AIR QUALITY IMPACT ASSESSMENT FOR THE 407 TRANSITWAY (HIGHWAY 400 TO KENNEDY ROAD)

Prepared for:

LGL Limited
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King City, Ontario
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SENES Consultants Limited
121 Granton Drive, Unit 12
Richmond Hill, Ontario
L4B 3N4

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EXECUTIVE SUMMARY

In the future, additional public transportation will be required to meet the increasing demands of population growth in the Greater Toronto Area. The addition of a bus rapid transit system in York Region will help to alleviate any anticipated pressure that current road and public transit systems will face in the future as a result of increased growth.

A Transit Project Assessment based on the *"Transit Projects and Greater Toronto Transportation Authority Undertakings, Ontario Regulation 231/08"*, is being undertaken to study the implementation of a 23 kilometre bus rapid transit (BRT) system (the 407 Transitway) that will be grade-separated and parallel to Highway 407 between Highway 400 and Kennedy Road in the municipalities of Vaughan, Richmond Hill and Markham, Ontario. The BRT system will consist of a two lane roadway occupied solely by buses. This air quality impact assessment examines existing and future air quality and climate change impacts based on the preferred alternative route of the undertaking.

Comparison of Existing Conditions with Future Scenarios

For both future scenarios with and without the 407 Transitway (2031), the study identifies that compared to existing conditions (2008), air quality will slightly improve for gaseous pollutants due to newer engine technologies and fuels, despite predicted increases in traffic resulting from population growth. However, air quality will deteriorate for particulate based compounds due to:

- increased traffic flow on Highway 407 resulting from population growth in the future and/or,
- increased road silt accumulation as a result of low bus volumes/heavier vehicles on the 407 Transitway.

Additionally, the pollutant burden of carbon dioxide equivalent (CO_{2e}) is expected to increase in the future as a result of increased traffic volumes due to population growth.

Comparison of Future Scenarios

The study shows that within the study area, when compared to the future no-build scenario (2031), adding the 407 Transitway will result in:

- negligible changes in gaseous pollutant concentrations and greenhouse gases (GHGs) throughout the study area;
- a slight increase in $PM_{2.5}$ (particulate matter less than 2.5 μm in diameter) concentrations, particularly at receptors whose distance from a roadway (emission source) decreases with the addition of the Transitway;

- an increase in total suspended particulate (TSP) and PM_{10} (particulate matter less than 10 µm in diameter) concentrations throughout the study area;
- approximately a 2% to 40% increase in TSP and PM_{10} concentrations at sensitive receptor locations adjacent to the 407 Transitway; and,
- negligible changes in gaseous and particulate matter concentrations when station parking lot and passenger pick-up and drop-off (PPUDO) emissions are considered.

Recommended Mitigation

Mitigative measures to reduce the impact of road dust at nearby sensitive areas are recommended where possible. Barriers (i.e., trees/shrubs, or where planned for safety and/or noise issues solid barriers) located along the 407 Transitway at sensitive receptor locations will act as screens and reduce the particulate matter flowing horizontally from the roadway. When recommended mitigation measures are considered it is expected that particulate matter concentrations at sensitive receptor locations will be within MOE standards. As a result, it is recommended that mitigation measures be implemented for the following five residential/sensitive receptor locations:

- Residences on Hartley Court; north of the Transtiway, west of the GO-Barrie rail line;
- Residences on Yellowood Circle; north of Transtiway, east of Dufferin Street;
- Residences on Sassafras Circle; Daniel Reaman Crescent and Lander Crescent; north of Transitway, east of Langstaff Road;
- Residences on Langstaff Road West; west of Transitway; and,
- St. Robert Catholic High School, south of Transitway, east of Leslie Street.

Mitigation through the planting of trees and shrubs has been considered and incorporated into the preliminary landscape design.

In addition, particulate matter emission estimates may have been overly conservative. Recently (June 2010), the U.S. EPA published draft guidance with an updated methodology for estimating road dust emissions (U.S. EPA, 2010). The revised methodology appears to give significantly lower levels of emissions compared to the U.S. EPA 2006 methods used in this assessment. The draft section proposing the revised calculation methodology as well as supporting documentation can be found at http://www.epa.gov/ttn/chief/ap42/ch13/index.html.

If during the detailed design phase of the project the proposed U.S. EPA methods become standard practice, the above recommendations to reduce the impact of particulate matter to nearby sensitive areas should be revisited.

Conservative Nature of Assessment

The air quality impact assessment is considered to be conservative based on the following:

- Industry standard conservative 90th percentile background monitoring values were added to model predicted contaminant concentrations;
- Background monitoring data for PM_{10} and TSP was not available, therefore, the conservative assumption was made that PM_{10} background concentrations are twice $PM_{2.5}$ and TSP background concentrations are twice PM_{10};
- The future with Transitway scenario assumes no reduction in vehicle traffic on Highway 407, however, based on discussions with the MTO and Delcan, it is reasonable to assume that the introduction of the 407 Transitway into the study area will reduce the number of vehicles present within the transportation corridor (i.e., Highway 7 and other regional roads); and,
- Recently (June 2010), the U.S. EPA published draft guidance with an updated methodology for estimating road dust emissions (U.S. EPA, 2010). The revised methodology appears to give significantly lower levels of emissions compared to the U.S. EPA 2006 methods used in this assessment.

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1.0 INTRODUCTION

1.1 PROJECT DESCRIPTION

A Transit Project Assessment based on the *"Transit Projects and Greater Toronto Transportation Authority Undertakings, Ontario Regulation 231/08"*, is being undertaken to study the implementation of a 23 kilometre bus rapid transit (BRT) system (the 407 Transitway) that will be grade-separated and parallel to Highway 407 between Highway 400 and Kennedy Road in the municipalities of Vaughan, Richmond Hill and Markham, Ontario. The Transitway will consist of a two lane roadway occupied solely by buses.

SENES Consultants Limited (SENES) was retained by LGL Limited (LGL) to complete a project-specific Air Quality Impact Assessment (AQIA) to establish the air quality effects that may arise due to the implementation of the undertaking. The preferred route of a BRT system along the Highway 407 right-of-way from Highway 400 to Kennedy Road developed by Delcan Corporation was used for this AQIA.

1.2 STUDY AREA

The study area is approximately 500 metres on either side of Highway 407 between Highway 400 and Kennedy Road. For air quality studies, however, physical boundaries have no meaning since air flows over and/or around everything. As a result, the air quality boundaries can be set arbitrarily to fit the important aspects of any project. Where possible, the project boundaries were used.

1.3 AIR QUALITY IMPACTS OF THE PROJECT ON THE ENVIRONMENT

Air quality manifests itself in two broad ways – through air pollutant concentrations in the air we breathe and through deposition of pollutants to surfaces. Air quality is usually assessed by examining the pollutants that are linked with a particular project. In this case, the pollutants of concern are:

- dust (particles of sizes smaller than 44 µm): three specific size ranges are important – Total Suspended Particulate (TSP), which are those particles approximately 44 µm in diameter and smaller; PM_{10}, which are those particles 10 µm in diameter and smaller; and, $PM_{2.5}$, which are those particles 2.5 µm in diameter and smaller. Dust is entrained in the air by the action of the wind, the wheels of a vehicle on road surfaces, deterioration of vehicle equipment (i.e., brake and tire wear) and directly from the exhaust of engines;
- carbon monoxide (CO): a gas formed by the incomplete combustion of carbon-based fuels that is emitted in vehicle exhaust;

- nitrogen dioxides (NO_x): gases formed when anything is burned in air that are emitted in vehicle exhaust;
- the following Volatile Organic Compounds (VOCs) are typically of concern in transportation projects: 1,3-butadiene, acetaldehyde, acrolein, benzene and formaldehyde which are primarily emitted in vehicle exhaust, but are also present in fuel vapour that escapes from the fuel tank; and,
- Greenhouse Gases (GHGs): carbon dioxide (CO_2), nitrous oxide (N_2O) and methane (CH_4) are emitted when any fuel is burned.

2.0 EXISTING ENVIRONMENTAL CONDITIONS

2.1 CLIMATE AND METEOROLOGICAL DATA

2.1.1 Introduction

Throughout the lower atmosphere (the troposphere), meteorological parameters vary widely in both time and space. For instance, the heat balance at the surface is disturbed when a single cloud moves across the sun.

Meteorology (weather) is the key to understanding air quality. The essential relationship between meteorology and atmospheric dispersion involves the wind in the broadest sense of the term. Wind fluctuations over a very wide range of time and space scales accomplish dispersion and strongly influence other processes associated with it.

In general, the wind flow over the earth is induced by large-scale pressure variations commonly shown on synoptic weather charts. The intensity of these pressure systems and their normal positions or trajectories, determines the general distribution of winds over a given area. Within this large-scale framework, there are many small-scale factors (e.g., local topography and obstacles) that influence the details of air movement in both the vertical and horizontal directions. For most air quality problems, it is the combination of elements of the broad and the detailed patterns that is important.

These patterns dictate where and how far from a source pollutants will travel. The characterization of the existing climatological (long term weather) conditions in the vicinity of a source of pollutants is, therefore, a critical aspect of assessing air quality.

The key meteorological parameters that must be taken into account are wind, temperature and atmospheric structure. The importance of these parameters is outlined below.

2.1.2 Wind

Wind has two significant components – direction and speed.

Direction

Wind direction is reported as the direction from which the wind blows and is based on surface (10 metre) observations. Over the course of a year, wind usually blows from all directions, but with varying frequencies. Certain directions occur more frequently than others. These are known as the prevailing wind directions.

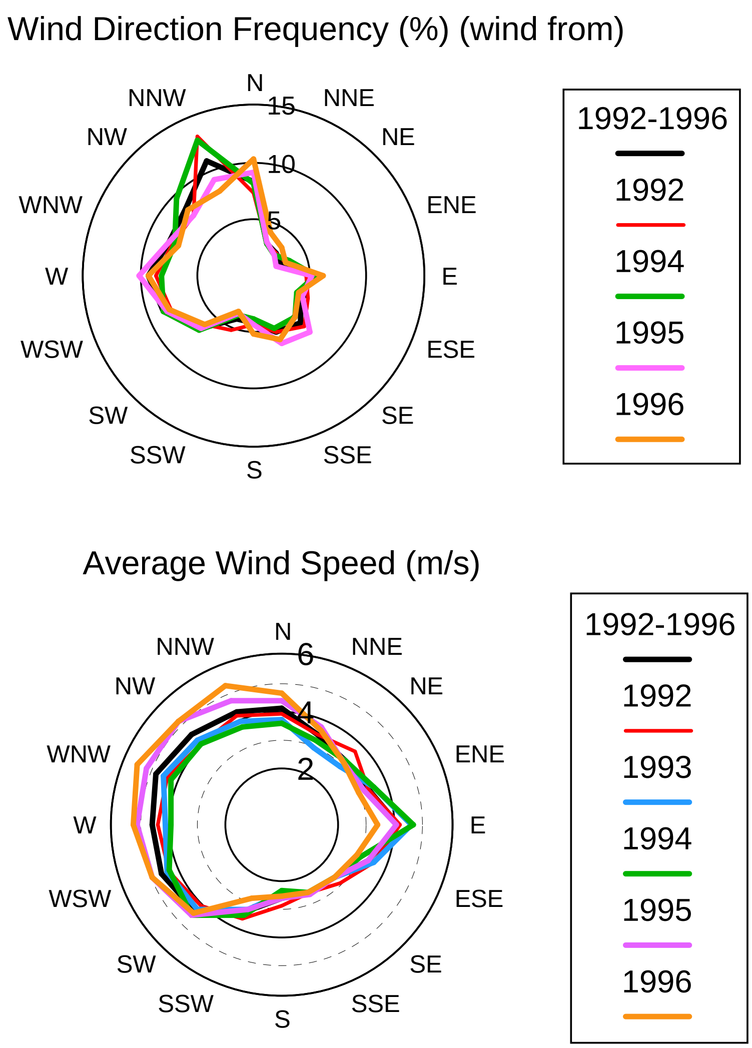
A wind rose is simply a circular representation of the frequencies of each wind direction and/or speed over some period of time (usually a year or longer). Figure 2.1 presents a wind rose for Pearson International Airport (the closest representative meteorological station to the study area) for the years 1992-1996. Figure 2.1 is derived from the current Ontario Ministry of Environment default five year meteorological dataset for the Region of York-Durham (MOE, 2007), which is considered to be representative of existing conditions within the 407 Transitway study area. Wind direction in the area varies considerably over the period. On average, the prevailing winds are from the north-northwest and less often from the west.

Speed

The distribution of average wind speed at the Pearson International Airport station is also presented in Figure 2.1. The average wind speed, based on the 1992-1996 period, is approximately 4 m/s (~14 km/hour).

The concentration of any pollutant in the air decreases with increasing wind speed as a result of dilution. When wind speeds are high there is good dispersion of gases and particles throughout the atmosphere, but more potential for re-suspension of surface dust. When wind speeds are near zero, dispersion is poor and local circulations can lead to very high pollutant concentrations near the surface. Wind speed also increases with height as surface friction decreases. This leads to better dispersion from smokestacks since the wind speed is higher aloft. The lower wind speeds near the ground are the driving force behind the initial mixing and transport of pollutants from vehicles.

Figure 2.1 Wind Rose and Wind Speed for Pearson International Airport



2.1.3 Temperature

There are two key temperature effects that influence air quality – temperature near the surface and temperature aloft.

Temperature near the Surface

Temperature near the surface can greatly affect the dispersion of particulate matter. When it is hot, the surface can dry out, making particulate matter available to be picked up by the wind. Cool temperatures, on the other hand, enable the surface to retain moisture longer, thereby binding the dust particles together and reducing windblown dust. The study area is typical of the Southern Ontario Great Lakes Region with relatively cool spring and fall seasons, hot and humid summers and cold, wet winters.

Temperature Aloft

The change in temperature vertically determines the stability of the atmosphere which is a key parameter controlling the dispersion of gases and particles.

Atmospheric stability is an inherent feature of the vertical temperature structure. It is a measure of the atmosphere's ability to mix pollutants. A stable atmosphere has little vertical motion (is less turbulent) and cannot disperse pollutants as well as a more turbulent, unstable atmosphere. A number of classification schemes have been developed for describing stability classes.

An atmospheric stability classification scheme, developed by Pasquill-Gifford and modified by Turner, is now widely used. Six atmospheric stability classes, A through F, are defined using commonly measured meteorological parameters including wind speed, temperature, lapse rate (rate of change of temperature with height), degree of solar insolation (the strength of the sun at a particular time of day) and the amount of cloud cover.

Class A is the most unstable class, while class F is the most stable. The intermediate Class D is described as a neutral atmosphere. Classes E and F represent progressively more stable conditions, and Classes C, B and A progressively more unstable conditions, respectively. A statistical summary of the atmospheric stability was generated based on the results from a United States Environmental Protection Agency (U.S. EPA) regulatory meteorological pre-processor [PCRAMMET] and applied to the data from the Toronto Pearson Airport station for the period 1992-1996. At this station, neutral stability D (neutral) occurs approximately 53% of the time, C (near neutral) conditions occur about 11% of the time, and stable conditions (E, F) occur about 30% of the time. Stable conditions can produce higher concentrations near the ground because of reduced vertical mixing. Unstable conditions (A, B) occur approximately 5% of the time.

2.1.4 Atmospheric Structure

The structure of the atmosphere is also defined by the vertical temperature change in another fundamental way – by setting a limit on the vertical distance through which pollutants can mix. This vertical extent through which a plume of pollutants can be mixed is called the "mixing height". With a higher mixing height there is a larger volume of air available within which the pollutants can mix, producing lower concentrations. With a lower mixing height, a surface plume from a vehicle would be trapped close to the ground, resulting in higher concentrations.

The concept of mixing height is founded on the principle that heat transferred to the atmosphere at the earth's surface results in convection (vigorous vertical mixing) and the establishment of a dry-adiabatic lapse rate (Holzworth, 1967). In general, mixing height does not have much effect on modelled annual and 24-hour average ground level concentrations (Young and Radonjic, 1993). For 1-hour concentrations, however, mixing height can be very important. The use of variable mixing heights, that are as close as possible to the actual conditions, improves the ability of a model to accurately predict downwind concentrations.

Mixing height is calculated from the vertical temperature profile measured by weather balloon ascents. The distance between stations that release weather balloons is approximately 300 kilometres. The closest upper air station to Toronto is Buffalo, NY. Because mixing height is a regional parameter, the data measured in Buffalo is representative of conditions over Toronto.

2.2 AIR QUALITY STANDARDS

Several measures are used to describe impacts from roadways. Those used in this assessment are as follows:

- Total Suspended Particulate (TSP);
- Fine Particulate Matter less than 10 and 2.5 µm in diameter (PM_{10} and $PM_{2.5}$);
- Nitrogen Oxides (NO_x) with a discussion of NO_2 and NO components;
- Carbon Monoxide (CO);
- Volatile Organic Compounds (VOCs: 1,3-butadiene, acetaldehyde, acrolein, benzene and formaldehyde); and,
- Greenhouse Gases (GHGs: CO_2, N_2O and CH_4).

The contaminants listed above and relevant criteria are discussed in some detail in the remainder of this section.

2.2.1 Total Suspended Particulate (TSP)

Total Suspended Particulate (TSP) is often used to characterize air quality near a dust source. TSP is measured with a high-volume (Hi-Vol) sampler over 24-hours and consists of particles less than 44 μm in diameter. An annual average is calculated as the geometric mean of samples measured every six days.

The provincial ambient air quality criteria for TSP are summarized in Table 2.1.

Table 2.1 MOE Ambient Air Quality Criteria for TSP

Pollutant	Averaging Period	Ambient Air Quality Criteria
Total Suspended Particulate (TSP)	24-hours	120 μg/m^3
	1 year*	60 μg/m^3

* Geometric Mean

The ambient TSP criteria were set to prevent a reduction in visibility. Particles suspended in the atmosphere reduce visibility or the visual range by reducing the contrast between an object being viewed and its background. This reduction is a result of particles scattering or absorbing light coming from both the object and its background, and from particles scattering light into the line of sight (Robinson, 1977). Particles with a radius of 0.1 to 1.0 μm are most effective at reducing visibility. In a rural area where TSP levels are on the order of 30 μg/m^3, the visibility would be about 40 km. At 150 μg/m^3, a common urban concentration, the range would be reduced to about 8 km. The MOE 24-hour criterion of 120 μg/m^3 is based on a visual range of about 10 km.

The importance of TSP as an indicator of air quality is generally decreasing. Impacts from elevated TSP concentrations are extremely localized and are generally nuisance based rather than health based. Consequently, more emphasis is being placed on the finer particulate fractions, namely PM_{10} and $PM_{2.5}$.

2.2.2 Fine Particulate Matter - PM_{10} and $PM_{2.5}$

Many studies over the past few years have indicated that fine particulate matter (PM_{10} and $PM_{2.5}$) in the air is associated with various adverse health effects in people who already have compromised respiratory systems and suffer from asthma, chronic pneumonia and cardiovascular problems. However, the available studies have not been able to link the adverse health effects in such people to any one component of the pollution mix. Fine particulate matter is a mixture of chemically and physically diverse dusts and droplets, and some of these components may be important in determining the effects of PM_{10} and $PM_{2.5}$ on health.

The current 24-hour suggested regulatory limits for fine particulate matter are presented in Table 2.2 as follows:

Table 2.2 Ambient Air Quality Criteria for PM_{10} and $PM_{2.5}$

Pollutant	Averaging Period	Guideline Level	Ambient Air Quality Criteria
PM_{10}	24-hours	Ontario Interim	50 μg/m^3
$PM_{2.5}$	24-hours	Proposed CWS (by 2010)	30 μg/m^3*

CWS = Canada Wide Standard
*Compliance is measured as the 98th percentile over three years

2.2.3 Criteria Air Contaminants (NO_X, CO)

Criteria Air Contaminants (CACs), including nitrogen oxides and carbon monoxide are common air pollutants that are typically released into the air by activities such as fossil fuel combustion.

Nitrogen oxides (NO_x) is the generic term for a group of highly reactive gases, all of which contain nitrogen and oxygen in varying ratios. Nitrogen dioxide (NO_2) is the primary component of concern in NO_x. NO_2 is a reddish brown gas with a pungent odour, which upon reaction with other atmospheric compounds, becomes a major contributor to smog, acid rain, inhalable particulates and reduced visibility. NO_2 also plays a major role in atmospheric reactions that produce ground level ozone. Man-made sources of NO_x include all fossil fuel combustion such as heating buildings, commercial and industrial operations, etc. While motor vehicle exhaust is a significant source of NO_x, only a small percentage is emitted as NO_2 directly from the tailpipe (X. Yao et al, 2005). The main component of NO_x from tailpipes is NO which reacts in the atmosphere over time and distance to form NO_2. The rate of reaction is influenced by many factors including initial concentration, sunlight, ozone concentrations and others.

Carbon monoxide (CO) is a colourless, odourless gas that is produced as a result of incomplete oxidation of carbon during combustion. According to the MOE, in Ontario, over 60% of CO produced is from the transportation sector (MOE, 1999). The remainder is the result of other sources of fossil fuel combustion such as heating buildings, commercial and industrial operations, etc.

The provincial ambient air quality criteria for NO_x and CO are shown in Table 2.3.

Table 2.3 MOE Ambient Air Quality Criteria for Criteria Air Contaminants

Pollutant	CAS No.	Ambient Air Quality Criteria (AAQC)			
		Annual (μg/m^3)	24-hour (μg/m^3)	8-hour (μg/m^3)	1-hour (μg/m^3)
Nitrogen Oxides	10102-44-0	NS	200	NS	400
Carbon Monoxide	630-08-0	NS	15,700	36,200	NS

NS – No Standard.

2.2.4 Volatile Organic Compounds

Volatile Organic Compounds (VOCs) are defined technically as organic compounds having a saturation vapour pressure greater than 0.1 mm of mercury 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. Almost all VOCs contribute to ground-level ozone, and most do not break down in the troposphere during photochemical reactions.

VOCs are emitted into the atmosphere from a variety of sources, including vehicles, fossil fuel combustion, steel-making, petroleum refining, fuel refilling, industrial and residential solvent use, paint application, manufacturing of synthetic materials (e.g., plastics, carpets), food processing, agricultural activities and wood processing and burning.

The U.S. Environmental Protection Agency (U.S. EPA) has identified over 600 air pollutants present in gasoline/diesel exhaust of which 188 are considered to be hazardous air pollutants (HAPs) under the U.S. Clean Air Act (U.S. EPA, 2006a). The U.S. EPA has evaluated this list of HAPs and has identified 21 Mobile Source Air Toxics (MSATs) of which 6 are considered to be priority substances (U.S. EPA, 2000). The priority list of MSATs includes five (5) VOCs (acrolein, benzene, formaldehyde, acetaldehyde and 1,3-butadiene) with the other MSAT being particulate matter. Accordingly, acrolein, benzene, formaldehyde, acetaldehyde and 1,3-butadiene are the VOCs being considered in this study.

The provincial ambient air quality criteria for VOCs are shown in Table 2.4.

Table 2.4 Air Quality Criteria for VOCs

Pollutant	CAS No.	Averaging Period	Ambient Air Quality Criteria
Benzene[a]	71-43-2	24-hour	2.3 µg/m^3
Formaldehyde	50-00-0	24-hour	65 µg/m^3
Acetaldehyde	75-07-0	½-hour and 24-hour	500 µg/m^3
Acrolein[b]	107-02-8	1-hour	4.5 µg/m^3
		24-hour	0.4 µg/m^3
1,3-butadiene[c]	106-99-0	24-hour	10 µg/m^3

a. Proposed MOE AAQC for benzene (EBR Registry No. 010-7186; July, 2009)
b. Acrolein AAQC revised December, 2009 (EBR Registry No. 010-6241)
c. Proposed MOE AAQC for 1,3-butadiene (EBR Registry No. 010-6214; July, 2009)
Source: Ontario's Ambient Air Quality Criteria (February 2008)

Many VOCs are odorous compounds at higher concentrations. Odours from vehicular exhaust are generally acknowledged to be associated with the presence of aldehyde constituents, other minor volatile organic compounds and nitrogen oxides in the exhaust. The aldehydes are largely comprised of formaldehyde, acrolein and acetaldehyde. Table 2.5 indicates the pollutants considered in this study that contribute to odour emissions, together with their associated odour threshold. By definition, the odour threshold of a particular compound is the concentration at which 50% of the population can just detect the presence of an odour under laboratory conditions.

Table 2.5 Considered Constituents of Vehicular Odour Emissions

Pollutant	Odour Threshold (µg/m^3)
Nitrogen Dioxide	230
Formaldehyde	300
Benzene	108,000
Acetaldehyde	120
1, 3 Butadiene	2,400
Acrolein	4,100

Source: American Industrial Hygiene Association, 1989.

2.2.5 Greenhouse Gases

Greenhouse Gases (GHGs) absorb and emit radiation within the thermal infrared range, which is the process regarded as the fundamental cause of the non-natural part of the "greenhouse effect." Greenhouse gases include carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone and chlorofluorocarbons (CFCs). Fossil fuel combustion is the main source of GHG emissions related to this project, which results in emissions of methane (CH_4), carbon dioxide (CO_2) and nitrous oxide (N_2O).

For a given mixture of different GHGs, carbon dioxide equivalent (CO_{2e}) is the unit of measure used to describe the amount of CO_2 that would have the same global warming potential as CO_2 when measured over a time period (typically a 100 year period). The carbon dioxide equivalency for a gas is calculated by multiplying the mass (of the gas) by its global warming potential. For example, the global warming potential for CH_4 over 100 years is 25 and for N_2O is 298 (IPPC, 2007). This means that the emission of 1 tonne of CH_4 is equivalent to the emission of 25 tonnes of CO_2, and the emission of 1 tonne of N_2O is equivalent to the emission of 298 tonnes of CO_2.

2.3 EXISTING AIR QUALITY

2.3.1 Historical Ambient Monitoring Data

The Ontario Ministry of the Environment (MOE) measures air contaminants at various locations throughout Ontario, and reports on the state of Ontario's air quality on an annual basis. To assess the current air quality in the study area, historical air quality monitoring data from the closest MOE monitoring stations to the study area were considered. Tables 2.6 through 2.8 outline the most recent measurement history (2004 to 2008) for NO_x, $PM_{2.5}$ and CO and present a summary of the data in terms of mean, 90^{th} percentile and 1-hour maximum and 24-hour maximum values (8 hour maximum for CO). The MOE Toronto North (34020) monitoring station located on Hendon Avenue near Yonge and Finch was the closest station having available NO_x and $PM_{2.5}$ data. The MOE Toronto Downtown (31103) monitoring station located near the intersection of Bay and Wellesley was the closest station measuring CO. PM, PM_{10}, VOCs and GHGs have not been measured at these locations during the past five years.

The tables indicate that historically, CO has been well within the accepted standards. NO_x and $PM_{2.5}$ have exceeded the standard from time to time, sometimes by as much as double the allowable concentration (usually during smog events which are regional in nature). In summary, the historical data outlines a typical urban/suburban airshed with occasional smog periods during which air quality is compromised. In Ontario, the smog season occurs from May through September, with most events of compromised air quality occurring as a result of transboundary pollution from polluted air masses that flow northward from the Ohio Valley in the United States.

Table 2.6 Recent Ambient Air Quality for $PM_{2.5}$

Station ID	Station Location	Averaging Time	$PM_{2.5}$ (µg/m³)					
			AAQC	Year				
				2004	2005	2006	2007	2008
#34020	Toronto North	Annual Background		9.0	10.0	9.0	9.0	9.0
		24-hr Mean	-	7.7	9.4	7.6	7.8	7.2
		24-hr 90th Percentile	-	17.2	23.7	16	16.4	14.4
		1-hr Maximum	-	69	65	52	60	54
		24-hr Maximum	30*	43	51	36	40	35
		No. of Times above proposed CSW	-	12	19	2	7	1
Average		24-hr 90th Percentile	-	**17.5**				

ND = No Data
*Compliance is measured as the 98th percentile over three years, therefore 10 exceedances (1% of 365x3) of the 24-hr criteria is within compliance for three years or nominally 3 exceedances per year on average for the three most recent monitoring years.
Note: All values are calculated from hourly data available from the http://www.airqualityontario.ca/ website.

Table 2.7 Recent Ambient Air Quality Monitoring for Nitrogen Oxides

Station ID	Station Location	Averaging Time	Nitrogen Oxides (µg/m³)					
			AAQC	Year				
				2004	2005	2006	2007	2008
#34020	Toronto North	24-hr Mean	-	53	57	52	47	46
		1-hr 90th Percentile	-	115	119	111	100	96
		24-hr 90th Percentile	-	102	99	95	87	84
		1-hr Maximum	400	642	803	482	657	476
		24-hr Maximum	200	260	300	253	188	210
		No. of Times above 1-hr AAQC	-	18	26	11	9	9
		No. of Times above 24-hr AAQC	-	2	5	3	0	1
Average		1-hr 90th Percentile	-	**108.2**				
		24-hr 90th Percentile	-	**93.4**				

ND = No Data
Note: All values are calculated from hourly data available from the http://www.airqualityontario.ca/ website.

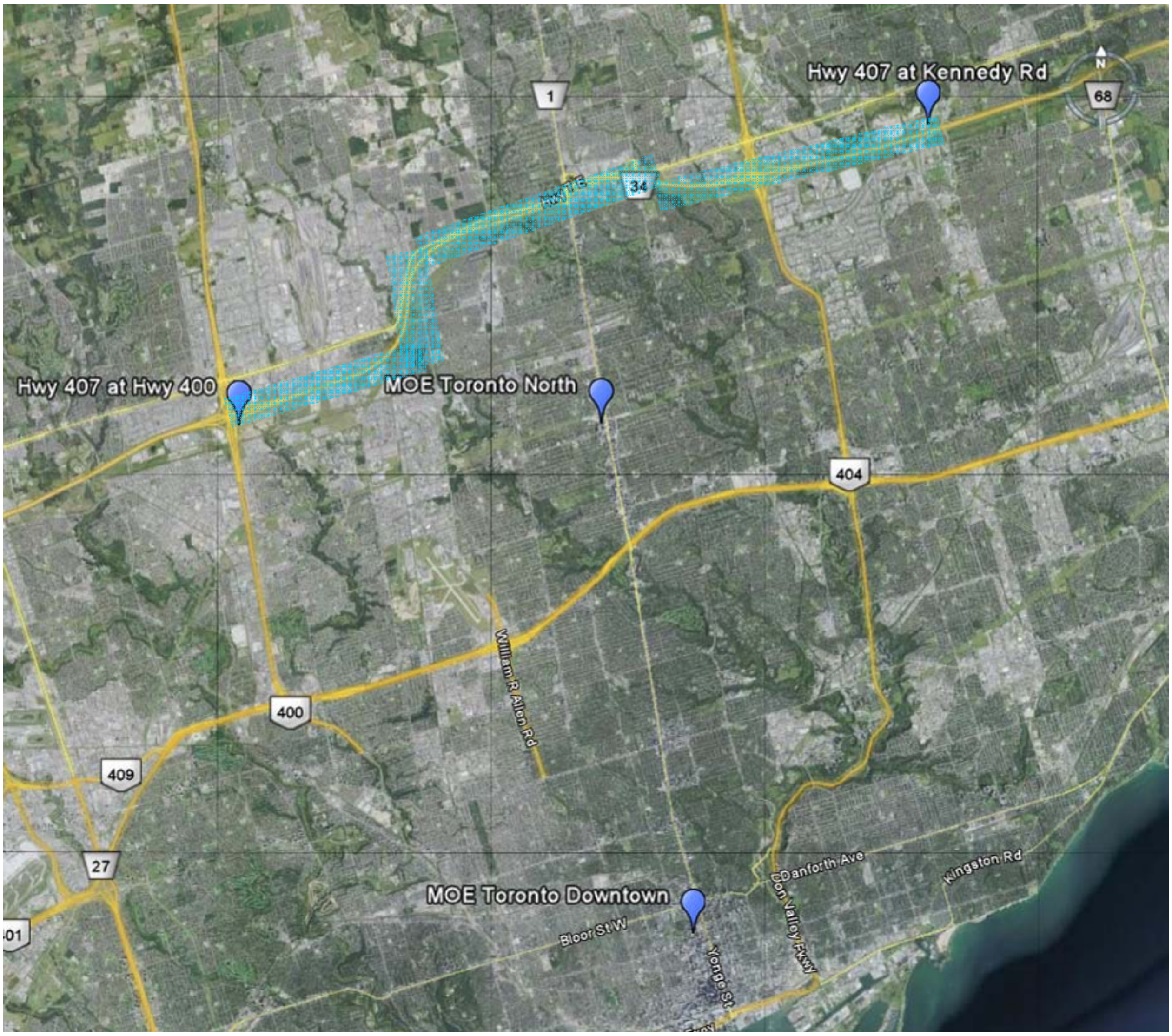
Table 2.8 Recent Ambient Air Quality Monitoring for Carbon Monoxide

Station ID	Station Location	Averaging Time	Carbon Monoxide (μg/m^3)					
			AAQC	Year				
				2004	2005	2006	2007	2008
#31103	Toronto Downtown	1-hr 90th Percentile	-	607	630	584	412	229
		8-hr 90th Percentile	-	591	613	573	424	218
		1-hr Maximum	36,200	2176	1821	1672	1947	1065
		8-hr Maximum	15,700	1431	1317	1168	1237	553
		No. of Times above 1-hr AAQC	-	0	0	0	0	0
		No. of Times above 8-hr AAQC	-	0	0	0	0	0
Average		1-hr 90th Percentile	-	**492.4**				
		8-hr 90th Percentile	-	**483.6**				

ND = No Data
Note: All values are calculated from hourly data available from the http://www.airqualityontario.ca/ website.
All measured 8-hour values are based on 'rolling' 8-hr periods.

Figure 2.2 presents the location of the MOE air quality monitoring locations considered for this study. The approximate extent of the study area is shaded blue for reference.

Figure 2.2 MOE Toronto North and Downtown Monitoring Stations



2.4 BACKGROUND CONCENTRATIONS

Ambient background concentrations used in air quality assessments should represent the contribution from sources such as upwind industrial facilities, other roadways, transboundary pollution, etc. It is important to add background contaminant concentrations to modelled vehicle emission concentrations in order to assess the combined effect of all sources at a specific receptor location for comparison against relevant standards and guidelines because air pollution monitoring stations measure the total pollution in the atmosphere not just that coming from a part of it.

For this assessment, the average 2004 to 2008 90th percentile $PM_{2.5}$, NO_x and CO concentrations (a concentration that will only be exceeded 10% of the time) from the MOE monitoring stations outlined above were used as ambient background values. Although not located within the study area, monitoring station background values were considered to be representative of main road intersections within the study area (e.g., Highway 7 and Leslie Street). A quality assurance estimation showed that the total number of vehicles impacting the Yonge/Finch location was about 60,000 per day in 2001/2002 (City of Toronto, 2002). Similarly, 2001 traffic data for the intersection of Highway 7/Leslie Street showed that about 60,000 vehicles per day impact this location (SENES, 2005) suggesting that the monitoring station 90th percentile values at the Yonge/Finch location are representative of the worst case background concentrations within the study area. Moreover, it is SENES' opinion that 90th percentile values will actually over-estimate the true background concentrations because emissions near Yonge/Finch or Bay/Wellesley will be dispersed less due to the number of buildings in these locations, leading to higher concentrations in general at those locations.

Remaining sources of background not captured by available monitoring data were modelled. The contribution of Highway 407 was not considered to be part of the background value established from the monitoring data. Therefore, Highway 407 was included in the modelling so that all of the background contribution was captured in this assessment.

Ambient background concentrations developed from the monitoring data are outlined in Table 2.9.

Table 2.9 Representative MOE Monitoring Station Average 90th Percentile Background Concentrations (µg/m^3)

Pollutant	$PM_{2.5}$* (24-hr)	NO_x (24-hr)	NO_x (1-hr)	CO (8-hr)	CO (1-hr)
Background	17.5	93	108	**483.6**	**492.4**
MOE Criteria	30	200	400	15,700	36,200

*Canada-Wide Standard

As outlined in the above table, the average 90th percentile CO concentrations are well within MOE AAQC, however, the average 90th percentile 24-hr NO_x and $PM_{2.5}$ concentrations are 47% and 58% of the AAQC, respectively. Oxides of nitrogen exist in several forms in the atmosphere, with most of the vehicular emissions emitted as NO and the remainder as NO_2. NO_x is the sum of all forms of oxides of nitrogen expressed as equivalent NO_2. It should be noted that the AAQC is for NO_2; however, the emission factors used in this assessment are for NO_x. NO is converted over time in the atmosphere to NO_2 in complex reactions. The approach taken is conservative because the emissions estimated will be for NO_x, which will over-estimate the actual NO_2 emitted.

MOE Technical Support Staff have suggested 50 to 60% of PM_{10} is considered to be $PM_{2.5}$ and 50 to 80% of TSP is considered to be PM_{10}. In other words, PM_{10} is 1.7 to 2 times the concentration of $PM_{2.5}$ and TSP is 1.3 to 2 times the concentration of PM_{10}. Since there was no monitoring data available for TSP or PM_{10} concentrations from the representative MOE monitoring stations, the background $PM_{2.5}$ value of 17.5 µg/m^3 was conservatively assumed to be 50% of the PM_{10} value, and the PM_{10} value was conservatively assumed to be 50% of the TSP value. As can be seen in Table 2.10 the estimated background particulate concentrations are between 59% and 70% of AAQC, which is conservatively high.

Table 2.10 24-hour Background Particulate Concentrations (µg/m^3)

Pollutant	**TSP***	**PM_{10}***	**$PM_{2.5}$**
Background	70	35	17.5
Criteria	120	50	30

* PM_{10} concentrations were estimated by doubling the measured $PM_{2.5}$ concentration and TSP concentrations were estimated by doubling the PM_{10} concentration.

The VOCs considered for this study are not generally monitored at any of the MOE Stations within the Region of York, with only benzene and 1,3-butadiene monitored at a select few MOE stations in Ontario. Therefore, urban concentrations measured in major cities similar to Toronto, as provided on the TOXNET website (http://toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB) were used as they would be conservatively high.

Table 2.11 Conservative Background VOC Concentrations (µg/m^3)

Pollutant	Acetaldehyde		Acrolein		Benzene*		1,3-Butadiene*		Formaldehyde	
	1-hr	24-hr	1-hr	24-hr	1-hr	24-hr	1-hr	24-hr	1-hr	24-hr
Background	4.0		0.7		4.4		21		6	
MOE AAQC	500	500	4.5	0.4	n/a	2.3	n/a	10	n/a	65

*Proposed MOE AAQC (July, 2009)

The data in Table 2.11 are likely to be conservatively high since many of the measurements originated from larger U.S. cities in the mid-1970's. Therefore, actual background concentrations are expected to be substantially lower.

It should be noted that the acrolein background of 0.7 µg/m^3 is greater than the 24-hour AAQC (0.4 µg/m^3). Therefore, the modelled plus background concentrations will also be above the 24-hour AAQC. Additionally, the benzene background value (4.4 µg/m^3) and the 1,3-butadiene background value (21 µg/m^3) are greater than the proposed 24-hour AAQC (2.3 µg/m^3 and 10 µg/m^3, respectively). Therefore, the modelled plus background concentrations of benzene and 1,3-butadiene will also be above the proposed 24-hour AAQC. Since the background acrolein, benzene and 1,3-butadiene background values were based on urban concentrations of 0.7, 4.4 and 21 µg/m^3, respectively (New Jersey, 1976) they are considered to be reasonable worst-case background concentrations.

3.0 ATMOSPHERIC EMISSIONS

To assess the impact on air quality within the study area based on the presence of the 407 Transitway, contaminant emissions of CO, NO_x, VOCs, GHGs (CO_2, CH_4, N_2O and CO_{2e}) and particulate matter (PM, PM_{10} and $PM_{2.5}$) were calculated. Modelling was undertaken for all contaminants but GHGs. For GHGs, a pollutant burden analysis was completed whereby the total annual emissions in tonnes or kilotonnes per year of CO_2, CH_4, N_2O and CO_{2e} (CO_2 equivalent) were estimated.

3.1 DESCRIPTION OF ASSESSMENT SCENARIOS

To put the project into perspective over its lifetime, the assessment covered three different scenarios: Existing Conditions (2008), Future **Without** the 407 Transitway (2031), and Future **With** the 407 Transitway (2031). Detailed descriptions and assumptions used in each of the assessment scenarios are as follows.

3.1.1 Existing Conditions (2008)

The 407 Transitway will be constructed in the major traffic corridor of Highway 7 and Highway 407 from Highway 400 to Kennedy Road in the municipalities of Vaughan, Richmond Hill and Markham, Ontario. In particular, the Transitway will be built parallel to and within 100 metres of Highway 407 for most of the route. As a result, it is important to consider traffic impacts of the existing road network in and around the proposed Transitway as a background contribution. As discussed previously, background values established in Section 2.4 are representative of concentrations in and around Highway 7, but are not inclusive of Highway 407. Therefore, the current road network of Highway 407 (typically three lanes in each direction) and its use by an existing vehicle fleet was modelled so that all remaining background was captured.

Using the emissions estimating methods outlined in Section 3.2, an emissions inventory for existing conditions (2008) was developed for Highway 407 between Highway 400 and Kennedy Road. This inventory (excluding GHGs) was input into the CAL3QHCR transportation model (Section 4.0) and the distribution of maximum pollutant concentrations throughout the study area calculated based on hourly meteorological data. Estimated ambient background values (Tables 2.9 to 2.11) were added to modelled concentrations to determine the combined effect of the Transitway and all background sources at specific receptor locations.

A pollutant burden analysis was completed for GHGs whereby the total annual emissions in tonnes or kilotonnes per year were estimated.

3.1.2 Future Without the 407 Transitway (2031)

2031 is the expected year that the Transitway will be in full operation. The future (2031) scenario **without** the 407 Transitway assumes that there are no changes to the existing road network of Highway 407 compared to the Existing Conditions scenario (i.e., three lanes remain in each direction). However, in response to population growth, traffic volumes on Highway 407 will increase in the future. This future scenario also assumed that additional public transit (i.e., buses) will be present on Highway 407. As a worst-case scenario, it was assumed that the future bus fleet would be diesel-fuelled. A new emissions inventory was developed for the future scenario without the Transitway based on the above changes and the inventory (excluding GHGs) input into the CAL3QHCR transportation model. The same background values used for the Existing Conditions scenario were used for this future scenario. A pollutant burden analysis was completed for GHGs.

3.1.3 Future With the 407 Transitway (2031)

This future (2031) scenario is the same as the above future scenario except for the addition of a 23 kilometre bus rapid transit (BRT) system (the 407 Transitway) that will be grade-separated and approximately parallel to Highway 407 from Highway 400 to Kennedy Road in the municipalities of Vaughan, Richmond Hill and Markham, Ontario. The preferred route consists of a two lane roadway (one lane in each direction) occupied solely by buses as described in the main Environmental Project Report (EPR) for the undertaking. In this scenario, buses are restricted to the Transitway, meaning that buses from the previous scenario were moved from Highway 407 to the Transitway. Again, it was assumed that the future bus fleet on the Transitway would be diesel-fuelled as a worst-case scenario. Emissions from vehicles present on Highway 407 and the 407 Transitway were calculated and input (excluding GHGs) into the CAL3QHCR model and the same background values as before were added to modelled concentrations. Again, a pollutant burden analysis was completed for GHGs.

The 407 Transitway also includes seven (7) bus stations where buses will temporarily idle to allow passengers to board/alight buses. Three (3) of the bus stations are considered main intermodal stations (Spadina Subway/Jane, Yonge/Richmond Hill Centre and Kennedy stations) which will connect with larger transportation systems such as proposed subway line extensions. The remaining four (4) stations will be smaller stations where buses will stop for very short periods to allow passengers to board/alight buses. All bus stations will include added parking lots and some will have passenger pick-up and drop-off (PPUDO) areas.

It should be noted that bus idling emissions were not considered in this assessment. During peak hours there will be approximately 1 bus per minute travelling through each of the stations; therefore, buses will stop for very short periods to allow passengers to board/alight. Idling emissions are estimated by the CAL3QHCR dispersion model during vehicle queuing at signalled road intersections. Neither the Transitway nor Highway 407 have signalled road intersections, therefore, idling emissions were estimated to be insignificant and were not considered in this assessment. However, the impacts from the addition of station parking lots and PPUDO areas were assessed. Only two stations (GO Barrie (Concord) and Leslie) were chosen for this assessment. The associated rationale for selecting these two stations is as follows.

3.1.3.1 Bus Stations Assessment

The impact of the GO Barrie (Concord) and Leslie station parking lots and PPUDO were assessed as worst-case scenarios due to their close proximity to sensitive receptor locations (R1 and R10, respectively, outlined in Section 4.5). If predicted air quality impacts are determined to be minimal at these two stations, then impacts from the remaining five stations on local air quality will also be minimal. Moreover, the impacts of Spadina Subway/Jane Station and Yonge/Richmond Hill Centre Station, which are intermodal stations connecting to the Spadina and Yonge subway line extensions, respectively, have already been assessed as part of previous Environmental Assessments (URS, 2006 and 2009). These assessments demonstrated that the addition of the intermodal stations did not significantly impact local air quality. In general, CO, NO_2 and $PM_{2.5}$ concentrations increased by less than 4% with the addition of intermodal subway stations when compared to a similar “No-Build” scenario. Since the 407 Transitway bus stations will only make up a small component of these larger, intermodal subway stations, it is expected that there will not be any significant cumulative impacts from the addition of the Spadina Subway/Jane and Yonge/Richmond Hill Centre stations.

For the bus station assessment, only TSP and NO_x were modelled as indicators of the impact to air quality. Using traffic data supplied by IBI Group, emissions were estimated and the impacts assessed using the U.S. EPA’s Industrial Source Complex Short Term Version 3 (ISCST3) air dispersion model. Detailed descriptions and assumptions used for the bus station assessment are provided in Appendix D.

3.2 VEHICLE EMISSIONS ESTIMATION

3.2.1 Traffic Volumes

The rate of contaminant emissions from a section of road is proportional to the number and types of vehicles travelling along that road as well as vehicle speed. Hourly traffic flows for Highway 407 and the 407 Transitway were calculated based on average daily traffic flows as well as average weekday and weekend hourly traffic profiles. IBI Group provided annual average daily traffic (AADT) volumes for Highway 407 and the proposed 407 Transitway for the following three scenarios:

- Existing Conditions – 2008;
- Future **Without** the 407 Transitway – 2031; and,
- Future **With** the 407 Transitway – 2031.

It should be noted that only traffic data for Highway 407 and the 407 Transitway were used in the modelling. Other roads within the transportation corridor (i.e., Highway 7) were considered to be part of background concentrations (see Section 2.4 above). Based on discussions with the MTO and Delcan, it is reasonable to assume that the introduction of the 407 Transitway into the study area will reduce the number of vehicles present within the transportation corridor. However, this is not reflected in Highway 407 traffic data and as a result, the vehicle emissions in the future with the 407 Transitway scenario shown in this study are likely higher than they may reasonably be expected to be.

3.2.2 Vehicle Emissions

All pollutants considered in this study are emitted in vehicle exhaust. Additionally, particulate (TSP, PM_{10} and $PM_{2.5}$) is emitted from roadway surfaces as a result of tire/break wear, and re-suspension of surface dust by (1) the action of the tires on the surface and (2) the wake created by the passing of the vehicle. Both tailpipe and mechanically generated particulate were included in this study. Tailpipe emissions from vehicles are a function of many variables. Some of the more important parameters are listed below.

- age of the vehicle (newer vehicles emit less);
- number of kilometres which the vehicle has driven;
- emission control equipment that may have been tampered with;
- type of fuel (gasoline, diesel);
- Reid Vapour Pressure (RVP) of gasoline used (adjusted seasonally);
- ambient air temperature;
- vehicle speed;
- rate of acceleration;
- time spent idling;
- type of vehicle (automobile, light truck, heavy truck, bus, etc.); and
- cold or hot start mode.

Vehicular emissions are generally estimated by using emission factors in units of mass of contaminant emitted per vehicle, per distance travelled. To obtain a mass emission rate for a particular road section, the length of the road section is multiplied by the number of vehicles using that section to obtain the total number of vehicle kilometres travelled (VKT). The VKT are then multiplied by the appropriate emission factors.

The vehicular emission rates were estimated for existing conditions (2008), and for the future year 2031. Emission factors were obtained by running the MOBILE6C model (the 'C' denotes the adjustment for the average Canadian fleet by Environment Canada). Nitrous oxide (N_2O) emission factors are from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006). The MOBILE6C model was run for SENES by Air Improvement Resources (AIR), who is one of the original developers of the MOBILE model. The model outputs emission factors in grams per vehicle kilometre travelled (g/VKT) for all contaminants of concern. All expected technological and regulatory changes affecting future emissions up to 2031 are built into the MOBILE6C model run in order to generate the most representative emission factors possible.

It should be noted that Table 3.1 indicates a reduction in tailpipe emissions between 2008 and 2031, which is due to expected emission reductions from more sophisticated engine technologies and fuels.

Table 3.1 summarizes the emission factors used in the existing conditions and future year for 100 km/h, which is the posted speed limit of both Highway 407 and the proposed 407 Transitway.

It should be noted that Table 3.1 indicates a reduction in tailpipe emissions between 2008 and 2031, which is due to expected emission reductions from more sophisticated engine technologies and fuels.

Table 3.1 MOBILE6C Tailpipe Emission Factors for 2008 and 2031

2008					
Cars					
Speed (km/h)	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**NO_x**	**CO**
100	0.02759	0.02759	0.01746	1.3167	12.3690
Speed (km/h)	**Benzene**	**Acetaldehyde**	**Formaldehyde**	**1,3-Butadiene**	**Acrolein**
100	0.015826	0.00262	0.00599	0.00188	0.00031
Speed (km/h)	**CO_2**	**CH_4**	**N_2O***		
100	340.33	0.02858	0.008		
Trucks/Buses					
Speed (km/h)	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**NO_x**	**CO**
100	0.12682	0.12682	0.10787	6.6456	0.98114
Speed (km/h)	**Benzene**	**Acetaldehyde**	**Formaldehyde**	**1,3-Butadiene**	**Acrolein**
100	0.00261	0.00716	0.01944	0.00152	0.00087
Speed (km/h)	**CO_2**	**CH_4**	**N_2O***		
100	840.28	0.01118	0.003		
2031					
Cars					
Speed (km/h)	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**NO_x**	**CO**
100	0.01665	0.01665	0.00746	0.21313	7.7678
Speed (km/h)	**Benzene**	**Acetaldehyde**	**Formaldehyde**	**1,3-Butadiene**	**Acrolein**
100	0.00752	0.00128	0.00274	0.00083	0.00014
Speed (km/h)	**CO_2**	**CH_4**	**N_2O***		
100	350.76	0.01429	0.008		
Trucks/Buses					
Speed (km/h)	**TSP**	**PM_{10}**	**$PM_{2.5}$**	**NO_x**	**CO**
100	0.02187	0.02187	0.011309	0.38898	0.10128
Speed (km/h)	**Benzene**	**Acetaldehyde**	**Formaldehyde**	**1,3-Butadiene**	**Acrolein**
100	0.001268	0.00348	0.00945	0.00074	0.00042
Speed (km/h)	**CO_2**	**CH_4**	**N_2O***		
100	839.78	0.00497	0.003		

Note: Emission factors are in g/VKT (grams per vehicle kilometre travelled).
* Emission factors from 2006 IPCC Guidelines for National Greenhouse Gas Inventories

3.2.3 Mechanically Generated Dust Emissions

The U.S. EPA provides an emission factor (U.S. EPA AP-42 Section 13.2.1 Paved Roads, 2006b) to estimate the amount of dust suspended by vehicles on the road, according to the following equation:

$$E = k\left(\frac{sL}{2}\right)^{0.65} \times \left(\frac{W}{3}\right)^{1.5} - C$$

where:	E = particulate emission factor (g/VKT)	
	k = particle size multiplier	24 (g/VKT) for TSP
		4.6 (g/VKT) for PM_{10}
		0.66 (g/VKT) for $PM_{2.5}$
	sL = silt loading (g/m^2)	0.6 (< 500 vehicles per day)
		0.2 (500 – 5,000 vehicles per day)
		0.06 (5,000 – 10,000 vehicles per day)
		0.03 (> 10,000 vehicles per day)
	W = weight of fleet (tons/vehicle)	3.0 US Tons for cars (average)
		15 US tons for buses/trucks (average)
	C = emission factor for 1980's vehicle fleet exhaust, brake wear and tire wear	
		0.1317 (g/VKT) for TSP and PM_{10}
		0.1005 (g/VKT) for $PM_{2.5}$
	VKT = vehicle kilometres travelled	

The mechanically generated dust emissions from vehicular travel on paved roads are not expected to change over time.

It should be noted that AP-42 Section 13.2.1 indicates that there may be situations where low silt loading and/or low average weight will yield calculated negative emissions from the equation outlined above. If this occurs, it is recommended that the calculated emission factor be set to zero.

3.3 CONSTRUCTION PHASE

The construction of the 407 Transitway has the potential to affect the air quality in the vicinity of the site during the construction phase. Emissions that are associated with road construction activities are particulate matter (TSP, PM_{10} and $PM_{2.5}$) and typical combustion emissions, such as CO, NO_x and VOCs, from construction equipment. As with any construction site, these emissions will be of relatively short duration and are unlikely to have any long-lasting effect on the surrounding area. As well, dust impacts can be successfully mitigated through the use of proper controls, such as:

- periodic watering of unpaved (non-vegetated) areas;
- periodic watering of stockpiles;
- limiting speed of vehicular travel;
- use of water sprays during the loading, unloading of materials; and,
- sweeping and/or water flushing of the entrances to the construction zones.

These types of controls aid in minimizing impacts to the environment during the construction phase. Night time construction activities should also be considered in order to reduce emissions from vehicles that are slowed down by any reduced road capacity during the day.

New developments in materials science and their application will continue to provide options for construction processes that could help to reduce emissions related to road and highway construction, rehabilitation and maintenance. Substitution of materials with more durable ones will result in overall emission reductions associated with the extended service life of structures and pavements. Also new developments in engine technologies and more advanced high-efficiency, low-emission type equipment and vehicles can significantly reduce associated emissions. Thus, it can be expected that construction related emissions from projects that are carried out in the years to come will be lower than if the same activities were undertaken today.

4.0 AIR DISPERSION MODELLING

4.1 MODELLING METHODOLOGY

Air quality is a measure of the amount of polluting chemical in a given volume of air. The typical unit of measurement is concentration or the number of micrograms of chemical, or particles, per cubic metre of air (µg/m^3). This concentration will vary from point-to-point and from minute-to-minute in response to changing atmospheric conditions (wind speed, wind direction, temperature, atmospheric stability and mixing height) and the amount of pollutant emitted.

To calculate the concentration at a given location near an emission source, an atmospheric dispersion model is used. These models take the emissions from a source and disperse them into the surrounding atmosphere, typically using historical hourly meteorological data from a local weather station.

To assess the changes in the study area, the model was run for ten pollutants and the resulting concentrations were obtained for three different scenarios:

- Existing conditions – 2008;
- Future **Without** the 407 Transitway – 2031; and,
- Future **With** the 407 Transitway – 2031.

The same meteorological conditions were used for all scenarios. The only differences between the three sets of model simulations of air quality were (1) the amount of emissions released and (2) the number, or location, of sources (road lanes) that were input into the model. In general terms, if the emissions are reduced, the resulting impact on the surrounding community (gas or particulate concentrations) will be reduced. Conversely, if the emissions increase, the impacts will increase.

The atmospheric dispersion model used for this study was CAL3QHCR, which is described in further detail in the following section. An example CAL3QHCR input file is provided in Appendix C.

4.2 CAL3QHCR

CAL3QHCR is a model developed specifically to predict the impacts of vehicle emissions from free flowing traffic conditions and near roadway intersections (U.S. EPA, 1995). The model combines the CALINE-3 (Benson, 1979) line source dispersion model and a traffic algorithm for estimating vehicular queue lengths at signalized intersections. The CALINE-3 line source dispersion model predicts more realistic concentrations immediately around roads because of the initial mixing in the wake zone of the vehicle. This initial mixing, combined with the traffic algorithm for queuing (added emissions from idling vehicles), provides improved model predictions of the impact of vehicle tailpipe emissions adjacent to roadways.

The average vehicle travel speeds were chosen based on the posted speed limits on the roadways, which is 100 km/h.

CAL3QHCR model guidance documents recommend using a source release height of 0 m assuming light duty vehicles dominate the vehicle fleet. However, as heavy duty vehicles (i.e., trucks and buses) are expected within the study area, SENES used a release height of 1 m. Additionally, sections of the Transitway will be constructed to go over or under existing roadways (e.g., Highway 407), railways or ponds/streams. As such, sources were assigned appropriate release heights to reflect changes in elevation and were designated as being either “at grade”, “above grade” or “below grade” in the model.

The model was originally designed to simulate dispersion of CO and PM_{10} from roadways. However, it is applicable to all gaseous pollutants, provided that minor alterations to the model source code are made. To model NO_x and VOC emissions, the model was modified to reflect the difference in the contaminant molecular weight.

Since emission factors differ by vehicle class, the vehicle mix was used to calculate a composite emission factor for each pollutant for a given roadway based on the fraction of cars and diesel trucks or buses that travel on it. A weekday and weekend hourly traffic profile was provided by IBI Group and was used to develop emission factors for each pollutant for each hour of the day.

4.3 METEOROLOGICAL DATA

For CAL3QHCR modelling, hourly meteorological data is required, including: mixing height, temperature, cloud cover, cloud opacity, wind speed and wind direction. For calculating hourly mixing heights, upper air measurements are needed. Using upper air observations (twice daily), morning and afternoon mixing heights are calculated and, based on these measurements, hourly mixing heights are estimated using the U.S. EPA's regulatory meteorological pre-processor PCRAMMET.

The meteorological data used for this assessment was the Ontario Ministry of Environment (MOE) default five year meteorological dataset for the Region of York-Durham. This data is based on 1992 to 1996 hourly surface meteorological data from Pearson International Airport, and upper air (mixing height) data from the Buffalo International Airport. Mixing heights are a regional parameter and do not change significantly over moderate distances. Buffalo is the closest upper air meteorological station to Toronto.

Typically, five years of hourly meteorological data are used in dispersion modelling calculations, as recommended by the U.S. EPA in order to include all of the possible combinations of meteorological conditions expected to occur in the area to be modelled. The CAL3QHCR model can process only one year of data per model run, therefore results for each year of meteorological data were compared to determine the maximum concentration for each contaminant. The model was run with five years of meteorological data for ten contaminants over the three scenarios to determine maximum contaminant concentrations at ten sensitive receptors (see Section 4.5). To develop isopleths for illustrative purposes the worst case meteorological year (i.e., the year that most often gave the highest maximum ground-level concentrations) was selected (1993), and used to model concentrations at 2091 receptors (see Section 4.4).

4.4 RECEPTOR GRID

In order to avoid modelling artefacts (mathematical anomalies created by the model that do not occur in reality), it was important to ensure that there were no receptors on or unreasonably close to the modelled road source. The end-points of the centreline of each road link were determined from the digital maps supplied in UTM coordinates. Assuming the width of the road is W, a series of receptors were placed parallel to the road links at a width of 2W centred on the centreline of the road. This placed the points at a distance of 1.5W from the edge of the roadway. Receptors were placed every 100 m parallel to all arterial roads within the study area.

A second set of receptors were placed at a width of 5W or at a distance of 4.5W from the edge of the roadway, again with 100 m spacing as described above. A Cartesian grid with a spacing of 200 m was overlaid to cover the rest of the modelling domain and converted to discrete receptors. All Cartesian grid points that fell closer to the road than the 5W receptors were removed. The receptor height was selected as 1.5 m above the ground.

4.5 DISCRETE/SENSITIVE RECEPTORS

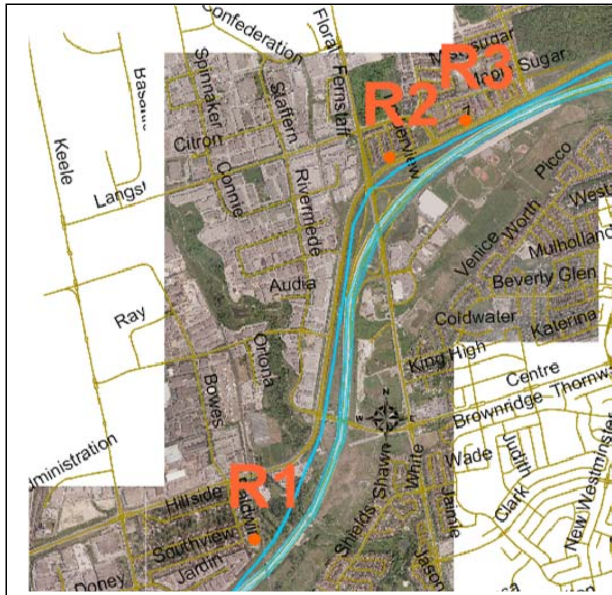
In addition to the modelling grid, a series of ten discrete/sensitive receptors were chosen to help summarize the modelling results and at which a comparison was made to applicable criteria. Chosen discrete/sensitive receptors included nearby existing/future residential areas or schools located throughout the study area at varying distances from the roadway.

The selected receptors are outlined in Table 4.1 and presented in Figure 4.1 below.

Table 4.1 Sensitive Receptors

	Receptor Description
R1	Residences on Hartley Ct; north of Transitway, west of GO Barrie Line
R2	Residences on Yellowood Circle; north of Transitway, east of Dufferin St
R3	Residences on Sassafras Circle; north of Transitway, east of Langstaff Rd
R4	Residences on Langstaff Rd W; west of Transitway
R5	Residence on Cedar Ave, south of Transitway
R6	Apartment building, northeast corner of Bayview Ave and Highway 7
R7	Potential residential development, south of South Park Rd
R8	Residences on Huntington Park Dr; south of Transitway
R9	Potential residential development north of Transitway, east of Warden Ave
R10	St. Robert Catholic High School, south of Transitway, east of Leslie St

Figure 4.1 Location of Sensitive Receptors



A: Western Section of Study Area	**B:** Eastern Section of Study Area

5.0 ASSESSMENT OF AIR QUALITY

5.1 BACKGROUND

When following the Transit Project Assessment Process and assessing the merits of the proposed 407 Transitway compared to the future scenario without the Transitway, it is the incremental change in total model predicted concentrations between the two future cases that is the true measure of the future impact. The same background concentrations were added to the modelled concentrations for the Existing Conditions (2008) scenario, the Future Without the 407 Transitway (2031) scenario and the Future With the 407 Transitway scenario. Therefore, when assessing the incremental change in the combined concentrations, the background concentration cancels out. However, it is also important to understand the magnitude of the change in total predicted combined concentrations (i.e., background plus project related).

The constant ambient background concentrations established in Section 2.4 above were added to the model predicted concentrations (inclusive of the background contribution from Highway 407) to obtain a true estimate of ambient concentrations at each receptor location.

5.2 CALQ3HCR MODELLING RESULTS

The output from the model is the maximum predicted 1-hour average concentration at each of the modelled receptor points based on a full year of meteorological data (8760 simulated hours). Hourly data is post-processed to determine the maximum predicted 24-hour average (or 8-hour for CO) concentrations.

The results from the air dispersion modelling have been presented in graphical format with complete results provided in appendices at the back of the report. Contour plots (averaging period depends on the contaminant of concern), have been created for all three scenarios (i.e., Existing Conditions (2008), Future Without the 407 Transitway (2031) and Future With the 407 Transitway (2031)) and compared to applicable provincial MOE AAQCs or federal Canada-Wide standards. The results for all three scenarios have also been presented in tabular form for the ten specific sensitive receptor locations outlined above.

As outlined in Section 4.3, due to computational constraints a worst case meteorological year (1993) was used to develop graphical isopleths for each contaminant. A total of 2091 receptors are included in this modelling analysis to ensure an accurate depiction of isopleths (lines of equal concentration).

Nitrogen oxides (NO_x) graphical results are presented in Section 5.3 below, with all other gaseous compounds demonstrating trends similar to those for NO_x. As was noted in Section 2.4

above, the 24-hour background acrolein concentration is greater than the MOE AAQC. However, as outlined in Figure A.7 in Appendix A, the model predicted 24-hour acrolein values (excluding background) are less than the AAQC standards throughout the study area. Similarly, the benzene and 1,3-butadiene background concentrations are greater than proposed AAQC, but Figures A.10 and A.13 in Appendix A show that the model predicted 24-hour concentrations are less than the proposed standards when background is excluded.

PM_{10} and $PM_{2.5}$ graphical results are presented below in Sections 5.4 and 5.5, respectively with TSP demonstrating trends similar to those of PM_{10}. $PM_{2.5}$ results are different from other particulate matter size fractions as described below. Complete graphical results and tabular results for all pollutants assessed are provided in Appendix A and Appendix B, respectively.

5.3 Graphical and Tabular Presentation of Results - NO_X

As illustrated in Appendix A (graphical) and Appendix B (tabular), each of the gaseous contaminants studied show similar patterns to the NO_x results. The predicted 24-hour maximum NO_x concentrations for all scenarios are presented in Table 5.1. The maximum 24-hour average modelled concentrations for NO_x for all scenarios are presented as concentration isopleths over a base map in Figures 5.1a through 5.1c. The contours are lines of equal predicted maximum 24-hour concentrations. For presentation purposes each figure is separated into two sections, a western section and an eastern section of the study area. These figures do not represent a snapshot in time as the maximum concentrations at each receptor typically occur during different meteorological conditions (i.e., different hours and/or days) and thus do not occur simultaneously. For example, at a point south of a road, winds blowing from the north in January may give rise to the maximum 24-hour concentration, whereas for a point north of the road, the worst meteorological conditions may occur in June with a different wind direction. The concentration values presented include background, as discussed earlier. It can be seen in the figures that the contour lines closely follow the road links and drop off rapidly with distance from the centre of the road.

5.3.1 Comparison of Existing Conditions (2008) to Future Scenarios (2031)

As illustrated in Table 5.1, the predicted 24-hour maximum concentrations for existing conditions (2008) for NO_x are greater than the two future scenarios (2031). As outlined in Section 3.2.2 above, this is a result of emission reductions due to advancements in fuel and vehicle technologies, despite the predicted increases in traffic due to population growth. As indicated in it should be noted that Table 3.1 indicates a reduction in tailpipe emissions between 2008 and 2031, which his due to expected emission reductions from more sophisticated engine technologies and fuels. Table 3.1 above, the NO_x emission factor for cars in 2031 is approximately 16% of the emission factor in 2008 and approximately 6% for trucks/buses.

Table 5.1 Maximum 24-hour NO_x Concentrations – Existing and Future Scenarios

Receptor	Existing Conditions	Future No Transitway		Future With Transitway		AAQC
	$\mu g/m^3$	$\mu g/m^3$	% change from Existing	$\mu g/m^3$	% change from Existing	$\mu g/m^3$
R1	142	105	-26%	105	-26%	200
R2	140	104	-26%	104	-25%	200
R3	173	112	-35%	112	-35%	200
R4	154	107	-30%	107	-30%	200
R5	184	114	-38%	113	-38%	200
R6	134	102	-23%	102	-23%	200
R7	175	111	-36%	111	-36%	200
R8	119	99	-17%	99	-17%	200
R9	138	106	-23%	106	-23%	200
R10	143	104	-27%	105	-27%	200

Note: All values include a conservative background NO_x concentration of 93.4 $\mu g/m^3$.

Table 5.1 also indicates that there are no exceedances of the 24-hour NO_x for any scenario. In contrast, exceedances of the 1-hour NO_x AAQC are predicted for the Existing Conditions scenario only as shown in Appendix A and B. Due to the reduction in the tailpipe emission factor in the future, there are no exceedances of the 1-hour NO_x AAQC in either future scenario.

5.3.2 Comparison of Future with and without the 407 Transitway (2031)

The predicted 24-hour maximum concentrations at the ten sensitive receptors for the future with and without the 407 Transitway scenarios (2031) for NO_x are presented in Table 5.2. The table indicates the air quality impact on concentrations of NO_x as a result of the proposed 407 Transitway will be insignificant (less than 1%). A comparison of Figures 5.1b and 5.1c also illustrates negligible changes in NO_x concentrations between the future no-build and future with the 407 Transitway scenarios.

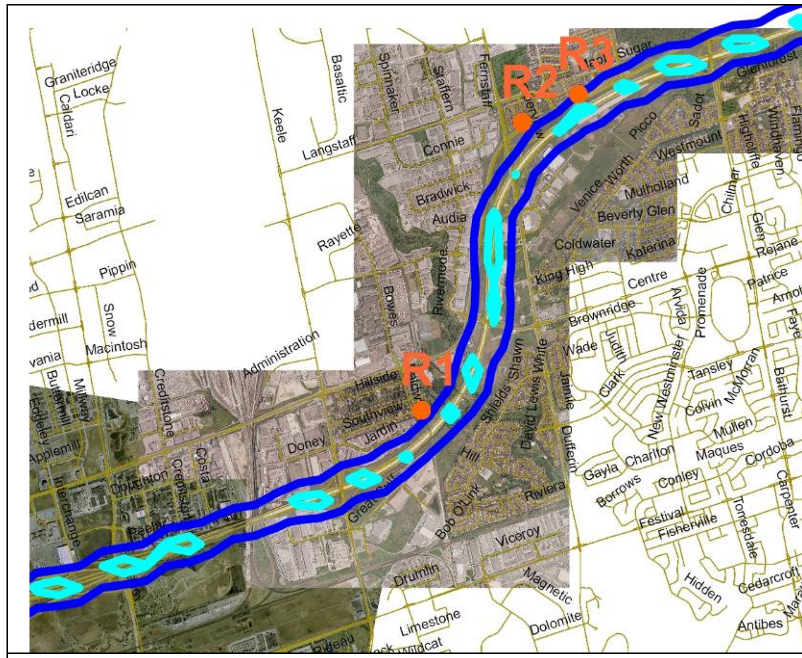
Figures and tablatures for all other gaseous compounds are provided in Appendix A and B, respectively and demonstrate results similar to those of NO_x. Exceedances of 24-hour AAQC for acrolein, benzene and 1,3-butadiene concentrations were predicted in this study. As noted previously, benzene and 1,3-butadiene standards are only proposed. Section 2.4 outlined that the background acrolein, benzene, and 1,3-butadiene concentrations already exceed applicable criteria which suggests that there is likely an underlying problem today with elevated concentrations of these three contaminants throughout urbanized areas in Southern Ontario. However, as with all gaseous compounds, based on the implementation of the proposed 407 Transitway, there will be negligible changes in acrolein, benzene and 1,3-butadiene concentrations within the study area compared to the future scenario without the Transitway.

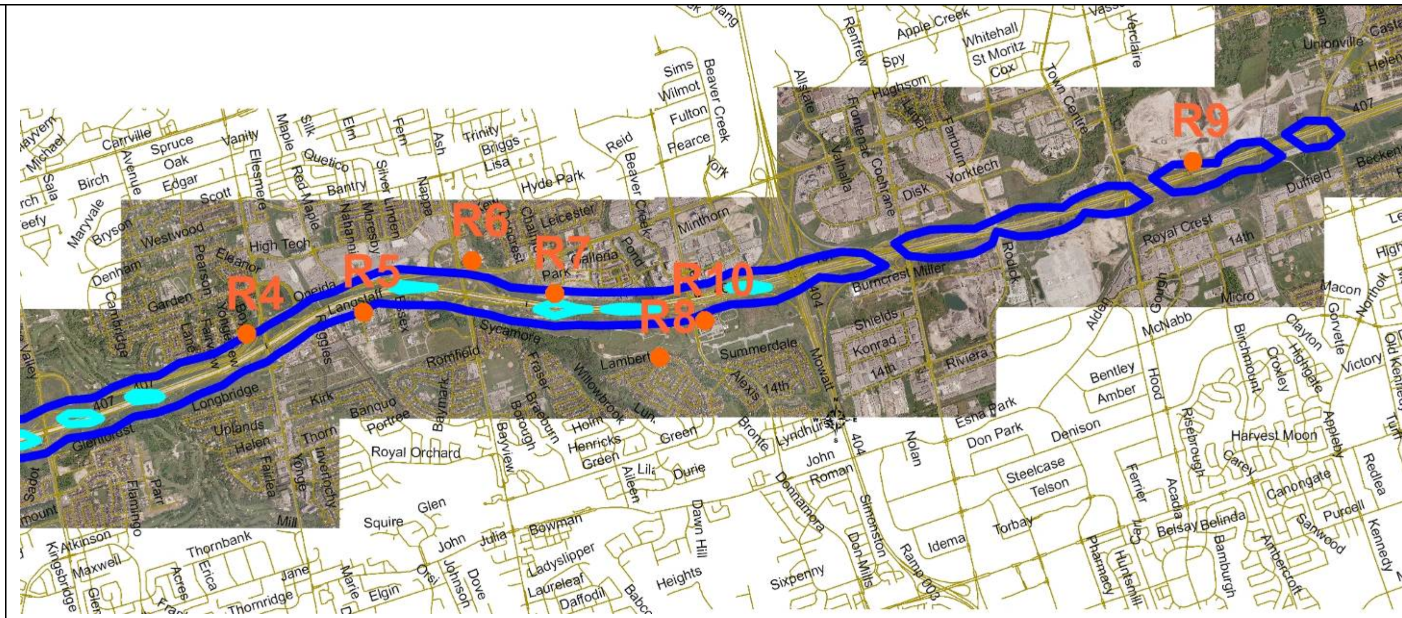
Table 5.2 Maximum 24-hour NO_x Concentrations – Future Scenarios Comparison

Receptor	Future Without Transitway (μg/m^3)	Future With Transitway (μg/m^3)	% Change from Without Transitway	AAQC (μg/m^3)
R1	105	105	0.01%	200
R2	104	104	0.14%	200
R3	112	112	0.10%	200
R4	107	107	-0.03%	200
R5	114	113	-0.24%	200
R6	102	102	0.01%	200
R7	111	111	-0.11%	200
R8	99	99	-0.09%	200
R9	106	106	0.12%	200
R10	104	105	0.28%	200

Note: All values include a conservative background NO_x concentration of 93.4 μg/m^3.

Figure 5.1 Maximum 24-hour NO_x Concentrations for Existing and Future Scenarios

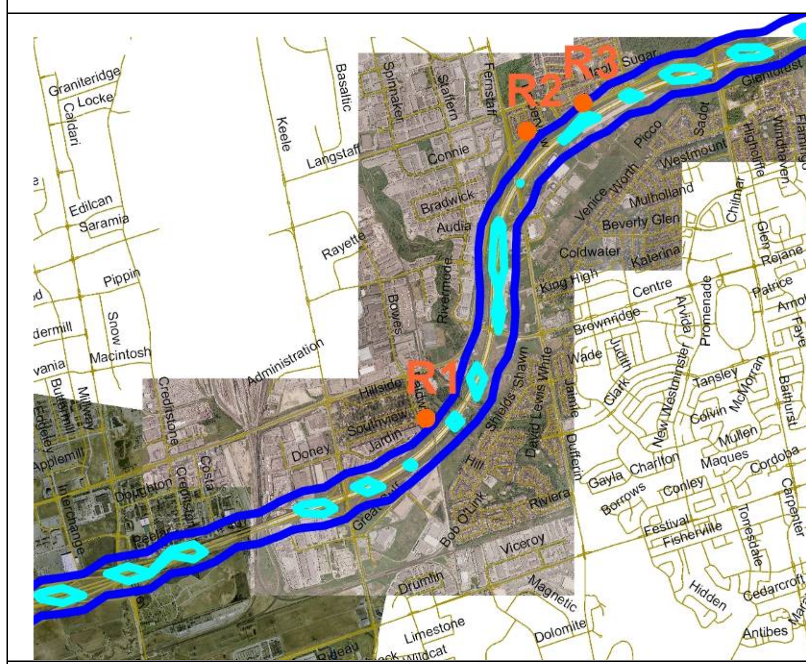


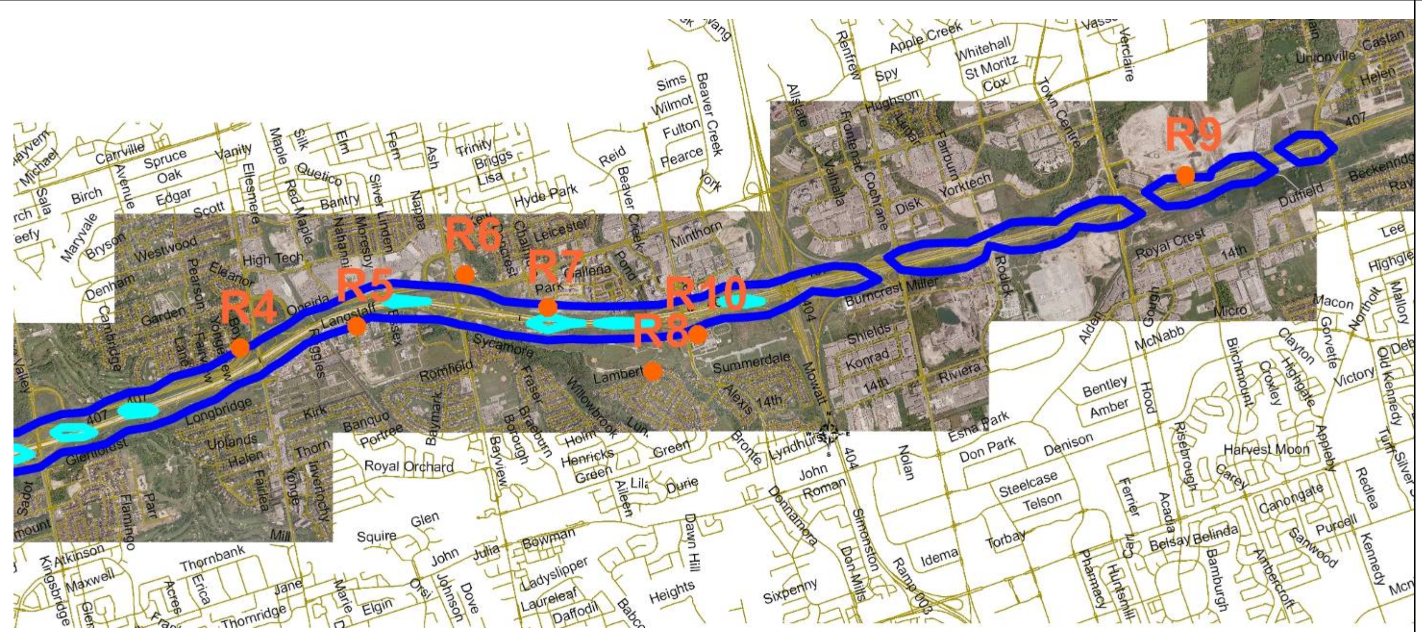


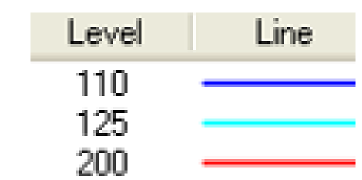
Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

A: 24-Hour NO_x Concentrations including background – **Existing** Conditions (2008)





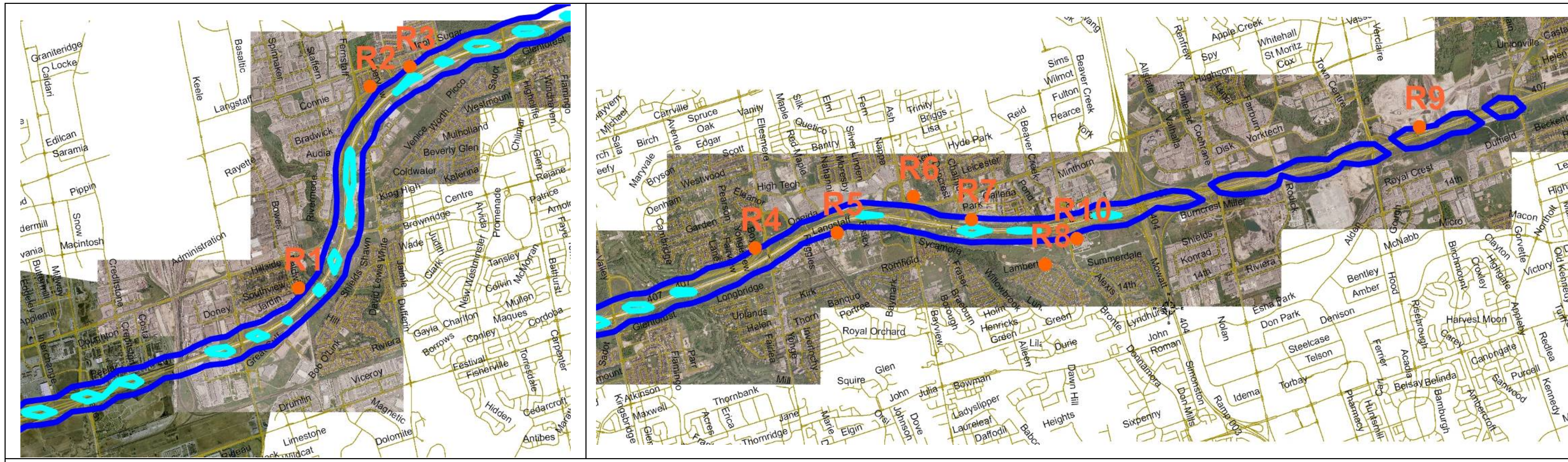


Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

B: 24-Hour NO_x Concentrations including background – **Future Without** Transitway (2031)

Figure 5.1 Maximum 24-hour NO_x Concentrations for Existing and Future Scenario (Cont'd)



Level	Line
110	(blue)
125	(cyan)
200	(red)

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

C: 24-Hour NO_x Concentrations including background - **Future With** Transitway (2031)

5.4 GRAPHICAL AND TABULAR PRESENTATION OF RESULTS - PM_{10}

The maximum 24-hour average modelled concentrations of PM_{10} for all scenarios are presented with contour lines over a base map in Figures 5.2a through 5.2c. The contours are lines of equal predicted maximum 24-hour concentrations. As outlined in Section 5.3 above, these maximum concentrations do not occur simultaneously, but are the maximum 24-hour concentrations predicted at each grid point during a one year period added to a conservative background concentration. It can be seen in the figures that the contour lines closely follow the road links and drop off rapidly with distance from the road centreline.

5.4.1 Comparison of Existing Conditions (2008) to Future Scenarios (2031)

As illustrated in Table 5.3, the predicted 24-hour maximum concentrations for the two future scenarios (2031) are greater than the concentrations predicted for existing conditions (2008) for all sensitive receptor locations. As indicated in it should be noted that Table 3.1 indicates a reduction in tailpipe emissions between 2008 and 2031, which is due to expected emission reductions from more sophisticated engine technologies and fuels.

Table 3.1 above, the PM_{10} MOBILE6C emission factor for cars in 2031 is approximately 60% of the emission factor in 2008 and approximately 17% for trucks/buses. However, as over 95% of vehicle tailpipe particulate emissions are less than 2.5 µm, emissions of larger particulate fractions (i.e., PM_{10} and TSP) are made up of re-suspended road dust rather than tailpipe emissions. Therefore, the total PM_{10} emission factor (tailpipe + road dust) only slightly decreased in the future (2031) and increased PM_{10} concentrations were predicted as a result of increased traffic within the study area due to population growth.

Table 5.3 also indicates that there are predicted exceedances of the PM_{10} AAQC at three receptor locations for the Existing Conditions scenario and at eight receptor locations for the Future Without the 407 Transitway scenario. These predicted increases are due to an increase in traffic as a result of future population growth, as previously discussed. For the Future With the 407 Transitway scenario, there are exceedances of the PM_{10} AAQC at all but one of the sensitive receptors. The greatest predicted increase from the Existing Conditions scenario to the Future With the 407 Transitway scenario is 62% at receptor R10 due to its close proximity to the Transitway (about 40 m). This receptor was previously about 120 m away from Highway 407 which is why this large increase was not seen for the Future Without the 407 Transitway scenario. Differences between the two future scenarios are further discussed in the following section.

Table 5.3 Maximum 24-hour PM_{10} Concentrations – Existing and Future Scenarios

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		Canada-Wide Standard
	µg/m^3	µg/m^3	% change from Existing	µg/m^3	% change from Existing	µg/m^3
R1	45.4	51.6	13.6%	57.5	26.5%	50
R2	44.9	51.2	14.0%	60.3	34.4%	50
R3	51.8	63.0	21.5%	71.4	37.8%	50
R4	47.7	56.9	19.4%	62.5	31.1%	50
R5	54.3	67.4	24.2%	69.0	27.2%	50
R6	43.4	49.3	13.5%	55.2	27.2%	50
R7	51.9	64.1	23.5%	68.9	32.7%	50
R8	40.4	44.1	9.1%	47.5	17.4%	50
R9	43.3	52.6	21.4%	62.2	43.8%	50
R10	45.3	52.6	16.0%	73.4	61.9%	50

Note: All values include a background PM_{10} concentration of 35.1 µg/m^3.

5.4.2 Comparison of Future Particulate Matter with and without the 407 Transitway (2031)

The predicted 24-hour maximum concentrations at the ten sensitive receptors for the future with and without the 407 Transitway (2031) for PM_{10} are presented in Table 5.4. This table indicates that there will be air quality impacts as a result of the addition of the 407 Transitway. Particularly, Table 5.4 suggests that PM_{10} concentrations will increase anywhere from 2 to 20 µg/m^3 (approximately 2% to 40%) at sensitive receptor locations with the addition of the Transitway compared to the future no-build scenario.

A comparison of Figures 5.2b and 5.2c also illustrates PM_{10} impacts with the addition of the Transitway. The predicted increases are due to (1) an increase in road silt accumulation on the roadway as a result of low traffic volumes/heavier vehicles on the Transitway, and (2) a decrease in the distance from the nearest roadway for some receptor locations. As shown by the U.S. EPA AP-42 Road Dust Emission Factor equation in Section 3.2.3, road segments having lower 24-hour AADT (annual average daily traffic) counts will have a higher silt loading factor. As a result, more road dust is re-suspended. Additionally, the equation shows that heavier vehicles (i.e., trucks and buses) also generate more road dust. Thus, the increased PM_{10} concentrations shown in Figure 5.2c are a consequence of the low number of buses exclusively occupying the 407 Transitway which causes more road dust to be re-suspended due to higher silt loading and heavier vehicles.

With the addition of the Transitway, the distance between all sensitive receptors and the closest roadway (i.e., the closest emission source) becomes shorter with the exception of R5 and R7. For example, R10 is located about 120 m away from Highway 407 in the absence of the

Transitway, however, when the Transitway is constructed, R10 will be closer to the Transitway at a distance of about 40 metres. As shown in Table 5.4, the greatest predicted impact of the Transitway occurs at R10 - the closest sensitive receptor to the Transitway.

Table 5.4 Maximum 24-hour PM_{10} Concentrations – Future Scenarios Comparison

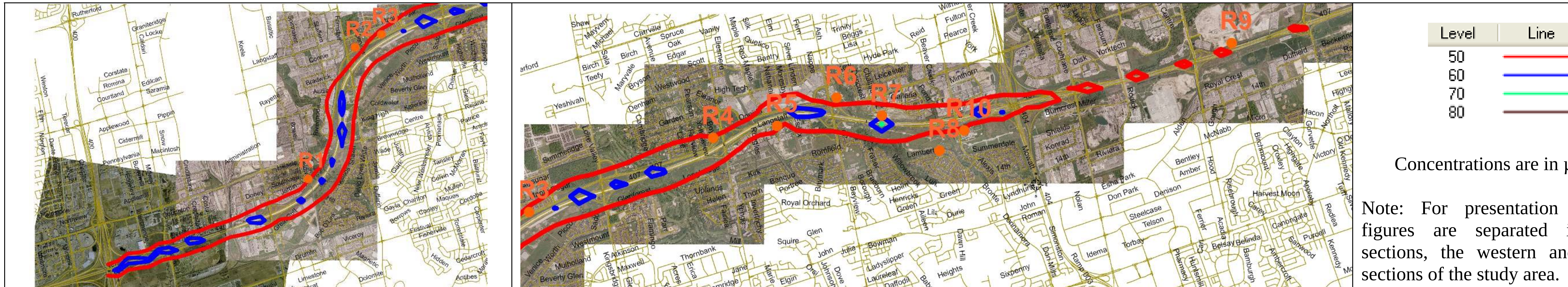
Receptor	Future Without Transitway (μg/m^3)	Future With Transitway (μg/m^3)	% Change from Without Transitway	Canada-Wide Standard (μg/m^3)
R1	52	57	11.4%	50
R2	51	60	17.9%	50
R3	63	71	13.4%	50
R4	57	62	9.8%	50
R5	67	69	2.4%	50
R6	49	55	12.0%	50
R7	64	69	7.5%	50
R8	44	47	7.6%	50
R9	53	62	18.4%	50
R10	53	73	39.5%	50

Note: All values include a background PM_{10} concentration of 35.1 μg/m^3.

Figures for TSP are provided in Appendix A and demonstrate results similar to those of PM_{10}; however, the predicted number of exceedances of the TSP AAQC was greater than for the PM_{10} AAQC. As mentioned previously, a large fraction of PM_{10} and TSP air emissions are from re-suspended road dust rather than tailpipe emissions, with TSP making up an even smaller fraction of tailpipe emissions than PM_{10}. Therefore, the fraction of TSP in road dust emissions will be greater than the fraction of PM_{10}, resulting in more exceedances with the addition of the Transitway. Tabular TSP results at the discrete/sensitive receptor locations are presented in Appendix B.

In all, based on the implementation of the proposed 407 Transitway, there will be an increase in PM_{10} and TSP contaminant concentrations immediately adjacent to the Transitway. In the following section, a discussion of PM_{10} and TSP exceedances of MOE criteria is provided.

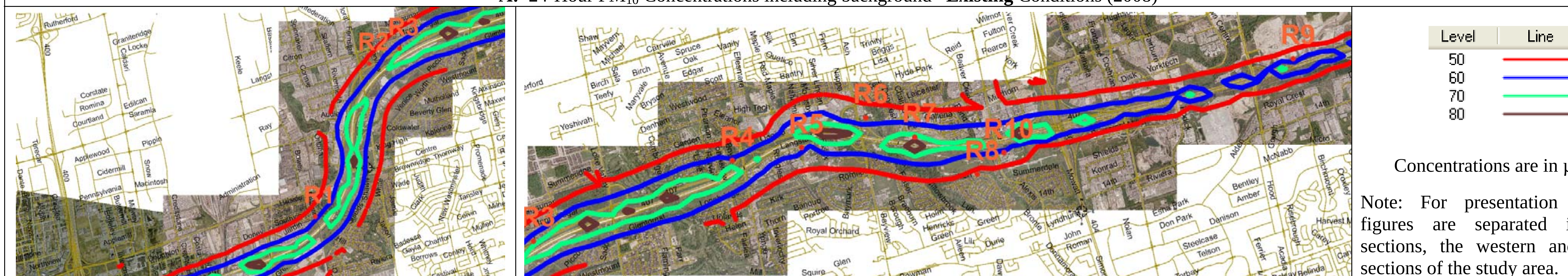
Figure 5.2 Maximum 24-hour PM_{10} Concentrations for Existing and Future Scenarios



Concentrations are in µg/m³

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

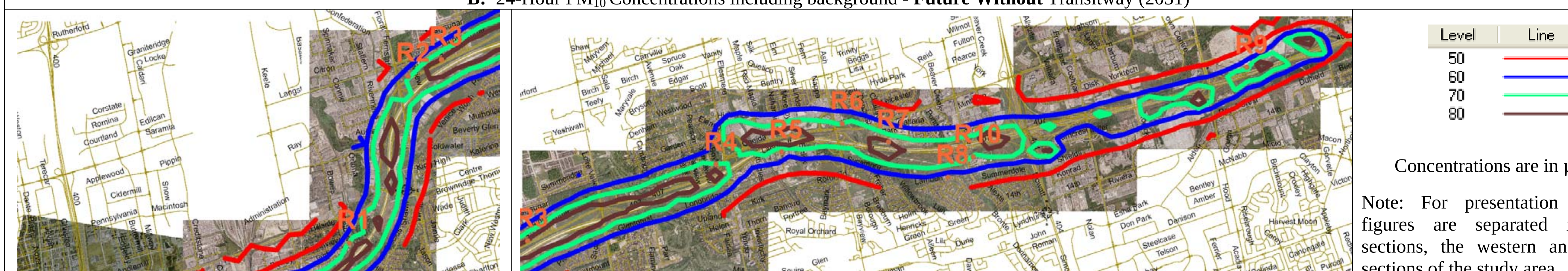
A: 24-Hour PM_{10} Concentrations including background – **Existing** Conditions (2008)



Concentrations are in µg/m³

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

B: 24-Hour PM_{10} Concentrations including background - **Future Without** Transitway (2031)



Concentrations are in µg/m³

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

C: 24-Hour PM_{10} Concentrations including background – **Future With** Transitway (2031)

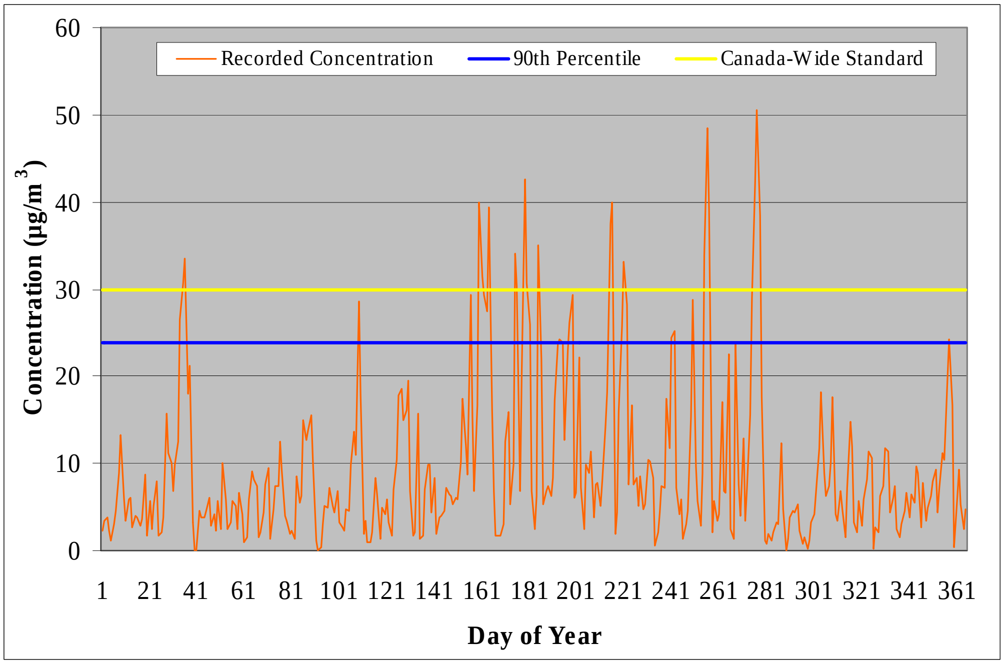
5.4.3 PM_{10} and TSP Exceedances

5.4.3.1 Conservativeness of Using the 90^{th} Percentile Background for Calculating Exceedances

As discussed in Section 2.4, the 90^{th} percentile of ambient $PM_{2.5}$ monitoring data was used to determine the background concentrations of PM_{10} and TSP. In order to attempt to capture the highest 24-hour concentration of a contaminant to compare against applicable MOE criteria, the MOE usually requires that air quality assessments use the 90^{th} percentile concentration of ambient air monitoring data as the ambient background value. The 90^{th} percentile value used for PM_{10} (and TSP) is conservatively high for two reasons: 1) it was conservatively assumed that PM_{10} concentrations are 2 times higher than monitored $PM_{2.5}$ concentrations (see Section 2.4 and Table 2.10 for discussion); and 2) the 90^{th} percentile is reflective of a background concentration which is actually lower 90% of the time and higher 10% of the time.

While using the 90^{th} percentile background may under-predict the absolute maximum concentrations reported, it can over-predict the number of exceedances of MOE criteria caused directly by the addition of a transportation element because the background concentration is artificially elevated for most of the time. This concept is illustrated in Figure 5.3 using ambient $PM_{2.5}$ monitoring data for the Toronto North MOE station. As shown in Figure 5.3, the use of the 90^{th} percentile as the background concentration is an overestimate of the actual background concentration for a significant part of the year. In addition, Figure 5.3 shows that the day-to-day variability in ambient (background) concentrations is typically several µg/m^3 and can approach or even exceed the 30 µg/m^3 standard for $PM_{2.5}$.

Figure 5.3 2005 Toronto North $PM_{2.5}$ Daily Background Concentration



5.4.3.2 Comparison of PM_{10} Concentrations Using a Constant and Variable Background

To illustrate the conservativeness of using a constant 90th percentile background value to predict the number of exceedances caused directly by the implementation of the Transitway, a sensitivity analysis was undertaken in which PM_{10} concentrations were predicted using the constant background established in Section 2.4 as well as using a variable background. To predict 24-hour PM_{10} concentrations using a variable background, ambient PM_{10} concentrations obtained from the Toronto North monitoring station (ambient $PM_{2.5}$ concentrations multiplied by 2) were added to model predicted 24-hour concentrations on a day-by-day basis. For this analysis, a meteorological data set corresponding to a year of MOE $PM_{2.5}$ monitoring data was required. As such, a 2005 meteorological data set for Toronto Pearson Airport, prepared by SENES for a previous transportation project using CAL3QHCR, was used. 2005 was selected as it was the worst-case meteorological year for that particular project and it corresponded to a year that MOE $PM_{2.5}$ monitoring data was available.

Results

The results of the sensitivity analysis are presented in Table 5.5. As can be seen from the table, the predicted PM_{10} concentrations as well as the total number of exceedances are greater when a variable background concentration is used. The source responsible for the exceedances (background or the Transitway) was investigated for R10 – the receptor previously showing the greatest impact from the addition of the Transitway as outlined in Section 5.4.1.

Table 5.5 Maximum 24-hour PM_{10} Concentrations and Exceedances – Constant and Variable Background Comparison

Receptor	Future Without Transitway				Future With Transitway			
	Constant		Variable		Constant		Variable	
	Concentration (μg/m³)[1]	Exceedances[2]	Concentration (μg/m³)[1]	Exceedances[2]	Concentration (μg/m³)[1]	Exceedances[2]	Concentration (μg/m³)[1]	Exceedances[2]
R1	50.4	1	112.1	38	55.5	4	116.5	41
R2	49.8	0	111.4	38	56.4	5	116.5	41
R3	57.1	2	115.5	42	63.2	16	120.8	46
R4	54.9	1	114.3	41	60.2	8	119.3	45
R5	57.4	5	101.4	38	57.7	6	101.3	38
R6	45.2	0	109.5	38	49.8	0	113.2	42
R7	59.3	14	120.2	46	62.7	34	123.5	49
R8	41.7	0	101.2	32	44.0	0	101.2	33
R9	50.6	1	112.5	41	59.8	9	119.1	43
R10	52.1	1	101.2	36	67.9	14	101.2	40

[1]All values include an ambient background PM_{10} concentration of 35.1 μg/m³.
[2]Interim MOE AAQC for PM_{10} is 50 μg/m³.

Predicted PM_{10} Concentrations and Exceedances at R10

Figures 5.4 and 5.5 provide a graphical representation of the daily concentrations of PM_{10} at R10 for the Future With the 407 Transitway scenario. As can be seen in the figures, background concentrations dominate when either a constant 90th percentile or variable background is used.

When adding a constant background to model predicted concentrations at R10, there were a total of 14 exceedances with the Transitway compared to 1 exceedance without (Table 5.5). Since the 90th percentile background value is below 50 $\mu g/m^3$, it can be concluded that 13 of the 14 predicted exceedances were caused by the addition of the Transitway. In contrast, there were 36 exceedances predicted for the Future Without the Transitway scenario and 40 exceedances predicted for the Future With the Transitway scenario when a variable background was used. As Figure 5.5 illustrates, there are a number of days when the background PM_{10} concentration already exceeds the MOE AAQC. Specifically, there were 32 days when the AAQC was exceeded. This leaves only 4 days when exceedances of the AAQC can be attributed to the traffic increment (i.e., Highway 407) in the future no-build scenario and 8 days in the future scenario with the added Transitway. This result shows that the addition of the Transitway only caused 4 more exceedances compared to the 13 exceedances predicted when a constant background was used. Therefore, in actuality, the number of predicted exceedances caused by the Transitway increment decreased when a variable background was used. It just so happened that there were a significant number of days in 2005 when ambient PM_{10} concentrations already exceeded the MOE AAQC which inflated the number of exceedances compared to the case when a constant background was used.

In all, these results suggest that using a 90th percentile background value will over-predict the number of exceedances resulting directly from the addition of the Transitway. However, the total number of exceedances predicted may increase when using a variable background, depending upon the number of ambient (background) exceedances already occurring.

In addition, the number of exceedances predicted for PM_{10} (and TSP) is also likely to be overestimated regardless of the scenario being assessed because it was conservatively assumed that $PM_{2.5}$ is 50% of PM_{10} and that PM_{10} is 50% of TSP.

Figure 5.4 Daily PM_{10} Concentration at R10 using a Constant Background

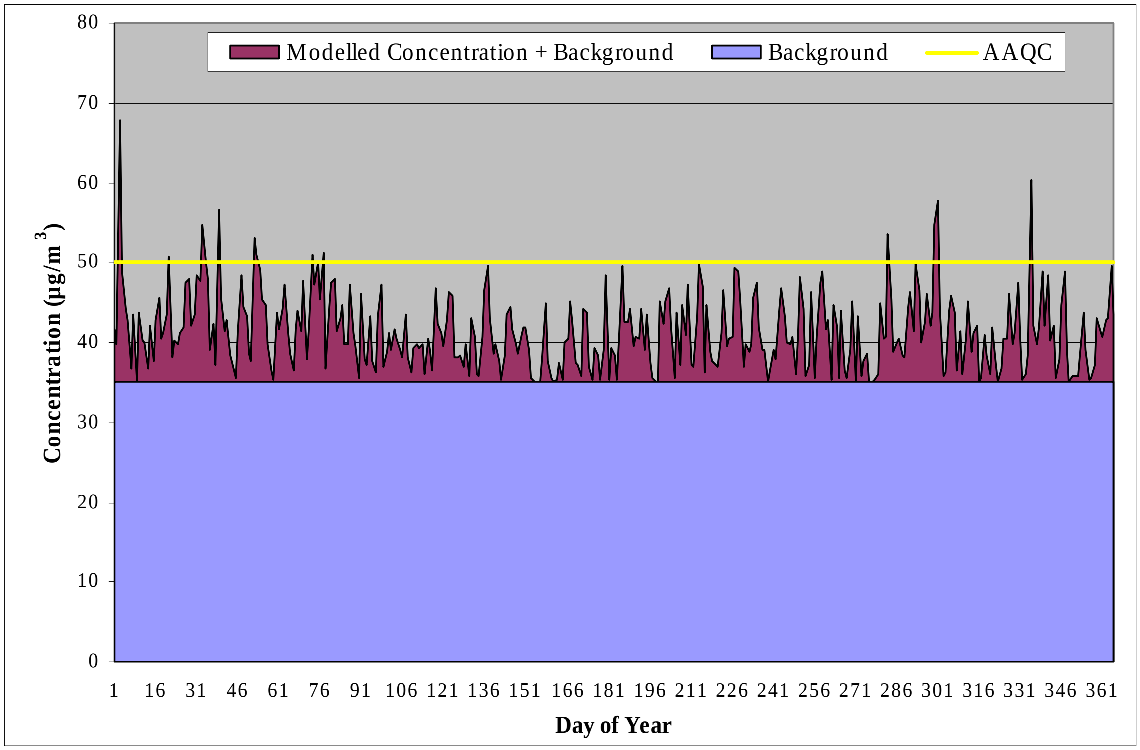
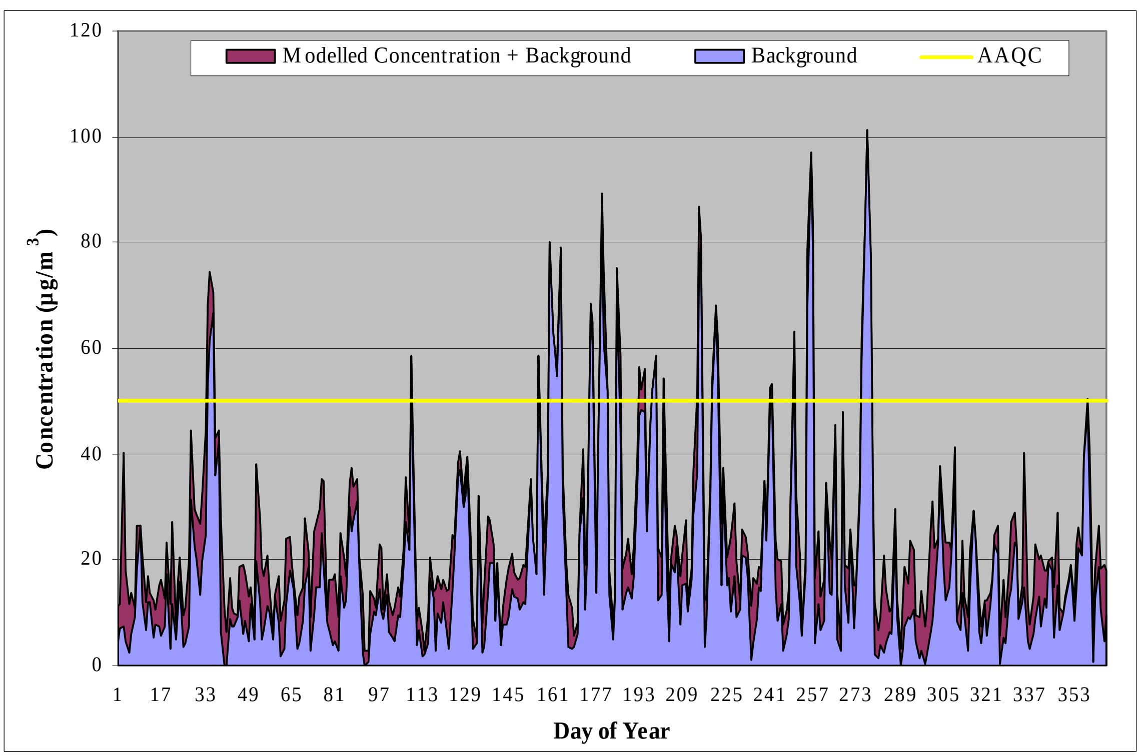


Figure 5.5 Daily PM_{10} Concentration at R10 using a Variable Background



5.4.4 Control of TSP and PM_{10} Emissions from the 407 Transitway

Section 4.5 identified all possible sensitive receptors in the study area where an impact on local air quality from the addition of the Transitway may occur. Locations included nine (9) existing/possible future residential areas, and one school, St. Robert Catholic High School. Predicted impacts of TSP and PM_{10} on local air quality within these residential areas and at the school were summarized in Table 5.4. As was indicated in the table, all receptors with the exception of R5, R7 and R8 were significantly impacted by increased road dust associated with the addition of the Transitway. As a result, it is recommended that road dust impacts of the Transitway be mitigated in and around all significantly impacted residential/sensitive areas.

Control measures are recommended to reduce future impacts of road dust (i.e., TSP and PM_{10}) generated by the 407 Transitway. The U.S. EPA (2006b) recommends road dust controls that either prevent or mitigate high silt loading on roadways. Preventative options include traffic controls such as speed reduction, load restriction etc., whereas mitigative options include road cleaning practices such as vacuum sweeping, water flushing or broom sweeping and flushing combined (U.S. EPA, 2006b).

The U.S. EPA (2006b) remarks that the cost-effectiveness of mitigative options is generally poor and becomes even poorer as the size of an area to be controlled increases. As well, the cost-effectiveness will also be low if there is only a short amount of time required for the silt loading to return to its equilibrium (i.e., for dust to settle back on the roadway) (U.S. EPA, 2006b). Since TSP and PM_{10} were projected to significantly impact seven sensitive areas along the Transitway, a large area of road would have to be controlled. Moreover, dust will be able to settle back down on the Transitway (in the absence of significant winds) since the volume of buses is too low to continuously suspend road dust into the air so that it can be dispersed by the wind. Additionally, suspended road dust generated by Highway 407 could also settle onto the adjacent Transitway. Therefore, the time to replenish the silt loading on the Transitway is likely to be short and, combined with the fact that a large area of roadway must be controlled, direct mitigative options do not appear to be a feasible method of control.

Moreover, preventative methods are also not a possible control option since the speed and type of vehicle (i.e., buses) cannot be changed on the 407 Transitway.

Since it appears impractical to control the level of silt loading on the Transitway, mitigative measures to reduce the **impact** of road dust at nearby sensitive areas should be undertaken. Barriers (i.e., trees/shrubs, or where planned for safety and/or noise issues solid barriers) located along the Transitway in locations identified as being significantly impacted by road dust will act as screens and significantly reduce (with a 2 metre high screen) the particulate matter flowing horizontally from the roadway (Watson and Chow, 2000). Therefore, planting a tree/shrub screen adjacent to the Transitway is suggested, where possible, for mitigating impacts of TSP and PM_{10}. Specific areas where barriers are recommended are identified in Table 5.6. At all locations, the barrier should be at least 2 metres high and be planted or installed adjacent to the Transitway. As outlined in the table, it is also recommended that a barrier be created along the west property line of St. Robert Catholic High School because road dust can impact this location when winds blow from a northwest direction.

Mitigation through the planting of trees and shrubs has been considered and incorporated into the preliminary landscape design.

In addition, particulate matter emission estimates may have been overly conservative. Recently (June 2010), the U.S. EPA published draft guidance with an updated methodology for estimating road dust emissions (U.S. EPA, 2010). The revised methodology appears to give significantly lower levels of emissions compared to the U.S. EPA 2006 methods used in this assessment. The draft section proposing the revised calculation methodology as well as supporting documentation can be found at http://www.epa.gov/ttn/chief/ap42/ch13/index.html.

If during the detailed design phase of the project the proposed methods become standard practice, the recommendations outlined in Table 5.6 to reduce the impact of particulate matter to nearby sensitive areas should be revisited.

Table 5.6 Recommended Mitigation Options to Minimize Road Dust Impacts

Sensitive Area	Nearby Sensitive Receptor	Recommended Mitigation
Residences on Hartley Court; north of the Transitway, west of the GO Barrie Line	R1	Trees/shrubs or another barrier type for noise and/or safety purposes should be constructed on the north side of the Transitway, east of the GO Barrie rail line if feasible.
Residences on Yellowood Circle; north of Transitway, east of Dufferin Street	R2	Trees/shrubs or another barrier type for noise and/or safety purposes should be constructed on the north side of the Transitway, beginning at Yellowood Circle and ending at Thornhill Woods Drive if feasible.
Residences on Sassafras Circle; Daniel Reaman Cres. and Lander Cres., north of Transitway, east of Langstaff Road	R3	
Residences on Langstaff Road W; west of Transitway	R4	Since the Transitway is elevated in this area, it will not be possible to use a separate barrier as a mitigation option. Safety barriers constructed on the Transitway overpass at Yonge Street will block and retain some of the road dust at the base of the safety barrier.
Residence on Cedar Avenue, south of Transitway	R5	This area is not significantly impacted by the addition of the Transitway.
Apartment building, northeast corner of Bayview Avenue and Highway 7	R6	This section of the Transitway is below grade (approximately 8 m) and as a result, a retaining wall will be built on either side of the Transitway. This will act as a barrier and retain road dust at the base of the retaining wall.
Potential residential development, south of South Park Road	R7	This area is not significantly impacted by the addition of the Transitway.
Residences on Huntington Park Dr; south of Transitway	R8	This area is not significantly impacted by the addition of the Transitway.
Potential residential development north of Transitway, east of Warden Avenue	R9	If residences are ever constructed, trees/shrubs or another barrier type for noise and/or safety purposes will have to be constructed by the future builder on the north side of the Transitway from approximately the Markham Centre Tributary to the Stouffville Line where necessary.
St. Robert Catholic High School, south of Transitway, east of Leslie Street	R10	Trees/shrubs or another barrier type for noise and/or safety purposes should be constructed on the south side of the Transitway, just east of Leslie and extending approximately 500 m eastward. As well, it is recommended that trees be planted along the west property line of St. Robert Catholic High School. The trees and shrubs should form a visual boundary between the school and the Transitway.

5.5 GRAPHICAL PRESENTATION OF RESULTS - $PM_{2.5}$

The maximum 24-hour average modelled concentrations for $PM_{2.5}$ for all three scenarios are presented with contour lines over a base map in Figures 5.6a through 5.6c. The contours are lines of equal predicted maximum 24-hour concentrations. As outlined in Section 5.3 above, these maximum concentrations do not occur simultaneously, but are the maximum 24-hour concentrations predicted at each grid point during a one year period added to a conservatively high background concentration.

It can be seen in the figures and Table 5.7 that the predicted $PM_{2.5}$ concentrations decrease for the future (2031) scenario without the Transitway. This is a result of emission reductions resulting from advancements in fuel and vehicle technologies, despite the predicted increases in traffic due to population growth. As indicated in Table 3.1 above, the $PM_{2.5}$ emission factor for cars in 2031 is approximately 43% of the emission factor in 2008 and 10% for trucks/buses. In contrast, predicted $PM_{2.5}$ concentrations increase at all but two receptor locations (R5 and R7) for the future (2031) scenario with the Transitway. Although the MOBILE6C $PM_{2.5}$ emission factor decreases in the future, the addition of the 407 Transitway increases road dust emissions significantly and also shortens the distance between some receptors and the nearest source of emissions (i.e., roads). The greatest predicted increase from existing conditions to the Future With the 407 Transitway scenario is 12.6% at receptor R10.

As outlined in Section 3.1.3 above, AP-42 Section 13.2.1 – Paved Roads indicates that there may be situations where low silt loading and/or low average vehicle weight will yield calculated negative emissions. If this occurs, AP-42 Section 13.2.1 recommends the calculated $PM_{2.5}$ road dust emissions be set to zero. Keeping in mind the background value for $PM_{2.5}$ (17.5 $\mu g/m^3$), Figures 5.6a and 5.6b suggest little $PM_{2.5}$ emissions from vehicle traffic along the majority of Highway 407. This is a result of low silt loading due to Highway 407 segments having 24-hour AADT (annual average daily traffic) counts greater than 10,000 which will result in zero predicted emissions from the fine component of road dust. In contrast, roadways with a 24-hour AADT (annual average daily traffic) count less than 10,000 (i.e., the 407 Transitway) will emit $PM_{2.5}$ road dust emissions. Also, the average vehicle weight on the Transitway is greater than Highway 407 since it is occupied only by buses. Thus, the increased $PM_{2.5}$ concentrations shown in Figure 5.3c are a result of low 24-hour AADT counts and a higher average vehicle weight on the Transitway which causes more road dust to be generated.

The figures below also suggest that $PM_{2.5}$ behaves differently from PM_{10} and TSP. As discussed in Section 5.4.2, PM_{10} and TSP concentrations are primarily a function of mechanically generated dust whereas $PM_{2.5}$ is typically a function of tailpipe emissions.

The predicted 24-hour maximum concentrations at the ten sensitive receptors for the future with and without the 407 Transitway (2031) for $PM_{2.5}$ are presented in Table 5.8. The table indicates there will be some significant air quality impacts as a result of the proposed bus rapid transit system, namely at R10. As with PM_{10}, the greatest predicted impact of $PM_{2.5}$ occurred at R10 with an increase of 12.6% compared to the future scenario without the Transitway. As discussed previously, R10 and the Transitway are only separated by a distance of about 40 metres, whereas the distance between Highway 407 and R10 is 120 metres. Due to the close proximity of R10 to the 407 Transitway and the increased amount of road dust emissions on the Transitway, an impact on air quality is to be expected.

Tables 5.6 and 5.7 also show that the background concentration of 17.5 µg/m^3 represents the majority of the overall estimated $PM_{2.5}$ concentrations. As well, there are no predicted exceedances of the proposed Canada Wide Standard for $PM_{2.5}$ at any of the receptor locations.

Table 5.7 Maximum 24-hour $PM_{2.5}$ Concentrations – Existing and Future Scenarios

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		Canada-Wide Standard
	µg/m^3	µg/m^3	% change from Existing	µg/m^3	% change from Existing	µg/m^3
R1	18.2	17.8	-2.2%	18.7	2.5%	30
R2	18.2	17.8	-2.1%	18.9	4.0%	30
R3	18.6	18.0	-3.4%	19.0	1.8%	30
R4	18.4	17.9	-2.7%	19.0	3.4%	30
R5	18.8	17.9	-4.7%	18.4	-2.0%	30
R6	18.1	17.7	-1.9%	18.5	2.5%	30
R7	18.6	18.0	-3.5%	18.6	-0.3%	30
R8	17.9	17.7	-1.2%	18.0	1.0%	30
R9	18.2	17.9	-1.7%	19.0	4.5%	30
R10	18.2	17.8	-2.2%	20.5	12.6%	30

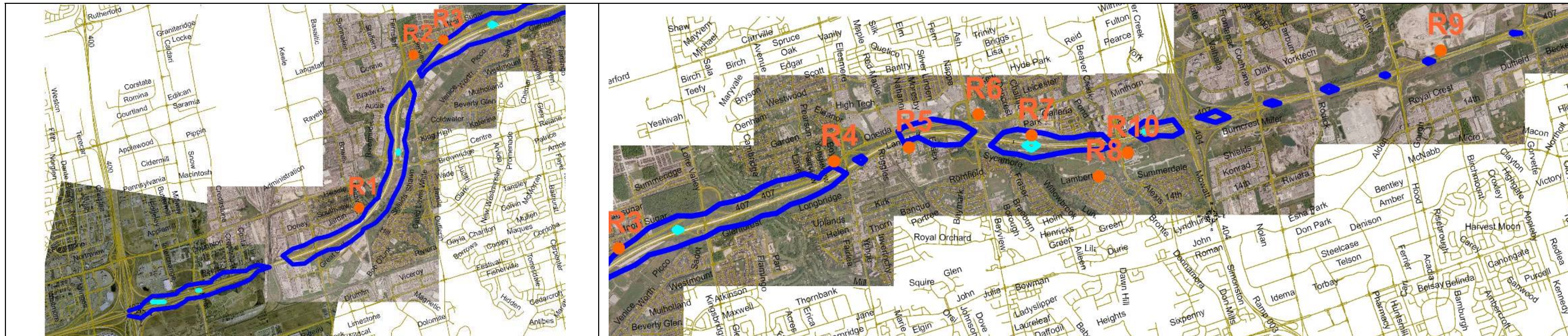
Note: All values include a background $PM_{2.5}$ concentration of 17.5 µg/m^3.

Table 5.8 Maximum 24-hour $PM_{2.5}$ Concentrations – Future Scenarios Comparison

Receptor	Future Without Transitway (μg/m^3)	Future With Transitway (μg/m^3)	% Change from Without Transitway	Canada-Wide Standard (μg/m^3)
R1	17.8	18.7	4.8%	30
R2	17.8	18.9	6.2%	30
R3	18.0	19.0	5.3%	30
R4	17.9	19.0	6.3%	30
R5	17.9	18.4	2.8%	30
R6	17.7	18.5	4.5%	30
R7	18.0	18.6	3.4%	30
R8	17.7	18.0	2.2%	30
R9	17.9	19.0	6.3%	30
R10	17.8	20.5	15.2%	30

Note: All values include a background $PM_{2.5}$ concentration of 17.5 μg/m^3.

Figure 5.6 Maximum 24-hour $PM_{2.5}$ Concentrations for Existing and Future Scenarios

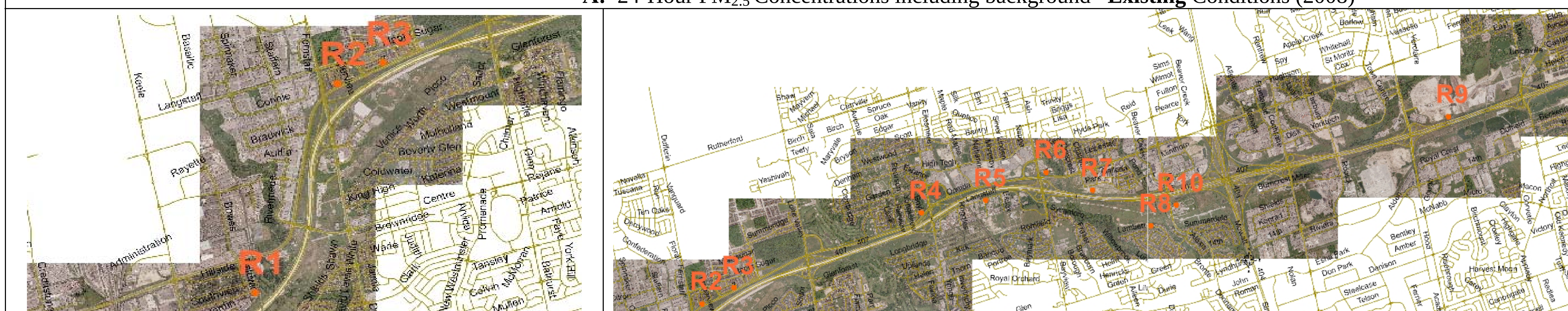


Level	Line
18.8	blue
19.5	cyan
21	green

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

A: 24-Hour $PM_{2.5}$ Concentrations including background – **Existing** Conditions (2008)

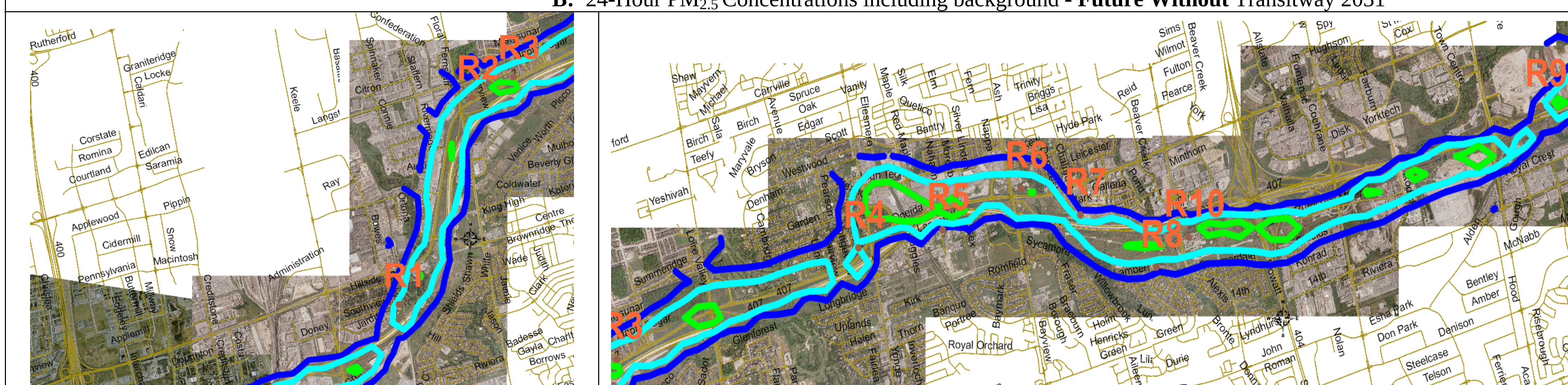


Level	Line
18.8	blue
19.5	cyan
21	green

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

B: 24-Hour $PM_{2.5}$ Concentrations including background - **Future Without** Transitway 2031



Level	Line
18.8	blue
19.5	cyan
21	green

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

C: 24-Hour $PM_{2.5}$ Concentrations including background – **Future With** Transitway 2031

5.6 STATION MODELLING RESULTS

Detailed results of the station modelling are provided in Appendix D. In all, the assessment showed that the additional impact of the Leslie and GO Barrie (Concord) stations on air quality is negligible. Since these stations were considered to represent the worst-case scenarios, impacts from the remaining stations will also be negligible.

5.7 POLLUTANT BURDEN ANALYSIS OF GREENHOUSE GASES

To assess the potential changes in greenhouse gas (GHG) pollutant burden within the study area based on the addition of the 407 Transitway, contaminant emissions of CO_2, CH_4, and N_2O in terms of CO_{2e} were calculated for all three assessment scenarios.

The results of the pollutant burden analysis are presented below for CO_{2e}. Complete results for the individual gases are presented in Appendix F.

5.7.1 Carbon Dioxide Equivalent (CO_{2e})

As outlined in Table 5.9 below, the annual CO_{2e} pollutant burden within the study area corridor is estimated to increase by approximately 83% in the future. Since the CO_2 emission factor will increase in the future (Table 3.1) along with the volume of traffic in response to population growth, the CO_{2e} pollutant burden will also increase. When comparing the two future scenarios, it can be seen that there is a very small reduction in annual CO_{2e} pollutant burden (about 1 kilotonne or 0.2%). This small difference is based on approximately the same number of vehicles occupying Highway 407, but with the future bus fleet moved to the 407 Transitway. It was estimated that for the future scenario **without** the Transitway, buses would travel an approximate distance of 24.5 km on Highway 407. In contrast, buses would travel 23 km on the Transitway, accounting for this small reduction in CO_{2e} pollutant burden. Note that this difference is within the error of estimating the distances travelled by the Highway 407 and the Transitway vehicle fleets. Therefore, the difference in the annual CO_{2e} pollutant burden between the two future scenarios is negligible.

Table 5.9 CO_{2e} Pollutant Burden

Scenario	CO_{2e} Pollutant Burden in kilotonnes/year	% Change from Existing Conditions in kilotonnes/year
Existing Conditions (2008)	344	-
Future **Without** Transitway (2031)	632	+83.4%
Future **With** Transitway (2031)	631	+83.1%

A negligible change in annual CO_{2e} pollutant burden due to the addition of the 407 Transitway was estimated in the above table. However, future traffic volume estimates were based on expected increases in population growth and did not take into consideration the number of vehicles that may be taken off of the road when the 407 Transitway is in full operation. As a result, it is difficult to quantify the change in annual GHG pollutant burden due to the addition of the Transitway.

6.0 CONCLUSIONS AND MITIGATION PLAN

6.1 CONCLUSIONS

6.1.1 Discussion of Existing Conditions

The results of the study show, through monitoring and modelling, that the existing air quality in the study area is typical of an urban setting, which is characterized by elevated pollutant concentrations in relation to rural areas, with periodic compromised air quality due to nitrogen oxides and fine particulate based contaminants, which typically occur during smog events.

Available historical monitoring data near to the study area indicates that:

- CO concentrations are well within all applicable standards;
- $PM_{2.5}$ concentrations periodically exceed the 24-hour Canada-Wide standard; and
- NO_x concentrations periodically exceed the 1-hour and 24-hour AAQC standards, typically during smog events.

6.1.2 Comparison of Existing Conditions with Future Scenarios

For both future scenarios with and without the 407 Transitway (2031), the study identifies that compared to existing conditions (2008), air quality will slightly improve for gaseous pollutants due to newer engine technologies and fuels, despite predicted increases in traffic resulting from population growth. However, air quality will deteriorate for particulate based compounds due to:

- increased traffic flow on Highway 407 resulting from population growth in the future and/or,
- increased road silt accumulation as a result of low bus volumes/heavier vehicles on the 407 Transitway.

Additionally, the annual pollutant burden of carbon dioxide equivalent (CO_{2e}) is expected to increase in the future as a result of increased traffic volumes due to population growth, coupled with an increase in the MOBILE6C emission factor for carbon dioxide (CO_2).

6.1.3 Comparison of Future Scenarios

The results show that within the study area, when compared to the future no-build scenario (2031), adding the 407 Transitway will result in:

- negligible changes in gaseous pollutant concentrations and greenhouse gases (GHGs) throughout the study area;

- a slight increase in $PM_{2.5}$ (particulate matter less than 2.5 μm in diameter) concentrations, particularly at receptors whose distance from a roadway (emission source) decreases with the addition of the Transitway;
- an increase in total suspended particulate (TSP) and PM_{10} (particulate matter less than 10 μm in diameter) concentrations throughout the study area;
- approximately a 2% to 40% increase in TSP and PM_{10} concentrations at sensitive receptor locations adjacent to the 407 Transitway; and,
- negligible changes in gaseous and particulate matter concentrations when station parking lot and passenger pick-up and drop-off (PPUDO) emissions are considered.

In all, the implementation of a 23 kilometre bus rapid transit system from Highway 400 to Kennedy Road in the municipalities of Vaughan, Richmond Hill and Markham, Ontario will result in increases in particulate matter (mainly TSP and PM_{10}) concentrations at sensitive receptor locations within the study area. The ambient air quality criterion for TSP is based on visibility, and the criterion for PM_{10} is based on health effects. Therefore, the study shows that there will be an appreciable increase in one contaminant (PM_{10}) with health based standards. The recommended broad-based mitigation measures outlined below are proposed to reduce PM_{10} impacts, and will also reduce TSP impacts.

6.2 BROAD-BASED MITIGATION PLAN

Mitigation measures are recommended to reduce future particulate based (TSP and PM_{10}) air quality impacts from the 407 Transitway which includes increased tree planting or constructing other solid barriers for noise and/or safety purposes adjacent to the Transitway which are at least 2 metres tall where possible. Trees/shrubs or solid barriers for noise and/or safety purposes located along the Transitway will act as screens and significantly reduce the particulate matter emission rate for material flowing horizontally from the roadways (Watson and Chow, 2000). In particular, it is recommended that trees be planted (or a solid barriers for noise and/or safety purposes be constructed) adjacent to the Transitway near St. Robert Catholic High School (receptor R10) and existing/planned residential areas with the exception of receptors R5, R6, R7, R8 and R9. Table 5.6 provided a summary of recommended mitigation options.

Mitigation through the planting of trees and shrubs has been considered and incorporated into the preliminary landscape design.

In addition, particulate matter emission estimates may have been overly conservative. Recently (June 2010), the U.S. EPA published draft guidance with an updated methodology for estimating road dust emissions (U.S. EPA, 2010). The revised methodology appears to give significantly lower levels of emissions compared to the U.S. EPA 2006 methods used in this assessment. The

draft section proposing the revised calculation methodology as well as supporting documentation can be found at http://www.epa.gov/ttn/chief/ap42/ch13/index.html.
If during the detailed design phase of the project the proposed methods become standard practice, the recommendations outlined in Table 5.6 to reduce the impact of particulate matter to nearby sensitive areas should be revisited.

The construction of the 407 Transitway has the potential to affect the air quality in the vicinity of the site during the construction phase. As with any construction site, these emissions will be of relatively short duration and are unlikely to have any long-lasting effect on the surrounding area. Dust impacts should be mitigated through the use of proper controls, such as:

- periodic watering of unpaved (non-vegetated) areas;
- periodic watering of an material stockpiles;
- limiting the speed of construction vehicular travel;
- use of water sprays during the loading, unloading of materials; and
- sweeping and/or water flushing of the entrances to the construction zones.

These types of controls aid in minimizing the impacts on the environment during the construction phase. Night time construction activities should also be considered in order to reduce emissions from vehicles that are slowed down by any reduced road capacity during the day.

6.3 CONSERVATIVE NATURE OF ASSESSMENT

The air quality impact assessment is considered to be conservative based on the following:

- Industry standard conservative 90th percentile background monitoring values were added to model predicted contaminant concentrations;
- Background monitoring data for PM_{10} and TSP was not available, therefore, the conservative assumption was made that PM_{10} background concentrations are twice $PM_{2.5}$ and TSP background concentrations are twice PM_{10};
- The future with Transitway scenario assumes no reduction in vehicle traffic on Highway 407, however, based on discussions with the MTO and Delcan, it is reasonable to assume that the introduction of the 407 Transitway into the study area will reduce the number of vehicles present within the transportation corridor (i.e., Highway 7 and other regional roads); and,
- Recently (June 2010), the U.S. EPA published draft guidance with an updated methodology for estimating road dust emissions (U.S. EPA, 2010). The revised methodology appears to give significantly lower levels of emissions compared to the U.S. EPA 2006 methods used in this assessment.

7.0 REFERENCES

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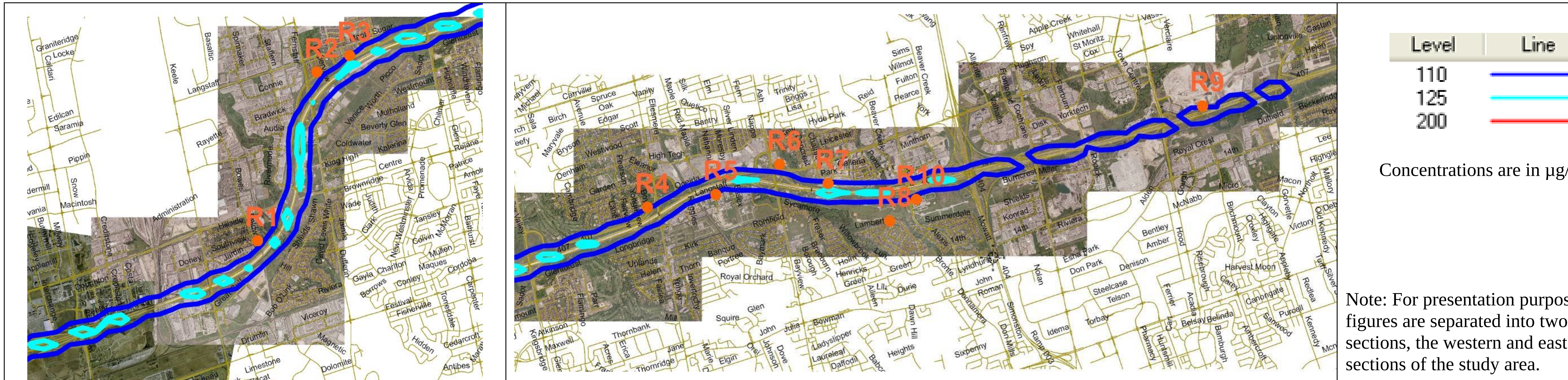
APPENDIX A

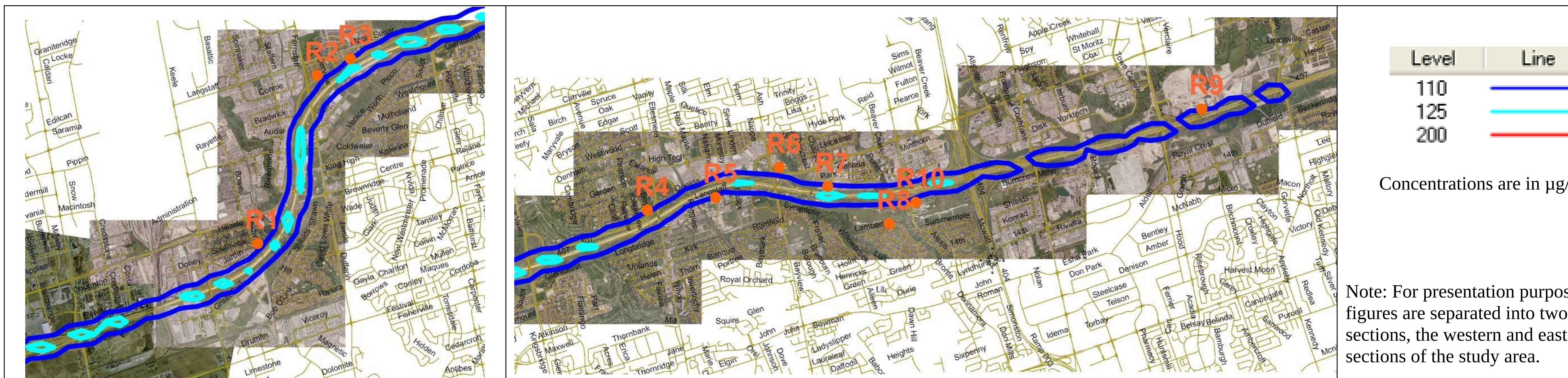
GRAPHICAL PRESENTATION OF MODELLING RESULTS



Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

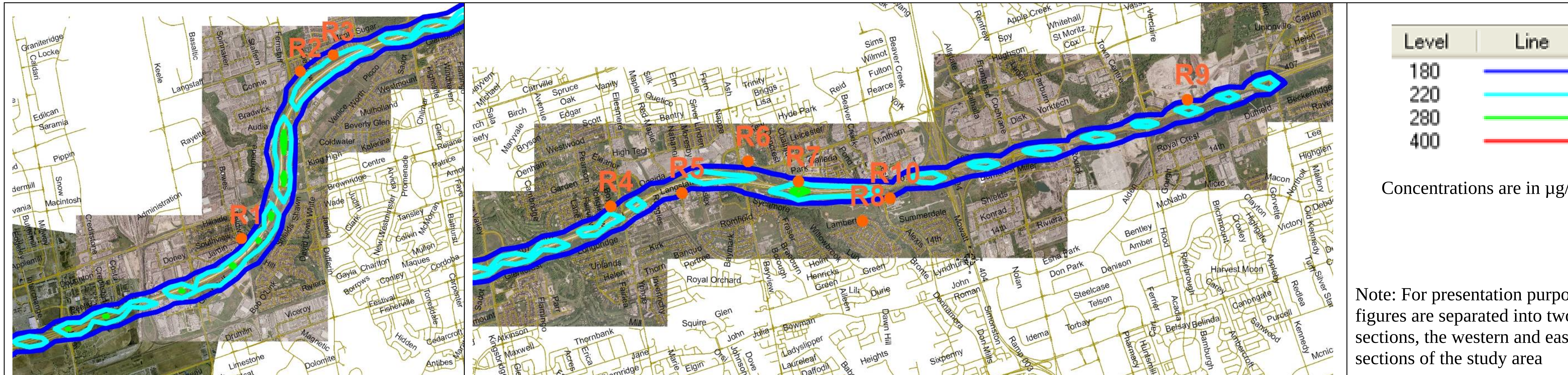
Figure A.1a 24-Hour NO_x Concentrations including background in µg/m^3 – **Future Without** Transitway (2031)



Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

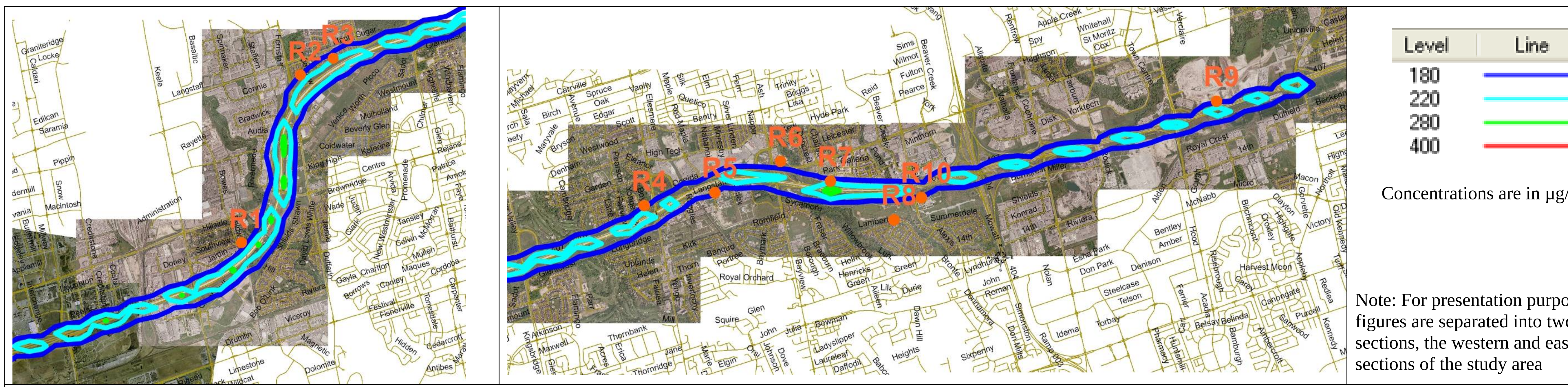
Figure A.1b 24-Hour NO_x Concentrations including background in µg/m^3 - **Future With** Transitway (2031)



Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

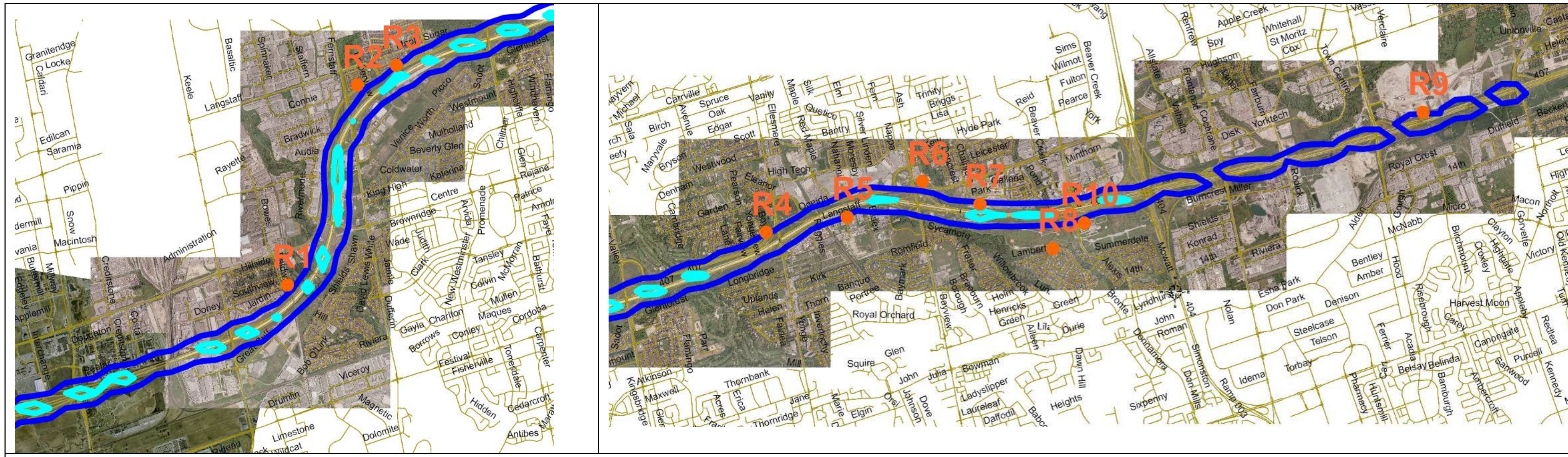
Figure A.2a 1-Hour NO_x Concentrations including background in µg/m^3 – **Future Without** Transitway (2031)



Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.2b 1-Hour NO_x Concentrations including background in µg/m^3 – **Future With** Transitway (2031)

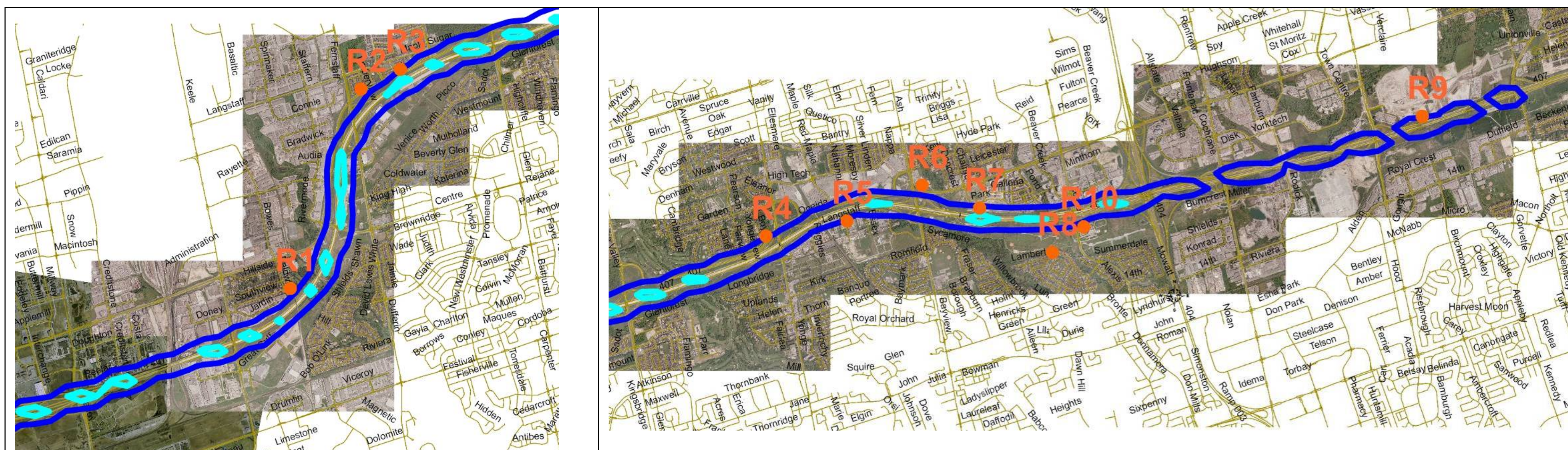


Level	Line
110	blue
125	cyan
200	red

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.3a 24-Hour NO_x Concentrations including background in µg/m^3 – **Existing Conditions** (2008)

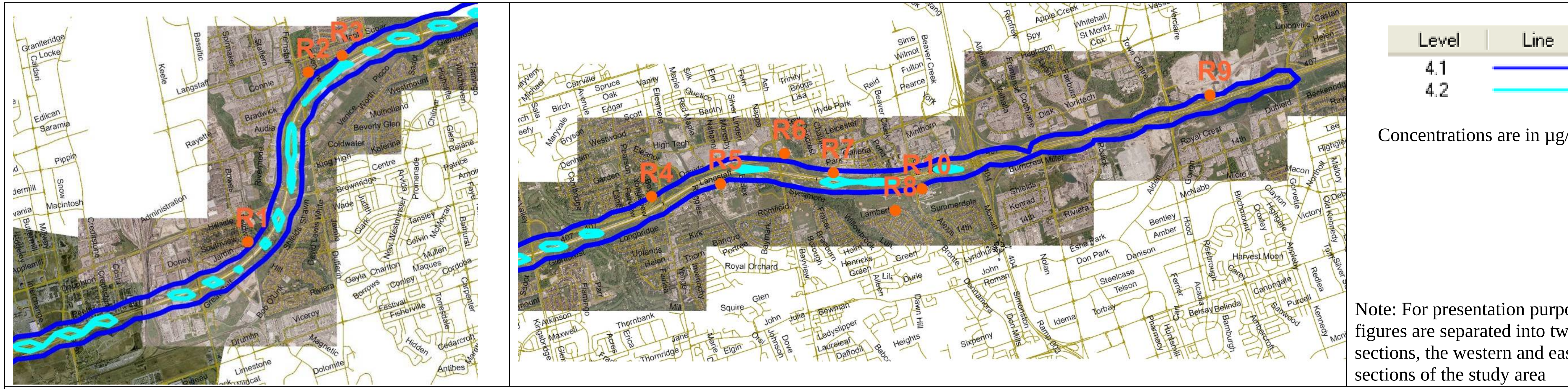


Level	Line
180	blue
220	cyan
280	green
400	red

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

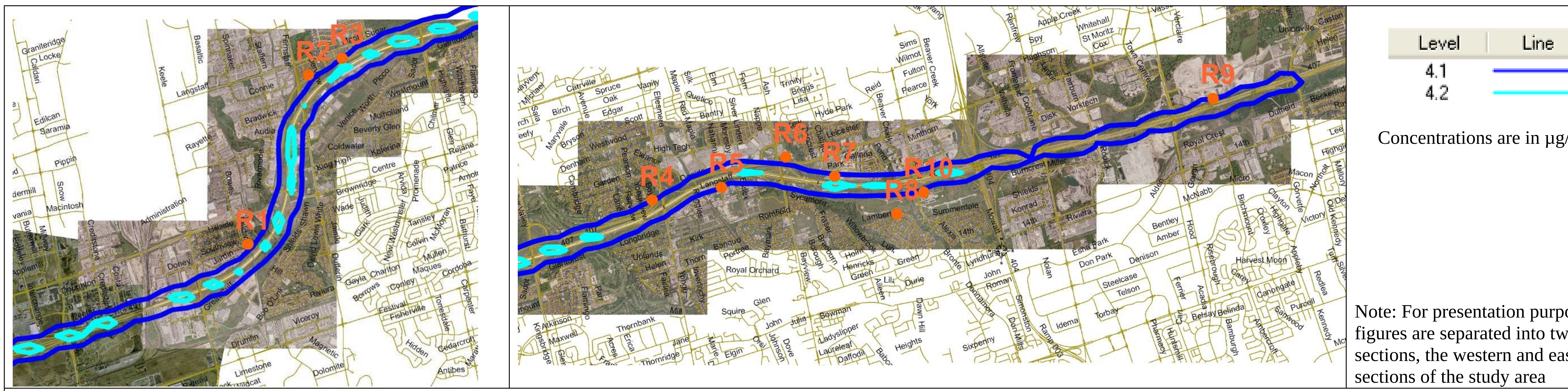
Figure A.3b 1-Hour NO_x Concentrations including background in µg/m^3 - **Existing Conditions** (2008)



Concentrations are in µg/m³

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

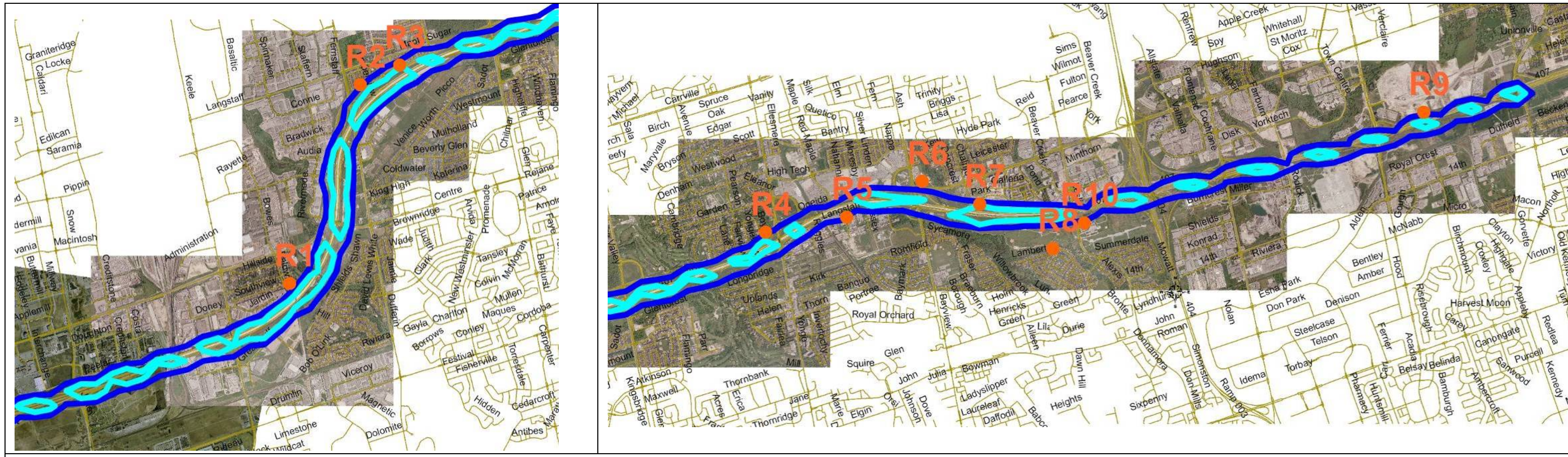
Figure A.4a 24-Hour Acetaldehyde Concentrations including background in µg/m³ – **Future Without** Transitway (2031)



Concentrations are in µg/m³

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.4b 24-Hour Acetaldehyde Concentrations including background in µg/m³ – **Future With** Transitway (2031)

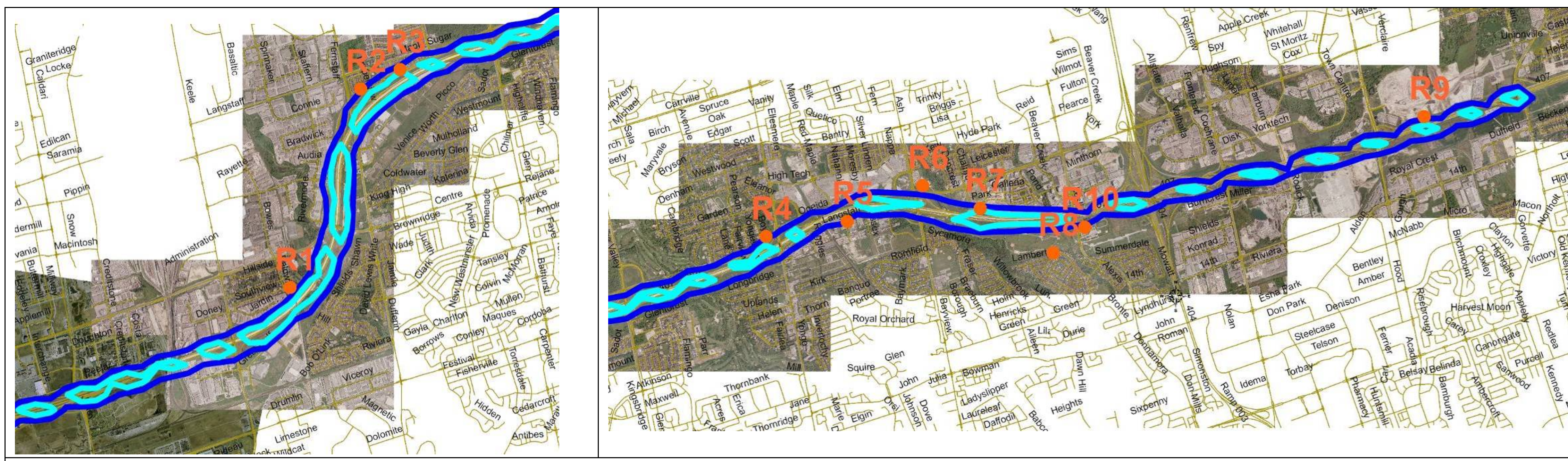


Level	Line
4.5	
4.75	

Concentrations are in $\mu g/m^3$

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.5a 1-Hour Acetaldehyde Concentrations including background in $\mu g/m^3$ – **Future Without** Transitway (2031)

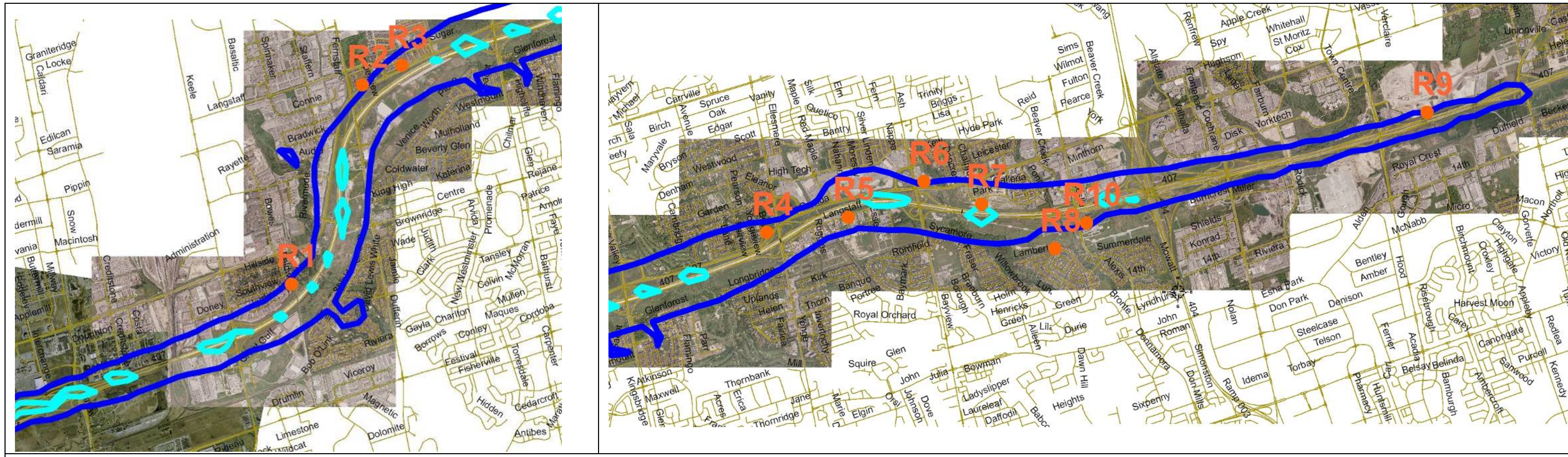


Level	Line
4.5	
4.75	

Concentrations are in $\mu g/m^3$

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.5b 1-Hour Acetaldehyde Concentrations including background in $\mu g/m^3$ – **Future With** Transitway (2031)

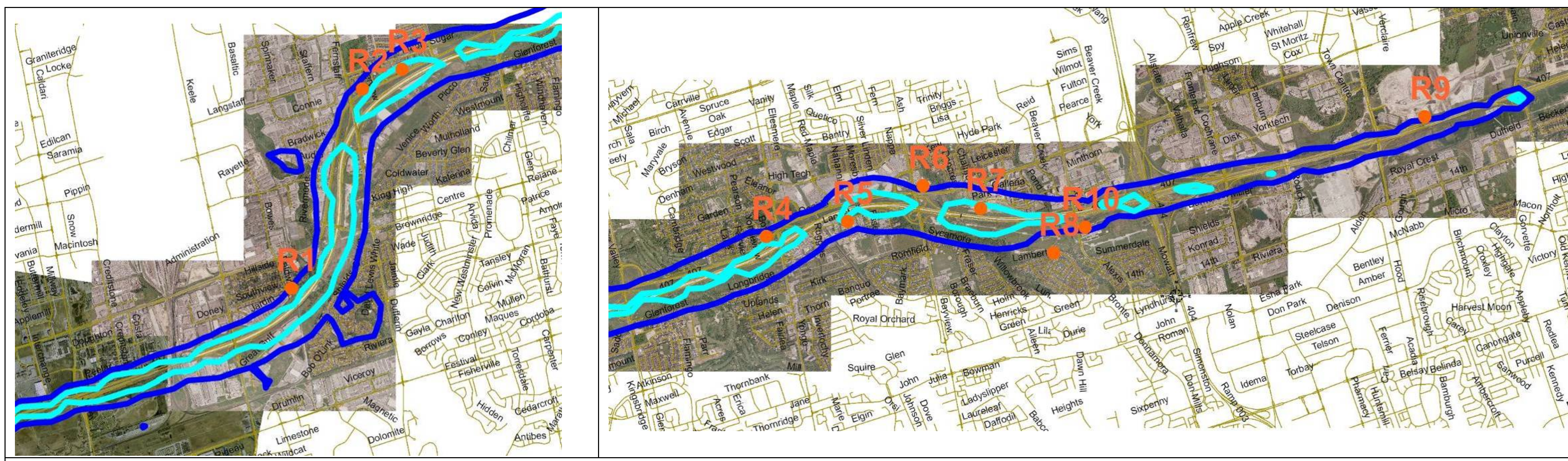


Level	Line
4.1	(blue)
4.2	(cyan)

Concentrations are in μg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.6a 24-Hour Acetaldehyde Concentrations including background in μg/m^3 – **Existing Conditions** (2008)

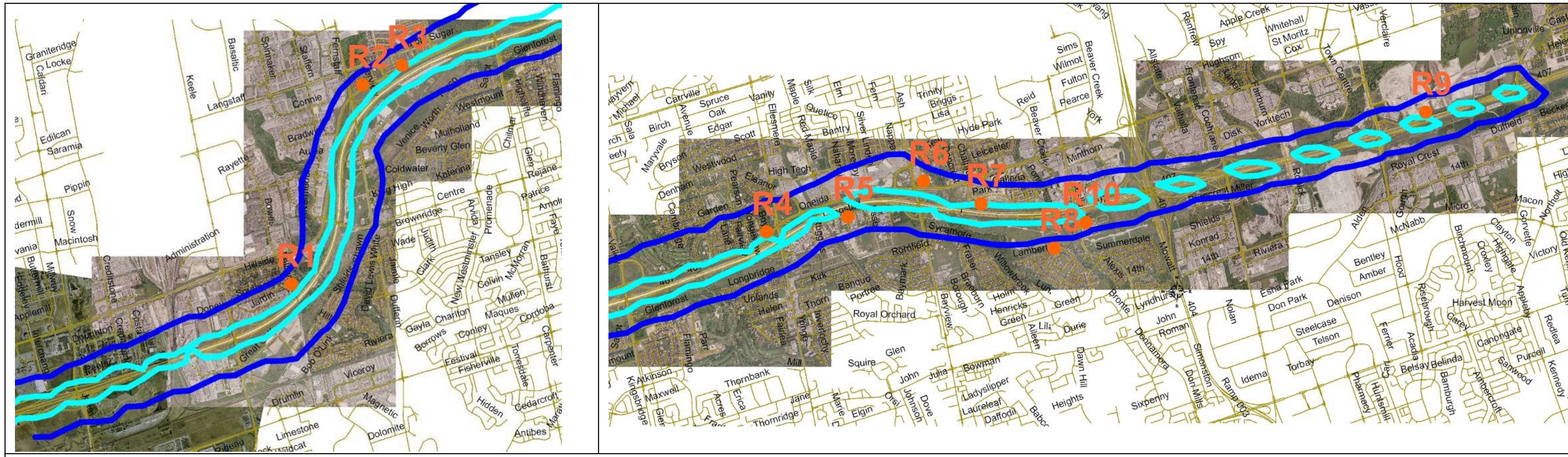


Level	Line
4.5	(blue)
4.75	(cyan)

Concentrations are in μg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.6b 1-Hour Acetaldehyde Concentrations including background in μg/m^3 – **Existing Conditions** (2008)

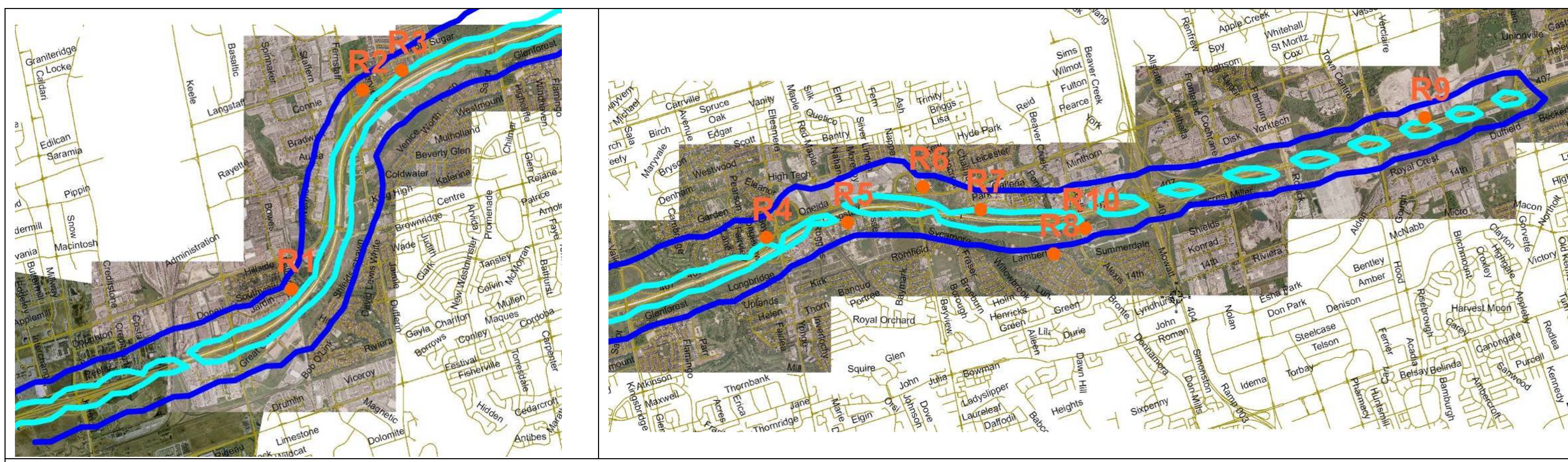


Level	Line
0.705	
0.715	

Concentrations are in μg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.7a 24-Hour Acrolein Concentrations including background in μg/m^3 – **Future Without** Transitway (2031)

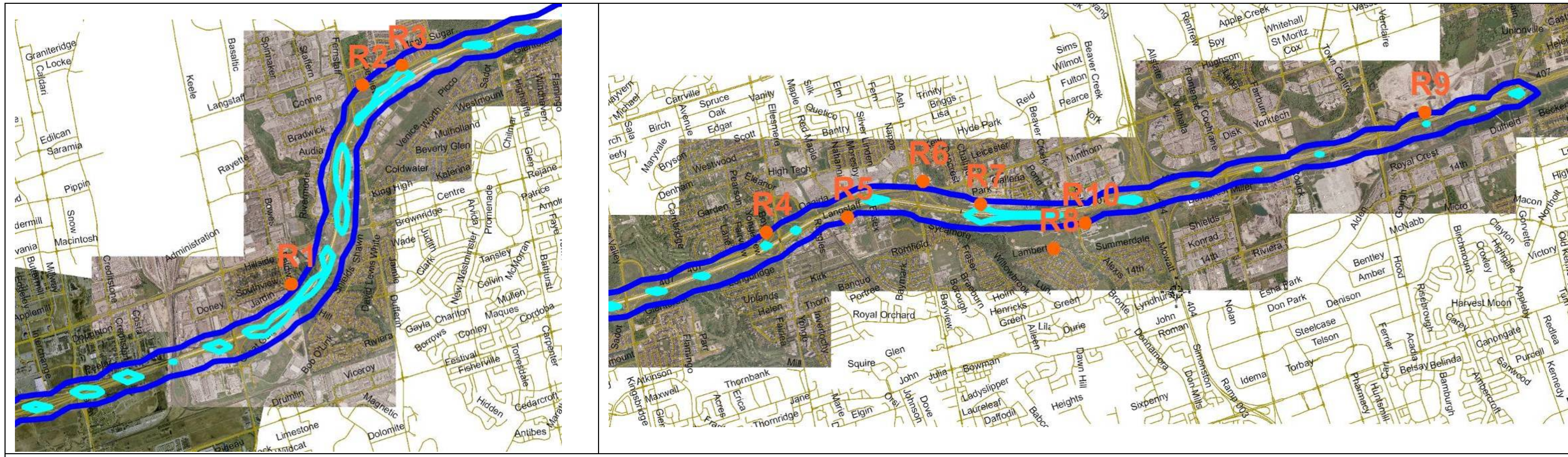


Level	Line
0.705	
0.715	

Concentrations are in μg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

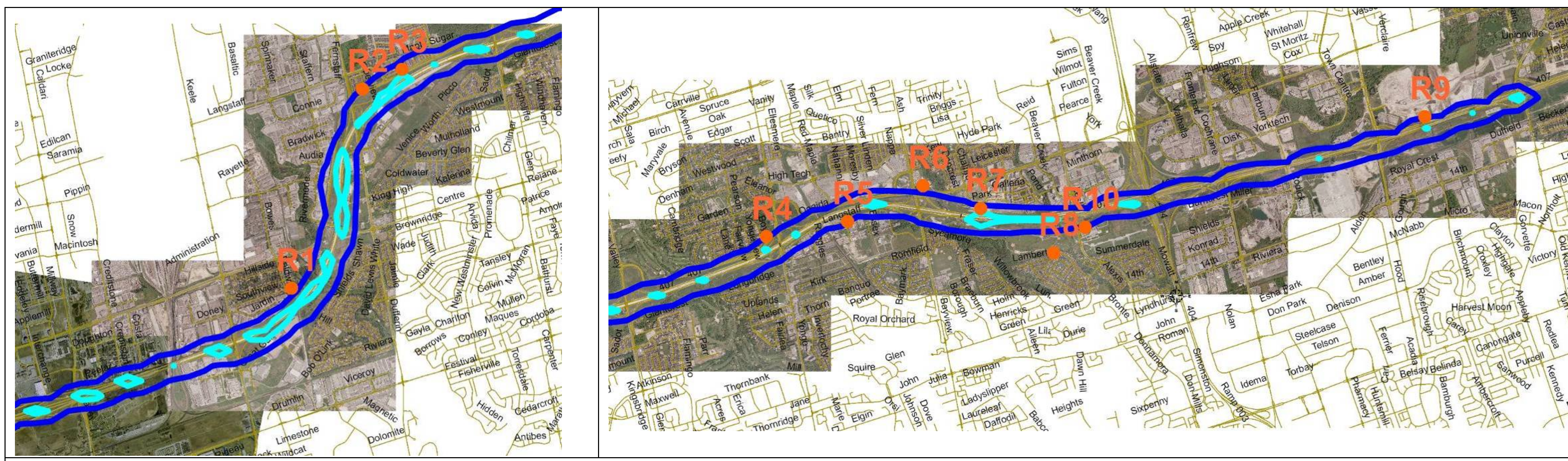
Figure A.7b 24-Hour Acrolein Concentrations including background in μg/m^3 – **Future With** Transitway (2031)



Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

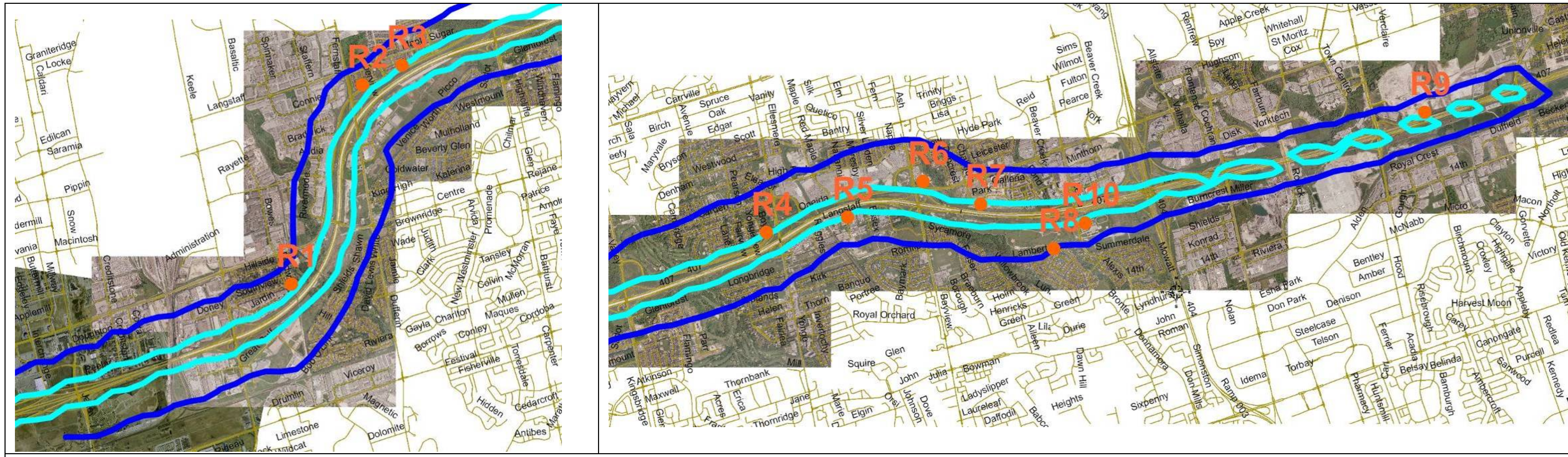
Figure A.8a 1-Hour Acrolein Concentrations including background in µg/m^3 – **Future Without** Transitway (2031)



Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

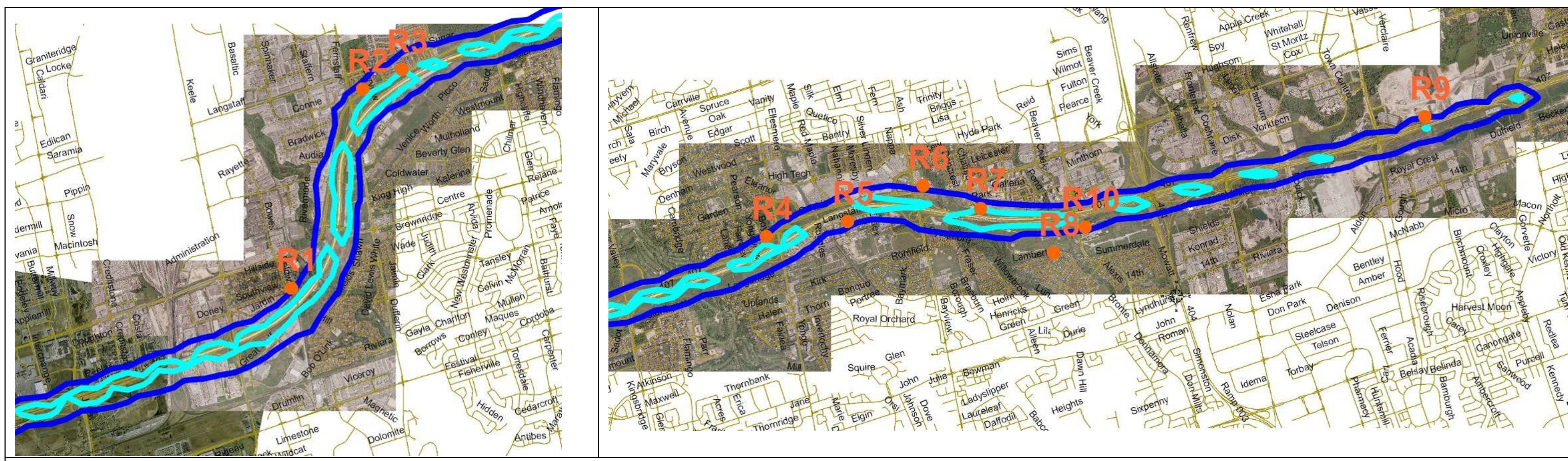
Figure A.8b 1-Hour Acrolein Concentrations including background in µg/m^3 – **Future With** Transitway (2031)



Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

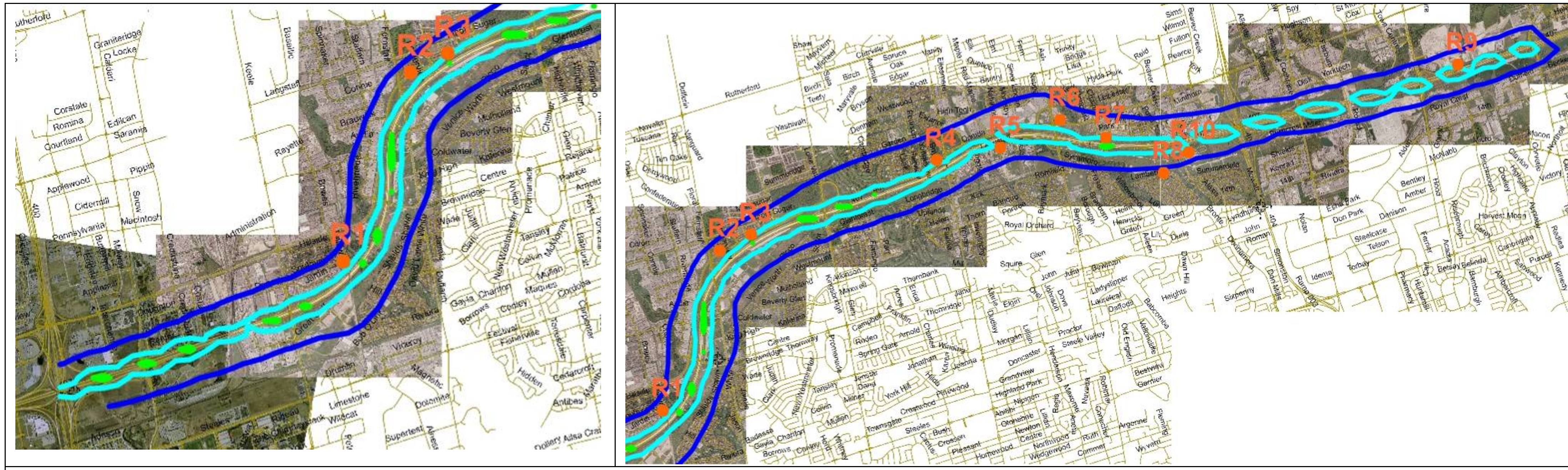
Figure A.9a 24-Hour Acrolein Concentrations including background in µg/m^3 – **Existing Conditions** (2008)



Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

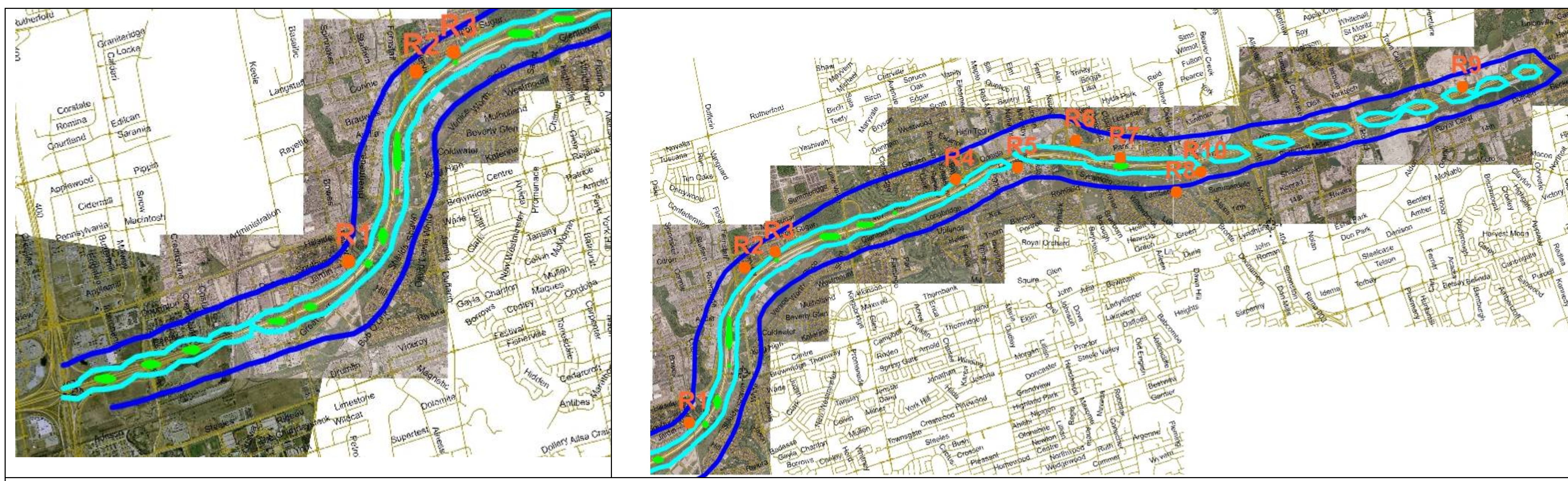
Figure A.9b 1-Hour Acrolein Concentrations including background in µg/m^3 – **Existing Conditions** (2008)



Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

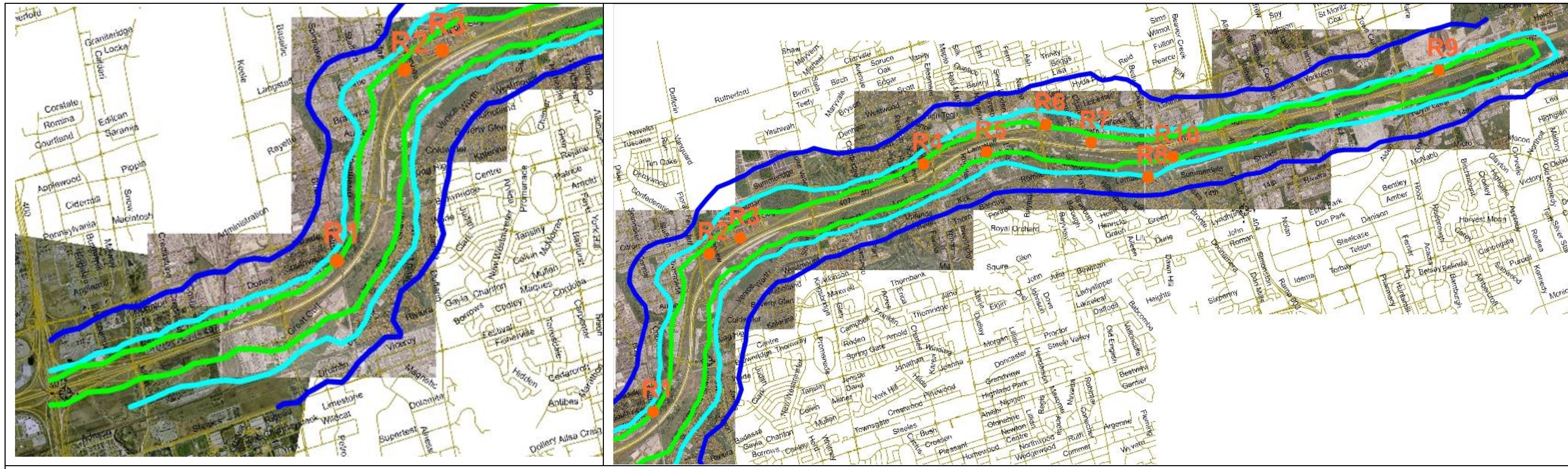
Figure A.10a 24-Hour Benzene Concentrations including background in µg/m^3 – **Future Without** Transitway (2031)



Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

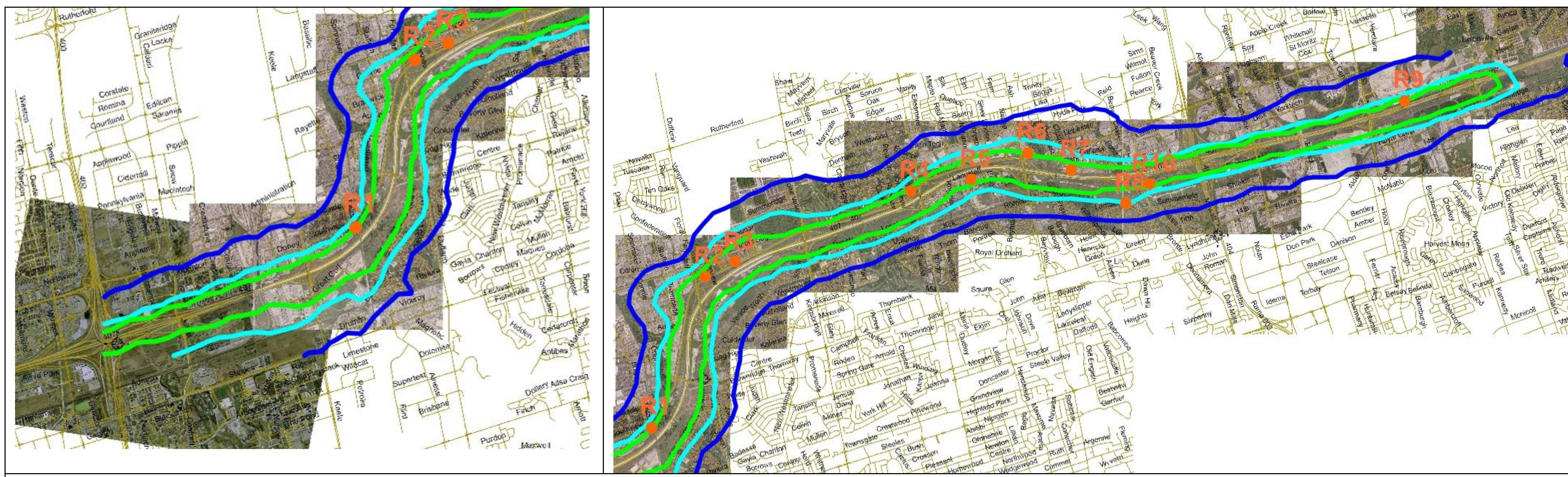
Figure A.10b 24-Hour Benzene Concentrations including background in µg/m^3 – **Future With** Transitway (2031)

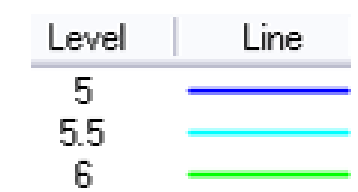


Concentrations are in $\mu g/m^3$

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.11a 1-Hour Benzene Concentrations including background in $\mu g/m^3$ – **Future Without** Transitway (2031)





Concentrations are in $\mu g/m^3$

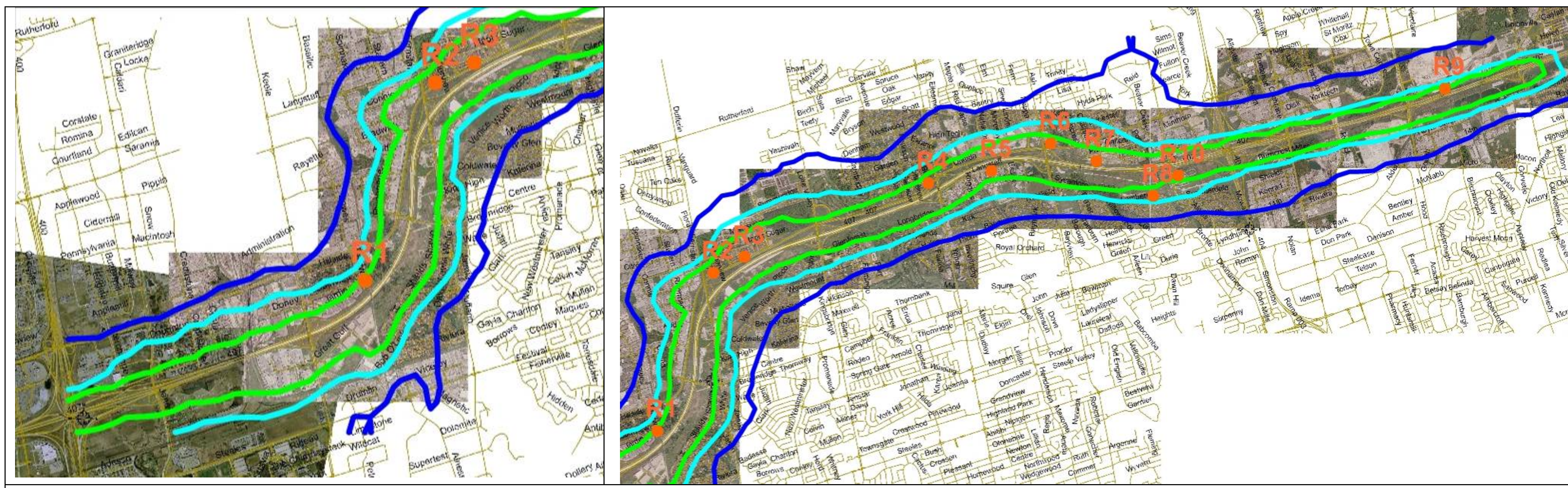
Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.11b 1-Hour Benzene Concentrations including background in $\mu g/m^3$ – **Future With** Transitway (2031)

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

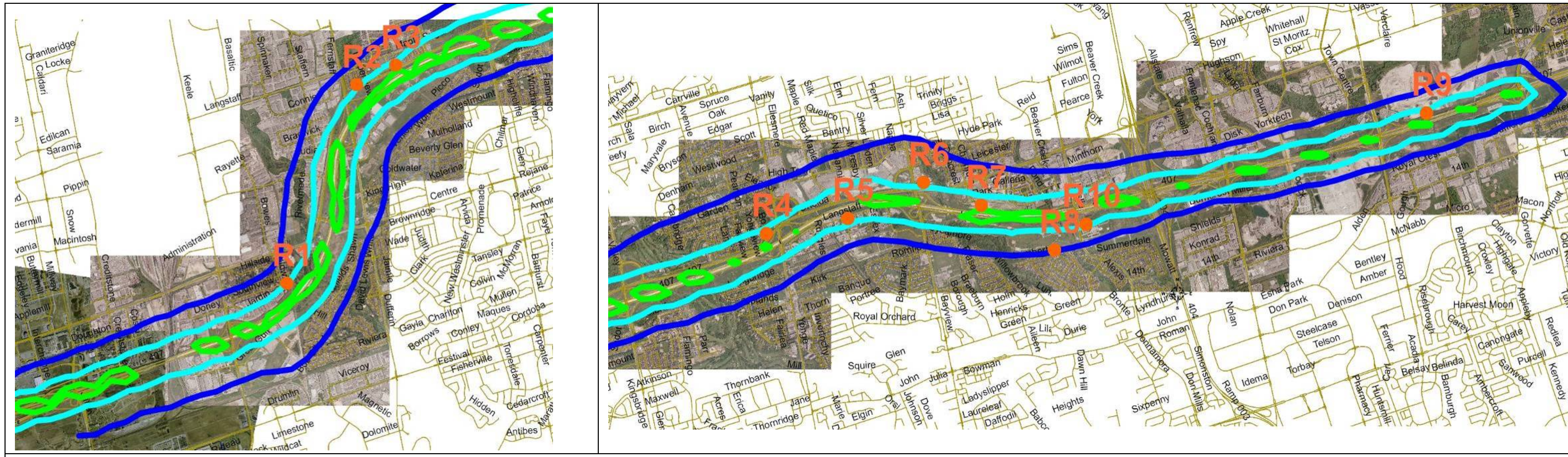
Figure A.12a 24-Hour Benzene Concentrations including background in µg/m^3 – **Existing Conditions** (2008)



Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.12b 1-Hour Benzene Concentrations including background in µg/m^3 – **Existing Conditions** (2008)

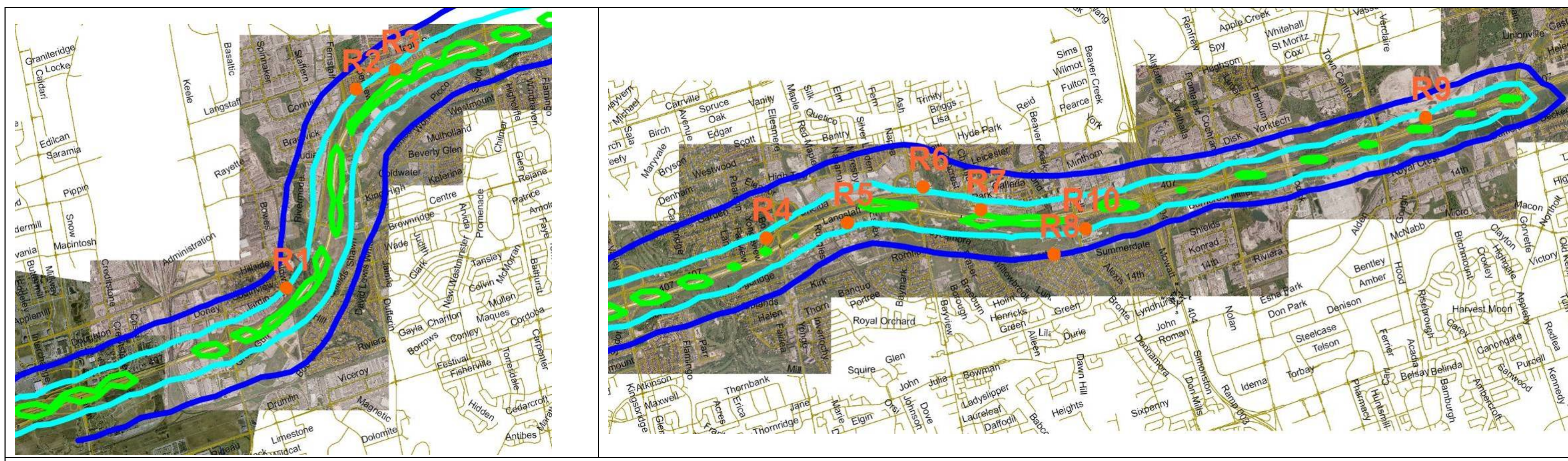


Level	Line
21.02	
21.04	
21.1	

Concentrations are in $\mu g/m^3$

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.13a 24-Hour 1,3-Butadiene Concentrations including background in $\mu g/m^3$ – **Future Without** Transitway (2031)

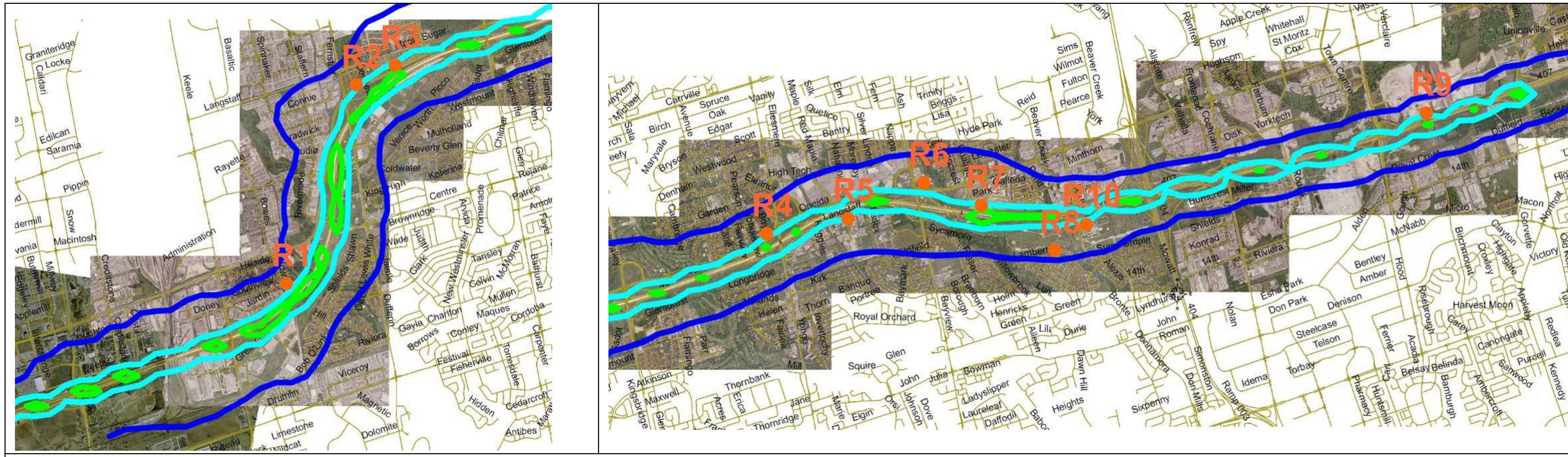


Level	Line
21.02	
21.04	
21.1	

Concentrations are in $\mu g/m^3$

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.13b 24-Hour 1,3-Butadiene Concentrations including background in $\mu g/m^3$ – **Future With** Transitway (2031)

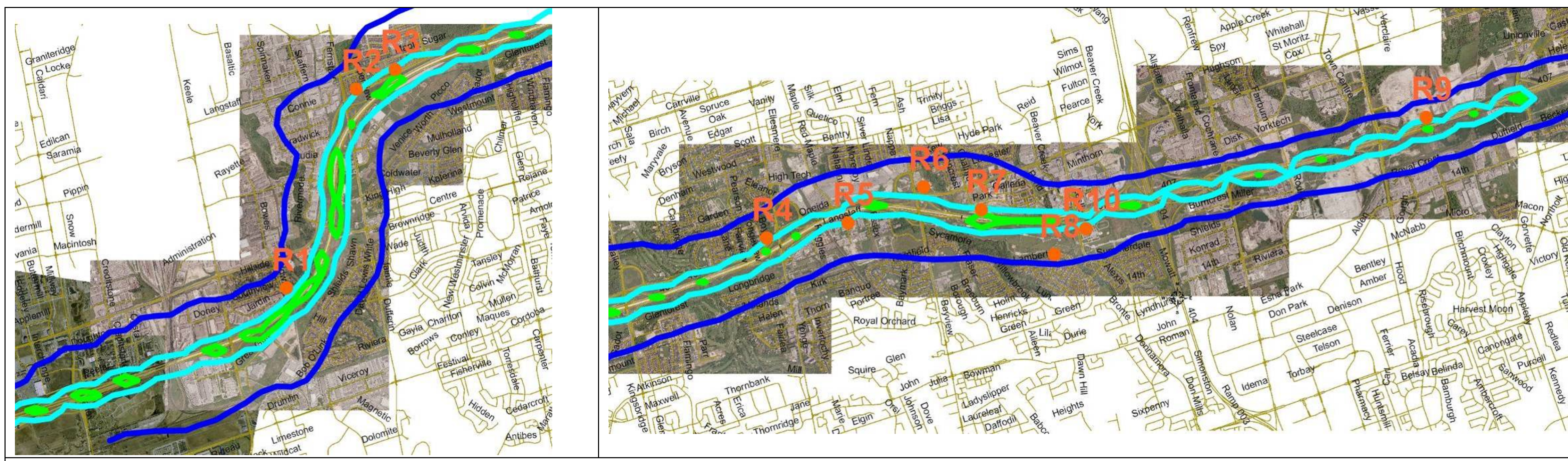


Level	Line
21.1	
21.3	
21.5	

Concentrations are in μg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.14a 1-Hour 1,3-Butadiene Concentrations including background in μg/m^3 – **Future Without** Transitway (2031)

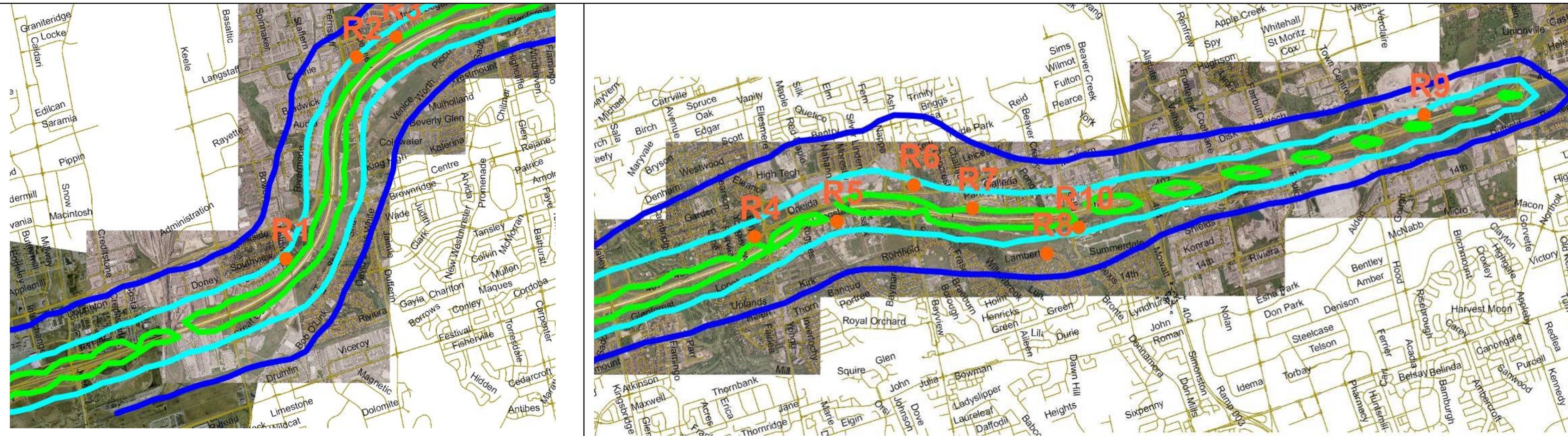


Level	Line
21.1	
21.3	
21.5	

Concentrations are in μg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.14b 1-Hour 1,3-Butadiene Concentrations including background in μg/m^3 – **Future With** Transitway (2031)

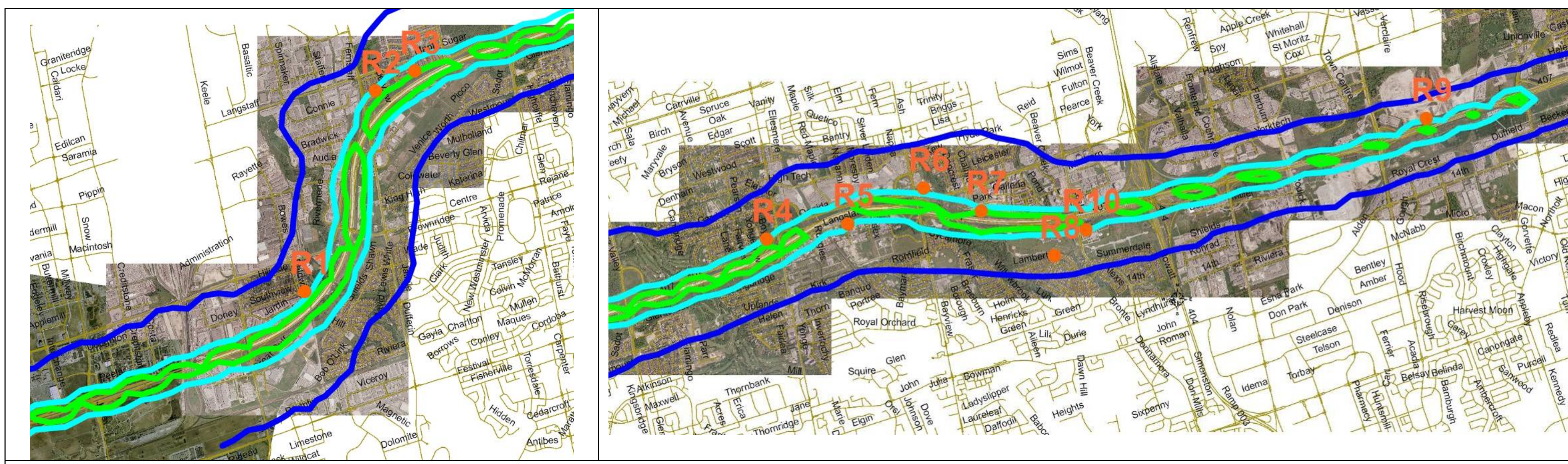


Level	Line
21.02	(blue)
21.04	(cyan)
21.1	(green)

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.15a 24-Hour 1,3-Butadiene Concentrations including background in µg/m^3 – **Existing Conditions** (2008)

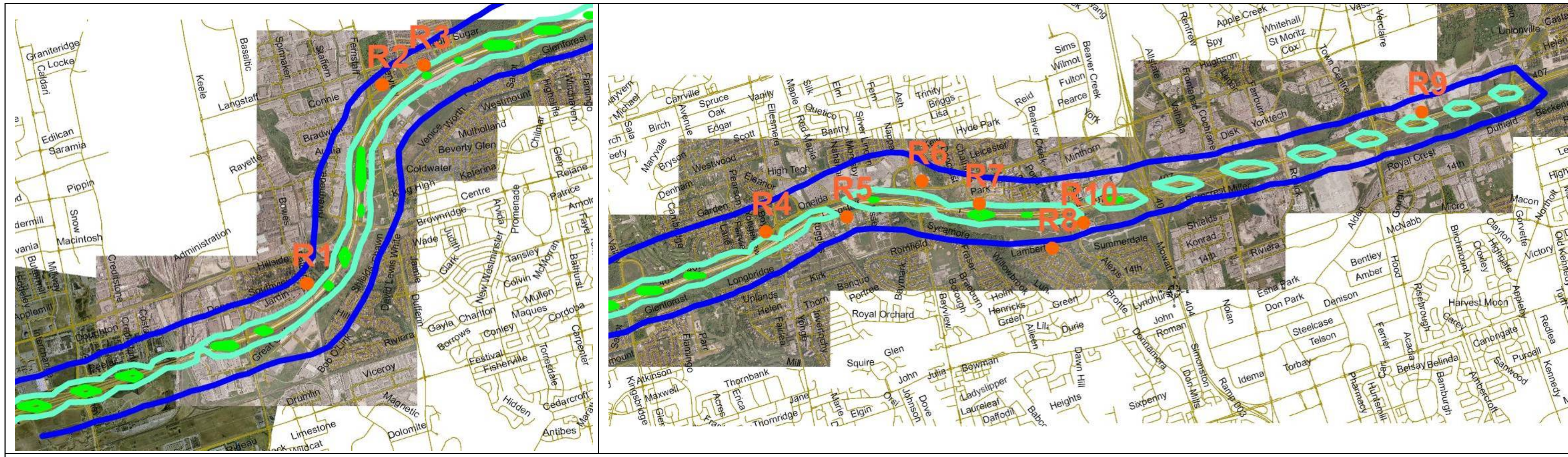


Level	Line
21.1	(blue)
21.3	(cyan)
21.5	(green)

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.15b 1-Hour 1,3-Butadiene Concentrations including background in µg/m^3 – **Existing Conditions** (2008)

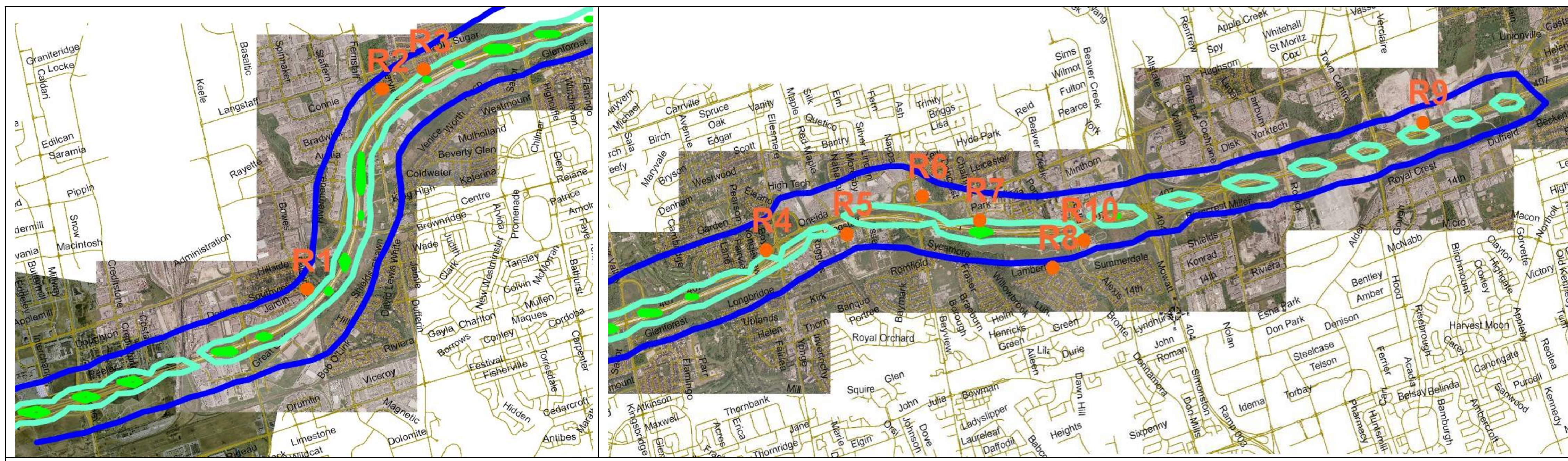


Level	Line
6.1	blue
6.3	light blue
6.5	green

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.16a 24-Hour Formaldehyde Concentrations including background in µg/m^3 – **Future Without** Transitway (2031)

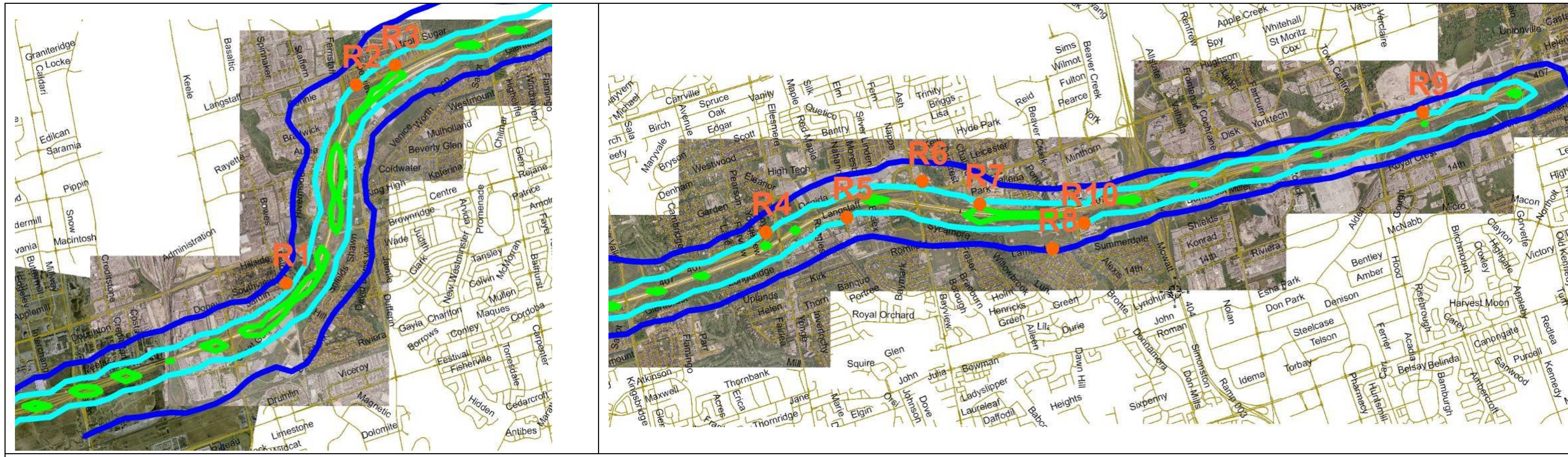


Level	Line
6.1	blue
6.3	light blue
6.5	green

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

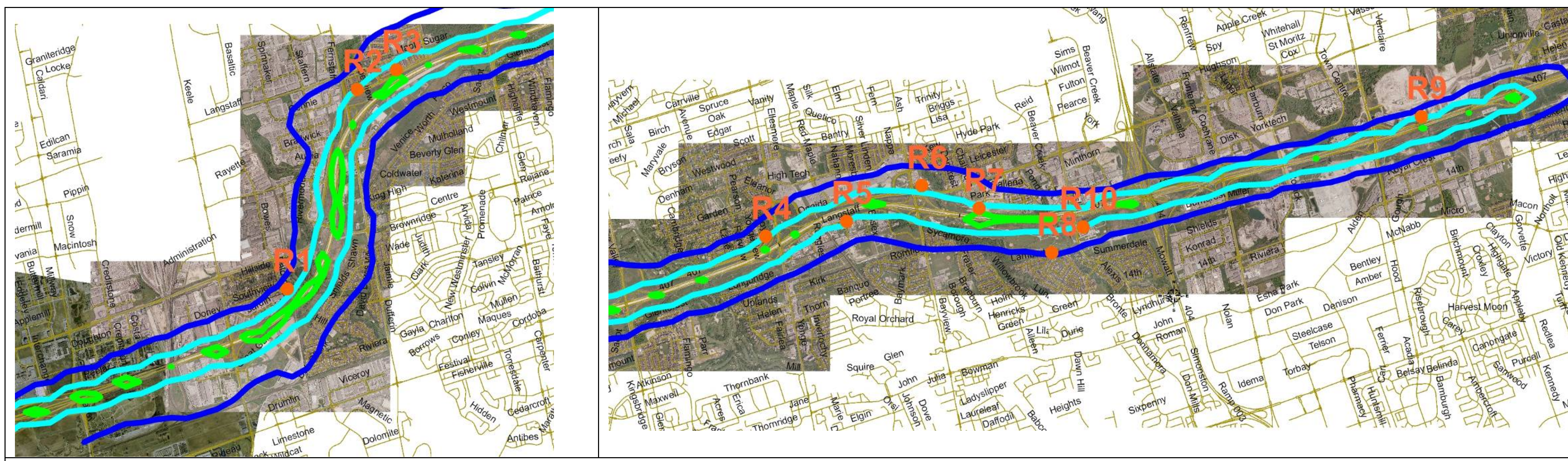
Figure A.16b 24-Hour Formaldehyde Concentrations including background in µg/m^3 – **Future With** Transitway (2031)



Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

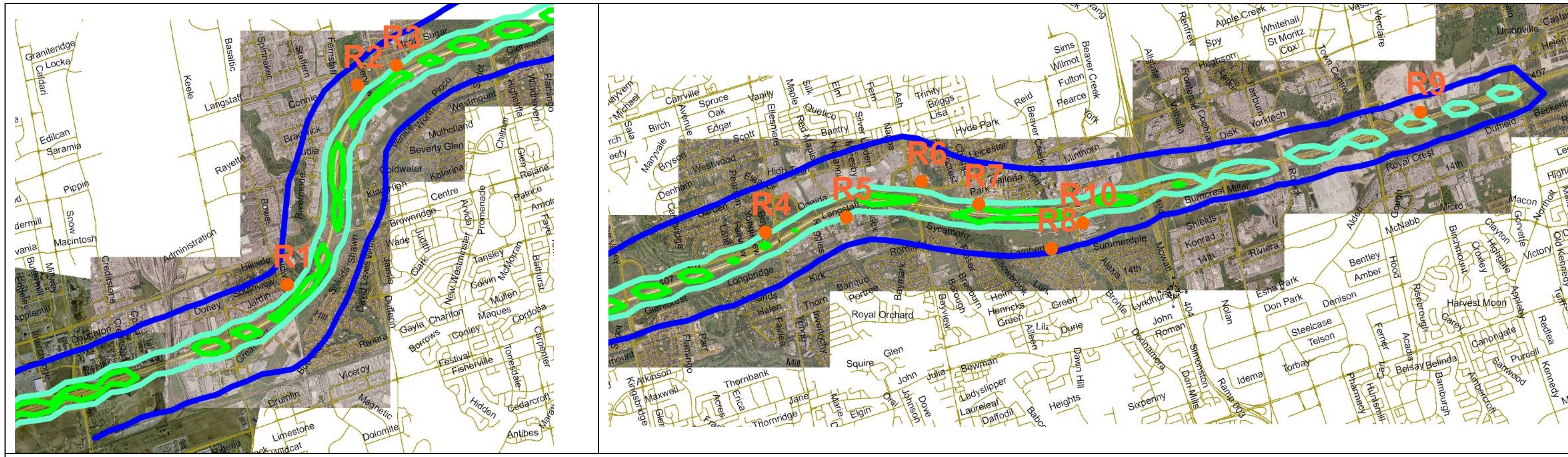
Figure A.17a 1-Hour Formaldehyde Concentrations including background in µg/m^3 – **Future Without** Transitway (2031)



Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.17b 1-Hour Formaldehyde Concentrations including background in µg/m^3 – **Future With** Transitway (2031)

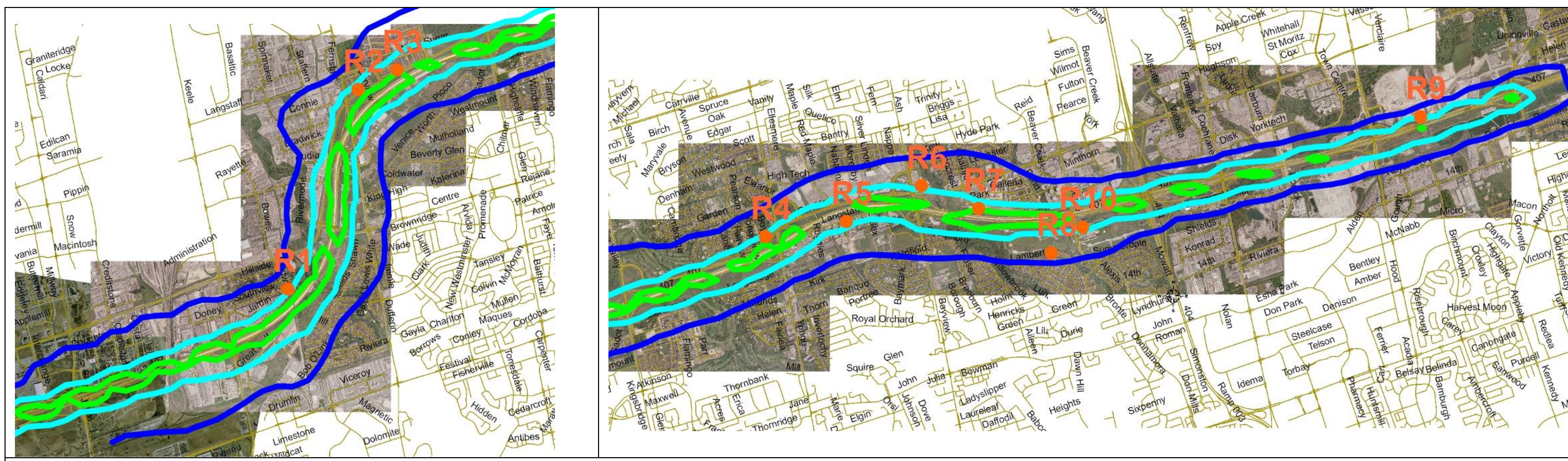


Level	Line
6.1	blue
6.3	light blue
6.5	green

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.18a 24-Hour Formaldehyde Concentrations including background in µg/m^3 – **Existing Conditions** (2008)

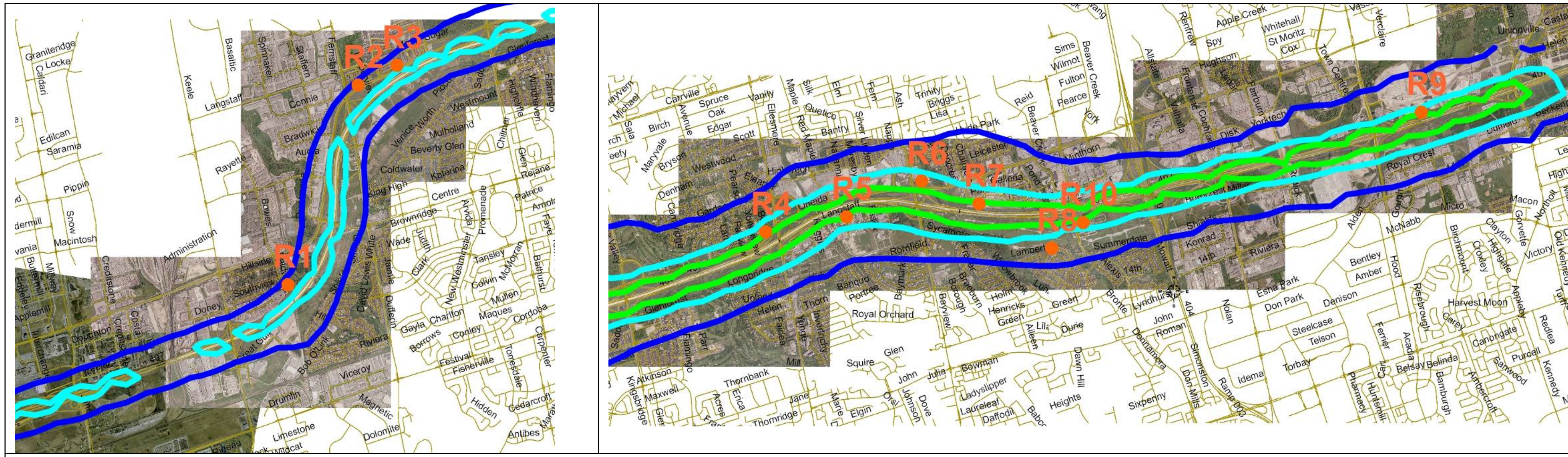


Level	Line
6.5	blue
7	light blue
8	green

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.18b 1-Hour Formaldehyde Concentrations including background in µg/m^3 – **Existing Conditions** (2008)

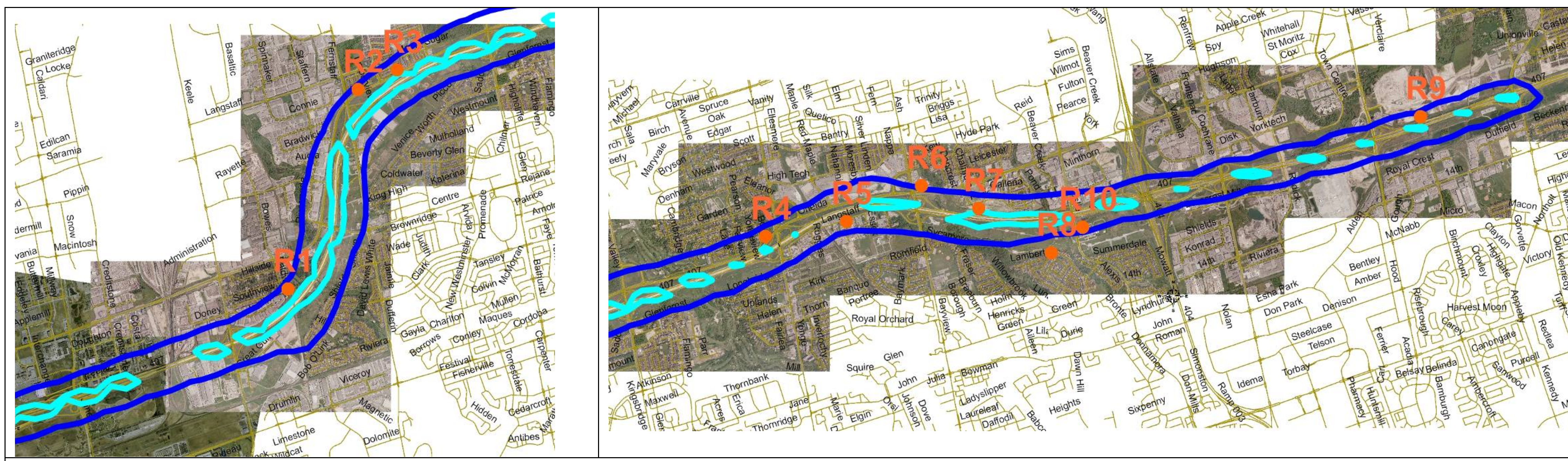


Level Line
1000
2000

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.19a 8-Hour CO Concentrations including background in µg/m^3 – **Future Without** Transitway (2031)

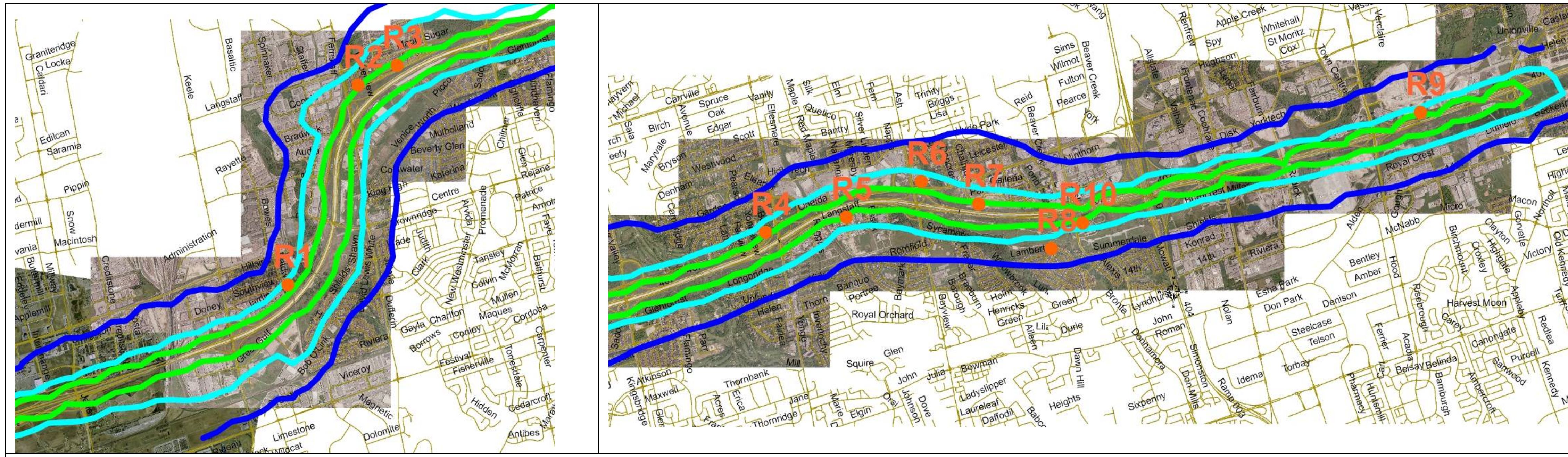


Level Line
1000
2000

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.19b 8-Hour CO Concentrations including background in µg/m^3 – **Future With** Transitway (2031)

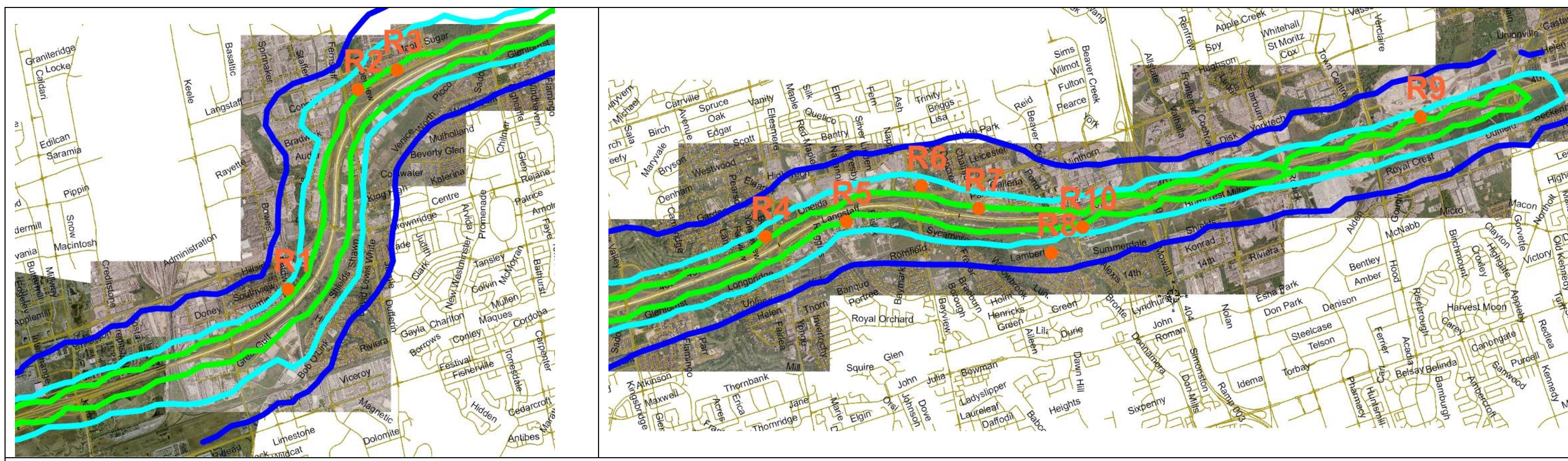


Level	Line
1200	
1800	
3000	

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.20a 1-Hour CO Concentrations including background in µg/m^3 – **Future Without** Transitway (2031)

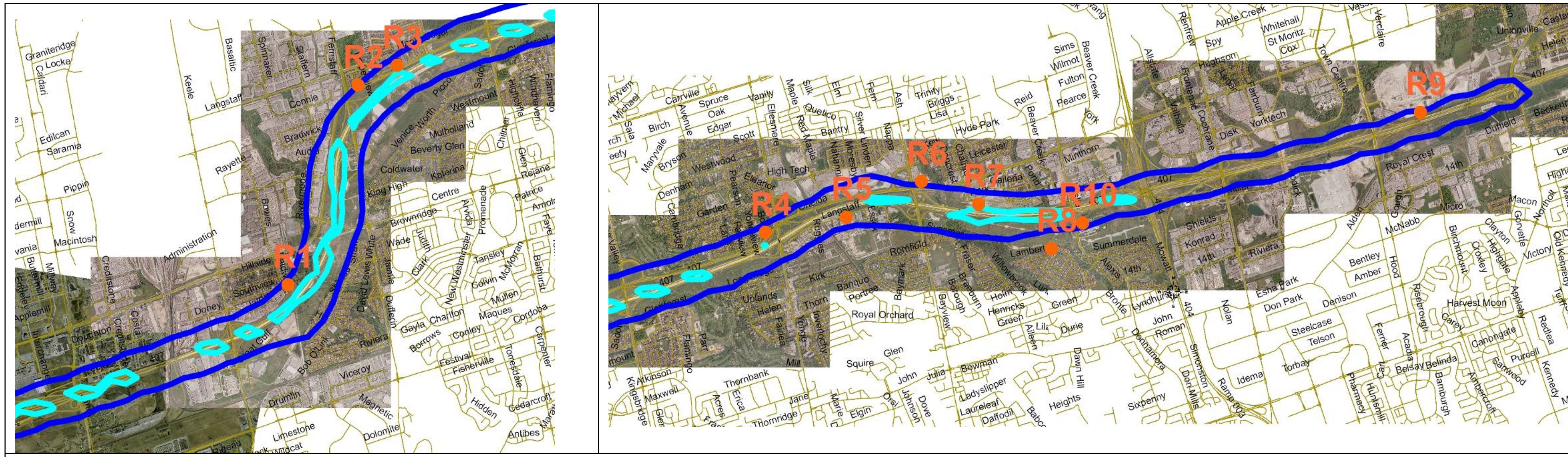


Level	Line
1200	
1800	
3000	

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.20b 1-Hour CO Concentrations including background in µg/m^3 – **Future With** Transitway (2031)

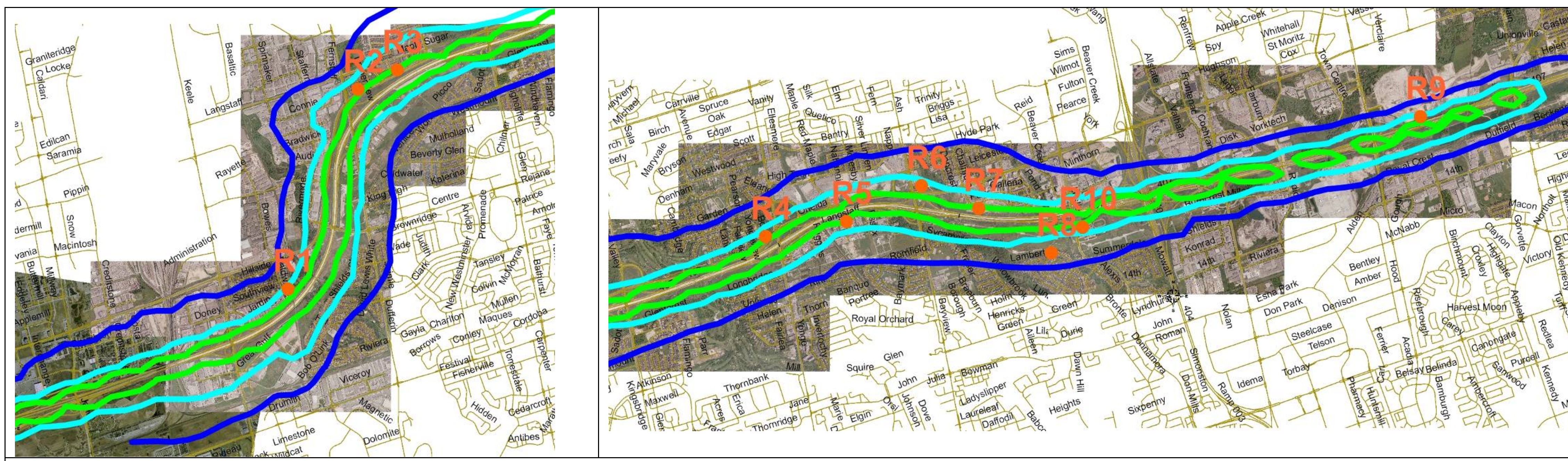


Level	Line
1000	(blue)
2000	(cyan)

Concentrations are in $\mu g/m^3$

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.21a 8-Hour CO Concentrations including background in $\mu g/m^3$ – **Existing Conditions** (2008)

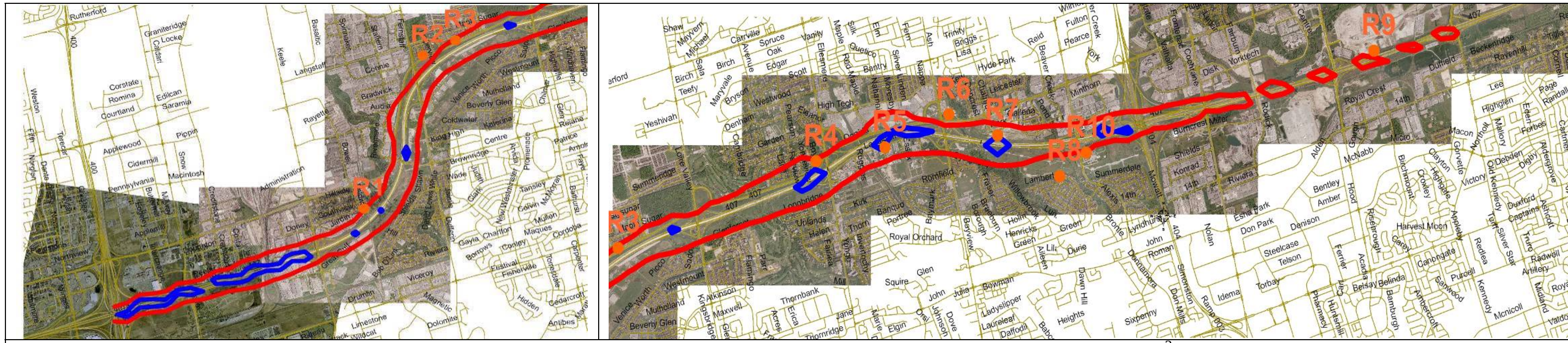


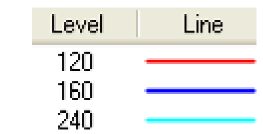
Level	Line
1200	(blue)
1800	(cyan)
3000	(green)

Concentrations are in $\mu g/m^3$

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area

Figure A.21b 1-Hour CO Concentrations including background in $\mu g/m^3$ – **Existing Conditions** (2008)

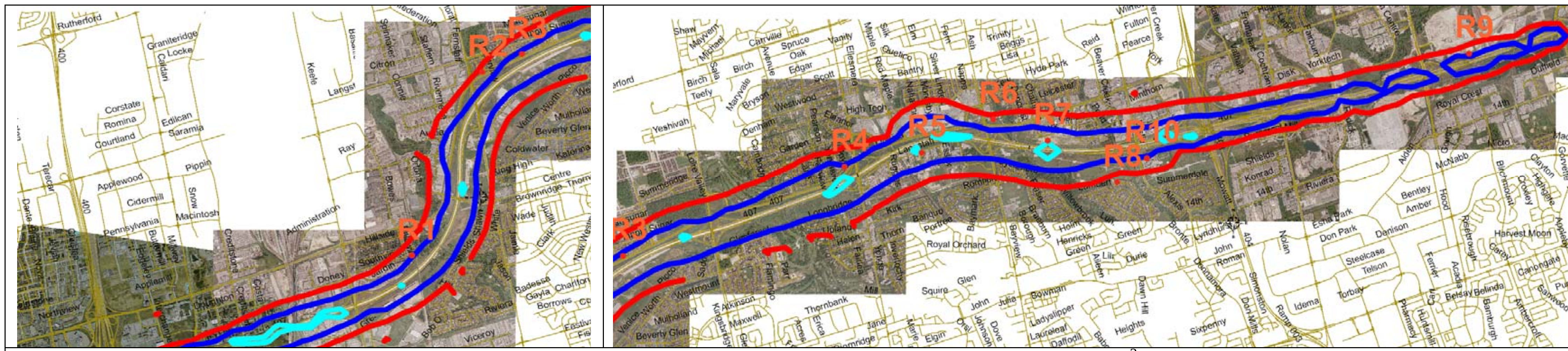


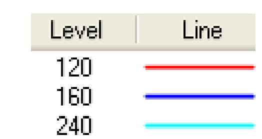


Concentrations are in $\mu g/m^3$

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

Figure A.22a 24-Hour PM Concentrations including background in $\mu g/m^3$ – **Existing Conditions** (2008)

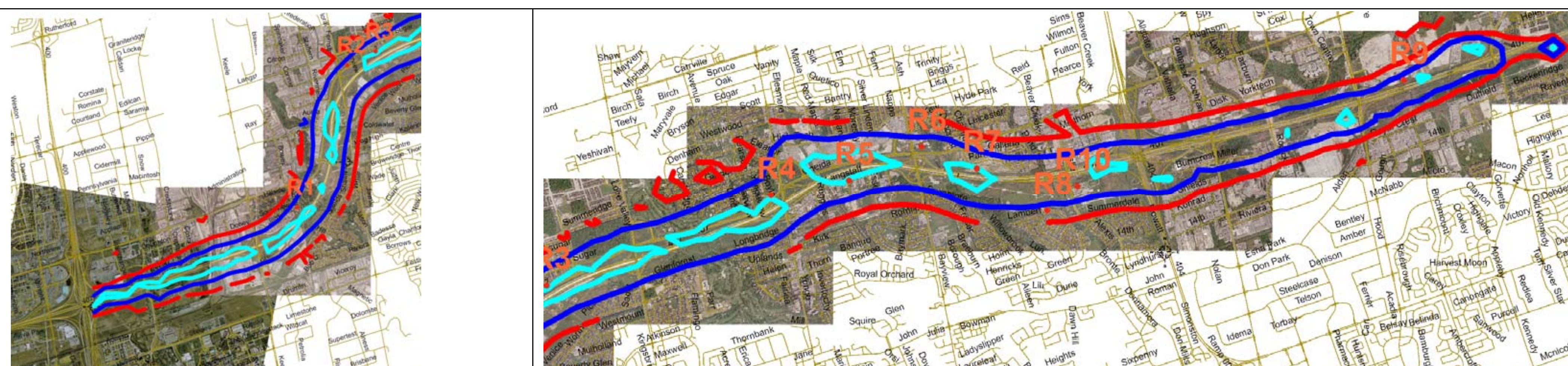


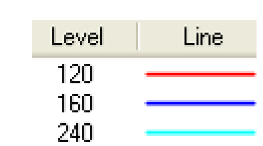


Concentrations are in $\mu g/m^3$

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

Figure A.22b 24-Hour PM Concentrations including background in $\mu g/m^3$ - **Future Without** Transitway (2031)

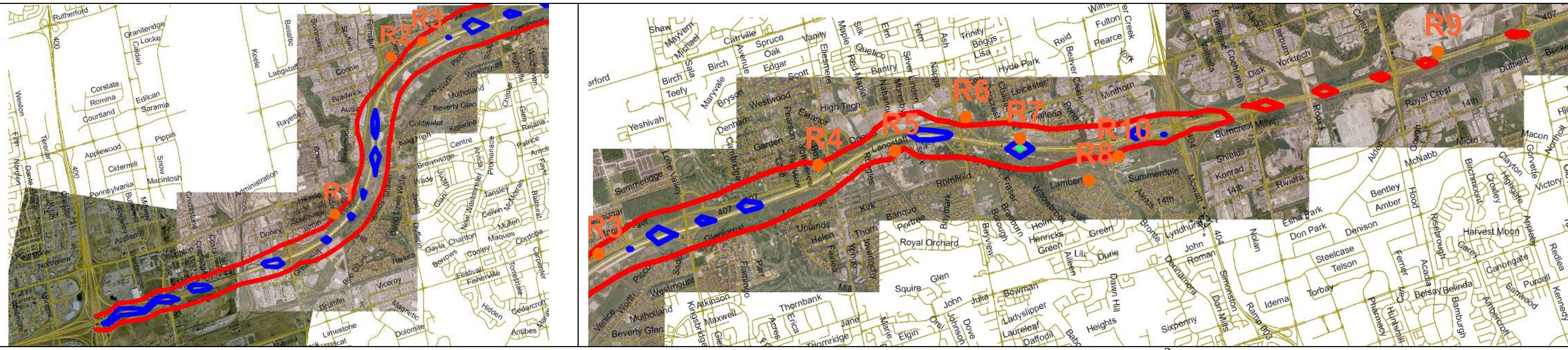




Concentrations are in $\mu g/m^3$

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

Figure A.22c 24-Hour PM Concentrations including background in $\mu g/m^3$ – **Future With** Transitway (2031)

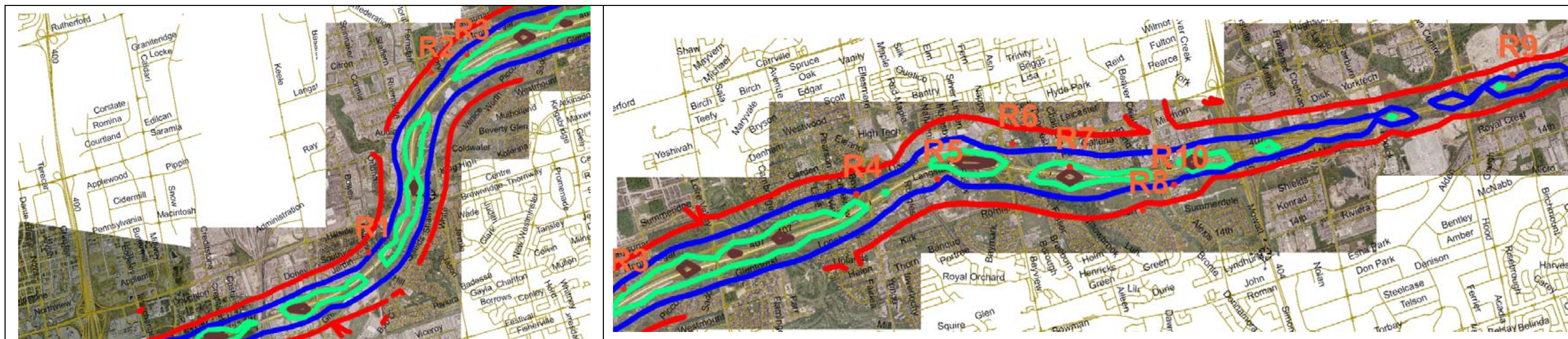


Level	Line
50	
60	
70	
80	

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

Figure A.23a 24-Hour PM_{10} Concentrations including background in µg/m^3 – **Existing Conditions** (2008)

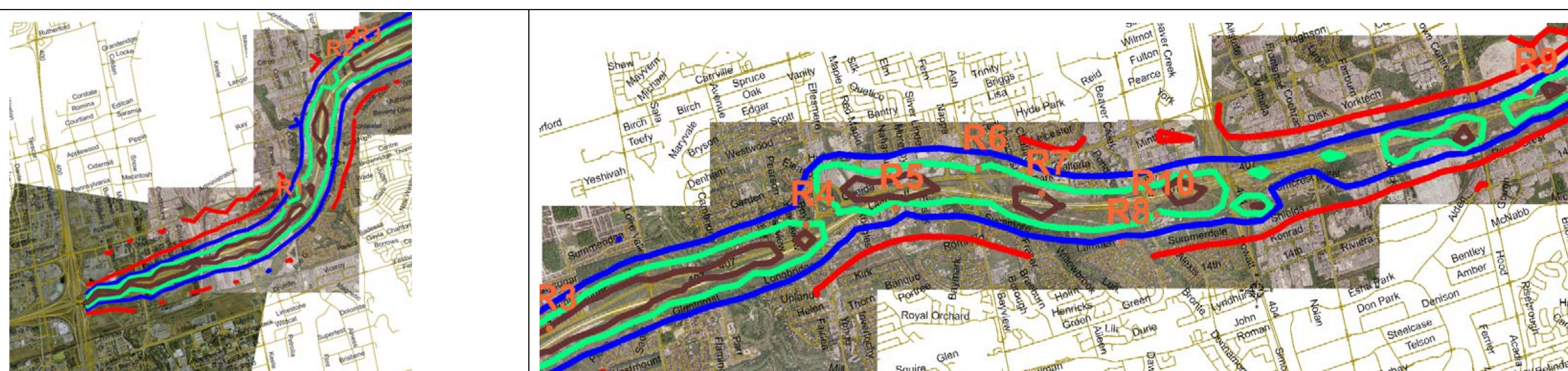


Level	Line
50	
60	
70	
80	

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

Figure A.23b 24-Hour PM_{10} Concentrations including background in µg/m^3 - **Future Without** Transitway (2031)

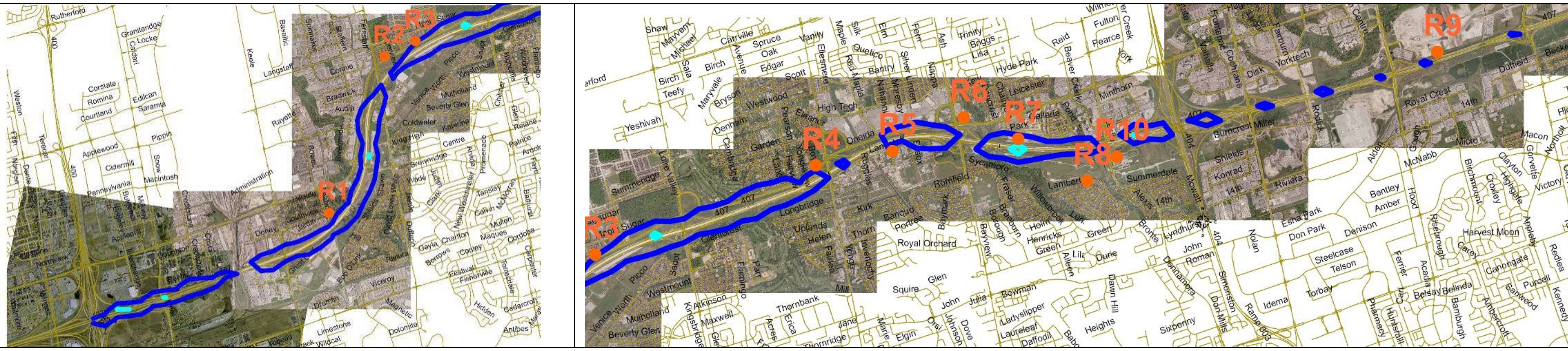


Level	Line
50	
60	
70	
80	

Concentrations are in µg/m^3

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

Figure A.23c 24-Hour PM_{10} Concentrations including background in µg/m^3 – **Future With** Transitway (2031)

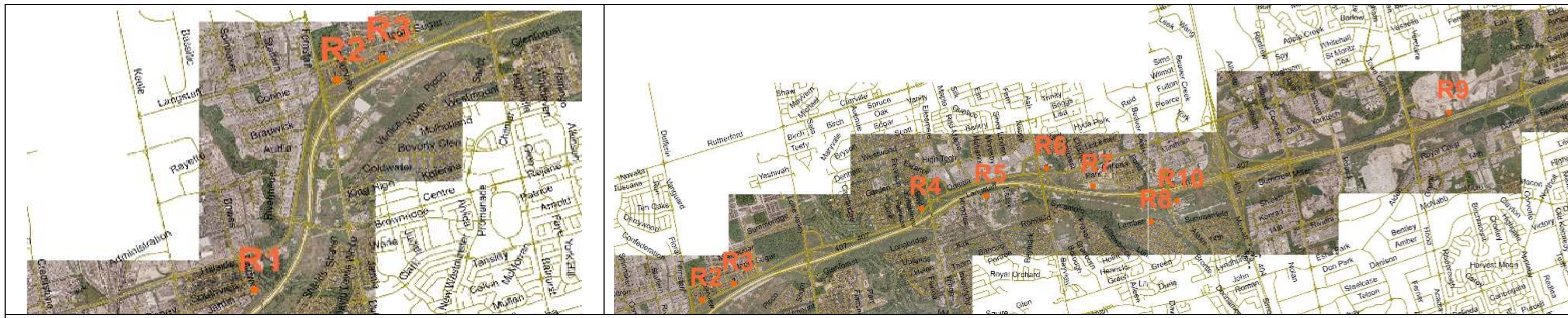


Level	Line
18.8	(blue)
19.5	(cyan)
21	(green)

Concentrations are in $\mu g/m^3$

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

Figure A.24a 24-Hour $PM_{2.5}$ Concentrations including background in $\mu g/m^3$ – **Existing Conditions** (2008)

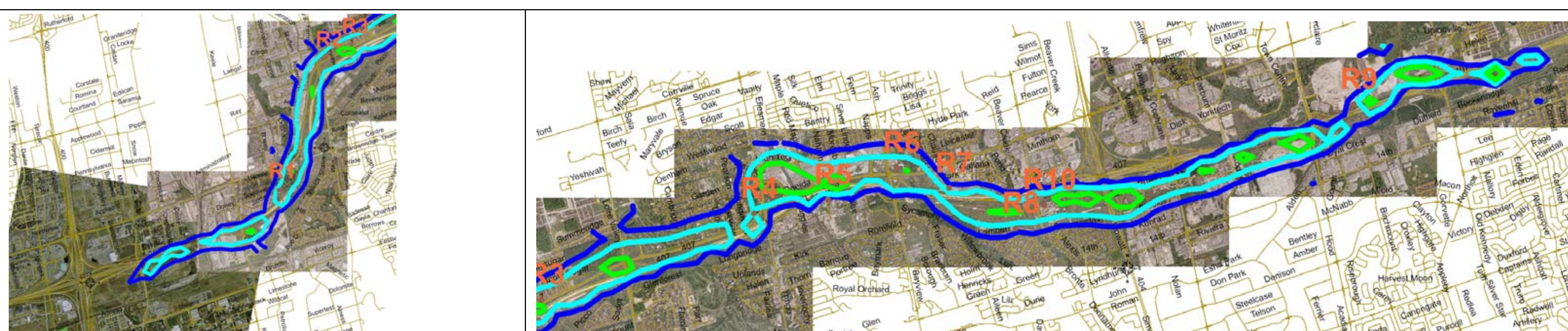


Level	Line
18.8	(blue)
19.5	(cyan)
21	(green)

Concentrations are in $\mu g/m^3$

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

Figure A.24b 24-Hour $PM_{2.5}$ Concentrations including background in $\mu g/m^3$ - **Future Without** Transitway (2031)



Level	Line
18.8	(blue)
19.5	(cyan)
21	(green)

Concentrations are in $\mu g/m^3$

Note: For presentation purposes figures are separated into two sections, the western and eastern sections of the study area.

Figure A.24c 24-Hour $PM_{2.5}$ Concentrations including background in $\mu g/m^3$ – **Future With** Transitway (2031)

APPENDIX B

TABULAR PRESENTATION OF MODELLING RESULTS AT SENSITIVE RECEPTORS

Table B.1 a Model Predicted Maximum 24-hr $PM_{2.5}$ Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		Canada-Wide Standard
	µg/m³	µg/m³	% change from Existing	µg/m³	% change from Existing	µg/m³
R1	18.2	17.8	-2.2%	18.7	2.5%	30
R2	18.2	17.8	-2.1%	18.9	4.0%	30
R3	18.6	18.0	-3.4%	19.0	1.8%	30
R4	18.4	17.9	-2.7%	19.0	3.4%	30
R5	18.8	17.9	-4.7%	18.4	-2.0%	30
R6	18.1	17.7	-1.9%	18.5	2.5%	30
R7	18.6	18.0	-3.5%	18.6	-0.3%	30
R8	17.9	17.7	-1.2%	18.0	1.0%	30
R9	18.2	17.9	-1.7%	19.0	4.5%	30
R10	18.2	17.8	-2.2%	20.5	12.6%	30

Note: All values include a background $PM_{2.5}$ concentration of 17.5 µg/m³.

Table B.1 b Model Predicted Maximum 24-hr $PM_{2.5}$ Comparison of Future Scenarios

Receptor	Future Without Transitway (µg/m³)	Future With Transitway (µg/m³)	% Change from Without Transitway	Canada-Wide Standard (µg/m³)
R1	17.8	18.7	4.8%	30
R2	17.8	18.9	6.2%	30
R3	18.0	19.0	5.3%	30
R4	17.9	19.0	6.3%	30
R5	17.9	18.4	2.8%	30
R6	17.7	18.5	4.5%	30
R7	18.0	18.6	3.4%	30
R8	17.7	18.0	2.2%	30
R9	17.9	19.0	6.3%	30
R10	17.8	20.5	15.2%	30

Note: All values include a background $PM_{2.5}$ concentration of 17.5 µg/m³.

Table B.2 a Model Predicted Maximum 24-hr PM_{10} Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		Canada-Wide Standard
	μg/m³	μg/m³	% change from Existing	μg/m³	% change from Existing	μg/m³
R1	45	52	14%	58	27%	50
R2	45	51	14%	60	34%	50
R3	52	63	22%	71	38%	50
R4	48	57	19%	63	31%	50
R5	54	67	24%	69	27%	50
R6	43	49	14%	55	27%	50
R7	52	64	24%	69	33%	50
R8	40	44	9%	48	17%	50
R9	43	53	21%	62	44%	50
R10	45	53	16%	73	62%	50

Note: All values include a background PM_{10} concentration of 35.1 μg/m³.

Table B.2 b Model Predicted Maximum 24-hr PM_{10} Comparison of Future Scenarios

Receptor	Future Without Transitway (μg/m³)	Future With Transitway (μg/m³)	% Change from Without Transitway	Canada-Wide Standard (μg/m³)
R1	52	57	11%	50
R2	51	60	18%	50
R3	63	71	13%	50
R4	57	62	10%	50
R5	67	69	2%	50
R6	49	55	12%	50
R7	64	69	8%	50
R8	44	47	8%	50
R9	53	62	18%	50
R10	53	73	40%	50

Note: All values include a background PM_{10} concentration of 35.1 μg/m³.

Table B.3 a Model Predicted Maximum 24-hr TSP Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		AAQC
	µg/m³	µg/m³	% change from Existing	µg/m³	% change from Existing	µg/m³
R1	97	119	22%	139	43%	120
R2	94	114	21%	146	54%	120
R3	109	143	31%	171	57%	120
R4	110	142	29%	175	59%	120
R5	134	184	37%	193	43%	120
R6	91	107	18%	124	37%	120
R7	121	161	34%	177	47%	120
R8	83	93	12%	102	23%	120
R9	95	123	30%	160	68%	120
R10	98	120	23%	181	84%	120

Note: All values include a background PM concentration of 70.2 µg/m³.

Table B.3 b Predicted Maximum 24-hr TSP Comparison of Future Scenarios

Receptor	Future Without Transitway (µg/m³)	Future With Transitway (µg/m³)	% Change from Without Transitway	AAQC (µg/m³)
R1	119	139	17%	120
R2	114	146	27%	120
R3	143	171	20%	120
R4	142	175	23%	120
R5	184	193	5%	120
R6	107	124	16%	120
R7	161	177	10%	120
R8	93	102	10%	120
R9	123	160	29%	120
R10	120	181	50%	120

Note: All values include a background TSP concentration of 70.2 µg/m³.

Table B.4 a Model Predicted Annual TSP Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		AAQC
	μg/m³	μg/m³	% change from Existing	μg/m³	% change from Existing	μg/m³
R1	47	53	14%	60	28%	60
R2	44	49	12%	57	28%	60
R3	48	57	18%	65	35%	60
R4	49	58	18%	68	40%	60
R5	54	66	23%	70	29%	60
R6	44	48	10%	54	22%	60
R7	54	66	24%	72	34%	60
R8	42	45	7%	47	13%	60
R9	46	55	19%	65	40%	60
R10	46	53	14%	69	50%	60

Note: All values include a background PM concentration of 38.4 μg/m³.

Table B.4 b Predicted Annual TSP Comparison of Future Scenarios

Receptor	Future Without Transitway (μg/m³)	Future With Transitway (μg/m³)	% Change from Without Transitway	AAQC (μg/m³)
R1	53	60	12%	60
R2	49	57	15%	60
R3	57	65	14%	60
R4	58	68	19%	60
R5	66	70	5%	60
R6	48	54	11%	60
R7	66	72	8%	60
R8	45	47	6%	60
R9	55	65	18%	60
R10	53	69	32%	60

Note: All values include a background TSP concentration of 38.4 μg/m³.

Table B.5 a Model Predicted Maximum 24-hr NO_x Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		AAQC
	μg/m³	μg/m³	% change from Existing	μg/m³	% change from Existing	μg/m³
R1	142	105	-26%	105	-26%	200
R2	140	104	-26%	104	-25%	200
R3	173	112	-35%	112	-35%	200
R4	154	107	-30%	107	-30%	200
R5	184	114	-38%	113	-38%	200
R6	134	102	-23%	102	-23%	200
R7	175	111	-36%	111	-36%	200
R8	119	99	-17%	99	-17%	200
R9	138	106	-23%	106	-23%	200
R10	143	104	-27%	105	-27%	200

Note: All values include a conservative background NOx concentration of 93.4 μg/m³.

Table B.5 b Predicted Maximum 24-hr NO_x Comparison of Future Scenarios

Receptor	Future Without Transitway (μg/m³)	Future With Transitway (μg/m³)	% Change from Without Transitway	AAQC (μg/m³)
R1	105	105	0.01%	200
R2	104	104	0.14%	200
R3	112	112	0.10%	200
R4	107	107	-0.03%	200
R5	114	113	-0.24%	200
R6	102	102	0.01%	200
R7	111	111	-0.11%	200
R8	99	99	-0.09%	200
R9	106	106	0.12%	200
R10	104	105	0.28%	200

Note: All values include a conservative background NOx concentration of 93.4 μg/m³.

Table B.6 a Model Predicted Maximum 1-hr NO_x Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		AAQC
	$\mu g/m^3$	$\mu g/m^3$	% change from Existing	$\mu g/m^3$	% change from Existing	$\mu g/m^3$
R1	327	159	-51%	159	-51%	400
R2	432	184	-58%	184	-58%	400
R3	515	205	-60%	204	-60%	400
R4	451	187	-59%	186	-59%	400
R5	409	176	-57%	174	-57%	400
R6	386	172	-56%	171	-56%	400
R7	502	196	-61%	195	-61%	400
R8	283	147	-48%	146	-48%	400
R9	332	171	-49%	170	-49%	400
R10	411	174	-58%	174	-58%	400

Note: All values include a conservative background NOx concentration of 108.2 $\mu g/m^3$.

Table B.6 b Predicted Maximum 1-hr NO_x Comparison of Future Scenarios

Receptor	Future Without Transitway ($\mu g/m^3$)	Future With Transitway ($\mu g/m^3$)	% Change from Without Transitway	AAQC ($\mu g/m^3$)
R1	159	159	0.00%	400
R2	184	184	0.00%	400
R3	205	204	-0.28%	400
R4	187	186	-0.50%	400
R5	176	174	-0.96%	400
R6	172	171	-0.55%	400
R7	196	195	-0.86%	400
R8	147	146	-0.38%	400
R9	171	170	-0.22%	400
R10	174	174	-0.32%	400

Note: All values include a conservative background NOx concentration of 108.2 $\mu g/m^3$.

Table B.7 a Model Predicted Maximum 8-hr CO Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		AAQC
	μg/m³	μg/m³	% change from Existing	μg/m³	% change from Existing	μg/m³
R1	1090	1142	5%	1142	5%	15,700
R2	1090	1164	7%	1164	7%	15,700
R3	1527	1644	8%	1644	8%	15,700
R4	1217	1263	4%	1263	4%	15,700
R5	1520	1565	3%	1564	3%	15,700
R6	1041	1073	3%	1073	3%	15,700
R7	1560	1630	4%	1629	4%	15,700
R8	815	830	2%	830	2%	15,700
R9	996	1146	15%	1164	17%	15,700
R10	1186	1211	2%	1211	2%	15,700

Note: All values include a conservative background CO concentration of 483.6 μg/m³.

Table B.7 b Predicted Maximum 8-hr CO Comparison of Future Scenarios

Receptor	Future Without Transitway (μg/m³)	Future With Transitway (μg/m³)	% Change from Without Transitway	AAQC (μg/m³)
R1	1142	1142	-0.03%	15,700
R2	1164	1164	-0.01%	15,700
R3	1644	1644	0.00%	15,700
R4	1263	1263	-0.01%	15,700
R5	1565	1564	-0.01%	15,700
R6	1073	1073	-0.01%	15,700
R7	1630	1629	-0.02%	15,700
R8	830	830	-0.01%	15,700
R9	1146	1164	1.58%	15,700
R10	1211	1211	-0.02%	15,700

Note: All values include a conservative background CO concentration of 483.6 μg/m³.

Table B.8 a Model Predicted Maximum 1-hr CO Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		AAQC
	μg/m^3	μg/m^3	% change from Existing	μg/m^3	% change from Existing	μg/m^3
R1	1959	2078	6%	2078	6%	36,200
R2	2659	2874	8%	2874	8%	36,200
R3	3193	3495	9%	3495	9%	36,200
R4	2770	2924	6%	2924	6%	36,200
R5	2491	2585	4%	2583	4%	36,200
R6	2343	2466	5%	2465	5%	36,200
R7	3068	3225	5%	3224	5%	36,200
R8	1624	1671	3%	1671	3%	36,200
R9	2054	2543	24%	2543	24%	36,200
R10	2458	2531	3%	2530	3%	36,200

Note: All values include a conservative background CO concentration of 492.4 μg/m^3.

Table B.8 b Predicted Maximum 1-hr CO Comparison of Future Scenarios

Receptor	Future Without Transitway (μg/m^3)	Future With Transitway (μg/m^3)	% Change from Without Transitway	AAQC (μg/m^3)
R1	2078	2078	0%	36,200
R2	2874	2874	0%	36,200
R3	3495	3495	0%	36,200
R4	2924	2924	0%	36,200
R5	2585	2583	-0.04%	36,200
R6	2466	2465	-0.05%	36,200
R7	3225	3224	-0.04%	36,200
R8	1671	1671	0%	36,200
R9	2543	2543	0%	36,200
R10	2531	2530	-0.05%	36,200

Note: All values include conservative background CO concentration of 492.4 μg/m^3.

Table B.9 a Model Predicted Maximum 24-hr Acetaldehyde Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		AAQC
	μg/m³	μg/m³	% change from Existing	μg/m³	% change from Existing	μg/m³
R1	4.1	4.1	0%	4.1	-0.27%	500
R2	4.1	4.1	0%	4.1	-0.20%	500
R3	4.1	4.1	0%	4.1	-0.34%	500
R4	4.1	4.1	0%	4.1	-0.34%	500
R5	4.2	4.1	-1%	4.1	-0.65%	500
R6	4.1	4.1	0%	4.1	-0.25%	500
R7	4.1	4.1	0%	4.1	-0.51%	500
R8	4.0	4.0	0%	4.0	-0.17%	500
R9	4.1	4.1	0%	4.1	0.12%	500
R10	4.1	4.1	0%	4.1	-0.24%	500

Note: All values include a conservative background Acetaldehyde concentration of 4.0 μg/m³.

Table B.9 b Predicted Maximum 24-hr Acetaldehyde Comparison of Future Scenarios

Receptor	Future Without Transitway (μg/m³)	Future With Transitway (μg/m³)	% Change from Without Transitway	AAQC (μg/m³)
R1	4.1	4.1	0.02%	500
R2	4.1	4.1	0.05%	500
R3	4.1	4.1	0.02%	500
R4	4.1	4.1	0.00%	500
R5	4.1	4.1	-0.05%	500
R6	4.1	4.1	0.02%	500
R7	4.1	4.1	-0.02%	500
R8	4.0	4.0	0.00%	500
R9	4.1	4.1	0.05%	500
R10	4.1	4.1	0.07%	500

Note: All values include a conservative background Acetaldehyde concentration of 4.0 μg/m³.

Table B.10 a Model Predicted Maximum 1-hr Acetaldehyde Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		AAQC
	µg/m³	µg/m³	% change from Existing	µg/m³	% change from Existing	µg/m³
R1	4.4	4.3	-1%	4.3	-1%	n/a
R2	4.6	4.5	-2%	4.5	-2%	n/a
R3	4.7	4.6	-2%	4.6	-2%	n/a
R4	4.6	4.5	-2%	4.5	-2%	n/a
R5	4.5	4.4	-2%	4.4	-2%	n/a
R6	4.5	4.4	-2%	4.4	-2%	n/a
R7	4.7	4.6	-2%	4.6	-2%	n/a
R8	4.3	4.2	-1%	4.2	-1%	n/a
R9	4.4	4.4	0%	4.4	0%	n/a
R10	4.5	4.4	-2%	4.4	-2%	n/a

Note: All values include a conservative background Acetaldehyde concentration of 4.0 µg/m³.

Table B.10 b Predicted Maximum 1-hr Acetaldehyde Comparison of Future Scenarios

Receptor	Future Without Transitway (µg/m³)	Future With Transitway (µg/m³)	% Change from Without Transitway	AAQC (µg/m³)
R1	4.3	4.3	-0.1%	n/a
R2	4.5	4.5	0%	n/a
R3	4.6	4.6	-0.1%	n/a
R4	4.5	4.5	-0.2%	n/a
R5	4.4	4.4	-0.3%	n/a
R6	4.4	4.4	0%	n/a
R7	4.6	4.6	-0.2%	n/a
R8	4.2	4.2	-0.1%	n/a
R9	4.4	4.4	0%	n/a
R10	4.4	4.4	0%	n/a

Note: All values include a conservative background Acetaldehyde concentration of 4.0 µg/m³.

Table B.11 a Model Predicted Maximum 24-hr Acrolein Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		AAQC
	μg/m³	μg/m³	% change from Existing	μg/m³	% change from Existing	μg/m³
R1	0.71	0.71	0%	0.71	0%	0.4
R2	0.71	0.71	0%	0.71	0%	0.4
R3	0.72	0.71	0%	0.71	0%	0.4
R4	0.71	0.71	0%	0.71	0%	0.4
R5	0.71	0.72	0%	0.71	0%	0.4
R6	0.71	0.71	0%	0.71	0%	0.4
R7	0.72	0.71	0%	0.71	0%	0.4
R8	0.71	0.70	0%	0.70	0%	0.4
R9	0.71	0.71	0%	0.71	0%	0.4
R10	0.71	0.71	0%	0.71	0%	0.4

Note: All values include a conservative background acrolein concentration of 0.7 μg/m³.

Table B.11 b Predicted Maximum 24-hr Acrolein Comparison of Future Scenarios

Receptor	Future Without Transitway (μg/m³)	Future With Transitway (μg/m³)	% Change from Without Transitway	AAQC (μg/m³)
R1	0.71	0.71	0%	0.4
R2	0.71	0.71	0%	0.4
R3	0.71	0.71	0%	0.4
R4	0.71	0.71	0%	0.4
R5	0.72	0.71	0%	0.4
R6	0.71	0.71	0%	0.4
R7	0.71	0.71	0%	0.4
R8	0.70	0.70	0%	0.4
R9	0.71	0.71	0%	0.4
R10	0.71	0.71	0%	0.4

Note: All values include a conservative background acrolein concentration of 0.7 μg/m³.

Table B.12 a Model Predicted Maximum 1-hr Acrolein Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		AAQC
	μg/m³	μg/m³	% change from Existing	μg/m³	% change from Existing	μg/m³
R1	0.75	0.74	-1%	0.74	-1%	4.5
R2	0.76	0.76	-1%	0.76	-1%	4.5
R3	0.78	0.77	-2%	0.77	-2%	4.5
R4	0.77	0.76	-2%	0.76	-2%	4.5
R5	0.76	0.75	-1%	0.75	-1%	4.5
R6	0.76	0.75	-1%	0.75	-1%	4.5
R7	0.78	0.77	-2%	0.76	-2%	4.5
R8	0.74	0.73	-1%	0.73	-1%	4.5
R9	0.74	0.75	1%	0.75	1%	4.5
R10	0.76	0.75	-2%	0.75	-2%	4.5

Note: All values include a conservative background acrolein concentration of 0.7 μg/m³.

Table B.12 b Predicted Maximum 1-hr Acrolein Comparison of Future Scenarios

Receptor	Future Without Transitway (μg/m³)	Future With Transitway (μg/m³)	% Change from Without Transitway	AAQC (μg/m³)
R1	0.74	0.74	0%	4.5
R2	0.76	0.76	-0.1%	4.5
R3	0.77	0.77	0%	4.5
R4	0.76	0.76	-0.3%	4.5
R5	0.75	0.75	-0.1%	4.5
R6	0.75	0.75	0%	4.5
R7	0.77	0.76	-0.3%	4.5
R8	0.73	0.73	-0.1%	4.5
R9	0.75	0.75	0%	4.5
R10	0.75	0.75	0%	4.5

Note: All values include a conservative background acrolein concentration of 0.7 μg/m³.

Table B.13 a Model Predicted Maximum 24-hr Benzene Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		AAQC
	µg/m³	µg/m³	% change from Existing	µg/m³	% change from Existing	µg/m³
R1	4.8	4.7	-2%	4.7	-2%	2.3
R2	4.8	4.7	-1%	4.7	-1%	2.3
R3	5.1	5.0	-2%	5.0	-2%	2.3
R4	4.9	4.8	-2%	4.8	-2%	2.3
R5	5.2	5.0	-3%	5.0	-3%	2.3
R6	4.7	4.7	-1%	4.7	-1%	2.3
R7	5.1	5.0	-3%	5.0	-3%	2.3
R8	4.6	4.6	-1%	4.6	-1%	2.3
R9	4.8	4.8	0%	4.8	0%	2.3
R10	4.8	4.7	-2%	4.7	-2%	2.3

Note: All values include a conservative background Benzene concentration of 4.4 µg/m³.

Table B.13 b Predicted Maximum 24-hr Benzene Comparison of Future Scenarios

Receptor	Future Without Transitway (µg/m³)	Future With Transitway (µg/m³)	% Change from Without Transitway	AAQC (µg/m³)
R1	4.7	4.7	0.0%	2.3
R2	4.7	4.7	0.0%	2.3
R3	5.0	5.0	0.0%	2.3
R4	4.8	4.8	0.0%	2.3
R5	5.0	5.0	0.0%	2.3
R6	4.7	4.7	0.0%	2.3
R7	5.0	5.0	0.0%	2.3
R8	4.6	4.6	0.0%	2.3
R9	4.8	4.8	0.0%	2.3
R10	4.7	4.7	0.0%	2.3

Note: All values include a conservative background Benzene concentration of 4.4 µg/m³.

Table B.14 a Model Predicted Maximum 1-hr Benzene Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		AAQC
	μg/m³	μg/m³	% change from Existing	μg/m³	% change from Existing	μg/m³
R1	6.3	6.0	-5%	6.0	-5%	n/a
R2	7.2	6.7	-6%	6.7	-7%	n/a
R3	7.9	7.3	-7%	7.3	-7%	n/a
R4	7.3	6.8	-7%	6.8	-7%	n/a
R5	7.0	6.5	-7%	6.5	-8%	n/a
R6	6.8	6.3	-7%	6.3	-7%	n/a
R7	7.7	7.1	-8%	7.1	-8%	n/a
R8	5.9	5.6	-5%	5.6	-5%	n/a
R9	6.4	6.4	0%	6.4	0%	n/a
R10	6.9	6.4	-8%	6.4	-8%	n/a

Note: All values include a conservative background Benzene concentration of 4.4 μg/m³.

Table B.14 b Predicted Maximum 1-hr Benzene Comparison of Future Scenarios

Receptor	Future Without Transitway (μg/m³)	Future With Transitway (μg/m³)	% Change from Without Transitway	AAQC (μg/m³)
R1	6.0	6.0	0%	n/a
R2	6.7	6.7	0%	n/a
R3	7.3	7.3	0%	n/a
R4	6.8	6.8	0%	n/a
R5	6.5	6.5	0%	n/a
R6	6.3	6.3	0%	n/a
R7	7.1	7.1	0%	n/a
R8	5.6	5.6	0%	n/a
R9	6.4	6.4	0%	n/a
R10	6.4	6.4	0%	n/a

Note: All values include a conservative background Benzene concentration of 4.4 μg/m³.

Table B.15 a Model Predicted Maximum 24-hr 1, 3-Butadiene Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		AAQC
	μg/m³	μg/m³	% change from Existing	μg/m³	% change from Existing	μg/m³
R1	21.05	21.04	-0.1%	21.04	-0.06%	10.0
R2	21.05	21.04	-0.1%	21.04	-0.05%	10.0
R3	21.09	21.07	-0.1%	21.07	-0.08%	10.0
R4	21.06	21.05	-0.1%	21.05	-0.07%	10.0
R5	21.10	21.07	-0.1%	21.07	-0.12%	10.0
R6	21.04	21.03	-0.1%	21.03	-0.05%	10.0
R7	21.09	21.07	-0.1%	21.07	-0.09%	10.0
R8	21.03	21.02	0.0%	21.02	-0.03%	10.0
R9	21.05	21.05	0.0%	21.05	-0.01%	10.0
R10	21.05	21.04	-0.1%	21.04	-0.06%	10.0

Note: All values include a conservative background 1, 3 Butadiene concentration of 21.0 μg/m³.

Table B.15 b Predicted Maximum 24-hr 1, 3-Butadiene Comparison of Future Scenarios

Receptor	Future Without Transitway (μg/m³)	Future With Transitway (μg/m³)	% Change from Without Transitway	AAQC (μg/m³)
R1	21.04	21.04	0%	10.0
R2	21.04	21.04	0.01%	10.0
R3	21.07	21.07	0%	10.0
R4	21.05	21.05	0%	10.0
R5	21.07	21.07	0%	10.0
R6	21.03	21.03	0%	10.0
R7	21.07	21.07	0%	10.0
R8	21.02	21.02	0%	10.0
R9	21.05	21.05	0%	10.0
R10	21.04	21.04	0.01%	10.0

Note: All values include a conservative background 1, 3 Butadiene concentration of 21.0 μg/m³.

Table B.16 a Model Predicted Maximum 1-hr 1, 3-Butadiene Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		AAQC
	$\mu g/m^3$	$\mu g/m^3$	% change from Existing	$\mu g/m^3$	% change from Existing	$\mu g/m^3$
R1	21.2	21.2	-0.2%	21.2	-0.3%	n/a
R2	21.3	21.3	-0.4%	21.3	-0.4%	n/a
R3	21.4	21.3	-0.4%	21.3	-0.4%	n/a
R4	21.4	21.3	-0.4%	21.3	-0.4%	n/a
R5	21.3	21.2	-0.4%	21.2	-0.4%	n/a
R6	21.3	21.2	-0.3%	21.2	-0.3%	n/a
R7	21.4	21.3	-0.5%	21.3	-0.5%	n/a
R8	21.2	21.1	-0.2%	21.1	-0.2%	n/a
R9	21.2	21.2	-0.1%	21.2	-0.1%	n/a
R10	21.3	21.2	-0.4%	21.2	-0.4%	n/a

Note: All values include a conservative background 1, 3 Butadiene concentration of 21.0 $\mu g/m^3$.

Table B.16 b Predicted Maximum 1-hr 1, 3-Butadiene Comparison of Future Scenarios

Receptor	Future Without Transitway ($\mu g/m^3$)	Future With Transitway ($\mu g/m^3$)	% Change from Without Transitway	AAQC ($\mu g/m^3$)
R1	21.2	21.2	-0.005%	n/a
R2	21.3	21.3	0.0%	n/a
R3	21.3	21.3	-0.005%	n/a
R4	21.3	21.3	-0.009%	n/a
R5	21.2	21.2	-0.014%	n/a
R6	21.2	21.2	-0.005%	n/a
R7	21.3	21.3	-0.009%	n/a
R8	21.1	21.1	-0.005%	n/a
R9	21.2	21.2	-0.005%	n/a
R10	21.2	21.2	-0.005%	n/a

Note: All values include a conservative background 1, 3 Butadiene concentration of 21.0 $\mu g/m^3$.

Table B.17 a Model Predicted Maximum 24-hr Formaldehyde Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		AAQC
	μg/m^3	μg/m^3	% change from Existing	μg/m^3	% change from Existing	μg/m^3
R1	6.2	6.2	-0.6%	6.2	-0.5%	65
R2	6.2	6.2	-0.5%	6.2	-0.4%	65
R3	6.3	6.3	-0.8%	6.3	-0.7%	65
R4	6.2	6.2	-0.7%	6.2	-0.7%	65
R5	6.4	6.3	-1.1%	6.3	-1.2%	65
R6	6.2	6.1	-0.5%	6.1	-0.5%	65
R7	6.3	6.3	-0.9%	6.3	-1.0%	65
R8	6.1	6.1	-0.3%	6.1	-0.3%	65
R9	6.2	6.2	0%	6.2	0%	65
R10	6.2	6.2	-0.6%	6.2	-0.5%	65

Note: All values include a conservative background Formaldehyde concentration of 6.0 μg/m^3.

Table B.17 b Predicted Maximum 24-hr Formaldehyde Comparison of Future Scenarios

Receptor	Future Without Transitway (μg/m^3)	Future With Transitway(μg/m^3)	% Change from Without Transitway	AAQC (μg/m^3)
R1	6.2	6.2	0.03%	65
R2	6.2	6.2	0.08%	65
R3	6.3	6.3	0.05%	65
R4	6.2	6.2	0.02%	65
R5	6.3	6.3	-0.08%	65
R6	6.1	6.1	0.02%	65
R7	6.3	6.3	-0.06%	65
R8	6.1	6.1	0%	65
R9	6.2	6.2	0.08%	65
R10	6.2	6.2	0.16%	65

Note: All values include a conservative background Formaldehyde concentration of 6.0 μg/m^3.

Table B.18 a Model Predicted Maximum 1-hr Formaldehyde Concentrations

Receptor	Existing Conditions	Future Without Transitway		Future With Transitway		AAQC
	µg/m³	µg/m³	% change from Existing	µg/m³	% change from Existing	µg/m³
R1	6.9	6.7	-2.3%	6.7	-2.3%	n/a
R2	7.3	7.1	-3.0%	7.1	-3.1%	n/a
R3	7.7	7.4	-3.4%	7.4	-3.5%	n/a
R4	7.4	7.1	-3.4%	7.1	-3.6%	n/a
R5	7.2	7.0	-3.3%	7.0	-3.8%	n/a
R6	7.1	6.9	-2.9%	6.9	-3.0%	n/a
R7	7.6	7.3	-3.9%	7.3	-4.3%	n/a
R8	6.7	6.6	-2.1%	6.6	-2.2%	n/a
R9	6.9	6.9	-0.3%	6.9	-0.4%	n/a
R10	7.2	7.0	-3.4%	7.0	-3.4%	n/a

Note: All values include a conservative background Formaldehyde concentration of 6.0 µg/m³.

Table B.18 b Predicted Maximum 24-hr Formaldehyde Comparison of Future Scenarios

Receptor	Future Without Transitway (µg/m³)	Future With Transitway(µg/m³)	% Change from Without Transitway	AAQC (µg/m³)
R1	6.7	6.7	-0.07%	n/a
R2	7.1	7.1	-0.04%	n/a
R3	7.4	7.4	-0.05%	n/a
R4	7.1	7.1	-0.20%	n/a
R5	7.0	7.0	-0.49%	n/a
R6	6.9	6.9	-0.07%	n/a
R7	7.3	7.3	-0.41%	n/a
R8	6.6	6.6	-0.11%	n/a
R9	6.9	6.9	-0.03%	n/a
R10	7.0	7.0	0.01%	n/a

Note: All values include a conservative background Formaldehyde concentration of 6.0 µg/m³.

APPENDIX C

CAL3QHCR SAMPLE MODEL INPUT (EXISTING CONDITIONS PM_{10})

```
'407 Transitway EA Base Case -
PM10' 60.0 108.0 0.3 0.3 2091
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01 01 93 12 31 93
61587 93 72528 93
0 0 'U'
'R1' 621620.1 4850635.0 1.5
'R2' 622555.0 4853280.2 1.5
'R3' 623075.1 4853538.5 1.5
'R4' 626149.4 4854776.7 1.5
'R5' 627212.2 4854978.1 1.5
'R6' 628204.1 4855443.8 1.5
'R7' 628959.9 4855146.5 1.5
'R8' 629922.7 4854562.6 1.5
'R9' 634796.4 4856357.3 1.5
'R10' 630335.1 4854901.2 1.5
'R11' 617752.7 4848792.2 1.5
'R12' 617848.2 4848821.1 1.5
…
'R2091' 625846.0 4855004.0 1.5
2 'P'
1 1 1 1 1 2 2
" 70
1 1
'FF1' 'AG' 617646.5 4848796.9
617902.4 4848876.5 1.0 24.4
2 1
'FF2' 'AG' 617902.4 4848876.5
618818.7 4849161.6 1.0 20.7
3 1
'FF3' 'AG' 618818.7 4849161.6
619626.0 4849445.8 1.0 20.7
4 1
'FF4' 'BR' 619626.0 4849445.8
620399.2 4849717.5 11.0 24.4
5 1
'FF5' 'AG' 620399.2 4849717.5
620888.0 4849894.0 1.0 20.7
6 1
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621317.1 4850096.1 1.0 20.7
7 1
'FF7' 'AG' 621317.1 4850096.1
621718.7 4850407.2 1.0 24.4
8 1
'FF8' 'AG' 621718.7 4850407.2
622030.1 4850807.1 1.0 20.7
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'FF9' 'AG' 622030.1 4850807.1
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'FF12' 'AG' 622300.5 4852291.4
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13 1
'FF13' 'AG' 622475.8 4852748.1
622752.3 4853081.5 1.0 24.4
14 1
'FF14' 'AG' 622752.3 4853081.5
623002.1 4853279.5 1.0 24.4
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'FF15' 'AG' 623002.1 4853279.5
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'FF16' 'AG' 623414.3 4853529.1
623689.5 4853654.5 1.0 24.4
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'FF17' 'AG' 623689.5 4853654.5
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'FF18' 'AG' 624316.7 4853859.2
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'FF22' 'BR' 626838.6 4854950.2
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'FF27' 'AG' 630204.9 4855042.8
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'FF28' 'AG' 631178.2 4855268.4
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'FF30' 'AG' 632179.0 4855508.8
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'FF42' 'AG' 632171.5 4855547.3
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'FF43' 'AG' 631534.6 4855393.4
631170.8 4855305.4 1.0 20.7
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'FF44' 'AG' 631170.8 4855305.4
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'FF46' 'AG' 629414.3 4855017.6
628707.8 4855072.2 1.0 24.4
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'FF47' 'AG' 628707.8 4855072.2
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'FF48' 'AG' 628135.3 4855156.7
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'FF49' 'BR' 627421.1 4855185.1
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'FF50' 'BR' 626821.7 4854987.6
626327.6 4854691.1 9.0 20.7
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'FF51' 'BR' 626327.6 4854691.1
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'FF68' 'AG' 619614.7 4849481.8
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34 120 0.536
35 120 0.536
36 111 0.532
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39 112 0.537
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41 112 0.537
42 116 0.553
43 116 0.553
44 140 0.618
45 157 0.594
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53 165 0.583
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57 162 0.578
58 162 0.578
59 168 0.569
60 168 0.569
61 168 0.569
62 168 0.569
63 168 0.569
64 168 0.569
65 168 0.569
66 171 0.618
67 171 0.618
68 171 0.618
69 168 0.633
70 168 0.633
2 0.0
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2 86 0.63
3 88 0.602
4 88 0.602
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6 89 0.558
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12 89 0.558
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14 87 0.57
15 87 0.57
16 87 0.57
17 87 0.57
18 83 0.578
19 83 0.578
20 83 0.578
21 80 0.573
22 80 0.573
23 80 0.573
24 81 0.59
25 81 0.59
26 81 0.59
27 71 0.618
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29 63 0.549
30 61 0.534
31 61 0.534
32 61 0.534
33 59 0.545
34 59 0.545
35 59 0.545
36 55 0.532
37 55 0.532
38 55 0.532
39 56 0.546
40 56 0.546
41 56 0.546
42 58 0.562
43 58 0.562
44 69 0.624
45 77 0.606
46 77 0.606
47 77 0.606
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50 76 0.581
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63 85 0.575
64 85 0.575
65 85 0.575
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67 84 0.626
68 84 0.626
69 83 0.634
70 83 0.634
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2 66 0.629
3 67 0.611
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5 67 0.611
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36 39 0.551
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31	878	0.371
32	878	0.371
33	792	0.367
34	792	0.367
35	792	0.367
36	818	0.371
37	818	0.371
38	818	0.371
39	896	0.373
40	896	0.373
41	896	0.373
42	898	0.38
43	898	0.38
44	1063	0.397
45	1151	0.395
46	1151	0.395
47	1151	0.395
48	1131	0.391
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51	1178	0.395
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54	1185	0.397
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65	1227	0.393
66	1287	0.408
67	1287	0.408
68	1287	0.408
69	1219	0.418
70	1219	0.418
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5	1473	0.406
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18	1395	0.386
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20	1395	0.386
21	1338	0.381
22	1338	0.381
23	1338	0.381
24	1380	0.388
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26	1380	0.388
27	1255	0.388
28	1081	0.377
29	1081	0.377
30	1067	0.371
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32	1067	0.371
33	985	0.368
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35	985	0.368
36	1018	0.371
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38	1018	0.371
39	1090	0.373
40	1090	0.373
41	1090	0.373
42	1092	0.379
43	1092	0.379
44	1307	0.397
45	1415	0.395
46	1415	0.395
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48	1363	0.391
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69	1479	0.418
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20	1607	0.386
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24	1544	0.388
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26	1544	0.388
27	1405	0.388
28	1222	0.377
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30	1206	0.371
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36	1144	0.371
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39	1232	0.373
40	1232	0.373
41	1232	0.373
42	1234	0.38
43	1234	0.38
44	1463	0.397
45	1584	0.394
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48	1571	0.391
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51	1636	0.395
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66	1745	0.408
67	1745	0.408
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69	1654	0.418
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21	1677	0.381
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27	1520	0.388
28	1294	0.377
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30	1278	0.371
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36	1234	0.371
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39	1304	0.373
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42	1307	0.38
43	1307	0.38
44	1583	0.397
45	1714	0.394
46	1714	0.394
47	1714	0.394
48	1709	0.391
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67	1888	0.408
68	1888	0.408
69	1789	0.418
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18	1827	0.386
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21	1752	0.381
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26	1772	0.387
27	1612	0.388
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42	1386	0.379
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44	1679	0.397
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66	2021	0.408
67	2021	0.408
68	2021	0.408
69	1915	0.418
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27	1668	0.388
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44	1737	0.397
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26 1834 0.388
27 1669 0.388
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20 1906 0.386
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26 1830 0.388
27 1665 0.388
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45 1878 0.394
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57 728 0.396
58 728 0.396
59 753 0.394
60 753 0.394
61 753 0.394
62 753 0.394
63 753 0.394
64 753 0.394
65 753 0.394
66 756 0.409
67 756 0.409
68 756 0.409
69 717 0.418
70 717 0.418
23 0.0
1 709 0.414
2 709 0.414
3 737 0.407
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5 737 0.407
6 737 0.39
7 737 0.39
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45 772 0.395
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47 772 0.395
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70 745 0.419

APPENDIX D

BUS STATION MODELLING

D.1 INTRODUCTION

To assess the impact on air quality in the study area from the addition of bus stations for the Future With Transitway (2031) scenario, two stations, GO Barrie (Concord) and Leslie, were modelled due to their close proximity to sensitive receptor locations (R1 and R10, respectively, outlined in Section 4.5). All other station locations are situated at much greater distances from sensitive areas, therefore, the GO Barrie (Concord) and Leslie stations were considered to be worst-case scenarios. If predicted air quality impacts are determined to be minimal at these two stations, then the impacts of the remaining five stations on local air quality will also be minimal.

The atmospheric dispersion model used for the bus station assessment was the U.S. EPA Industrial Source Complex Short Term Version 3 (ISCST3) model, which is described in further detail in Section E.3. The maximum 24-hour model predicted concentrations were added to CAL3QHCR results (including ambient background) to determine the cumulative effect of the Transitway and the bus stations at specific receptor locations (i.e., R1 and R10). Only nitrogen oxides (NO_x) and total suspended particulate (TSP) were modelled as indicators of the impact on air quality.

D.2 ATMOSPHERIC EMISSIONS

D.2.1 DESCRIPTION OF ASSESSMENT SCENARIOS

Leslie Station

Leslie Station will be situated just west of Leslie Street. It is considered to be an intermodal station as it will eventually connect with a proposed Light Rail Transit (LRT) system that will travel north/south on Leslie Street. There are also two (2) proposed parking lots west of Leslie Street and south of the Transitway. As well, there will be a passenger pick-up and drop-off (PPUDO) area located in the larger of the two parking lots. Refer to the main Environmental Project Report (EPR) for the undertaking for a detailed description of the design of this station.

Only emissions from additional vehicular traffic entering/exiting the parking lots will be considered in this scenario. Idling emissions from buses on the Transitway will not be considered as it is expected that one (1) bus will pass through the station every minute during peak travel hours.

GO Barrie (Concord) Station

GO Barrie (Concord) Station will be situated east of the existing GO Barrie rail line. It has been planned that this station will connect with existing VIVA transit buses. There are two proposed parking lots east of the GO Barrie line and north of the Transitway. As well, there will be a passenger pick-up and drop-off (PPUDO) area located in the larger of the two parking lots. A roadway will also be built leading to the parking lots. Again, refer to the main Environmental Project Report (EPR) for the undertaking for a detailed description of the design of this station.

As with Leslie Station, only emissions from additional vehicular traffic entering/exiting the parking lots will be considered in this scenario. Idling emissions from Transitway buses will not be considered as it is expected that one (1) bus will pass through the station every minute during peak travel hours.

D.2.2 EMISSIONS ESTIMATION

In order to be conservative, a maximum emissions scenario was developed to capture expected worst-case maximum daily emissions from the Leslie and GO Barrie (Concord) stations. The worst-case scenario was based upon maximum 24-hour AADT volumes entering/exiting the parking lots provided by IBI Group.

The same emissions estimating methods used for CAL3QHCR modelling were used for this assessment. However, since the speed travelled by vehicles entering/exiting the parking lots will be much less than the posted speed limit on Highway 407 and the Transitway (100 km/h), different MOBILE6C emission factors were used. Typical speeds in parking lots are approximately 25 km/h; however, only MOBILE6C emission factors for either 4 or 40 km/h were available. The TSP emission factors are the same for either speed, but the NO_x emission factor is higher for 40 km/h, therefore, it was selected as it is the more conservative value. MOBILE6C emission factors used in this assessment are shown in the following table.

Table D.1 MOBILE6C Tailpipe Emission Factors for 2031

Cars	
TSP	**NO_x**
0.01659	0.18828
Trucks/Buses	
TSP	**NO_x**
0.02187	0.26098

Note: Emission factors are in g/VKT (grams per vehicle kilometre travelled).

D.3 AIR DISPERSION MODELLING

The Industrial Source Complex Short Term Version 3 (ISCST3) model was used with the projected emissions to predict total suspended particulate (TSP) concentrations, as well as nitrogen oxide (NO_x) concentrations, at discrete receptors in the areas surrounding the stations. This model was developed for the U.S. Environmental Protection Agency (U.S. EPA) and was designed specifically to determine downwind air concentrations and deposition rates of various airborne pollutants from industrial sources. The ISCST3 model simulates the dispersion of pollutants by advecting a plume of material with an assumed Gaussian profile. The dilution of the plume as it travels downstream is calculated based on wind speed and mixing caused by atmospheric conditions.

An example ISCST3 input file is provided in Attachment A.

D.3.1 ISCST3 SETTINGS

Emissions from the parking lots were designated as “VOLUME” sources in ISCST3, which applies the total emission rate to a volume of air. In addition, connecting roadways (GO Barrie (Concord) Station only) were designated as “LINE” sources which is a series of volume sources spread evenly out over the length of the source. Emissions from the roadway are divided equally among the generated volume sources. The modelling configurations for both the GO Barrie (Concord) and Leslie Station are shown in Figure E.1 and Figure E2, respectively. Note that the Transitway and Highway 407 CAL3QHCR sources (in blue) were included for reference only – they were not included in ISCST3 modelling.

All contaminants modelled used 24-hour total emissions, with the exception of NO_x, which also has a 1-hour total. The emission rate of NO_x used was the same during the 1-hour period as each hour of the 24-hour periods; therefore, it was not necessary to perform separate model runs for 1-hour and 24-hour averaging times.

The variable emissions option was selected in ISCST3 so that an hourly profile of the parking lot emissions was considered by the model. It was assumed that there are two peak hours of emissions between 7 a.m. and 8 a.m. and 5 p.m. and 6 p.m. when the largest volume of vehicles enter and exit the parking lots at the beginning and end of a typical weekday. Two shoulder hours, before and after the AM and PM peaks, were also considered and were assumed to have fewer vehicles entering/exiting the parking lots. For all remaining hours of the day, emissions were set to zero.

D.3.2 METEOROLOGICAL DATA

The ISCST3 model uses hourly meteorological data records to define the conditions for plume rise, transport and dispersion. The model estimates the concentration or deposition value for each source-receptor combination, for each hour of input meteorology, and calculates short-term averages, such as one-hour, eight-hour and 24-hour periods. The hourly averages can also be combined into longer averages (1-month, seasonal, annual or period).

In this assessment, the ISCST3 model was run using the same meteorological data set that was used for CAL3QHCR modelling. Refer to Section 4.3 for a description of this meteorological data set. Again, the worst case meteorological year, 1993, was used to complete this assessment.

D.3.2 TERRAIN

Terrain was considered to be flat for this assessment.

D.3.3 DISCRETE/SENSITIVE RECEPTORS

Discrete receptors as well as the same sensitive receptors used in the CAL3QHCR modelling, R1 and R10, were used in this assessment so that model predicted results could be summed with previous CAL3QHCR results to obtain a cumulative concentration at these locations. Recall that R1 is a residential area located west of the GO Barrie (Concord) Station and R10 is a high school located east of Leslie Street at Highway 407 and south of the Transitway. The locations of the discrete receptors are shown by red markers in Figures E.1 and E.2.

Figure D.1 GO Barrie (Concord) Station Modelling Configuration

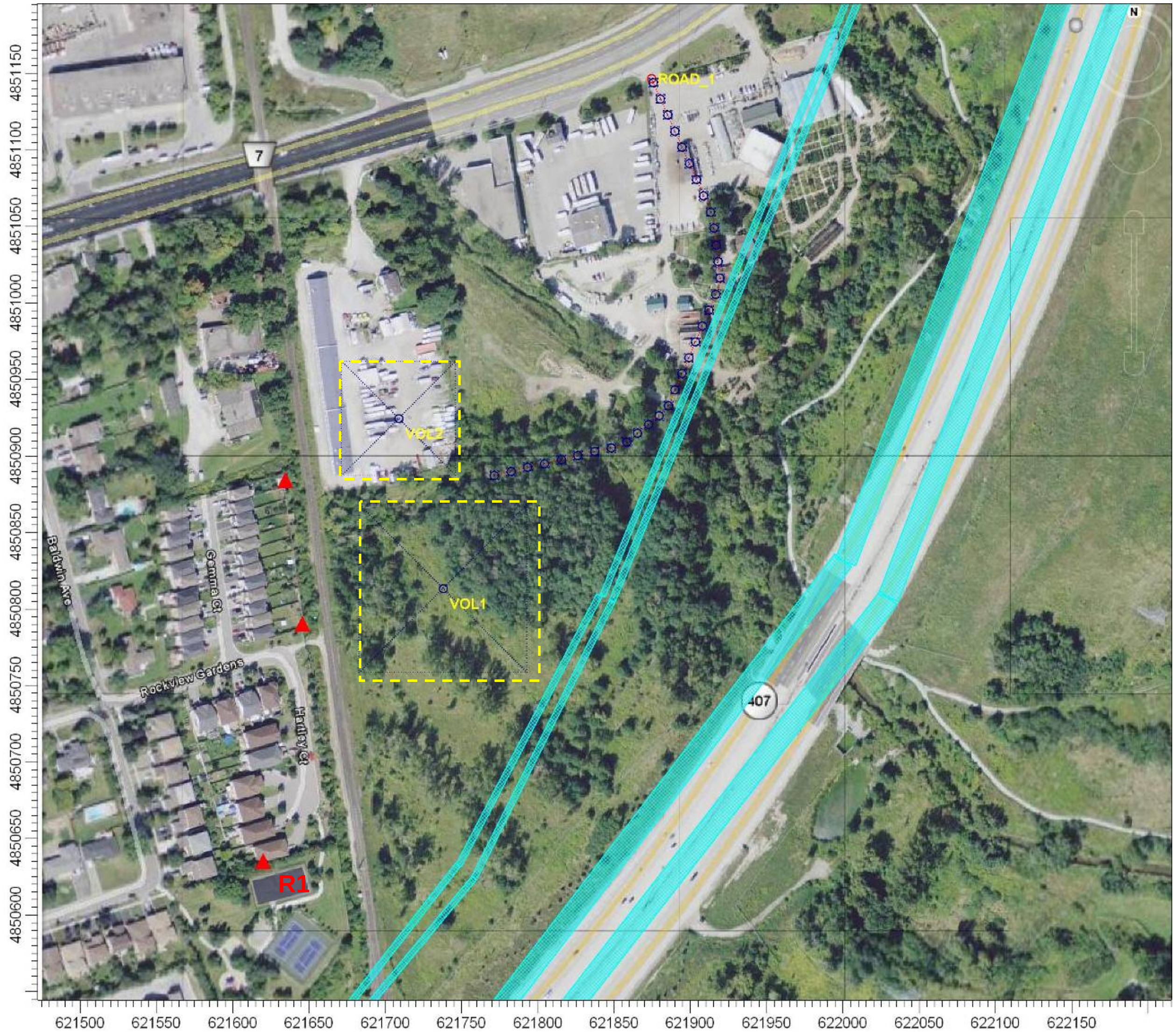

Figure D.2 Leslie Station Modelling Configuration

D.4 RESULTS

The results from the air dispersion modelling have been presented in tabular form for the discrete receptor locations outlined in the above figures.

Results are presented separately for each contaminant.

D.4.1 TABULAR RESULTS – NO_X

Table E.4.2 presents the maximum modelled concentrations of NO_x (1- and 24-hour) at both the GO Barrie (Concord) and Leslie stations. As can be seen in the table, maximum predicted NO_x concentrations for both averaging periods are small at only about 1% of the 1-hour NO_x criteria of 400 µg/m^3 and 0.1% of the 24-hour criteria of 200 µg/m^3 for both stations. Furthermore, these concentrations are only a fraction of the maximum 1- and 24-hour NO_x concentrations predicted at receptors R1 (GO Barrie (Concord)) and R10 (Leslie). For example, the maximum predicted 24-hour NO_x concentration by the CAL3QHCR modelling at R1 was 105 µg/m^3 (Table 5.2), so the addition of GO Barrie (Concord) station emissions would add an insignificant 0.20 µg/m^3 or (0.19%) to CAL3QHCR predicted concentrations. Note that the maximum predicted concentrations for each station and the maximums presented in Table 5.2 would not necessarily occur on the same day and therefore represent a worst-case scenario.

In all, the station assessment has shown that the impact of bus station emissions on NO_x levels in the study area, and at sensitive receptors in particular, is insignificant compared CAL3QHCR results. Similarly, the impact on other gases (i.e., CO, VOCs) would also be insignificant.

Table D.4.2 Maximum Modelled 1- and 24-hour NO_x Concentrations

Station	Receptor	Max 1-hr NO_x Concentration (µg/m^3)	Max 24-hr NO_x Concentration (µg/m^3)
GO Barrie (Concord)	Residences on Hartley Crt. (R1)	4.24	0.20
	Residences on south end of Gemma Crt.	4.12	0.25
	Residences on north end of Gemma Crt.	3.53	0.21
Leslie	High School West Property Line	2.5	0.24
	High School North Property Line (R10)	5.0	0.11

D.4.2 TABULAR RESULTS – TSP

Table E.4.3 presents the maximum modelled 24-hour concentrations of TSP at both the GO Barrie (Concord) and Leslie stations. As can be seen in the Table, maximum predicted TSP concentrations are less than approximately 7% of the 24-hour MOE criteria of 120 $\mu g/m^3$ for both stations. As shown in Tables B.3a and B.3b in Appendix B, the maximum model predicted TSP concentration at R1 was 139 $\mu g/m^3$ and 181 $\mu g/m^3$ at R10. Therefore, the stations would increase the concentration by 4% at R1 and by 2% at R10. As noted previously in the NO_x discussion, the maximum predicted concentrations at R1 and R10 for each station assessment and the concentrations predicted by CAL3QHCR would not necessarily occur on the same day and therefore represent a worst-case scenario. Although seemingly insignificant at 4 and 2%, the contribution of the stations to TSP levels may cause additional exceedances since TSP levels were already predicted to be substantially high at R1 and R10 by the CAL3QHCR modelling (Section 5.5). As a result, the cumulative effect of the Transitway and the bus stations were examined in more detail. This analysis is presented below.

Table D.4.3 Maximum Modelled 24-hour TSP Concentrations

Station	Receptor	Max 24-hr TSP Concentration ($\mu g/m^3$)
GO Barrie (Concord)	Residences on Hartley Crt. (R1)	5.3
	Residences on south end of Gemma Crt.	7.5
	Residences on north end of Gemma Crt.	8.0
Leslie	High School West Property Line	6.7
	High School North Property Line (R10)	3.2

<u>Refined TSP Station Assessment</u>

To better understand the cumulative effect of the stations on TSP concentrations near the GO Barrie (Concord) and Leslie stations, ISCST3 concentrations for receptors R1 and R10 were summed on a daily basis with CAL3QHCR predicted concentrations for the future scenario (2031) with the Transitway (including background) for 1993.

Table E.4.4 presents the cumulative TSP modelling results for R1 and R10. As can be seen in the table, the maximum 24-hour concentrations and the number of exceedances do not change when ISCST3 daily concentrations are added to CAL3QHCR concentrations. This indicates that the maximum predicted concentrations at R1 and R10 resulting from station emissions did not occur on the same day as the maximums resulting from Transitway emissions. In other words, this assessment shows that it is conservative to sum the maximum predicted concentrations from the station assessments to the maximum CAL3QHCR concentrations.

Table D.4.4. Cumulative 24-hour TSP Concentrations at R1 and R10

Receptor	Station Only		Future with Transitway		Future with Transitway & Station	
	Max 24-hr Concentration ($\mu g/m^3$)	Exceedances	Max 24-hr Concentration* ($\mu g/m^3$)	Exceedances	Max 24-hr Concentration* ($\mu g/m^3$)	Exceedances
R1	5.3	0	139	21	139	21
R10	3.2	0	174	87	174	87

*Concentration includes a background 24-hr TSP concentration of 70.2 $\mu g/m^3$

Note: Exceedances based on the 24-hour MOE criteria of 120 $\mu g/m^3$

Since the refined assessment showed that there were no additional exceedances at R1 and R10 and that the maximum concentrations did not increase when the stations were considered in the Future With Transitway (2031) scenario, it can be concluded that the impact of the bus stations on TSP levels in the study area, and at sensitive receptors in particular, is also insignificant. Similarly, the impact on other particulate size fractions (i.e., PM_{10} and $PM_{2.5}$) would also be insignificant.

D.5 CONCLUSION

In sum, the station assessment has shown that the impact of bus station parking lots and PPUDO areas on air quality in the study area are negligible compared to the impacts predicted by previous CAL3QHCR modelling. In particular, 24-hour NO_x concentrations increased by less than 0.2% at both R1 and R10 when the GO Barrie (Concord) and Leslie Stations were considered. TSP concentrations were shown to increase by 2% at R10 and 4% at R1 when ISCST3 and CAL3QHCR predicted maximums were summed. However, a refined assessment of TSP showed that these predicted increases were conservative. When predicted concentrations from each model were summed on a daily basis, it was shown that the maximums did not occur on the same day and that there were no additional exceedances predicted at R1 or R10 when station emissions were considered.

As previously discussed, GO Barrie (Concord) Station and Leslie Station were chosen for the station assessment since they were considered to represent the worst-case scenarios due to their close proximity to sensitive areas. Since the impact was determined to be insignificant, it can also be concluded that the remaining five stations (Jane, Bathurst, Yonge, Woodbine/Rodick and Kennedy) would also not significantly increase contaminant concentrations in surrounding areas.

ATTACHMENT A

EXAMPLE ISCST3 INPUT FILE
(GO Barrie (Concord) – PM)

```
**
****************************************
*
**
** ISCST3 Input Produced by:
** AERMOD View Ver. 6.4.0
** Lakes Environmental Software Inc.
** Date: 2010/04/28
** File: D:\300000 Projects\34573-2
407ETR\34573-2 Station
Modelling\ISC\GoBarrie\GoBarrie.INP
**
****************************************
*
**
**
****************************************
*
** ISCST3 Control Pathway
****************************************
*
**
**
CO STARTING
   TITLEONE GO Barrie Stn Modelling
   TITLETWO PM
   MODELOPT DFAULT CONC NOCMPL  URBAN
   AVERTIME 24
   POLLUTID TSP
   TERRHGTS FLAT
   RUNORNOT RUN
CO FINISHED
**
****************************************
*
** ISCST3 Source Pathway
****************************************
*
**
**
SO STARTING
** Source Location **
** Source ID - Type - X Coord. - Y
Coord. **
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4850813.153
** DESCRSRC 400 parking space lot
   LOCATION VOL2 VOLUME 621708.995
4850924.357
** DESCRSRC 200 parking space lot
** Line Source represented by Separated
Volume Sources
** -----------------------------------
--------------------------------
** LINE Source ID = ROAD_1
** DESCRSRC Entrance road to parking
lots
** Length of Side = 6.00
** Emission Rate = 0.359
** Vertical Dimension = 2.00
** SZINIT = 0.93
** Nodes = 6
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0.0
** 621914.81, 4851056.31, 0.00, 0.00,
5.38
** 621920.07, 4851012.91, 0.00, 0.00,
5.09
** 621884.57, 4850930.07, 0.00, 0.00,
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** 621856.30, 4850907.06, 0.00, 0.00,
4.24
** 621768.85, 4850886.68, 0.00, 0.00,
5.22
** -----------------------------------
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4851122.630
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4851112.065
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5.38 0.93
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4.24 0.93
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   SRCPARAM L0000027 0.0108787879 0.00
5.22 0.93
   SRCPARAM L0000028 0.0108787879 0.00
5.22 0.93
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5.22 0.93
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5.22 0.93
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5.22 0.93
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5.22 0.93

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of-Day"
** Variable Emission Scenario:
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   EMISFACT L0000001 HROFDY 0.0 0.0 0.0
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   EMISFACT L0000001 HROFDY 0.34 0.0
0.0 0.0 0.0 0.0
   EMISFACT L0000002 HROFDY 0.0 0.0 0.0
0.0 0.0 0.0
   EMISFACT L0000002 HROFDY 0.22 1.0
0.22 0.0 0.0 0.0
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0.0 0.34 1.0
   EMISFACT L0000002 HROFDY 0.34 0.0
0.0 0.0 0.0 0.0
   EMISFACT L0000003 HROFDY 0.0 0.0 0.0
0.0 0.0 0.0
   EMISFACT L0000003 HROFDY 0.22 1.0
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   EMISFACT L0000003 HROFDY 0.0 0.0 0.0
0.0 0.34 1.0
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0.22 0.0 0.0 0.0
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0.0 0.34 1.0
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   EMISFACT L0000010 HROFDY 0.0 0.0 0.0
0.0 0.34 1.0
   EMISFACT L0000010 HROFDY 0.34 0.0
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   EMISFACT L0000011 HROFDY 0.0 0.0 0.0
0.0 0.0 0.0
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   EMISFACT L0000011 HROFDY 0.34 0.0
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0.0 0.0 0.0
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0.22 0.0 0.0 0.0
   EMISFACT L0000012 HROFDY 0.0 0.0 0.0
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   EMISFACT L0000013 HROFDY 0.34 0.0
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   EMISFACT L0000015 HROFDY 0.34 0.0
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   EMISFACT L0000016 HROFDY 0.22 1.0
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   EMISFACT L0000016 HROFDY 0.0 0.0 0.0
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   EMISFACT L0000016 HROFDY 0.34 0.0
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   EMISFACT L0000020 HROFDY 0.0 0.0 0.0
0.0 0.34 1.0
   EMISFACT L0000020 HROFDY 0.34 0.0
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   EMISFACT L0000022 HROFDY 0.0 0.0 0.0
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0.0 0.34 1.0
   EMISFACT L0000026 HROFDY 0.34 0.0
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   EMISFACT L0000027 HROFDY 0.0 0.0 0.0
0.0 0.0 0.0
   EMISFACT L0000027 HROFDY 0.22 1.0
0.22 0.0 0.0 0.0
   EMISFACT L0000027 HROFDY 0.0 0.0 0.0
0.0 0.34 1.0
   EMISFACT L0000027 HROFDY 0.34 0.0
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0.0 0.0 0.0
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0.22 0.0 0.0 0.0
   EMISFACT L0000028 HROFDY 0.0 0.0 0.0
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   EMISFACT L0000028 HROFDY 0.34 0.0
0.0 0.0 0.0 0.0
   EMISFACT L0000029 HROFDY 0.0 0.0 0.0
0.0 0.0 0.0
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0.22 0.0 0.0 0.0
   EMISFACT L0000029 HROFDY 0.0 0.0 0.0
0.0 0.34 1.0
   EMISFACT L0000029 HROFDY 0.34 0.0
0.0 0.0 0.0 0.0
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   EMISFACT L0000030 HROFDY 0.0 0.0 0.0
0.0 0.34 1.0
   EMISFACT L0000030 HROFDY 0.34 0.0
0.0 0.0 0.0 0.0
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0.0 0.0 0.0
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0.22 0.0 0.0 0.0
   EMISFACT L0000031 HROFDY 0.0 0.0 0.0
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0.0 0.0 0.0
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   EMISFACT L0000032 HROFDY 0.0 0.0 0.0
0.0 0.34 1.0
   EMISFACT L0000032 HROFDY 0.34 0.0
0.0 0.0 0.0 0.0
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0.0 0.0 0.0
   EMISFACT L0000033 HROFDY 0.22 1.0
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   EMISFACT L0000033 HROFDY 0.0 0.0 0.0
0.0 0.34 1.0
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0.34 1.0
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   EMISFACT VOL2 HROFDY 0.0 0.0 0.0 0.0
0.34 1.0
   EMISFACT VOL2 HROFDY 0.34 0.0 0.0
0.0 0.0 0.0
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L0000003 L0000004 L0000005 L0000006
   SRCGROUP ROAD_1 L0000007 L0000008
L0000009 L0000010 L0000011 L0000012
   SRCGROUP ROAD_1 L0000013 L0000014
L0000015 L0000016 L0000017 L0000018
   SRCGROUP ROAD_1 L0000019 L0000020
L0000021 L0000022 L0000023 L0000024
   SRCGROUP ROAD_1 L0000025 L0000026
L0000027 L0000028 L0000029 L0000030
   SRCGROUP ROAD_1 L0000031 L0000032
L0000033
   SRCGROUP VOL1 VOL1
   SRCGROUP VOL2 VOL2
   SRCGROUP ALL
SO FINISHED
**
***************************************
*
** ISCST3 Receptor Pathway
***************************************
*
**
**
RE STARTING
** DESCRREC "" ""
   DISCCART    621620.10   4850635.02
   DISCCART    621645.99   4850789.91
   DISCCART    621634.73   4850883.98
RE FINISHED
**
***************************************
*
** ISCST3 Meteorology Pathway
***************************************
*
**
**
ME STARTING
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~1\347DB8~1\METDAT~1\Tor93.met
   ANEMHGHT 10 METERS
   SURFDATA 61587 1993 TORONTO
   UAIRDATA 72528 1993
ME FINISHED
**
***************************************
*
** ISCST3 Output Pathway
***************************************
*
**
**
OU STARTING
   RECTABLE ALLAVE 1ST
   RECTABLE 24 1ST
   MAXTABLE ALLAVE 100
   MAXIFILE 24 ALL 120
GoBarrie.IS\PM24.MAX
   POSTFILE 24 ALL PLOT
GoBarrie.IS\93PM.POS
** Auto-Generated Plotfiles
   PLOTFILE 24 ALL 1ST
GoBarrie.IS\24H1GALL.PLT
   PLOTFILE 24 ROAD_1 1ST
GoBarrie.IS\24H1G001.PLT
   PLOTFILE 24 VOL1 1ST
GoBarrie.IS\24H1G002.PLT
   PLOTFILE 24 VOL2 1ST
GoBarrie.IS\24H1G003.PLT
OU FINISHED
**
***************************************
*
** Project Parameters
***************************************
*
** PROJCTN  CoordinateSystemUTM
** DESCPTN  UTM: Universal Transverse
Mercator
** DATUM    North American Datum 1983
** DTMRGN   CONUS
** ZONE     17
**
```

APPENDIX E

RESULTS OF GREENHOUSE GAS BURDEN ANALYSIS

Table E.1 CO_2 Pollutant Burden

Scenario	CO_2 Pollutant Burden in kilotonnes/year	% Change from Existing Conditions in kilotonnes/year
Existing Conditions (2008)	342	-
Future **Without** Transitway (2031)	628	+84%
Future **With** Transitway (2031)	626	+83%

Table E.2 CH_4 Pollutant Burden

Scenario	CH_4 Pollutant Burden in tonnes/year	% Change from Existing Conditions in tonnes/year
Existing Conditions (2008)	24	-
Future **Without** Transitway (2031)	22	-12%
Future **With** Transitway (2031)	22	-12%

Table E.3 N_2O Pollutant Burden

Scenario	N_2O Pollutant Burden in tonnes/year	% Change from Existing Conditions in tonnes/year
Existing Conditions (2008)	7	-
Future **Without** Transitway (2031)	12	+76%
Future **With** Transitway (2031)	12	+76%