ENVIRONMENTAL IMPACT OF THE INDUCED TRAFFIC FROM HIGHWAY 25 EXTENSION PROJECT

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Introduction

Environmentalists and researchers are concerned on the environment burdens of road infrastructure and counter-productivity of highway expansion strategies due to unprecedented rates of greenhouse gases (GHGs) emissions from transport sector, land conversion, and negative externalities on the ecology (Farrington and Ryder, 1993; Newman and Kenworthy, 1999). A holistic approach to the environmental effects of road infrastructure is imperative. Farrington and Ryder (1993) described the necessity of developing the concept and application of Strategic Environmental Assessment (SEA) before developing the road infrastructure. Ironically, some people narrowly focus on the environmental impacts as end-of-the pipe or tailpipe factors for which they propose technological solutions. Sometimes these impacts are seen as localized matters and treated by reducing the levels of certain pollutants (e.g. carbon dioxide, oxides of nitrogen etc.) rather than treating as a systemic problem that needs to be addressed first at the level of policy and planning and then with technology when and where appropriate (Schiller et al., 2010).

The construction of highway 25 was started in 1966 as a link to enhance the economic transactions between Montreal, Laval and Longueuil. This link is part of the TransCanada corridor connecting Metropolitan Boulevard (A-40) with A-20. The Ministère des Transports du Québec (MTQ) postponed the construction of highway 25 on Rivére des Prairies because of strong opposition from several citizen groups and business associations. The government decided to complete the extension of highway 25 on 2007 and the project was opened to traffic on May 21, 2011. This extension connects the Boulevard Henri-Bourassa in Montreal with Highway 440 in Laval. The project had three main components: (1) construction of tracks

and structures of the freeway and service roads between Boulevard Henri-Bourassa and the south bank of the Rivière des Prairies (Boulevard Gouin) in the territory of the Montreal Island; (2) construction of highway's 25 bridge known as Olivier Charbonneau Bridge above the Rivére des Prairies; and (3) construction of the highway structures and service roads between north bank of the Rivière des Prairies (Boulevard Lévesque) and Highway 440 in the territory of Laval. The main objectives of this project were to (1) improve the traffic volume between North-East Montreal and Laval; (2) reduce the traffic congestion on major roads such as highways 440, 40, 125, 19, and 15; (3) support the economic development of East Montreal and Laval.

By the time of construction, there were already environmental concerns on this project. The Green Coalition, an association of many groups and individuals to protect natural environment, opposed the extension of highway 25. The association blamed that this extension project didn't consider or follow-through other alternatives or issues such as improved freight rail networks with intermodal nodes or terminals, reserved and separated light rail, transit oriented development, integrated living (or compact city concept), prime farmland and need for local sources of food supply, consequences of urban sprawl, destruction of green fields and negative impacts on the De Montigny Stream Eco-territory (Green Coalition, 2007). The Groupe en Recheche Urbaine (2007) noticed that the project didn't address land use changes and air pollution from induced traffic during and after the construction.

The objective of this study is to address the air pollution from the induced traffic during and after the construction of highway 25 extension project in Montreal Island. This study is conducted into two parts. The first portion interpolates the spatial pattern of carbon dioxide equivalent (CO2e) GHGs concentrations within a 5-km buffer zone of highway 25 extension project in Montreal Island. The second part simulates the AADT for each road link of the road network within a 5-km buffer zone of the project for different scenarios in order to understand the change of traffic volumes during and after the construction of the extension project.

Methodology

Spatial-temporal analysis of air quality within 5-km buffer zone of highway 25 extension project

This study initially determines any change in air quality during and after the construction of highway 25 extension project. A buffer zone of 5-km on either side of the highway 25 extension project is considered as the study area considering traveling abilities of the pollutants (Chiaburu et al., 2010). The nitrous oxide, SO_2, CO_2, and methane (CH_4) are major GHGs produced by on-road vehicles and are significant contributors to global warming (IPCC, 2007). Since CH_4 contributes to the growing global background concentration of tropospheric Ozone (O_3), data on ozone was assumed to provide a good representation of CH_4. Data on the selected air pollutants at ten air recording stations within Montreal island were collected from the *Réseau de surveillance de la qualité de l'air* of City of Montreal. This study considers air records from ten stations within Montreal Island because these stations have records of the selected GHGs during the period of 2003-2011. This study performs the spatial analyses of air pollutions for the period of 2003-2011 to understand the spatial pattern of air pollution before, during and after the construction of highway 25 extension project.

This study estimates the CO2e GHGs concentration to determine the environmental exposure of selected air pollutants. This study estimates the CO2e GHGs concentration at ten air record stations during the period of 2003-2011. The CO2e GHGs concentration at ten air record stations is spatially interpolated to determine the contour surface of CO_2e GHGs concentration at the study area. The geo-statistics tools of ArcGIS are applied to perform the spatial interpolation of CO_2e GHGs concentration assuming that data are purely spatial (Szentimrey et al., 2007). The geo-statistics incorporate different statistical techniques to determine the relationship between spatially distributed values that estimates values at un-sampled locations (Chappell, 1998). This study applies the residuals from the cross-validation procedure to determine the best fitted model for the spatial interpolation of CO2e GHGs concentration.

Simulation of traffic volume under four scenarios

Origin-Destination (O-D) data of the Montreal metropolitan area were collected for the years 2003 and 2008. Traffic assignment models were used to estimate the traffic volume on each road segment of Montreal road network within 5-km buffer zone of the construction site. Several traffic assignment methods are currently practicing in transportation planning, such as: All-or-Nothing (AON), STOCH, Incremental, Capacity Restraint, User Equilibrium (UE), Stochastic User Equilibrium (SUE) and System Optimum (SO) assignment models. This study applies the SO assignment model since this study aims to determine the air pollution of induced traffic during the construction of highway 25 extension project. The SO model computes an assignment that minimizes total travel time on the road network.

This study has considered two primary factors for simulating traffic volume during and after the construction of highway 25 extension project such as, traffic growth during the period of 2003-2011 and additional traffic because of the construction of highway 25 extension. The SO assignment model estimates AADT on each road link of the Montreal road network for four scenarios: (1) AADT in the year 2003 without highway 25 extension; (2) AADT in the year 2003 with highway 25 extension; (3) AADT in the year 2008 during the construction of highway 25 extension project; and (4) AADT in the year 2011 after the construction of highway 25 extension project. Scenario 2 explains what would be the traffic volume if there were highway 25 extension in the year 2003. Scenario 2 explains the impact of constructing highway 25 extension project on the traffic volume of the surrounding road network in the year 2003. Scenario 3 accounts the traffic growth and the inducted traffic during the construction of highway 25 extension project. Scenario 4 estimates the AADT considering both traffic growth and the additional traffic after the construction of highway 25 extension project. *TransCAD* software was applied to simulate the traffic volumes for the four scenarios.

Data analysis

Spatial-temporal analysis of air pollution

This study identifies the IDW as the best fitted model for the spatial interpolation of CO_2e GHGs concentration during the period of 2000 -2011. The spatial pattern of CO_2e GHGs concentration in the year 2003 explains the air pollution before the construction of highway 25 extension project. The spatial pattern of CO_2e GHGs concentration during the construction of 25 extension project can be well understood by observing the air pollution trend during the period of 2007-2010. The spatial pattern of CO_2e GHGs concentration in the year 2011 explains the air pollution after the construction of highway extension project.

During the year 2003, the CO_2e GHGs concentration was 4.51 - 6.82 ppm and 6.82 - 8.41 ppm at the north- and south-side of the highway 25 extension within 1 km buffer zone. The CO_2e GHGs concentration was decreased to 2.41 - 4.51 ppm at the north-side at a distance of 1-2 km from the project site. On the contrary, it was increased to 8.41 - 10.64 ppm, 8.41 - 10.64 ppm and 10.64 - 11.55 ppm within 2-3 km, 3-4 km and 4-5 km vicinity of the south-side of project site respectively. The CO_2e GHGs concentration was increasing on south-side of the highway 25 extension project because of more urban traffic in the Montreal Island. The *Institut de la Statistique du Québec* identified that 92.47% of the trip to work were originated and destined to Montreal Island in the year 2001. The *Ministere des Transport* (2000) estimated that the number of trips using mass transit during morning rush hour declined from 395000 in 1987 to 342000 in 1998, while car trips per day were increased 1.3 million during the same period. The OD survey in 2003 (origin-destination) revealed that during a typical day of a week, there were 6.4 million vehicle trips in the metropolitan area of which only 1.2 million were made by public transport. It also identified that the share of trips made by public transport was reduced from 25.7% in 1987 to 18.9% in 2003. The increased car trips and major share of urban traffic in the Montreal Island caused increasing rate of CO_2e GHGs concentration within the close proximity of downtown Montreal.

During the period of 2007-2010, the concentration of CO_2e GHGs was highly increased at the north-side of the project site during this period comparing to the concentration level in the year of 2003. The increasing air pollution at the north-side of the project was resulted from the air pollutants emitted from the construction processes and additional traffic during the construction period.

On the south-side of project area, the CO_2e GHGs concentration was increased within 2-km buffer zone of the project site during the same period. However, the CO_2e GHGs concentration was decreased from within the vicinity of 2-3 km, 3-4 km and 4-5 km. The reason for the decrease of CO_2e GHGs concentration in close proximity to downtown Montreal is that the government has taken different initiatives such as Greater Montreal Area Transport Plan 2000 to ensure sustainable transportation system and to promote mass transit. The decrease of air pollution with distance from project site (close proximity to the downtown Montreal) and increase of air pollution within 2-km buffer zone of project site persuade this study to hypothesize that air pollution was resulted from the induced traffic during the construction of highway 25 expansion project. There are several sources of air pollutions such as industrial processes, burning of fossil fuel and fuel consumption. However, trend analysis of satellite images during the period of 2002-2010 reveals that there was insignificant change of land use within the 5-km buffer zone of the highway 25 extension.

This hypothesis is justified by the spatial interpolation of CO_2e GHGs concentration in the year 2011. On the south-side of the project area, the CO_2e GHGs concentration was 10.14-10.57 ppm, 10.57-11.15 ppm and 11.15-12.10 ppm within the 0-1 km, 1-2 km and 2-5 km buffer zone of highway 25 extension respectively. On the north-side of the project area, the CO_2e GHGs concentration was 10.14-10.57 ppm, 9.75-10.14 ppm, 9.29-9.75 ppm and 8.71-9.29 ppm within the 0-1 km, 1-3 km, 3-4 km and 4-5 km buffer zone of highway 25 extension respectively. This increase of CO2e GHGs concentration might be resulted from the induced traffic after the opening of highway 25 extension site.

Construction of highway 25 expansion project and its impact on traffic volume

The AADT for scenario 2, 3 and 4 were compared with the base scenario (i.e. AADT in the year 2003 without highway 25 extension) in order to understand the changes of traffic volume under different scenarios. Significant change in AADT is observed along the highway that connects Laval and Longueuil in scenarios 2 comparing to a base case scenario. The AADT increased by 3.3% to 5% along this highway (Figure 1). The traffic volume is also increased by 4% to 5% on the Northwestern part of Montreal Island. The impact of highway 25 extension is also observed on the traffic volume of arterial and local roads of Montreal Island (Figure 1).

Traffic volume is increased by 4% to 5% in the southern part and 2% to 3.3% in the northern part of the borough Montréal Nord compared to the base case scenario (Figure 1). This is due to the fact that the northern part of this borough is dominated by underdeveloped land. The traffic volume of arterial and local roads in Rivière-des-Prairies/Pointe-aux-Trembles, Montréal Nord, Saint-Léonard, Rosemont/La Petite Patrie and Mercier/Hochelaga-Maisonneuve boroughs shows that traffic volume would increase by 3.3% to 4% if the highway 25 extension were existed in the year 2003 (Figure 1). Increase in traffic volume on arterial and local roads in close proximity to highways is also observed. More trips are produced and attracted in these boroughs because of the high building density and residential land use.

The insignificant amount of change (1%-2%) is observed on local roads in upper part of the borough Mercier/Hochelaga-Maisonneuve and lower part of the borough Anjou that is Northeastern part of the Montreal Island (Figure 1). Major part of borough Anjou is dominated by vacant land use category and it is more likely that this area will face less change of traffic volume irrespective of the construction of highway 25 extension. Mixed land use is the dominant category of land use in Mercier/Hochelaga-Maisonneuve. Low to medium level of CO_2e GHGs concentration is observed in this borough. The CO_2e GHGs concentration is high in these boroughs

representing a strong positive correlation between the induced traffic of the highway 25 extension and air pollution.

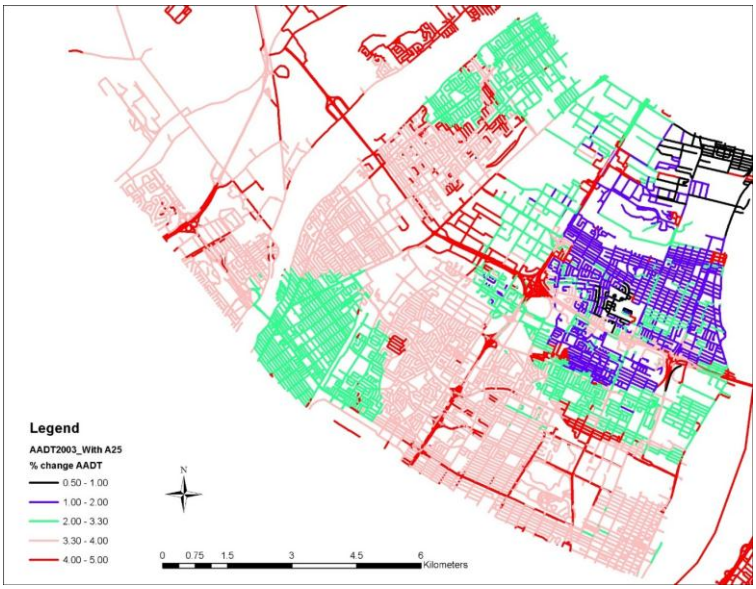

Figure 1: Impact of highway 25 extension on the traffic volume in 2003 under scenario 2

During the period of 2003-2008, traffic volume increased on all roads of Montreal Island because of the traffic growth. However, the construction of highway 25 extension had an impact on the traffic volume of the surrounding road links under scenario 3. For example, traffic volume was increased by 5.5% to 6% on highways connecting Laval and Longueuil under scenario 3 that was 1% to 2% higher than the change of traffic volume under scenario 2 (Figure 1 and 2). The change of traffic volume was up to 6% because of trip generation resulted from growth in population and building density and change in land uses. Significant change (up to 6%) in traffic is also observed along the arterial roads and local roads those are in close proximity to highway 25 (Figure 2). The CO2e GHGs concentration map shows that air pollution was high within the range of 7.91-10.91 ppm. This

explains that CO2e GHGs concentration was high because of the emissions from the increased traffic volume.

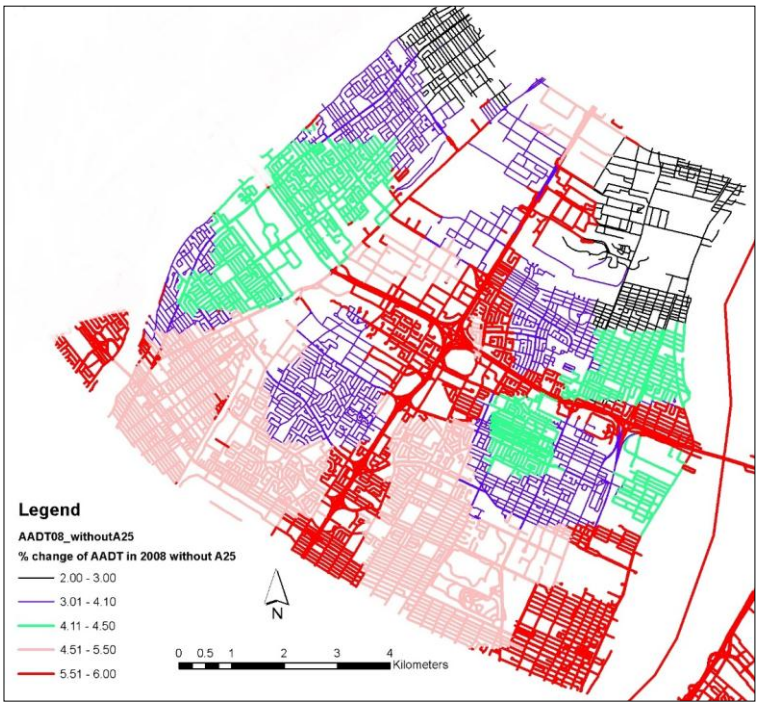

Figure 2: Traffic volume in 2008 without highway 25 extension under scenario 3

The traffic growth was 3.51% to 5% in the west part of borough Mercier/Hochelaga-Maisonneuve during the construction of highway 25 extension project. Level of CO2e GHGs concentration was low to medium level that remains unchanged compare to scenario 1. Significant traffic growth was observed on the arterial roads of this area. For example, traffic volume was increased by 4.11% to 4.5% on approximately half of the arterial roads in this area. On the other hand, traffic volume was increased by 2% to 3% on the other categories of roads in this area. This was because of the ongoing construction of highway 25 extension project that caused less traffic

volume comparing to scenario 2. Lowest level of CO2e GHGs concentration is observed in this area that is 0.98 to 7.91 ppm. Significant increase in AADT is observed in the local roads on the eastern side of the Boulevard Henri Bourassa and the change is 4.51% to 5% (Figure 2) and the pollution level is also high that is 10.91 to 12.20 ppm. This traffic growth was resulted from increased trips that were generated from increased population and building density.

In the year 2011, traffic volume was significantly increased on the highway 25 especially on the part between boulevard Gouin East and Boulevard Henry Bourassa East. Traffic volume was increased by 5.1% to 12% on the highway 25 connecting Montreal with Laval and Longueuil after the opening of highway 25 extension project comparing to the base scenario (Figure 1 and 5). Traffic volume was increased by 7.1% to 12% on the highway 25 between Gouin East and Boulevard Henry Bourassa East (Figure 3). This is the highest traffic growth compare to all other scenarios. The increased traffic volume was resulted from the combined effects of traffic growth during the period of 2003-2011 and the opening of highway 25 extension project. The most significant increase of traffic volume was observed in the Montréal Nord, Anjou and Rivière-des-Prairies/Pointe-aux-Trembles boroughs. The traffic volume in the northern part of Montréal Nord, close to the highway 25 extension project, was increased by 7.1% to 12% (Figure 3). The southern part of Montréal Nord, close to highway 125 (Boulevard Pie-IX), observed comparatively less increase of traffic volume i.e. 4.1% to 7% (Figure 3). Similarly, traffic volume was significantly increased by 5.1% to 12% on the roads between Highway 25 and Boulevard Armand Bombardier within the borough Rivière-des-Prairies/Pointe-aux-Trembles (Figure 3). The rate of AADT increase along highway 25 (Boulevard Louis h. Lafontaine) was highest under scenario 4 compare to all other scenarios. Local roads close to this boulevard shows 5.1% to 7% change in traffic compare to base case scenario except in the case of those in boroughs Montréal Nord and Rivière-des-Prairies/Pointe-aux-Trembles (Figure 3). Local roads, in close proximity to highway 25, observed up to 12% increase in traffic volume after the opening of highway 25 extension project (Figure 3).

The Boulevard Henri Bourassa East experienced 5.1% to 7% increase of traffic volume in the year 2011 (Figure 3). Traffic volume on the access roads at the western side of Boulevard Henri Bourassa East was increased at a higher rate comparing to those on the eastern side of this boulevard. The access roads in the western side of Boulevard Henri Bourassa East experienced an increase of 7% of traffic volume comparing to change in traffic volume under scenario 3 (Figure 2 and 3). However, the access roads on the eastern side of Boulevard Henri Bourassa East experienced only a slight increase of traffic volume after the opening of highway 25 extension project (Figure 3). These changes are due to the induced traffic resulted from the opening of highway A25 extension that generates additional traffic volume in the vicinity of the project area.

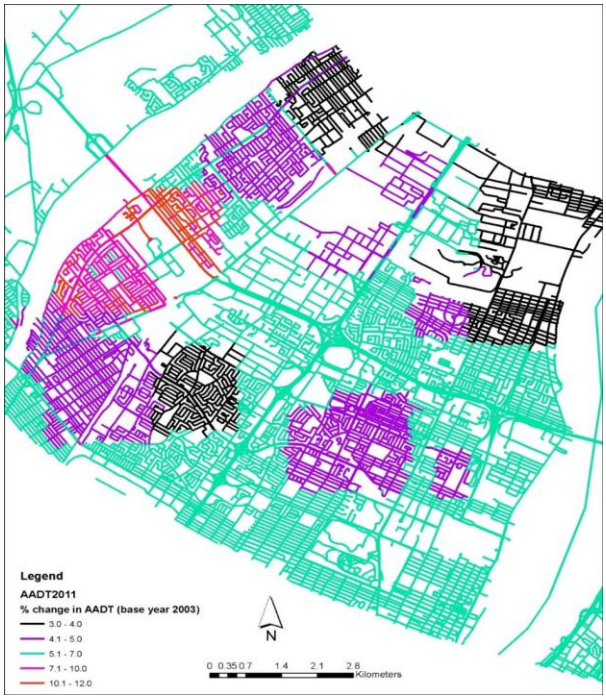

Figure 3: Impact of highway 25 extension on the traffic volume in 2011 under scenario 4

Least change in traffic volume is observed in the borough Montréal East (0.5% to 1% increase in AADT) under scenario 2 (Figure 1). For scenario 3 and 4, the AADT change is 2% to 3% and 3% to 4%, respectively (Figure 2 and 3). Although heavy industry is prominent in this area, building density is less compare to other boroughs that generates and attracts less traffic in this borough. The pollution map represents the CO2e GHGs concentration is less in this borough. Although this part of Montreal Island is concentrated with heavy industries, pollution level is less. This implies the fact that pollution is generated mostly from vehicle emission. Moreover, level of pollution is high near the highways, boroughs with high building density and the boroughs those are located close to the central part of the Island. Boroughs with residential land use and mixed land use represents highest to medium level of CO2e GHGs concentration.

This study finds out two-fold outcomes from the analyses. First, the CO2e GHGs concentration was increased within the 5-km buffer zone of highway 25 extension projects during the period of 2003-2011. The increment of CO2e GHGs concentration was resulted from the additional traffic during and after the construction of the project. The increment of CO2e GHGs concentration during the construction period of highway 25 extension project was also resulted from the construction processes. Secondly, the simulated traffic volume under four scenarios explains that the traffic volume significantly increased both on arterial and access roads within the close vicinity of the highway 25 extension project during and after its construction. This study justifies the concerns of the environmentalists on the potential air pollution from the additional traffic resulted from the construction of highway 25 extension project.

The outcomes of this study urge the *Ministére des Transports du Québec* as well as other transport authorities to conduct studies on air pollution from an induced traffic perspective during and after the construction of road infrastructure; and to include these studies as part of the feasibility studies before the construction of road infrastructure. This study also suggests the transport authorities should assess other alternative solutions in order to reduce the environmental degradation.

Conclusion

The construction of road infrastructure has adverse effect on the environment not only for construction process but also for vehicle emission from the additional traffic resulted from the construction of the new road infrastructure. The construction of highway 25 in Greater Montreal was started in 1966 for enhancing the economic transaction between Montreal Island, Laval and Longueuil. The *Ministère des Transports du Québec* (MTQ) postponed the construction of highway 25 on *Rivére des Prairies* because of strong opposition from several citizen groups and associations. The government started the extension of highway 25 on 2007 and opened to traffic on 2011. There were environmental concerns on this project such as, the project didn't properly address the land use change and air pollution from the additional traffic during and after the construction of the project.

The aim of this study is to address the air pollution from the induced traffic during and after the construction of highway 25 extension project. This study initially analyzes the spatial and temporal patterns of CO_2e GHGs concentrations during the period of 2003-2011 to understand the spatial pattern of air pollution before, during and after the construction of highway 25 extension project. Before the construction of highway 25 extension project, the CO2e GHGs concentration was increasing on south-side of the highway 25 extension project because of more urban traffic in the Montreal Island. On the other hand, the CO2e GHGs concentration was decreasing with distance from the project site on the north-side of project site. During the construction period (2007-2010) of highway 25 extension project, concentration of CO2e GHGs was highly increased at the north of the project site comparing to the concentration level in the year of 2003. On the south-side of project area, the CO2e GHGs concentration was increased within 2-km buffer zone and the concentration was decreasing beyond 2-km buffer zone. The reason for the decrease of CO2e GHGs concentration in close proximity to downtown Montreal was that the government had taken different initiatives such as Greater Montreal Area Transport Plan 2000 to ensure sustainable transportation system and to promote

mass transit. The decrease of air pollution with distance from project site (close proximity to the downtown Montreal) and increase of air pollution within 2-km buffer zone of project site were also observed from the spatial pattern of CO2e GHGs concentration in the year of 2011.

The simulated traffic during the period of 2003-2008 revealed that traffic volume was increased on all roads of Montreal Island because of the traffic growth. However, the construction of highway 25 extension had an impact on the traffic volume of the surrounding road links. For example, traffic volume was increased by 5.5% to 6% on highways connecting Laval and Longueuil in the year 2008 (without the project) that was 1% to 2% higher than the change of traffic volume in the year 2003 (with the project) comparing to the base scenario (traffic in the year 2003 without the project). Significant increase (up to 6%) in traffic is also observed along the arterial roads and local roads those are in close proximity to highway 25 in the year 2008 (without the project). In the year 2011, traffic volume was significantly increased on the highway 25 especially on the part between boulevard Gouin East and Boulevard Henry Bourassa East. Traffic volume was increased by 5.1% to 12% on the highway 25 connecting Montreal with Laval and Longueuil after the opening of highway 25 extension comparing to the base scenario. Traffic volume was increased by 7.1% to 12% on the highway 25 between Gouin East and Boulevard Henry Bourassa East. This is the highest traffic growth compare to all other scenarios. This increased traffic volume was resulted from the combined effects of traffic growth during the period of 2003-2011 and the opening of highway 25 extension project.

This study justifies the concerns of the environmentalists on the potential air pollution from the additional traffic resulted from the construction of highway 25 extension project. The outcomes of this study urge the *Ministére des Transports du Québec* as well as other transport authorities to conduct studies on air pollution from the perspective of induced traffic during and after the construction of road infrastructure; and to include these studies in the feasibility studies before the construction of such road infrastructure. This study

also suggests the transport authorities to assess other alternative solutions in order to reduce the environmental degradation.

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