Appendix K
Air Quality Assessment

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Local Air Quality Assessment
Winston Churchill Boulevard – Class EA
From Highway 401 to Embleton Road
Regional Municipality of Peel, Ontario

Novus Reference No. 14-0016 Version No. 2 April 17, 2023

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1.0 Introduction

Novus Environmental Inc. (Novus) was retained by Hatch Infrastructure (Hatch) to conduct an air quality assessment for the widening of Winston Churchill Boulevard to six lanes between Highway 401 and Embleton Road, in the Regional Municipality of Peel. This report assesses the impacts of the roadway widening at nearby sensitive receptors. The study area is approximately 4.5 km in length and is shown in **Figure 1**.

Figure 1: Study Area Showing the Proposed Roadway Widening in Orange

1.1 Study Objectives

The objective of the study is to assess the local air quality impacts due to the widening of Winston Churchill Boulevard to six lanes between Highway 401 and Embleton Road. The study also includes an assessment of total greenhouse (GHG) emissions due to the project. These objectives are considered as follows:

- **2014 Existing** – Assess the existing conditions at representative receptors. Predicted contaminant concentrations from the existing roadway alignment were combined with hourly measured ambient concentrations to determine the combined impact.

- **2031 Future Build** – Assess the future conditions for the proposed roadway alignment. Predicted contaminant concentrations from the proposed roadway alignment 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 are provided in **Table 1**.

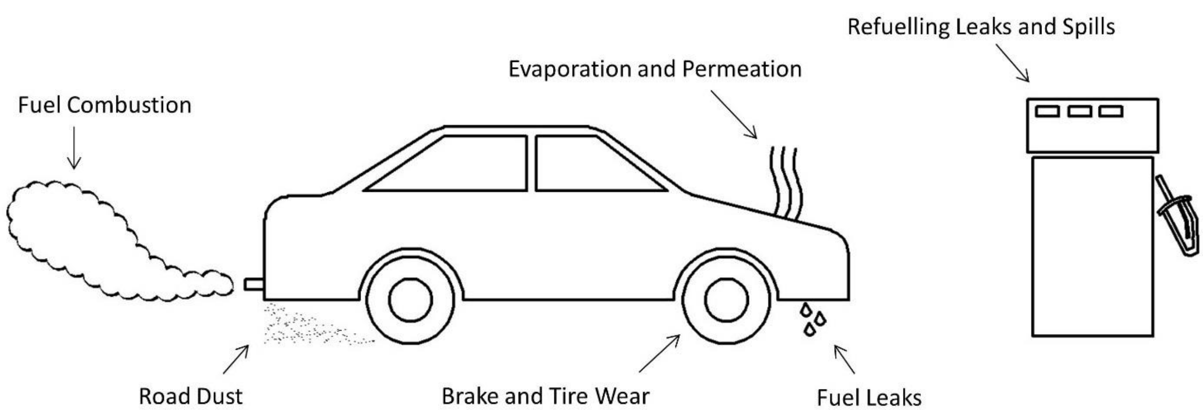


Figure 2: Motor Vehicle Emission Sources

Table 1: Contaminants of Interest

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

1.3 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 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 were used to assess the maximum predicted impact at sensitive receptors derived from computer simulations. The contaminants of interest are compared against 1-, 8-, and 24-hour averaging periods. The threshold values and averaging periods used in this assessment are presented in **Table 2** below. It should be noted that the CWS 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 (µg/m³)	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 µg/m³ 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	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 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

1.4 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: 2014 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) datasets for the most representative locations; typically the 'representative locations' are 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 2014 Existing and 2031 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 southwest U.S. border. 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

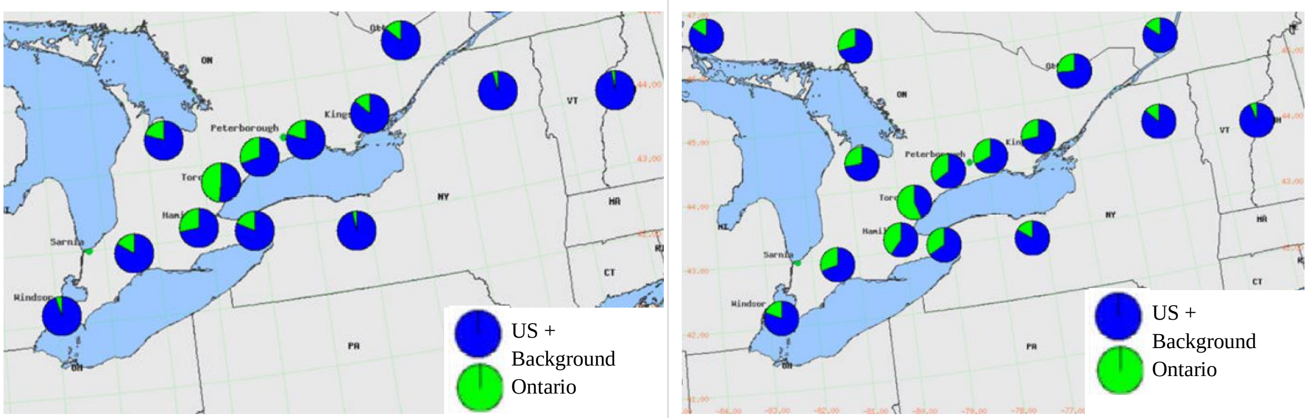


Figure 3: Effect of Trans-Boundary Air Pollution (MOECC, 2005)

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 blowing from the south 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.

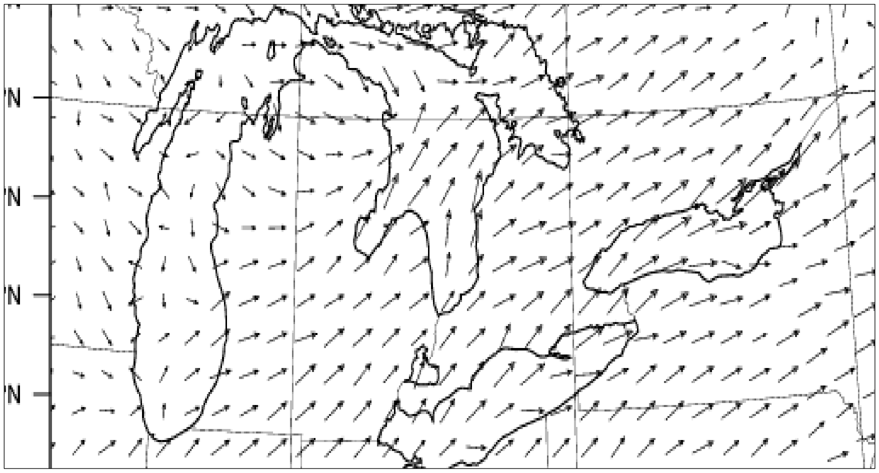


Figure 4: Typical Wind Direction during a Smog Episode

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 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. Four MOECC (Brampton, Mississauga, Oakville and Toronto West) and five NAPS (Brampton, Etobicoke North, Etobicoke South, Toronto Downtown and Windsor) stations were determined to be representative. Note that Windsor is the only station in Ontario at which background Acrolein, Formaldehyde, and Acetaldehyde are measured in recent years. Only these pollutants were considered from the Windsor station; the remaining pollutants 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**.

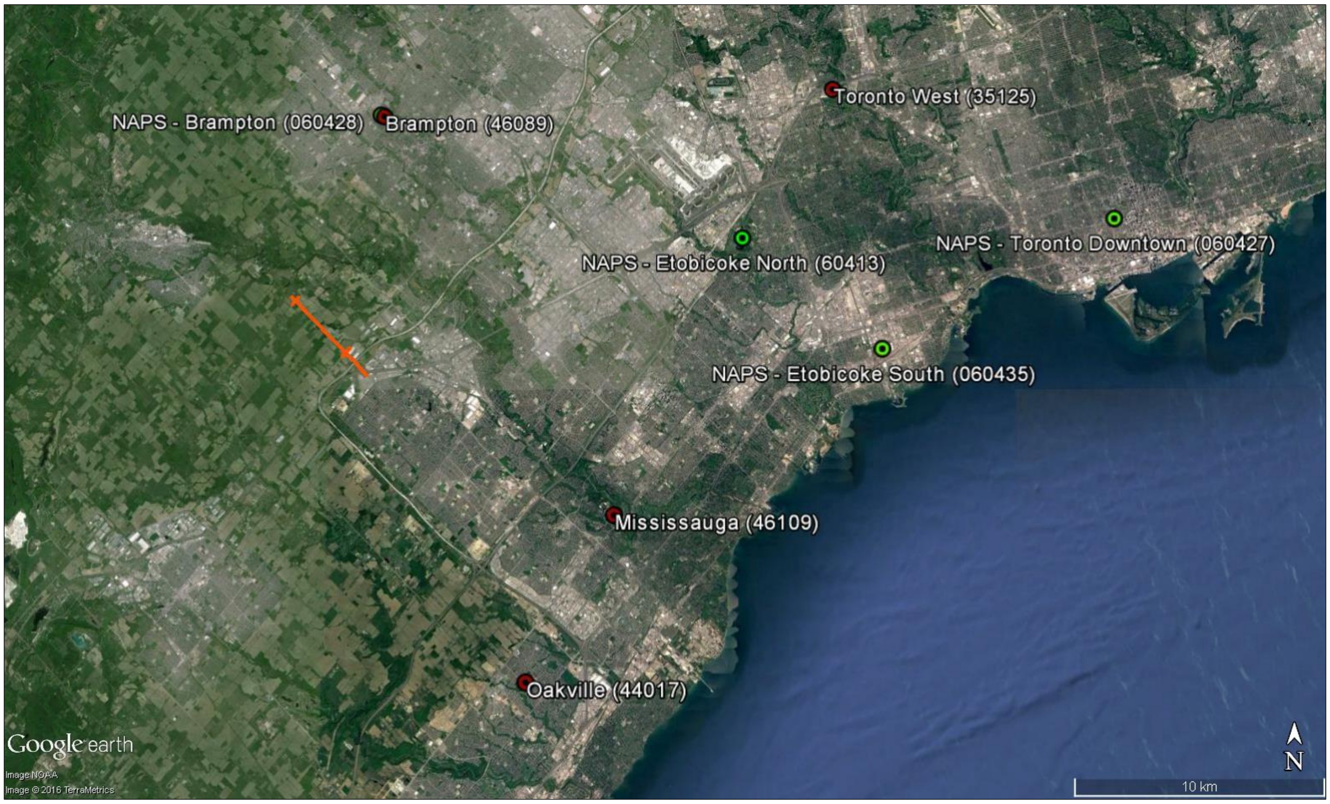


Figure 5: Relevant MOECC (shown in red) and NAPS (shown in green) Monitoring Stations; Windsor NAPS Station Not Shown; Study Area in Orange

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	Frank Mckenchnie Comm. Ctr	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

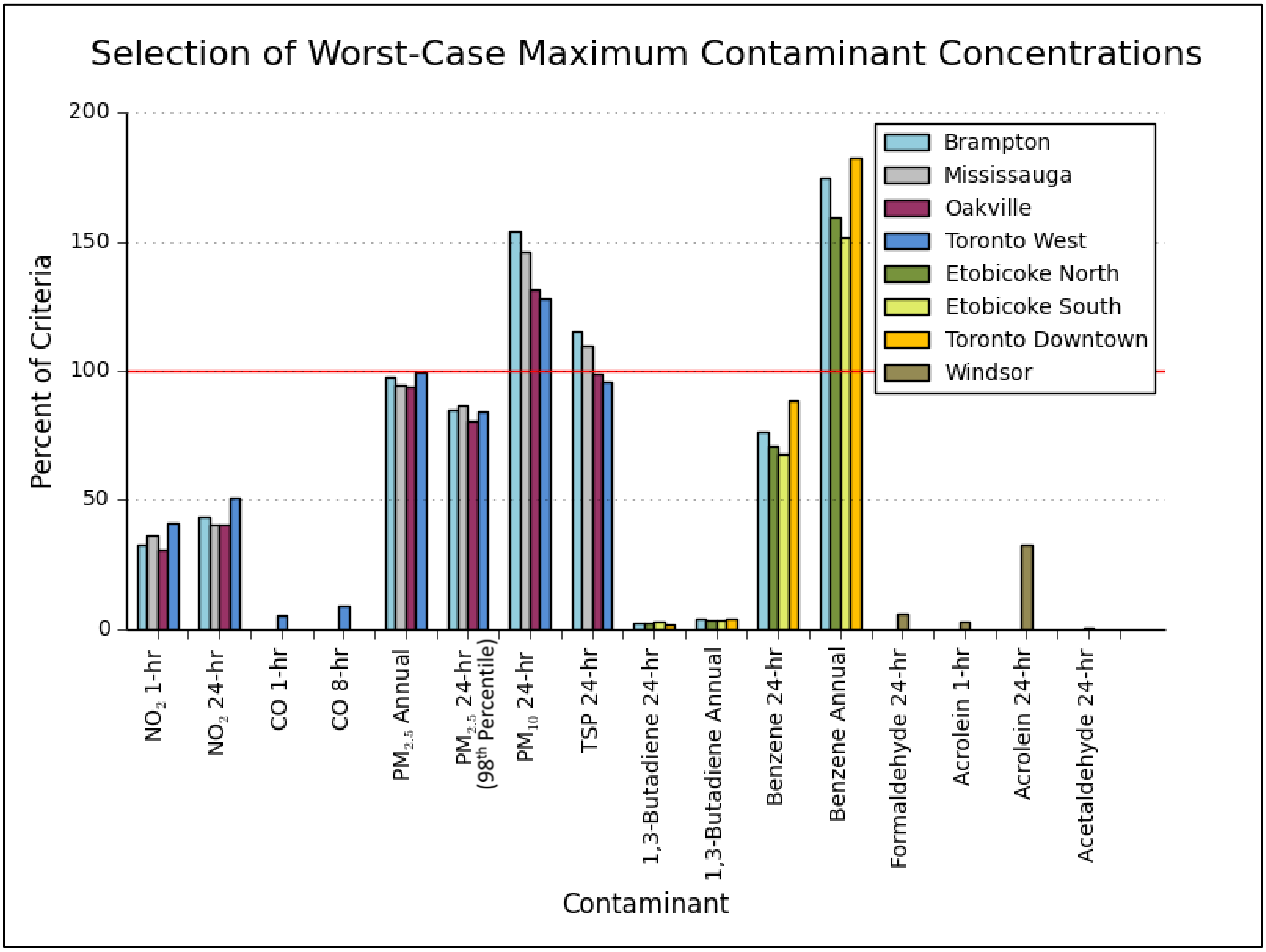
Since there are several monitoring stations which could be used to represent the study area, a comparison was performed for the available data on a contaminant basis, to determine the worst-case representative background concentration (see **Section 2.3**). Selecting the worst-case ambient data will 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 publically 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 (i.e. 2011-2014 for benzene and butadiene and 2011-2013 for formaldehyde, acetaldehyde and acrolein). For benzene and butadiene, 2010 measured data was used to represent 2015 for the combined analysis, and for formaldehyde, acetaldehyde, and acrolein, 2009 was used to represent 2014 and 2010 was used to represent 2015.

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)	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		

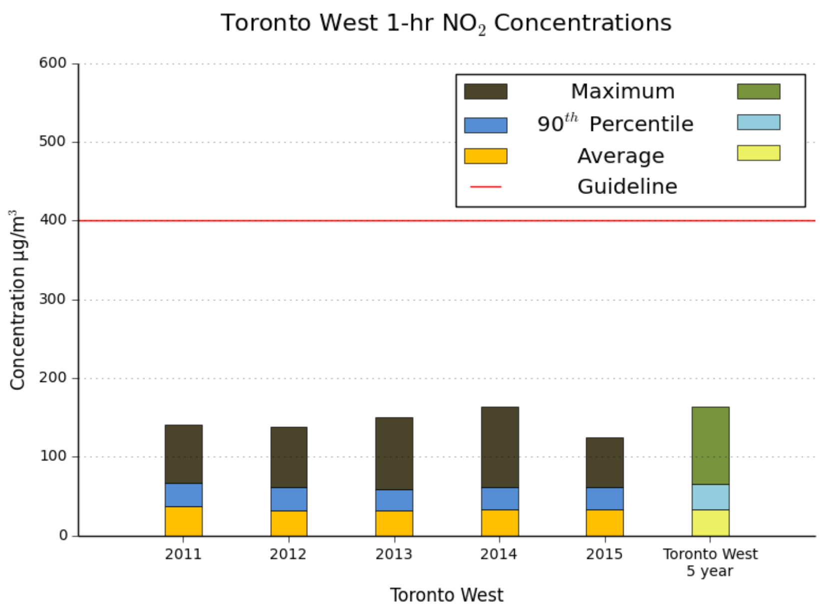
2.4 Detailed Analysis of Selected Worst-case Monitoring Stations

A detailed statistical analysis of the selected worst-case background monitoring station for each of the contaminants 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.

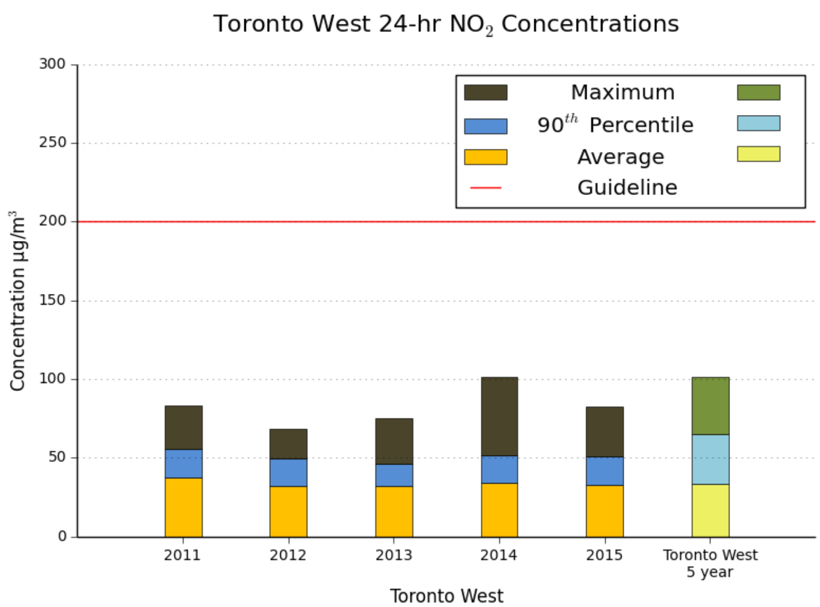
Table 5: Summary of Background NO_2

Statistical Analysis | **Five-Year Summary**



Statistic	% of Guideline
Maximum	41%
90th Percentile	15%
Average	8%

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

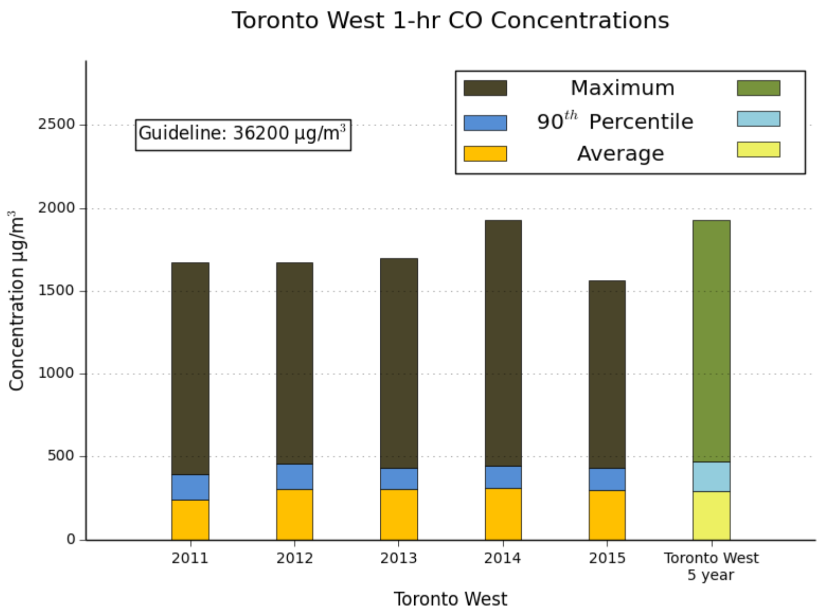


Statistic	% of Guideline
Maximum	51%
90th Percentile	26%
Average	17%

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

Table 6: Summary of Background CO

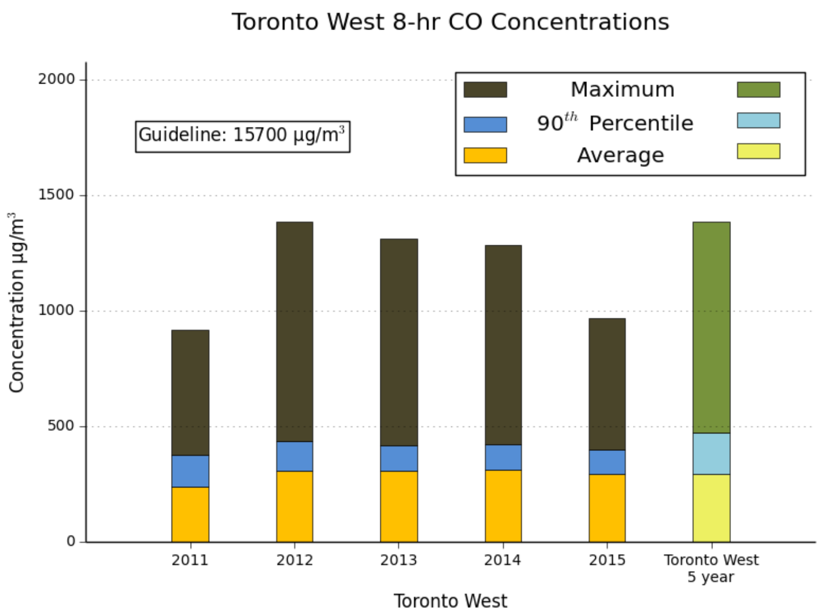
Statistical Analysis	Five-Year Summary



Statistic	% of Guideline
Maximum	5%
90th Percentile	1%
Average	1%

Conclusion:

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



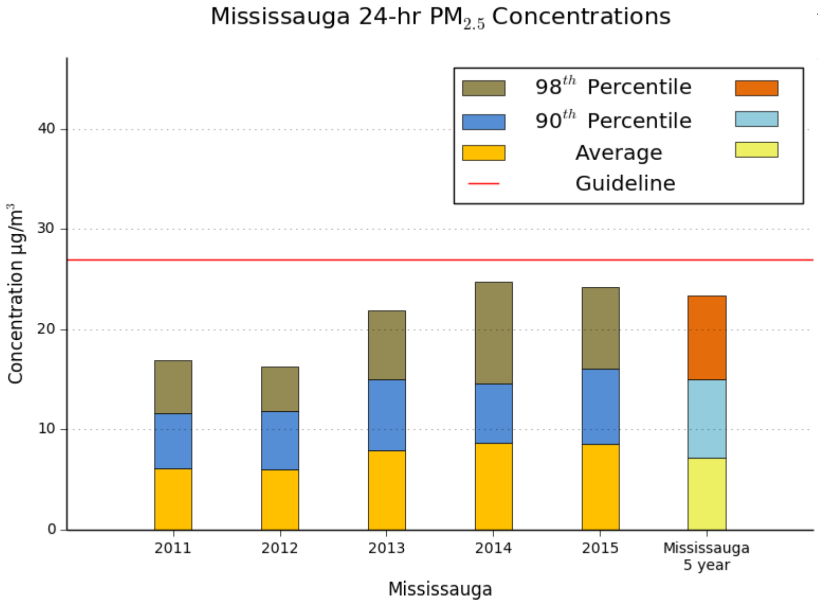
Statistic	% of Guideline
Maximum	9%
90th Percentile	3%
Average	2%

Conclusion:

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

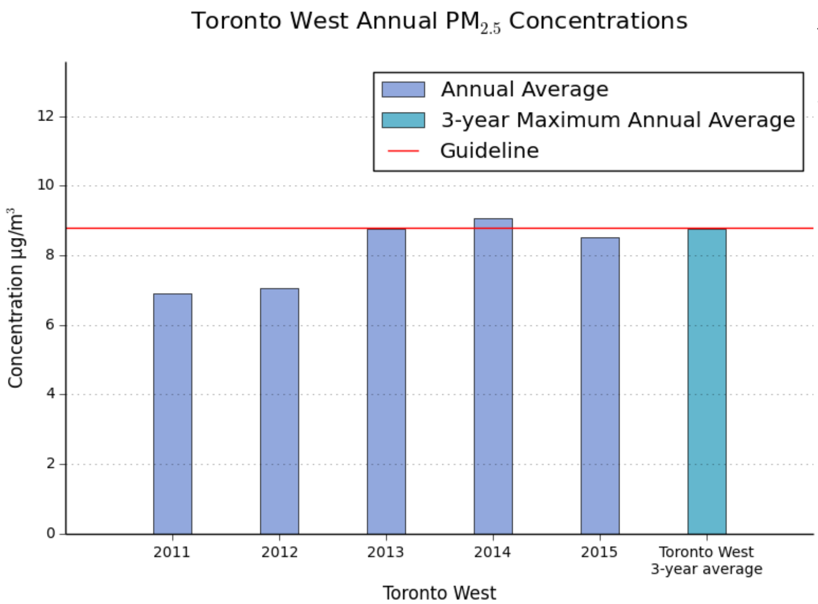
Table 7: Summary of Background $PM_{2.5}$

Statistical Analysis	Five-Year Summary



Statistic	% of Guideline
98th Percentile	87%

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 23.36 µg/m³ from 2013 to 2015 is 87% of the guideline.

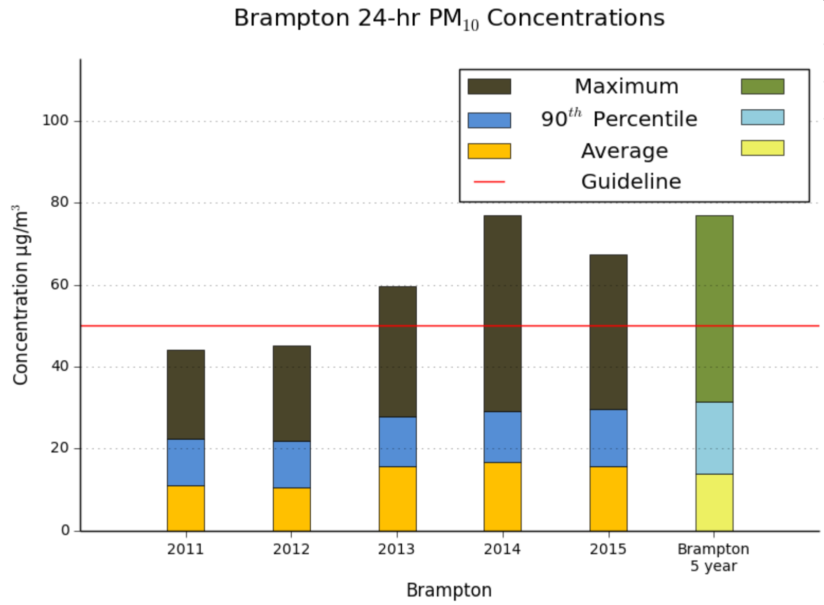


Statistic	% of Guideline
3-year Maximum Annual Average	100%

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 Toronto West Station indicated that the highest 3-year average of 8.8 µg/m³ from 2013 to 2015 is 100% of the guideline.

Table 8: Summary of Background PM_{10}

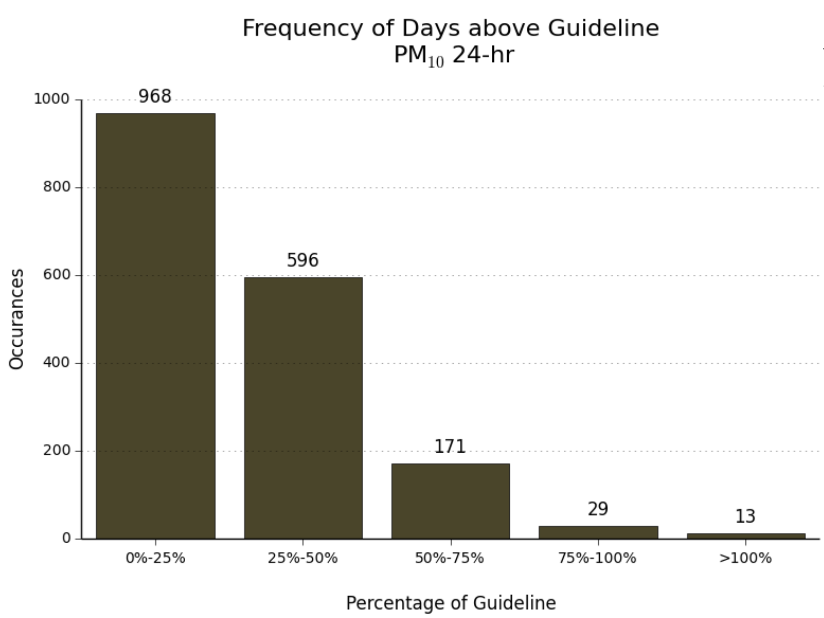
Statistical Analysis	Five-Year Summary



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)

Statistic	% of Guideline
Maximum	154%
90th Percentile	53%
Average	28%

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).

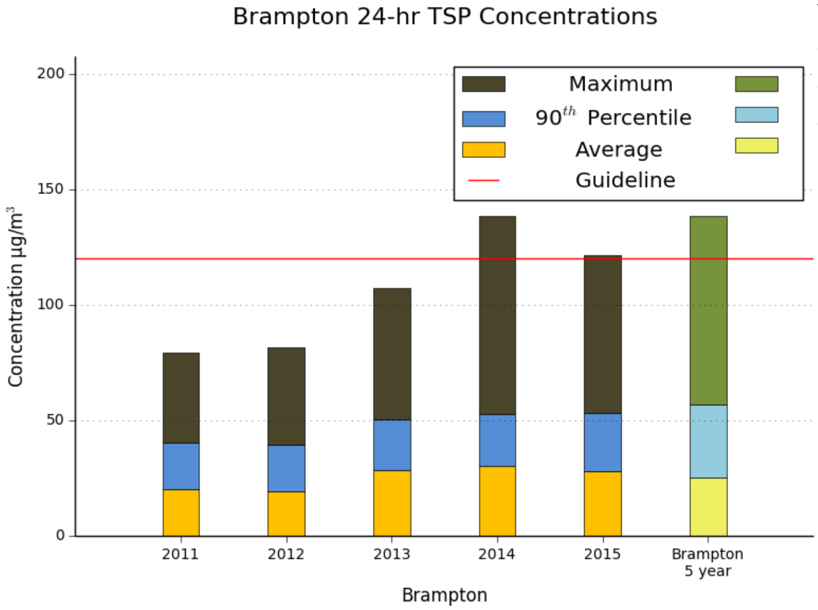


Number of Days Measured	Number of Days > Guideline
1777	13

Conclusion:
Frequency analysis determined that 24-hr concentrations exceeded the guideline on an infrequent basis. Measured concentrations exceeded the guideline 13 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

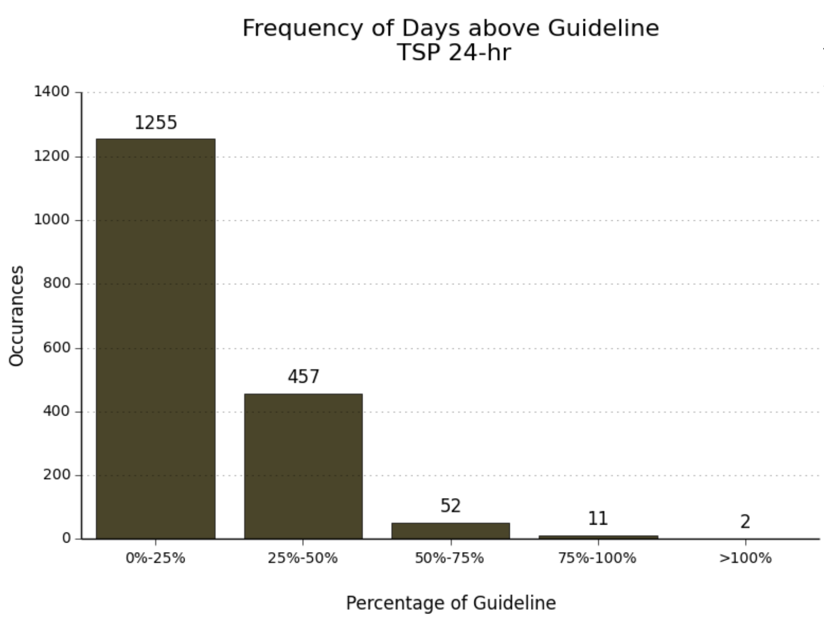


Five-Year Summary

Statistic	% of Guideline
Maximum	115%
90th Percentile	40%
Average	21%

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 $PM_{2.5}$/TSP ratio of 0.3. Lall et al. (2004)

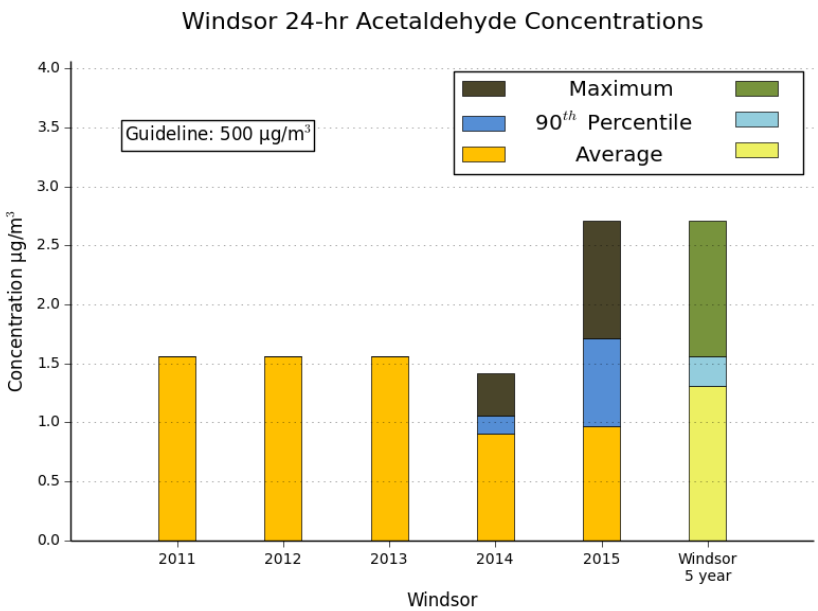


Number of Days Measured	Number of Days > Guideline
1777	2

Conclusion:
Frequency analysis determined that 24-hr concentrations exceeded the guideline on an infrequent basis. Measured concentrations exceeded the guideline 2 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 10: Summary of Background Acetaldehyde

Statistical Analysis



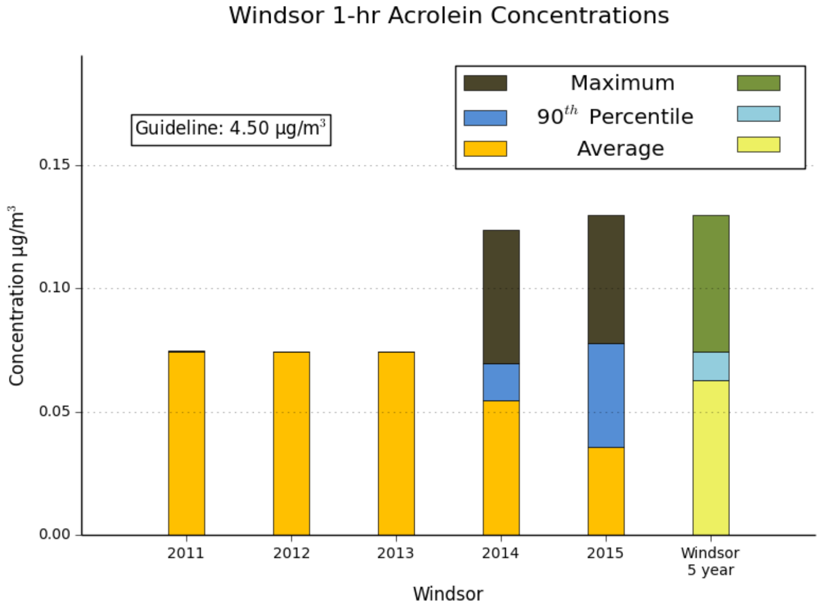
Five-Year Summary

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

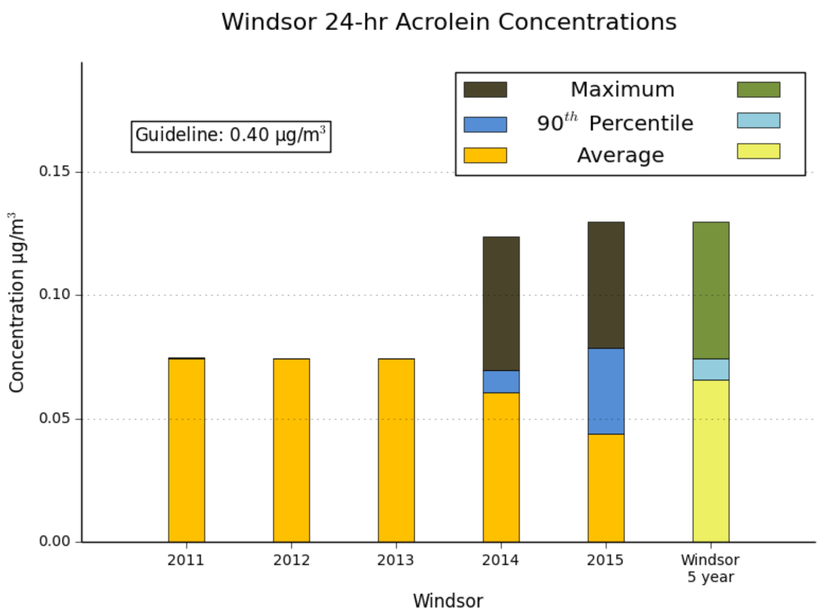
Statistical Analysis	Five-Year Summary



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 are well below the Guideline on a 1-hour basis.



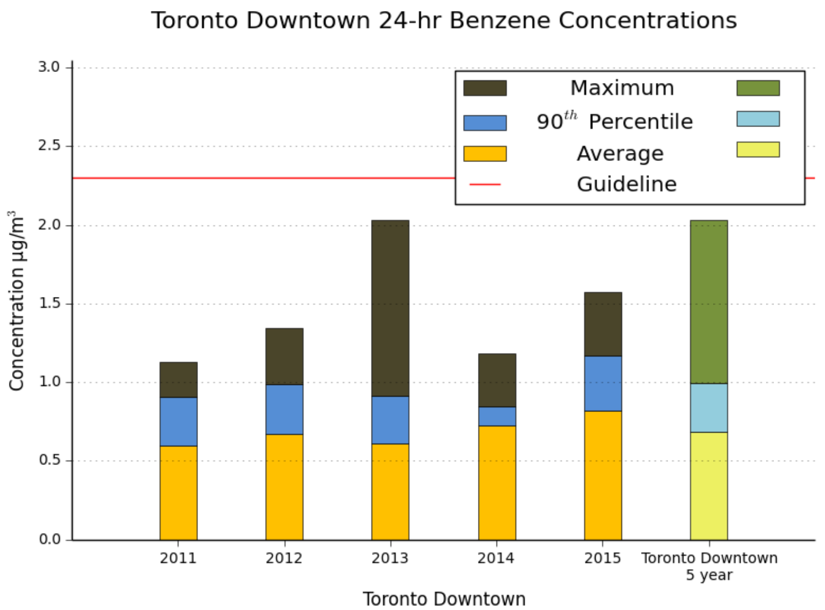
Statistic	% of Guideline
Maximum	32%
90th Percentile	19%
Average	16%

Conclusion:

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

Table 12: Summary of Background Benzene

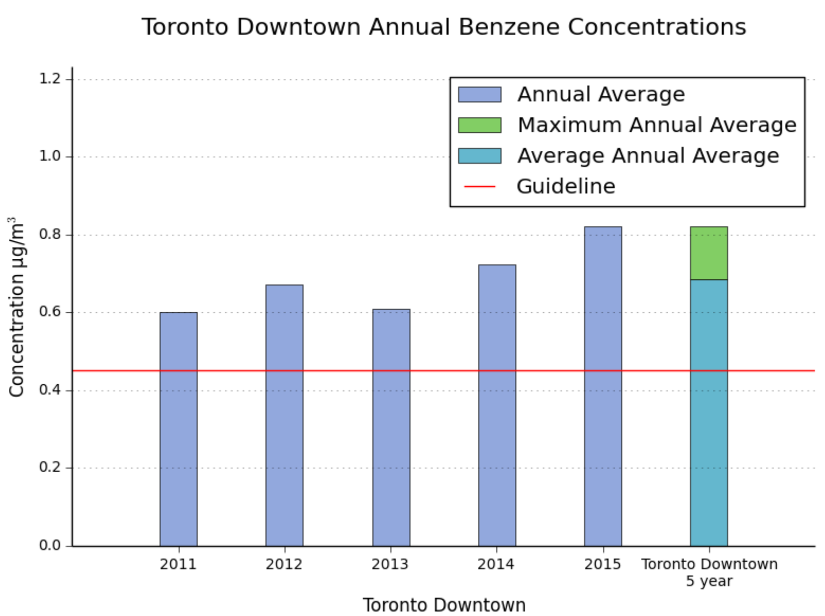
Statistical Analysis



Five-Year Summary

Statistic	% of Guideline
Maximum	88%
90th Percentile	43%
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.

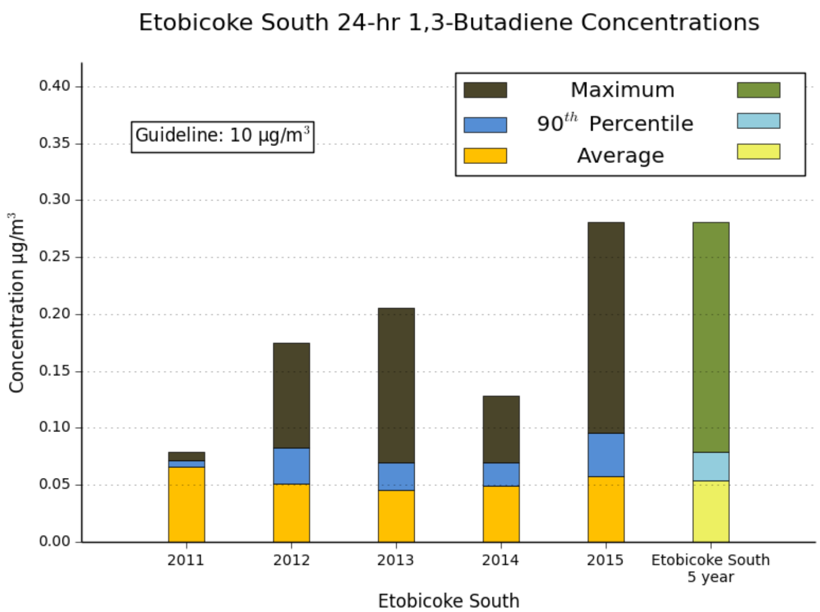


Statistic	% of Guideline
Maximum Annual Average	182%
Average Annual Average	152%

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 152% of the standard.

Table 13: Summary of Background 1,3-Butadiene

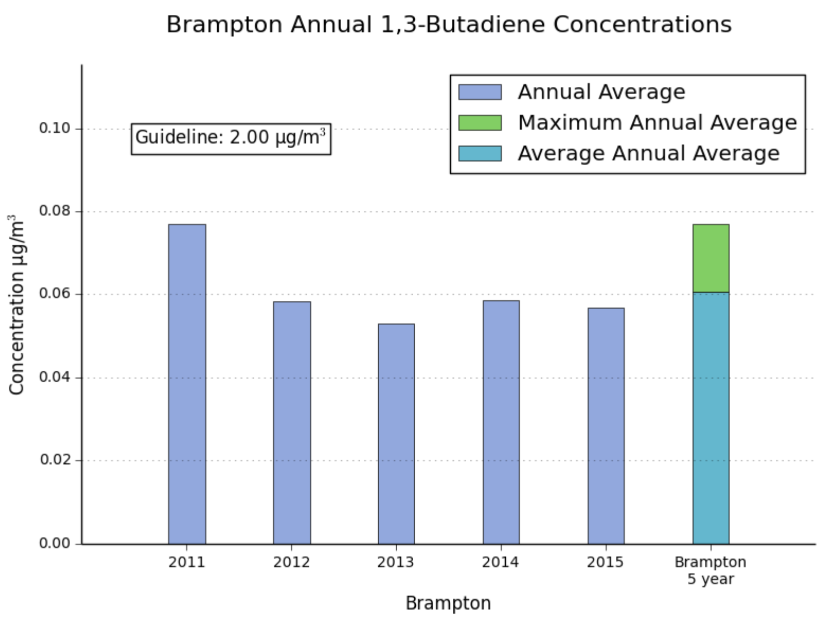
Statistical Analysis | **Five-Year Summary**



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.



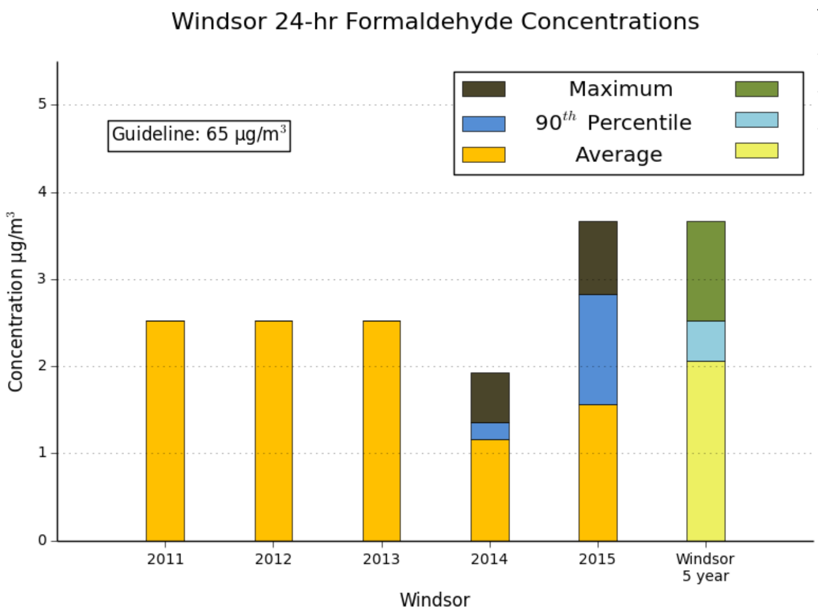
Statistic	% of Guideline
Maximum Annual Average	4%
Average Annual Average	3%

Conclusion:

A review of five years of ambient monitoring data from the Brampton Station indicated that background concentrations were 4% of the maximum 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 2011-2015, all contaminants were below their respective guidelines with the exception of PM_{10}, TSP, and annual 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**.

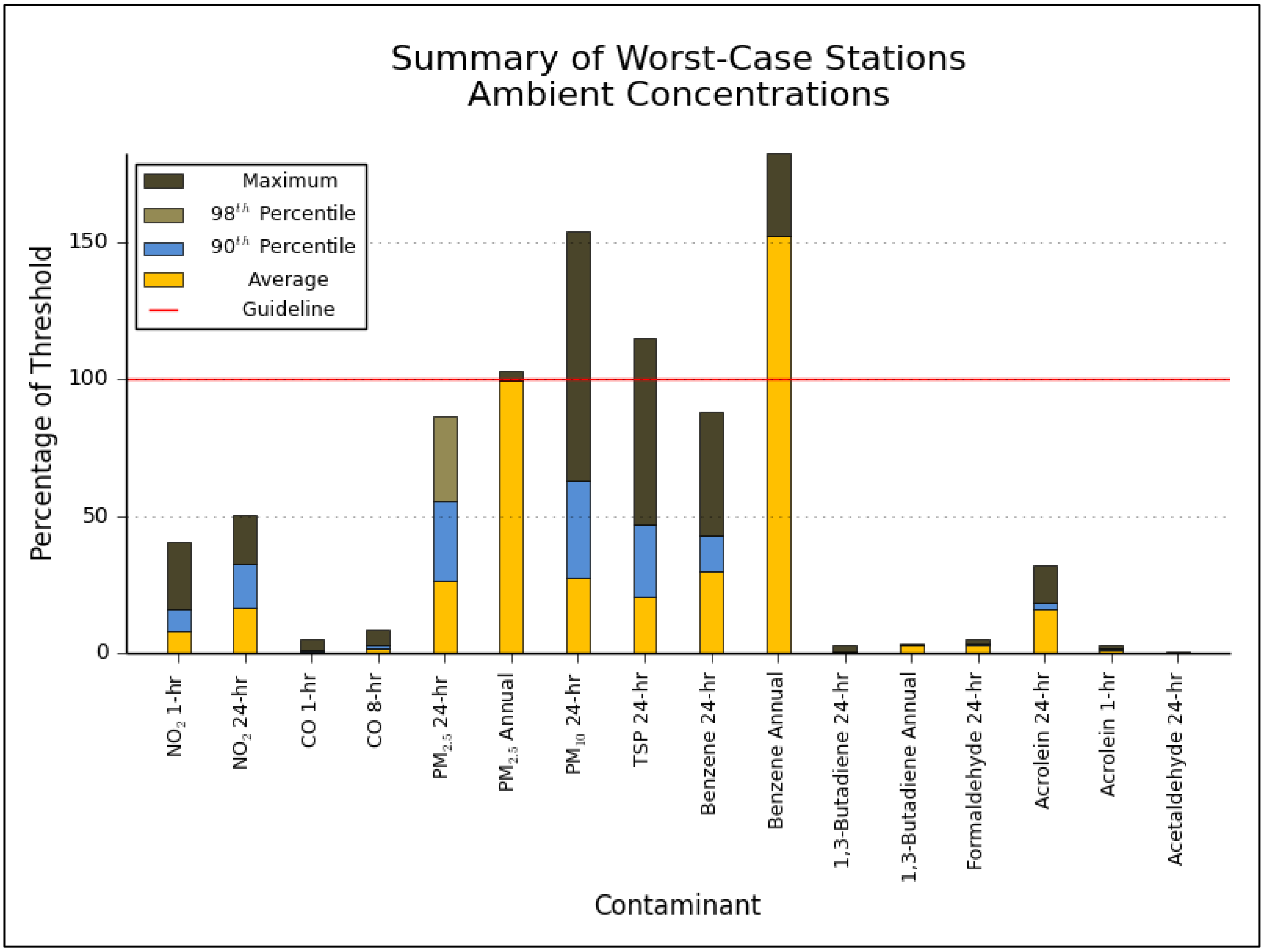


Figure 6: Summary of Background Conditions

3.0 Local Air Quality Assessment

3.1 Overview

The worst-case impacts due to roadway vehicle emissions were assessed for two scenarios: 2014 Existing (or No Build/NB) and 2031 Future Build (FB). The two scenarios include the following activities:

2014 Existing (NB):

- Existing traffic volumes on Winston Churchill Boulevard for the existing alignment.

2031 Future Build (FB):

- Projected vehicle volumes on Winston Churchill Boulevard 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 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.

Thirty-five sensitive receptors were modelled to represent worst-case impacts surrounding the project area. All the receptors chosen were placed at residential locations surrounding the roadway. The receptor locations on mapping are identified in **Figure 7** through **Figure 9**.

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 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.

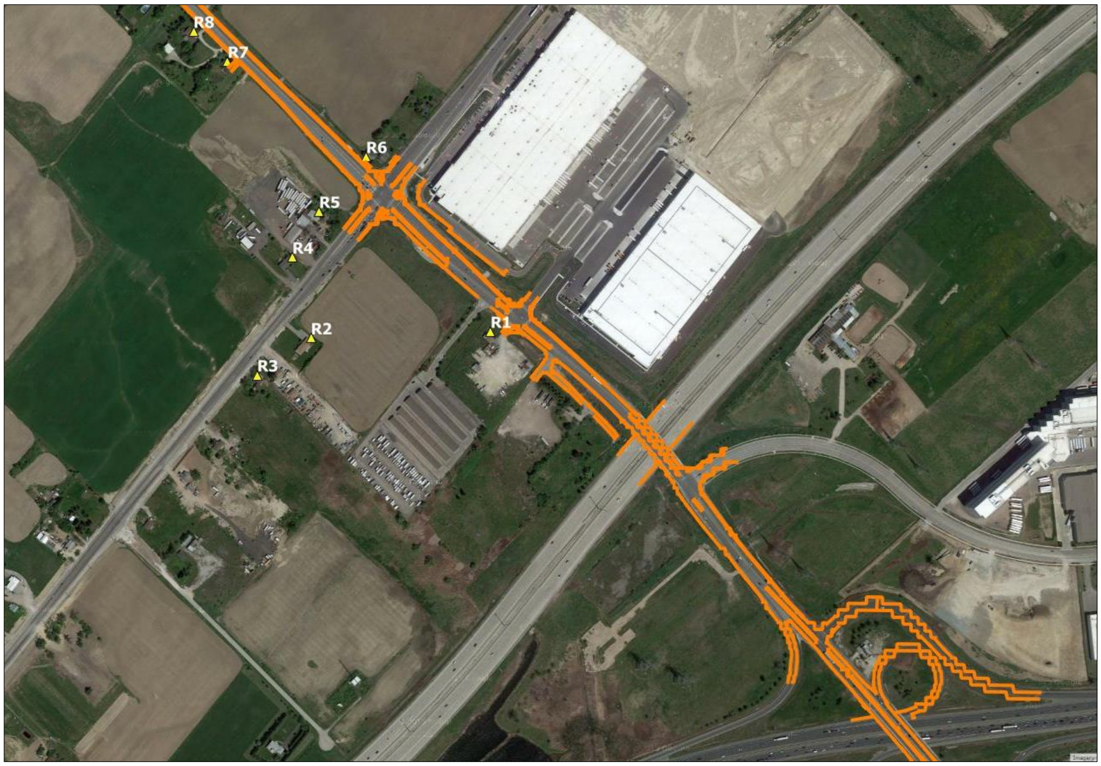


Figure 7: Receptors R1-R8 Locations Within the Study Area

Figure 8: Receptors R9-R25 Locations Within the Study Area

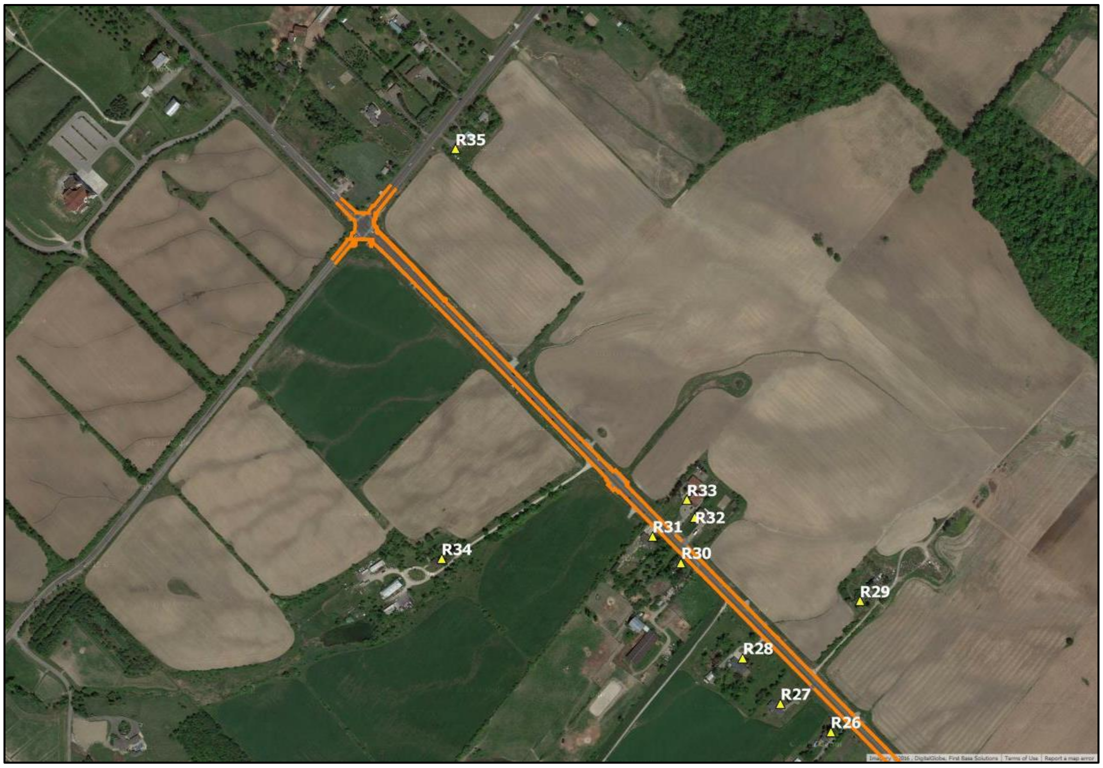


Figure 9: Receptors R26-R35 Locations Within the Study Area

3.3 Road Traffic Data

Traffic volumes for Winston Churchill Boulevard and the surrounding roadways were provided by Hatch in the form of Annual Average Daily Traffic (AADT) volumes for the 2014 Existing and 2031 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 15** and **Table 16**. Also provided were the heavy duty vehicle volumes, from which the heavy duty vehicle percentages were determined. The U.S. EPA rural hourly vehicle distribution was used to determine hourly traffic volumes for the assessment. Day/night traffic splits were provided by Hatch for the roadways in the study area, and were found to be similar to the day/night split of the U.S. EPA traffic distribution used; this hourly vehicle distribution is presented in **Table 17**. Lastly, signal timing information was provided by Hatch for all traffic lights within the study area.

Table 15: 2014 Traffic Volumes (AADT) and Heavy Duty Vehicle Percentages Used in the Assessment

Roadway	2014 Existing AADT		Heavy Duty Vehicle (%)	Speed (km/hr)
	Northbound /Eastbound	Southbound /Westbound		
WCB between 401 Eastbound and Westbound off-ramps	12110	11810	12%	60
WCB between 401 Westbound off-ramp and Meadowpine Blvd	12270	11970	12%	60
WCB between Meadowpine Blvd and Orlando Access	11230	10960	12%	60
WCB between Orlando Access and Steeles Ave	10900	10630	12%	60
WCB between Steeles Ave and Maple Lodge Farms	6300	5560	12%	60
WCB between Maple Lodge Farms and Embleton Rd	6130	5420	8%	80
WCB north of Embleton Rd	4810	4690	2%	80
Steeles Ave east of WCB	12680	12560	10%	60
Steeles Ave west of WCB	9770	9260	10%	60
Embleton Rd east of WCB	3230	3310	6%	60
Embleton Rd west of WCB	4250	4360	6%	60

Table 16: 2031 Traffic Volumes (AADT) and Heavy Duty Vehicle Percentages Used in the Assessment

Roadway	2031 Future Build AADT		Heavy Duty Vehicle (%)	Speed (km/hr)
	Northbound /Eastbound	Southbound /Westbound		
WCB between 401 Eastbound and Westbound off-ramps	17100	16690	12%	60
WCB between 401 Westbound off-ramp and Meadowpine Blvd	17100	17040	12%	60
WCB between Meadowpine Blvd and Orlando Access	16130	15830	12%	60
WCB between Orlando Access and Steeles Ave	14370	13330	12%	60
WCB between Steeles Ave and Maple Lodge Farms	11080	9770	12%	60
WCB between Maple Lodge Farms and Embleton Rd	10980	9720	8%	80
WCB north of Embleton Rd	8660	8060	2%	80
Steeles Ave east of WCB	15170	14700	10%	60
Steeles Ave west of WCB	12040	11740	10%	60
Embleton Rd east of WCB	4420	4530	6%	60
Embleton Rd west of WCB	5810	5960	6%	60

Table 17: U.S. EPA Rural Hourly Vehicle Distribution

Hour	Weekday	Weekend
1	1.0%	1.8%
2	0.7%	1.1%
3	0.6%	0.9%
4	0.7%	0.8%
5	0.9%	0.8%
6	2.0%	1.0%
7	4.1%	1.9%
8	5.8%	2.7%
9	5.4%	3.9%
10	5.3%	5.2%
11	5.5%	6.3%
12	5.8%	7.0%
13	5.9%	7.2%
14	6.0%	7.2%
15	6.6%	7.3%
16	7.2%	7.4%
17	7.8%	7.3%
18	7.6%	7.0%
19	5.9%	6.1%
20	4.3%	5.1%
21	3.6%	4.1%
22	3.1%	3.3%
23	2.4%	2.6%
24	1.8%	2.0%

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.

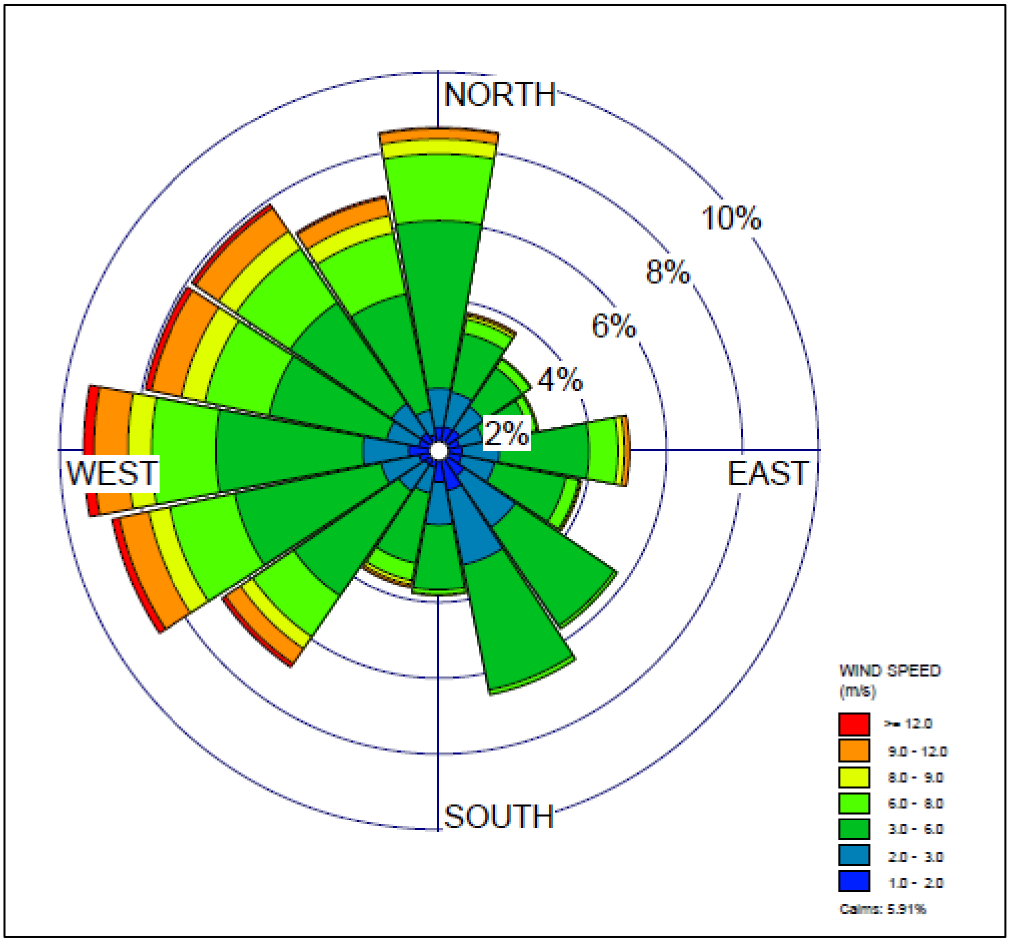


Figure 10: Wind Frequency Diagram for Toronto Pearson International Airport

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 Hatch. Vehicle age was based on the U.S. EPA's default distribution. **Table 18** specifies the major inputs into MOVES.

Table 18: 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	2014 (Existing) and 2031 (Future Build)
Geographical Bounds	Custom County Domain
Fuels	Compressed Natural Gas / Diesel Fuels / Gasoline Fuels
Source Use Types	Combination Long-haul Truck / Combination Short-haul Truck / Intercity Bus / Light Commercial Truck / Motor Home / Motorcycle / Passenger Car / Passenger Truck / Refuse Truck / School Bus / Single Unit Long-haul Truck / Single Unit Short-haul Truck / Transit Bus
Road Type	Rural 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 was selected to represent a worst-case emission rate. The emission rates for each speed modelled for a 12% heavy duty vehicle percentage are shown in **Table 19**. Note that more heavy duty vehicle percentages were modelled but are not presented in this table for brevity. As shown in **Table 19**, emissions in the future year for all contaminants are predicted to decrease.

Table 19: 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
2014	80 km/hr	0.586	2.839	0.026	0.048	0.048	0.001602	0.000190	0.003224	0.000326	0.002877
	60 km/hr	0.610	3.334	0.032	0.077	0.077	0.002016	0.000239	0.004015	0.000408	0.003625
	Idle	5.493	21.099	0.330	0.363	0.363	0.042533	0.004826	0.073852	0.009836	0.071242
2031	80 km/hr	0.100	1.047	0.007	0.026	0.026	0.000251	0.000034	0.000848	0.000002	0.000683
	60 km/hr	0.099	1.166	0.010	0.052	0.052	0.000310	0.000042	0.000987	0.000003	0.000852
	Idle	0.621	2.601	0.057	0.063	0.063	0.004690	0.000682	0.011912	0.000105	0.012701

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 20**.

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

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 20: 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 21** 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 21: 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 'rural/row crops'. The average surface roughness height for low intensity residential for all seasons 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 2014 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 receptors for each contaminant and averaging period (see **Table 22**), which were identified as the maximum combined concentration for the 2031 Future Build scenario. Results for all modelled receptors are provided in **Appendix A.** It should be noted that the maximum combined concentration at any sensitive receptor often occurs infrequently and actually may only occur for one hour or day over the 5-year period.

Table 22: Worst-Case Sensitive Receptors for 2031 Future Build Scenario

Contaminant	Averaging Period	Sensitive Receptor
NO_2	1-hour	R1
	24-hour	R7
CO	1-hour	R7
	8-hour	R6
$PM_{2.5}$	24-hour	R6
	Annual	R6
PM_{10}	24-hour	R6
TSP	24-hour	R7
Acetaldehyde	24-hour	R6
Acrolein	1-hour	R5
	24-hour	R5
Benzene	24-hour	R6
	Annual	R6
1,3-Butadiene	24-hour	R6
	Annual	R6
Formaldehyde	24-hour	R6

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

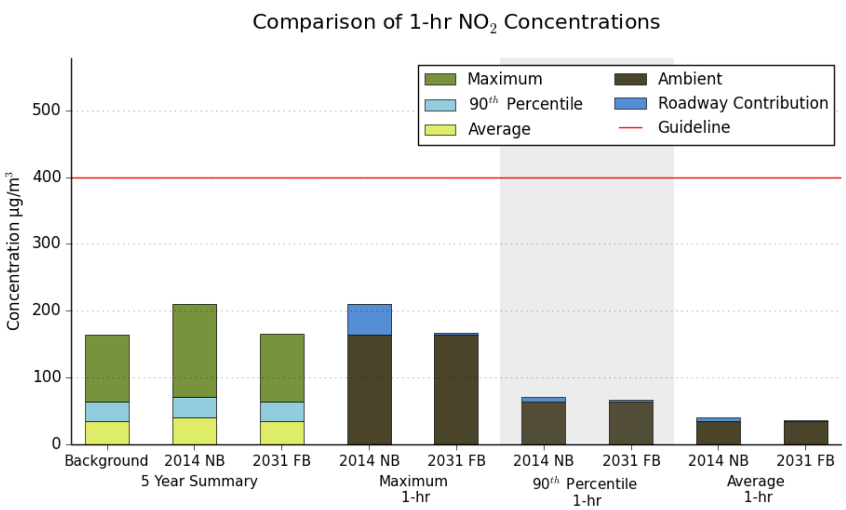
Nitrogen Dioxide

Table 23 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:

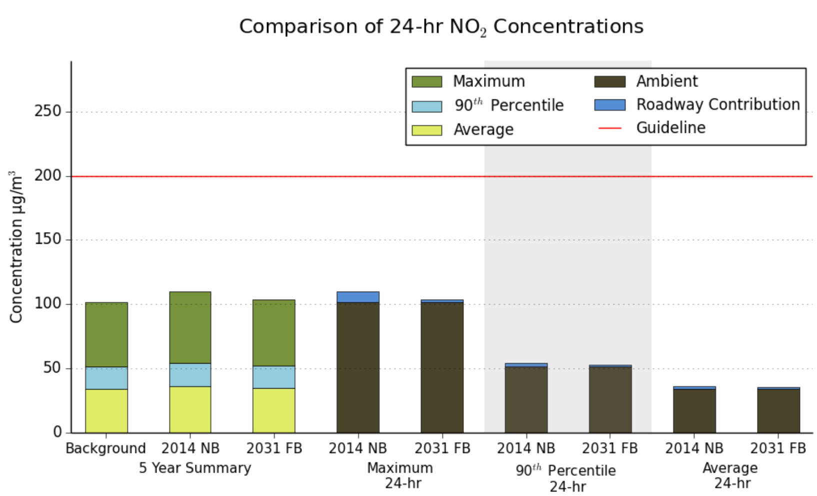
- *Both the maximum 1-hour and 24-hour NO_2 combined concentrations were below their respective MOECC guidelines.*

Table 23: Summary of Predicted NO_2 Concentrations

Statistical Analysis



% of MOECC Guideline:	
Maximum	41%
90th Percentile	16%
Average	9%
Roadway Contribution:	
Maximum	1%
90th Percentile	1%
Average	1%



% of MOECC Guideline:	
Maximum	51%
90th Percentile	26%
Average	17%
Roadway Contribution:	
Maximum	2%
90th Percentile	1%
Average	2%

Conclusions:

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

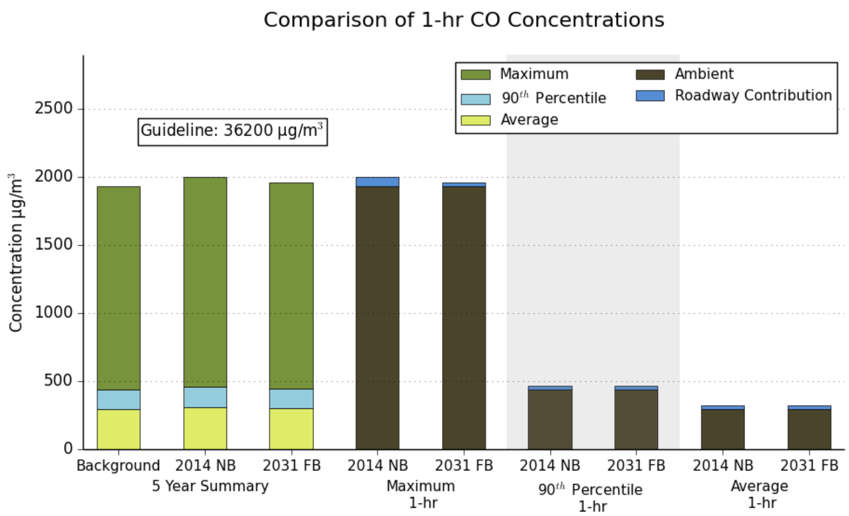
Carbon Monoxide

Table 24 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:

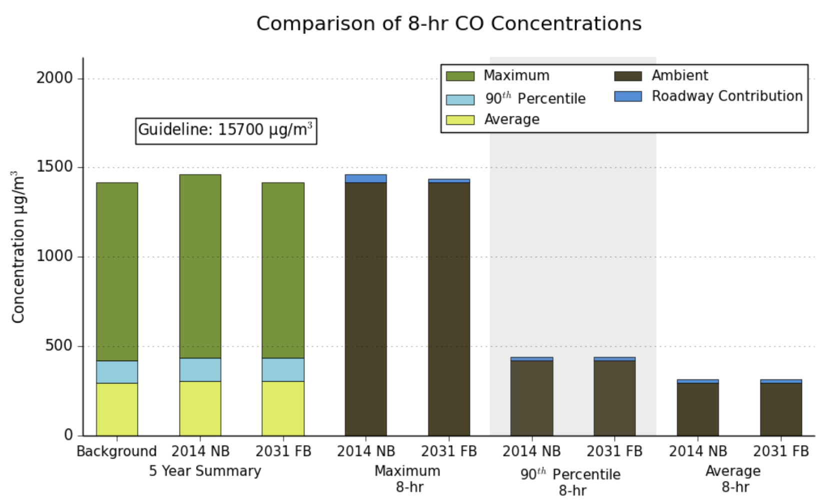
- *Both the maximum 1-hour and 8-hour CO combined concentrations were well below their respective MOECC guidelines.*

Table 24: Summary of Predicted CO Concentrations

Statistical Analysis



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



% of MOECC Guideline:	
Maximum	9%
90th Percentile	3%
Average	2%
Roadway Contribution:	
Maximum	7%
90th Percentile	4%
Average	4%

Conclusions:

- All combined concentrations were below their respective MOECC guidelines.
- The contribution from the roadway to the combined concentrations was 7% or less.

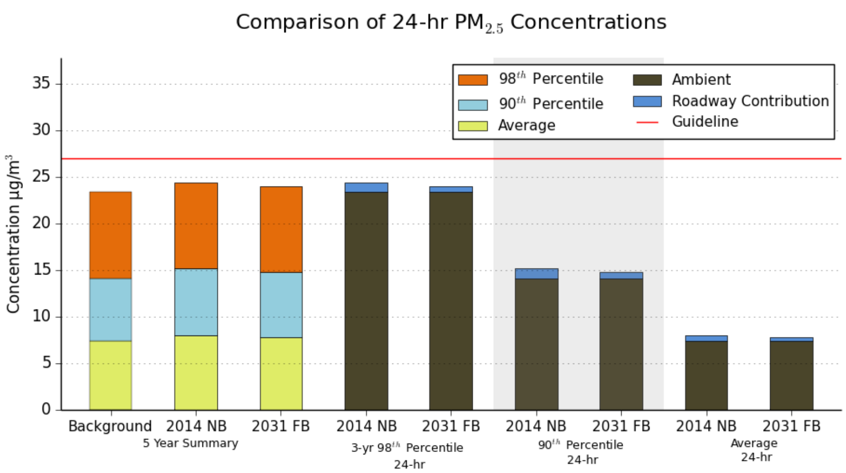
Fine Particulate Matter ($PM_{2.5}$)

Table 25 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour $PM_{2.5}$ 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 three-year annual average exceeded the guideline with a 5% contribution from the roadway*

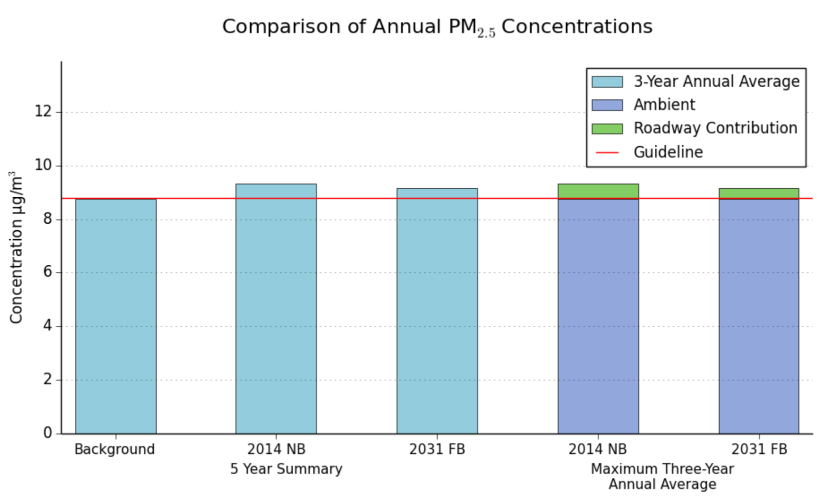
Table 25: Summary of Predicted $PM_{2.5}$ Concentrations

Statistical Analysis



% of MOECC Guideline:	
98th Percentile	89%
90th Percentile	55%
Average	29%
Roadway Contribution:	
98th Percentile	4%
90th Percentile	4%
Average	6%

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 24 µg/m³ or 90% of the CWS.



% of MOECC Guideline:	
3-Year Annual Average	107%
Roadway Contribution:	
3-Year Annual Average	5%

The $PM_{2.5}$ results were above the 3-year CWS. The maximum 3-year annual average concentration was 107% of the guideline. It should be noted that ambient concentrations alone were 100% of the guideline.

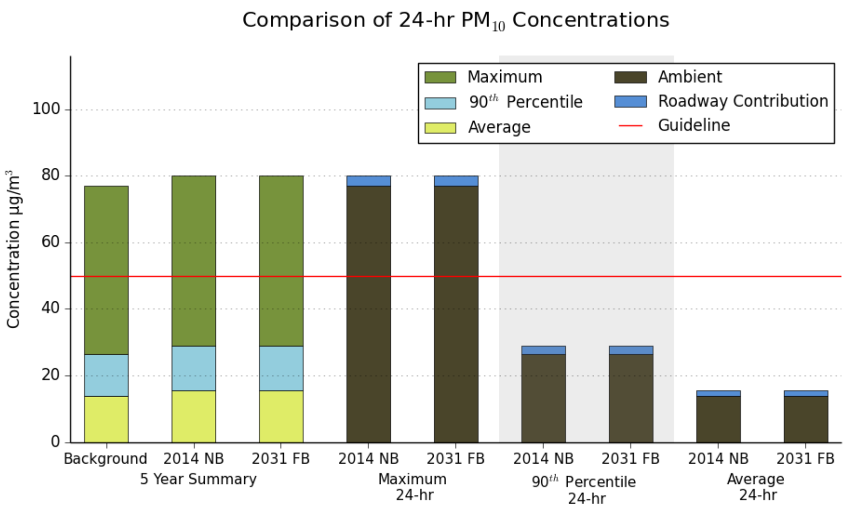
Coarse Particulate Matter (PM_{10})

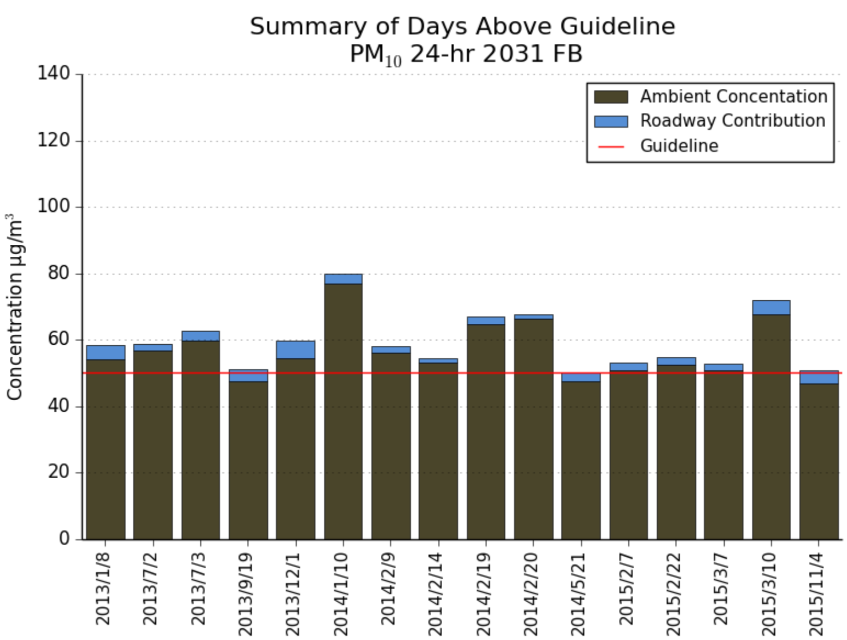
Table 26 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour PM_{10} based on 5 years of meteorological data. The results conclude that:

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

Table 26: Summary of Predicted PM_{10} Concentrations

Statistical Analysis





% of MOECC Guideline:	
Maximum	160%
90th Percentile	58%
Average	31%
Roadway Contribution:	
Maximum	4%
90th Percentile	10%
Average	14%

Conclusions:

The combined concentrations of PM_{10} surrounding the study area exceed the standard of 50 µg/m³. 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 no additional exceedances are expected due to the roadway over the five-year period between 2014 Existing and 2031 Future Build.

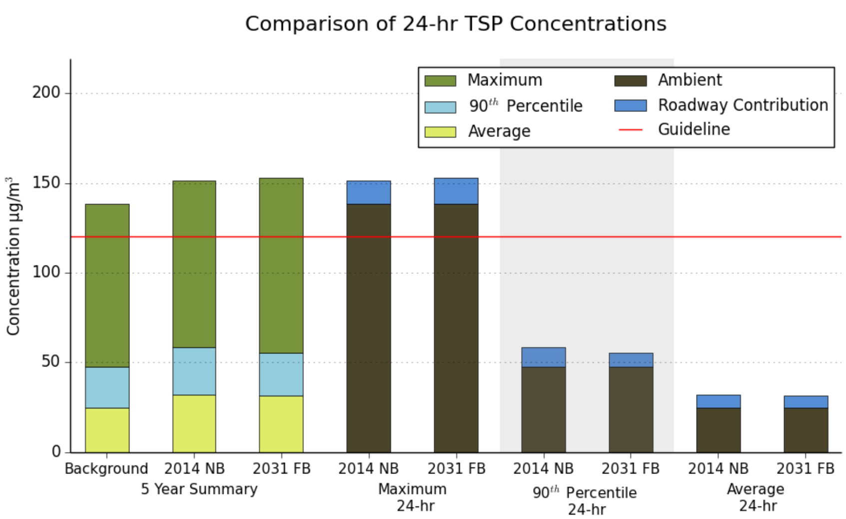
Total Suspended Particulate Matter (TSP)

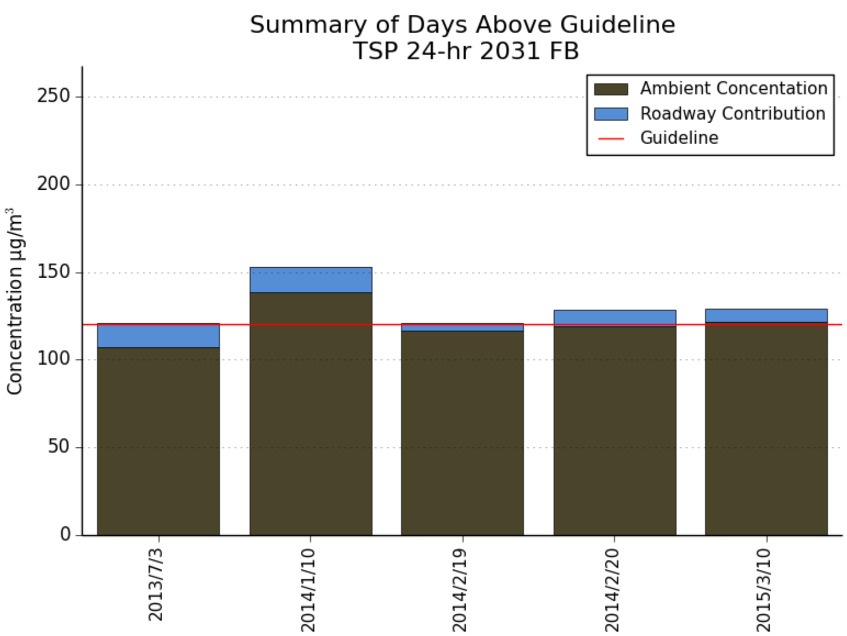
Table 27 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour TSP based on 5 years of meteorological data. The results conclude that:

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

Table 27: Summary of Predicted TSP Concentrations

Statistical Analysis





% of MOECC Guideline:	
Maximum	127%
90^{th} Percentile	46%
Average	26%
Roadway Contribution:	
Maximum	9%
90^{th} Percentile	19%
Average	33%

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 9% 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 2014 Existing and 2031 Future Build.

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.

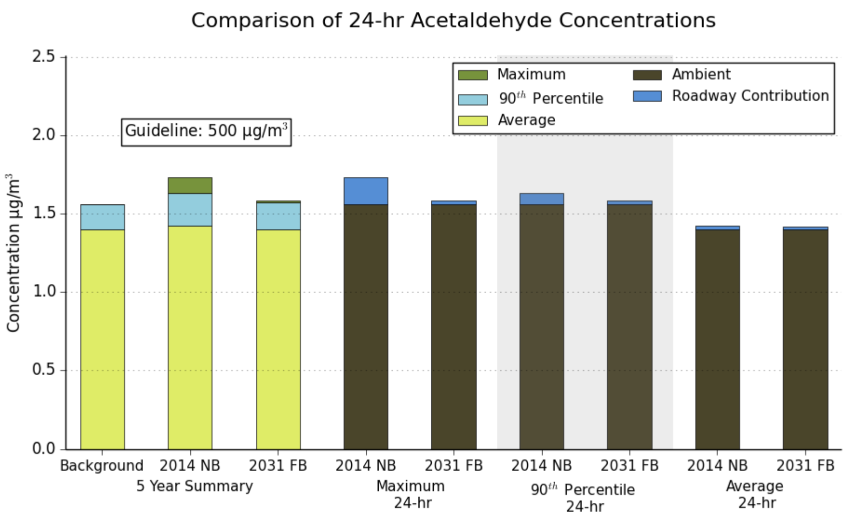
Acetaldehyde

Table 28 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 28: 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 1% or less.

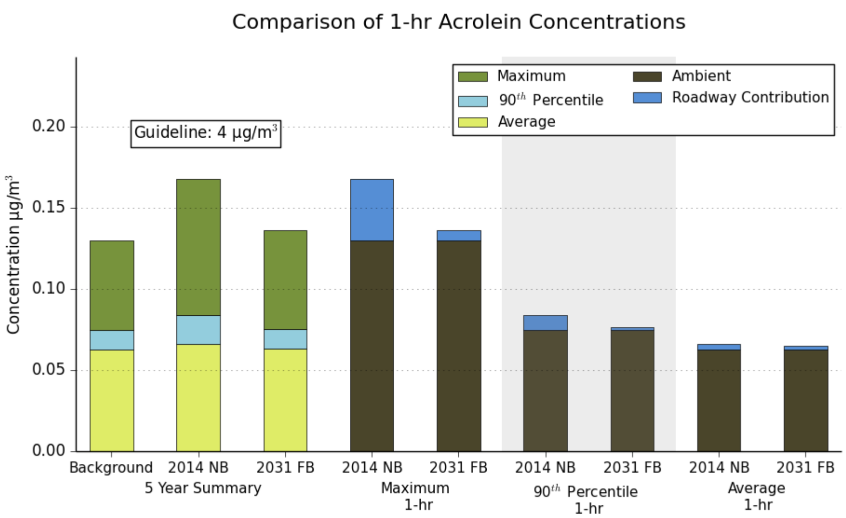
Acrolein

Table 29 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour acrolein based on 5 years of meteorological data. The results conclude that:

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

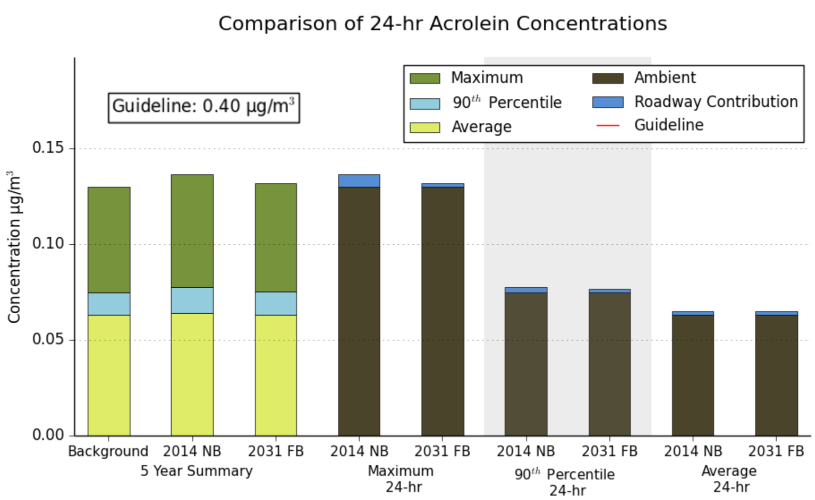
Table 29: Summary of Predicted Acrolein Concentrations

Statistical Analysis



% 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.

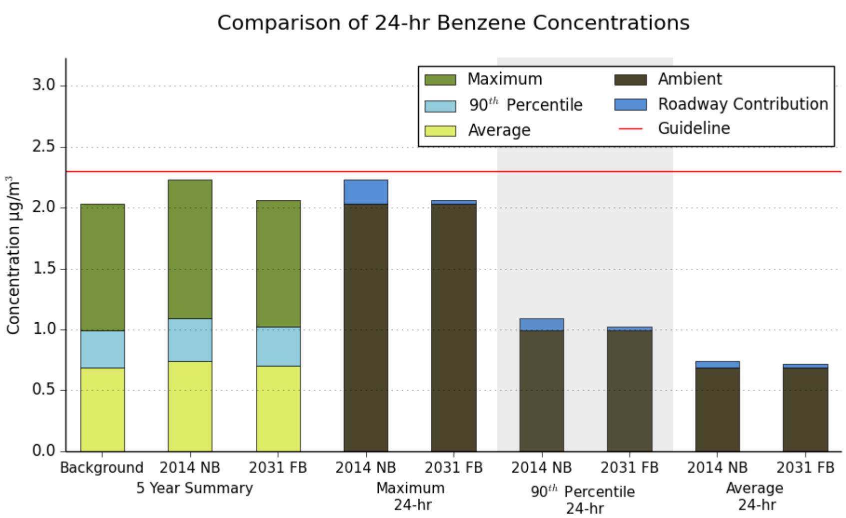
Benzene

Table 30 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour 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 2%.*

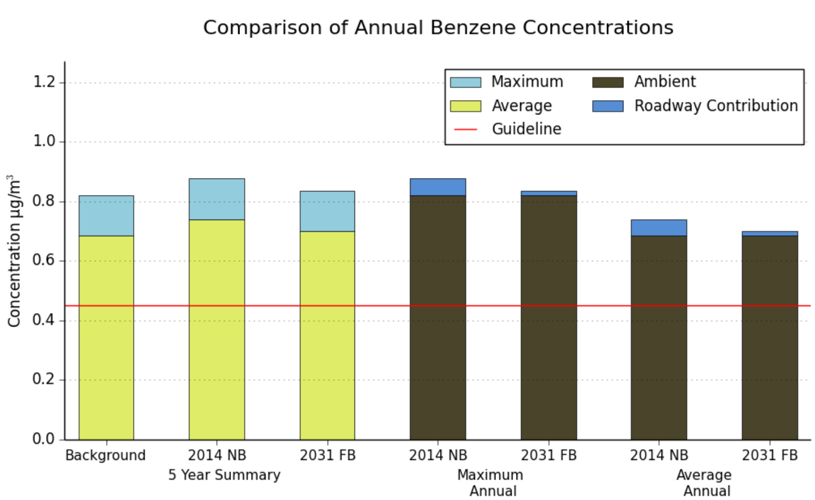
Table 30: Summary of Predicted Benzene Concentrations

Statistical Analysis



% of MOECC Guideline:	
Maximum	90%
90th Percentile	44%
Average	30%
Roadway Contribution:	
Maximum	2%
90th Percentile	2%
Average	2%

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



% of MOECC Guideline:	
Maximum	185%
Average	155%
Roadway Contribution:	
Maximum	2%
Average	2%

Conclusions:
The combined concentration exceeded the MOECC guideline. It should be noted that ambient concentrations were 185% of the guideline and the roadway contribution to the maximum was 2%.

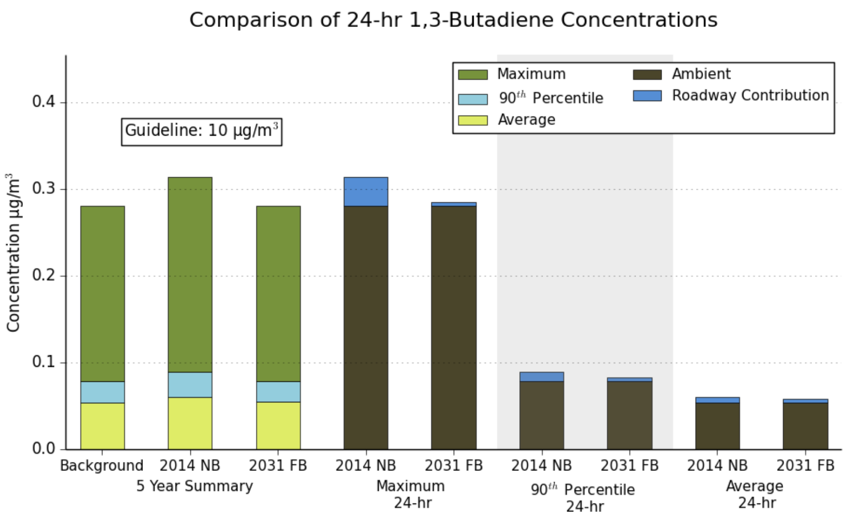
1,3-Butadiene

Table 31 presents the predicted combined concentrations for the worst-case sensitive receptor for 24-hour 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.*

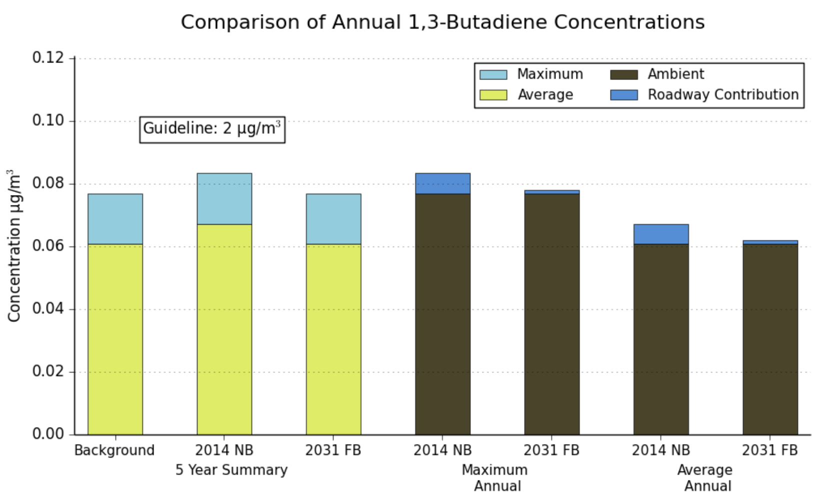
Table 31: Summary of Predicted 1,3-Butadiene Concentrations

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%.

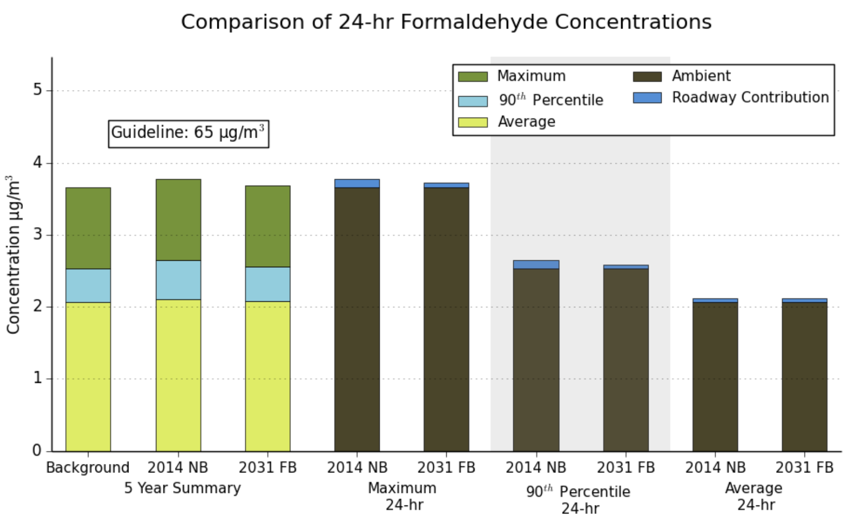
Formaldehyde

Table 32 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 32: 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 1% or less.

4.0 Greenhouse Gas Assessment

In addition to the contaminants of interest assessed in the local air quality assessment, the total greenhouse gas (GHG) emissions from the project were predicted to qualify the project's impact on climate change. Potential impacts were assessed by calculating the relative change in total emissions between the 2014 Existing and 2031 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 various speeds and heavy duty vehicle percentages on Winston Churchill Boulevard. **Table 33** summarizes the length of the roadway, traffic volumes, and emission rates used to determine total GHG emissions on Winston Churchill Boulevard for the 2014 Existing and 2031 Future Build scenarios.

Table 33: Summary of Winston Churchill Boulevard Traffic Volumes, Roadway Length and Emission Rates

Roadway	2014 Two-Way AADT	2031 Two-Way AADT	Length of Roadway (Miles)	Heavy Duty Vehicle Percentage (%)	Posted Speed (km/hr)	2014 CO_2 Equivalent Emission Rate (g/VMT)	2031 CO_2 Equivalent Emission Rate (g/VMT)
WCB between 401 EB and WB off-ramps	23920	33790	0.25	12	60	438.55	292.73
WCB between 401 WB off-ramp and Meadowpine Blvd	24240	34140	0.20	12	60	438.55	292.73
WCB between Meadowpine Blvd and Orlando Access	22190	31960	0.22	12	60	438.55	292.73
WCB between Orlando Access and Steeles Ave	21530	27700	0.18	12	60	438.55	292.73
WCB between Steeles Ave and Maple Lodge Farms	11860	20850	0.66	12	60	438.55	292.73
WCB between Maple Lodge Farms and Embleton Rd	11550	20700	1.28	8	80	387.36	253.16

The total predicted annual GHG emission for the 2014 Existing and 2031 Future Build scenarios are shown in **Table 34**. 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 almost all sections of the study area. The exception is on Winston Churchill Boulevard between Steeles Avenue and Maple Lodge Farms, where total GHG emissions are predicted to increase, due to greater increases in traffic volumes on this section of Winston Churchill Boulevard.

Table 34: Predicted GHG Emissions

Roadway	2014 Total CO_2 Equivalent (tonnes/year)	2031 Total CO_2 Equivalent (tonnes/year)	Change in Emissions (%)
WCB between 401 EB and WB off-ramps	950	895	-6%
WCB between 401 WB off-ramp and Meadowpine Blvd	758	712	-6%
WCB between Meadowpine Blvd and Orlando Access	793	762	-4%
WCB between Orlando Access and Steeles Ave	620	532	-14%
WCB between Steeles Ave and Maple Lodge Farms	1248	1464	17%
WCB between Maple Lodge Farms and Embleton Rd	950	895	-6%
TOTAL WINSTON CHURCHILL BOULEVARD	**6458**	**6815**	**6%**

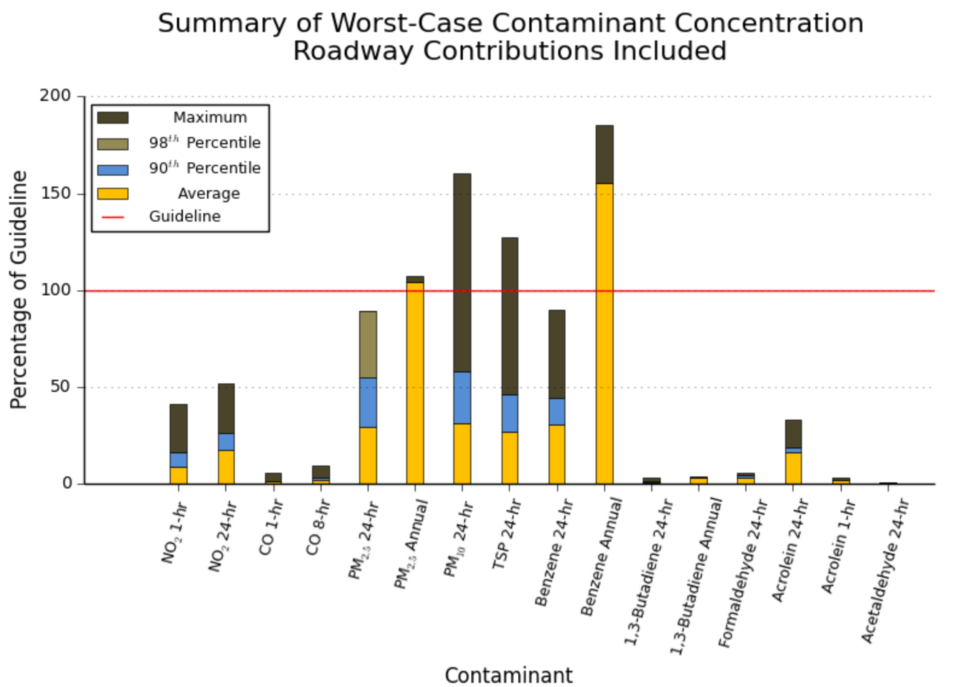
5.0 Conclusions and Recommendations

The potential effects of the proposed project infrastructure on local air quality and GHG emissions have been assessed and are summarized in **Table 35** . 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 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 occurred of PM_{10} and TSP between the 2014 Existing and 2031 Future Build scenarios.*
- *Mitigation measures are not warranted, due to the small number of days which are expected to exceed the guideline.*
- *Total GHG emissions were reduced everywhere in the study area except between Steeles Avenue and Maple Lodge Farms. Overall, there was a 6% increase in total GHG emissions due to the project.*

Table 35: 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 24 µg/m^3 or 89% of the CWS.

% of Guideline	
20314Future Build	
NO_2 (1-hr)	41%
NO_2 (24-hr)	52%
CO (1-hr)	5%
CO (8-hr)	9%
$PM_{2.5}$ (24-hr See Note)	89%
$PM_{2.5}$ (Annual)	107%
PM_{10}	160%
TSP	127%
Acetaldehyde	1%
Acrolein (1-hr)	3%
Acrolein (24-hr)	33%
Benzene (24-hr)	90%
Benzene (Annual)	185%
1,3-Butadiene (24-hr)	3%
1,3-Butadiene (Annual)	4%
Formaldehyde	6%

6.0 References

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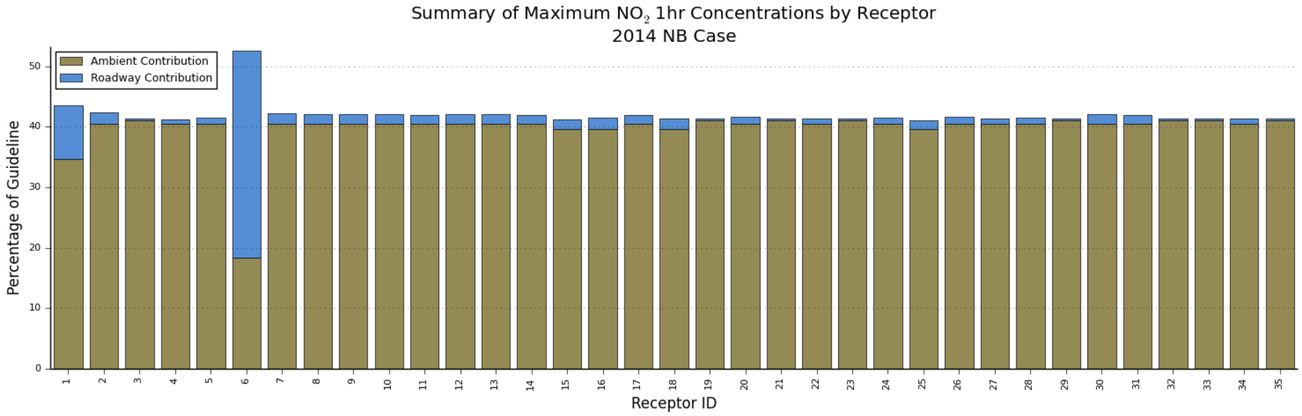
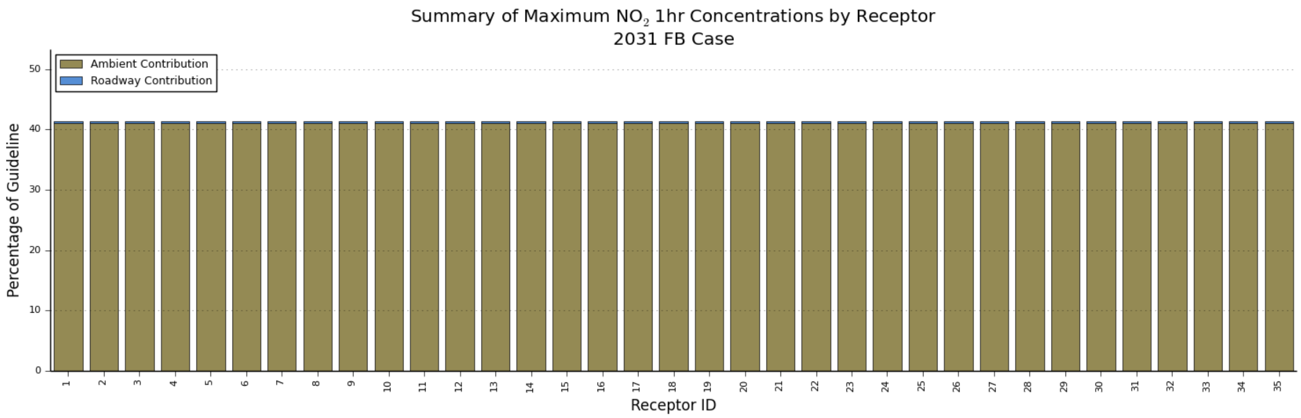
Appendix A
Receptor Specific Modelling Results

This section shows the maximum results predicted by the air dispersion modelling at each receptor within the study area for the 2014 Existing and 2031 Future Build scenarios. **Figure A1** shows the location of the receptors within the study area.

Figure A1: Receptor R1-R19 Locations within the Study Area

Figure A2: Receptor R20-R35 Locations within the Study Area


Summary of Maximum NO_2 1hr Concentrations by Receptor
2014 NB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID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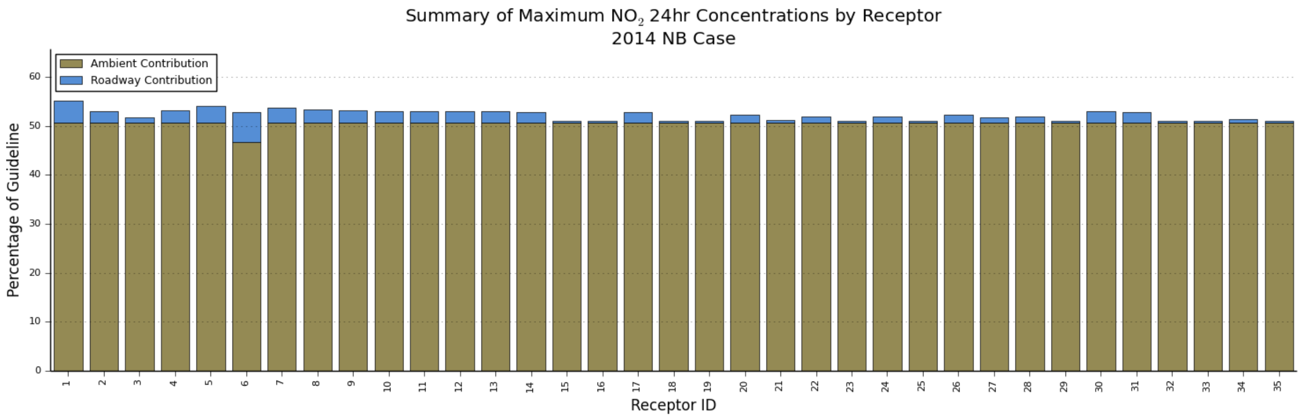
2031 FB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum NO_2 24hr Concentrations by Receptor
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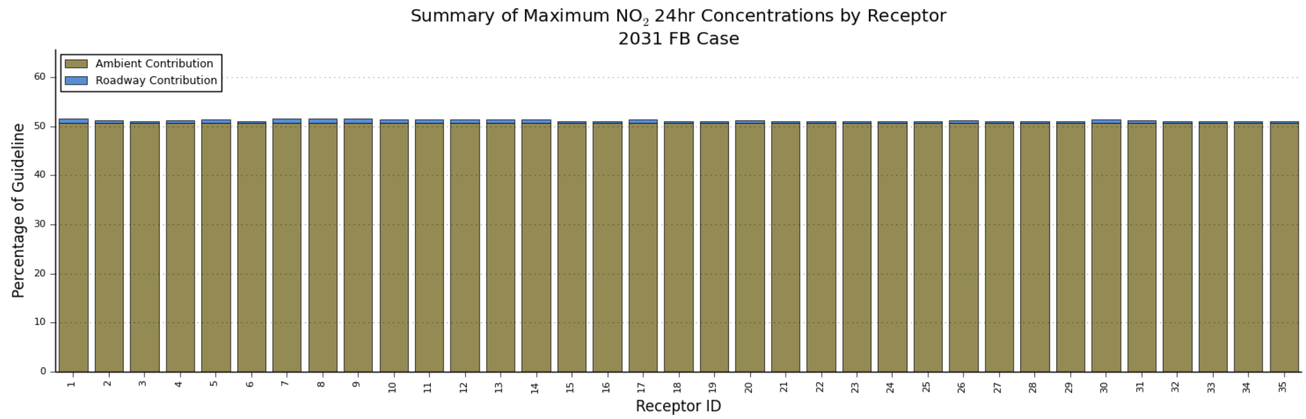
Roadway Contribution
Percentage of Guideline
Receptor ID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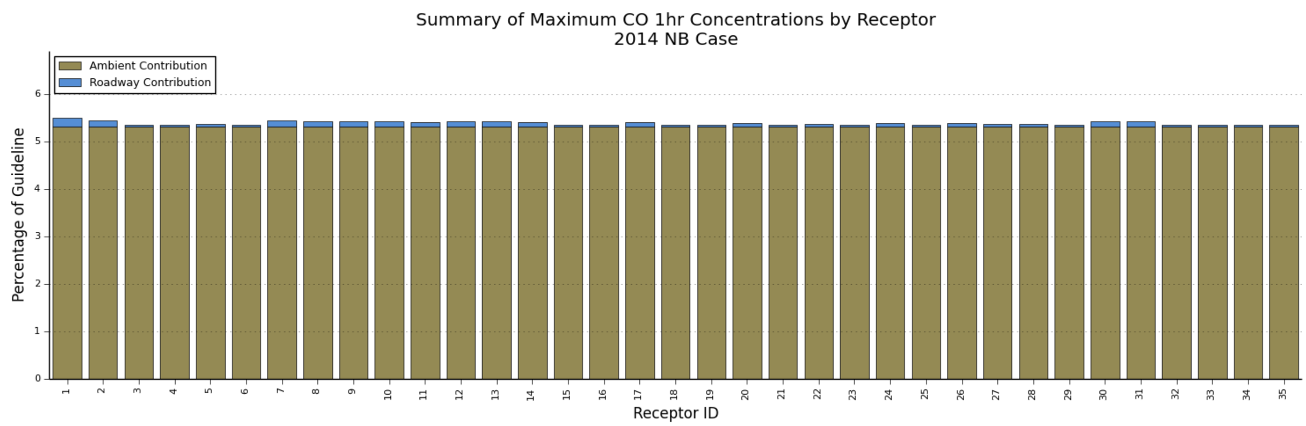
Roadway Contribution
Percentage of Guideline
Receptor ID


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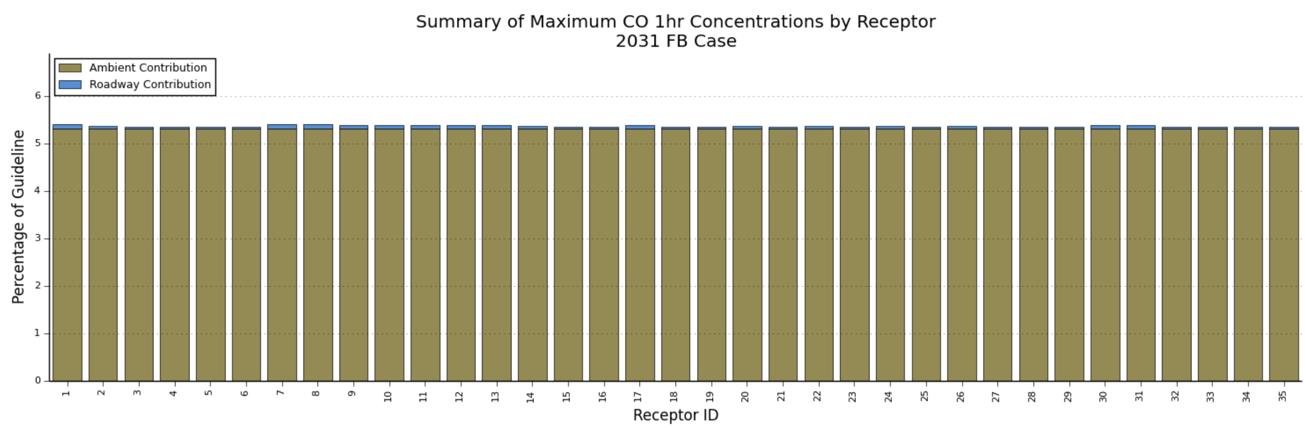
Roadway Contribution
Percentage of Guideline
Receptor ID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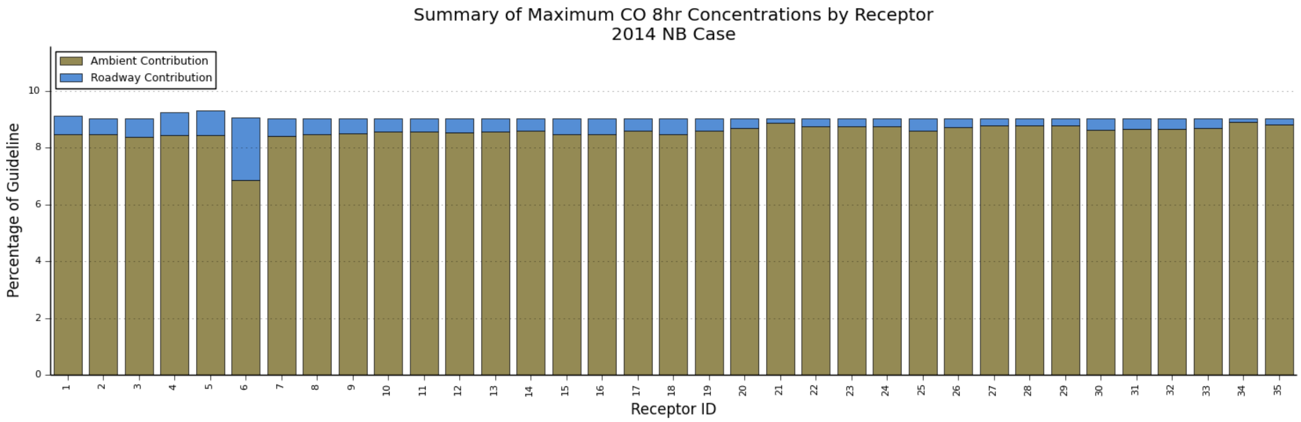
Roadway Contribution
Percentage of Guideline
Receptor ID


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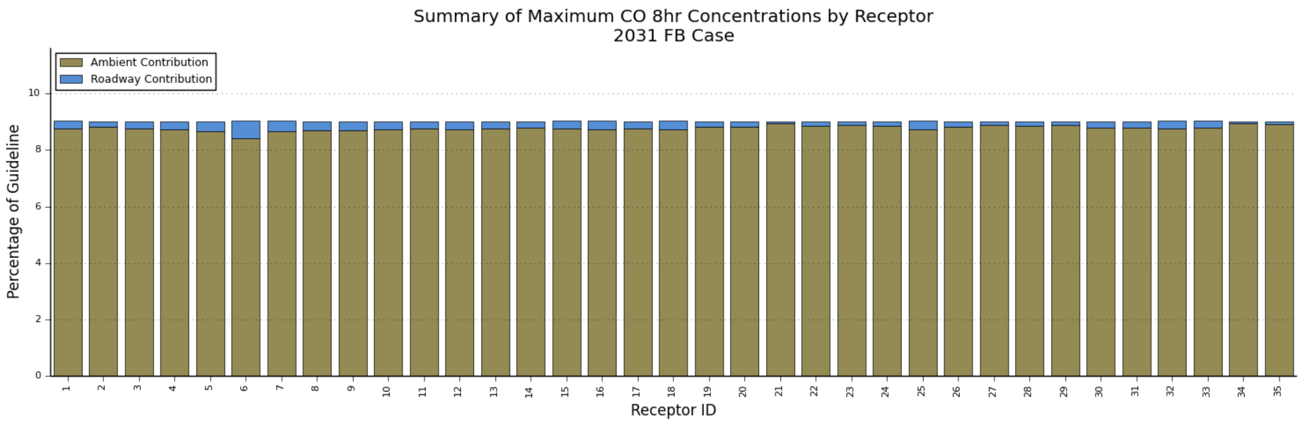
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID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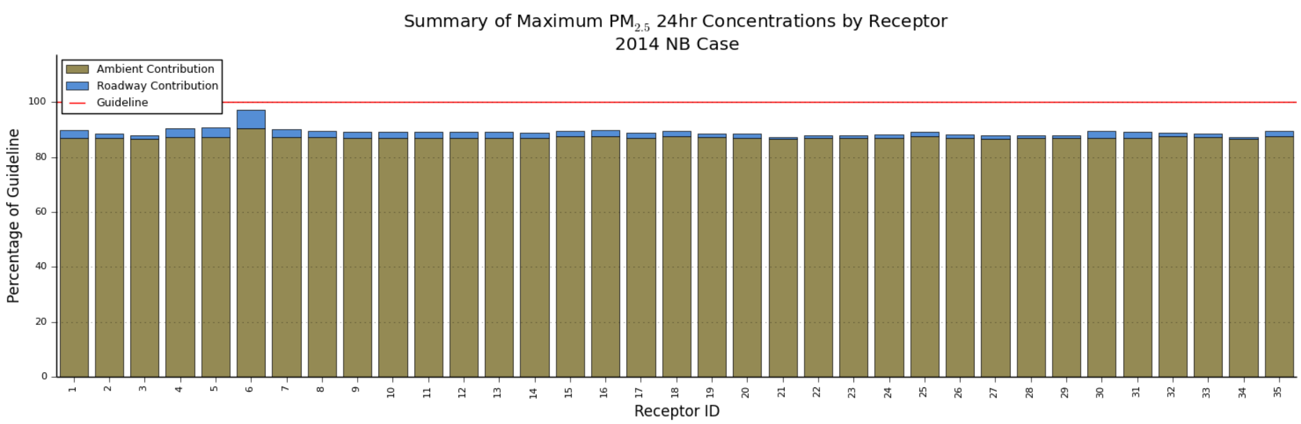
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID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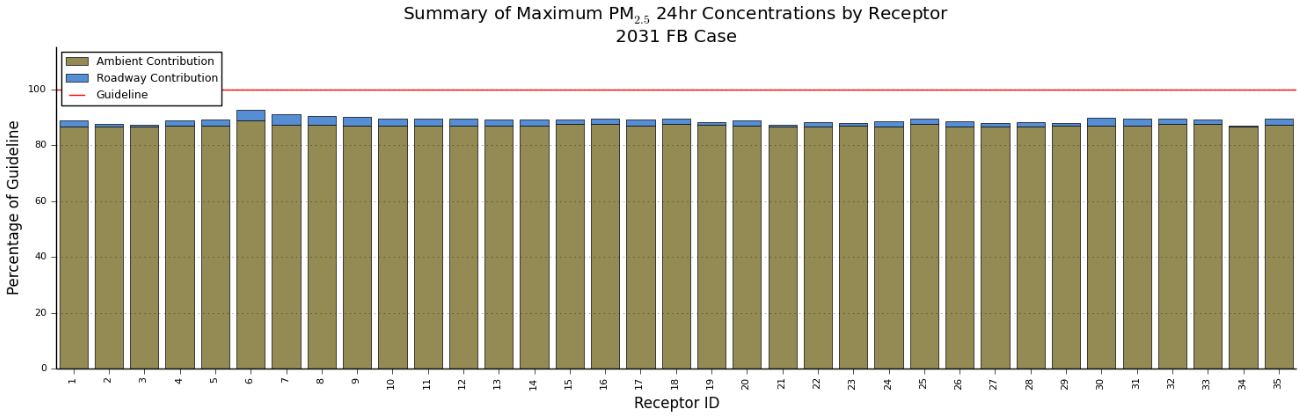
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID


Summary of Maximum $PM_{2.5}$ 24hr Concentrations by Receptor
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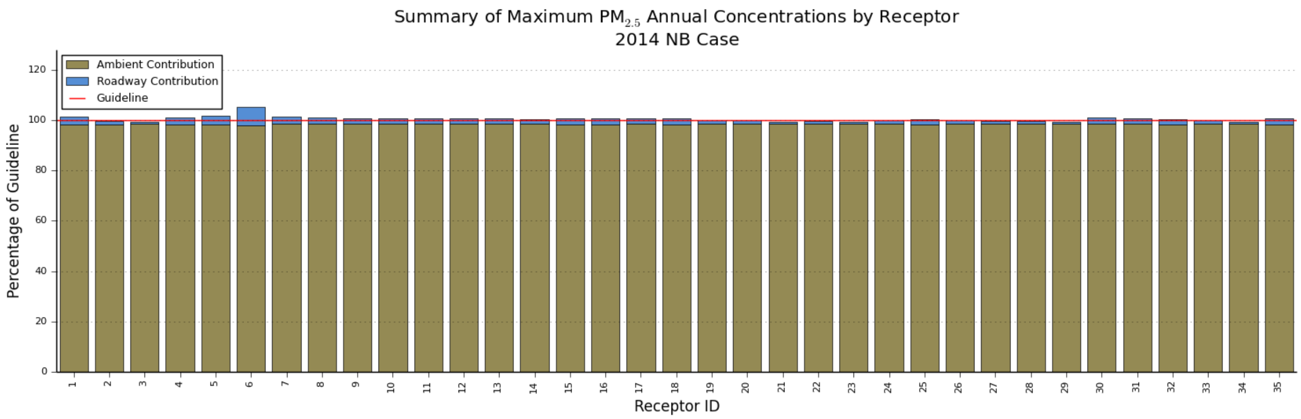
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID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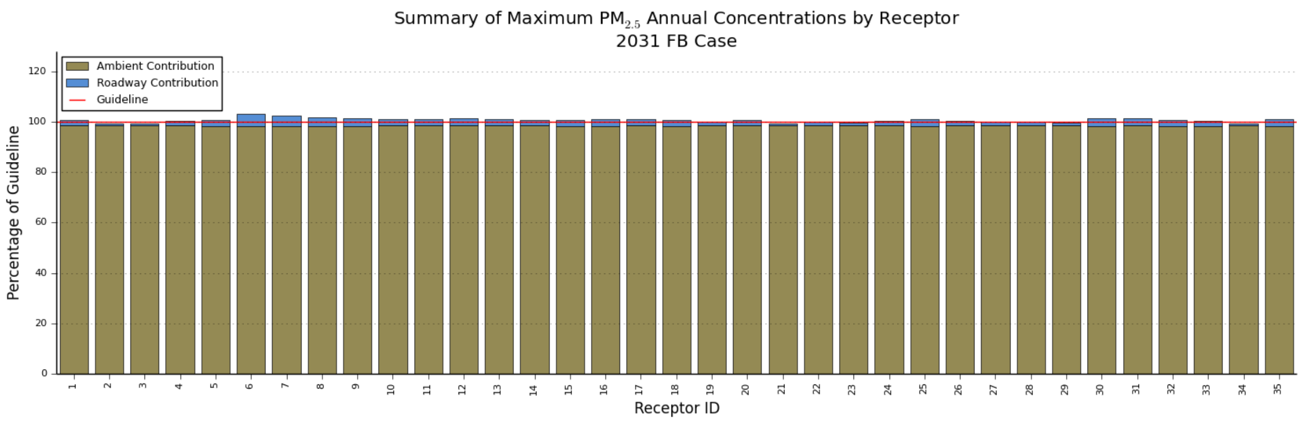
2014 NB Case
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID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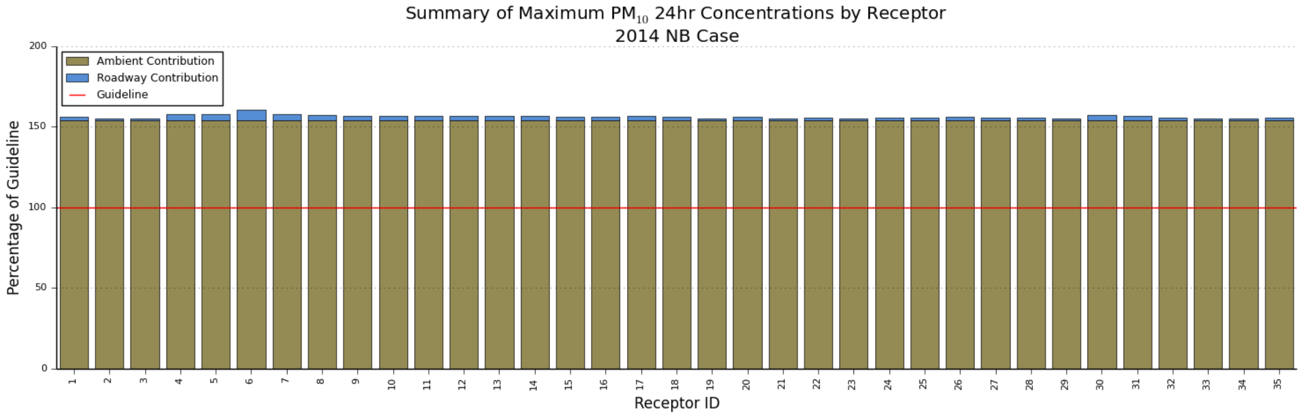
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID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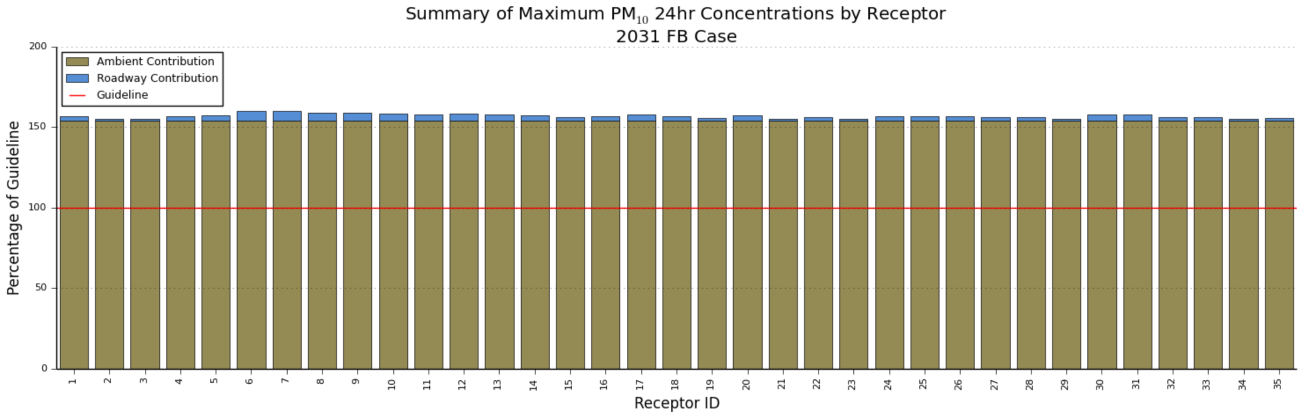
Ambient Contribution
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID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Percentage of Guideline
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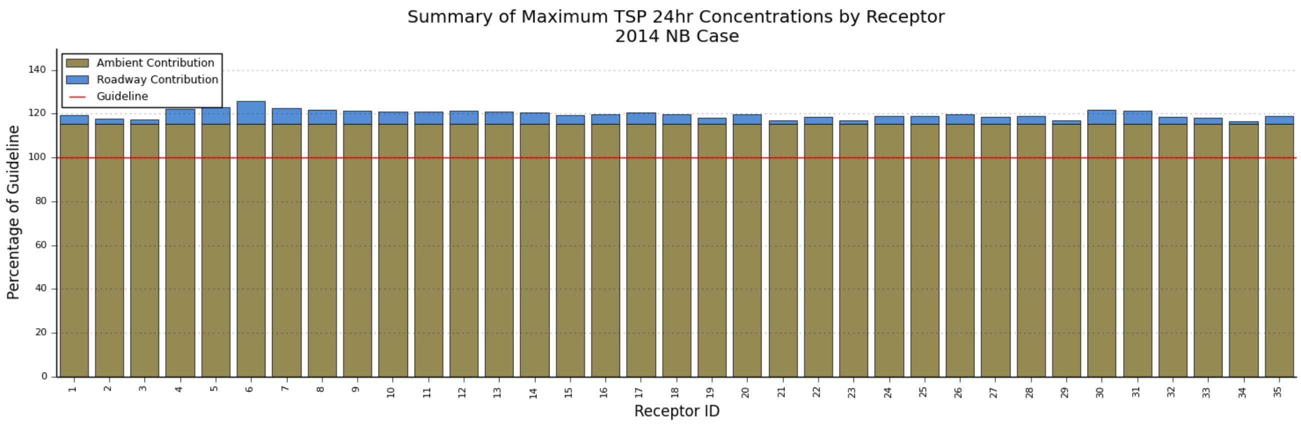
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Guideline
Percentage of Guideline
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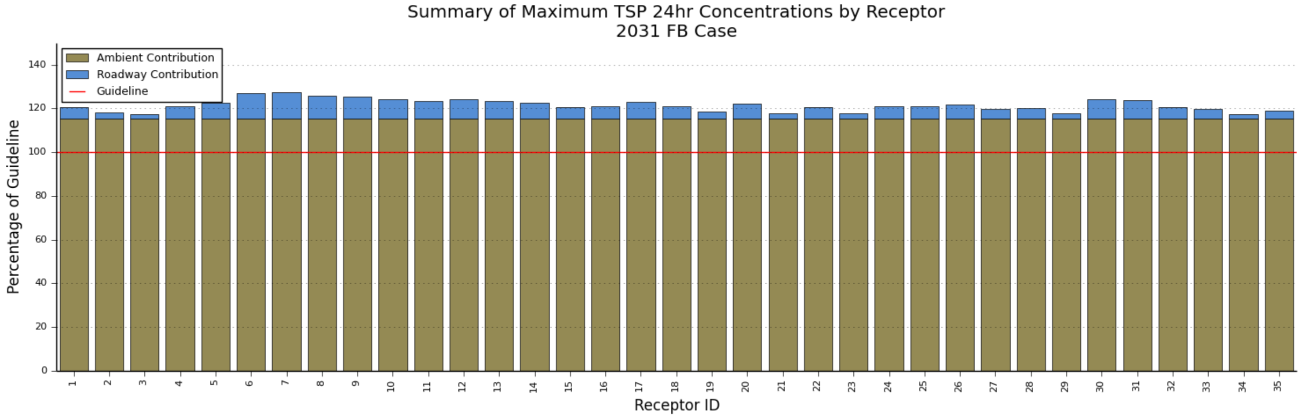
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Percentage of Guideline
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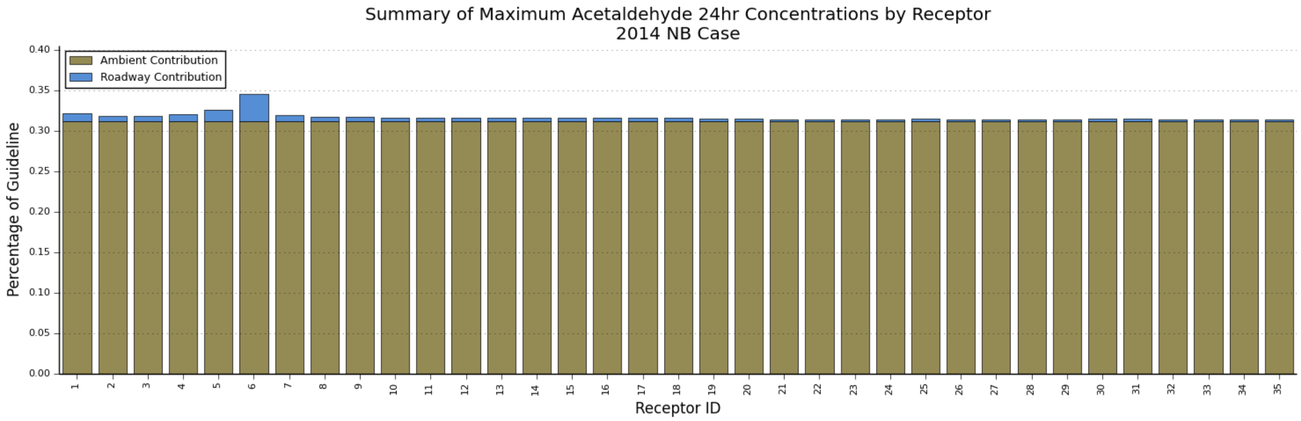
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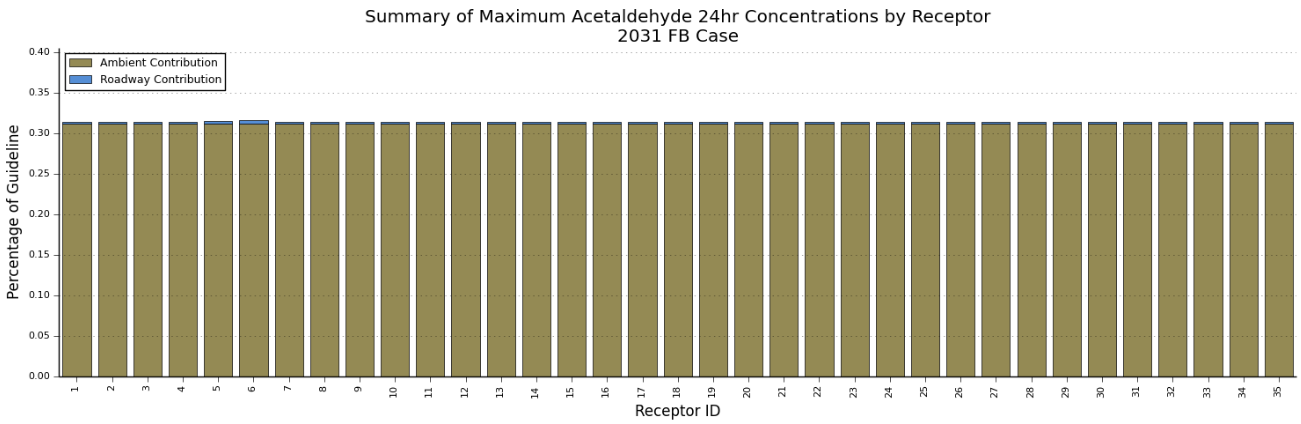
Roadway Contribution
Percentage of Guideline
Receptor ID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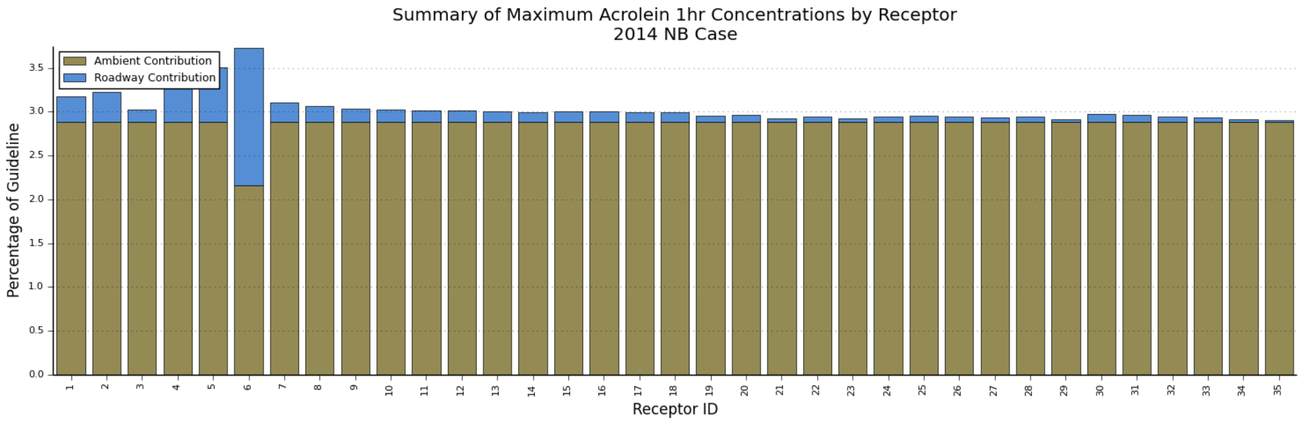
Roadway Contribution
Percentage of Guideline
Receptor ID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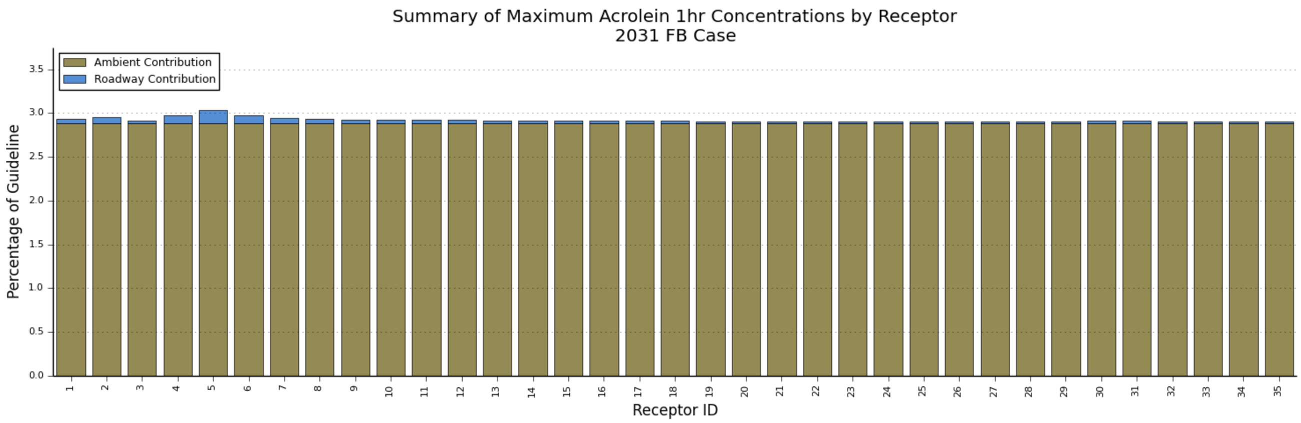
Roadway Contribution
Percentage of Guideline
Receptor ID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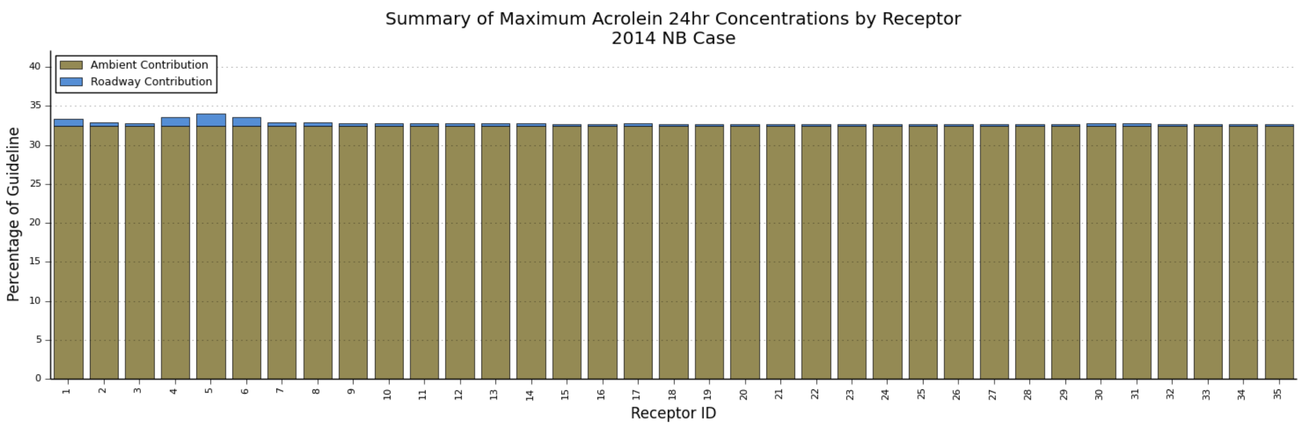
Roadway Contribution
Percentage of Guideline
Receptor ID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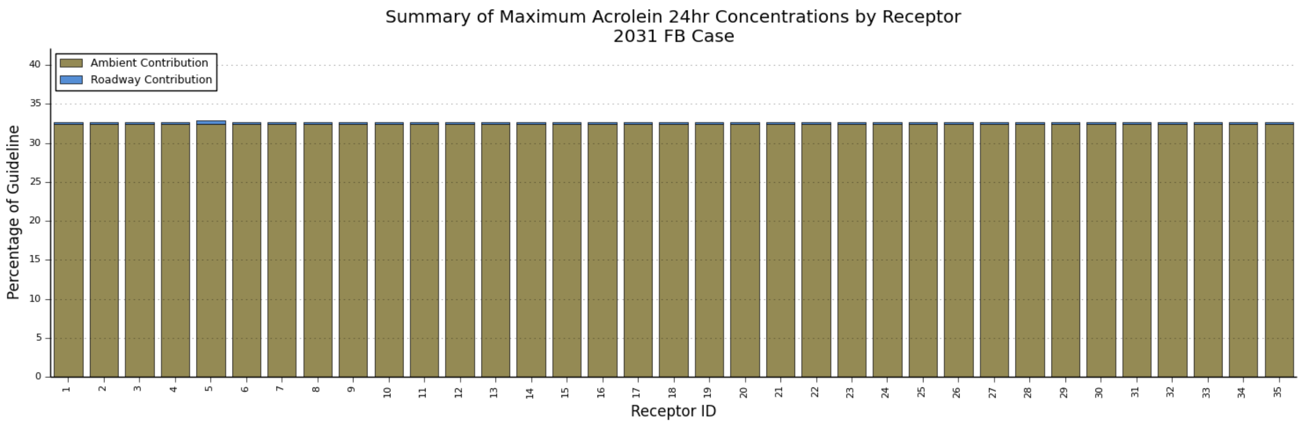
Roadway Contribution
Percentage of Guideline
Receptor ID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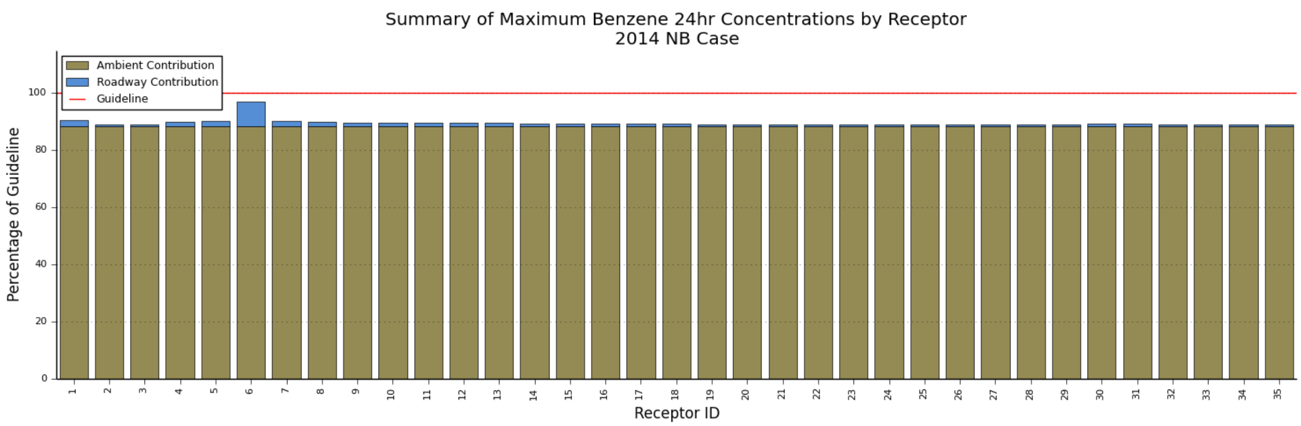
Roadway Contribution
Percentage of Guideline
Receptor ID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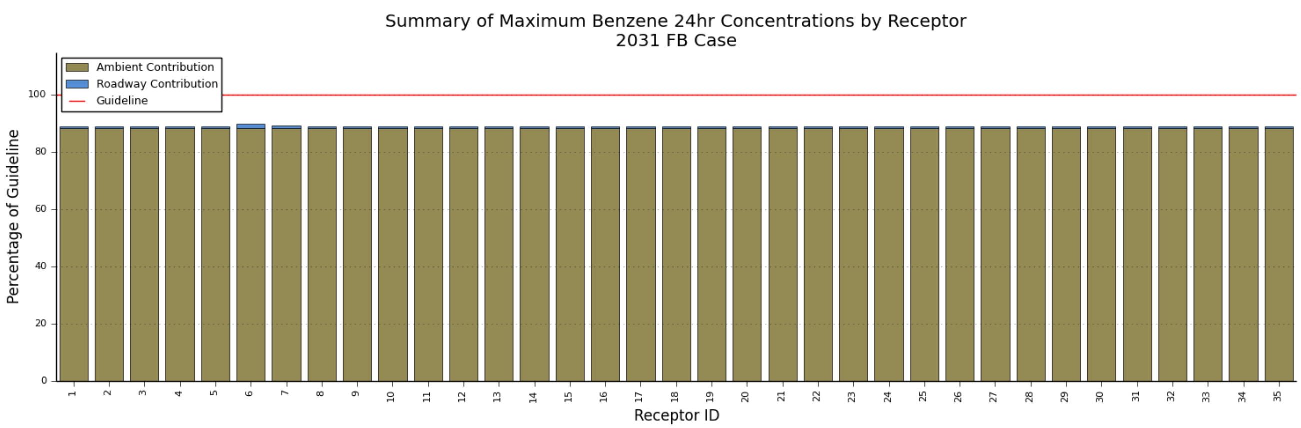
Roadway Contribution
Guideline
Percentage of Guideline
Receptor ID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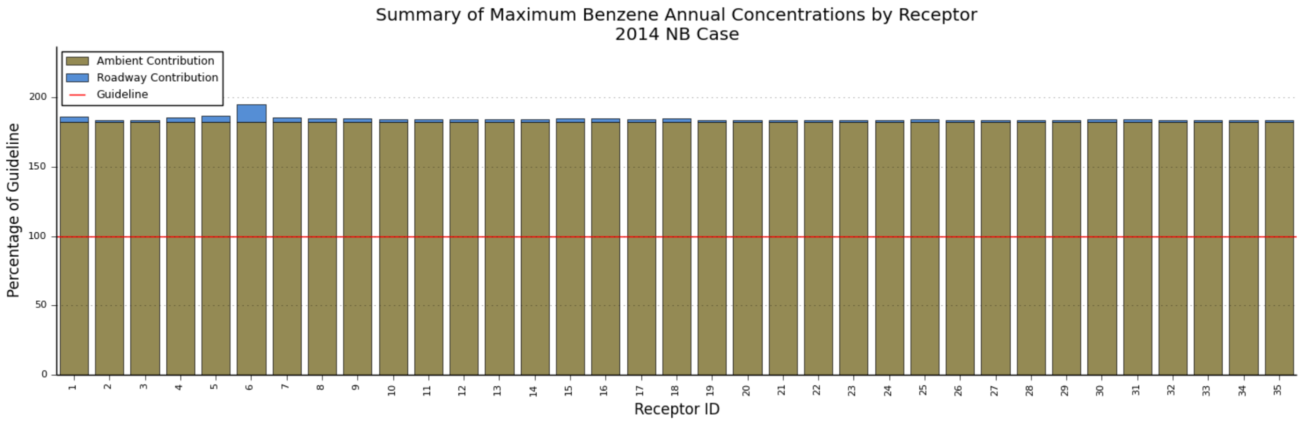
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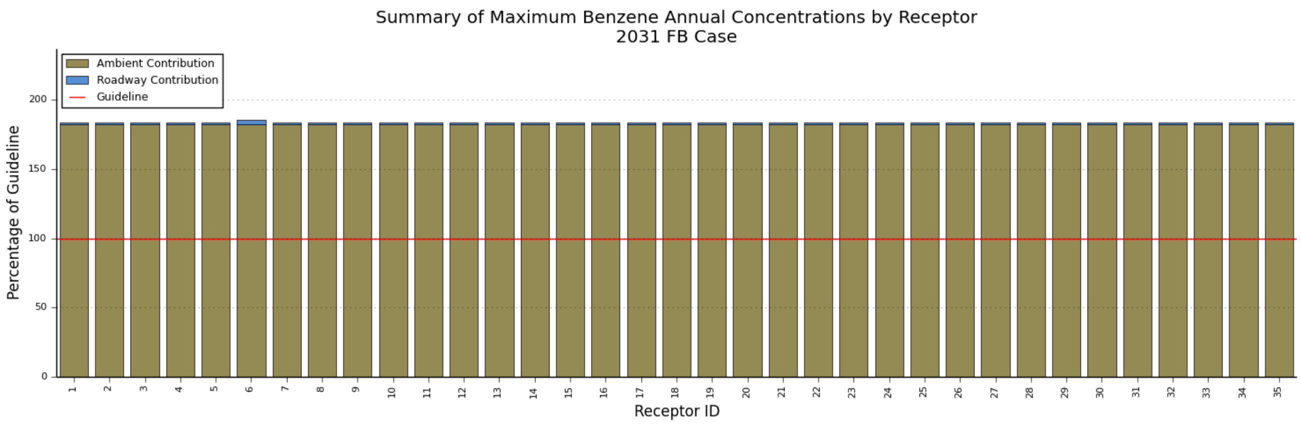
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Percentage of Guideline
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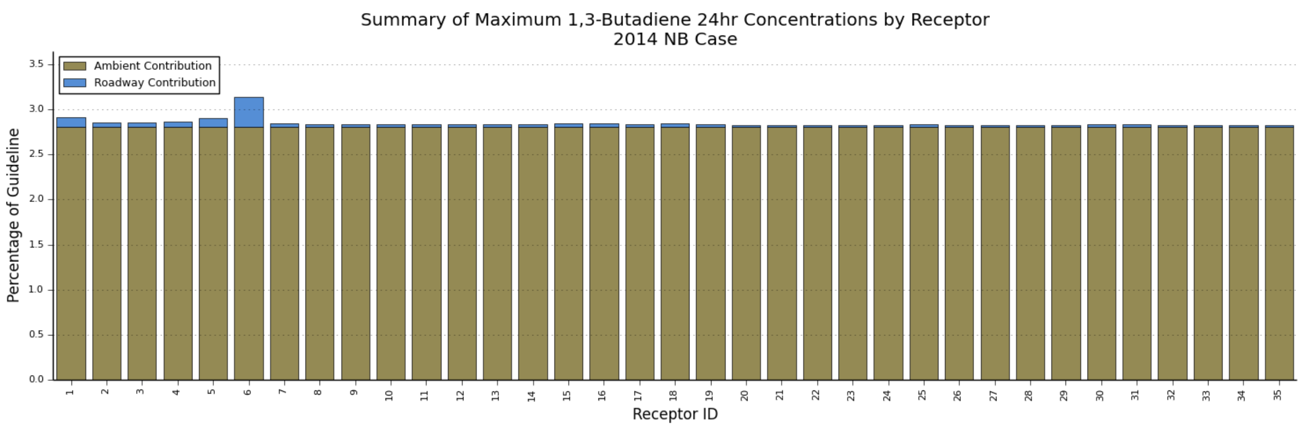
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Roadway Contribution
Percentage of Guideline
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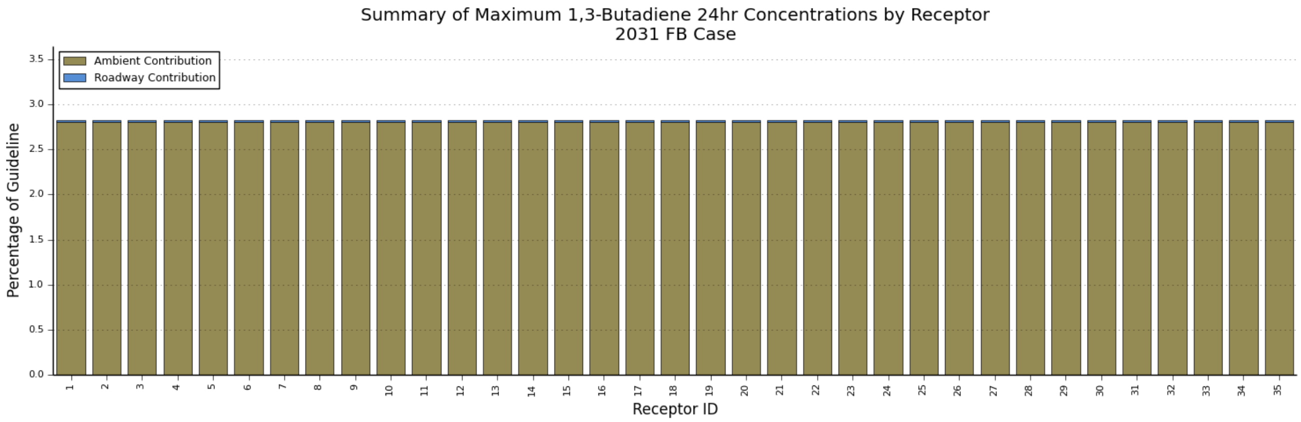
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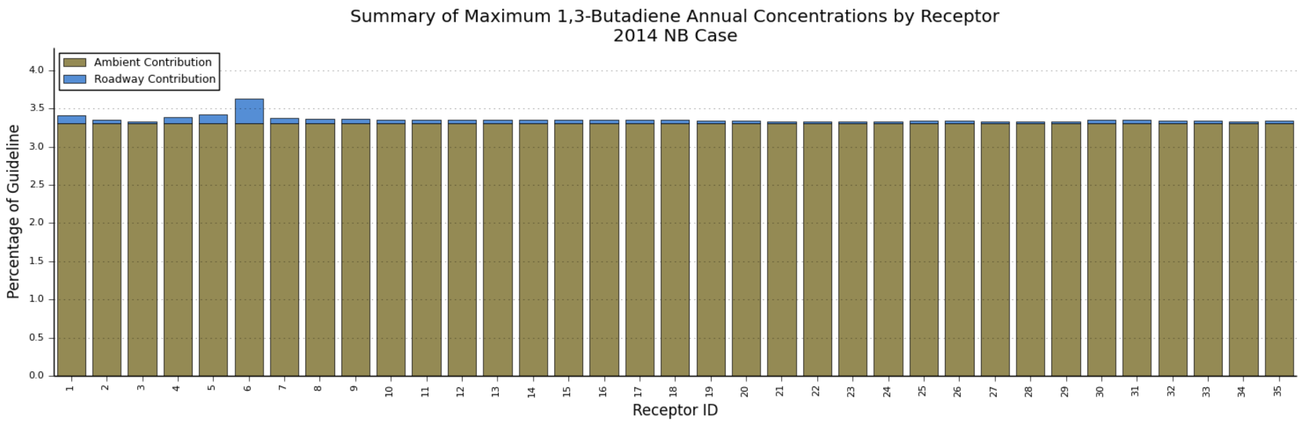
Roadway Contribution
Percentage of Guideline
Receptor ID


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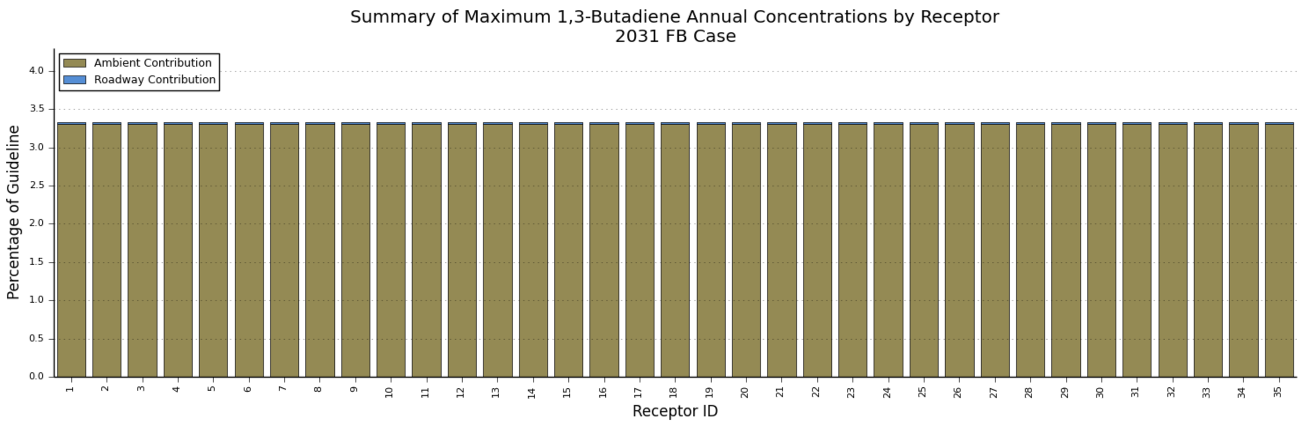
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


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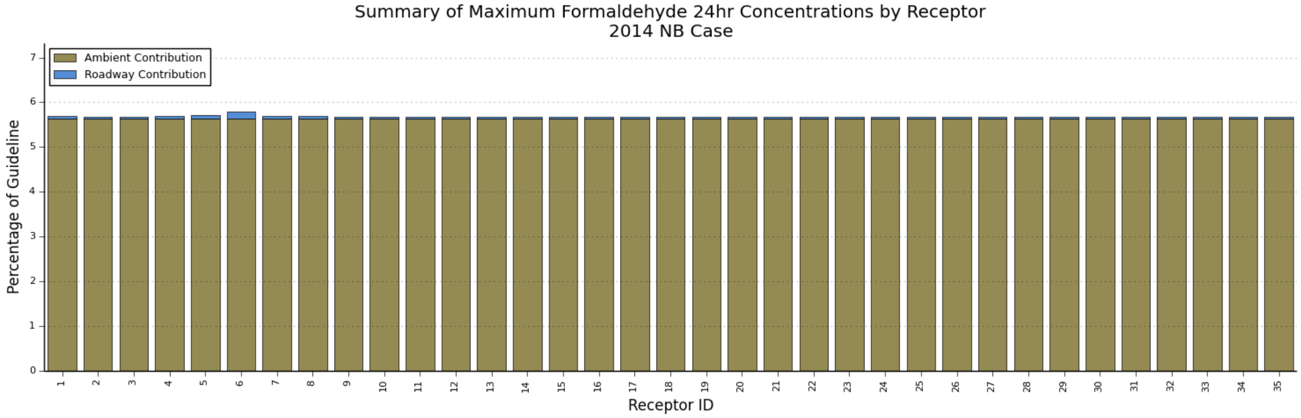
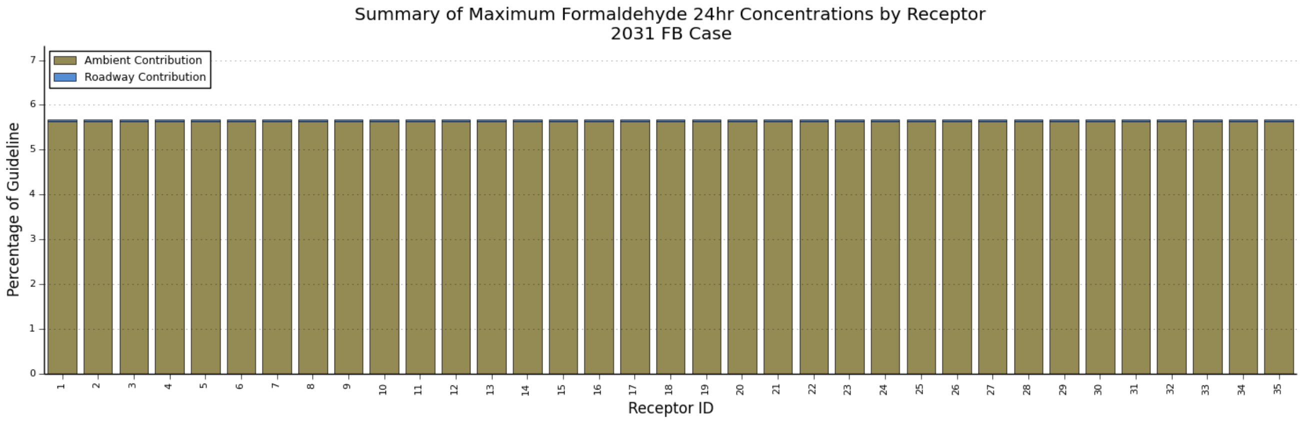
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


Summary of Maximum Formaldehyde 24hr Concentrations by Receptor
2014 NB Case
Ambient Contribution
Roadway Contribution
Percentage of Guideline
Receptor ID


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