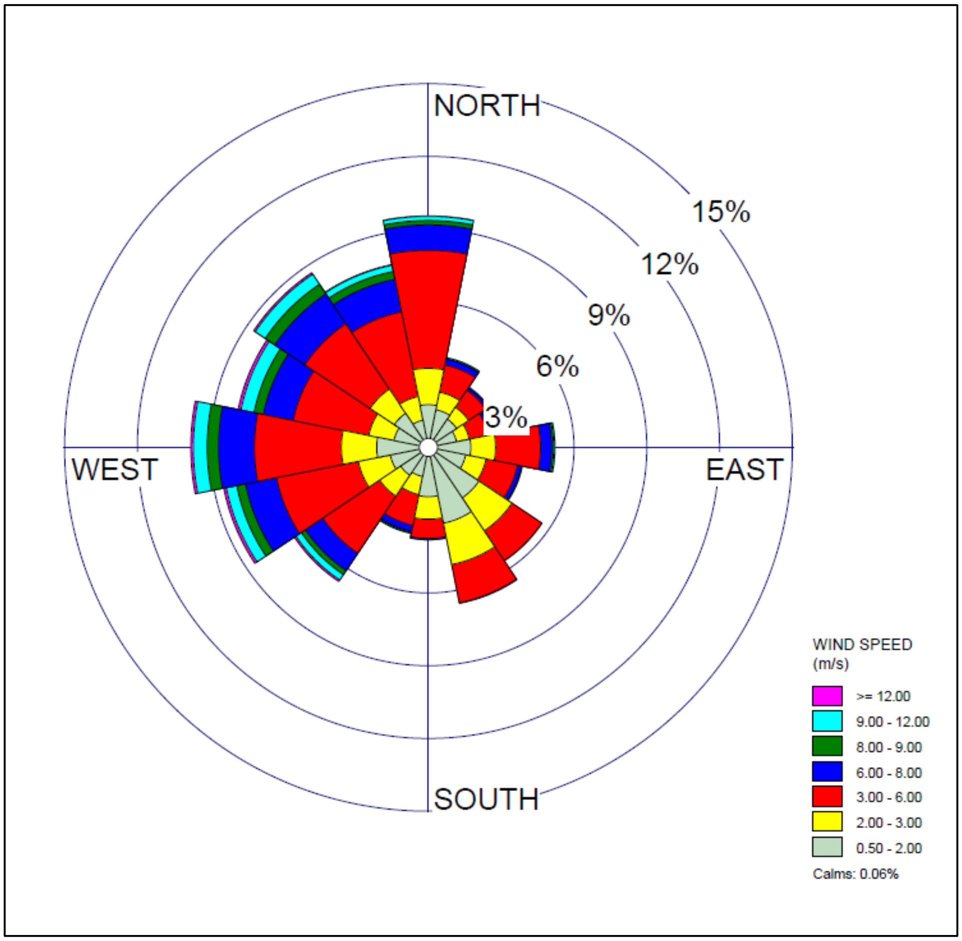


Figure 10: Wind Frequency Diagram for Pearson Airport (2010-2014)

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 and vehicle fleet composition. MOVES 2014, released in October 2014, is the U.S. EPA's tool for estimating vehicle emissions due to the combustion of fuel, brake and tire wear, fuel evaporation, permeation and refuelling leaks. The model is based on "an analysis of millions of emission test results and considerable advances in the Agency's understanding of vehicle emissions and accounts for changes in emissions due to proposed standards and regulations". For this project, MOVES was used to estimate vehicle emissions based on vehicle type, road type, model year, and vehicle speed. Emission rates were estimated based on the heavy duty vehicle percentages provided by MMM. Vehicle age was determined based on the U.S. EPA's default distribution. **Table 17** specifies the major inputs into MOVES.

Note that total NO_x was modelled in MOVES and it was assumed that 100% of NO_x would convert to NO_2. This is conservative in determining NO_2 concentrations.

Table 17: MOVES Input Parameters

Parameter	Input
Scale	Custom County Domain
Meteorology	Temperature and Relative Humidity were obtained from meteorological data from Pearson Airport for the years 2010 to 2014.
Years	2015, 2031
Geographical Bounds	Custom County Domain
Fuels	Compressed Natural Gas / Diesel Fuels / Gasoline Fuels
Source Use Types	Combination Long-haul Truck / Combination Short-haul Truck / Intercity Bus / Light Commercial Truck / Motor Home / Motorcycle / Passenger Car / Passenger Truck / Refuse Truck / School Bus / Single Unit Long-haul Truck / Single Unit Short-haul Truck / Transit Bus
Road Type	Rural Unrestricted Access
Contaminants and Processes	NO_x / CO / $PM_{2.5}$ / PM_{10} / Acetaldehyde / Acrolein / Benzene / 1,3-Butadiene / Formaldehyde. TSP can't be directly modelled by MOVES. However, the U.S. EPA has determined, based on emissions test results, that >97% of tailpipe particulate matter is PM_{10} or less. Therefore, the 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 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 18**.

Table 18: 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	60 km/hr	0.48	2.82	0.025	0.074	0.074	0.0013	0.00014	0.0031	0.00028	0.0023
	70 km/hr	0.48	2.50	0.021	0.050	0.050	0.0011	0.00012	0.0027	0.00024	0.0020
	80 km/hr	0.47	2.41	0.019	0.041	0.041	0.0011	0.00012	0.0026	0.00023	0.0019
	Idle	3.55	17.04	0.24	0.26	0.26	0.029	0.003	0.058	0.007	0.046
2031	60 km/hr	0.097	1.09	0.011	0.058	0.058	0.00027	0.000036	0.00093	0.000002	0.00073
	70 km/hr	0.099	1.0	0.0079	0.036	0.036	0.00023	0.000031	0.00085	0.000002	0.0062
	80 km/hr	0.099	0.98	0.0068	0.028	0.028	0.00022	0.000029	0.00083	0.000002	0.00059
	Idle	0.48	2.58	0.045	0.050	0.050	0.0037	0.00051	0.012	0.000053	0.010

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 19**.

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

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

Table 19: Re-suspended Particulate Matter Emission Factors

Roadway AADT	K ($PM_{2.5}$/PM_{10}/TSP)	sL (g/m^2)	W (Tons)	E (g/VMT)		
				$PM_{2.5}$	PM_{10}	TSP
<500	0.25/1.0/5.24	0.6	3	0.503	2.015	10.561
500-5,000	0.25/1.0/5.24	0.2	3	0.185	0.741	3.886
5,000-10,000	0.25/1.0/5.24	0.06	3	0.061	0.247	1.299
>10,000	0.25/1.0/5.24	0.03	3	0.0176	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 statistics for the contaminants of interest at the identified sensitive receptor locations. **Table 20** 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 20: 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	2010-2014 data from Pearson 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 generally rural. The rural surface roughness height for crop lands of 10 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 2031 Future Build scenarios based on 5-years of meteorological data. For each contaminant, combined concentrations are presented along with the relevant contribution due to the background and roadway. Results in this section are presented for the worst-case sensitive receptor (see **Table 21**), which was identified as the receptor with the maximum combined concentration for the 2031 Future Build scenario. Results for all modelled receptors are provided in **Appendix A.** It should be noted that the maximum combined concentration at any sensitive receptor often occurs infrequently and actually may only occur for one hour or day over the 5-year period.

Table 21: Worst-Case Sensitive Receptor for 2031 Future Build Scenario

Contaminant	Averaging Period	Sensitive Receptor
NO_2	1-hour	39
	24-hour	37
CO	1-hour	37
	8-hour	37
$PM_{2.5}$	24-hour	57
	Annual	57
PM_{10}	24-hour	57
TSP	24-hour	66
Acetaldehyde	24-hour	37
Acrolein	1-hour	37
	24-hour	36
Benzene	24-hour	37
	Annual	37
1,3-Butadiene	24-hour	39
	Annual	39
Formaldehyde	24-hour	39

Coincidental hourly modelled roadway and background CAC concentrations were added to derive the combined concentration for each hour over the 5-year period. Hourly combined concentrations were then used to determine contaminant concentrations based on the applicable averaging period. Statistical analysis in the form of maximum, 90th percentile, and average combined concentrations were calculated for the worst-case sensitive receptor for each contaminant and are presented below. The maximum combined concentration (or 3-year average annual 98th percentile concentration in the case of 24-hour $PM_{2.5}$ and 3-year average for annual $PM_{2.5}$) was used to assess compliance with MOECC guidelines or CWS. 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.

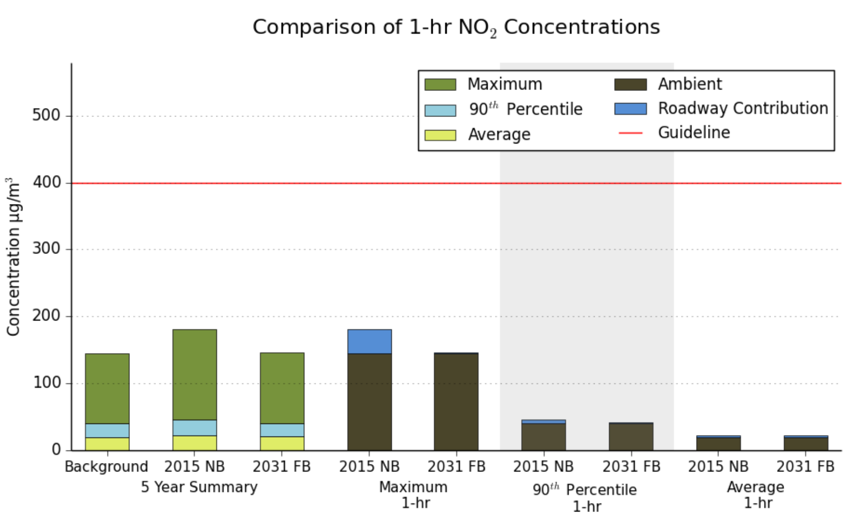
Nitrogen Dioxide

Table 22 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. Total NO_x was modelled and assumed to be all NO_2 to account for atmospheric conversion. The results conclude that:

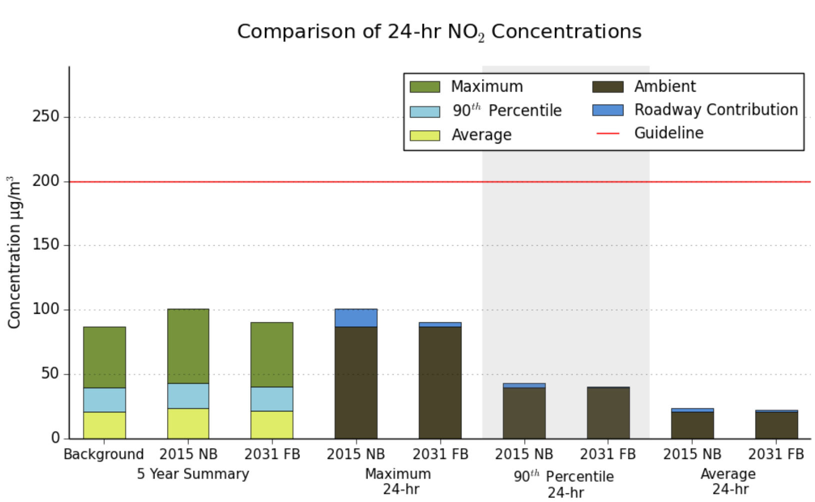
- *Both the maximum 1-hour and 24-hour NO_2 combined concentrations were below their respective MOECC guidelines.*

Table 22: Summary of Predicted NO_2 Concentrations

Statistical Analysis



% of MOECC Guideline:	
Maximum	36%
90th Percentile	10%
Average	5%
Roadway Contribution:	
Maximum	1%
90th Percentile	2%
Average	3%



% of MOECC Guideline:	
Maximum	44%
90th Percentile	20%
Average	11%
Roadway Contribution:	
Maximum	4%
90th Percentile	3%
Average	4%

Conclusions:

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

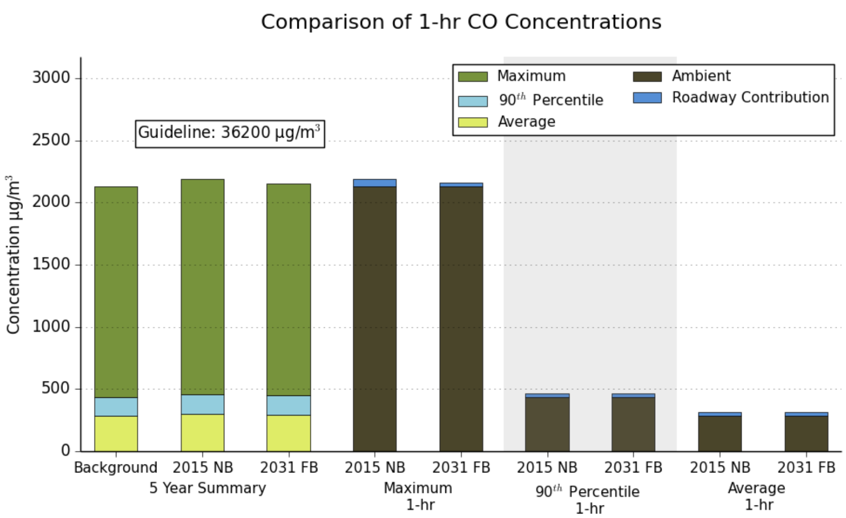
Carbon Monoxide

Table 23 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:

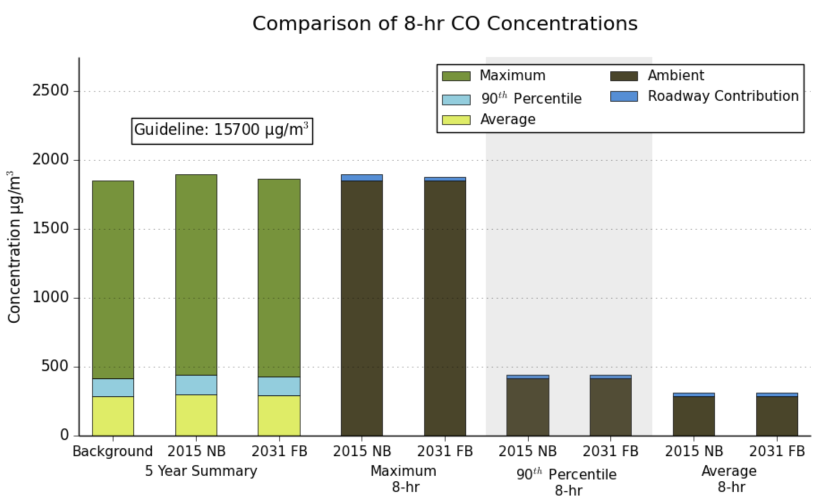
- *Both the maximum 1-hour and 8-hour CO combined concentrations were well below their respective MOECC guidelines.*

Table 23: Summary of Predicted CO Concentrations

Statistical Analysis



% of MOECC Guideline:	
Maximum	6%
90th Percentile	1%
Average	1%
Roadway Contribution:	
Maximum	1%
90th Percentile	3%
Average	2%



% of MOECC Guideline:	
Maximum	12%
90th Percentile	3%
Average	2%
Roadway Contribution:	
Maximum	3%
90th Percentile	3%
Average	2%

Conclusions:

- All combined concentrations were below their respective MOECC guidelines.
- The contribution from the roadway to the combined concentrations was 3% or less.

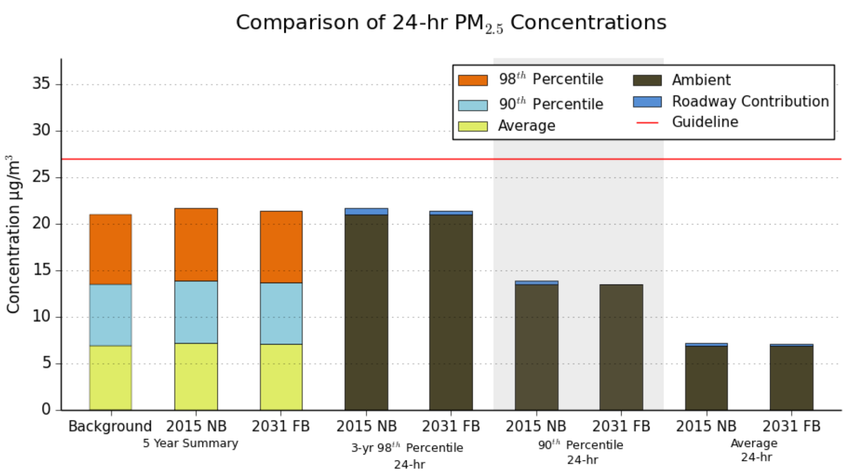
Fine Particulate Matter ($PM_{2.5}$)

Table 24 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 CWS.*
- *The maximum three-year annual average $PM_{2.5}$ combined concentration was below the CWS*

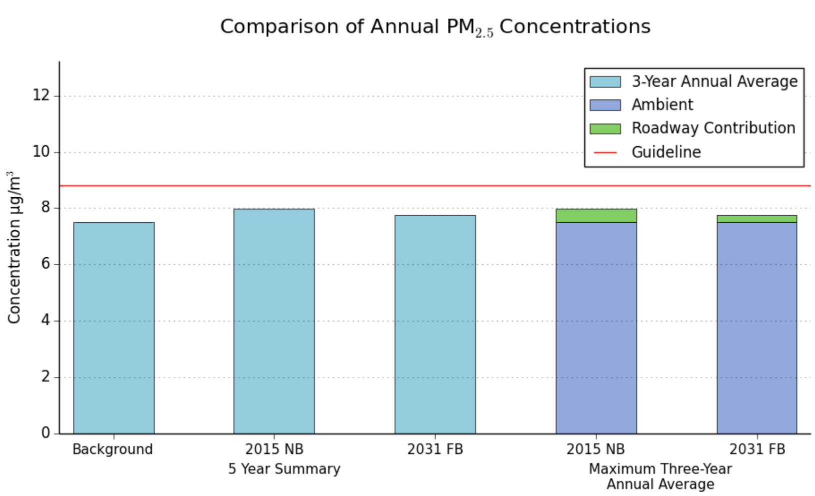
Table 24: Summary of Predicted $PM_{2.5}$ Concentrations

Statistical Analysis



% of MOECC Guideline:	
98th Percentile	79%
90th Percentile	51%
Average	27%
Roadway Contribution:	
98th Percentile	3%
90th Percentile	3%
Average	3%

Conclusions:
The $PM_{2.5}$ results were below the 3-year CWS. The highest 3 year rolling average of the yearly 98th percentile combined concentrations was calculated to be 21.4 µg/m^3 or 79% of the CWS.



% of MOECC Guideline:	
3-Year Annual Average	88%
Roadway Contribution:	
3-Year Annual Average	3%

Conclusions:
The $PM_{2.5}$ results were below the 3-year CWS. The maximum 3-year annual average concentration was 88% of the guidelines.

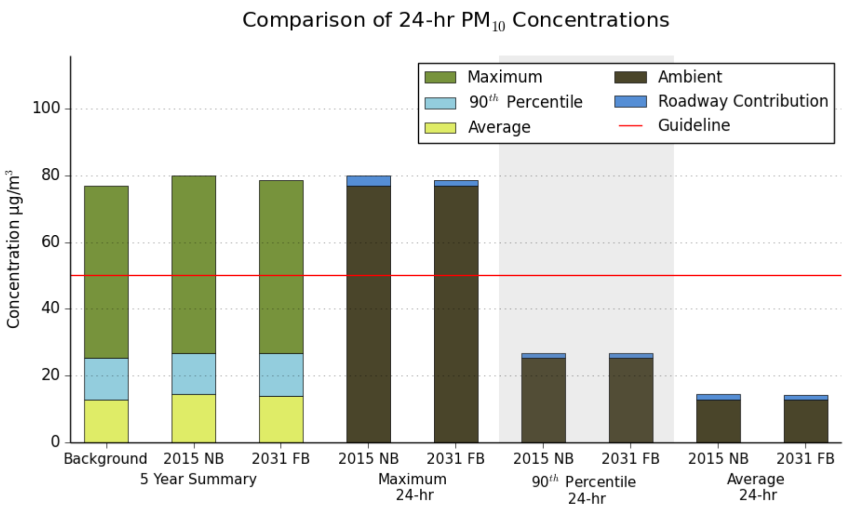
Coarse Particulate Matter (PM_{10})

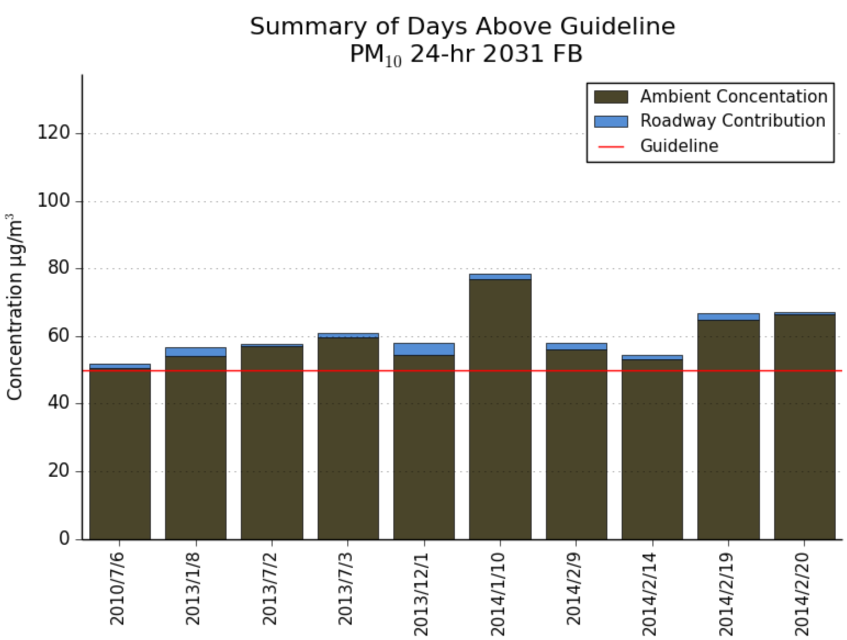
Table 25 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour PM_{10} based on 5 years of meteorological data. The results conclude that:

- *The maximum 24-hr PM_{10} combined concentrations exceeded the MOECC guideline.*

Table 25: Summary of Predicted PM_{10} Concentrations

Statistical Analysis





% of MOECC Guideline:	
Maximum	157%
90th Percentile	53%
Average	28%
Roadway Contribution:	
Maximum	2%
90th Percentile	6%
Average	13%

Conclusions:
The combined concentrations of PM_{10} 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 2% 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 occur due to the roadway over the five-year period.

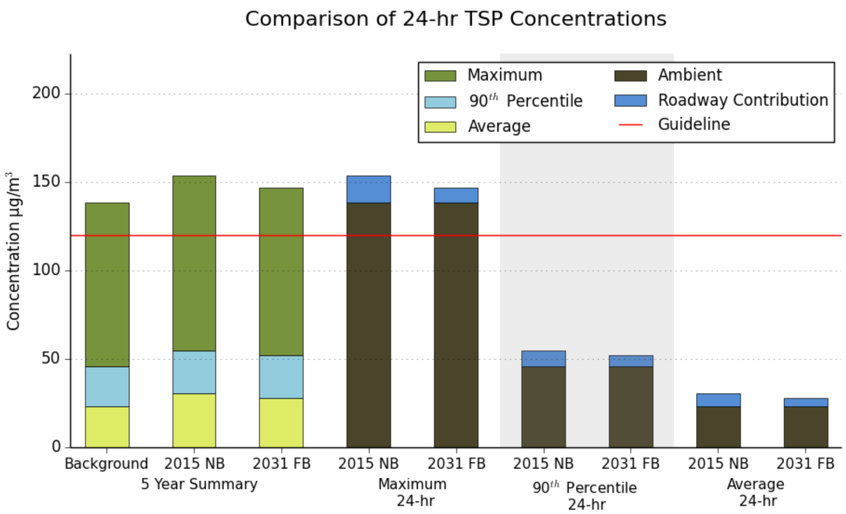
Total Suspended Particulate Matter (TSP)

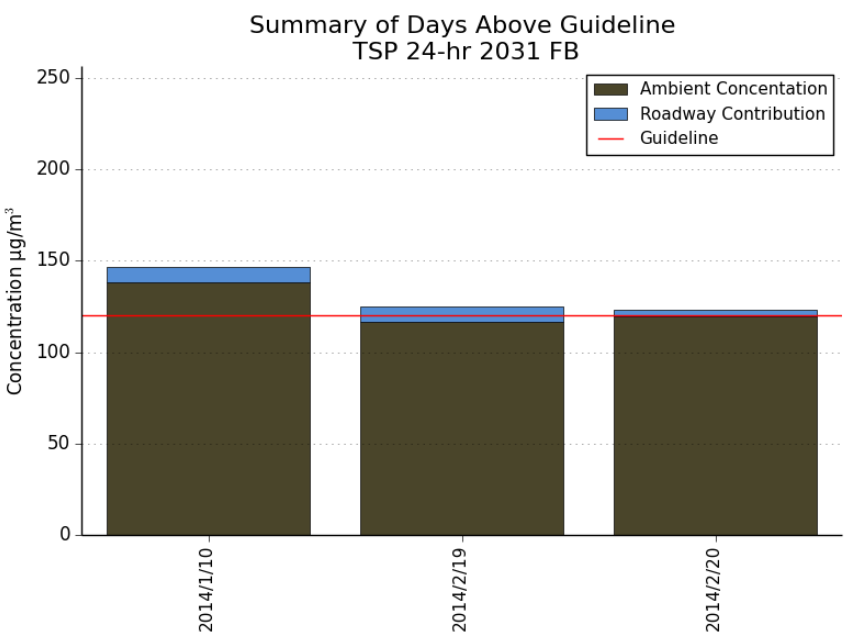
Table 26 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour TSP based on 5 years of meteorological data. The results conclude that:

- *The maximum 24-hr TSP combined concentrations exceeded the MOECC guideline.*

Table 26: Summary of Predicted TSP Concentrations

Statistical Analysis





% of MOECC Guideline:	
Maximum	122%
90th Percentile	43%
Average	23%
Roadway Contribution:	
Maximum	6%
90th Percentile	15%
Average	15%

Conclusions:

The TSP results show that the combined concentrations exceed the guideline. It should be noted that ambient concentrations alone exceeded the standard and that the roadway contribution was 6% 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 two additional exceedances are expected due to the roadway over the five-year period, which is less than 1% of the time.

Ambient VOC concentrations are typically measured every 6 days in Ontario. In order to be able 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. The combined hourly results were added to these concentrations to obtain the following results.

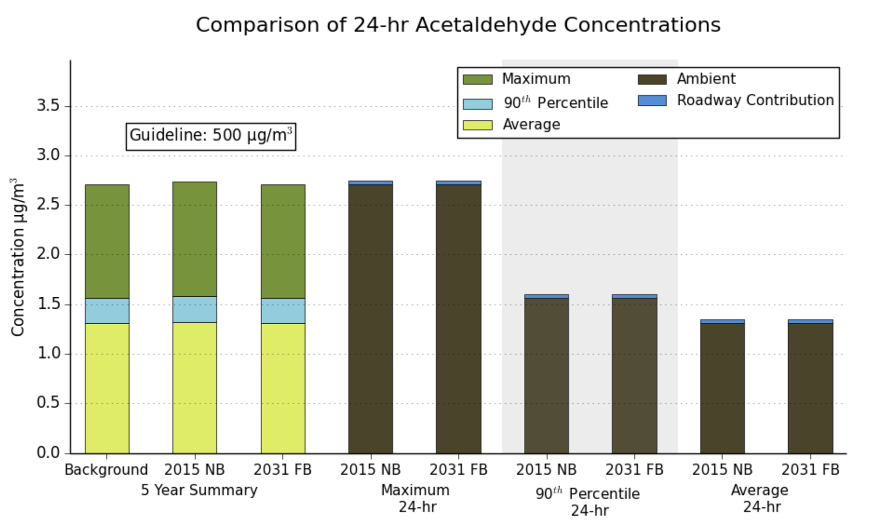
Acetaldehyde

Table 27 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 27: Summary of Predicted Acetaldehyde Concentrations

Statistical Analysis



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

Conclusions:

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

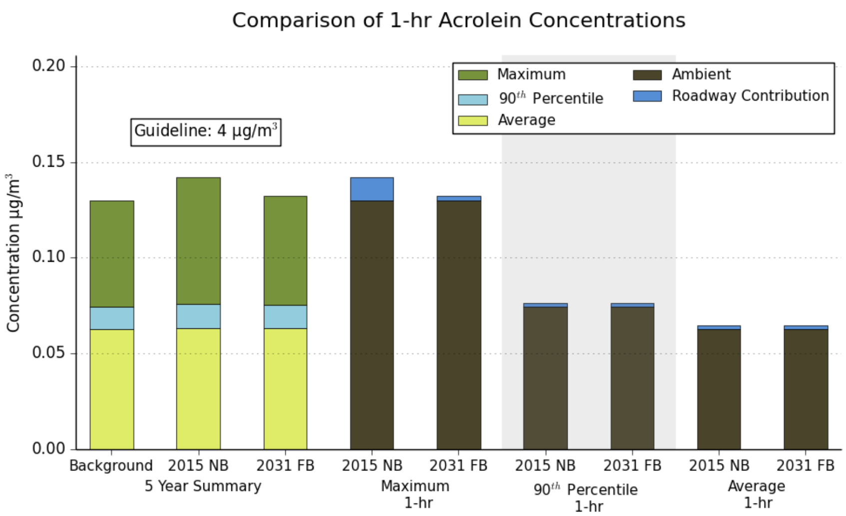
Acrolein

Table 28 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 acrolein combined concentration was below the respective MOECC guideline.*
- *The maximum 24-hour acrolein combined concentration was below the respective MOECC guideline.*

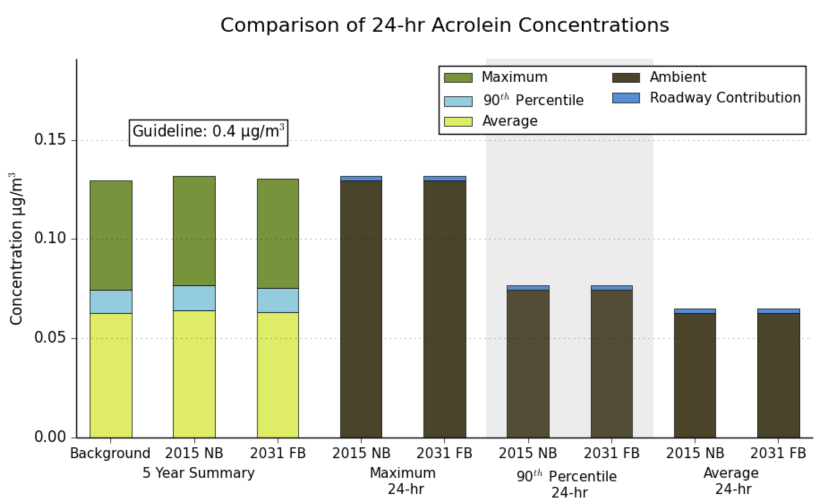
Table 28: Summary of Predicted Acrolein Concentrations

Statistical Analysis



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

Conclusions:
The combined concentrations were below the respective MOECC guidelines. The contribution from the roadway was 2% 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%.

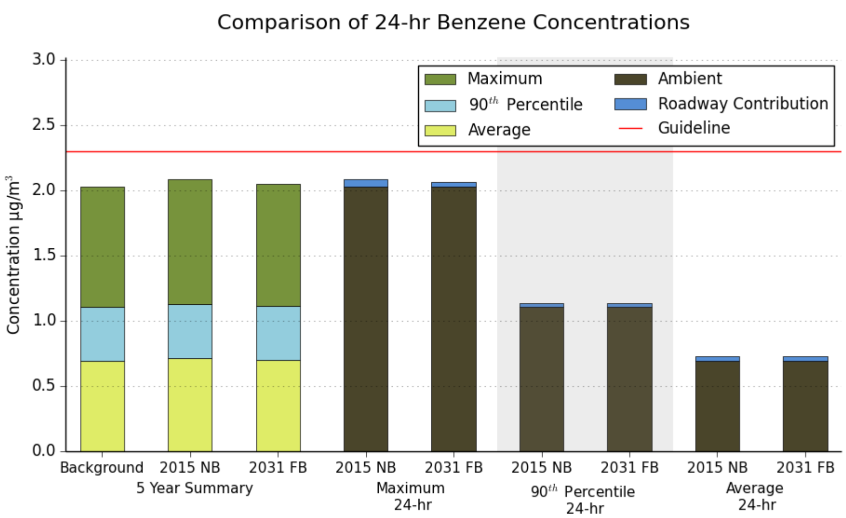
Benzene

Table 29 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 maximum annual benzene combined concentrations exceeded the respective MOECC guideline*

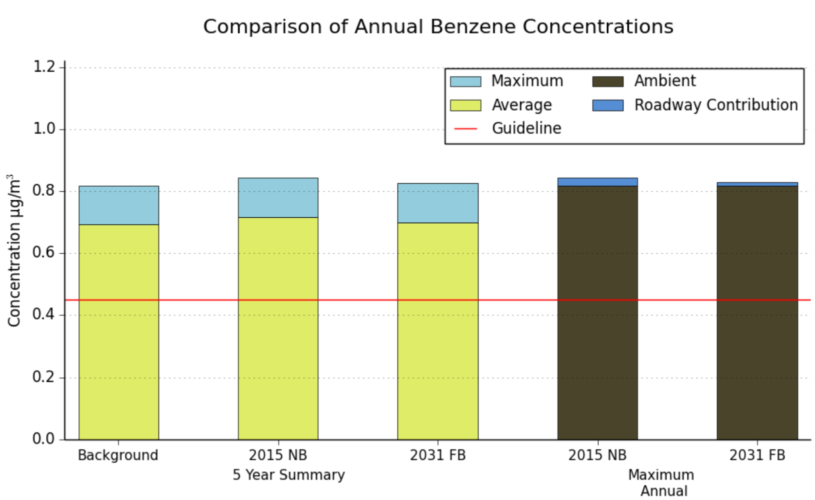
Table 29: Summary of Predicted Benzene Concentrations

Statistical Analysis



% of MOECC Guideline:	
Maximum	89%
90th Percentile	48%
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:	
Annual Maximum	184%
Roadway Contribution:	
Annual Maximum	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 1%.

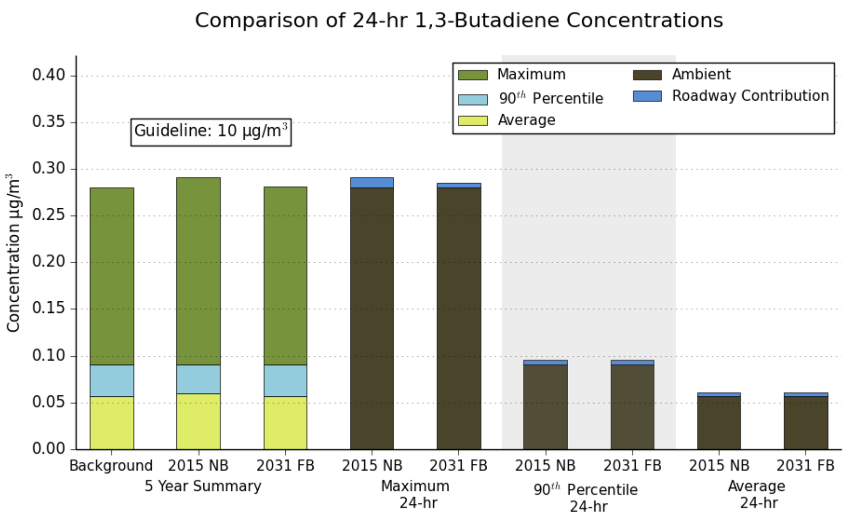
1,3-Butadiene

Table 30 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 1,3-butadiene combined concentration was well below the respective MOECC guideline.*
- *The maximum annual 1,3-butadiene combined concentration was well below the respective MOECC guideline.*

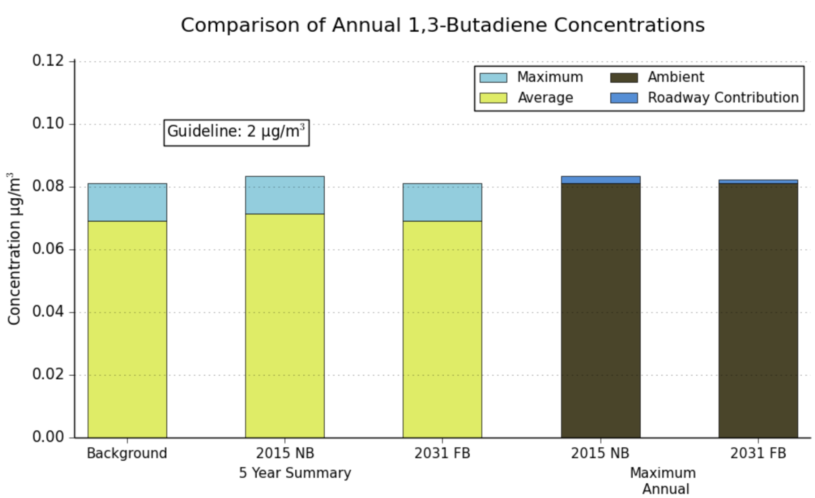
Table 30: Summary of Predicted 1,3-Butadiene Concentrations

Statistical Analysis



% 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%.

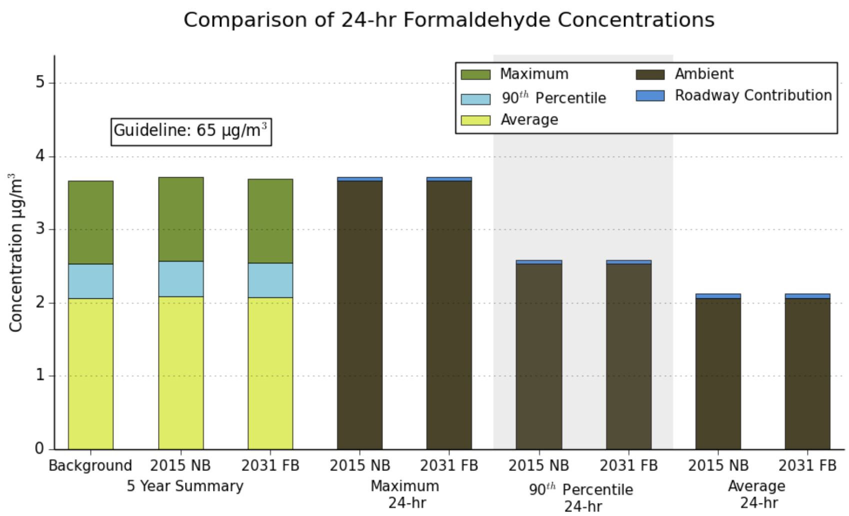
Formaldehyde

Table 31 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 31: Summary of Predicted Formaldehyde Concentrations

Statistical Analysis



% 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 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.

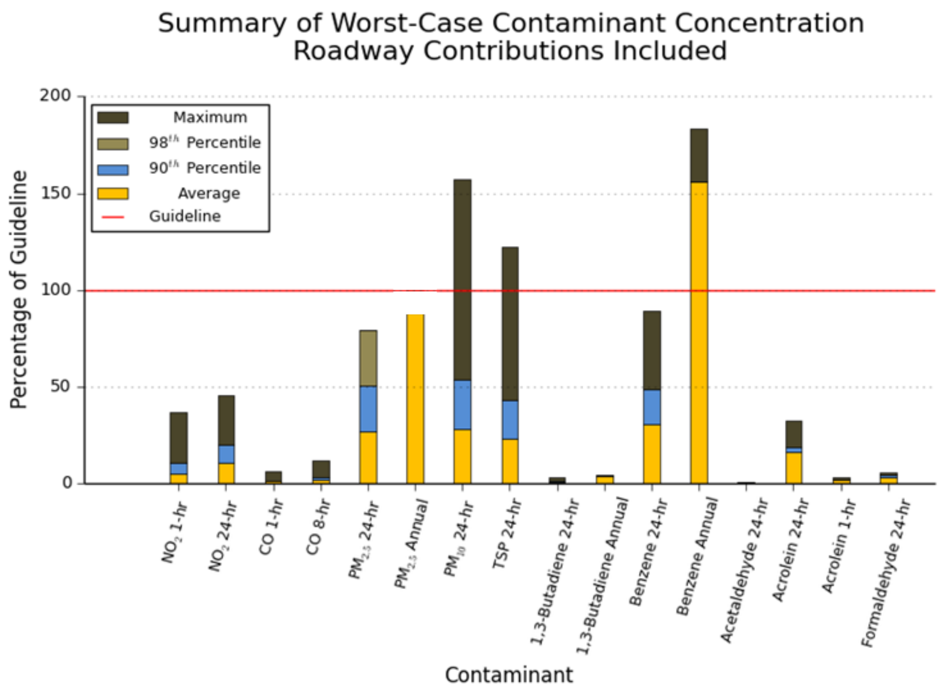
5.0 Conclusions and Recommendations

The potential effects of the proposed project infrastructure on local air quality have been assessed and are summarized in **Table 32** . The following conclusions and recommendations are a result of this assessment.

- *The maximum combined concentrations for the future build scenario were all below their respective MOECC guidelines or CWS, with the exception of PM_{10}, TSP, and annual benzene.*
- *Frequency Analysis determined that the project did not have additional exceedances of the PM_{10} guideline over the 5 year period. The TSP guideline was exceeded 2 additional days over the 5 year period. For TSP this equates to additional exceedances less than 1% of the time.*
- *Ambient annual benzene exceeded the relevant guideline without the roadway contribution. The contribution from the roadway was 1% of the maximum combined concentration.*
- *Mitigation measures are not warranted, due to the small number of additional days which are expected to exceed the guideline.*

Table 32: Summary of 2031 Future Build Results

5 Year Statistical Summary



Note: The $PM_{2.5}$ results are in compliance with the CWS. The highest 3 year rolling average of the yearly 98th percentile combined concentrations was calculated to be 21.4 µg/m³ or 79% of the CWS. The highest 3-year annual average was 7.8 µg/m³ or 88% of the guideline

% of Guideline

2031 Future Build	
NO_2 (1-hr)	36%
NO_2 (24-hr)	44%
CO (1-hr)	6%
CO (8-hr)	12%
$PM_{2.5}$ (24-hr See Note)	79%
$PM_{2.5}$ (annual)	88%
PM_{10}	157%
TSP	122%
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%

6.0 References

Air & Waste Management Association, 2011. The Role of Vegetation in Mitigating Air Quality Impacts from Traffic Emissions. [online] http://www.epa.gov/nrmrl/appcd/nearroadway/pdfs/baldauf.pdf

CCME, 2000. Canadian Council of Ministers of the Environment. Canada-Wide Standards of Particulate Matter and Ozone. *Endorsed by CCME Council of Ministers,* Quebec City. [Online]http://www.ccme.ca/assets/pdf/pmozone_standard_e.pdf

Environment Canada. 2000. Priority Substances List Assessment Report: Respirable Particulate Matter Less Than or Equal to 10 Microns. Canadian Environmental Protection Act, 1999. Environment Canada, Health Canada. [Online] http://www.ec.gc.ca/Substances/ese/eng/psap/final/PM-10.cfm.

Health Canada. 1999. National Ambient Air Quality Objectives for Particulate Matter Part 1: Science Assessment Document. Health Canada. A report by the CEPA/FPAC Working Group on Air Quality Objectives and Guidelines.

Lall, R., Kendall, M., Ito, K., Thurston, G., 2004. Estimation of historical annual $PM_{2.5}$ exposures for health effects assessment. *Atmospheric Environment* 38(2004) 5217-5226.

Ontario Publication 6570e, 2008. *Ontario's Ambient Air Quality Criteria.* Standards Development Branch, Ontario Ministry of the Environment.

Ontario Ministry of the Environment, 2005. *Transboundary Air Pollution in Ontario.* Queens Printer for Ontario.

Randerson, D., 1984. *Atmospheric Science and Power Production* . United States Department of Energy.

Seinfeld, J.H. and Pandis, S.P.,2006. *Atmospheric Chemistry and Physics From Air Pollution to Climate Change.* New Jersey: John Wiley & Sons.

United States Environmental Protection Agency, 2008. *AERSURFACE User's Guide*. USEPA.

United States Environmental Protection Agency, 1997. *Document AP 42,* Volume I, Fifth Edition, Chapter 13.2.1. USEPA.

United States Environmental Protection Agency, 2010. *Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling – Compression-Ignition*. USEPA.

United States Environmental Protection Agency, 2009. *MOVES 2010 Highway Vehicles: Population and Activity Data*. USEPA.

WHO. 2005. WHO air quality guidelines global update 2005. Report on a Working Group meeting, Boon, Germany, October 18-20, 2005.

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 2031 Future-Build scenarios. **Figure A1** shows the location of the receptors within the study area.

Figure A1: Receptors 1-5 within the Study Area

Figure A2: Receptors 6-14 within the Study Area

Figure A3: Receptors 15-22 within the Study Area

Figure A4: Receptors 23-30 within the Study Area

Figure A5: Receptors 31-35 within the Study Area

Figure A6: Receptors 36-48 within the Study Area

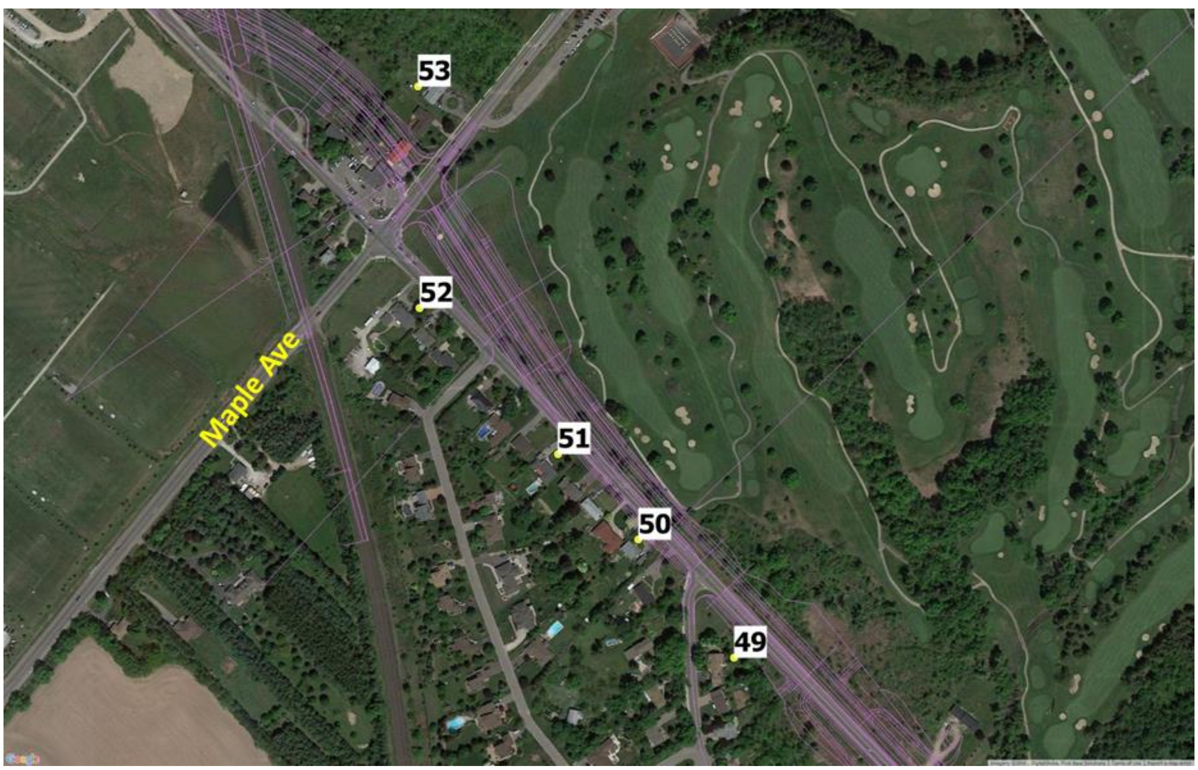


Figure A7: Receptors 49-53 within the Study Area

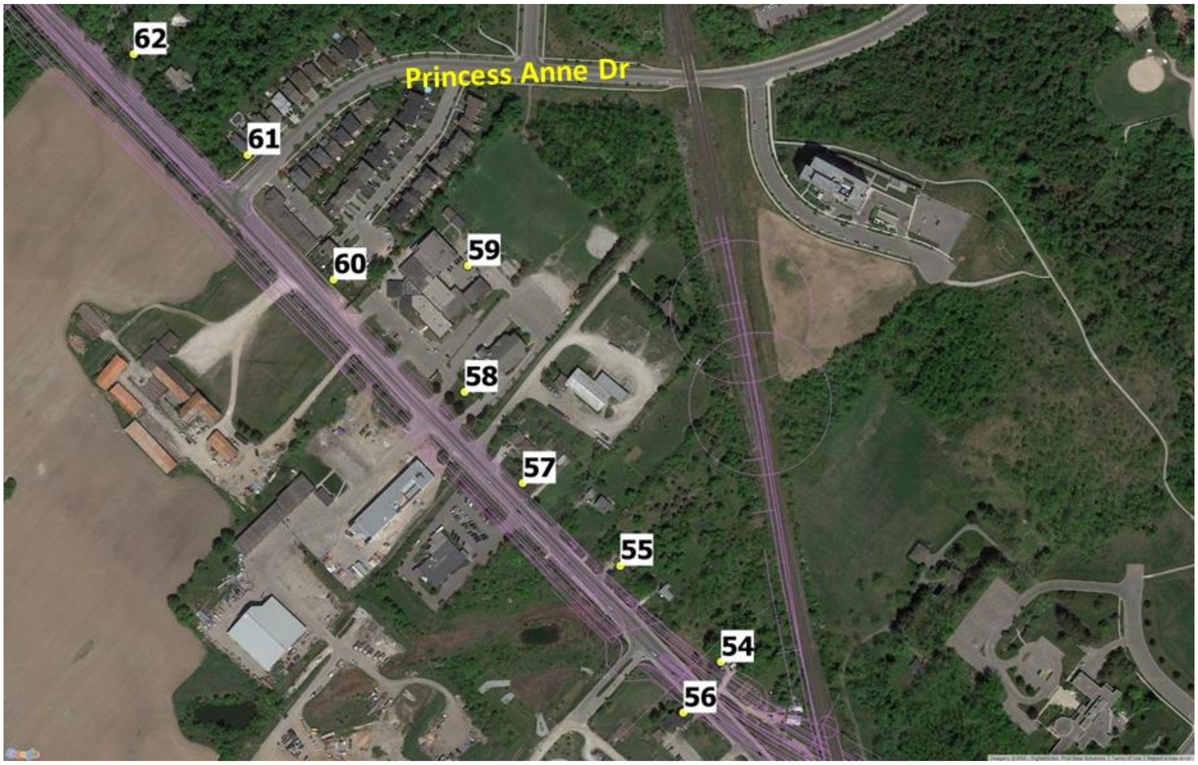


Figure A8: Receptors 54-62 within the Study Area

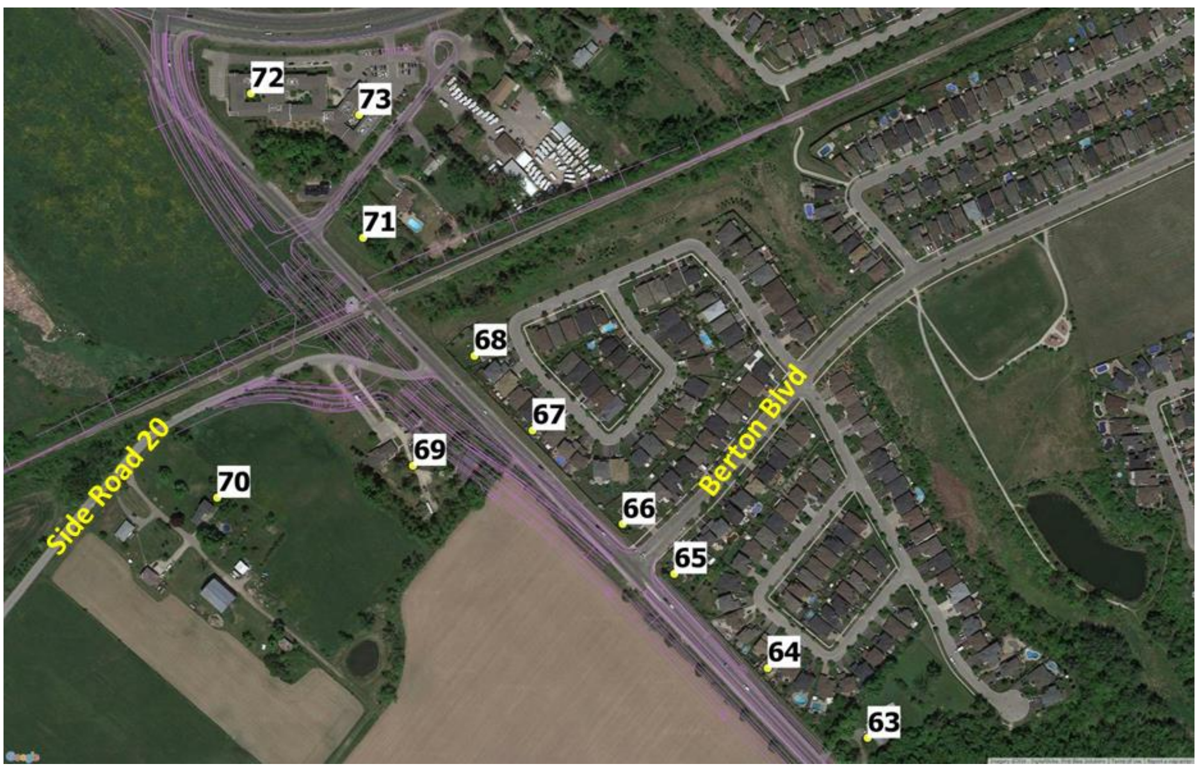
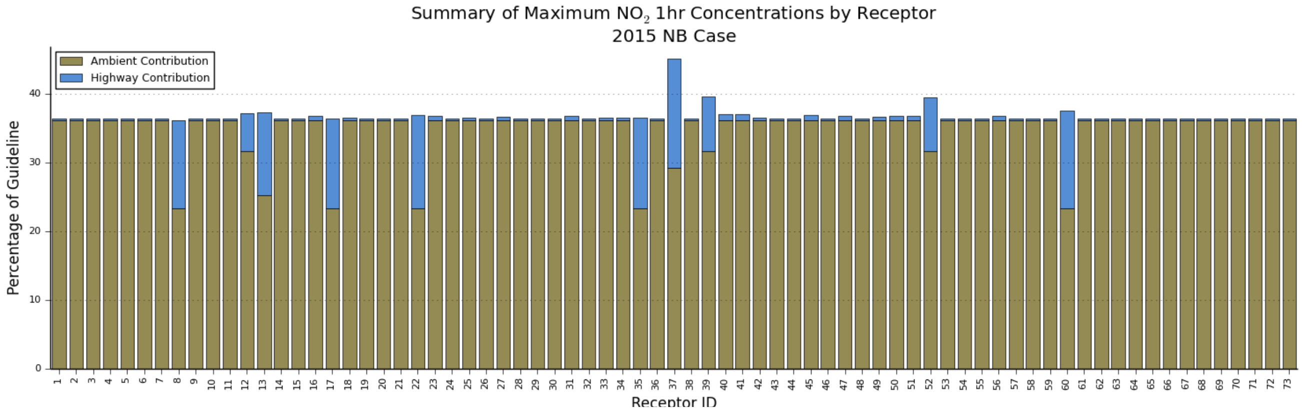
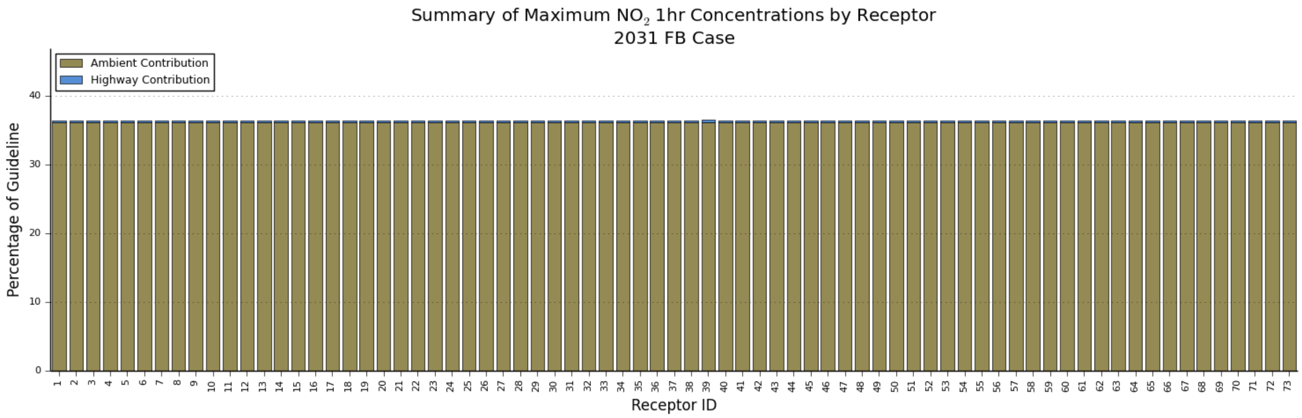
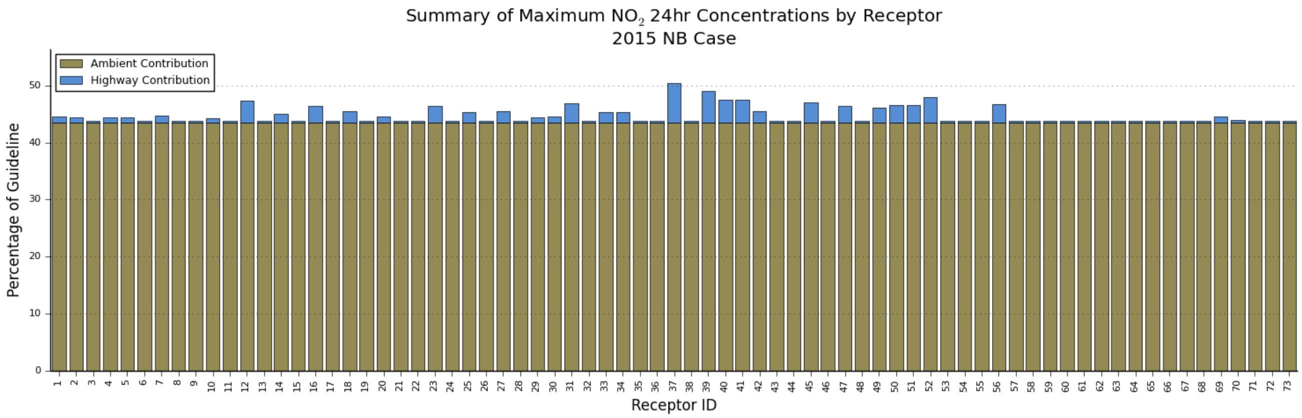


Figure A9: Receptors 63-72 within the Study Area


Summary of Maximum NO2 1hr Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum NO2 1hr Concentrations by Receptor
2031 FB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum NO2 24hr Concentrations by Receptor
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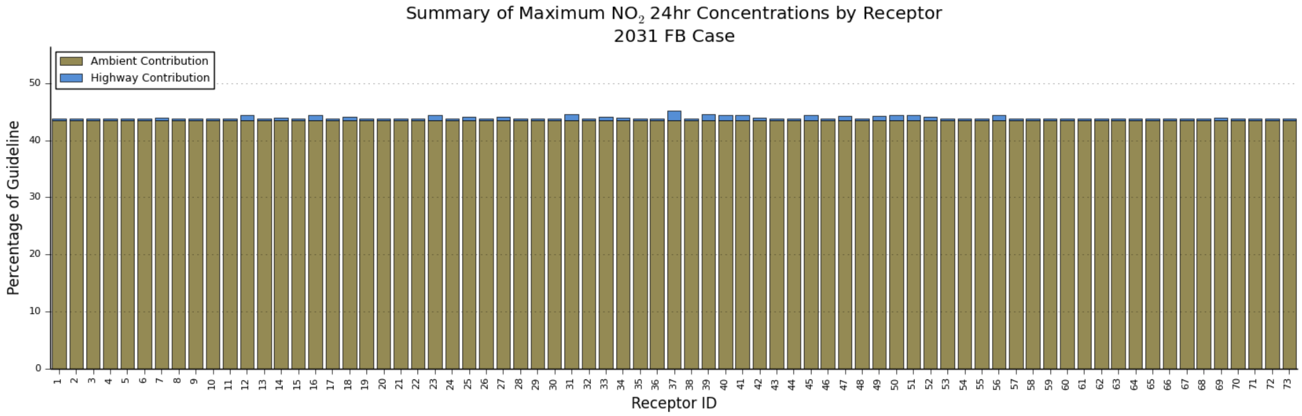
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID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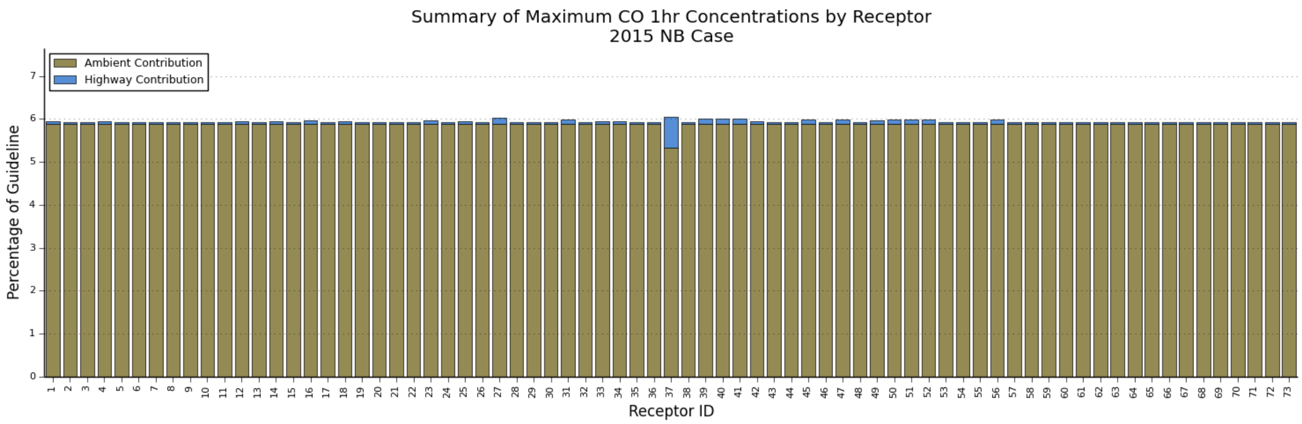
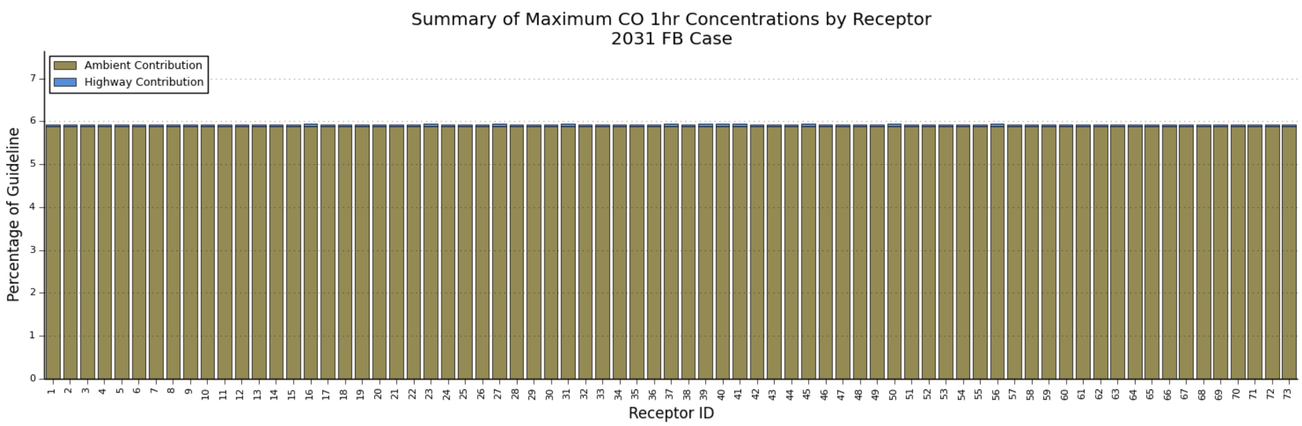
Highway Contribution
Percentage of Guideline
Receptor ID


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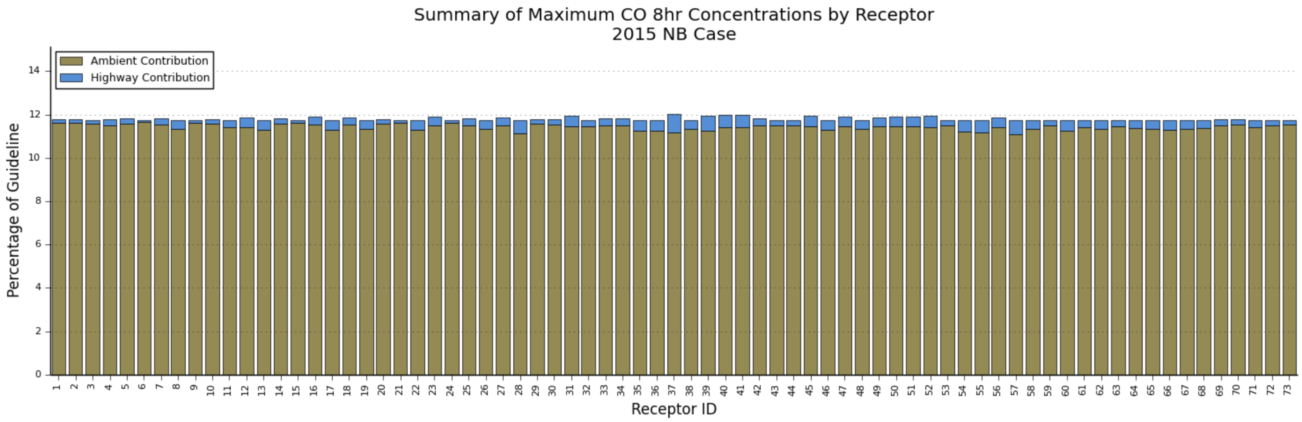
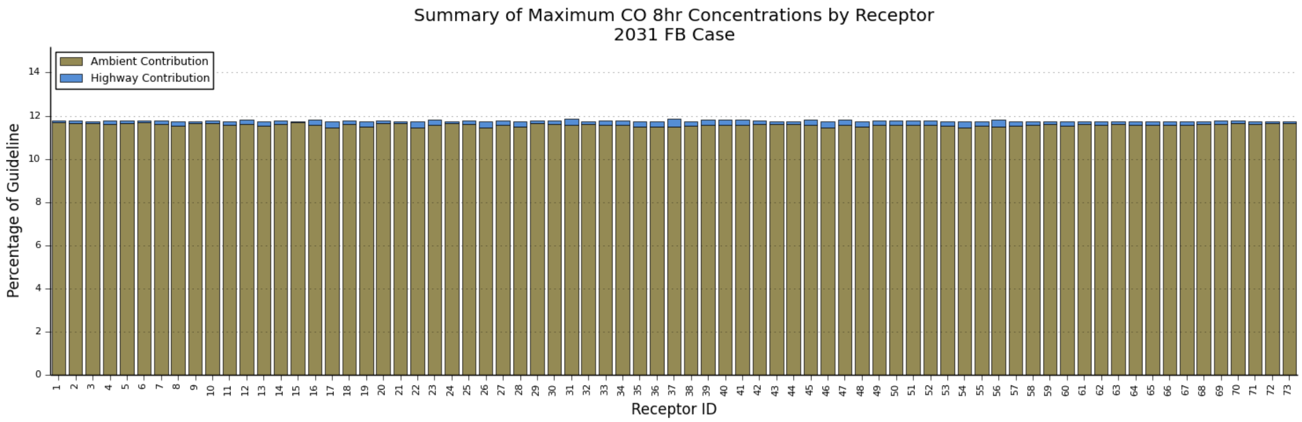
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum CO 8hr Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID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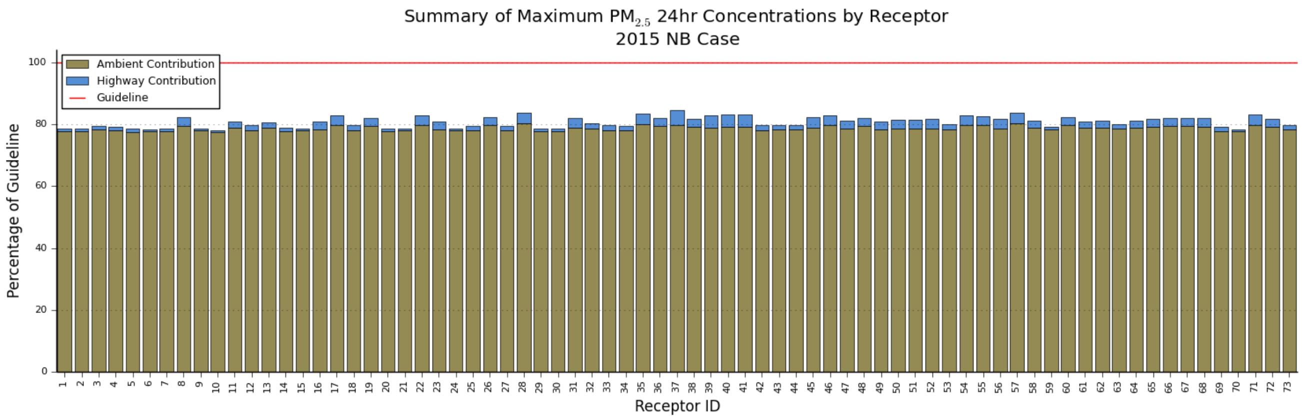
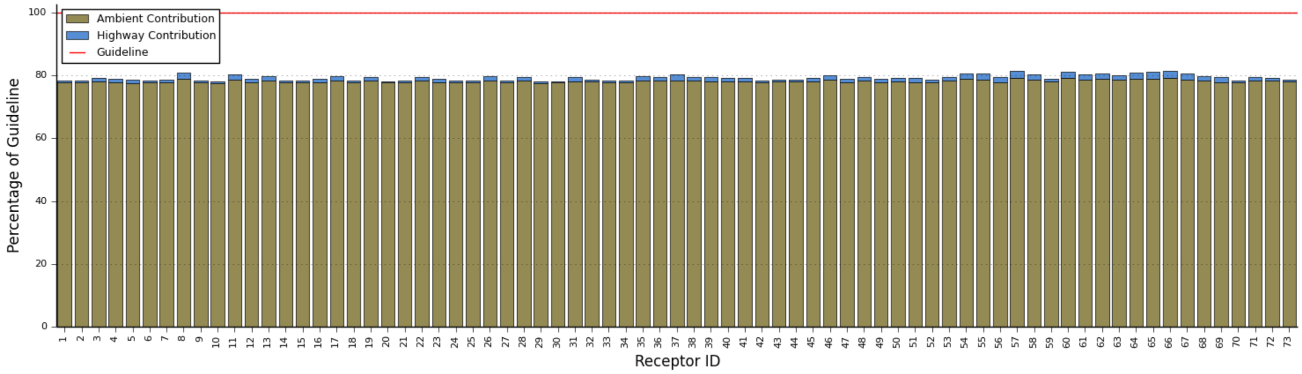
2031 FB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum $PM_{2.5}$ 24hr Concentrations by Receptor
2015 NB Case
Ambient Contribution
Highway Contribution
Guideline
Percentage of Guideline
Receptor ID

Summary of Maximum $PM_{2.5}$ 24hr Concentrations by Receptor
2031 FB Case



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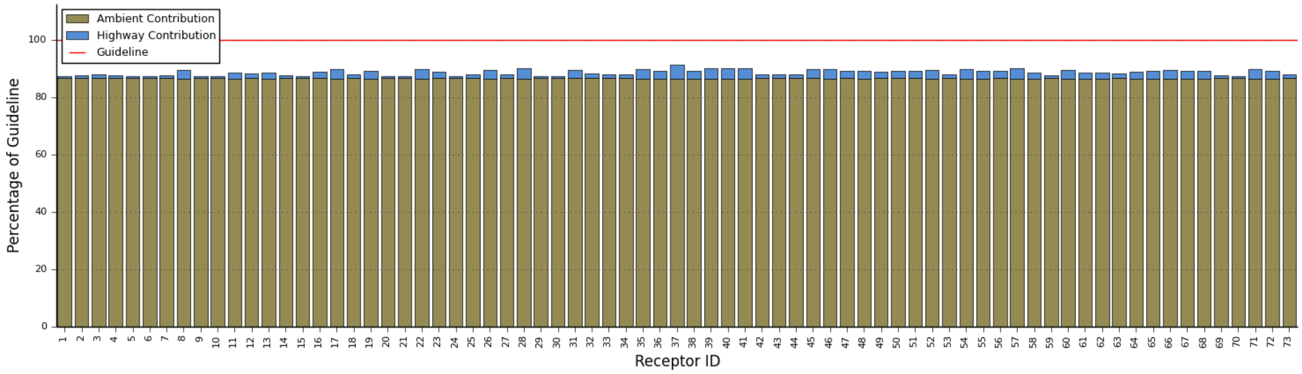

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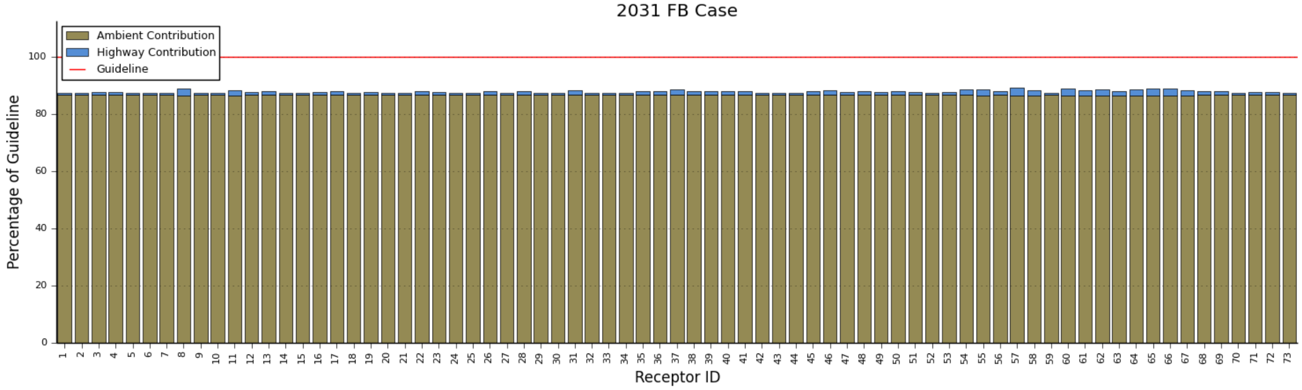

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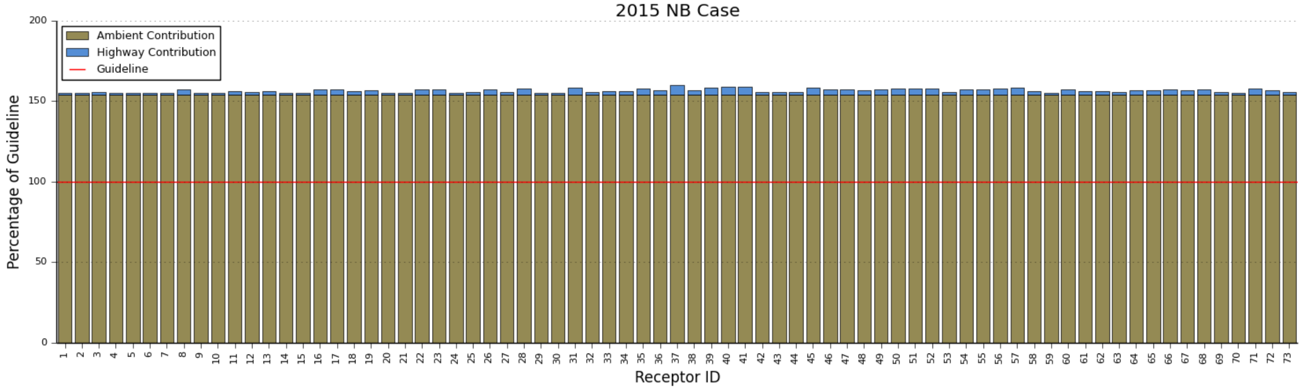

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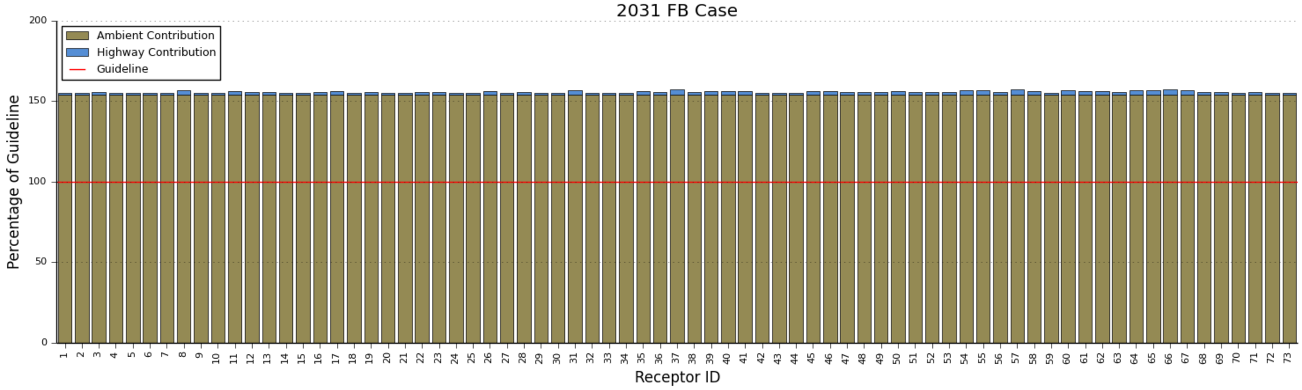

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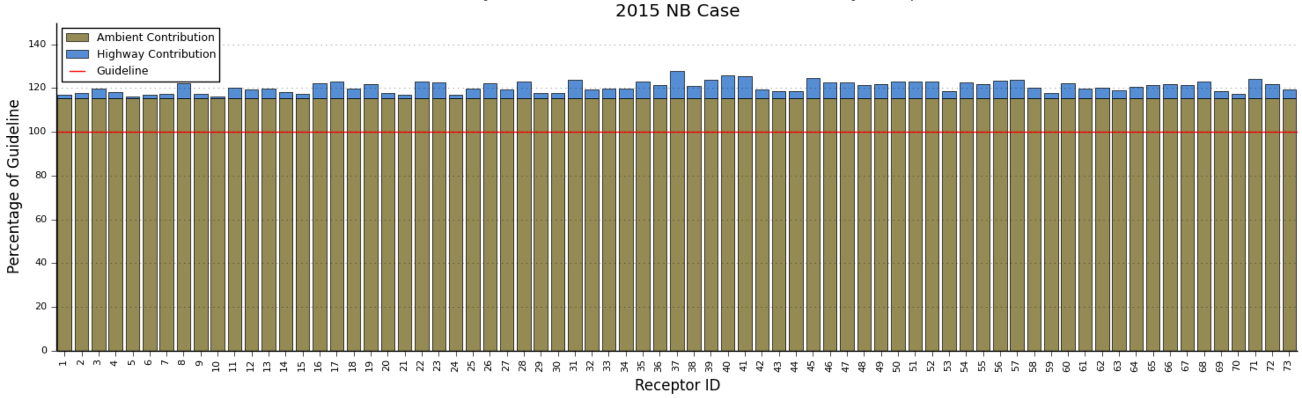

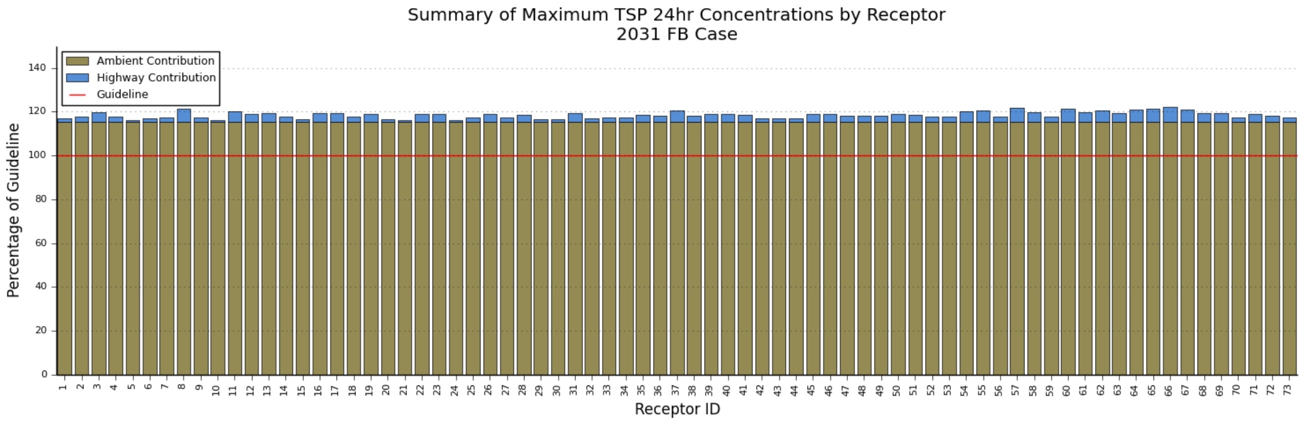
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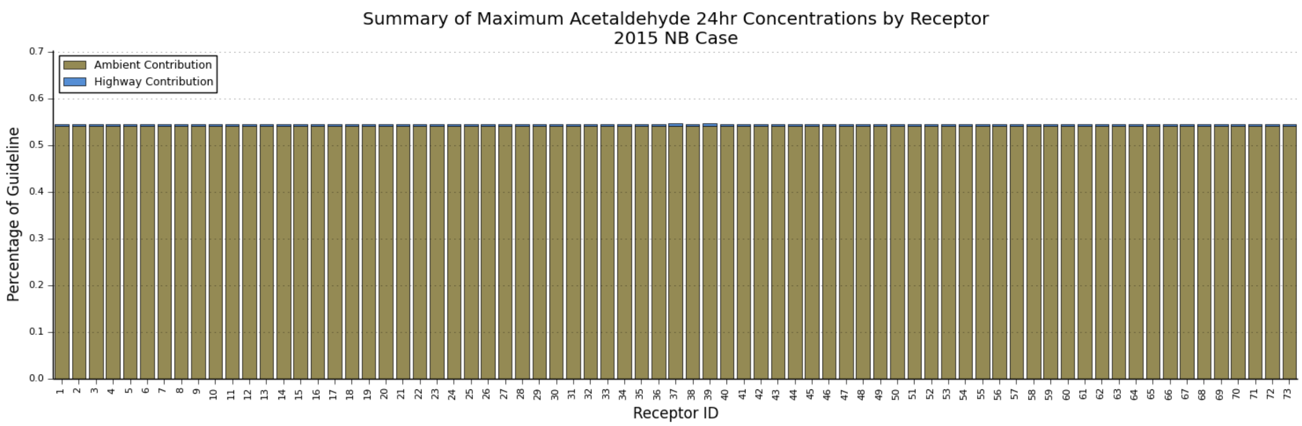
Highway Contribution
Guideline
Percentage of Guideline
Receptor ID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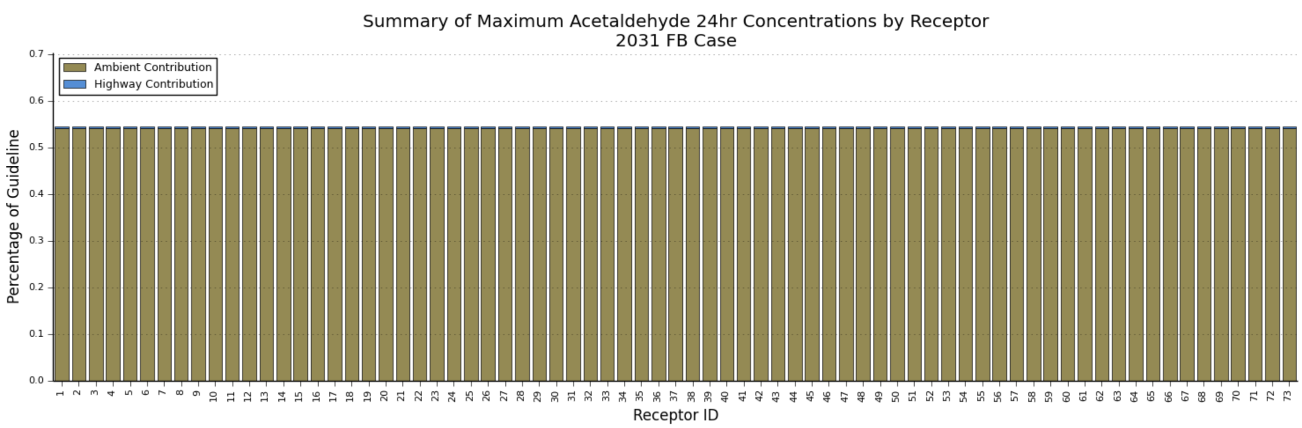
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID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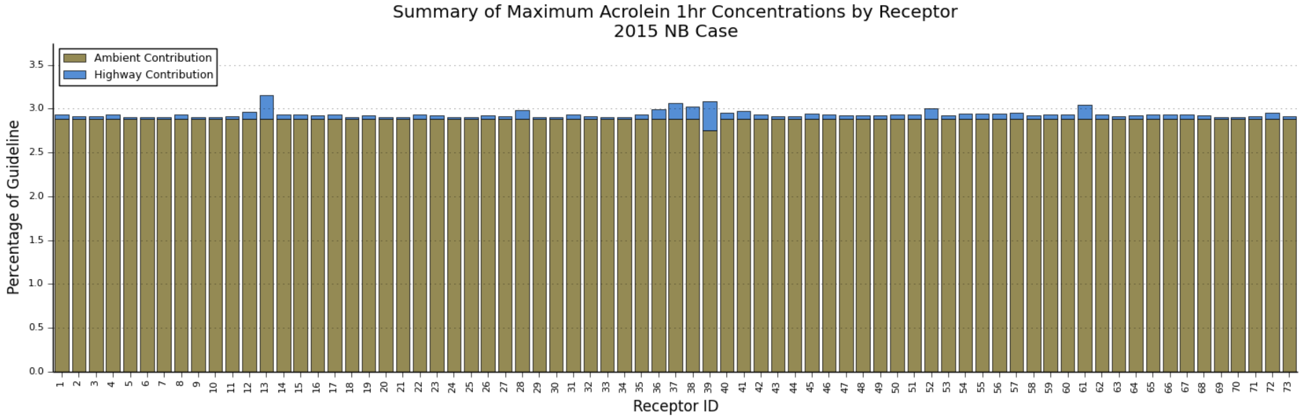
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID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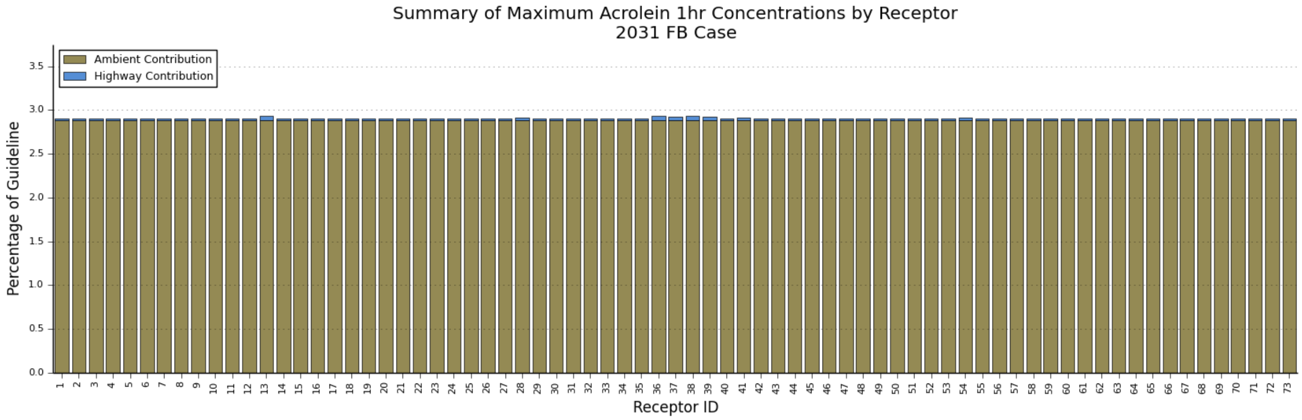
Highway Contribution
Percentage of Guideline
Receptor ID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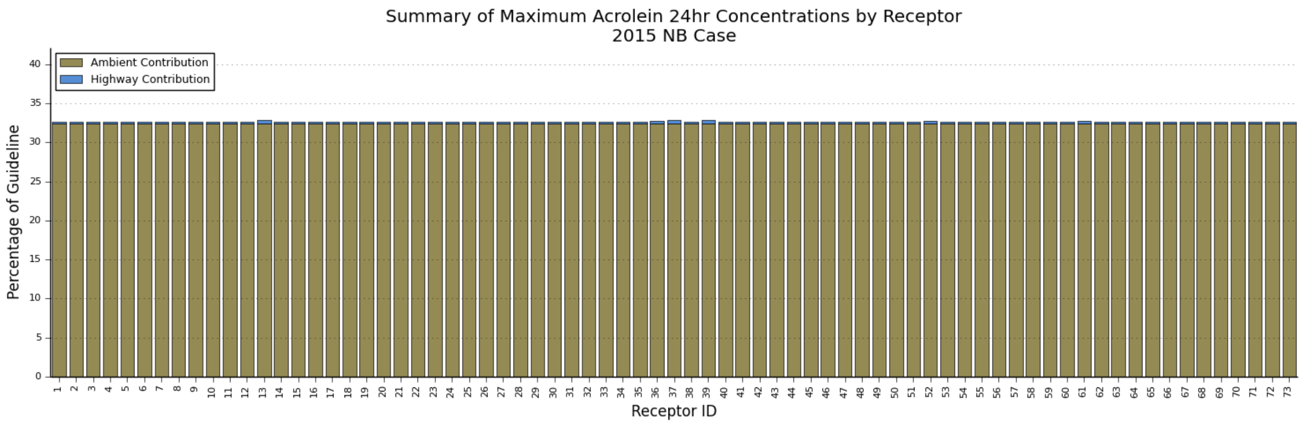
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID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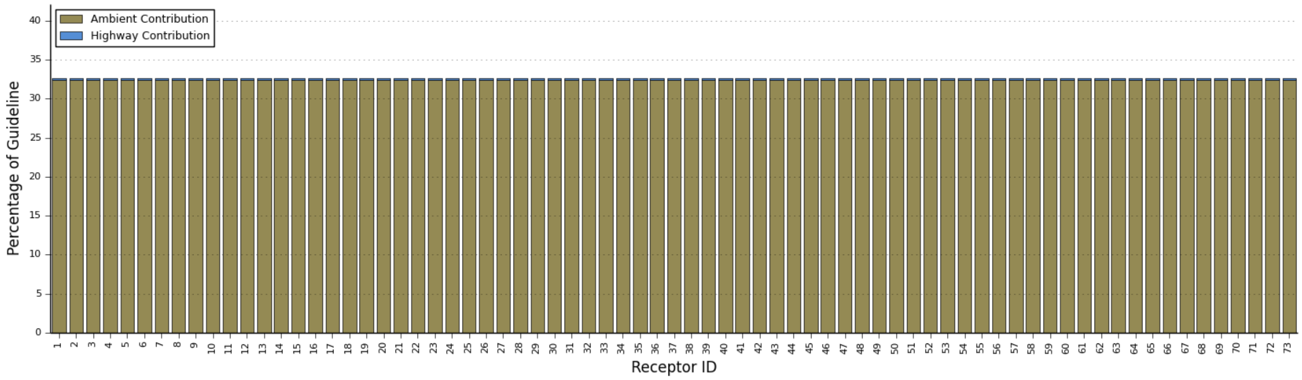
2015 NB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID

Summary of Maximum Acrolein 24hr Concentrations by Receptor
2031 FB Case



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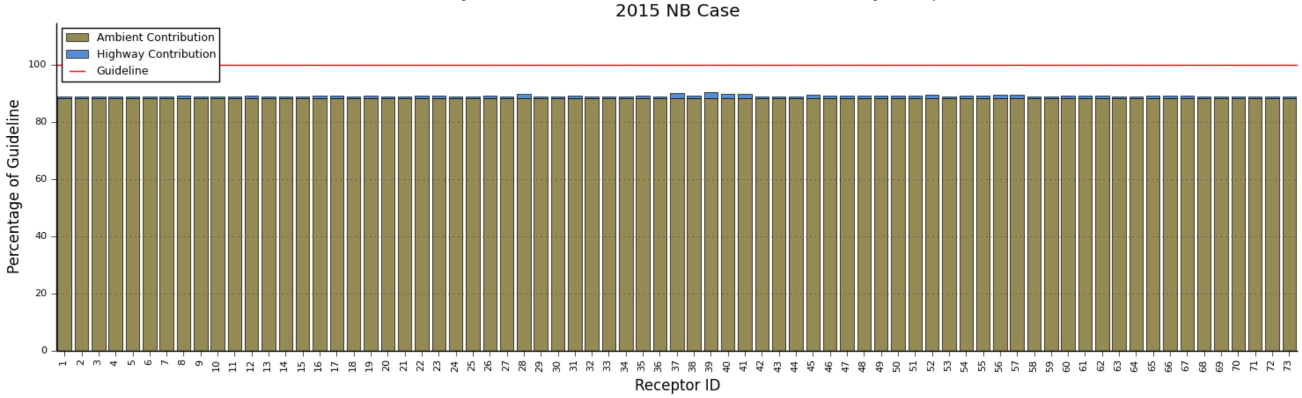

Summary of Maximum Benzene 24hr Concentrations by Receptor
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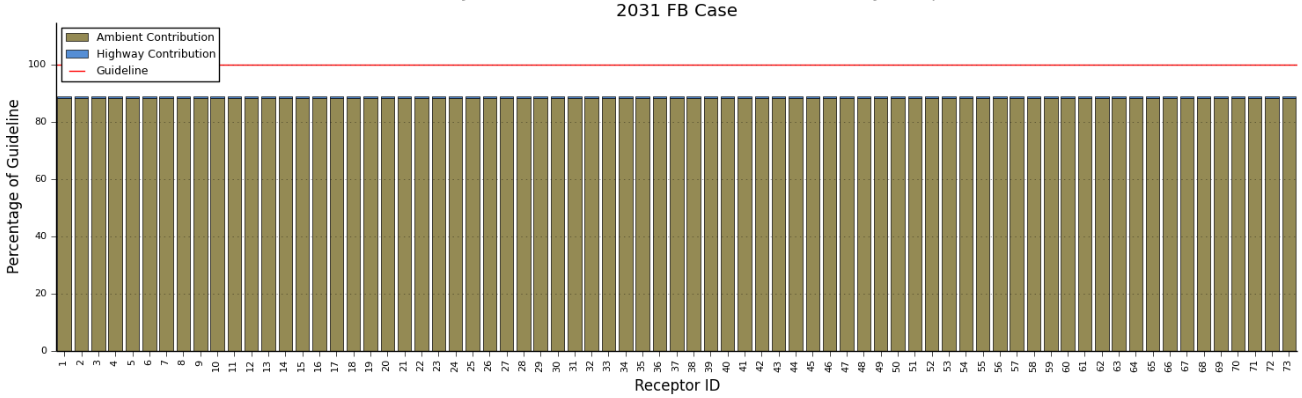

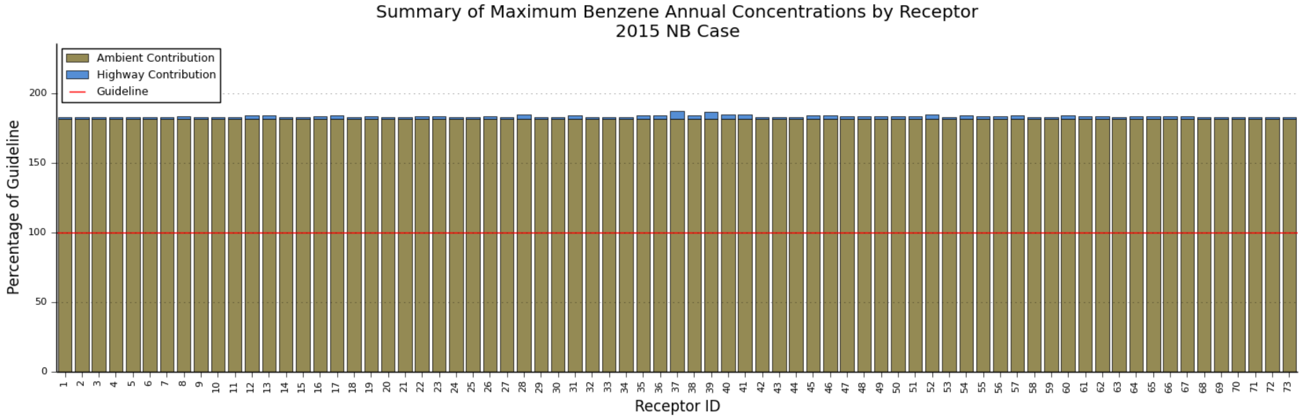
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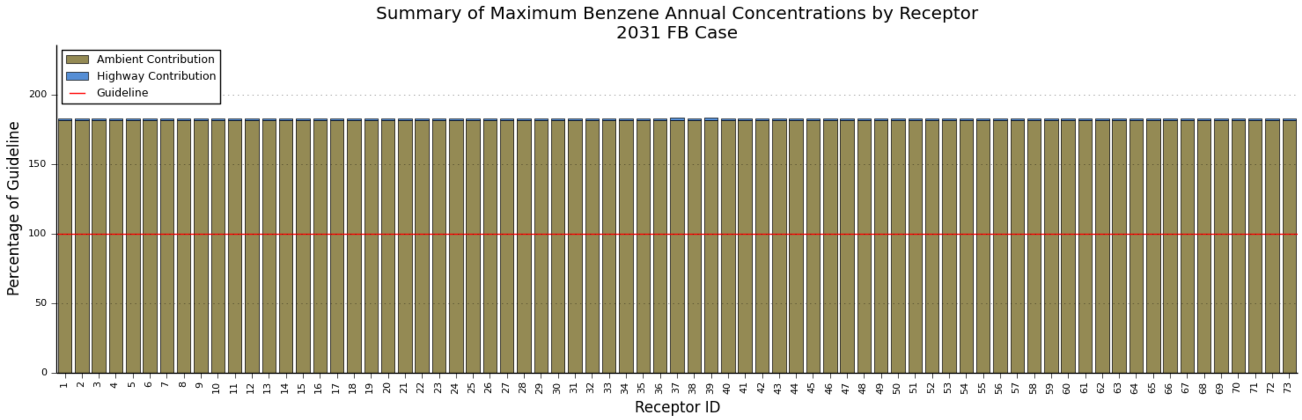
Guideline
Percentage of Guideline
Receptor ID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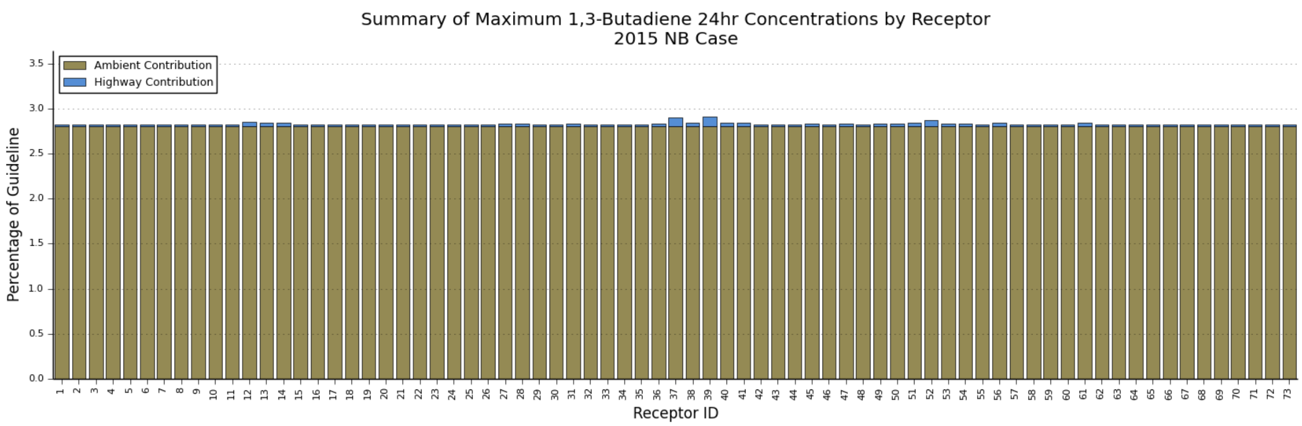
Guideline
Percentage of Guideline
Receptor ID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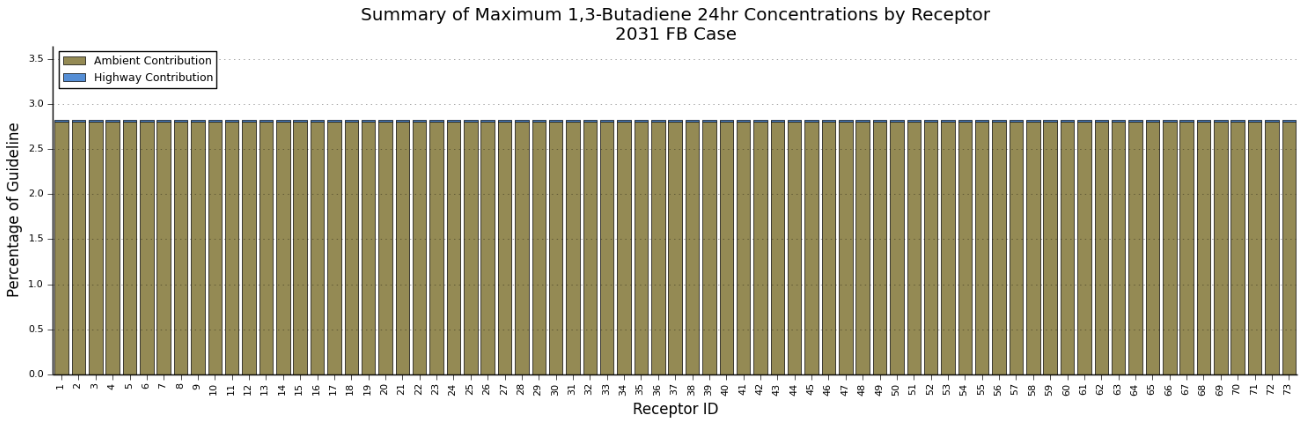
Highway Contribution
Percentage of Guideline
Receptor ID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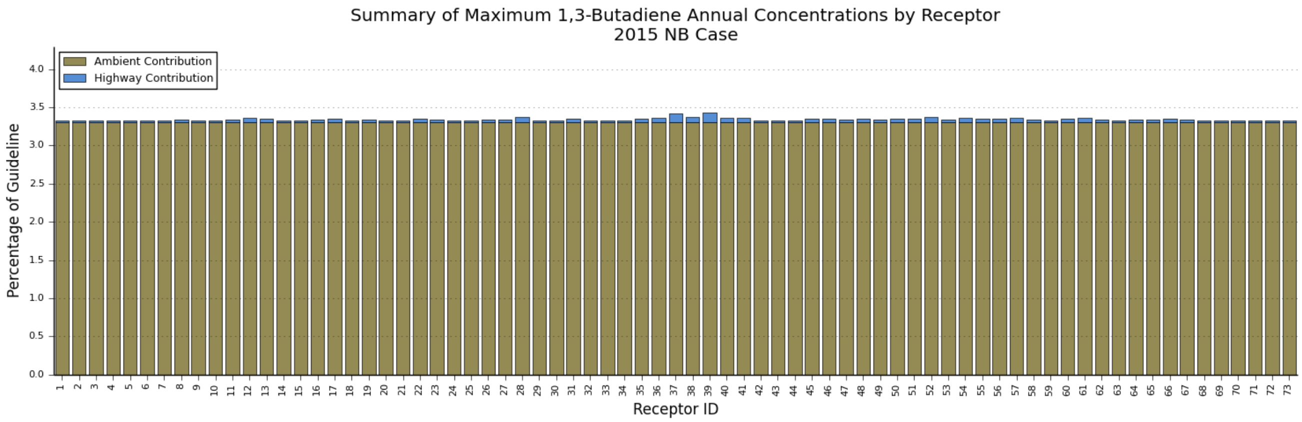
Highway Contribution
Percentage of Guideline
Receptor ID


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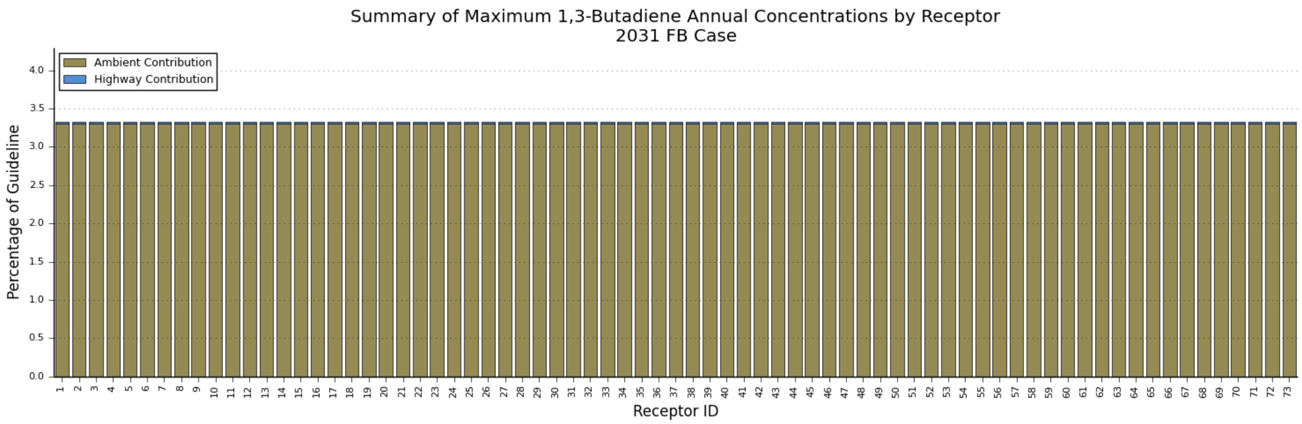
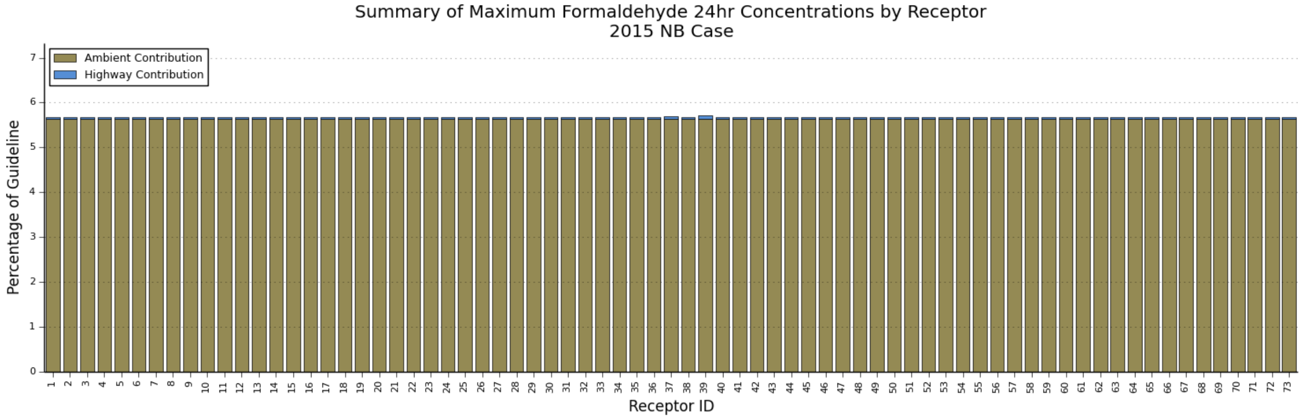
Highway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum 1,3-Butadiene Annual Concentrations by Receptor
2031 FB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID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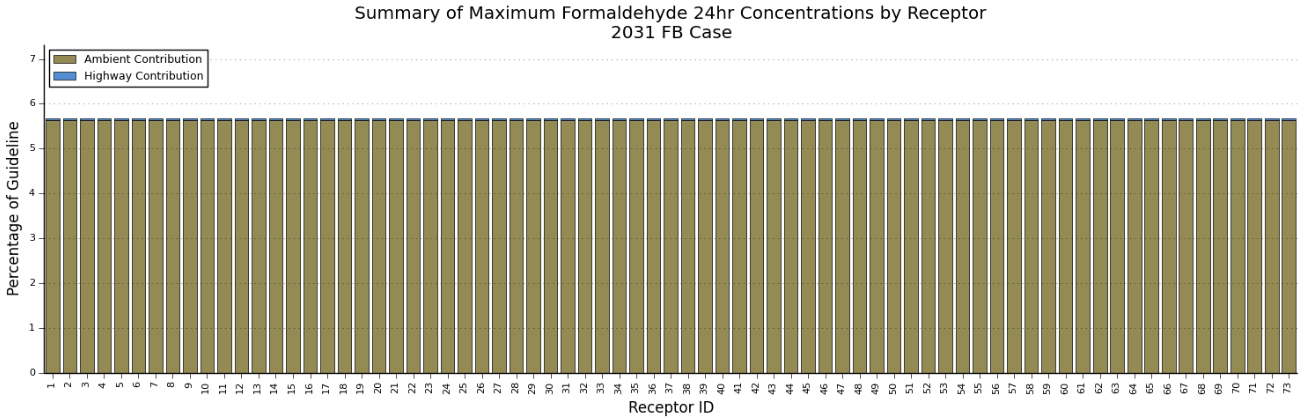
2015 NB Case
Ambient Contribution
Highway Contribution
Percentage of Guideline
Receptor ID


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