Appendix H: Air Quality Assessment

DRAFT REPORT

AIR QUALITY ASSESSMENT
HIGHWAY 6 (HANLON EXPRESSWAY) IMPROVEMENTS
GUELPH, ONTARIO

CONSULTING ENGINEERS & SCIENTISTS

Project Number: #W08-5174A **February 05, 2009**

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EXECUTIVE SUMMARY

RWDI AIR Inc. (RWDI) was retained by Stantec to conduct an air quality assessment for the proposed improvements to Highway 6 (Hanlon Expressway) in Guelph, Ontario. The objective of the assessment was to quantify air contaminant emissions from vehicular traffic travelling along, entering, exiting and crossing the highway and to determine how these emissions will affect air quality in the vicinity of Highway 6. The assessment was undertaken for a future no-build alternative (without improvements for the year 2031) and a future build alternative (with improvements for the year 2031) in order to gain an understanding of incremental impacts resulting from the proposed project. The existing highway without modification represents the future no-build alternative.

The Ministry of Transportation is currently undertaking a planning, preliminary design and environmental assessment study for Highway 6 (Hanlon Expressway) improvements from south of Maltby Road to the Speed River. The purpose of this study is to develop a preliminary design plan to upgrade the Hanlon Expressway to a freeway with access restricted to interchange locations only. The removal of the existing at-grade intersections and traffic signals will significantly improve safety and operations on the Hanlon Expressway.

The Preferred Plan for the project includes:

- Closure of the intersections at Maltby Road and Clair Road / Phelan Road.
- A Parclo A4 interchange at Laird Road.
- A partial diamond interchange at Kortright Road/Downey Road (ramps to and from the south).
- A full interchange (Parclo A / Diamond) at Stone Road.
- A grade-separation at College Avenue.
- Signalized intersections at all of the interchange ramp terminals.
- A connecting service road from Kortright (West of Highway 6) to Stone road (West of Highway 6)
- Noise barriers on the east and west sides of Highway 6 between Kortright Road / Downey Road and College Avenue.

Traffic volumes on the mainline Highway 6 are not predicted to change as a result of the Preferred Plan. When the Preferred Plan is constructed, the posted speed is expected to be increased to 100 km/hr. A 100 km/h posted speed is appropriate for this type of facility and the existing highway alignment has been designed to meet this standard. The posted speed for the facility will be reconsidered during detail design. The modified highway is known as the future build alternative. The purpose of the proposed action is to improve traffic flow and alleviate queue times for vehicles at the intersections.

The study examined the main contaminants of concern for motor vehicles, specifically: carbon monoxide, oxides of nitrogen, inhalable (coarse) particulate matter, respirable (fine) particulate matter, and the key volatile organic compounds consisting of formaldehyde, acetaldehyde, 1, 3-butadiene, benzene and acrolein.

The results of the assessment can be summarized as follows:

- Maximum predicted CO, NO_2, $PM_{2.5}$, PM_{10}, formaldehyde, and acetaldehyde concentrations are all less than their respective government criteria.
- Maximum predicted acrolein concentrations are greater than the applicable government criterion; however, the 90^{th} percentile background level already exceeds the criterion. This suggests that the local acrolein background levels in the study area may continue to exceed in the future, regardless of whether or not the project is built.
- Maximum predicted CO andNO_2 concentrations at the most impacted receptor are predicted to increase marginally for the future build alternative relative to the future no-build alternative. This is primarily due to the decrease in separation distance between the receptor and adjacent roads. However, the maximum predicted concentrations at the most impacted receptor are still less than the applicable government criteria.
- PM_{10} concentrations were p$_r$edicted to increase marginally at the most impacted receptor location mainly due to decrease in separation distances for the future build alternative as compared to the future no-build alternative.
- Maximum predicted VOC concentrations are predicted to remain similar at the worst-case receptor location for the future build alternative relative to the future no-build condition. This is primarily due to the improved free flow conditions (i.e. less idle emissions) resulting from the future build alternative.

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1. INTRODUCTION

RWDI AIR Inc. (RWDI) was retained by Stantec to conduct an air quality assessment for the proposed improvements to Highway 6 (Hanlon Expressway) in Guelph, Ontario. The objective of the assessment was to quantify air contaminant emissions from vehicular traffic travelling along, entering, exiting and crossing the highway and to determine how these emissions will affect air quality in the vicinity of the Highway 6. The assessment was undertaken for a future no-build alternative (without improvements for the year 2031) and a future build alternative (with improvements for the year 2031) in order to gain an understanding of incremental impacts resulting from the proposed project. The existing highway without modification represents the future no-build alternative.

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Appendix A provides a glossary of terms.

2. STUDY AREA

The Highway 6 (Hanlon Expressway) Improvement Project study area extends from just 0.5 kilometers south of Maltby Road to the Speed River in Guelph, Ontario. The Hanlon Expressway is part of Highway 6 and Highway 7 (Woodlawn Road West) to Highway 401. This study area is a mix of residential and commercial development and is shown in **Figures 1a to 1d**.

Air quality impacts were assessed at 101 locations (known as sensitive receptors). These receptors were selected to represent worst-case impacts at residences surrounding the Hanlon Expressway. A sensitive receptor was defined as a residence, church, school, hospital, daycare or senior housing facility. The receptor locations are labelled R1 through R101 on **Figures 1a to 1d.**

3. CONTAMINANTS OF INTEREST

Vehicular traffic produces a variety of air contaminants as a result of combustion of fuel inside the engine, evaporation of fuel from the tank, brake and tire wear, and re-suspension (also known as re-entrainment) of material on the road surface as the vehicle travels over the road surface. The contaminants selected represent those that are typically of greatest concern by Provincial and Federal regulatory authorities and are those typically associated with local human health or regional smog. **Table 3.1** outlines the contaminants of interest and provides a summary of their limiting factors.

Table 3.1: Contaminants of Interest

Contaminant	Symbol	Limiting Factor(s)	
		Human Health	Smog
Carbon Monoxide	CO	X	
Nitrogen Oxides	NO_x	X	X
Respirable Particulate Matter	$PM_{2.5}$	X	X
Inhalable Particulate Matter	PM_{10}	X	X
Formaldehyde	CCHO	X	X
Acetaldehyde	HCHO	X	X
Benzene	C_6H_6	X	
1,3-Butadiene	C_4H_6	X	
Acrolein	C_3H_4O	X	

Refer to Appendix A for a detailed description of the air quality contaminants modelled.

4. RELEVANT GUIDELINES

The Ontario Ministry of the Environment (MOE) has developed Ambient Air Quality Criteria (AAQCs) for numerous contaminants, including those that are typically emitted from vehicular traffic and are known to have the potential to cause human health or environmental impacts [1]. Environment Canada (EC) has established National Ambient Air Quality Objectives (NAAQOs) for the same contaminants [2]. In general, these objectives represent desirable or acceptable ambient contaminant levels. Finally, the Canadian Council of Ministers of the Environment (CCME) created a Canada Wide Standard (CWS) for $PM_{2.5}$ [3]. The CWS for $PM_{2.5}$ was established for the year 2010 and is based on the 98th percentile ambient measurement (24-hour) annually averaged over three consecutive years.

These aforementioned air quality criteria, objectives and standards are collectively referred to as air quality thresholds in this report. The thresholds used to assess potential impacts from transportation projects are summarized in **Table 4.1**. It should be noted that these values represent target levels and are not enforceable within any of the jurisdictions.

Table 4.1: Summary of Relevant Air Quality Thresholds (µg/m^3)

Contaminant	Averaging Time			Source			Air Quality Threshold
	1 hr	8 hr	24 hr	AAQC	NAAQO	CWS	
CO	X			X			36,200*
	X				X		35,000*
		X		X			15,700*
		X			X		15,000*
NO_2	X			X			400
			X		X		200
$PM_{2.5}$			X			X	30
PM_{10}			X				50
1,3-Butadiene							N/A
Benzene							N/A
Formaldehyde			X	X			65
Acetaldehyde			X	X			500
Acrolein			X	X			0.08

Notes: *The AAQC and NAAQO for CO represent the same value in parts per million (ppm). The two jurisdictions base their conversion from ppm to (µg/m^3) on different ambient temperatures.

For this project, where there were thresholds for multiple averaging periods for a given contaminant, attainment was assessed using the threshold corresponding to the shortest averaging period (i.e., 1-hour). Considering the typical relationship between 1-hour and other averaging times, the 1-hour threshold is generally more stringent than other thresholds. If the 1-hour threshold is met, then it can be assumed that the thresholds for the remaining averaging periods are met as well.

5. BACKGROUND AIR QUALITY CONDITIONS

For this study, ambient monitoring data were collected to determine existing ambient background concentrations. The MOE and EC operate and maintain ambient air monitoring stations across Ontario. This monitoring network is not extensive and only includes the Guelph region for a couple contaminants ($PM_{2.5}$, CO, NO_2, Benzene and 1,3-Butadiene). The standard approach in roadway assessments is to select the closest ambient air monitoring location to represent the study site. For this study, the closest ambient air monitoring station to the study area is located in Guelph (Exhibition/Clark St). Data from this station were applied, where available. Data for contaminants not monitored at this station were derived from the nearest alternative station (Kitchener, Toronto and Simcoe) as listed in **Table 5.1**. The data for 2000 are summarized to coincide with the meteorological data applied in the assessment. The consideration of a single year of ambient monitoring and meteorological data is an acceptable approach for doing roadway air quality assessments. It is important to note that the selection of a specific year should not have an effect on the results of the assessment as the worst-case impacts occur under meteorological conditions that are not unique to any particular year.

Table 5.1 provides a description of the stations used for the contaminants referenced in Section 3 and **Table 5.2** provides a summary of the data. The mean values are representative of typical conditions, 90th percentile values (exceeded only 10% of the time) are representative of credible worst-case conditions, and maximum values are representative of rare peak events.

Table 5.1: Ambient Station Information [4,5]

Contaminant	Station ID	City	Location	Year
CO	MOE #26060	Kitchener	West Ave./Homewood	2000
NO_2	MOE #26060	Kitchener	West Ave./Homewood	2000
$PM_{2.5}$	MOE #28028	Guelph	Exhibition/Clark St.	2000
PM_{10}*	N/A	N/A	N/A	N/A
Formaldehyde	NAPS #060418	Toronto	Ruskin and Perth St	2000
Acetaldehyde	NAPS #060418	Toronto	Ruskin and Perth St	2000
Benzene	NAPS #061502	Kitchener	Bronte Rd and Woburn Cres	2000
1,3-Butadiene	NAPS #061502	Kitchener	West Ave./Homewood	2000
Acrolein	MOE #22071	Simcoe	Hwy 3/Blue Line Rd	2000

*** Ambient monitoring data were not available for PM_{10}.**

Table 5.2: Summary of Ambient Air Measurements (µg/m³)

Contaminant	Averaging Period	90^{th} Percentile	Mean	Maximum	Threshold	No. of Times > Threshold
CO	1 hr	715	404	5,746	36,200	0
NO_2	1 hr	57	28	108	400	0
$PM_{2.5}$	24 hr	22	INS	61	30	1
PM_{10}*	24 hr	37	-	-	50	-
Formaldehyde	24 hr	4.7	2.7	5.6	65	-
Acetaldehyde	24 hr	2.8	1.8	4.5	500	-
Benzene	24 hr	2.9	-	4.9	-	-
1,3-Butadiene	24 hr	0.4	-	1.0	-	-
Acrolein	24 hr	0.1	0.062	0.2	0.08	-

Notes: * The 90^{th} percentile for PM_{10} was calculated based on the 90^{th} percentile for $PM_{2.5}$ concentration times a factor of 1.7. INS – Insufficient data.

The measured values summarized in **Table 5.2** result from a combination of local and regional sources and transboundary effects. In the case of $PM_{2.5}$, elevated levels that occur during smog events are commonly related to regional photochemical processes. According to the MOE's "Air Quality in Ontario – 2005 Report" and "Transboundary Air Quality in Ontario – 2005 Report", transboundary air pollution (mainly from United States) is one of the largest contributors to Ontario's smog events in the summer.

Ambient background levels were combined with the modelled concentrations to determine cumulative impacts. The 90^{th} percentile background was chosen for the analysis because it provides a reasonable worst-case level that does not include extreme events such as upsets or monitoring equipment irregularities. The year 2000 corresponds to the meteorological data used in the air quality assessment. Continuous ambient monitoring data were not available for PM_{10}. The 90^{th} percentile PM_{10} value was calculated based on the 90^{th} percentile $PM_{2.5}$ concentration times a factor of 1.7 [6].

6. METHODOLOGY

The local air quality assessment considered the impacts from vehicular emissions within approximately 500m of the Hanlon Expressway. For emission sources that are close to grade level, such as vehicular sources, the worst-case impacts occur immediately adjacent to the sources. Emissions disperse significantly with downwind distance from these sources resulting in a decrease in air quality impacts. Impacts beyond 500m from a roadway are typically indistinguishable from ambient background levels. Finally, the contaminants of concern for the local air quality assessment are limited to those that have the potential to result in human health effects.

The following summarizes the methodology used for the local air quality assessment. This methodology included emission estimates, dispersion modelling, attainment evaluation, and combined effects analysis. The detailed methodology for the emission estimates and dispersion modelling is provided in Appendix B.

The amount of air pollution produced by an automobile depends on a large number of factors, including the type, age and weight of vehicle, the mode of operation, the weather conditions and the maintenance condition of the vehicle and the road. The standard approach for estimating vehicular emissions is to use computer simulation techniques that are based on extensive previous testing of a wide range of vehicles. The most widely used software for this purpose was developed by the U.S. Environmental Protection Agency, and the latest version of the software is known as MOBILE6.2. This model was applied to determine emissions for existing and future conditions.

In addition to tailpipe emissions, emissions also result from the re-suspension of dust as vehicles travel over a roadway surface. The re-suspended dust emissions were calculated based on the U.S. EPA's AP-42, Chapter 13.2.1 emission factors for paved roads. For particulate matter, the tailpipe emission factor is added to the road dust emission factor in order to account for both emission sources. A discussion of the methodology and the assumptions applied in the emission estimates is provided in Appendix B.

Air contaminants emitted from vehicles on the Hanlon Expressway will drift downwind and disperse as they travel. Contaminant concentrations depend on a variety of factors:

- As speed increases CO and NO_2 concentrations will increase, whereas VOC concentrations will decrease and PM concentrations are not speed dependent;
- As percent heavy duty vehicles travelling on the road increases all contaminant concentrations will increase;
- During idling emissions for CO, NO_2 and VOC will increases, whereas PM concentrations are not affected by speed;
- As the volume of traffic on the road increases, CO, NO_2 and VOC contaminant concentrations will increase, whereas PM concentrations will decrease as the amount of silt loading decreases with the increase in traffic volumes;
- Increase in calm weather conditions will increases concentrations; and
- Decrease in distance from the infrastructure will increase concentrations;

The only approach to determine potential future downwind concentrations from a proposed project is through the use of computer simulation that predicts the dispersal of air pollutants as they drift off-site. These simulations are performed using dispersion models.

Dispersion modelling is a very common approach for assessing local air quality near an emission source such as vehicular traffic. The U.S. EPA developed a model known as CAL3QHCR that is used to determine air contaminant levels along roadways. The model takes the emission data that is calculated with the MOBILE6.2 software and combines it with historical hourly meteorological data and information on the configuration of the roadway. It uses this information to predict roadway contributions to air quality levels at selected locations (receptors) adjacent to the highway under a variety of weather conditions. The detailed methodology for the dispersion modelling, including inputs to CAL3QHCR is provided in Appendix B.

The predicted maximum concentrations resulting from the project, as predicted by the dispersion model, were added to the 90^{th} percentile background concentrations in order to determine the reasonable worst-case cumulative effect. In order to assess attainment, the maximum predicted cumulative concentrations of the contaminants were compared to their applicable ambient thresholds.

7. RESULTS

Tables 7.1 to 7.2 present a summary of the future build and future no-build maximum predicted cumulative concentrations at the most impacted sensitive receptor (i.e. the receptor where the greatest impacts occur), which is a conservative approach. The resultant concentrations are compared to applicable thresholds in order to assess attainment.

Table 7.3 shows the incremental changes in percent between the future build alternative and future no-build alternative, corresponding to the most impacted receptor under the future build alternative. The predicted concentrations for each contaminant at each sensitive receptor location are provided in Appendix C.

Table 7.1: Maximum Predicted Concentrations (μg/m^3) for the Future No-Build Alternative

Contaminant	Averaging Time	Predicted Concentration	90th Percentile Background	Cumulative Concentration	Threshold	% of the Threshold
CO	1-hour	420	715	1135	36,200	3%
NO_2	1-hour	23	57	80	400	20%
$PM_{2.5}$	24-hour	0.1	22	22.1	30	74%
PM_{10}	24-hour	3.94	37	40.9	50	82%
Formaldehyde	24-hour	0.03	4.7	4.73	65	7%
Acetaldehyde	24-hour	0.01	2.8	2.81	500	1%
Benzene	24-hour	0.10	2.9	3.00	N/A	N/A
1,3-Butadiene	24-hour	0.01	0.4	0.41	N/A	N/A
Acrolein	24-hour	0.002	0.1	0.102	0.08	126%

Table 7.2: Maximum Predicted Concentrations (μg/m^3) for Future Build Alternative

Contaminant	Averaging Time	Predicted Concentration	90th Percentile Background	Cumulative Concentration	Threshold	% of the Threshold
CO	1-hour	593	715	1308	36,200	4%
NO_2	1-hour	31	57	88	400	22%
$PM_{2.5}$	24-hour	0.42	22	22.4	30	75%
PM_{10}	24-hour	8.08	37	45.1	50	90%
Formaldehyde	24-hour	0.04	4.7	4.74	65	7%
Acetaldehyde	24-hour	0.01	2.8	2.81	500	1%
Benzene	24-hour	0.13	2.9	3.03	N/A	N/A
1,3-Butadiene	24-hour	0.01	0.4	0.41	N/A	N/A
Acrolein	24-hour	0.002	0.1	0.102	0.08	126%

Table 7.3: Future No-Build Alternative versus Future Build Alternative (μg/m^3)

Contaminant	Averaging Time	Receptor	Future No-Build	Future Build	Incremental Change
CO	1-hour	R57	1135	1308	15%
NO_2	1-hour	R57	80	88	10%
$PM_{2.5}$	24-hour	R59	22.1	22.4	1%
PM_{10}	24-hour	R89	40.9	45.1	10%
Formaldehyde	24-hour	R57	4.73	4.74	0%
Acetaldehyde	24-hour	R57	2.81	2.81	0%
Benzene	24-hour	R57	3.00	3.03	1%
1,3-Butadiene	24-hour	R57	0.41	0.41	0%
Acrolein	24-hour	R57	0.102	0.102	0%

The maximum predicted concentrations for all contaminants at the most impacted sensitive receptor, with the exception of acrolein, were predicted to be less than their respective thresholds for both the future build and future no-build alternatives. In the case of Acrolein, the estimated 90th percentile background level is greater than the criterion, which suggests that the local acrolein levels in the study area already exceed the threshold today and may continue to do so in the future, regardless of whether or not the project is built.

At the most impacted receptor, the predicted maximum concentration of Acrolein due to the project-related emission sources is very small in comparison to the background level, i.e., less than 5%. This is true for both the build and no-build alternative, with very little difference between the two. Therefore, the proposed project has little effect on the predicted status of acrolein concentrations. Note that, in choosing monitoring data to represent the background concentration for Acrolein, data from across Ontario and various sites in the US were reviewed. All sites reported similar concentrations, which indicate that the estimated background level is reasonably reliable.

When comparing results for the future build alternative relative to the future no-build alternative at the most impacted receptor location, concentrations of CO, NO_2, and PM_{10} were predicted to increase while concentrations of $PM_{2.5}$ and VOCs remained similar. In case of CO and NO_2, the maximum predicted concentrations increased at the most impacted receptor (R57) mainly due to the decrease in separation distance between the receptor location and the new service road for future build alternative. However, the maximum predicted concentrations at this receptor location are less than the applicable government criteria.

The VOC concentrations remained similar mainly due to the improved free-flow conditions (i.e. less idle emission) resulting from the interchange improvements. PM_{10} concentrations were predicted to increase at most receptor locations mainly due to the decrease in separation distances for future build alternative as compared to future no-build alternative.

8. CONCLUSIONS

The results of the assessment can be summarized as follows:

- Maximum predicted CO, NO_2, $PM_{2.5}$, PM_{10}, formaldehyde, and acetaldehyde concentrations are all less than their respective government criteria.
- Maximum predicted acrolein concentrations are greater than the applicable government criterion; however, the 90th percentile background level already exceeds the criterion. This suggests that the local acrolein background levels in the study area may continue to exceed in the future, regardless of whether or not the project is built.
- Maximum predicted CO and NO_2 concentrations at the most impacted receptor are predicted to increase marginally for the future build alternative relative to the future no-build alternative. This is primarily due to the decrease in separation distance between the receptor and adjacent roads. However, the maximum predicted concentrations at the most impacted receptor are still less than the applicable government criteria.
- PM_{10} concentrations were predicted to increase marginally at most receptor locations mainly due to decrease in separation distances for the future build alternative as compared to the future no-build alternative.
- Maximum predicted VOC concentrations are predicted to remain similar at the worst-case receptor location for the future build alternative relative to the future no-build condition. This is primarily due to the improved free flow conditions (i.e. less idle emissions) resulting from the future build alternative.

9. REFERENCES

1. Ontario Ministry of the Environment. Summary of Point of Impingement Standards, Point of Impingement Guidelines, and Ambient Air Quality Criteria. December 2005.

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5. Ministry of the Environment. Air Quality in Ontario Summary Reports: 2000 and 2001. http://www.ene.gov.on.ca/envision/techdocs/index.htm#AirQuality.

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FIGURES

LEGEND:

Roadway Link

Sensitive Receptor

Site Plan Showing Location of Roadway Links and Residential Receptors

Future Build (2031) Configuration

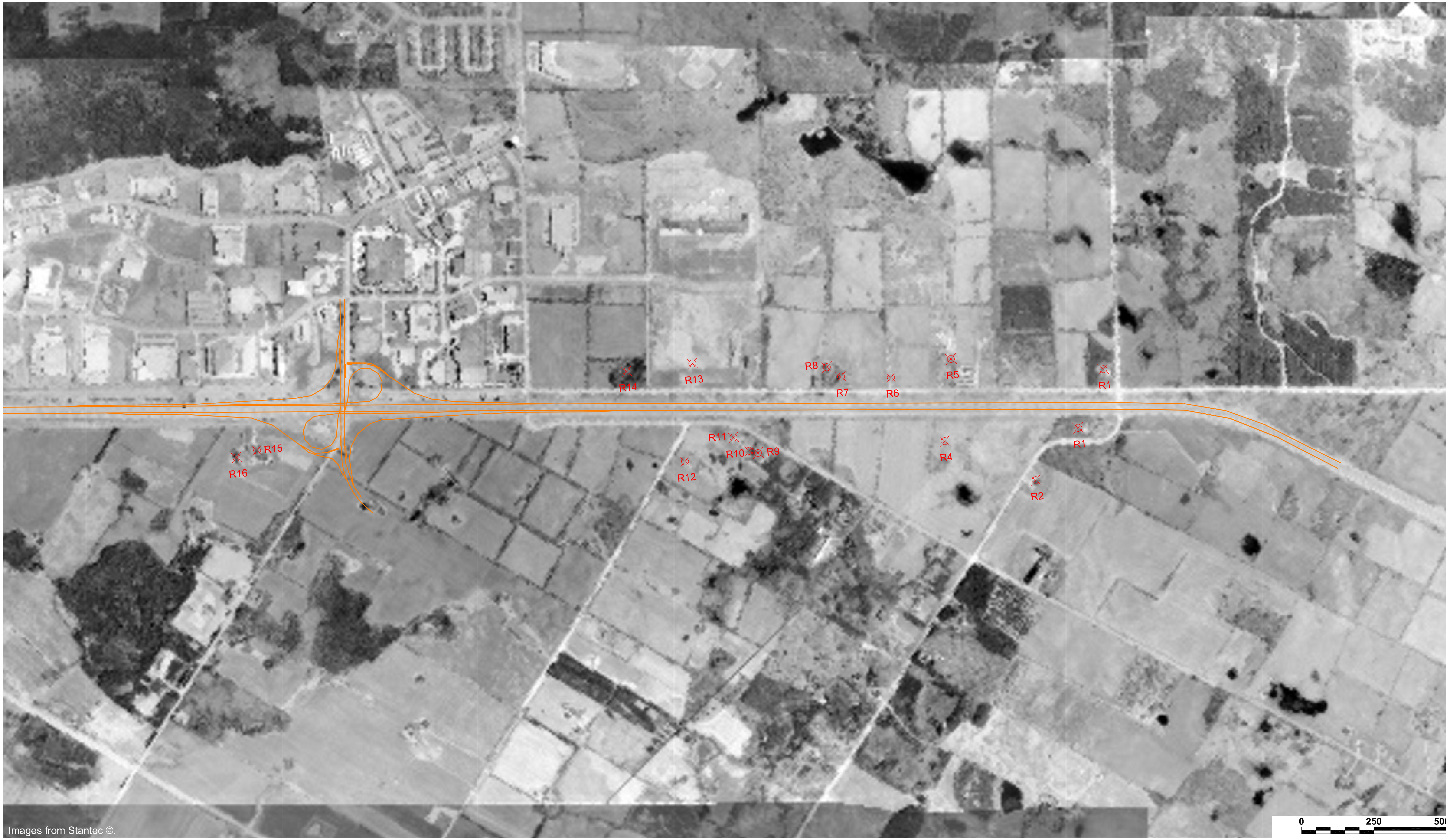
Highway 6 - Hanlon Expressway Improvements - Guelph, Ontario

Project #W08-5174

True North

Drawn by: NTN	Figure: **1a**
Approx. Scale:	1:12 500
Date Revised:	Feb. 5, 2009

RWDI



LEGEND:
Roadway Link
Sensitive Receptor

Site Plan Showing Location of Roadway Links and Residential Receptors
Future Build (2031) Configuration

Highway 6 - Hanlon Expressway Improvements - Guelph, Ontario

True North

Project #W08-5174

Drawn by: NTN | Figure: **1b**

Approx. Scale: 1:12 500

Date Revised: Feb. 5, 2009

RWDI

APPENDIX A

APPENDIX A: AIR QUALITY GLOSSARY OF TERMS

- **90th Percentile:** A term used in statistics to describe the distribution of data. A 90th percentile value selected to represent ambient background concentrations means that the selected background concentration is greater than or equal to 90% of all of the measured values in the dataset; 10% of the measured values are higher than the selected ambient background concentration.

- **AADT:** Annual average daily traffic volumes.

- **AAQC:** Ambient Air Quality Criterion.

- **Absolute Humidity:** Mass of water vapour per unit mass of dry air.

- **Ambient Air:** The air quality at a particular time and place outside of structures. Often used interchangeably with "outdoor air".

- **Atmospheric Stability:** Atmospheric Stability is a measure of the turbulent mixing capacity of the atmosphere. This affects how an exhaust plume will rise and disperse as it travels downwind. The atmosphere is classified as stable, neutral or unstable, according to the rate of change of potential temperature with height. Atmospheric stability is generally classified using the Pasquill-Gifford rating scheme from A to F, where A is unstable (greatest turbulent mixing) and F is the most stable (least turbulent mixing).

- **Carbon Monoxide (CO):** CO is a colourless, odourless, tasteless, and potentially poisonous gas produced primarily by incomplete combustion of fossil fuels. Exposure to high levels of CO is linked with impairment of vision, work capacity, learning ability, and performance of difficult tasks [1].

- **Deposition Velocity**: The rate at which particles are removed from the atmosphere through a number of removal mechanisms.

- **Dispersion Coefficient:** Variables that describe the lateral and vertical spread of a plume.

- **Free Flow Link**: A free flow link is as a straight segment of roadway having a constant width, height, traffic volume and travel speed.

- **Fuel Volatility:** A measure of how easily a fuel vapourizes. If the fuel does not vapourize completely, it will not burn completely.

- **g/VMT:** grams per vehicle mile traveled.

  - **HDV:** Heavy Duty Vehicles include transport trucks, buses etc.

  - **LDV:** Light duty vehicles include automobiles, pickup trucks, motorcycles etc.

- **Mixing Height:** The height above the surface through which relatively vigorous vertical mixing of the atmosphere occurs. The mixing height depth is least in the evening period and is at a maximum in the daytime.

- **Nitrogen Dioxide (NO_2):** All combustion in air produces oxides of nitrogen (NO_X), of which nitrogen dioxide (NO_2) is a major component. NO_2 is a reddish brown gas with a pungent and irritating odour. It transforms in the air to form gaseous nitric acid and toxic organic nitrates. NO_2 also plays a major role in atmospheric reactions that produce ground level ozone, a major component of smog [1].

  It is also a precursor to nitrates, which contribute to increased respirable particle levels in the atmosphere. Exposure to high levels can irritate the lungs and lower resistance to respiratory infection. People with asthma and bronchitis have increased sensitivity [1].

- **Particulate Matter:** Particulate matter is the general term used for a mixture of solid particles and liquid droplets found in the air. These particles, which come in a wide range of sizes, are emitted directly from sources or formed in the atmosphere by the transformation of gaseous emissions into secondary pollutants. Inhalable particulate matter, or PM_{10}, refers to the fraction of PM having a diameter less than or equal to 10 microns. Respirable particulate matter, or $PM_{2.5}$, refers to the fraction of PM having a diameter less than or equal to 2.5 microns. The smaller the particle size, the farther the particle can penetrate into the lungs. Therefore, smaller particles pose the greatest potential for human health effects. The greatest effect on human health is from particles 10 microns or less in diameter, which can aggravate bronchitis, asthma, and other respiratory diseases. People with asthma, cardiovascular or lung disease, as well as children and elderly people, are considered to be the most sensitive to the effects of airborne PM_{10} or $PM_{2.5}$ [1].

- **Queue Link**: A queue link is as a straight segment of roadway with constant width and emission source strength, on which vehicles are idling for a specified period of time (e.g., signalized intersections).

- **Re-suspended Particulate Matter:** Primary emissions of PM_{10} and $PM_{2.5}$ are directly generated from vehicles in the form of exhaust, brake wear and tire wear emissions, and re-suspension of loose material on the road surface (i.e., surface loading). In the absence of continuous addition of fresh material (e.g., localized dirt trackout or application of anti-skid material), paved road surface loading should reach an equilibrium value in which the amount of re-suspended material matches the amount replenished [2]. The equilibrium surface loading value depends upon numerous factors, including the mean speed of vehicles travelling the road, the average daily traffic volume, the number of lanes, the fraction of heavy vehicles, and the presence or absence of curbs, storm sewers, and parking lanes.

- **Roadway Link**: The CAL3QHCR dispersion model predicts pollutant concentrations near roadways by allocating emissions from motor vehicles to a series of linear sources, known as roadway links. A new link must be defined whenever the road width, traffic volume, speed, alignment, or type of traffic movement (free flow) changes.

- **Settling Velocity:** The rate at which particles are removed from the atmosphere due to gravitational settling, expressed in velocity units.

- **Surface Roughness Length:** A measure that indicates how the ground surface will affect local air turbulence and the spread of an exhaust plume as it travels downwind. The surface roughness length or coefficient is typically within a range of 3 cm to 400 cm [4, 5].

- **µg/m³:** Micrograms per cubic meter.

- **Volatile Organic Compounds:** VOCs are defined technically as organic compounds having a saturation vapour pressure greater than 10^{-1} Torr at 25°C and standard atmospheric pressure. Certain VOCs warrant special concern because they are capable of being transported very long distances in the atmosphere and play an important role in the formation of ground level ozone and fine particles. VOCs are emitted into the atmosphere from a variety of sources, including, vehicles, petroleum refining, solvent use (industrial and residential), and paint application [1].

  Formaldehyde is a colourless gas with a pungent, suffocating odour at room temperature. Formaldehyde is used mainly to produce resins. The major emission sources are power plants, manufacturing facilities, incinerators, and vehicle exhaust. Inhalation exposure to high levels of formaldehyde in humans can result in respiratory symptoms, and eye, nose, and throat irritation. Formaldehyde is classified as a probable human carcinogen [6].

  Acetaldehyde is a colourless, flammable liquid, volatile at ambient temperature and pressure, with an irritating odour. Acetaldehyde is used commercially in a wide variety of chemical reactions including the manufacturing of acetic acid. It is both directly emitted into the atmosphere through incomplete combustion as well as formed in the atmosphere from a variety of precursors. Acetaldehyde is classified as a probable human carcinogen [6].

  1,3-Butadiene is a colourless gas with a mild gasoline-like odour and is used in the production of rubber and plastics. Motor vehicle exhaust is a constant source of trace levels of 1,3-butadiene. Inhalation exposure in humans at elevated levels can result in irritation of the eyes, nasal passages, throat, and lungs. 1,3-Butadiene is classified as a probable human carcinogen [6].

  Benzene is primarily used in the production of plastics and other chemical products, which has been linked to various types of leukemia, lymphoma, and blood diseases. Benzene is classified as a human carcinogen [6].

  Acrolein is manufactured as an end-use product and as an un-isolated intermediate in the production of acrylic acid. Acrolein is not commercially produced in Canada but is imported from the United States for use mainly as a pesticide. Exposure to humans can cause eye irritation at low levels of exposure, and has effects on the respiratory system and even fatality at elevated levels of exposure.

References:

[1] Ministry of the Environment. Air Quality in Ontario Summary Reports: 1997 through 2000. http://www.ene.gov.on.ca/envision/techdocs/index.htm#AirQuality.

[2] United States Environmental Protection Agency. Emission Facts: Idling Vehicle Emissions (420-F-98-014). April 1998.

[3] United States Environmental Protection Agency. Compilation of Emission Factors, AP-42, Volume I: Stationary Point and Area Sources (5th ed.). Chapter 13.2.1: Paved Roads. December 2003. http://www.epa.gov/ttn/chief/ap42/index.html

[4] United States Environmental Protection Agency. User's Guide to CAL3QHCR Version 2: A Modelling Methodology for Prediction Pollutant Concentrations Near Roadway Intersections (454/R-92-006). September 1995.

[5] United States Environmental Protection Agency. Addendum to the User's Guide to CAL3QHC Version 2 (CAL3QHCR User's Guide). September 1995.

[6] United States Environmental Protection Agency. Technology Transfer Network Air Toxics Website. http://www.epa.gov/ttn/atw/. June 2004.

APPENDIX B

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Highway 6 (Hanlon Expressway) Improvements Environmental Air Quality Assessment Methodology

1. Local Air Quality Impacts Assessment

1.1 Tailpipe Emission Factors

Emission factors for carbon monoxide (CO), oxides of nitrogen (NO_x), inhalable particulate matter (PM_{10}), respirable particulate matter ($PM_{2.5}$), formaldehyde, acetaldehyde, benzene, 1,3-butadiene and acrolein were derived for the modelled years using the U.S. Environmental Protection Agency's (EPA's) MOBILE6.2 vehicle emissions model for tailpipe vehicle emission factors.

MOBILE6.2 is a software application designed by the United States Environmental Protection Agency (U.S. EPA) that provides estimates of current and future emissions from highway motor vehicles.

Table 1.1.1 summarizes the input parameters required by MOBILE6.2.

Table 1.1.1: MOBILE6.2 Key Model Input Parameters [1]

Parameter	Input
Pollutants	CO, NO_X, PM_{10}, $PM_{2.5}$, Acetaldehyde, Formaldehyde, 1,3-Butadiene, Benzene, Acrolein and CO_2.
Operating Year	2031
Evaluation Month	January
Ambient Temperature	Minimum Daily Temperature = 25.3 °F (-3.7 °C) Maximum Daily Temperature = 11.5 °F (-11.4°C) (Canadian Climate Normals, Guelph)
Altitude	Low
Absolute Humidity	20 Grains /lb
Fuel Volatility	Reid Vapor Pressure (RVP) = 9 psi
Fuel Program	Conventional Gasoline East
Vehicle Speed	100 km/h, 80 km/h, 70 km/h, 60 km/hr, 50 km/hr and 4 km/hr

There are 28 different vehicle types available in MOBILE6.2. The user may set the model to estimate emission factors for any combination of the vehicle types. By default, all of the available vehicle types are included. A summary of the MOBILE6.2 vehicle classification system is provided in Table 1.1.2

Table 1.1.2: MOBILE6.2 Vehicle Classification System [1]

Vehicle Class	Description
LDGV	Light-Duty Gas Vehicles (Passenger Cars)
LDGT1	Light-Duty Gas Trucks 1 (0-6,000 lbs. GVWR, 0-3,750 lbs LVW)
LDGT2	Light-Duty Gas Trucks 2 (0-6,000 lbs GVWR, 3,751-5,750 lbs LVW)
LDGT3	Light-Duty Gas Trucks 3 (6,001-8,500 lbs GVWR, 0-5,750 lbs ALVW)
LDGT4	Light-Duty Gas Trucks 4 (6,001-8,500 lbs GVWR, > 5,750 lbs ALVW)
HDGV2b	Class 2b Heavy-Duty Gasoline Vehicles (8,501-10,000 lbs GVWR)
HDGV3	Class 3 Heavy-Duty Gasoline Vehicles (10,001-14,000 lbs GVWR)
HDGV4	Class 4 Heavy-Duty Gasoline Vehicles (14,001-16,000 lbs GVWR)
HDGV5	Class 5 Heavy-Duty Gasoline Vehicles (16,001-19,500 lbs GVWR)
HDGV6	Class 6 Heavy-Duty Gasoline Vehicles (19,501-26,000 lbs GVWR)
HDGV7	Class 7 Heavy-Duty Gasoline Vehicles (26,001-33,000 lbs GVWR)
HDGV8a	Class 8a Heavy-Duty Gasoline Vehicles (33,001-60,000 lbs GVWR)
HDGV8b	Class 8b Heavy-Duty Gasoline Vehicles (>60,000 lbs GVWR)
LDDV	Light-Duty Diesel Vehicles (Passenger Cars)
LDDT12	Light-Duty Diesel Trucks 1and 2 (0-6,000 lbs GVWR)
HDDV2b	Class 2b Heavy-Duty Diesel Vehicles (8,501-10,000 lbs GVWR)
HDDV3	Class 3 Heavy-Duty Diesel Vehicles (10,001-14,000 lbs GVWR)
HDDV4	Class 4 Heavy-Duty Diesel Vehicles (14,001-16,000 lbs GVWR)
HDDV5	Class 5 Heavy-Duty Diesel Vehicles (16,001-19,500 lbs GVWR)
HDDV6	Class 6 Heavy-Duty Diesel Vehicles (19,501-26,000 lbs GVWR)
HDDV7	Class 7 Heavy-Duty Diesel Vehicles (26,001-33,000 lbs GVWR)
HDDV8a	Class 8a Heavy-Duty Diesel Vehicles (33,001-60,000 lbs GVWR)
HDDV8b	Class 8b Heavy-Duty Diesel Vehicles (>60,000 lbs GVWR)
MC	Motorcycles (Gasoline)
HDGB	Gasoline Buses (School, Transit and Urban)
HDDBT	Diesel Transit and Urban Buses
HDDBS	Diesel School Buses
LDDT34	Light-Duty Diesel Trucks 3 and 4 (6,001-8,500 lbs GVWR)

Notes: GVWR – Gross vehicle weight rating
LVW – Loaded vehicle weight

MOBILE6.2 provides default percentages of each vehicle type. The HDGV and HDDVs were categorized as heavy duty vehicle (HDV) (i.e., HDGV and HDDV) and the remaining vehicle types were categorized as light duty vehicles (LDV). Stantec provided a breakdown of LDV and HDV traffic volumes which were used to calculate composite emission factors for each vehicle type. The resultant emission factors are presented in Tables 1.1.3 and 1.1.4.

The emission factors listed in Tables 1.1.3 and 1.1.4 are based on vehicles operating during January ambient temperatures (minimum and maximum Climate Normals), which resulted in higher emission factors compared to warmer temperatures at other times of year. This was done to produce reasonable worst-case emissions for consideration in the study.

Table 1.1.3: Summary of LDV Emission Factors from MOBILE6.2 (g/VMT)

Year	Pollutant	**100 km/h**	**80 km/h**	**70 km/h**	**60 km/h**	**50 km/h**	**4 km/h**
2031	CO	9.05	7.83	7.26	6.69	6.44	28.2
	NO_x	0.41	0.38	0.37	0.36	0.36	0.74
	PM_{10} [1]	0.025	0.025	0.025	0.025	0.025	0.025
	$PM_{2.5}$ [1]	0.011	0.011	0.011	0.011	0.011	0.011
	Acetaldehyde	0.65	0.65	0.66	0.67	0.71	4.35
	Formaldehyde	1.74	1.73	1.75	1.79	1.91	11.69
	1,3-Butadiene	0.75	0.75	0.76	0.78	0.83	5.11
	Benzene	8.45	8.60	8.73	8.87	9.43	57.4
	Acrolein	0.09	0.09	0.10	0.10	0.11	0.65

Notes: VMT – Vehicle miles traveled
[1] MOBILE6.2 particulate matter emission factors are not speed dependant.
Vehicle particulate matter emission factors include exhaust, brake wear, and tire wear

Table 1.1.4: Summary of HDV Emission Factors from MOBILE6.2 (g/VMT)

Year	Pollutant	**100 km/h**	**80 km/h**	**70 km/h**	**60 km/h**	**50 km/h**	**4 km/h**
2031	CO	2.83	2.06	2.01	2.13	2.45	13.95
	NO_x	0.65	0.46	0.41	0.39	0.38	0.70
	PM_{10} [1]	0.05	0.05	0.05	0.05	0.05	0.05
	$PM_{2.5}$ [1]	0.03	0.03	0.03	0.03	0.03	0.03
	Acetaldehyde	3.32	3.56	3.89	4.40	5.14	16.98
	Formaldehyde	9.06	9.71	10.6	11.99	14.03	46.6
	1,3-Butadiene	0.74	0.80	0.87	0.98	1.16	4.11
	Benzene	2.15	2.28	2.54	2.94	3.59	18.57
	Acrolein	0.40	0.43	0.47	0.53	0.62	2.03

Notes: VMT – Vehicle miles traveled
[1] MOBILE6.2 particulate matter emission factors are not speed dependant.
Vehicle particulate matter emission factors include exhaust, brake wear, and tire wear

1.2 Re-Suspended Road Dust

Emissions of PM_{10} and $PM_{2.5}$ are also generated from re-suspension of loose material on the road surface (i.e., surface loading). Emission factors for re-suspended PM_{10} and $PM_{2.5}$ were estimated by using the following equations from U.S. EPA's AP-42 report, Chapter 13.2.1 [2].

$$E = k(sL/2)^{0.65} (W/3)^{1.5} - C$$

Where:

E = Particulate emission factor (g/VMT)

k = Particle size multiplier for particle size range:
7.3 g/VMT for PM_{10}
1.1 g/VMT for $PM_{2.5}$

sL = Ubiquitous baseline road surface silt loading:
0.015 g/m^2 for SADT traffic that is > 10,000 (freeway)
0.03 g/m^2 for SADT traffic that is > 10,000 (ramp/arterial)
0.06 g/m^2 for SADT traffic that is between 5,000-10,000
0.2 g/m^2 for SADT traffic that is between 500-5,000

W = Average weight of the vehicles travelling the road:
3 tons (recommended for limited access roads by MTO)

C = Emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear:
0.2119 g/VMT for PM_{10}
0.1617 g/VMT for $PM_{2.5}$

The re-entrained road dust particulate emission factors were calculated based on HDV hourly vehicle distributions for commercial vehicles. The particulate emission factors shown in Table 1.2.1 and 1.2.2 include only re-suspended particulate matter from the road surface for the Future No Build Scenario and Future Build Scenario respectively.

Table 1.2.1: AP-42 Re-suspended Particulate Matter Emission Factors for Future No Build Scenario

% Light Duty Vehicles	**% Heavy Duty Vehicles**	**sL (g/m^2)**	**PM_{10} (g/VMT)**	**$PM_{2.5}$ (g/VMT)**
80%	20%	0.03	0.78	0.00
84.8%	15.2%	0.03	0.57	0.00
86.9%	13.1%	0.03	0.48	0.00
88%	12%	0.03	0.44	0.00
		0.06	0.82	0.00
		0.02	2.03	0.18
89.7%	10.3%	0.03	0.37	0.00
91.5%	8.5%	0.03	0.31	0.00
96%	4%	0.03	0.15	0.00
98%	2%	0.03	0.09	0.00
		0.06	0.26	0.00
		0.2	0.81	0.00

Notes: VMT – Vehicle miles traveled.
AADT – Average Annual Daily Traffic.

Table 1.2.2: AP-42 Re-suspended Particulate Matter Emission Factors for Future Build Scenario

% Light Duty Vehicles	% Heavy Duty Vehicles	sL (g/m^2)	PM_{10} (g/VMT)	$PM_{2.5}$ (g/VMT)
80%	20%	0.03	0.78	0.00
85.0%	15.0%	0.03	0.56	0.00
87%	13.0%	0.03	0.48	0.00
88%	12%	0.03	0.44	0.00
90%	10%	0.2	1.76	0.14
91%	9%	0.03	0.33	0.00
95%	5%	0.2	1.14	0.04
96%	4%	0.03	0.15	0.00
98%	2%	0.03	0.09	0.00
		0.06	0.26	0.00
		0.2	0.81	0.00

Notes: VMT – Vehicle miles traveled.
AADT – Average Annual Daily Traffic.

The PM_{10} and $PM_{2.5}$ tailpipe emission factor (from Tables 1.1.3 and 1.1.4) is added to the road dust emission factor in order to account for both types of emission sources.

1.3 Dispersion Modelling

The U.S. EPA's CAL3QHCR dispersion model was used to predict pollutant concentrations attributable to vehicular emissions from future no-build and future build traffic volumes along Highway 6. The CAL3QHCR model is based on the Gaussian plume equation and predicts air pollutant concentrations near highways and arterial streets due to emissions from motor vehicles. The contributions from free flow and queue traffic conditions were included. The CAL3QHCR model processes one year of hourly meteorological data and calculates maximum 1-hour and 24-hour averaged pollutant concentrations [3, 4].

Table 1.3.1 summarizes the key input parameters required for CAL3QHCR.

Table 1.3.1 CAL3QHCR Key Input Parameters

Parameter	Input
Meteorological Data	Year 2000 hourly data and upper air data are from London Airport
Traffic Volumes (AADT)	Provided by Stantec
Hourly Traffic Volume Distribution	Institute of Transportation Engineers (ITE) hourly traffic volume distribution for a 24-hour period.
Deposition Velocity	PM_{10} = 1.1 cm/s $PM_{2.5}$ = 0.1 cm/s
Settling Velocity	PM_{10} = 0.5 cm/s PM2.5 = 0.005 cm/s
Surface Roughness	108 cm – single family residential
Dispersion Coefficient (Urban or Rural)	Urban

1.3.1 Modelling of Roadway Links

The CAL3QHCR dispersion model predicts air pollutant concentrations near highways and arterial streets by allocating emissions from motor vehicles to a series of line sources, known as roadway links. A new link must be defined whenever the road width, traffic volume, speed, alignment, or type of traffic movement (free flow or queue) changes. A free flow link is defined as a straight segment of roadway having a constant width, height, traffic volume, travel speed, and vehicle emission factor. A queue link is defined as a straight segment of roadway with constant width and emission source strength, on which vehicles are idling for a specified period of time (e.g., signalized intersections). The signal timing data at major intersections was provided by Stantec. The model calculates the contribution from all of the relevant links to each individual receptor so the cumulative impact can be determined. A total of 274 links were modelled for the Future Build Year 2031 scenario and 259 links were modelled for the Future No Build Year 2031.

1.3.2 MODELLING ASSUMPTIONS

The assumptions applied in the assessment were as follows:

1. Traffic lanes were modelled assuming the following
   (a) Future No-Build

   - Highway 6 south and north bound were modelled assuming two southbound lanes and two northbound lanes with traffic volumes provided by Stantec.
   - Maltby Road was modelled assuming one lane eastbound and one lane westbound with traffic volumes provided by Stantec.
   - Clair Road was modelled assuming one lane eastbound and one lane westbound with traffic volumes provided by Stantec.
   - Laird Road was modelled assuming one lane east of Highway 6 and one lane west of Highway 6 with traffic volumes provided by Stantec.

- Kortright Road/Downey Road were modelled assuming two lanes eastbound on Kortright Road and two lanes westbound on Downey Road with traffic volumes provided by Stantec.
- Stone Road was modelled assuming two lanes east of Highway 6 and one lane in each direction west of Highway 6 with traffic volumes provided by Stantec.
- College Avenue was modelled assuming two lanes east of Highway 6 and two lanes west of Highway 6 with traffic volumes provided by Stantec.

(b) Future Build
- Highway 6 south and north bounds were modelled assuming two southbound lanes and two northbound lanes with traffic volumes provided by Stantec.
- Access to Maltby Road from the highway is closed and the road is discontinued, therefore did not have traffic volumes.
- Access to Clair Road from the highway is closed and the road is discontinued, therefore did not have traffic volumes.
- Laird Road was modelled assuming three lanes east of Highway 6 and three lanes west of Highway 6 with traffic volumes provided by Stantec.
- Kortright Road and Downey Road were modelled assuming two lanes eastbound on Kortright and two lanes westbound on Downey Road with traffic volumes provided by Stantec.
- Stone Road was modelled assuming three lanes in each direction east of Highway 6 and three lanes in each direction west of Highway 6 with traffic volumes provided by Stantec.
- Access to College Avenue from the Highway is closed, but traffic will be rerouted under the Highway, volumes provided by Stantec
- A new connecting road from west of Kortright Road to west of Stone Road with traffic volumes provided by Stantec.

2. Based on data provided by Stantec, worst-case traffic speeds and volumes in Table 1.3.1 and Table 1.3.2 were assumed to be as follows:

Table 1.3.1 Future No-Build Traffic Speeds and Volumes

Road	Speed (km/h)	Volume (AADT) [1]
Highway 6 – South of Clair Road	80	40050
Highway 6 – Clair Road to Kortright Road	80	37700
Highway 6 – Kortright Road to Stone Road	70	38820
Highway 6 – Stone Road to Wellington Road	70	41170
Maltby Road – East West	50	600/600
Clair Road – East/West	50	5,100/600
Laird Road – East/West	60	12,000/6,250
Kortright/Downey Road	50	5200/78700
Stone Road	50	7370/2160
College Avenue	50	5580/2050

Notes:
[1] Used PM Peak hourly traffic volumes provided by Stantec (10% of AADT) for some roads where AADT was not provided.

Table 1.3.2 Future Build Traffic Speeds

Road	Speed (km/h)	Volume (AADT) [1]
Highway 6 – South of Clair Road	100	39,730
Highway 6 – Clair Road to Kortright Road	100	57,230
Highway 6 – Kortright Road to Stone Road	100	50,830
Highway 6 – Stone Road to Wellington Road	100	63,520
Laird Road – East/West	60	2600/12000
Laird Road - Ramps	60	2500
Kortright/Downey Road (East/West)	50	3670/8700
Kortright/Downey Road - Ramps	60	1880/5510
Stone Road – East/West	50	3710/15340
Stone Road – Ramps	60	4520/7280
College Avenue – East/West	50	2,500/3,500

Notes:
* Increased speed limit to 100 km/h as it approaches Highway 6 for long ramps.
[1] Used PM Peak hourly traffic volumes provided by Stantec (10% of AADT) for some roads and ramps where AADT was not provided.

3. Stantec provided worst-case queuing information for the following:
(a) Future No-Build
- Maltby Road Intersection
- Clair Road Intersection
- Laird Road Intersection
- Kortright and Downey Road Intersection
- Stone Road Intersection
- College Avenue Intersection

(b) Future Build
- Laird Road Ramp Lights
- Kortright Road Ramp Lights
- Stone Road Ramp Lights

1.3.3 Sensitive Receptors

In the context of this air quality assessment, sensitive receptors refer to residences, churches, daycare facilities, hospitals and senior housing facilities throughout the study area. Special consideration is given to sensitive receptors because of the increased potential for adverse health effects at these locations.

Based on RWDI's previous experience, predicted local air quality impacts associated with roadways tend to drop off significantly at downwind distances greater than 250 m from a roadway. A total of 101 receptors were identified within this separation distance along Highway 6 (between Wellington Street and Maltby Road) and have been included in the model. Refer to Figures 1a to 1d for the sensitive receptor locations considered in the assessment.

2. References

1. United States Environmental Protection Agency. User's Guide to MOBILE6.1 and MOBILE6.2: Mobile Source Emission Factor Model (420R-02-028). 2002.

2. United States Environmental Protection Agency. Compilation of Emission Factors, AP-42, Volume I: Stationary Point and Area Sources (5th ed.). Chapter 13.2.1: Paved Roads. December 2003. http://www.epa.gov/ttn/chief/ap42/index.html

3. United States Environmental Protection Agency. Addendum to the User's Guide to CAL3QHC Version 2 (CAL3QHCR User's Guide). September 1995.

4. United States Environmental Protection Agency. User's Guide to CAL3QHCR Version 2: A Modelling Methodology for Prediction Pollutant Concentrations Near Roadway Intersections (454/R-92-006). September 1995.

APPENDIX C

Table 7.4: Maximum Predicted 24-Hour Average PM_{10} and $PM_{2.5}$ Concentrations, Including 90th Percentile Background Concentration (µg/m3)

Receptor No.	PM10 [2]			PM2.5[4]		
	Future No-Build Predicted Cumulative Concentration [1] (µg/m³)	Future Build Predicted Cumulative Concentration [1] (µg/m³)	Percent Change Between Future No-Build and Future Build (%)	Future No-Build Predicted Cumulative Concentration [3] (µg/m³)	Future Build Predicted Cumulative Concentration [3] (µg/m³)	Percent Change Between Future No-Build and Future Build (%)
R1	43.59	40.95	-6%	22.18	22.38	0.9%
R2	39.36	38.58	-2%	22.07	22.15	0.3%
R3	40.45	39.67	-2%	22.11	22.27	0.7%
R4	41.31	39.84	-4%	22.11	22.28	0.8%
R5	39.89	39.22	-2%	22.07	22.23	0.7%
R6	41.1	40.23	-2%	22.10	22.33	1.0%
R7	41.02	40.16	-2%	22.10	22.32	1.0%
R8	40.31	39.58	-2%	22.08	22.26	0.8%
R9	40.41	39.37	-3%	22.09	22.24	0.6%
R10	40.55	39.46	-3%	22.10	22.24	0.7%
R11	41.77	40.23	-4%	22.13	22.32	0.9%
R12	40.01	39.24	-2%	22.09	22.21	0.5%
R13	40.12	39.57	-1%	22.09	22.23	0.7%
R14	40.64	40.28	-1%	22.12	22.25	0.6%
R15	40.88	**42.51**	4%	22.16	**22.26**	0.5%
R16	40.4	41.39	2%	22.13	22.21	0.4%
R17	40.86	38.76	-5%	22.11	22.08	-0.2%
R18	39.82	38.58	-3%	22.09	22.07	-0.1%
R19	40.68	38.72	-5%	22.11	22.07	-0.2%
R20	39.78	38.55	-3%	22.09	22.07	-0.1%
R21	41.5	40.23	-3%	22.13	22.11	-0.1%
R22	40.04	40.25	1%	22.09	22.11	0.1%
R23	41.31	41.46	0%	22.12	22.15	0.1%
R24	39.68	40.83	3%	22.09	22.13	0.2%
R25	39.37	41.89	6%	22.11	22.17	0.3%
R26	38.62	39.94	3%	22.07	22.10	0.1%
R27	38.24	39.05	2%	22.05	22.07	0.1%
R28	37.92	38.4	1%	22.04	22.06	0.1%
R29	39.4	42.58	8%	22.12	22.17	0.2%
R30	39.04	40.47	4%	22.10	22.11	0.1%
R31	38.55	40.18	4%	22.05	22.15	0.4%
R32	38.37	39.32	2%	22.04	22.11	0.3%
R33	38.19	38.61	1%	22.04	22.08	0.2%
R34	37.92	38.1	0%	22.03	22.05	0.1%
R35	38.04	38.17	0%	22.04	22.05	0.1%
R36	37.91	38.26	1%	22.03	22.05	0.1%
R37	38.29	39.28	3%	22.04	22.11	0.3%
R38	39.67	41.43	4%	22.11	22.13	0.1%
R39	39.18	39.81	2%	22.10	22.09	0.0%
R40	38.41	39.25	2%	22.07	22.08	0.1%
R41	38.2	38.66	1%	22.05	22.07	0.1%
R42	37.91	38.33	1%	22.03	22.06	0.1%
R43	38.19	38.68	1%	22.05	22.07	0.1%
R44	38.5	39.11	2%	22.06	22.08	0.1%
R45	39.78	40.97	3%	22.11	22.13	0.1%
R46	39.07	39.61	1%	22.08	22.10	0.1%
R47	39.27	42.17	7%	22.08	22.24	0.7%
R48	38.94	40.88	5%	22.07	22.18	0.5%
R49	39.74	42.82	8%	22.11	22.20	0.4%
R50	39.3	40.6	3%	22.09	22.13	0.2%
R51	39.82	40.55	2%	22.10	22.15	0.2%
R52	38.97	40.16	3%	22.08	22.14	0.3%
R53	39.43	40.89	4%	22.10	22.17	0.4%
R54	38.43	39.66	3%	22.06	22.12	0.3%
R55	41.49	43.66	5%	22.16	22.22	0.3%
R56	41.5	43.79	6%	22.16	22.25	0.4%
R57	41.52	44.83	8%	22.16	22.33	0.8%
R58	39.26	40.06	2%	22.09	22.14	0.3%
R59	40.94	45.08	10%	22.14	22.32	0.8%
R60	39.98	42.72	7%	22.11	22.25	0.6%
R61	39.14	41.24	5%	22.08	22.22	0.7%
R62	38.81	39.88	3%	22.07	22.14	0.3%
R63	38.68	39.9	3%	22.06	22.16	0.5%
R64	38.41	40.09	4%	22.05	22.25	0.9%
R65	38.52	39.25	2%	22.06	22.15	0.4%
R66	38.14	41.55	9%	22.04	22.38	1.5%
R67	38.1	38.63	1%	22.04	22.11	0.3%
R68	39.2	40.85	4%	22.09	22.17	0.4%
R69	38.59	40.4	5%	22.07	22.16	0.4%
R70	38.38	40.57	6%	22.07	22.17	0.5%
R71	38.58	41	6%	22.06	22.23	0.8%
R72	38.02	39.96	5%	22.04	22.21	0.8%
R73	38.11	39.65	4%	22.04	22.16	0.6%
R74	39.45	40.63	3%	22.10	22.17	0.3%
R75	39.06	40.3	3%	22.09	22.15	0.3%
R76	39.25	39.83	1%	22.10	22.12	0.1%
R77	39.85	40.1	1%	22.12	22.16	0.2%
R78	38.99	39.24	1%	22.09	22.11	0.1%
R79	40.73	41.27	1%	22.16	22.20	0.2%
R80	39.84	40.63	2%	22.13	22.16	0.1%
R81	40.31	40.26	0%	22.15	22.16	0.1%
R82	39.91	40.41	1%	22.14	22.17	0.1%
R83	39.83	40.34	1%	22.13	22.21	0.4%
R84	38.51	41.26	7%	22.07	22.29	1.0%
R85	38.22	40.58	6%	22.06	22.31	1.1%
R86	37.98	38.45	1%	22.04	22.09	0.2%
R87	**43.49**	40.88	-6%	**22.35**	22.26	-0.4%
R88	40.21	41.81	4%	22.19	22.36	0.8%
R89	38.95	42.59	9%	22.10	22.42	1.4%
R90	37.91	38.43	1%	22.04	22.10	0.3%
R91	37.77	38.25	1%	22.04	22.09	0.3%
R92	38.21	39.46	3%	22.06	22.17	0.5%
R93	40.13	39.8	-1%	22.13	22.18	0.2%
R94	41.02	40.04	-2%	22.17	22.13	-0.2%
R95	41.07	40.5	-1%	22.17	22.14	-0.2%
R96	38.95	38.54	-1%	22.08	22.09	0.0%
R97	39.69	39.28	-1%	22.11	22.16	0.2%
R98	39.82	39.21	-2%	22.12	22.16	0.2%
R99	38.81	38.42	-1%	22.08	22.09	0.1%
R100	41.01	42.86	5%	22.17	22.24	0.3%
R101	41.41	42.79	3%	22.16	22.33	0.8%

Notes:

[1] The 90th percentile background concentration was calculated from year 2000 $PM_{2.5}$ hourly ambient data from MOE Station No. 28028 (Guelph) of 37 µg/m³.

[2] The MOE's Interim 24-Hour AAQC for PM10 is 50µg/m³.

[3] The 90th percentile background concentration (22 µg/m³) is from year 2000 from MOE Station No. 28028 (Guelph).

[4] Canada Wide Standard (CWS) for PM2.5 is 30 µg/m3 established for the year 2010 based on the 98th percentile ambient measurement annually, average over three consecutive years.

Bold Indicates the highest impact per modelling scenario

Table 7.5: Maximum Predicted 1-Hour Average NO2 and CO Concentrations, Including 90th Percentile Background Concentration (µg/m3)

Receptor No.	NO2 [2]			CO [4]		
	Future No-Build Predicted Cumulative Concentration [1] (µg/m³)	Future Build Predicted Cumulative Concentration [1] (µg/m³)	Percent Change Between Future No-Build and Future Build (%)	Future No-Build Predicted Cumulative Concentration [3] (µg/m³)	Future Build Predicted Cumulative Concentration [3] (µg/m³)	Percent Change Between Future No-Build and Future Build (%)
R1	79	66	-17.2%	1078	868	-20%
R2	66	62	-5.3%	864	813	-6%
R3	71	62	-12.3%	939	809	-14%
R4	73	65	-10.9%	972	851	-12%
R5	69	63	-8.8%	904	815	-10%
R6	72	64	-11.7%	966	841	-13%
R7	72	64	-10.8%	962	848	-12%
R8	70	64	-8.7%	929	840	-10%
R9	70	67	-4.7%	932	893	-4%
R10	70	67	-5.0%	940	899	-4%
R11	74	69	-7.8%	1005	928	-8%
R12	68	67	-2.2%	912	901	-1%
R13	70	67	-3.9%	930	902	-3%
R14	72	69	-3.9%	966	936	-3%
R15	71	79	12.0%	955	1143	20%
R16	69	73	6.1%	924	1028	11%
R17	73	67	-7.8%	992	906	-9%
R18	69	67	-3.5%	926	891	-4%
R19	72	68	-5.7%	983	920	-6%
R20	69	67	-2.8%	926	899	-3%
R21	76	73	-4.3%	1050	1005	-4%
R22	71	69	-2.1%	969	939	-3%
R23	76	73	-3.7%	1056	1009	-4%
R24	70	71	0.7%	969	963	-1%
R25	70	73	3.7%	1023	999	-2%
R26	66	67	1.5%	901	893	-1%
R27	64	64	0.5%	856	852	0%
R28	64	64	0.0%	838	835	0%
R29	74	79	7.0%	1086	1118	3%
R30	71	74	4.5%	1006	1027	2%
R31	64	72	12.8%	869	999	15%
R32	63	69	9.9%	814	938	15%
R33	62	66	6.5%	804	880	9%
R34	61	62	1.8%	782	803	3%
R35	61	63	2.3%	801	819	2%
R36	61	62	2.1%	797	816	2%
R37	63	69	8.5%	846	934	10%
R38	73	72	-2.2%	1066	986	-8%
R39	71	70	-1.3%	1006	953	-5%
R40	69	69	0.3%	952	933	-2%
R41	67	65	-2.1%	915	868	-5%
R42	64	63	-1.7%	849	827	-3%
R43	65	65	-0.3%	878	857	-2%
R44	67	66	-1.4%	907	879	-3%
R45	74	75	0.5%	1047	1034	-1%
R46	70	69	-1.3%	950	933	-2%
R47	68	77	14.3%	919	1103	20%
R48	66	71	7.7%	889	983	10%
R49	72	77	7.5%	976	1093	12%
R50	70	70	0.0%	948	954	1%
R51	73	72	-2.2%	1022	995	-3%
R52	69	71	3.5%	926	988	7%
R53	69	73	5.3%	941	1023	9%
R54	67	66	-1.5%	910	890	-2%
R55	78	81	3.7%	1108	1146	3%
R56	79	82	4.2%	1110	1184	7%
R57	80	88	10.1%	1135	1308	15%
R58	69	70	1.2%	938	963	3%
R59	79	80	1.8%	1108	1155	4%
R60	74	76	1.9%	1027	1069	4%
R61	70	72	3.7%	946	998	6%
R62	67	68	1.3%	901	920	2%
R63	67	68	2.1%	889	913	3%
R64	65	66	2.2%	854	886	4%
R65	65	65	-0.2%	865	868	0%
R66	63	68	7.6%	817	910	11%
R67	62	62	-0.2%	803	810	1%
R68	69	70	1.3%	955	964	1%
R69	68	68	-0.1%	923	922	0%
R70	69	72	5.5%	939	1003	7%
R71	66	71	6.6%	884	975	10%
R72	62	67	7.7%	802	899	12%
R73	63	66	3.6%	823	875	6%
R74	69	76	10.7%	940	1072	14%
R75	68	75	10.9%	921	1054	14%
R76	73	71	-2.1%	1015	986	-3%
R77	73	73	-0.4%	1019	1017	0%
R78	70	67	-4.2%	959	897	-7%
R79	81	74	-9.1%	1164	1037	-11%
R80	75	73	-3.5%	1072	1016	-5%
R81	78	73	-6.8%	1129	1006	-11%
R82	76	70	-7.8%	1071	957	-11%
R83	74	68	-8.2%	1033	931	-10%
R84	67	75	11.4%	904	1057	17%
R85	64	71	10.0%	848	964	14%
R86	63	65	2.7%	819	853	4%
R87	**99**	**78**	-20.9%	**1573**	**1116**	-29%
R88	79	69	-12.6%	1133	952	-16%
R89	75	72	-3.8%	1069	996	-7%
R90	63	63	1.0%	823	836	1%
R91	63	64	1.3%	828	838	1%
R92	65	66	2.2%	871	894	3%
R93	77	73	-5.9%	1106	1014	-8%
R94	83	72	-13.5%	1196	996	-17%
R95	79	70	-11.6%	1127	997	-12%
R96	68	65	-5.7%	924	876	-5%
R97	77	70	-9.3%	1089	980	-10%
R98	83	72	-13.1%	1191	1028	-14%
R99	77	68	-10.8%	1076	939	-13%
R100	74	83	12.2%	1044	1203	15%
R101	74	79	5.9%	1077	1125	4%

Notes:
[1] The 90th percentile background concentration (57 µg/m³) is from year 2000 from MOE Station No. 26060 (Kitchener).
[2] The MOE's 1-Hour AAQC for NOX is 400µg/m³.
[3] The 90th percentile background concentration (715 µg/m³) is from year 2000 from MOE Station No. 26060 (Kitchener).
[4] The MOE's 1-Hour AAQC for CO is 36,200µg/m³.
Bold Indicates the highest impact per modelling scenario

Table 7.6: Maximum Predicted 24-Hour Average 1,3-Butadiene and Acetaldehyde Concentrations, Including 90th Percentile Background Concentration ximum Predicted 24-H

Receptor No.	1,3-Butadiene [2]			Acetaldehyde [4]		
	Future No-Build Predicted Cumulative Concentration [1] (µg/m³)	Future Build Predicted Cumulative Concentration [1] (µg/m³)	Percent Change Between Future No-Build and Future Build (%)	Future No-Build Predicted Cumulative Concentration [3] (µg/m³)	Future Build Predicted Cumulative Concentration [3] (µg/m³)	Percent Change Between Future No-Build and Future Build (%)
R1	0.41	0.40	-1.3%	2.81	2.81	-0.3%
R2	0.40	0.40	-0.3%	2.80	2.80	-0.1%
R3	0.40	0.40	-0.5%	2.81	2.80	-0.1%
R4	0.41	0.40	-0.7%	2.81	2.80	-0.2%
R5	0.40	0.40	-0.4%	2.81	2.80	-0.1%
R6	0.41	0.40	-0.5%	2.81	2.80	-0.2%
R7	0.41	0.40	-0.5%	2.81	2.80	-0.1%
R8	0.40	0.40	-0.3%	2.81	2.80	-0.1%
R9	0.40	0.40	-0.3%	2.81	2.80	-0.1%
R10	0.41	0.40	-0.3%	2.81	2.80	-0.1%
R11	0.41	0.40	-0.5%	2.81	2.80	-0.2%
R12	0.40	0.40	0.0%	2.81	2.80	-0.1%
R13	0.40	0.40	0.1%	2.81	2.80	-0.1%
R14	0.41	0.41	0.2%	2.81	2.80	-0.1%
R15	0.41	0.42	1.9%	2.81	2.81	0.1%
R16	0.41	0.41	1.2%	2.81	2.81	0.0%
R17	0.41	0.40	-0.5%	2.81	2.80	-0.2%
R18	0.40	0.40	-0.3%	2.81	2.80	-0.1%
R19	0.41	0.40	-0.5%	2.81	2.80	-0.2%
R20	0.40	0.40	-0.3%	2.81	2.80	-0.1%
R21	0.41	0.41	-0.3%	2.81	2.81	-0.1%
R22	0.41	0.41	0.1%	2.81	2.81	-0.1%
R23	0.41	0.41	0.1%	2.81	2.81	-0.1%
R24	0.41	0.41	0.3%	2.81	2.81	0.0%
R25	0.41	0.41	-0.1%	2.81	2.81	-0.1%
R26	0.41	0.41	0.0%	2.81	2.81	-0.1%
R27	0.40	0.40	0.0%	2.80	2.80	0.0%
R28	0.40	0.40	0.0%	2.80	2.80	0.0%
R29	0.41	0.41	-0.1%	2.81	2.81	-0.1%
R30	0.41	0.41	-0.4%	2.81	2.81	-0.1%
R31	0.40	0.41	0.8%	2.81	2.81	0.1%
R32	0.40	0.41	0.6%	2.80	2.80	0.0%
R33	0.40	0.40	0.3%	2.80	2.80	0.0%
R34	0.40	0.40	0.1%	2.80	2.80	0.0%
R35	0.40	0.40	0.1%	2.80	2.80	0.0%
R36	0.40	0.40	0.2%	2.80	2.80	0.0%
R37	0.40	0.40	0.5%	2.80	2.80	0.0%
R38	0.41	0.41	-0.2%	2.81	2.81	-0.1%
R39	0.41	0.40	-0.4%	2.81	2.80	-0.1%
R40	0.40	0.40	-0.2%	2.81	2.80	-0.1%
R41	0.40	0.40	0.1%	2.80	2.80	0.0%
R42	0.40	0.40	0.1%	2.80	2.80	0.0%
R43	0.40	0.40	0.1%	2.80	2.80	0.0%
R44	0.40	0.40	0.0%	2.81	2.80	-0.1%
R45	0.41	0.41	-0.3%	2.81	2.81	-0.1%
R46	0.41	0.41	0.0%	2.81	2.80	-0.1%
R47	0.41	0.41	1.5%	2.81	2.81	0.1%
R48	0.41	0.41	1.0%	2.81	2.81	0.1%
R49	0.41	0.41	0.8%	2.81	2.81	0.1%
R50	0.41	0.41	0.1%	2.81	2.81	-0.1%
R51	0.41	0.41	0.4%	2.81	2.81	0.0%
R52	0.41	0.41	0.8%	2.81	2.81	0.0%
R53	0.41	0.41	1.2%	2.81	2.81	0.0%
R54	0.40	0.41	0.6%	2.80	2.81	0.0%
R55	0.41	0.41	0.6%	2.81	2.81	0.0%
R56	0.41	0.41	1.1%	2.81	2.81	0.0%
R57	0.41	0.42	2.0%	2.81	2.81	0.1%
R58	0.41	0.41	0.4%	2.81	2.81	-0.1%
R59	0.41	0.42	2.2%	2.81	2.81	0.1%
R60	0.41	0.41	1.7%	2.81	2.81	0.1%
R61	0.40	0.41	1.2%	2.81	2.81	0.1%
R62	0.40	0.41	0.6%	2.81	2.81	0.0%
R63	0.40	0.41	0.6%	2.81	2.81	0.0%
R64	0.40	0.40	0.4%	2.80	2.80	0.0%
R65	0.40	0.40	0.3%	2.80	2.80	0.0%
R66	0.40	0.40	0.5%	2.80	2.80	0.0%
R67	0.40	0.40	0.1%	2.80	2.80	0.0%
R68	0.41	0.41	0.7%	2.81	2.81	0.0%
R69	0.40	0.41	0.6%	2.81	2.81	0.0%
R70	0.40	0.41	0.2%	2.81	2.81	0.0%
R71	0.40	0.41	1.4%	2.80	2.81	0.1%
R72	0.40	0.40	0.5%	2.80	2.80	0.0%
R73	0.40	0.41	0.7%	2.80	2.80	0.0%
R74	0.41	0.41	0.3%	2.81	2.81	0.0%
R75	0.41	0.41	0.4%	2.81	2.81	0.0%
R76	0.41	0.41	-0.1%	2.81	2.81	-0.1%
R77	0.41	0.41	0.0%	2.81	2.81	-0.1%
R78	0.41	0.40	-0.2%	2.81	2.80	-0.1%
R79	0.41	0.41	-0.1%	2.81	2.81	-0.1%
R80	0.41	0.41	0.0%	2.81	2.81	-0.1%
R81	0.41	0.41	-0.8%	2.81	2.81	-0.2%
R82	0.41	0.41	-0.6%	2.81	2.81	-0.2%
R83	0.41	0.41	-0.2%	2.81	2.81	-0.2%
R84	0.40	0.41	1.9%	2.81	2.81	0.1%
R85	0.40	0.41	1.0%	2.80	2.81	0.1%
R86	0.40	0.40	0.1%	2.80	2.80	0.0%
R87	**0.43**	**0.41**	-4.7%	**2.84**	**2.81**	-1.0%
R88	0.41	0.41	-0.3%	2.81	2.81	-0.3%
R89	0.41	0.41	1.6%	2.81	2.81	0.0%
R90	0.40	0.40	0.1%	2.80	2.80	0.0%
R91	0.40	0.40	0.0%	2.80	2.80	0.0%
R92	0.40	0.41	0.4%	2.80	2.80	0.0%
R93	0.41	0.41	-0.8%	2.81	2.80	-0.2%
R94	0.41	0.41	-0.4%	2.81	2.81	-0.2%
R95	0.41	0.41	-0.5%	2.81	2.81	-0.1%
R96	0.40	0.40	-0.3%	2.81	2.80	-0.1%
R97	0.41	0.41	-0.3%	2.81	2.81	-0.1%
R98	0.41	0.40	-0.7%	2.81	2.80	-0.1%
R99	0.40	0.40	-0.4%	2.81	2.80	-0.1%
R100	0.41	0.41	1.2%	2.81	2.81	0.0%
R101	0.41	0.41	0.8%	2.81	2.81	-0.1%

Notes:

[1] The 90th percentile background concentration (0.4 µg/m³) is from year 2000 from NAPS Station No. 061502 (Kitchener).

[2] There are no established air quality criteria for 1,3-Butadiene.

[3] The 90th percentile background concentration (2.8 µg/m³) is from year 2001 from NAPS Station No. 060418 (Toronto).

[4] The MOE's 24-Hour AAQC for Acetaldehyde is 500 µg/m³.

Bold Indicates the highest impact per modelling scenario

Table 7.7: Maximum Predicted 24-Hour Average Acrolein, Benzene and Formaldehyde Concentrations, Including 90th Percentile Background Concentration ximum Predicted 24-Hour Average PM10 and PM2.5 Concentrations, Includ

Receptor No.	Acrolein [2]			Benzene [4]			Formaldehyde [6]		
	Future No-Build Predicted Cumulative Concentration [1] (µg/m³)	Future Build Predicted Cumulative Concentration [1] (µg/m³)	Percent Change Between Future No-Build and Future Build (%)	Future No-Build Predicted Cumulative Concentration [3] (µg/m³)	Future Build Predicted Cumulative Concentration [3] (µg/m³)	Percent Change Between Future No-Build and Future Build (%)	Future No-Build Predicted Cumulative Concentration [5] (µg/m³)	Future Build Predicted Cumulative Concentration [5] (µg/m³)	Percent Change Between Future No-Build and Future Build (%)
R1	0.098	0.097	-1.1%	3.00	2.94	-1.9%	4.74	4.71	-0.5%
R2	0.097	0.096	-0.3%	2.93	2.92	-0.5%	4.71	4.71	-0.1%
R3	0.097	0.096	-0.5%	2.95	2.92	-0.8%	4.72	4.71	-0.2%
R4	0.097	0.097	-0.6%	2.96	2.93	-1.0%	4.72	4.71	-0.3%
R5	0.097	0.096	-0.4%	2.94	2.92	-0.6%	4.72	4.71	-0.2%
R6	0.097	0.097	-0.5%	2.96	2.93	-0.9%	4.72	4.71	-0.2%
R7	0.097	0.097	-0.5%	2.96	2.93	-0.9%	4.72	4.71	-0.2%
R8	0.097	0.096	-0.4%	2.95	2.93	-0.7%	4.72	4.71	-0.2%
R9	0.097	0.097	-0.4%	2.95	2.93	-0.7%	4.72	4.71	-0.2%
R10	0.097	0.097	-0.4%	2.95	2.93	-0.7%	4.72	4.71	-0.2%
R11	0.097	0.097	-0.6%	2.97	2.94	-1.0%	4.73	4.71	-0.3%
R12	0.097	0.097	-0.3%	2.95	2.93	-0.4%	4.72	4.71	-0.1%
R13	0.097	0.097	-0.3%	2.95	2.93	-0.4%	4.72	4.71	-0.1%
R14	0.097	0.097	-0.3%	2.95	2.94	-0.4%	4.72	4.71	-0.2%
R15	0.097	0.098	0.3%	2.98	3.02	1.3%	4.73	4.73	0.1%
R16	0.097	0.097	0.1%	2.97	2.99	0.8%	4.72	4.73	0.0%
R17	0.097	0.097	-0.7%	2.97	2.94	-1.0%	4.72	4.71	-0.3%
R18	0.097	0.096	-0.5%	2.95	2.93	-0.6%	4.72	4.71	-0.2%
R19	0.097	0.097	-0.6%	2.96	2.94	-0.9%	4.72	4.71	-0.3%
R20	0.097	0.096	-0.4%	2.95	2.93	-0.6%	4.72	4.71	-0.2%
R21	0.097	0.097	-0.5%	2.98	2.96	-0.7%	4.73	4.72	-0.2%
R22	0.097	0.097	-0.2%	2.96	2.95	-0.3%	4.72	4.72	-0.1%
R23	0.097	0.097	-0.3%	2.98	2.96	-0.5%	4.73	4.72	-0.1%
R24	0.097	0.097	-0.1%	2.96	2.96	-0.2%	4.72	4.72	0.0%
R25	0.098	0.097	-0.4%	2.99	2.98	-0.5%	4.73	4.72	-0.2%
R26	0.097	0.097	-0.2%	2.96	2.95	-0.4%	4.72	4.71	-0.1%
R27	0.097	0.097	-0.1%	2.94	2.93	-0.2%	4.71	4.71	-0.1%
R28	0.096	0.096	-0.1%	2.93	2.92	-0.2%	4.71	4.71	0.0%
R29	0.098	0.097	-0.3%	3.00	2.98	-0.4%	4.73	4.72	-0.1%
R30	0.097	0.097	-0.4%	2.98	2.95	-0.9%	4.72	4.72	-0.2%
R31	0.097	0.097	0.2%	2.94	2.96	0.6%	4.71	4.72	0.1%
R32	0.097	0.097	0.2%	2.93	2.94	0.5%	4.71	4.71	0.1%
R33	0.096	0.096	0.0%	2.92	2.93	0.2%	4.71	4.71	0.0%
R34	0.096	0.096	0.0%	2.92	2.92	0.0%	4.71	4.71	0.0%
R35	0.096	0.096	-0.1%	2.92	2.92	-0.1%	4.71	4.71	0.0%
R36	0.096	0.096	0.0%	2.92	2.92	0.0%	4.71	4.71	0.0%
R37	0.097	0.097	0.2%	2.93	2.94	0.4%	4.71	4.71	0.1%
R38	0.097	0.097	-0.4%	2.98	2.96	-0.6%	4.73	4.72	-0.2%
R39	0.097	0.097	-0.4%	2.97	2.94	-0.9%	4.72	4.71	-0.2%
R40	0.097	0.097	-0.3%	2.95	2.94	-0.5%	4.72	4.71	-0.1%
R41	0.097	0.096	-0.2%	2.93	2.93	-0.2%	4.71	4.71	-0.1%
R42	0.096	0.096	-0.1%	2.93	2.92	-0.1%	4.71	4.71	0.0%
R43	0.097	0.096	-0.2%	2.93	2.93	-0.2%	4.71	4.71	-0.1%
R44	0.097	0.097	-0.2%	2.94	2.93	-0.4%	4.71	4.71	-0.1%
R45	0.098	0.097	-0.6%	2.99	2.96	-0.9%	4.73	4.72	-0.2%
R46	0.097	0.097	-0.3%	2.96	2.94	-0.5%	4.72	4.71	-0.1%
R47	0.097	0.098	0.6%	2.96	3.01	1.4%	4.72	4.73	0.2%
R48	0.097	0.097	0.3%	2.95	2.98	0.8%	4.72	4.72	0.1%
R49	0.098	0.098	0.3%	2.99	3.01	0.8%	4.73	4.73	0.1%
R50	0.097	0.097	-0.2%	2.97	2.96	-0.3%	4.72	4.72	-0.1%
R51	0.097	0.097	-0.2%	2.97	2.96	-0.2%	4.72	4.72	-0.1%
R52	0.097	0.097	0.0%	2.95	2.96	0.1%	4.72	4.72	0.0%
R53	0.097	0.097	0.1%	2.96	2.97	0.3%	4.72	4.72	0.1%
R54	0.097	0.097	0.0%	2.94	2.95	0.2%	4.71	4.71	0.0%
R55	0.098	0.098	0.0%	3.01	3.01	0.1%	4.74	4.74	0.0%
R56	0.098	0.098	-0.1%	3.00	3.01	0.2%	4.73	4.73	0.0%
R57	0.098	0.098	0.2%	3.00	3.03	0.8%	4.73	4.74	0.1%
R58	0.097	0.097	-0.2%	2.96	2.95	-0.2%	4.72	4.72	-0.1%
R59	0.098	0.098	0.4%	2.99	3.02	1.1%	4.73	4.74	0.2%
R60	0.097	0.097	0.2%	2.97	3.00	0.7%	4.72	4.73	0.1%
R61	0.097	0.097	0.3%	2.95	2.98	0.9%	4.72	4.72	0.1%
R62	0.097	0.097	0.0%	2.94	2.95	0.3%	4.71	4.72	0.0%
R63	0.097	0.097	0.1%	2.94	2.96	0.6%	4.71	4.72	0.0%
R64	0.097	0.097	0.0%	2.94	2.94	0.3%	4.71	4.71	0.0%
R65	0.097	0.097	-0.1%	2.94	2.94	0.1%	4.71	4.71	0.0%
R66	0.097	0.097	0.1%	2.93	2.94	0.4%	4.71	4.71	0.1%
R67	0.096	0.096	-0.1%	2.93	2.93	0.0%	4.71	4.71	0.0%
R68	0.097	0.097	0.0%	2.96	2.96	0.1%	4.72	4.72	0.0%
R69	0.097	0.097	0.1%	2.95	2.96	0.2%	4.72	4.72	0.0%
R70	0.097	0.097	-0.1%	2.95	2.95	-0.1%	4.71	4.71	0.0%
R71	0.097	0.097	0.5%	2.94	2.98	1.3%	4.71	4.72	0.2%
R72	0.096	0.097	0.1%	2.93	2.93	0.3%	4.71	4.71	0.0%
R73	0.096	0.097	0.2%	2.93	2.94	0.5%	4.71	4.71	0.1%
R74	0.097	0.097	-0.2%	2.97	2.97	0.0%	4.72	4.72	-0.1%
R75	0.097	0.097	-0.1%	2.96	2.96	0.1%	4.72	4.72	0.0%
R76	0.097	0.097	-0.3%	2.96	2.94	-0.6%	4.72	4.71	-0.1%
R77	0.097	0.097	-0.4%	2.98	2.96	-0.7%	4.72	4.72	-0.1%
R78	0.097	0.097	-0.3%	2.96	2.94	-0.6%	4.72	4.71	-0.1%
R79	0.098	0.097	-0.5%	3.00	2.98	-0.7%	4.73	4.72	-0.2%
R80	0.097	0.097	-0.4%	2.99	2.97	-0.6%	4.73	4.72	-0.2%
R81	0.098	0.097	-0.9%	3.01	2.96	-1.5%	4.73	4.72	-0.3%
R82	0.098	0.097	-0.8%	3.01	2.97	-1.4%	4.73	4.72	-0.3%
R83	0.097	0.097	-0.6%	2.99	2.96	-1.2%	4.73	4.72	-0.2%
R84	0.097	0.097	0.5%	2.95	2.99	1.5%	4.71	4.72	0.2%
R85	0.097	0.097	0.5%	2.94	2.98	1.5%	4.71	4.72	0.2%
R86	0.096	0.096	-0.1%	2.93	2.93	-0.2%	4.71	4.71	0.0%
R87	**0.101**	**0.097**	-4.1%	**3.20**	**2.95**	-7.6%	**4.80**	**4.72**	-1.7%
R88	0.098	0.097	-1.1%	3.04	2.96	-2.7%	4.74	4.72	-0.4%
R89	0.097	0.097	-0.1%	2.98	2.97	-0.4%	4.72	4.72	0.0%
R90	0.096	0.096	-0.2%	2.93	2.92	-0.3%	4.71	4.71	-0.1%
R91	0.096	0.096	-0.2%	2.93	2.92	-0.3%	4.71	4.71	-0.1%
R92	0.097	0.097	-0.1%	2.94	2.93	-0.2%	4.71	4.71	0.0%
R93	0.097	0.097	-0.9%	2.99	2.94	-1.8%	4.73	4.71	-0.4%
R94	0.098	0.097	-0.8%	3.01	2.96	-1.6%	4.73	4.72	-0.3%
R95	0.098	0.097	-0.5%	3.01	2.96	-1.5%	4.73	4.72	-0.2%
R96	0.097	0.097	-0.4%	2.95	2.93	-0.8%	4.72	4.71	-0.1%
R97	0.097	0.097	-0.4%	2.97	2.95	-0.9%	4.72	4.72	-0.1%
R98	0.097	0.097	-0.6%	2.98	2.94	-1.3%	4.72	4.71	-0.2%
R99	0.097	0.096	-0.4%	2.95	2.93	-0.8%	4.72	4.71	-0.1%
R100	0.098	0.098	0.1%	2.98	3.01	0.9%	4.73	4.73	0.1%
R101	0.098	0.097	-0.3%	2.99	3.00	0.1%	4.74	4.73	-0.1%

Notes:
[1] The 90th percentile background concentration (0.1 µg/m³) is from year 2000 from MOE Station No. 22071 (Simcoe).
[2] The MOE's 24-Hour AAQC for Acrolein is 0.08 µg/m³.
[3] The 90th percentile background concentration (2.9 µg/m³) is from year 2001 from NAPS Station No. 061502 (Kitchener).
[4] There are no established air quality criteria for Benzene.
[5] The 90th percentile background concentration (4.7 µg/m³) is from year 2001 from NAPS Station No. 060418 (Toronto).
[6] The MOE's 24-Hour AAQC for Formaldehyde is 65 µg/m³.
Bold Indicates the highest impact per modelling scenario