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**THE ROLE OF BUS TRANSPORTATION IN REDUCING
GREENHOUSE GAS EMISSIONS: A CASE STUDY OF THE
NATIONAL CAPITAL AREA**

By

Petar Grubor B. Eng.

University of Belgrade

Faculty of Traffic and Transportation Engineering

Belgrade, Yugoslavia, 1982

A Thesis Submitted to the Faculty of Graduate Studies and Research
in Partial Fulfillment of the Requirements for the Degree of
Master of Engineering

Department of Civil and Environmental Engineering
Carleton University, Ottawa, Ontario

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October 2000

ABSTRACT

Concerns about the environmental effects of automobile use are reaching unprecedented levels, and governments around the world are giving attention to this problem as never before. This research was motivated by the fact that 27% of greenhouse gas (GHG) emissions are associated with transportation in Canada and there is considerable potential for reducing these gases in urban areas. The research is based on the thesis that appropriate policy changes in favor of transit can contribute to reducing GHG emissions in urban areas and that bus transportation has the potential to play an important role in this context.

Eleven scenarios were proposed in order to show the range of possible measures and their effectiveness in terms of increasing transit ridership and/or improving technology to reduce GHG emissions in the National Capital Region. These scenarios include: increasing parking costs, increasing fuel costs for vehicles other than public transit buses, decreasing transit fare, decreasing transit travel time, and using diesel-electric hybrid buses and fuel cell buses as replacements for diesel buses.

To assess the effectiveness of the scenarios, two tools were used: the transportation planning model, EMME/2, and the GHG Emission Calculator. The EMME/2 framework was used as a platform for the estimation of travel demand and GHG emissions. All the required socio-economic, travel and transportation network data were acquired and used.

Based on the results from this research, it can generally be concluded that bus transportation has the potential to play an important role in reducing GHG emissions, depending on the measures adopted to increase transit ridership.

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LIST OF ABBREVIATIONS

CBD	Central Business District
CUO	Communauté Urbaine de l'Outaouais
EMME/2	"Equilibre Multimodal, Multimodal Equilibrium", name of transportation planning software
EPA	Environmental Protection Agency
GHG	Greenhouse gas
IPCC	International Panel on Climate Change
Mobile5	Program for estimating gases that affects air quality
NCR	National Capital Region
O-D Survey	Origin-Destination Survey
RMOC	Regional Municipality of Ottawa-Carleton
STO	Société de transport de l'Outaouais
TRANS	Joint Technical Committee on Transportation System Planning
UTA	Urban Transit Area

CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Global climate change has the potential to alter precipitation patterns, ocean levels, and weather events, threatening ecosystems and settlements around the world. Thanks to the research of the Intergovernmental Panel on Climate Change (IPCC. 2000.), as well as the world's concern for climate change expressed through the conference in Rio in 1992 and in Kyoto in 1997, specialists in many areas of human activity are analyzing the magnitude of the problem in an effort to find solutions. Global climate change is the result of a phenomenon known as the greenhouse effect. Greenhouse gases trap heat energy near the earth's surface, allowing plant and animal life to flourish. However, the increase in greenhouse gas (GHG) concentrations due to human activities in the recent past has led to a process of global warming, known as the "enhanced greenhouse effect". As a result of human activities, global mean surface temperatures have increased 0.8-1.0°F (0.5-0.6°C) in the last century. As a result of these temperature changes, the sea level has risen 10-25cm (4-10 inches) over the past century, and worldwide precipitation over land has increased by about one percent (EPA. 2000).

Most scientists agree that if humans continue to add GHGs to the atmosphere through the combustion of fossil fuels, clearing of forests and other activities, the greenhouse effect will accelerate, causing temperatures to rise. Scientists expect that the average global surface temperature could rise 1.6-6.3°F by 2100, with significant regional variation. Given the potential impact of the global warming process, it is important to analyze GHG emissions from human activity and find ways to reduce them. Furthermore, by signing the Kyoto Protocol, Canada has expressed an interest in reducing GHG emissions by 6% compared to 1990 levels, by 2012 (Transportation Climate Change Table. 1999.).

Transportation is the single largest source of GHG emissions in Canada, accounting for approximately 27% of all GHGs produced in the nation in 1995 (TAC. 1998.). Any strategy for reducing GHG emissions in transportation must address the various parts of the transportation system, including vehicles, fuel, infrastructure and carriers. Moreover,

strategies must also address existing patterns of travel behavior. However, when speaking about transportation, it is important to emphasize that the efficiency of the transportation system is of critical importance for Canada's competitiveness, trade and tourism, and also plays an important role in people's quality of life.

Changes in travel behavior can be an effective means of reducing GHG emissions as people in urban areas switch from cars to more environmentally friendly modes of transportation, such as transit. It is important to mention that approximately 50% of transportation related GHG emissions were produced in urban areas in 1995 (TAC. 1998.). Almost 78% of Canadians reside in urban areas (Statistics Canada. 1996.) which are characterized by an auto dependent travel demand environment. Clearly there is considerable potential for switching people to transit and, as a result, reducing GHG emissions in urban areas.

The fact that people are generally concerned about automobile emissions and believe that more money should be spent on transit is encouraging. This suggests that people are looking to make a more environmentally friendly choice but are in need of direction and incentive. Thus, it is imperative to conduct transportation planning exercises in an environmentally responsible manner by ensuring that public transit has the highest utility value possible. In that context, "mode choice" and technology improvement strategies for reducing GHG emissions are presented and the role of bus transportation is investigated.

1.2 RESEARCH OBJECTIVE

Since public transit is an environmentally friendly mode of transportation, the main objective of this research is to investigate the role of bus transportation in reducing GHG emissions. On the basis of this "mode choice" strategy for reducing GHGs, several policy changes are proposed in favor of transit. The effectiveness of these measures is then analyzed, in terms of their ability to encourage people to use public transit and, as a result, reduce GHG emissions. A methodology is presented that enables transportation planners to analyze transportation systems from an environmental point of view in an innovative way.

1.3 RESEARCH SCOPE

The "mode choice" strategy for reducing GHG emissions in urban transportation is tested with data for National Capital Region (NCR). Also, the role of new technology is investigated. An analysis of the current situation is done for the Outaouais Region, while factors for the NCR are analyzed for comparison purposes as well.

Some basic information about transportation related GHGs in Canada and the global warming process in general are presented in order to highlight the magnitude of the problem. Public concerns about auto emissions and their readiness to change travel behavior in an environmentally responsible manner are also presented as a precondition for any success in terms of reducing GHGs.

Since the population in the NCR has access to several modes of transportation, mode choice decisions are analyzed to determine the variables of critical importance in the decision-making process. Given that public transit is more environmentally friendly compared to the auto mode, several policy changes are proposed in order to shift travelers to transit. The effectiveness of switching people to transit is then analyzed in terms of reducing GHG emissions.

1.4 RESEARCH APPROACH

The "Mode choice" strategy for reducing GHG emissions is based on the fact that a trip maker will choose the mode of transportation with the highest utility value. This strategy represents a set of measures that could be used to make public transit the mode with the highest utility value for travelers. This approach for reducing GHG emissions enables urban transportation planners to analyze systems from an environmental point of view in an innovative way.

Travel activity in the NCR is analyzed using the transportation planning software, EMME/2. As part of the auto assignment process, the impact of "background" traffic (heavy vehicles, school buses, inter-city buses, taxis and other vehicles) is taken into

consideration in order to determine vehicle travel time as a function of the total volume of traffic using the transportation network. The results of the EMME/2 analysis are then processed using an "Emission Calculator", which was recently developed for estimating GHGs and air quality pollutants based on travel data from EMME/2 (Armstrong. 2000.).

The calculation process is organized in such a way as to estimate fuel consumption and GHG emissions for each link in road network. These results are then aggregated according to geographic location (core, urban, suburban area or rural) and province (the Outaouais Region or the Regional Municipality of Ottawa-Carleton (RMOC)).

Conclusions regarding policies to reduce GHG emissions are drawn on the basis of the results for each proposed measure. In that context, the role of bus transportation in reducing GHG emissions is clarified.

1.5 RESEARCH METHODOLOGY

The research methodology depicted in Figure 1.1 was applied in order to achieve the thesis objective. A brief overview of the overall methodology is presented in order to clarify the study procedure and the interrelationships between various steps.

1.5.1 VISUALIZATION OF PROBLEM

Visualization of the GHG emission problem is done through analysis of the present situation in the Outaouais Region and RMOC as well as through basic information about global warming and transportation related GHG emissions in Canada.

Figure 1.1 Research Methodology Flow Chart

1.5.1.1 Analysis of Present Situation

In order to determine the potential for reducing GHG emissions in an urban area by switching people from cars to transit, there is a need to analyze the existing situation. Analysis of the existing situation is presented for the Outaouais Region, while some elements for the RMOC are presented for comparison purposes. Through the analysis of the urban activity system as a generator of travel demand on the one hand and the characteristics of the transportation system on the other, an understanding the relationship between the two systems can be achieved.

The urban activity system is analyzed through the socio-economic profile of the population and land use considerations. The socio-economic profile of the population is analyzed through population trends, household characteristics, population characteristics in terms of age, sex, labor force and occupation, then income characteristics and household car availability rate for the period of 1986-1996. Land use considerations are presented through land use types, land use densities and main activity centers. The primary sources of data for this analysis were statistical data (Statistics Canada. 1986-1996.) and related studies (DELUC. 1992a. and DELUC. 1992b.).

The transportation system is analyzed in terms of the characteristics of motorized trips, the spatial distribution of trips, the road system and transit transportation considerations. Changes in the transportation system are analyzed for the period of 1986-1995. The primary sources of data were the National Capital Region's 1986 and 1995 Origin Destination Survey and related studies (Commission de transport de la Communauté régionale de l'Outaouais. 1990., and Service de la modélisation des systèmes de transport, du ministère des Transports du Québec (MTQ). 1998.).

As mentioned earlier, approximately 78% of Canadians lived in urban areas in 1996: areas characterized by an auto dependent travel demand. Thus, it is clear that there is a considerable potential for switching people from automobiles to transit and, as a result, reducing GHG emissions. This is particularly true in the area of the Outaouais Region served by public transit (STO), since over a 24 hour period in 1995, 77.2% of trips were

by automobile, 6.2% were by public transit and 16.6% were by other modes of transportation (non-motorized and “other” motorized) (refer to Section 2.3.). In the area of the RMOC served by public transit, it was found that 70.9% of trips were by automobile, 12.4% of trips were by transit and 16.7% of trips were by “other” modes. From these statistics, it is clear that people in the RMOC use more transit than people in the Outaouais Region. However, in both areas, there is still considerable potential for switching auto persons to transit and, as a result, for reducing GHG emissions. Additional information concerning the present situation can be found in Chapter 2.

1.5.1.2 GHG Emissions and Global Warming

Scientists generally believe that the combustion of fossil fuels and other human activities are the primary reason for the increased concentration of GHGs in the atmosphere. Increasing concentrations of greenhouse gases are likely to accelerate the rate of climate change and scientists expect that the average global surface temperature could rise 1.6-6.3°F by 2100. Given the potential impact of the global warming process, it is important to analyze GHG emissions from human activity and find ways to reduce them. According to estimates (TAC. 1998.), 619 megatons of GHGs were produced in Canada in 1995. In this step of the research, transportation related GHG emissions in Canada are analyzed, as well as the social aspects of reducing these gases. It was previously pointed out that 27% of all GHGs in Canada were produced by the transportation field in 1995 and that about 50% of these transportation-related gases were produced in urban areas. Since the urban areas in Canada are characterized by an auto dependent travel demand, it means that there is a considerable potential for switching people from cars to transit and, as a result, reducing GHG emissions.

Social aspects of reducing GHG emissions are presented in terms of public concerns about auto emissions and people’s readiness to change travel behavior in favor of environmentally friendly modes of transportation, such as transit. The positive response of the public is a good sign that the policy changes in favor of transit that are presented in this research can be accepted and implemented. Chapter 3 presents more information about GHG emissions and global warming.

1.5.2 TRAVEL DEMAND MODELING

The TRANS model, which is supported by EMME/2 software, is used for travel-demand simulations in the National Capital Region. This model is capable of predicting future passenger vehicle and transit trips. According to the analysis in Section 5.1, the number of motorized trips will be increased by 48.3% during PM peak hour between 1995 and 2021. This means that there will be more traffic congestion on the roads, more fuel consumption and, as a result, more GHG emissions in National Capital region during this period of time. The situation will be slightly improved in terms of increased participation in the transit mode during this period of time. It is predicted that 1.6% of auto persons will switch to transit in 2021 when compared with 1995. These results are calculated on the basis of land use scenarios for 1995 and 2021 that are included in the TRANS model. These scenarios are considered to be “base” scenarios in this research. In addition to the base scenarios for 1995 and 2021, eleven scenarios are proposed for reducing GHG emissions as part of the "Mode choice" strategy. In order to make public transit the mode with the highest utility value, the changes in policy variables in favor of transit are proposed.

1.5.2.1 Modifying policy variables within modal split model and "first" running of TRANS model

Travel cost (parking cost and fuel cost for the auto person mode and transit fare for the transit mode) and transit travel time variables are modified in order to attract more people toward using transit. A range of changes in these variables is proposed in order to determine the effectiveness of the proposed measure in switching people from cars to transit and reducing GHG emissions. In addition, scenarios with new technology buses are proposed in order to assess the effectiveness of such measures in terms of their ability to reduce GHG emissions. The policies proposed are as follows:

- Parking cost could be increased by 10% (Scenario 1), 50% (2), and 100% (3)
- Fuel cost can be increased by 1% (4), 2.5% (5), and 5% (6)
- Transit fare can be decreased by 10% (7)
- Total transit travel time can be decreased by 10% (8) and 50% (9)

- Diesel-electric hybrid buses can be used instead of diesel buses in 2021 (10)
- Fuel cell buses can be used instead of diesel buses in 2021 (11)

When speaking about new technology buses, it was assumed that these buses would gradually replace existing diesel buses during the period of 1995-2021. These buses are currently in the testing phase and there is no evidence that they attract new passengers. Thus, it was assumed that operating these buses would not attract additional people towards using transit, but would reduce GHG emissions, since the proposed new-technology buses produce little or no GHG emissions. However, more passengers for new technology buses could be attracted by marketing activities that address the environmental awareness of the population.

The variables that are included in the modal split model within the TRANS model are analyzed in Chapter 4, while the proposed changes in policy variables are explained in detail in Section 5.3.2.

After policy variables for each scenario were modified, the TRANS model was run (see Figure 1.1, *First running of TRANS model*) and the volume of auto and transit vehicles per link was analyzed, as well as the number of people switching from auto to transit. Additional detail about the TRANS model as a platform for estimating GHG emissions can be found in Section 5.3.1, while details about running the TRANS model can be found in Section 5.3.3.

During the "first" running of the TRANS model, automobiles, transit buses and 80% of light duty trucks were analyzed. According to data from the "1996 Classification and Occupancy Counts", it was assumed that 80% of light duty trucks were used as passenger vehicles, while the remaining 20% were used as commercial vehicles.

The EMME/2 traffic assignment algorithm (INRO Consultants. 1998.) does not take into account the increased congestion resulting from "background traffic" (heavy vehicles, school buses and inter-city buses, taxis and other vehicles). Thus, these vehicles (based

on 1996 data) were calculated in order to estimate passenger vehicle travel time taking into account congestion caused by the total volume of traffic on the road network.

1.5.2.2 Volume of "background" traffic and "second" running of TRANS model

The output results from the TRANS Model (after the "first" running of the model) are auto and transit volumes assigned to each link of road network. From the assignment results, it is possible to compute the average link speed and vehicle kilometers traveled. Knowing the average speed and amount of travel, fuel consumption and GHG emissions can be estimated for each link in the transportation network in the next step of the calculations. In order to calculate link average speed and vehicle kilometers traveled, EMME/2 macros were used. These macros were developed recently (Armstrong. 2000.) and modified in order to distinguish between emissions generated in Ottawa and Hull.

The main EMME/2 macro for calculating vehicle kilometers traveled and average speed (*VKM_PMPHR.mac*) provides an interface between EMME/2 and the Emission Calculator. The Emission Calculator is a windows-based computer program designed to transform output results from EMME/2 into a format that can be used as input into MOBILE5, a program developed by the U.S. Environmental Protection Agency for calculation of vehicle emissions that affect air quality and human health. In addition, the Emission Calculator can compute GHG emissions using fuel consumption equations and GHG emission factors supplied by the user.

The main macro that calculates vehicle kilometers traveled and link average speed includes, among other macros, a macro to calculate "background" traffic from commercial vehicles. In order to determine the mix of vehicles on the road, ratios were developed for different vehicle categories using data from the 1996 Classification and Occupancy Counts. The ratio of heavy trucks, light trucks, taxis, "other" vehicles, and non-transit buses to passenger vehicles are analyzed in Section 5.3.4.3. These ratios were computed by dividing the number of vehicles of a particular type by the number of passenger vehicles and multiplying by 100. The ratios are computed for each

characteristic area (central core, urban area, suburban area and rural area) as well as for freeways and rural highways (see Table 5.1). Using these ratios, the volume of "background" traffic can be calculated directly from the volume of passenger vehicles assigned to the network in EMME/2 during the "first" run of TRANS model. In the macro for calculating "background" traffic during PM peak period (*bkgd_pm.mac* in Appendix E_3), the auto-volume on each link is multiplied by the appropriate ratios to determine the number of commercial vehicles using the link. The volume of trucks and buses in the traffic stream is then converted to an equivalent number of passenger vehicles and the assignment of passenger vehicles is repeated, accounting for the increased congestion from commercial vehicle traffic. The passenger car equivalency factors used in the analysis are presented in Table 5.2.

Since the TRANS model was calibrated on the basis of 1995 O-D Survey data (passenger vehicle trips) and did not consider the impact of background traffic, "background" traffic was only taken into account after the model converged by repeating the traffic assignment stage (see Figure 1.1, *"Second" running of TRANS model*). This was done in order to retain the integrity of the transportation model, otherwise, the model must be re-calibrated. According to preliminary analysis (Armstrong. 2000.), the total number of vehicle-kilometers traveled was not affected by the inclusion of "background" traffic volumes, and it can be concluded that vehicle routes remain virtually unchanged despite a significant increase in travel time.

In the main macro that calculates vehicle kilometers traveled and link average speed are two sub-macros that classify each link according to location (*region.mac*) and link type (*linktype.mac*). This classification is important in the determination of fuel consumption and greenhouse gas emissions in the subsequent step of the calculations. In the Outaouais Region, four characteristic areas were selected (central core, urban area, suburban area and rural area). These same areas were used for the RMOC. The link classification scheme used in the analysis is as follows: 1 = Local roads, 2 = Minor low speed roads, 3 = Minor high speed roads, 4 = Major low speed roads, 5 = Major high speed roads, 6 =

Freeways and rural highways, 7 = Centroid connectors (no external zones) and 8 = Transit only links. Additional detail can be found in Section 5.3.4.1.

When all required variables have been determined (see Section 5.3.4), the macro calculates vehicle kilometers traveled per each link as follows:

$$\text{Volume of traffic per link} * \text{link distance} = \text{vehicle kilometers traveled per link}$$

Also, on the basis of the link travel time (computed during the EMME/2 assignment based on the volume – delay function of the link) average travel speed is calculated as follows:

$$\text{Link distance} / \text{travel time per link} = \text{link average speed}$$

In this research, the vehicle kilometers of travel and average speed data are referred to as "travel data" and are used as input data for calculating fuel consumption and GHG emissions for each link (see Figure 1.1, *Post-processing*). The procedure for using the macro *VKM_PMPHR.mac* to calculate vehicle kilometers traveled and link average speed is explained in detail in Section 5.3.4.

1.5.3 FUEL CONSUMPTION AND GREENHOUSE GAS EMISSION ESTIMATIONS

Fuel consumption and GHG emissions are calculated using the Emission Calculator described earlier. First, the amount of travel on each link by different vehicle categories is determined using vehicle mix data supplied by the user as follows:

$$\text{Total vehicle kilometers traveled per link [VKM]} * \text{vehicle category participation [\%]} = \text{vehicle kilometers traveled per link by vehicle category [VKM]}$$

In Appendix E_5, vehicle mix data for the National Capital Region is presented for automobiles, light trucks and transit buses, for various link classifications. It is important to mention that, in order to simplify the calculation procedure, it was assumed that all vehicles in the traffic stream have the same link average speed.

The next step of the calculation process requires fuel consumption equations for each category of vehicles in order to calculate fuel consumption on the basis of link average speed and vehicle kilometers traveled for that category of vehicles. Since the objective in this research is to estimate fuel consumption and GHG emissions from passenger transportation in urban areas, fuel consumption equations for automobiles, light trucks and buses (heavy trucks) were used. These equations are based on data from Montreal (Ministère des transport du Québec. 1995.) and are able to predict fuel consumption as a function of average travel speed and vehicle type. Selected fuel consumption equations for 1995 are presented in Appendix E_95.

It is expected that fuel efficiency will be improved during the period of 1995 to 2021. Additional detail concerning the expected fuel efficiency improvements can be found in Section 5.3.5, where it is indicated that the fuel consumption rate (measured in liters of fuel/100 vehicle kilometers of travel) will be reduced by 23.3% for cars and light trucks and 14.7% for buses in 2021 compared with 1995. These reductions in the fuel consumption rate are applied to the fuel consumption equations for 2021 (see Appendix E_21). Fuel consumption equations by category of vehicles (autos, light trucks and buses) are developed for arterial roads and freeways, since there is a significant difference between urban and highway driving cycles.

The fuel consumption per link for each vehicle category is calculated as follows:

*Vehicle kilometers traveled [km] by vehicle type "i" * fuel consumption rate corresponding to the link average speed and vehicle type "i" [liters/km] = link fuel consumption for vehicle type "i" [liters]*

Along with fuel consumption equations, GHG emission rates (grams of GHGs/liter of fuel) for automobiles, light trucks and buses (see Table 5.3) must also be specified in order to calculate GHG emissions by vehicle category. GHG emissions are presented in terms of CO₂ equivalents by converting CO₂, CH₄ and N₂O emission rates on the basis of equivalency factors that reflect the relative long term greenhouse effect of these gases (see Section 3.1.). GHG emissions per link for each vehicle category are calculated as follows:

*Fuel consumption per link corresponding to vehicle category “i” [liters] * GHG emission rate [grams/liter of fuel] = GHG emissions per link for vehicle category “i” [grams]*

The fuel consumption and GHG emissions per link are then aggregated according to the link type and location and presented for each scenario proposed. (see Appendices F to R). This was done in order to determine the effectiveness of each measure in terms of reducing greenhouse gas emissions in the National Capital Region. Additional information about the fuel consumption and GHG emission estimates for each scenario can be found in Section 5.4.

It is important to mention that intra-zonal trips (trips that begin and end within the same traffic zone) are included in the modal split simulations but are not assigned to the road network. Thus, these intra-zonal trips are not included in the simulation results for fuel consumption and GHG emissions presented in Table 5.4. On the basis of an analysis recently undertaken using transportation GIS software (TransCAD GIS), vehicle kilometers traveled were estimated for intra-zonal trips during the PM peak hour in 1995 (Armstrong. 2000.). Assuming that intra-zonal trips have the same average speed as other trips, GHG emissions produced by these trips are approximated. In the modal split analysis, it was found that the modal split of intra-zonal trips was virtually unchanged for each proposed scenario.

It can be seen in the analysis of the proposed scenarios that there is a need for additional buses for the auto persons that switch from cars to transit. During the simulation process in the EMME/2 program, the number of additional buses required was not calculated. Assuming that these additional buses operate with the same average speed as other buses in the scenarios analyzed, the number of additional buses, as well as the fuel consumption and GHG emissions from these buses, were analyzed separately (see Section 5.4.12.).

1.6 THESIS ORGANIZATION

The research consists of six parts. In Chapter 1, a brief introduction to the global warming process and transportation related GHG emissions in Canada is presented. Then, the main objective of investigating the role of bus transportation in reducing GHG

emissions is introduced followed by brief explanation of the scope, approach and research methodology.

In Chapter 2, an analysis of the present situation in the Outaouais Region is presented through an analysis of the urban activity system as generator of travel demand. The characteristics of the transportation system in this part of the National Capital Region are presented as well. On the basis of this analysis, the magnitude of auto-dependency in the Region is clarified as well as the potential for reducing GHG emissions by encouraging people to use public transit instead of driving.

In Chapter 3, basic information about greenhouse gases and global warming is presented. The social aspects of reducing GHG emissions in urban areas is discussed, as well as the potential for these reductions at the national level.

In Chapter 4, an analysis of mode choice is reported for the National Capital Region. Indeed, mode choice decisions represent a basis for the next steps of the analysis. Mode choice models from the TRANS model are explained for different trip purposes, including: home based work, home based school, and other.

On the basis of the "mode choice" strategy for reducing GHG emissions, Chapter 5 presents the proposed scenarios and modified policy variables. Moreover, the travel demand simulations for each scenario are explained. Based on the travel demand simulation results, the procedure for calculating fuel consumption and GHG emissions is presented with final estimates.

Conclusions and recommendations can be found in Chapter 6, followed by references and appendices.

CHAPTER 2: ANALYSIS OF PRESENT SITUATION

2.1 URBAN ACTIVITY SYSTEM AS GENERATOR OF TRAVEL DEMAND

Since the principal objective of this research was to investigate the role of bus transportation in reducing greenhouse gas emissions, an analysis of the present situation in the Outaouais Region is presented, as well as a variety of trends in the National Capital Region as a whole for comparison purposes. The geopolitical position of the Outaouais region is unique in that it is located in the province of Quebec and at same time is part of the National Capital Region of Ottawa-Hull. Thus, the region is characterized by a specific and complex activity system.

According to Manhiem, "the activity system is defined as the totality of social, economic, political, and other transactions taking place over space and time in a particular region. These transactions, both actual and potential, determine the demand for transportation"(Manheim. 1979.). Most of the activities that have considerable influence on the transportation system occur in the urbanized part of the Outaouais region called the CUO - Communauté Urbaine de l'Outaouais. The CUO area encompasses the cities of Aylmer, Hull, Gatineau, Buckingham and Masson (DELUC. 1992b.) and is of particular interest in this research. The municipalities from the surrounding area are also taken into consideration for the way in which they influence the transportation system in the Outaouais Region. A simplified geopolitical map of the Region shown in Figure 2.1 reflects the complexity of existing jurisdictional interactions. Some statistical data for the period of 1976-1996 and other data for the period of 1986-1996 are used in order to see the changes in the urban activity system that occurred during these periods of time, and later, to see their reflection on the transportation system in the Region. This part of the analysis is of fundamental importance in that it reflects people's needs and behavior in terms of mode choice in actual circumstances.

Figure 2.1 Regional Geopolitical Map

Source: (ADI Limited. 1996.).

2.1.1 SOCIO-ECONOMIC PROFILE OF THE POPULATION

"The analysis of the socio-economic profile of the population is important in that it determines the magnitude and extent of activity in the urban area" (Garber et al. 1997.). Properly defined socio-economic characteristics help in seeing the influence of the activity system on the transportation system, and understanding the behavior and travel patterns of individuals. One should have in mind that "the levels and spatial patterns of those interactions are affected in part by the transportation services provided" (Manheim. 1979.). Some of the most important socio-economic factors are emphasized as follows: assessment and geographic distribution of the population, household characteristics, population characteristics in terms of age, sex, activity, occupation and income as well as the car availability rate of households. Using the most recent data, these factors are presented below.

2.1.1.1 Population Trends

Population trends are very important elements of the activity system in an area, and thus, it is of interest to see the specificity of the population in the Outaouais region, in the context of the National Capital Region. The data on population trends are presented in Table 2.1.

The general conclusion about the RMOC area is that there was a very strong increase in the population (37.4%) between 1976 and 1996. The population has increased differently in each city as follows: 497.4% in Kanata, 283.1% in Cumberland, 84.2% in Gloucester and 49.6% in Nepean. Only in Ottawa-Vanier has the population decreased, with a 3.2% decrease between 1976 and 1981, followed by a 9.1% increase between 1981 and 1996.

The population of the Outaouais Region as a whole grew by 32.5% between 1976 and 1996, which is slower than in the RMOC area. The population of the urbanized part of the Outaouais Region (CUO) grew by 26.4%, while the population of the surrounding rural area grew by 92.8% during the same period of time.

Table 2.1 Population trends in National Capital Region Ottawa - Hull

City	Year				
	1976	1981	1986	1991	1996
Aylmer	25714	26355	28976	32244	34901
Hull	61039	56565	58722	60707	62339
Gatineau	73479	74988	81244	92284	100702
Buckingham	7925	7992	8820	10548	11678
Masson	4025	4264	4842	5753	7989
Total CUO (1)	172182	170164	182604	201536	217609
<i>Rural – Outaouais (2)</i>	<i>17458</i>	<i>18841</i>	<i>20355</i>	<i>28895</i>	<i>33662</i>
Total Outaouais(1+2)	189640	189005	202959	230431	251271
Ottawa + Vanier	324265	313955	319189	332137	342582
Nepean	76930	84361	95490	107627	115100
Gloucester	56485	72859	89810	101677	104022
Kanata	8020	19728	27519	37344	47909
Cumberland	12365	16177	26999	40697	47367
Total R.M.O.C. (3)	478065	507080	559007	619482	656980
Total Nat. Cap. Reg. Ottawa-Hull (1+2+3)	667705	696085	761966	849913	908251

The population in the cities of the CUO area increased with different magnitude during the 1976 - 1996 period as follows: Masson 98.5%, Buckingham 47.4%, Gatineau 37.1% and Aylmer 35.7%. The population in Hull decreased by 7.3% during the 1976 - 1981 period and then increased by 10.2% during the period of 1981 -1996.

It is important to mention that the municipality of Cantley was part of the City of Gatineau until 1989 when it became an independent municipality. Thus, the population of Cantley is included in the data for Gatineau for the period of 1976-1986. However, for the period of 1991-1996, the population of Cantley is included in the data for the "Rural-Outaouais" area. The general conclusion is that the Quebec and Ontario part of the National Capital Region have been developed under complex socio-economic and political circumstances during the time period analyzed, resulting in different population trends. In the Outaouais region, some of the people have moved to the smaller cities and to the surrounding rural area, because there is cheaper and more available land. Population trends in the Outaouais Region are presented in Figure 2.2.

Figure 2.2 Population trends in the Outaouais Region

2.1.1.2 Household Characteristics

According to the results from Table 2.2, the average number of persons per household in the Outaouais Region was 2.9 in 1986. This number decreased to 2.6 in 1996. In the urbanized part of the Outaouais Region (CUO), the average number of persons per household decreased from 2.8 to 2.6 over the same period.

Table 2.2 Household characteristics in the Outaouais Region (1976 - 1996)

City	Number of households in the Outaouais Region				Persons per household	
	1976	1981	1986	1996	1986	1996
Aylmer	7140	8000	9150	12032	3.2	2.9
Hull	20320	21430	24235	28925	2.4	2.2
Gatineau	19945	22435	26280	36574	3.1	2.8
Buckingham	2340	2655	3135	4422	2.8	2.6
Masson	1140	1290	1610	2847	3.0	2.8
Total C.U.O. (1)	50885	55810	64410	84800	2.8	2.6
<i>Total rural (2)</i>	<i>4975</i>	<i>5940</i>	<i>6830</i>	<i>12091</i>	<i>3.0</i>	<i>2.8</i>
Total Outaouais (1+2)	55860	61750	71240	96891	2.9	2.6

Aylmer showed the highest average of 3.2 persons per household in 1986, but this value decreased to 2.9 in 1996. In Gatineau, the number of persons per household decreased from 3.1 to 2.8 over the same period. The lowest number of persons per household in 1986 was 2.4 in Hull, a value that decreased to 2.2 in 1996.

As a result of increasing population in the Region combined with a decreasing number of persons per household, the number of households in the Region increased accordingly during the period of 1976 - 1996. Household trends in the Outaouais Region are presented in Figure 2.3.

Figure 2.3 Household trends in the Outaouais Region (1976 - 1996)

2.1.1.3 Population Characteristics In Terms Of Age and Sex

The percentage of the population per age group and sex in the urbanized part of the Outaouais Region (CUO) and in the rural part of the Region are similar. Since the territory served by STO (Société de transport de l'Outaouais) buses encompasses the urbanized area (CUO) plus the municipalities of Chelsea and Cantley located in the rural area, the population characteristics of this territory are also similar, and are presented here for the purpose of further analysis. The population characteristics are later compared with the bus-passenger's characteristics in terms of age and sex.

Since O-D survey data for 1986 and 1995 are available, the Census data (Statistic Canada, 1986-1996.) for the population in terms of age and sex for 1986 and 1996 are presented in Table 2.3. Later, a comparison will be made to see how changes in the socio-economic system influence changes in the transportation system, as well as travel patterns.

The data in table 2.3 clearly show that the population has changed slightly in terms of age and sex over the analyzed period of time. The highest percentage (20%) of the population (for male and female) was in the 25-34 age group in 1986. This age category represented 20.8% of the population in 1996. Also, 18% of the population occurred in the 15-24 age group in 1986, a percentage which decreased to 14.5% in 1996. In the age group of 35-44, there was 16% of the population in 1986 and 17.9% in 1996. The 45-54 and 55-64 age groups accounted for 17% of the population in 1986 and 18.2% in 1996. In this table, one can also see that the population was well balanced in terms of sex. According to the available data, there were no major disparities between the municipalities in terms of sex.

Table 2.3 Population profile in terms of age and sex in the territory served by STO

Age group	Year					
	1986			1996		
	Men (%)	Women (%)	Total (%)	Men (%)	Women (%)	Total (%)
0 - 4	4	4	8	3.8	3.7	7.5
5-14	7	7	14	7.1	6.8	13.9
15-24	9	9	18	7.3	7.2	14.5
25 - 34	10	10	20	10.1	10.7	20.8
35 - 44	8	8	16	8.9	9	17.9
45 - 54	5	5	10	5.5	5.4	10.9
55 - 64	3	4	7	3.5	3.8	7.3
65 and over	3	4	7	2.9	4.3	7.2
Total (%)	49	51	100	49.1	50.9	100
Total number	91394	95118	186512	112471	116488	228959

Generally speaking, the population data show that there was less of the population in the lower age groups (0-4, 5-14, and 15-24) and more of the population in the higher age groups (25-34, 35-44, 45-54, 55-64 and "65 and over") in 1996 compared to 1986.

The population profile in terms of age is presented by the curves "1986" and "1996" in Figure 2.4, where it is obvious that the population has become older on average, during the period of 1986-1996. One can also see that most of the population was between 15 and 44 years old during this period of time.

Figure 2.4 Population profile in terms of age in the territory served by the STO

2.1.1.4 Population's Characteristics In Terms Of Labor Force and Occupation

Lifestyle is mostly determined by prevailing economic activities in an area. The participation rate of the population clearly shows the magnitude of their involvement in the activity system. Since the participation rates vary depending on economic conditions, they generally represent the economic conditions that prevail in a region. The population's characteristics in terms of labor force activity in the CUO area are presented in Table 2.4.

Employment data are presented for 1986, 1991 and 1996 for the urbanized part of the Outaouais Region (CUO) in order to see the changes in participation rates and unemployment rates and analyze their influence on the change in demand for transportation.

Participation rates are calculated by dividing the total labor force 15 years and over by the total population 15 years and over, and are presented in percents. Unemployment rates are calculated by dividing the number of unemployed people by the total labor force 15 years and over, and are also presented in percents.

Table 2.4 Population's characteristics in terms of labor force activity in CUO area

Labor force activity	CUO area		
	1986	1991	1996
	Total		
Total population 15 years and over	140785	156955	169170
Total labor force 15 years and over	98325	113420	116475
Employed	87720	104090	105245
Unemployed	10610	9330	11230
Participation rate	69.8%	72.2%	68.8%
Unemployment rate	10.8%	8.2%	9.6%
	Men		
Males 15 years and over	68420	76210	81600
Males 15 years and over in labor force	54815	60620	61300
Employed	48955	55510	54885
Unemployed	5855	5110	6415
Participation rate	80.1%	79.5%	75.1%
Unemployment rate	10.7%	8.4%	10.5%
	Women		
Females 15 years and over	72365	80745	87570
Females 15 years and over in labor force	43510	52800	55175
Employed	38765	48580	50360
Unemployed	4755	4220	4815
Participating rate	60.1%	65.4%	63.0%
Unemployment rate	10.9%	8.0%	8.7%

According to data from this table, the participation rates of men in the CUO area were higher than those of women while their unemployment rates were similar during the period of 1986-1996. Generally, the participation rate increased in total from 69.8% in 1986 to 72.2% in 1991, then decreased to 68.8% in 1996.

The spatial distribution of activities plays an important role in determining people's needs for mobility. That is why the participation rates of the population are analyzed for each city in the Outaouais region (see Appendix A). It is important to mention that the data illustrate the distribution of the residences of the population (employed or unemployed) and not the sites of the employment.

The data show that the participation rate has been different in each city and was the highest in Gatineau in 1986 (72.1%), where it increased to 74.8% in 1991, then decreased

to 71.3% in 1996. Aylmer followed Gatineau with a participation rate of 71.7% in 1986. This number increased to 74.0% in 1991, then decreased to 70.4% in 1996. The participation rate in Hull was 68.0% in 1986; it increased to 68.9% in 1991, then decreased to 65.2% in 1996.

The lowest participation rate in 1986 was 59.6% in Buckingham, where it increased to 66.7% in 1991 and then decreased to 61.9% in 1996. The participating rate in Masson increased from 63.4% in 1986, to 71.1% in 1991 and to 71.7% in 1996. It is important to mention that in the cities with higher participation rates, there were lower unemployment rates.

The percentage of the labor force 15 years and over by sex and major occupation groups in the CUO area is presented in Table 2.5.

Table 2.5 Percentage of labor force 15 years and over by sex and occupation major groups in CUO area

Sector of activity	Percentage of total labor force in CUO area		
	1986	1991	1996
Primary	1.0%	1.0%	0.9%
Secondary	18.7%	16.5%	13.6%
Tertiary professions	30.7%	34.0%	52.8%
Tertiary service	49.6%	48.5%	32.7%
Total	100.0%	100.0%	100.0%
	Percentage of men in labor force in CUO area		
	1986	1991	1996
Primary	1.5%	1.5%	1.4%
Secondary	31.1%	29.0%	24.0%
Tertiary professions	29.8%	32.6%	43.1%
Tertiary service	37.6%	36.9%	31.5%
Total	100.0%	100.0%	100.0%
	Percentage of women in labor force in CUO area		
	1986	1991	1996
Primary	0.3%	0.3%	0.3%
Secondary	3.1%	2.1%	2.0%
Tertiary professions	31.8%	35.7%	63.6%
Tertiary service	64.8%	61.9%	34.1%
Total	100.0%	100.0%	100.0%

According to the data from this table, it is clear that jobs in the CUO area were strongly concentrated in "tertiary professions" and "tertiary service" sectors, which represented 30.7% and 49.6% of the total jobs in 1986. In 1991, these sectors represented 34.0% and 48.5% of the total jobs respectively.

The strong influence of government activity in the Outaouais region has resulted in a high concentration of jobs in the tertiary sector. The data also show an increasing contribution of women in these sectors.

Statistical data concerning labor force by sex and major occupation groups were regrouped in the tertiary professions and tertiary service sectors in 1996. Thus, the percentage of the labor force in these sectors is very different for that year. The table also shows that the jobs in the secondary sector decreased from 18.7% in 1986 to 13.6% in 1996.

Labor force data for individuals 15 years and older are analyzed by sex and major occupation groups for each city in the CUO area and are presented in Appendix B. It is important to mention that the data illustrate the distribution of the residences of the population working in certain sectors and not the sites of the employment.

According to the data presented, the number of employed females in 1986 was 41985, a number that increased to 55155 in 1996, representing a 31.4% change. Over the same period, the number of employed males increased from 52960 to 61280, a 15.7% change. This clearly shows that the number of employed females has grown relatively faster than employed males over the analyzed period.

The number of jobs by sector of activity in the CUO area are presented in Figure 2.5 for 1986, in Figure 2.6 for 1991 and in Figure 2.7 for 1996.

Figure 2.5 Number of jobs by sector of activity in CUO area in 1986

Figure 2.6 Number of jobs by sector of activity in CUO area in 1991

Figure 2.7 Number of jobs by sector of activity in CUO area in 1996

2.1.1.5 Income Characteristics

Income characteristics for the urbanized part of the Outaouais Region (CUO) are analyzed for the period 1986 - 1996 and presented in Table 2.1.1.5.1. It can be seen that the average household income in the CUO area increased from \$35122 in 1986 to \$48324 in 1996.

Table 2.6 Average household income in CUO area (1986 - 1996)

City	Average household income (\$)		
	1986	1991	1996
Aylmer	41273	57569	58277
Hull	30726	41062	42262
Gatineau	37770	50156	50329
Buckingham	30492	43671	44413
Masson	32147	45143	47249
CUO area	35122	47509	48324

The average household income increased in each city in the CUO area between 1986 and 1996 and was the highest in Aylmer. Gatineau, Masson, Buckingham and Hull followed Aylmer, in terms of level of average household income (see Figure 2.8).

Figure 2.8 Household income trends in cities in the CUO area (1986 - 1996)

Detailed data about household income for each city and class of income, as well as data about income per employed male and female, are presented in Appendix C.

According to the data presented in Appendix C, one can see that households with income levels below \$30,000 accounted for 46% of the total households in 1986, a value that decreased to 33.8% in 1996. This clearly shows that there were more households with incomes of \$30,000 and over at the end of the analysis period, compared to the beginning. In other words, since there are more households with incomes of \$30,000 or more, the population's ability to buy items such as cars has increased.

When speaking about income groups below \$10,000, the situation in the CUO area in 1986 was similar to that in other regions of Quebec and Canada in that there was a much higher proportion of women (44.5%) than men (25.6%). However, in 1996, these percentages changed to 28.8% and 21.4% respectively. Besides the fact that the percentage of men and women in the lowest income class decreased, it is also clear that the difference between the percentage of men and women in this income class also decreased.

In contrast, in the \$30,000 and over income group, there was a much higher percentage of men (30.8%) than of women (8.9%) in 1986. However, these values changed to 46.3% and 29.9% respectively in 1996. In addition to this increase in the percentage of men and women in income groups of \$30,000 and over, one can see that the gap between the percentage of men and women in these income groups has decreased over the period analyzed.

The income distribution for males in the CUO area is presented in Figure 2.9 for 1986, in Figure 2.10 for 1991 and in Figure 2.11 for 1996. Comparing these three figures one can see that males gradually moved from lower income classes to higher income classes over the time period analyzed.

Figure 2.9 Income distribution for males in the CUO area in 1986

Figure 2.10 Income distribution for males in the CUO area in 1991

Figure 2.11 Income distribution for males in the CUO area in 1996

When speaking about the income distribution for females, one can see that, in each city women also moved gradually from lower income classes to higher ones, but these changes were much faster than for males. The income distribution for females in the CUO area is presented in Figure 2.12 for 1986, in Figure 2.13 for 1991 and in Figure 2.14 for 1996.

Figure 2.12 Income distribution for females in the CUO area in 1986

Figure 2.13 Income distribution for females in the CUO area in 1991

Figure 2.14 Income distribution for females in the CUO area in 1996

2.1.1.6 Household Car Availability Rate

Data about car availability, expressed in terms of the number of vehicles per household in the territory served by STO buses, are presented in Table 2.7 for 1986.

Table 2.7 Car availability rate in 1986 (DELUC. 1992a.)

City - territory	Population	Persons per household	Percent of households per car availability class (%)				Average number of cars per household
			0	1 car	2 cars	3+ cars	
Hull	58722	2.4	20	57	19	4	1.1
Gatineau	81244	3.1	9	54	31	6	1.3
Aylmer	28976	3.2	4	51	40	5	1.5
Buckingham	8820	2.8	11	54	31	4	1.3
Masson	4842	3.0	3	44	49	4	1.6
<i>Territory served by STO buses</i>	186512	2.8	12	54	29	5	1.3
National Capital Region	809598	2.7	14	51	29	6	1.3

In 1986, the bus transportation system served the urbanized part of the Outaouais region (CUO) and the municipality of Chelsea (3908 people) located in the rural area. According to the data, the municipality of Masson had the highest (1.6) car availability rate per household, while Hull had the lowest rate (1.1). One can also see that the average number of cars per household was similar in the territory served by STO buses to that of the National Capital Region (1.3).

The percentage of households per car availability class in 1986 is depicted in Figure 2.15. This figure shows that the percentage of households with 3 or more cars is very similar in each city (4% - 6%), as is the percentage with 1 car (51% - 57%), with the exception of Masson where only 44% of the households own one vehicle.

Table 2.8 contains the car availability rate per household for the territory served by STO buses in 1996, as well as for the National Capital Region.

Comparing the data for 1986 and 1996, one can see that the car availability rate increased only in Gatineau (from 1.3 in 1986 to 1.4 in 1996) and in Buckingham (from 1.3 in 1986 to 1.4 in 1996). In other cities, the car availability rate decreased during this period.

Figure 2.15 Percentage of households per car availability class in 1986

In 1996, the STO bus transportation system served the CUO area as well as the municipalities of Chelsea and Cantley located in the rural area. According to the available data, the car availability rate in these municipalities was very high: 1.7 and 1.8 respectively. The average number of cars per household in the territory served by STO buses and that of the National Capital Region were again similar (1.3).

Table 2.8 Car availability rate in 1996

City - territory	Population	Persons per household	Percent of household per car availability group (%)				Average number of cars per household
			0	1 car	2 cars	3+ cars	
Hull	62339	2.2	22.1	55	20.3	2.6	1.0
Gatineau	100702	2.8	8.5	50.6	34.9	6	1.4
Aylmer	34901	2.9	8.8	47	39.1	5.1	1.4
Buckingham	11678	2.6	6.6	51.5	37.5	4.4	1.4
Masson	7989	2.8	7.1	47.1	42	3.8	1.4
<i>CUO area (1)</i>	<i>217609</i>	<i>2.6</i>	<i>13.1</i>	<i>51.5</i>	<i>30.8</i>	<i>4.6</i>	<i>1.3</i>
Chelsea (2)	5925	2.7	2.1	34.1	54.4	9.4	1.7
Cantley (3)	5425	2.9	0	31.6	59.2	9.2	1.8
<i>Territory served by STO (1+2+3)</i>	<i>228959</i>	<i>2.6</i>	<i>12.5</i>	<i>50.6</i>	<i>32.1</i>	<i>4.8</i>	<i>1.3</i>
National Capital Region	972407	2.6	15.5	48.6	30.6	5.3	1.3

Figure 2.16 presents the percentage of households per car availability class in 1996. This figure shows that the percentage of households with 3 or more cars is still very similar in most cities (between 3.8% and 6%), except for Hull, where the percentage is 2.6% and Chelsea and Cantley, where the percentage is 9.4% and 9.2% respectively.

According to this figure, Hull had the highest percent of households without a car. This percent increased from 20% in 1986 to 22.1% in 1996. There were no households without a car in the municipality of Cantley. The percentage of households with 1 car are relatively lower in Chelsea (34.1%) and in Cantley (31.6%) compared with other cities, but the percent of households with 2 cars is much higher, 54.4% and 59.2% respectively.

When comparing the territories served by STO buses, 54% of households owned 1 car in 1986, a value which decreased to 50.6% in 1996. At the same time, the percent of households with 2 cars increased from 29% to 32.1%. Obviously, the municipalities of Chelsea and Cantley influenced these changes.

Figure 2.16 Percentage of households per car availability class in 1996

2.1.2 LAND USE CONSIDERATIONS

In addition to the socio-economic profile of the population that shows one part of the picture, the urban land use philosophy represents another important aspect of the urban activity system. The urban land use shows where the population (homes) and the activities (work, school, shopping, and recreational centers) are located.

Taking into consideration that the activity system (land use system) influences the transportation system in that it generates demand for transportation, it is of critical importance to understand the linkages between these two systems in both the spatial and temporal sense. As it is emphasized in many transportation planning texts, "in principle, the transportation-land use interaction is of fundamental importance to planning and should represent the starting point for the analysis of any transportation policies and issues" (Meyer et al. 1984.).

Generally speaking, people and activities will choose suitable locations based on a location's attractiveness and accessibility to the other activities. In other words, it is important that the people's residences and activities are adequately located in the urban area and well served by the transportation system. Thus, the steps of land use and transportation development should be planned simultaneously and in accordance to each other.

In order to undertake land use and transportation planning simultaneously, the Transit and Road Systems Integrated Plan (DELUC. 1992b.) was developed, using the concept of sustainable development in the Outaouais Region. Some elements from that plan concerning the current land use situation are presented in this research.

Generally, the Outaouais Region is an area with relatively low residential densities and with dispersed industrial, commercial, administrative, recreational and cultural centers. Each city in this area has its specificity in terms of land use philosophy and is analyzed through land use types, land use density and main activity centers.

2.1.2.1 Land Use Types

The data about land use types originate from the urban plans of the municipalities in the CUO area. Since these municipalities register land utilization differently, the information is not completely comparable, but is good as a general picture of land use in each city.

Many of the jobs are concentrated in the City of Hull as a result of a long period of development in the past. Now, there is a considerable portion of land in the city that is used for jobs in the secondary and tertiary sectors. According to the available data (DELUC. 1992a.), Hull is the only city in the CUO area that does not have a rural part, but parks and green space account for a very high percent (44%) of the total area of the city. Gatineau Park is located at the north part of the city and is spread over a vast territory. Residential land use accounts for 18% of the total area of Hull, a relatively smaller proportion than in Gatineau and Aylmer. Vacant land accounts for 11% of the total land and is mostly located in the west part of the city. Land for transportation (road infrastructure, communications) accounts for 14%, while land for commerce and industry accounts for 4%. Land for services accounts for 8% of the total area of the city of Hull.

The City of Gatineau is the most populated in the Outaouais Region and occupies a vast territory. The urbanized part of the city accounts for 55% of the total territory and is located south of Highway 50, while the rest of the city consists of rural land located north of Highway 50. Residential land accounts for 46% of the total urbanized part of the city, which clearly shows that Gatineau is a residential city that feeds the employment centers of the Outaouais region and the city of Ottawa. Commercial and industrial land accounts for 11% and 13% of the total urbanized area respectively, while 30% of the land is reserved for parks and green space.

The City of Aylmer is spread over a large area. The north part of Aylmer is rural and accounts for 65% of the total territory of the city. This area has enormous potential in agriculture. The urbanized part of the city of Aylmer is mainly residential, with residential land accounting for 40% of the total urbanized area. Commercial and industrial land accounts for 7% and 5% of the total urbanized area respectively, while

21% of the land is reserved for parks and green space. In addition to that, it is important to mention that vacant land accounts for 27% of total urbanized area and represents potential for future development.

The urban areas of Buckingham and Masson were, originally, developed around the primary sector. The opening of Highway 50 favored the interdependence of these municipalities with the rest of the Outaouais region and since then, its residential growth has been significant.

The municipalities in the rural ring adjacent to the CUO area have very low density of population and are experiencing isolated development in certain pockets.

2.1.2.2 Land Use Densities

Population density in the urbanized part of the Outaouais Region (CUO) is on average very low. The average density was 5.6 persons per hectare in 1989.

The development of Hull has been spatially limited and, as a result, this city had a relatively higher average population density of 16.3 persons/hectare. In other municipalities, the large amount of rural and vacant land resulted in very low population densities in 1989.

For the territory of Gatineau as a whole, the population density was 6.2 persons/hectare, while Aylmer had a population density of 3.6 persons/hectare. Taking into consideration only the urbanized part of these cities, the average population density was 13.6 persons/hectare in Gatineau and 9.4 persons/hectare in Aylmer.

According to the data presented in Table 2.9, the population density was increasing slowly in the territory served by STO in the period of 1986-1996.

Table 2.9 Population density in the territory served by STO buses (1986-1996)

City	Population per year			Surface (hectare)	Population density (persons/hectare)		
	1986	1991	1996		1986	1991	1996
Aylmer	28976	32244	34901	9120	3.2	3.5	3.8
Hull	58722	60707	62339	3740	15.7	16.3	16.7
Gatineau	77520	92284	100702	14060	5.5	6.6	7.2
Masson	4842	5753	7989	5560	0.9	1.0	1.4
Buckingham	8820	10548	11678	1460	6.1	7.2	8.0
<i>Total CUO</i>	<i>178880</i>	<i>201536</i>	<i>217609</i>	<i>33940</i>	<i>5.3</i>	<i>5.9</i>	<i>6.4</i>
Cantley	3731	5236	5425	13400	0.3	0.4	0.4
Chelsea	3908	5091	5925	11440	0.3	0.4	0.5
Total	186519	211863	228959	58780	3.2	3.6	3.9

It is important to mention that vast portions of land in Aylmer and Gatineau, and a relatively smaller portion of land in Hull, have a density of less than 7.5 persons/hectare (DELUC. 1992b. - Exhibit 1). The highest densities of more than 45 persons/hectare are located in the central parts of Hull and Gatineau.

According to the data (DELUC. 1992b. - Exhibit 2), in most parts of the region, the dwelling density is very low at less than 9 dwellings per hectare. In a few sectors of Hull and Gatineau, there are low densities of 9-18 dwellings per hectare, while there are medium densities of 18-36 dwellings per hectare in the central area of Hull.

Jobs are concentrated in several sectors of the Outaouais region. According to the data (DELUC. 1992b. - Exhibit 3), there are only three sectors with high employment densities of more than 150 jobs/hectare or medium employment densities of 25 to 150 jobs/hectare. Besides that, there are four sectors with low employment densities of 5 to 25 jobs/hectare, while in the vast part of the region, employment densities are less than 5. It is important to mention that many people live in the Outaouais Region and work in the city of Ottawa where there are higher employment densities.

2.1.2.3 Main Activity Centers

From the available data (DELUC. 1992b. - Exhibit 4), it can be seen that the majority of activity centers are located in the central business districts (CBD) of Hull and Ottawa.

Thus, the CBDs of Hull and Ottawa generate the greatest number of work-related trips in the National Capital Region.

Each municipality in the region has industrial parks that are generally planned along major highways and have low employment densities. In addition, there are several isolated industrial sites for industries that have been established for a long period of time.

Institutional centers such as hospitals and educational centers are located at isolated sites and are dispersed throughout Hull and Gatineau.

2.2 TRANSPORTATION SYSTEMS

The purpose of the transportation system analysis is to observe and understand the changes in the transportation systems that have occurred as a result of the influence of the activity system. "As the population, income and land-use patterns of metropolitan areas and states change, so do the patterns of demand for transportation-both the amount of transportation desired and the spatial and temporal distribution of that demand" (Manheim. 1979.). Moreover, one should have in mind that changes in transportation technology reflect back on the activity system through changes in quality of service. By doing so, changes in transportation technology participate in the overall demand-supply relationship.

Different groups of the population (eg. young, elderly, students, rich, poor, women, etc) are affected differently by the actual transportation system, and thus there is need to analyze the transportation system from their perspective. Finally, the social and environmental effects of transportation: air pollution, noise pollution, community disruption, and ecological effects are very important elements in transportation system analysis and transportation decision making.

2.2.1 CHARACTERISTICS OF MOTORIZED TRIPS

Motorized trips include the trips made by automobile and by transit. Total motorized trips within municipalities served by the STO in 1986, during the morning peak period (6AM

to 9AM) can be broken down into 56% work-related trips, 25% education-related trips and the remaining 19% of trips for miscellaneous reasons (Commission de transport de la Communauté régionale de l'Outaouais. 1990.). These percentages changed to 54.2%, 24.0% and 21.8% respectively, in 1995 (Service de la modélisation des systèmes de transport, du ministère des Transport du Québec. 1998.).

It is important to keep in mind that the participation rate of men and women in the labor force analyzed in Section 2.1.1.4, decreased in total from 69.8% in 1986 to 68.8% in 1996. This resulted in decreasing the work-related trips during the same period of time.

During the morning peak period, the preferred transportation mode in the Outaouais region is the automobile, which accounted for 68% of all trips in 1986, and 71.7% in 1995.

The total number of trips originating in the area served by STO during the morning peak period increased from 107250 in 1986 to 125943 in 1995 while the total number of trips with a destination in this area increased from 96250 to 104625. In 1986, 415050 trips originated in this area during a 24-hour period, a number which increased to 530737 in 1995. During the same period of time, the daily number of trips with a destination in the area increased from 414700 to 529959. Dividing the number of trips per day by the population in the territory served by STO, gives an average of 2.1 trips per person per day in 1986. This average increased to 2.4 trips in 1995. The number of trips per person per day in the National Capital Region decreased from 2.8 to 2.6 during the same period of time.

Transit accounted for 14% of all trips originating in the municipalities served by STO during the morning peak period in 1986. This value decreased to 9.9% in 1995. In contrast, transit accounted for 17% of all trips destined to these municipalities in 1986 and 10.7% in 1995.

According to the data for each municipality, transit is used for a greater number of trips in Hull. Transit accounted for 18% and 13.5% of the total trips originating in Hull during

the morning peak period in 1986 and 1995, respectively. During the same period of time, transit accounted for 26% of the total trips destined to Hull in 1986, a value which decreased to 18.4% in 1995.

There is a similar situation in Gatineau and Aylmer in terms of decreasing transit share over the period 1986 to 1995. Transit accounted for 12% of all trips originating in Gatineau during the morning peak period in 1986 and only 8.4% in 1995. Likewise, transit accounted for 6% of all trips destined to Gatineau in 1986 and only 3.4% in 1995. Transit accounted for 16% of all trips originating in the city of Aylmer during the morning peak period in 1986, a number which decreased to 13.3% in 1995. At the same time, transit accounted for 5% of all trips destined to Aylmer in 1986 and only 0.9% in 1995.

2.2.2 GENERAL CHARACTERISTICS OF THE SPATIAL DISTRIBUTION OF TRIPS

Trips from and to the Outaouais Region during the morning peak period accounted for 22.4% and 19.4% of all trips undertaken in the National Capital Region in 1986. This number was slightly less than the proportion of the population residing in the Outaouais Region (25.1%) in 1986. In 1995 these percentages were slightly changed to 22.5% and 19.6% respectively. These values are more closely related to the proportion of people living in the urbanized part of the Outaouais region (22.4%) compared to the population of the National Capital Region as a whole.

During the morning peak period, 68.4% of all trips originating in the Outaouais region in 1986 had a destination in the Outaouais region, a value which decreased to 67.7% in 1995. These trips represent internal trips. The rest of the trips were destined to other parts of the National Capital Region (31.6% in 1986 and 32.3% in 1995). Keeping in mind that most of the morning peak period trips are work and education-related, it is clear that the attractiveness of the rest of the National Capital Region increased for residents of the Outaouais Region during the 1986-1995 period.

When speaking about trips that were destined to the Outaouais Region during the morning peak period, it is important to note that 79.7% of all attracted trips in 1986 originated in the Outaouais region (internal trips), a value which increased to 81.4% in 1995. The remaining trips with a destination in the Outaouais Region originated from other parts of the National Capital Region (20.3% in 1986 and 18.6% in 1995). This shows that the attractiveness of the Outaouais Region decreased within the National Capital Region, in terms of work and education related trips, during the 1986-1995 period.

2.2.3 ROAD SYSTEM

During the period of 1984-1991, traffic increased considerably on the Outaouais' road system. In addition, there was a slight decrease in the occupancy rate of privately owned motor vehicles. All of these factors have resulted in increases in traffic congestion in the Outaouais Region. In 1992 these changes were analyzed (DELUC. 1992a. - Chapter 4) and transportation network problems were identified as follows:

- the Ottawa River Bridges
- the Gatineau River Bridges and
- the link between Aylmer and the Island of Hull

In addition to that, some intersection problems were identified, as well as problems with the arterial and freeway system. Since that time, reserved lanes for buses and car-pooling, "park and ride" services, and reconstruction of intersections and ramps has partially relieved congestion problems and favored public transit during the peak period.

2.2.4 TRANSIT TRANSPORTATION CONSIDERATIONS

A bus-based transit system works as an integrated system throughout the Outaouais Region and is managed from a central location in Hull. Even though the STO operates over a relatively sparsely populated area, which is not ideal for its development, the company engages its potential to provide adequate service for the population to attract as

many passengers as possible towards using bus transportation. Thus, data concerning the volume of passengers, bus routes, bus fleet, bus fleet management, logistics, and other elements of the system are relevant to this analysis.

2.2.4.1 Volume of Transit Transportation

According to the STO ridership data presented in Table 2.10, the number of passengers decreased by 12.2% during the period of 1986-1992, then increased by 11.7% in the 1992-1997 period. It is important to mention that, since 1992, drivers in Quebec have been required to pay an additional \$30 per year in license fees to support public transit in urban areas (Service de la modélisation des systèmes de transport, du ministère des Transports du Québec. 1998.). This measure may partially explain the increase in transit use that has been observed.

Table 2.10 Number of STO passengers per year

Year	Population served	Number of passengers
1986	186512	11893011
1987	186512	11893904
1988	186512	11913765
1989	186512	11629119
1990	200840	11603449
1991	200840	11328584
1992	211051	10446895
1993	211051	10455797
1994	228504	10772536
1995	228504	10844632
1996	228959	11086103
1997	228959	11667601

According to an analysis of Canadian cities (CUTA. 1992b.), socio-demographic trends generally affect transit ridership. Transit ridership is either flat or on the decline in most transit systems in Canada (CUTA. 1995.). The increase in STO ridership in the period of 1992-1997 presented in Figure 2.17 can be explained as a result of operating in a specific socio-economic environment, where some of the elements of sustainable development, applied between 1992 and 1997, favored public transit.

Figure 2.17 Number of STO passengers (1986-1997)

STO is increasingly interested in motivating potential passengers to use buses, by providing reserved lanes (for buses and car-pooling), and "park and ride" services, in order to offer more convenient service. As result of these measures, bus and car-pooling passengers can avoid some of the congestion problems encountered while driving during the peak period and are directly motivated by this benefit.

2.2.4.2 Characteristics of Transit Users

According to data describing the characteristics of STO passengers, there are interesting trends in terms of age as presented in Table 2.11.

Table: 2.11 Percent of STO passenger trips for an average day, by age group and sex

Age groups	Year					
	1986			1995		
	Men (%)	Women (%)	Total (%)	Men (%)	Women(%)	Total (%)
5(10)-14	3	4	7	3.3	2.8	6.1
15-24	13	24	37	15.4	17.4	32.8
25-34	7	12	19	7	11	18
35-44	7	10	17	8.5	13.1	21.6
45-54	4	6	10	5.5	7.3	12.8
55-64	3	4	7	1.5	2.5	4
65 +	1	2	3	1.1	3.6	4.7
Total percent	38	62	100	42.3	57.7	100
Total (number)	16055	26195	42250	15291	20852	36143

In 1986, the largest age groups of STO passengers were the 15-24 (37%), 25-34 (19%) and 35-44 (17%) groups. These percentages changed to 32.8%, 18.0% and 21.6% respectively in 1995. The changes in passenger characteristics in terms of age are the result of an “aging” population, as described in Section 2.1.1.3.

Although women use transit more than men, their participation rate decreased from 62% of all STO trips in 1986 to 57.7% in 1995 while men's participation rate increased from 38% to 42.3% over the same period. It is interesting to mention that the participation rate of women in the labor force, analyzed in Section 2.1.1.4, increased from 60.1% in 1986 to 63.0% in 1996. When comparing these data with the fact that women used STO buses less in 1995 than in 1986, it is clear that after finding a job, some women found other solutions for transportation (eg. buying a car, car-pooling, etc.).

Changes in the percentage of STO passengers per age group are presented in Figure 2.18. It can be seen that there were less school age (15-24 years) and more work age (25-54 years) STO passengers in 1995 than in 1986. According to the available data, in terms of professional categories, "students" accounted for 32%, "professional/management" 31% and "services" 20% of all trips, and represented the majority of STO's clientele in 1986.

Figure 2.18 Percent of STO passengers per age group (1986-1995)

2.2.4.3 Operational Characteristics of Transit Transportation

The bus routes in the region generally serve the main corridors between the cities of Ottawa, Aylmer, Hull and Gatineau. However, outside these corridors, the routes are spatially dispersed to be accessible to as many passengers as possible.

In order to provide adequate service for passengers, STO maintains an adequate bus fleet. Table 2.12 presents bus fleet data and exploitation data for the period of 1986-1997. It is important to mention that the bus fleet is primarily composed of standard buses (173 buses in 1997) and several small buses (6 minibuses in 1997). Fleet Management and Logistics are adapted for the transportation needs and the specificity of the territory served by STO buses. The buses are managed from a dispatcher center with the basic purpose of following the schedule and keeping the operations efficient. The largest number of buses operates during the peak period, while about 30% of the fleet are adequate (ACTU. 1999.) for service outside peak periods. All bus maintenance operations are planned and centralized in order to keep the buses in good technical condition.

Table 2.12 Bus fleet in STO during the period of 1986-1997

Year	Population served	Exploitation of buses		
		Hours of service	Bus kilometers	Bus fleet
1986	186512	342316	8643348	161
1987	186512	330899	8529400	161
1988	186512	388807	8615789	161
1989	186512	360126	8359398	169
1990	200840	370353	8448260	173
1991	200840	380733	8455000	177
1992	211051	368685	8241454	180
1993	211051	353064	7938521	180
1994	228504	350001	7817700	186
1995	228504	341742	7740358	185
1996	228959	342140	7761569	177
1997	228959	346368	7789937	179

In the scope of efforts to provide more efficient service, STO has installed electronic payment equipment in all buses. High school children already use "smart cards", which will soon be provided to college students to improve service. As it is known, the mode of payment affects operations and the commercial administration of public transit considerably.

2.3 THE ENVIRONMENTAL IMPACT OF TRANSPORTATION: INTRODUCTION

The transportation system in general has an impact on the environment through air, water, and noise pollution as well as through the use of land that could be set aside for other purposes. Although all these impacts are important, the intent of this research is to analyze the impact of transportation on the global warming process.

According to the analysis of the activity system in the Outaouais Region, a number of changes took place during the period from 1986 to 1996 which resulted in an increased number of cars on the streets. Consequently, traffic congestion increased, which had a negative impact on the environment.

The increased availability of cars brought about changes in the use of automobiles. According to data from 1986, the preferred transportation mode in the area served by STO buses was the automobile, which accounted for 74% of all trips during a 24-hour period. This number increased to 77.2% in 1995.

When comparing transit trips with total trips in the area served by STO buses (Figure 2.19), one can see that there was a decrease in transit from 11% of all trips originating in the municipalities served by STO in 1986 to 6.2% in 1995.

Figure 2.19 Changes in the daily number of trips originating in the area served by STO

During the same period of time (1986 - 1995), the daily number of trips with a destination in the area served by STO buses increased from 414,700 to 529,959. The participation rate of transit was the same for trips with a destination in the area served by STO buses as for trips that originated in this area, decreasing from 11% in 1986 to 6.2% in 1995. This clearly shows that the portion of total trips taken by buses was smaller in 1995 than in 1986.

In general, it can be concluded that there were more cars on the streets in 1995 than in 1986, more traffic congestion and, as a result, more vehicle emissions. This required more investment in reconstruction of streets and intersections.

Since 1992, when traffic congestion problems were analyzed, reserved lanes for buses and car-pooling, "park and ride" services, and reconstruction of some intersections and ramps were provided to partially relieve congestion problems. These changes have acted in favor of public transit during the peak period and, as a result, in recent years bus ridership has been slightly increasing. Although the increase in volume of bus passengers is encouraging, the volume of car passengers was growing much faster, and this has had a negative impact on the environment.

The analysis of transportation related greenhouse gases in Canada as well as the social aspects of reducing these gases in urban areas are presented in Chapter 3.

The calculation of fuel consumption and greenhouse gas (GHG) emissions for the Outaouais Region and the RMOC, as part of the National Capital Region, is done for 1995 as a base year and for 2021. The results of these calculations are presented in Chapter 5.

CHAPTER 3: GREENHOUSE GASES AND GLOBAL WARMING

The earth's climate is predicted to change because human activities are altering the chemical composition of the atmosphere through the buildup of greenhouse gases, such as carbon dioxide, methane, and nitrous oxide. Although uncertainty exists about how the earth's climate responds to these gases, global temperatures are rising.

One should know that hundreds of different substances participate in air pollution and the global warming process. Some of them, like carbon dioxide (CO₂), nitrous oxide (N₂O) and methane (CH₄), contribute to global warming. Others, like volatile organic compounds (VOC) and various oxides of nitrogen (NOX) combine in sunlight to form smog. Carbon monoxide (CO) and particulate matter (PM), along with smog, contribute to poor air quality in urban areas. Therefore, although these air emissions derive from the same sources, their effects are quite different.

Natural factors also contribute to the global warming process. Naturally occurring greenhouse gases include water vapor, carbon dioxide, methane, nitrous oxide, and ozone. Certain human activities, however, add to the levels of most of these naturally occurring gases (EPA. 2000.):

- ⇒ *Carbon dioxide* is released to the atmosphere when solid waste, fossil fuels (oil, natural gas, and coal), wood and wood products are burned.
- ⇒ *Methane* is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from the decomposition of organic wastes in municipal solid waste landfills, and the raising of livestock.
- ⇒ *Nitrous oxide* is emitted during agricultural and industrial activities, as well as during combustion of solid waste and fossil fuels.

Atmospheric greenhouse gases (water vapor, carbon dioxide, and other gases) trap some of the outgoing energy, retaining heat somewhat like the glass panels of a greenhouse. Without this natural “greenhouse effect,” temperatures would be much lower than they

are now, and life as known today would not be possible. However, problems may arise when the atmospheric concentration of greenhouse gases increases. The accelerating increase in greenhouse gas (GHG) concentrations due to human activities in the recent past has led to the global warming process, known as the "enhanced greenhouse effect".

Scientists generally believe that the combustion of fossil fuels and other human activities are the primary reason for the increased concentration of carbon dioxide. Plant respiration and the decomposition of organic matter release more than 10 times the CO₂ released by human activities; but these releases have always been in balance with the carbon dioxide absorbed by plant photosynthesis. What has been changed in the last hundred years is the additional release of carbon dioxide by human activities.

As a result of these human activities, global mean surface temperatures have increased 0.8-1.0°F (0.5-0.6°C) in the last century. Figure 3.1 depicts global temperature changes between 1861 and 1996 (Reference 12).

Figure 3.1

Because of these temperature changes and because of air pollution emissions in general, the snow cover in the Northern Hemisphere, and floating ice in the Arctic Ocean have decreased. Globally, the sea level has risen 10-25cm (4-10 inches) over the past century, and worldwide precipitation over land has increased by about one percent.

Increasing concentrations of greenhouse gases are likely to accelerate the rate of climate change. Scientists expect that the average global surface temperature could rise 1.6-6.3°F by 2100, with significant regional variation. Given the potential impact of the global

warming process, it is important to analyze GHG emissions from human activity and find ways to reduce it.

3.1. TRANSPORTATION RELATED GREENHOUSE GASES

Carbon dioxide accounted for 81% of all GHGs produced in Canada in 1995 (TAC.1998.), most of which comes from burning fossil fuels. Methane accounted for 13%, nitrogen oxide accounted for 5%, while other gases accounted for 1% of all GHG emissions.

Since various GHGs have different warming potential, they are usually expressed as "CO₂ equivalents". In order to find the CO₂ equivalent of different gases, equivalency factors are used which reflect their relative long-term greenhouse effect. The equivalency factors are 1 for CO₂, 21 for CH₄ and 310 for N₂O (Khan. 1999.).

According to the data (TAC. 1998.), there were 619 megatons of greenhouse gas emissions in Canada in 1995. They were produced in several sectors of human activity (see Figure 3.2). From this figure, one can see that GHG emissions produced by the transportation sector accounted for 27% of all GHGs produced in Canada in 1995.

Figure 3.2 GHG Emissions in Canada in 1995 by Sector (in CO₂ equivalents)

The main GHG from transportation is carbon dioxide, responsible for 30% of all Canadian CO₂. Figure 3.3 depicts GHG emissions from transportation. As this figure shows, carbon dioxide accounted for 90.7% of the 167 megatons of GHGs produced in this sector in 1995, while nitrous oxide (N₂O) and methane (CH₄) accounted for 9.1% and 0.2% respectively.

Figure 3.3 GHG Emissions from Transportation in 1995 (in CO₂ equivalent)

It is important to emphasize that the majority of carbon dioxide emissions are produced by passenger travel. Figure 3.4 depicts CO₂ emissions by mode of transportation, where it can be seen that automobile and other passenger modes accounted for 42% and 10% respectively, while the freight mode accounted for 48% of the 151 megatons of CO₂ emissions from transportation in 1995.

Figure 3.4 CO₂ Emissions by Mode of Transportation in 1995

According to the estimates (TAC. 1998.), approximately 50% of all CO₂ emissions from transportation in Canada originate from urban areas. Therefore, any strategy to reduce GHG emissions from human activities in Canada must consider the transportation sector in general and urban transportation in particular. It can be assumed that any success in reducing GHG emissions from urban transportation will depend on the public's concern about auto emissions and their readiness to change their travel behavior in favor of more environmentally friendly modes of transportation, such as public transit.

3.2 THE SOCIAL ASPECTS OF REDUCING TRANSPORTATION RELATED GREENHOUSE GASES IN URBAN AREAS

Concerns about the environmental effects of automobile use are reaching unprecedented levels, and governments around the world are giving attention to this problem as never before (CUTA. 1992b.). Automobiles consume a much greater amount of energy per person moved than other modes, they demand much more infrastructure support than other modes, and they contribute to urban sprawl, which in turn leads to serious reductions in arable land (CUTA. 1990.). In addition to that, the urban forms that develop to serve the automobile are in most cases hostile to pedestrians and cyclists. This fact, combined with the common problem of urban traffic congestion reduces the mobility of some groups of the population. Since automobiles are an increasingly large source of air pollution, it is important to know at what level Canadians are concerned about the problem of automobile emissions.

3.2.1 PUBLIC PERCEPTION OF THE IMPACT OF AUTOMOBILE EMISSIONS IN CANADA

In order to assess the public perception of the impact of automobile emissions, survey results can be used. According to a 1992 Survey conducted by Environics Research Group Limited (CUTA. 1992a.), people in Canadian households with at least one car are concerned or very concerned about automobile emissions in 80% of the cases (see Figure 3.5).

Figure 3.5 Concern over automobile emissions in households with at least one car (CUTA. 1992a.)

Although the best automobile still does not compete with a loaded bus in terms of energy use or emissions per passenger, the personal comfort and level of service associated with private auto use is often a prevailing factor in the public's choice of this mode of transportation. However, public opinion concerning the need to invest more money in transit is promising. According to the survey results depicted in Figure 3.6, the public's opinion in 71% of the cases is that more should be spent on public transit.

Figure 3.6 Public response to question: "Do you think more or less should be spent on public transit?" (CUTA. 1992b.)

The apparent dichotomy between public support for environmentally friendly modes of transportation and the observed choice of the majority of people towards private auto use makes it clear that the public are looking to make a more environmentally friendly choice but are in need of direction and incentive.

3.2.2 SOCIAL BENEFITS AND POSSIBILITIES FOR INCREASING TRANSIT MODE SHARE IN THE NATIONAL CAPITAL REGION

All the evidence available from urban areas in Canada indicates that if nothing is done to support transit and reduce GHG emissions, its modal share will be relatively small, to the detriment of urban society in general. Thus, there is a need for adequate support of public transit in order to reach a "critical mass" of transit development where this mode of transportation will be more attractive for passengers (CUTA. 1990.). Social benefits of increasing transit mode share are as follows (CUTA. 1992b.):

- For the general public, increased transit use means reduced pollution and traffic congestion.
- For business, this means a more efficient society, as the dependency on energy and material intensive auto use is reduced in favor of transit.
- For developers, increased use of transit means better land utilization, as less space is required for traffic and parking lots.
- For local governments, traffic congestion can be greatly reduced by increased use of transit, with reduced maintenance and capital costs for supporting the growing auto mode.
- For provincial and federal governments, increased transit use will reduce the need to borrow for public sector investments, while contributing to important environmental and social objectives.

The environmental arguments for improving the transit situation combined with people's readiness to change travel behavior in favor of environmentally friendly modes of transportation are a good base for creating a transit strategy in the National Capital Region.

In the next steps of this research, mode choice variables of critical importance are analyzed for the National Capital Region and policy changes in favor of transit are proposed in order to attract passengers towards using public transit.

CHAPTER 4: MODE CHOICE ANALYSIS

The mode choice analysis is based on data from the 1995 Origin-Destination (OD) survey for National Capital Region (NCR). The objective of this analysis is to investigate the relative importance of mode choice variables. Some of these mode choice variables are used in the next step of this research (Chapter 5) as a basis for analyzing proposed policy changes and their impact on reducing GHG emissions in the Outaouais region and RMOC.

4.1 STRUCTURE OF MODES OF TRANSPORTATION

The available modes of transportation in an urban area provide a basis for mode choice analysis. Figure 4.1 depicts available transportation modes in the National Capital Region. From this figure, two categories of transportation modes become evident: motorized modes such as auto and transit, and non-motorized modes such as cycling and walking. In general, motorized modes of transportation are faster than non-motorized modes, but tend to have greater environmental impacts.

Figure 4.1 Transportation modes in the National Capital Region

By incorporating mode choice models in the travel demand modeling process that include all available modes of transportation, the model becomes sensitive to significant factors affecting travel behavior. For example, increasing the cost of fuel makes automobile travel less attractive. As a result, some individuals switch to transit, walk and bike modes,

reducing traffic congestion and lowering GHG emissions. However, the TRANS model that is used to model travel demand in the National Capital Region includes only motorized modes of transportation (auto and transit), even though the OD survey also collects information on non-motorized trips.

4.1.1 AVAILABLE MODES OF TRANSPORTATION IN THE “TRANS” MODEL

Figure 4.2 depicts the available modes of transportation included in TRANS model which is used to predict travel demand in the National Capital Region. From this figure it can be seen that only auto and transit modes are included in the model.

Figure 4.2 Modes of transportation included in TRANS model

4.2 THE "TRANS" MODE CHOICE MODEL

In the TRANS model, several trip purposes are modeled for the PM peak hour, including: home-based work, home-based school, home-based other, and non-home based. The mode choice models in the TRANS model were developed based on the 1995 OD survey (Region of Ottawa-Carleton. 1999.) and apply to motorized trips only (auto person and transit). The underlying structure of the models is as follows:

- Home-based work trips: logit model
- Home-based school trips: logit model
- All other trip purposes: diversion curves

Disaggregate mode choice models are based on the fact that travel is a result of choices made by individuals. The structure of the model is of critical importance; when created properly, such models can accurately predict transit ridership and automobile use within an urban area. The mathematical form of the logit model is as follows:

$$P_i = (e^{U_i}) / (e^{U_a} + e^{U_t})$$

Where:

P_i = probability of choosing mode i , (a-auto or t-transit)

U_i = mean utility of mode i , (a-auto or t-transit)

Logit models, as mathematical techniques, reproduce the decisions of individuals, which are based on both the socio-economic characteristics of the individuals as well as level of service variables describing the available modes. Data for the urban transit area (UTA) were analyzed in order to develop a logit model for the National Capital Region which incorporates the auto and transit modes.

The logit models were developed based on data from the 1995 OD survey, specifically for 12000 auto and transit trips which occurred during the PM peak hour. The information collected during the survey includes: *household and household location, number of vehicles per household, employment and student status, sex and age of trip-maker, trip purpose, location of trip origin and destination, trip start time, trip mode, and whether a parking cost was incurred (not the amount paid to park).*

Since level of service variables such as *travel time* and *cost* were not collected in the survey, the EMME/2 model was used to assign observed PM peak hour travel demand to the auto and transit network to estimate travel time in minutes from trip origin to destination. In contrast, the cost of travel was determined based on local data for the National Capital Region.

Transit fare for 1995 was estimated by developing a fare matrix system, which is presented in Table 4.1. The transit fare required to travel between different areas in the

matrix is a function of cash fares and monthly passes, taking into account the dual OC Transpo and STO fare structure for regular and express service.

Table 4.1 Transit Fare Matrix

Origin Area		Destination Area								
Area No.	Description	1	2	3	4	5	6	7	8	9
1	RMOC inner UTA	1.35	1.73	1.73	3.1	3.1	3.1	1.35	1.73	3.1
2	RMOC outer UTA West& South	1.35	1.35	1.73	1.35	3.1	3.1	1.35	1.73	3.1
3	RMOC outer UTA -east	1.35	1.73	1.35	3.1	3.1	3.1	1.35	1.73	3.1
4	RMOC Stitsville	1.35	1.35	1.73	1.35	3.1	3.1	1.35	1.73	3.1
5	RMOC Richmond	1.35	1.35	1.73	3.1	1.35	3.1	1.35	1.73	3.1
6	RMOC Rockland	1.35	1.73	1.73	3.1	3.1	1.35	1.35	1.73	3.1
7	CUO West of Gatineau River	1.35	1.73	1.73	3.1	3.1	3.1	1.35	1.73	3.1
8	CUO East of Gatineau River	1.35	1.73	1.73	3.1	3.1	3.1	1.35	1.35	3.1
9	CUO, Rural East Quebec	3.1	3.1	3.1	3.1	3.1	3.1	3.1	3.1	1.35

area No. emme2 traffic zones in areas

- 1-45, 57-104, 106, 110-122, 201, 232-234
- 46-56, 123-133, 135-138, 140, 206 - 215, 220-231
- 105, 107-109, 139, 141 -144, 202-205, 235-247
- 216-219
- 134
- 145
- 146-164, 182-184, 254-258
- 165-177, 248-253
- 178 - 180

Concept: The high fares of \$1.73 are for accessing green express buses.
It is assumed that the green fare of \$1.73 is for outbound trips, while inbound trips have the regular fare of \$1.35. For across region service as from Orleans to area 2, the \$1.73 fare is assumed, since they would have to go to the central area and then transfer to a green route to complete their trip.

emme2 zones assumed outside of the UTA for 1995 are:
132, 133, 135, 137 - 141, 146, 147, 177, 181-185, 186-200, 212-215, 227-230

Auto cost consists of an operating cost assumed to be equal to the cost of fuel consumed, as well as the cost of parking. According to a report by the Canadian Automobile Association, the average consumption rate in Canada in 1995 was 9.2 liters/100km. Since the average fuel price was 55 cents/liter, a cost of 5 cents per kilometer was used as the fuel cost.

Parking cost was estimated by contacting major parking suppliers and determining what the monthly fee was for all-day parking. This amount was then divided by 20 to compute a daily parking rate, which was then multiplied by the proportion of auto drivers who paid for parking at the work place as recorded in the 1995 OD survey. This factoring

process was necessary in order to be consistent with the approach used to aggregate this variable to a zonal level.

In addition, *province* was selected as a dummy variable to distinguish between trip-makers residing in Ontario and Quebec. The variable is based on the geographic location of individuals zone of residence, and reflects potentially significant differences in transportation service which may not be fully captured by more tangible service attributes such as travel time or cost.

4.2.1 TRANS HOME-BASED WORK LOGIT MODEL

Home-based work trip logit model is presented in Table 4.2. It can be seen that all variables (*travel cost*, *travel time*, *number of vehicles per household* and *province*) are statistically significant for both modes of transportation.

Table 4.2 Home-based work trip logit model

Mode	Travel cost	Travel time	Number of vehicles per household	Province	Constant
Auto person	-0.8641 (-27.9)	-0.0096 (-2.14)			
Transit	*-0.8641 **(-27.9)	-0.0096 (-2.14)	-1.738 (-15.6)	-0.8367 (-5.64)	0.9091 (-5.41)

Where:

Auto cost = cost for parking (cents) and fuel consumption (5 cents/km)

Transit cost = transit fare based on matrix shown in Table 4.1 (cents)

Travel time = total time of the trip from origin to destination (minutes)

Vehicles per househ. = coded as 0 for no veh./hh, 1 for 1 veh/hh, and 2 for >1 veh/hh

Province = coded as 0 for Ontario and 1 for Quebec residents

* = coefficient

** = t-statistic

In Table 4.2, the coefficient values for the transit mode are presented with respect to the auto person mode. This means that the auto-person mode was considered first and then,

the coefficients of this mode were normalized to zero. However, the conditional variables *travel cost* and *travel time* can vary depending on the mode, and thus appear twice in the table.

The *travel cost* variable is the most significant with a t-statistic of -27.9. Although the coefficient of this variable is high, it is important to recall that the units are measured in cents. The *travel time* variable is also significant with t-statistic of -2.14, but less so than travel cost.

The *number of vehicles per household* is very significant as well, with t-statistic of -15.6. The negative sign and the high value of the estimated coefficient (-1.738) show that the number of vehicles per household has a very negative impact on transit.

The *province* variable is statistically significant with a t-statistic of -5.64. The negative sign for the coefficient shows that people in Quebec (coded as 1) are more likely to use the auto-person mode when compared to residents of Ontario. Finally, the high value of the *constant* and its statistical significance show that there are many other factors that were not included in this model that are also important.

The results of a sensitivity analysis for the home-based work trip logit model consisting of the auto person and transit modes are presented in Table 4.3.

Table 4.3 Sensitivity analysis results for the home-based work trip logit model

Variable	% Change in auto person mode split
Auto time (increased by 10%)	-1.2
Auto cost (increased by 10%)	-2.6
Vehicles/household (from 1 to 2)	3.5
Province (Ontario rather than Quebec resident)	-5.1
Transit fare (increased by 10%)	6.5
Transit time (increased by 10%)	0.1

The sensitivity analysis for home-based work trips explored the effects of possible policy changes on travel behavior. The results of this analysis are as follows:

- ⇒ When *auto time* is increased by 10%, it produces a decrease in auto person trips of -1.2%. These people would switch from their cars to transit.
- ⇒ When *auto cost* is increased by 10%, it produces a decrease in auto person trips of -2.6%. As a result, it is possible to conclude that people are more sensitive to increased auto cost than increased auto time. These people would switch from their cars to transit.
- ⇒ When the *vehicles per household* variable is changed from 1 to 2, it produces an increase in auto person trips of 3.5%. This means that the number of vehicles per household has a profound impact on transit, causing people to switch from transit to the auto person mode.
- ⇒ When the *province* variable is set to Ontario rather than Quebec, it produces a decrease in auto person trips of -5.1%. This means that residents of Ontario are more likely to use transit since there are better facilities compared to the situation in Quebec.
- ⇒ When *transit fare* is increased by 10%, it produces an increase in auto person trips of 6.5%. This means that increasing the transit fare has a significant impact on switching people from transit to the auto person mode. Indeed, one can see that increasing the transit fare has a much larger impact than increasing the auto cost, which causes a relatively smaller shift from auto to transit (-2.6%).
- ⇒ When *transit time* is increased by 10%, it produces an increase of 0.1% in auto person trips. This shows that people would switch from the transit mode to the auto-person mode in the case of increased transit time but are not as sensitive to such changes as they are to increased transit fare.

4.2.2 TRANS HOME-BASED SCHOOL LOGIT MODEL

In the logit model for home-based school trips, both the auto person and transit mode are included (see Table 4.4). In this table, coefficient values for the transit mode are presented with respect to the auto person mode. This means that the auto-person mode

was considered first and then, the coefficients of this mode were normalized to zero. It can be seen that all variables are statistically significant for both modes of transportation.

Table 4.4 Home-based school trip logit model

Mode	Out of vehicle travel time	Number of vehicles per household	Province	Constant
Auto person				
Transit	*-0.0926 **(-2.87)	-1.083 (-5.59)	-0.527 (-1.95)	2.85 (-6.05)

Where:

Out of vehicle travel time = 0 for auto mode. For transit, equals the total travel time minus the in-vehicle travel time

Vehicles per household = 0 for no veh/hh, 1 for 1 veh/hh, 2 for more than 1 veh/hh

Province = 0 for residents of Ontario and 1 for residents of Quebec

* = coefficient

** = t-statistic

The *out of vehicle travel time* variable is significant with t-statistic of -2.87. Since this variable is presented in minutes, its coefficient value is relatively high (-0.0926). Moreover, the negative sign of the coefficient shows that this variable has a negative impact on selecting the transit mode.

The *number of vehicles per household* variable is also significant with a t-statistic of -5.59. The negative sign and the high value of the estimated coefficient (-1.083) show that this variable has a very negative impact on selecting the transit mode.

The *province* variable is statistically significant with t-statistic of -1.9. The negative sign of the coefficient shows that people in Quebec (coded as 1) are more likely to use the auto person mode when compared to residents of Ontario.

The high value of the *constant* (2.85) and its statistical significance show that there are many other factors that were not analyzed in this model, that are also important in explaining travel behavior.

The results of a sensitivity analysis for the home-based school trip logit model are presented in Table 4.5.

Table 4.5 Sensitivity analysis results for home-based school trip logit model

Variable	% Change in auto person mode split
Vehicles/household (from 1 to 2 or more)	2.6
Ontario rather than Quebec resident	-2.6
Out of vehicle travel time (increased by 10%)	1.0

The sensitivity analysis explores the impact of changes in policy variables on travel behavior. The results of this analysis are outlined below:

- ⇒ When the *vehicles per household* variable is changed from 1 to 2, it produces an increase in auto person trips of 2.6%. This means that the number of vehicles per household has a profound impact on transit, causing people to switch from transit to the auto person mode.
- ⇒ When the *province* variable is set to Ontario rather than Quebec, it produces a decrease in auto person trips of -2.6%. This means that residents of Ontario are more likely to use transit for home-based school trips than residents of Quebec.
- ⇒ When *out of vehicle travel time* for transit is increased by 10%, it produces an increase in auto person trips of 1.0%. This shows that out of vehicle travel time has a negative impact on the transit mode, causing people to switch to the auto person mode as the out of vehicle time increases. Out of vehicle travel time is assumed to be 0 for auto person trips. For transit trips, out of vehicle travel time includes access and egress time as well as waiting and transfer time.

4.2.3 TRANS MODAL SPLIT MODELS FOR "OTHER" TRIP PURPOSES

Trip-makers for home-based other and non-home-based trips do not follow a distinguishable pattern of behavior which can be represented by a logit model. Thus, all remaining trip purposes were grouped together to build a modal split model based on the ratio of transit to auto travel time.

Two modal split equations are necessary: one for auto trips under 15 minutes, and one for auto trips over 15 minutes. These equations are presented in Table 4.6.

Table 4.6 Mode split equations – "other" trip purposes

Auto travel time interval	Equation	R squared
0-15 minutes	Auto mode split = $1.052 - 0.26 * (1 / (\text{transit time} / \text{auto time}))$	0.91
15 minutes and over	Auto mode split = $1.071 - 0.249 * (1 / (\text{transit time} / \text{auto time}))$	0.71

It was observed that 75% of trip makers in this group have travel times of less than 15 minutes. Since R squared is 0.91 for such trips, it means that the model explains 91% of the variation in modal choice. For the remaining 25% of trips makers that have auto travel times of 15 minutes and over, the model explains 71% of the observed variation in modal choice.

4.2.4 MODE CHOICE MODELS AS A BASIS FOR PROPOSING POLICY CHANGES IN FAVOR OF GREENHOUSE GAS REDUCTION

On the basis of the analysis in Section 4.2.1, Section 4.2.2 and Section 4.2.3, it can be seen that the mode choice models include several statistically significant independent variables. The high value of the constants in the logit models for home-based work and school trips shows that there are many other independent variables not included in the model that can additionally explain travel behavior of trip makers. The *travel cost* and *travel time* variables represent the level of service provided by the transportation mode, and can therefore be used to propose policy changes.

The policy variables that are analyzed later (Chapter 5) include *travel cost* (*parking* and *fuel costs* for the auto person mode and *transit fare* for the transit mode) as well as *transit travel time*. However, from the mode choice analysis, it can be seen that the travel cost variable is only included in the home-based work trip logit model, and thus the impact of changes in this variable will only be applied to this group of trips makers. This shows that there is a need to include as many variables as possible in mode choice models in order to ensure that they are sensitive to the significant factors affecting travel behavior.

Recently, an extensive mode choice analysis (Siddiqui. 1999.) was completed, in which motorized and non-motorized modes of transportation were analyzed based on the structure depicted in Figure 4.1. The models were created for the Urban Transit Area (UTA) in the National Capital Region using data from the 1995 OD survey conducted between September 6 and December 14.

According to the theory of logit models, all modes of transportation must be available to the trip maker. However, since the 1995 OD survey was conducted in the autumn, the results of the survey (including bike and walk trips) were not influenced by winter weather conditions.

To include as many cases as possible in the model development, data for the PM peak period (3:30 - 5:59) were analyzed. Once the travel demand analysis was completed and the models were created, Peak Hour Factors (PHF) were used to convert peak period trips to peak hour trips to be used in subsequent traffic assignment stages in EMME/2. As a result of this approach, more independent variables were identified as being statistically significant in defining mode choice models.

Among the selected variables, *travel cost* and *travel time* were found to be statistically significant for all trips purposes. It was found that the most appropriate form of the mode choice model was a Nested Logit Model for home-based work and school trips, and a Multinomial Logit Model for “*other*” trips, including trips for shopping, personal business, and entertainment.

Nested logit models were created to express the fact that all available modes cannot be treated equally in all situations. As an example, motorized modes of transportation are attractive for long trips, while non-motorized modes (bike and walk) will not even be taken into consideration since they are attractive only for shorter trips (1-2 km). Thus, in the lower level nest, *walk* and *bike* trips are analyzed while in the higher level nest, *auto* and *transit* modes are analyzed, as well as the *composite utility* (or *inclusive value*) of the lower level nest. Since there is variety of trip purposes in the “other” trip category, the best model was found to be a simple multinomial logit model with auto person, transit and non-motorized modes at the same level.

Unfortunately, the mode choice models that were developed have not been incorporated into the TRANS model which forecasts travel activity in the National Capital Region. In order to use mode split models that include both motorized and non-motorized modes of transportation, the TRANS model must be modified so that non-motorized trips are included in the trip generation and trip distribution stages. To do so, the entire model would need to be re-calibrated. Moreover, the group of macros that run the model must be modified to take into account the additional non-motorized trips. It is recommended that this work be done as soon as possible so that the TRANS model is better able to simulate travel demand for all modes of transportation in the National Capital Region. By so-doing, the mode choice models that include motorized and non-motorized trips will become powerful tools for comprehensive transportation planning, especially in promoting environmentally friendly options. Since there is a need to modify the transportation system in favor of more sustainable transportation modes (Transport Canada. 1999.), it is expected that such models will be useful in simulating the effects of policy changes on travel behavior.

Although in its present form the TRANS model only includes motorized trips, it is acceptable for simulation modeling of GHG emissions. Since the primary objective is to determine the role of bus transportation in reducing GHG emissions by encouraging people to switch from cars to buses, an analysis of motorized modes only (cars and buses) is acceptable.

CHAPTER 5: TRIP FORECASTING AND GHG EMISSION CALCULATIONS FOR THE PERIOD OF 1995 - 2021

It is mentioned earlier that approximately 78% of Canadians lived in urban areas in 1996. The fact that these urban areas are characterized by an auto dependent travel demand clearly shows that there is considerable potential for switching people from cars to transit and as a result, reducing GHG emissions. Indeed, of the trips occurring in the urban transit area of the Outaouais Region in 1995, 77.2% of daily trips were by auto, while only 6.2% were by public transit. An additional 16.6% were associated with "other" motorized and non-motorized transportation modes. As this data shows, there is significant potential for reducing GHG emissions by encouraging greater use of public transit.

It is also important to mention that in the urban transit area of the Region of Ottawa-Carleton, 70.9% of daily trips are by private automobile, while 12.4% are by public transit. The remaining 16.7% of trips are associated with "other" motorized and non-motorized modes. From these statistics, it is clear that people in the RMOC use public transit more frequently than people in the Outaouais Region. However, there is still considerable potential for increasing transit ridership. In the next section, transit and auto vehicle travel in the National Capital Region is forecast using the TRANS model for years 1995 and 2021.

5.1 TRIP FORECASTING FOR THE PERIOD OF 1995-2021

The TRANS model, which is supported by EMME/2 software, is used for travel-demand simulations in the National Capital Region. This model is capable of predicting future passenger vehicle and transit trips.

According to the TRANS model report (Region of Ottawa-Carleton. 1999.), the number of motorized trips during PM peak hour will increase by 48.3% between 1995 and 2021. Detailed results are shown in Figure 5.1. Thus, it can be concluded that there will be

more traffic congestion on the roads, more fuel consumption and, as a result, more GHG emissions in the National Capital Region in the future.

Figure 5.1 Trip forecasting for the National Capital Region (1995 - 2021)

One can also see that the situation will be slightly improved in terms of increased participation in the transit mode during this period of time. It is predicted that 1.6% of auto persons will switch to transit in 2021 compared with conditions in 1995.

The results depicted in Figure 5.1 are calculated on the basis of the 1995 and 2021 land use scenarios developed for the TRANS model. These scenarios are considered to be the base scenarios in this research.

Since the main objective of this research is to investigate the role of bus transportation in reducing GHG emissions, a "mode choice" strategy for reducing GHG emissions is presented in the following section in order to encourage urban transportation planners to analyze transportation systems from an environmental point of view, in an innovative way.

5.2 MODE CHOICE STRATEGY FOR REDUCING GHG EMISSIONS

The "mode choice" strategy that was developed for reducing GHG emissions is based on the fact that a trip maker will choose the mode of transportation with the highest utility value. The strategy represents a set of measures that could be used to make public transit the most attractive mode of transportation to trip-makers.

The variables included in the TRANS mode choice model were discussed in Chapter 4. From that analysis, it is clear that *travel cost* (*parking* and *fuel costs* for the auto person mode and *transit fare* for the transit mode) and *transit travel time* can be modified in order to attract more people towards using transit. Once the mode choice model has been adjusted, it is possible to analyze the impact of increased transit ridership on reducing GHG emissions.

For each variable, a range of values are investigated in order to determine the effectiveness of the proposed measures. In addition, scenarios involving new technology buses are proposed in order to see the effectiveness of such measures in terms of reducing GHG emissions.

5.2.1 SCENARIOS FOR REDUCING GREENHOUSE GAS EMISSIONS

In order to reduce GHG emissions, scenarios are proposed that modify the values of *travel cost* and *transit travel time* in order to shift trips from cars to transit, an environmentally friendly mode of transportation. In addition to these scenarios, it is also proposed that new technology buses gradually replace existing diesel buses from now to 2021. These buses are currently in the testing phase. Since there is no evidence that such buses attract new passengers, it was assumed that the use these buses would not attract additional people towards using transit. However, the use of new technology buses would reduce GHG emissions, since less (for diesel-electric buses) or no GHG emissions are produced (for fuel cell buses) during operation. Moreover, as the environmental

consciousness of the population grows, new technology buses may have the potential to attract new passengers if extensive marketing activities are undertaken.

The scenarios that are proposed for reducing GHG emissions are as follows:

- Base scenario: "Do nothing"
- Scenario 1: Parking cost increased by 10%
- Scenario 2: Parking cost increased by 50%
- Scenario 3: Parking cost increased by 100%
- Scenario 4: Fuel cost increased 1% above inflation during the 1995-2021 period
- Scenario 5: Fuel cost increased 2.5% above inflation during the 1995-2021 period
- Scenario 6: Fuel cost increased 5% above inflation during the 1995-2021 period
- Scenario 7: Transit fare decreased by 10%
- Scenario 8: Total transit travel time decreased by 10%
- Scenario 9: Total transit travel time decreased by 50%
- Scenario 10: Diesel-electric hybrid buses used instead of diesel buses in 2021
- Scenario 11: Fuel cell buses used instead of diesel buses in 2021

In order to analyze the effectiveness of each proposed scenario, it is important to organize the calculation process. The GHG emission calculations are discussed in the following section.

5.3 ORGANIZATION OF GHG EMISSION CALCULATIONS

According to Khan (1999.), the EMME/2 software can be used as a platform for estimating GHG emissions. In order to better understand the travel demand scenarios and related calculations, there is a need to describe in greater detail the TRANS model for the National Capital Region which is supported by the EMME/2 software.

In Section 4.2, modal split sub-model was discussed as one of the four sub-models included in TRANS model. Here, more information is presented about TRANS 4-stage model as a whole.

5.3.1 TRANS MODEL AS A PLATFORM FOR ESTIMATING GHG EMISSIONS

The TRANS model was calibrated using data from the 1995 OD survey and thus reflects 1995 travel behavior. The 1995 OD survey sampled 5 percent of households in urban areas and 20 percent of households in rural areas. The information collected includes details about the household, characteristics of household members as well as information about each trip made by persons 10 years of age or older.

Since travel behavior changes over time, the TRANS model is re-calibrated every 10 years using new survey data to take into account current travel behavior characteristics.

The TRANS model is a traditional 4-stage travel demand model consisting of *trip generation*, *trip distribution*, *modal split* and *trip assignment sub-models*. A brief description of these sub-models is as follows:

- *Trip generation*: trip productions and attractions at each zone are calculated as a function of the zone's land use characteristics. The results are expressed as an array of trips originating in each zone, and an array of trips destined to each zone.
- *Trip distribution*: generated trips are distributed among the zones, as a function of zonal land use as well as road and transit network characteristics. The results are expressed as person-trip origin-destination matrices.
- *Modal split*: the total number of trips is apportioned by modes. Modal split is calculated for three modes: auto vehicle, auto person, and transit person. The results are expressed in terms of matrices for each mode.
- *Trip assignment*: auto vehicle, auto person and transit person matrices are loaded onto road links and transit routes, respectively. For auto travel, the results are expressed in terms of directional auto volumes for each link in the transportation network. For transit travel, the results are expressed in terms of passengers per route, road link or transitway link.

On the basis of the proposed scenarios, changes in the modal split for the National Capital Region are accomplished by modifying the mode choice variables. Generally, there are two possibilities for implementing the desired changes: modifying the underlying data matrices or modifying the macros which manipulate the matrices. As an example, in Scenario 1, parking cost is increased by 10% (see Section 5.2.1.). The parking cost matrix ("mo1") in the TRANS model can be modified by increasing the value of each element in this matrix by 10%. However, it is also possible to modify the macros that are used for the modal split calculations. Modifications to the macros are discussed in the following section.

5.3.2 MODIFYING MODAL SPLIT MACROS FOR PROPOSED SCENARIOS

The macros that run the modal split models for the 1995 and 2021 land use scenarios in the TRANS model are called *ms_all95.mac* and *ms_all21.mac* respectively. These macros are capable of calculating the modal split within EMME/2. Since the 1995 and 2021 land use scenarios included in the TRANS model were used as base scenarios with no changes to the underlying variables, *ms_all95.mac* and *ms_all21.mac* could be applied to these scenarios with no modifications. Copies of the *ms_all95.mac* and *ms_all21.mac* macros are presented in Appendix D_95b and Appendix D_21b respectively.

5.3.2.1 Modifying the Modal Split Macros for the Proposed Scenarios (1995 Analysis)

As highlighted earlier, it was necessary to modify the modal split macros for each proposed scenario. In *Scenario 1*, the modal split macros were modified to reflect the 10% increase in parking costs during the modal split calculations. This was accomplished by multiplying the parking-cost matrix (mo1) by 1.1 within the *ms_all95.mac* macro in order to increase the value of each element of the matrix by 10%. By so doing, the macro could be used in the 1995 travel demand simulations for Scenario 1.

Likewise, the parking cost matrix was multiplied by 1.5 in *Scenario 2* in order to increase parking costs by 50%. In *Scenario 3*, parking costs are increased by 100%. As a result, the parking cost matrix (mo1) is multiplied by 2 in the *ms_all95.mac* macro in order to increase all elements of the matrix by 100%.

In *Scenarios 4, 5 and 6*, fuel costs for auto mode are increased by 1%, 2.5%, and 5% above inflation respectively. The effects of these measures can be expected after 1995. Thus, the modal split macros used to simulate travel demand in 1995 for these scenarios were the same as the macros used with the 1995 base scenario, which was described in Section 5.3.2.

Since transit fare is decreased by 10% in *Scenario 7*, the modal split macro, *ms_all95.mac*, was modified accordingly. Upon macro execution, the transit fare matrix (mf18) is multiplied by 0.9, decreasing the matrix values by 10%. After modifying the macro, it could be used in the 1995 travel demand simulations for Scenario 7. In a similar manner, the *ms_all95.mac* macro was modified to decrease transit travel time by 10% in *Scenario 8*. In this case, the transit-travel time matrix (mf14) is multiplied by 0.9 prior to the modal split calculations.

In *Scenario 9* transit travel time is decreased by 50%. As a result, the transit travel time matrix (mf14) is multiplied by 0.5 during macro execution in order to decrease the matrix elements by 50%. Again, once the *ms_all95.mac* macro was modified, it could be used in the 1995 travel demand analysis for Scenario 9.

New technology buses are proposed in *Scenario 10* (diesel-electric hybrid buses) and *Scenario 11* (fuel cell Ballard buses). It was assumed that standard diesel buses would be gradually replaced from now to 2021. Since the gradual adoption of these buses is assumed to have no impact on transit ridership levels, the modal split macros used in Scenarios 10 and 11 were the same as the macro applied to the 1995 base scenario, which was described in Section 5.3.2.

5.3.2.2 Modifying the Modal Split Macros for the Proposed Scenarios (2021 Analysis)

The approach used to modify the modal split macros for the 2021 analysis is similar to the approach used for the 1995 analysis described in the previous section. In *Scenario 1*, the modal split macros were modified to reflect a 10% increase in parking costs. This was accomplished by multiplying the parking-cost matrix (mo1) by 1.1 within the

ms_all21.mac macro. Once the macro was modified, it could be used in the 2021 travel demand analysis for Scenario 1.

Since parking costs are increased by 50% in *Scenario 2*, the parking cost matrix (mo1) is multiplied by 1.5 in the modal split macro (*ms_all21.mac*) in order to increase the elements of this matrix by 50%. In *Scenario 3* parking costs are increased by 100% and, thus, the parking cost matrix (mo1) is multiplied by 2 during macro execution to reflect the 100% increase in cost.

In *Scenario 4*, fuel cost is increased by 1% above inflation. The effects of this measure can be expected during the 1995-2021 period. In order to account for the increased fuel cost during this 26 year period, the modal split macro for 2021 was modified to reflect the increase in fuel cost from 5 cents/kilometer in 1995 to 6.5 cents/kilometer in 2021 (in 1995 \$). To implement this change, the auto distance matrix (mf3) in EMME/2 is multiplied by 0.065 prior to the modal split calculations. A similar approach was adopted for Scenarios 5 and 6. In *Scenario 5*, the fuel cost is increased by 2.5% above inflation, causing fuel prices to rise to 9.5 cents/kilometer from their previous 1995 level of 5 cents/kilometer. In *Scenario 6*, fuel costs are increased to 17.8 cents/kilometer (in 1995 \$), a 5% increase above inflation.

Since transit fare is decreased by 10% in *Scenario 7*, modifications to the modal split macro for 2021 are done in such a manner that the macro takes into account the decreased transit fare (10%) during calculation of modal split. Thus, the transit fare matrix (mf18) is multiplied by 0.9 in the *ms_all21.mac* macro in order to decrease the elements of this matrix by 10%. At this point, the macro can be used for the 2021 travel demand simulations for Scenario 7.

In a similar manner, the *ms_all21.mac* macro was modified to decrease transit travel time by 10% in *Scenario 8*. In this case, the transit-travel time matrix (mf14) is multiplied by 0.9 prior to the modal split calculations.

In *Scenario 9*, transit travel time is decreased by 50% and thus, the transit travel time matrix (mf14) is multiplied by 0.5 in the *ms_all21.mac* macro in order to decrease the elements of this matrix by 50%.

New technology buses are proposed in *Scenario 10* (diesel-electric hybrid buses) and *Scenario 11* (fuel cell Ballard buses). It was assumed that standard diesel buses would be gradually replaced during the now-2021 period. Since these buses have the same operational characteristics as diesel buses, it was assumed that the modal split would be the same as the 2021 base scenario. Thus, the same modal split macro can be used in all three scenarios with no modifications. This macro was described in Section 5.3.2.

5.3.3 RUNNING THE TRANS MODEL FOR EACH PROPOSED SCENARIOS

After the modal split macros were modified, the TRANS model was used to simulate travel demand for the proposed scenarios. Since the trip generation and distribution were assumed to be the same for all scenarios, a "level 2" analysis could be performed (see Figure 5.2). Detailed instructions for running the TRANS model can be found in TRANS model Report (Region of Ottawa-Carleton. 1999. - Exhibit 6.6).

The procedure for running the TRANS model and simulating travel demand for the proposed scenarios is briefly explained using the 1995 base scenario as an example. The command needed to execute the EMME/2 macros is as follows:

```
~<level295.mac 1995b 95Testb mf58 mf57 mf59 100 0.05 0.05
```

Where: level295.mac = macro that runs the TRANS model from the "level 2" stage

1995b = matrix name

95Testb = run description

mf58 = auto vehicle matrix

mf57 = auto person matrix

mf59 = transit person matrix

100 = maximum number of assigned iterations

0.05 = assignment stop criteria, relative gap

0.05 = assignment stop criteria, normal gap

The macro that performs a "level 2" analysis is called *level295.mac* for the 1995 land use databank, and *level221.mac* for the 2021 databank. These macros are presented in Appendix D_295 and Appendix D_221 respectively.

Figure 5.2 TRANS Model Applications (Region of Ottawa-Carleton. 1999.)

Since the output results from the TRANS Model are auto and transit volumes assigned to each link on the road network, there is a need to compute the link average speed and vehicle kilometers traveled. Using this information, fuel consumption and GHG emissions can be estimated for each scenario. In order to calculate link average speed and vehicle kilometers traveled, EMME/2 macros developed for modeling vehicle emissions (Armstrong. 2000.) were used. These macros work in conjunction with the Emission Calculator, a Visual Basic program which uses the EMME/2 travel data to estimate greenhouse gases and criteria pollutants.

5.3.4 THE EMME/2 MACROS FOR SUMMARIZING TRAVEL DATA

The main macro that was used to calculate vehicle kilometers traveled and average speed for each link in the EMME/2 road network is called *VKM_PMPHR.mac*. This macro, presented in Appendix E, provides an interface between EMME/2 and the Emission Calculator. It was developed to transform the output results from EMME/2 into a format that can be used to compute vehicle emissions. Within the Emission Calculator, criteria pollutants are estimated using the U.S. Environmental Protection Agency's MOBILE5 model, while greenhouse gas emissions are estimated using fuel consumption equations and greenhouse gas emission factors supplied by the user.

As Appendix E illustrates, the main EMME/2 macro (*VKM_PMPHR.mac*) requires several sub-macros in order to calculate vehicle kilometers traveled and average travel speed. The calculations are performed on a link by link basis, which has several advantages when determining fuel consumption and GHG emissions in the next step of calculations. Indeed, the travel data from the EMME/2 macro serve as input data for calculating fuel consumption and GHG emissions for each road in the transportation network.

The EMME/2 macro that calculates the travel data (vehicle kilometers traveled and link average speed) can be modified for analysis of any urban area. In this research, travel data for the National Capital Region (NCR) as a whole and for the Outaouais Region in particular are used to analyze the role of bus transportation in reducing GHG emissions.

As mentioned previously, the NCR includes urban areas in both Ontario (RMOC) and Quebec (Outaouais Region) that should be analyzed independently. Moreover, each region should be divided into different land use categories to determine greenhouse gas trends. The categories selected were: central core, urban, suburban and rural. In order to present the results of the analysis using this rather complex classification scheme, the *VKM_PMPHR.mac* macro was modified before executing it in EMME/2.

The procedure for using this macro is explained using the 1995 base scenario as an example. The command required to run the EMME/2 macro is as follows:

```
~<VKM_PMPHR.mac 333 999 region.mac linktype.mac mf58 none transit  
bkgd_pm.mac 8 8 1 95b
```

Where: VKM_PMPHR.mac = main macro that calculates vkt and average link speed

333 = EMME/2 scenario number

999 = link by link analysis

region.mac = macro that classifies links according to location (core, urban,
suburban, rural)

linktype.mac = macro that classifies links according to functional classification

mf58 = auto vehicle matrix

none = cold start trip table (not applicable for GHG calculations)

transit = transit output desired

bkgd_pm.mac = macro that calculates "background" traffic volume-PM peak hour

8 = number of locations to analyze

8 = number of link types to analyze

1 = for "link by link" analysis

95b = output file extension (for base scenario in 1995)

It can be seen that in order to run this macro, there are 12 variables (macros and other parameters) that must be specified. In order to clarify the role of the sub-macros, a brief explanation is provided.

5.3.4.1 Allocating Results by Location within the Study Area

The travel data from EMME/2 (vehicle kilometers traveled and link average speed) are summarized on a link by link basis. Each link is classified according to location so that the fuel consumption and GHG emissions calculated in the next step can be aggregated based on the land use categories selected. In this way, decision-makers can easily understand the distribution of GHG emissions and select appropriate reduction strategies. In this research, 8 categories were selected for the National Capital Region based on the 1995 land use. The categories include:

- 1 = Central core-RMOC (traffic zones: 1-25, 201)
- 2 = Urban area-RMOC (26-118, 120-128, 232, 234)
- 3 = Suburban area-RMOC (119, 129-131, 136, 140, 142-144, 202-226, 229, 231, 235-247)
- 4 = Rural area-RMOC (132-135, 137-139, 141, 145, 190-200, 227, 228, 230)
- 5 = Central core-Outaouais (153-155, 254, 255)
- 6 = Urban area-Outaouais (148-152, 156-170, 252, 253, 256-258)
- 7 = Suburban area-Outaouais (171-176, 178, 248-251)
- 8 = Rural area-Outaouais (146, 147, 177, 179-189)

The macro that classifies links according to the above scheme is called *region.mac* (see Appendix E_1 for more details).

5.3.4.2 Allocating Results per Link Type in the Region

In a similar manner, links are also classified according to function as a basis for aggregating fuel consumption and GHG emissions within the Emission Calculator. The classification scheme used in the analysis is as follows:

- 1 = local roads
- 2 = Minor low speed roads
- 3 = Minor high speed roads
- 4 = Major low speed roads

- 5 = Major high speed roads
- 6 = Freeways and rural highways
- 7 = Centroid connectors (no external zones)
- 8 = Transit only links

The macro (called *linktype.mac*) classifies links on the basis of their volume-delay function (which includes data of the link capacity and posted speed limit). The macro is presented in Appendix E_2.

5.3.4.3 Background Traffic as Factor that Contributes to Determining Vehicle Travel Time

As mentioned earlier, the TRANS model was used to simulate travel demand, taking into account changes in the modal split variables for each proposed scenario. Transit buses and passenger vehicles (automobiles and light duty trucks) were analyzed, since the objective was to estimate GHG emissions produced by passenger transportation and investigate the role of bus transportation in reducing these gases.

In the TRANS model, commercial vehicle travel is ignored. Indeed, the EMME/2 traffic assignment algorithm does not take into account the increased congestion resulting from "background traffic" (heavy vehicles, school buses and inter-city buses, taxis, etc.). Thus, a macro is used to compute the volume of "background traffic" after an initial traffic assignment has been performed. The macro computes the vehicle mix using ratios developed from the 1996 Classification and Occupancy Counts which are based on the volume of passenger vehicles assigned to the network. A second traffic assignment is then performed, taking into account the increased congestion from commercial vehicles. In this way, it is possible to improve the accuracy of the travel time estimates since the total volume of traffic using the road network is known.

The macro that calculates background traffic is called *bkgd_pm.mac* and is presented in Appendix E_3. As stated previously, this macro was developed using traffic count data from 1996. In order to determine the mix of vehicles, ratios were developed for each vehicle category.

Based on data from the 1996 Classification and Occupancy Counts, it was assumed that 80% of light duty trucks are used as passenger vehicles, while the remaining 20% are used as commercial vehicles. Table 5.1 presents the vehicle mix ratios that were used in the analysis.

Table 5.1 Ratio of heavy trucks, light trucks, taxis, other vehicles and non-transit buses to passenger vehicles in the National Capital Region (1996)

Area	Facility	PM Peak Hour				
		Heavy Trucks	Light Trucks	Taxis	Other vehicles	Non-transit buses
Core	Collector/Arterial	1.3	21.8	4.0	0.5	0.9
Urban	Collector/Arterial	1.3	23.6	1.9	0.3	0.5
Suburban	Collector/Arterial	2.2	30.4	0.3	0.5	0.5
Rural	Collector/Arterial	7.0	38.9	0.1	0.5	0.9
Freeways and Rural Highways		3.9	27.7	0.3	0.3	0.5

These ratios were computed by dividing the number of vehicles for each vehicle category by the number of passenger vehicles and multiplying by 100. By basing the ratios on passenger vehicle volumes, "background" traffic can be calculated directly from auto volumes assigned in the EMME/2 program.

The conversion of heavy vehicles (trucks and buses) to an equivalent number of passenger cars allows the analysis to be made on a consistent basis. Passenger car equivalency factors (Transportation Research Board. 1985., and Richardson et al. 1984.) are presented in Table 5.2.

Table 5.2 Passenger Car Equivalency Factors for EMME/2 Traffic Assignment

Facility	Vehicle Type	Passenger Car Equivalency Factor
Freeways	Trucks	2.0
	Buses	1.6
Arterials /Collectors	Trucks	2.0
	Buses	1.75

After an initial traffic assignment is performed, the volume of "background" traffic is computed and the traffic assignment is repeated, taking into account traffic congestion from all vehicle categories using the road network. Thus, in the main macro that calculates vehicle kilometers traveled and link average speed (*VKM_PMPHR.mac*), it is

important to specify the "background" traffic macro (*bkgd_pm.mac*) as one of the required parameters.

Once the parameters for *VKM_PMPHR.mac* (see Section 5.3.4.) have been selected, the macro transforms the traffic volumes, travel speeds, and link characteristics from the EMME/2 model to vehicle kilometers traveled and link average speed. The results from this phase of the calculations are in a format that can be read by the Emission Calculator in order to estimate fuel consumption and GHG emissions in the next step.

A sample output file showing vehicle kilometers traveled and link average speed for the 1995 base scenario is presented in Appendix E_4.

5.3.5 CALCULATION PROCEDURE FOR ESTIMATING FUEL CONSUMPTION AND GREENHOUSE GAS EMISSIONS

Travel data from EMME/2 (vehicle kilometers traveled and link average speed) are used as input data for calculating fuel consumption and GHG emissions on a link by link basis. Once the total vehicle kilometers traveled per link and link average speed are known, vehicle mix data are required in the next step of the calculations in order to estimate vehicle kilometers of travel by vehicle category, as follows:

*Total vehicle kilometers traveled per link [VKM] * vehicle category participation [%] = vehicle kilometers traveled per link by vehicle category [VKM]*

Thus, after the EMME/2 travel data are input into the Emission Calculator, vehicle mix data must be specified for each link classification in order to calculate vehicle kilometers traveled by vehicle category. Appendix E_5 presents the vehicle mix data for the National Capital Region for automobiles, light trucks and buses (transit). Since the vehicle mix varies according to the type of road and its location in the study area, ratios are specified for the land use classifications and link types discussed previously.

In order to simplify the calculation process, the Emission Calculator assumes that all vehicles follow each other within the traffic stream and thus, have the same link average speed.

Once vehicle kilometers traveled by vehicle category are known for each link, it is possible to compute the fuel consumption on each link by vehicle category as follows:

*Vehicle kilometers traveled per link [km] by vehicle type "i" * fuel consumption rate corresponding to the link average speed and vehicle type "i" [liters/km] = fuel consumption per link by vehicle type "i" [liters]*

In order to perform such calculations, the Emission Calculator requires fuel consumption equations for each vehicle category in order to calculate fuel consumption based on the link average speed.

Since the objective of this research was to estimate fuel consumption and GHG emissions from passenger transportation in urban areas, fuel consumption equations for automobiles, light trucks and buses (heavy trucks) were used from Montreal (Ministère des transports du Québec. 1995.). The reason for selecting these equations is the fact that they were created on the basis of average travel speed for different vehicle categories.

It was assumed that the categories of vehicles in Montreal correspond to the categories of vehicles in the National Capital Region. Thus, the selected fuel consumption equations can be used in the study area with the same vehicle categories. Selected fuel consumption equations are presented in Appendix E_95 for 1995.

It is important to mention that more recent fuel consumption equations from the United States were also analyzed (Oak Ridge National Laboratory. 1999), but since they reflect fuel consumption results for instantaneous vehicle speeds, they could not be used in this research.

It is expected that fuel efficiency will be improved during the period of 1995 - 2021. A recent report entitled "OECD Environmentally Sustainable Transportation Study - Quebec Windsor Corridor" (IBI Group et al. 1998. - Appendix B - Exhibit B.2 and Exhibit B.3) shows what might happen if past trends continue in terms of changes in the major features of technology and operations. It was predicted that fuel consumption rates

(liters of fuel/100 vehicle kilometers) will be reduced by 23.3% for cars and light trucks and 14.7% for buses in 2030 compared with 1990. These reductions were applied to the fuel consumption equations for 2021 (see Appendix E_21), since it is expected that the trend of increasing fuel cost in recent years will continue into the future, accelerating the research and production of more fuel efficient vehicles.

It can be seen that fuel consumption equations for vehicle category (autos, light trucks and transit) are developed for arterial roads and freeways, reflecting the different driving cycles on such facilities.

Along with fuel consumption equations, this step of the calculations also requires GHG emission rates for automobiles, light trucks and buses in order to calculate GHG emissions for each category of vehicles. These rates are presented in Table 5.3.

Table 5.3 GHG emission rates for automobiles, light duty trucks and buses

Vehicle type	Fuel type	CO ₂ emissions (g/L of fuel)	CH ₄ emissions (g/L of fuel)	N ₂ O emissions (g/L of fuel)
Automobiles	gasoline	2360	0.25-0.52	0.21-0.58
Light duty trucks	gasoline	2360	0.19-0.56	0.20-1.0
Heavy duty vehicles (buses)	diesel	2730	0.12-0.15	0.1

Source: (Natural Resources Canada. 1999.)

In order to present GHG emissions in CO₂ equivalents, CO₂, CH₄ and N₂O emission rates were converted into CO₂ equivalents on the basis of equivalency factors (see Section 3.1.) that reflect the relative long term greenhouse effect of these gases. Thus, the GHG emission factors for automobiles, light trucks, and buses, expressed in CO₂ equivalents, are as follows:

Automobiles = 2490.5 (grams/litre of fuel)

Light trucks = 2553.9 (grams/litre of fuel)

Heavy trucks (buses) = 2763.8 (grams/litre of fuel)

Since fuel consumption and GHG emissions are calculated for each link, the results can be displayed graphically within EMME/2. As an example, the assigned GHG emissions for the 2021 base scenario in the National Capital Region during PM peak hour are depicted in Figure 5.3.

Figure 5.3 GHG emissions in the NCR during PM peak hour in 2021 (kilograms)

In this research, fuel consumption and GHG emissions were aggregated according to the link classification and presented for each proposed scenario in order to determine the effectiveness of each measure in reducing GHG emissions in the National Capital Region.

5.4 FUEL CONSUMPTION AND GREENHOUSE GAS EMISSION ESTIMATES FOR THE PROPOSED SCENARIOS

Detailed fuel consumption (liters) and GHG emission (grams) calculation results are presented for each proposed scenario in Appendices F to R. Final results from these appendices are also analyzed in Sections 5.4.1 to 5.4.11.

Table 5.4 presents the modal split results for the National Capital Region, as well as the total GHG emissions for the Outaouais Region and NCR for each proposed scenario. From this table, one can see that modal split and GHG emissions vary for each proposed scenario compared to the base scenario, and thus, it is useful to analyze these trends in greater detail.

It is important to mention that intra-zonal trips (the trips that begin and end within the same traffic zone) are included in the modal split simulations but are not assigned to the road network. Thus, the results in Table 5.4 do not include GHG emissions produced by intra-zonal trips.

In a recent analysis of 1995 O-D survey data using the transportation GIS software, TransCAD GIS (Armstrong. 2000.), it was estimated that intra-zonal trips during the PM Peak Hour produce approximately 44600 vehicle kilometers of travel in the National Capital Region. This means that the 1739800 vehicle kilometers of travel estimated by EMME/2 for the 1995 base scenario (see Appendix F) should be increased by the amount of intra-zonal travel (2.6%) to obtain the total number of vehicle kilometers traveled.

Assuming that intra-zonal trips have the same average speed as other trips, the GHG emissions associated with these trips can be approximated. Thus, it was found that there are 12760 kilograms of GHG emissions produced by intra-zonal trips during the PM peak hour. In the modal split analysis, it was found that the modal split of intra-zonal trips was virtually unchanged for each scenario.

Table 5.4 Summary results of GHG emission calculations

Scenario	Modal split in National Capital Region in 1995						Modal split in National Capital Region in 2021						GHG emissions in Outaouais / National Capital Region during PM peak hour in 1995		GHG emissions in Outaouais / National Capital Region during PM peak hour in 2021	
	Auto mode			Transit			Auto mode			Transit			GHGs (kg)	% of reduction compared to base scenario	GHGs (kg)	% of reduction compared to base scenario
	Number of trips	% of total trips	Number of trips	% of total trips	Number of trips	% of total trips	Number of trips	% of total trips	Number of trips	% of total trips	Number of trips	% of total trips				
Base 0	196186	86.3	31283	13.7	285323	84.6	51932	15.4	130312	-	497606	-	118996	-	564024	-
Scenario 1	194691	85.6	32778	14.4	283362	84.0	53893	16.0	128103	1.7	492134	1.1	117989	0.8	558814	0.9
Scenario 2	189072	83.1	38397	16.9	277392	82.3	59863	17.7	122601	5.9	476226	4.3	114581	3.7	544914	3.4
Scenario 3	184750	81.2	42719	18.8	273177	81.0	64078	19.0	117918	9.5	463867	6.8	112301	5.6	535048	5.1
Scenario 4	196186	86.3	31283	13.7	283395	84.0	53860	16.0	130312	0	497606	0	117519	1.2	558174	1.0
Scenario 5	196186	86.3	31283	13.7	279180	82.8	58075	17.2	130312	0	497606	0	114002	4.2	544589	3.4
Scenario 6	196186	86.3	31283	13.7	266162	78.9	71093	21.1	130312	0	497606	0	103552	13.0	505292	10.4
Scenario 7	195237	85.8	32232	14.2	283598	84.1	53657	15.9	129554	0.6	494349	0.6	117921	0.9	560593	0.6
Scenario 8	194759	85.6	32710	14.4	283227	84.0	54028	16.0	128733	1.2	493272	0.9	118172	0.7	560971	0.5
Scenario 9	187958	82.6	39511	17.4	276751	82.1	60504	17.9	125808	3.5	481419	3.3	115656	2.8	551228	2.3
Scenario 10	196186	86.3	31283	13.7	285323	84.6	51932	15.4	130312	0	497606	0	118460	0.5	560560	0.6
Scenario 11	196186	86.3	31283	13.7	285323	84.6	51932	15.4	130312	0	497606	0	116848	1.8	550153	2.5

The base scenario (0) was used as a benchmark to determine the effectiveness of the eleven proposed scenarios. For the 1995 base scenario, fuel consumption and GHG emissions were calculated on the basis of travel data and fuel consumption rates for 1995. Fuel consumption and GHG emission estimates for 2021 were based on travel data for 2021, as well as fuel consumption relationships adjusted for predicted fuel efficiency improvements. Figure 5.4 depicts the PM peak hour GHG emissions and vehicle kilometers of travel (VKT) in the National Capital Region for the base scenario.

Figure 5.4 GHG emissions and vehicle kilometers traveled in the National Capital Region during PM peak hour (1995 - 2021)

One can see that the amount of automobile travel will increase from 1,345,303 in 1995 to 1,966,972 in 2021, an increase of 46.2%. At the same time, the vehicle kilometers traveled by light trucks will increase by 50.2% (from 379,291 in 1995 to 569,852 in 2021). The vehicle kilometers traveled by transit will increase by 46.8% (from 15,223 in 1995 to 22,353 in 2021). As a result of this increased travel activity, GHG emissions will increase by 13.3% (from 497,606 kg in 1995 to 564,024 kg in 2021), an increase which is lower than the increase in travel, due to predicted fuel efficiency improvements for 2021.

Figure 5.5 depicts the PM peak hour GHG emissions and vehicle kilometers traveled (VKT) in the Outaouais Region for the base scenario. It can be seen that the amount of

travel by private automobiles in the Outaouais Region will increase from 334519 in 1995 to 411323 in 2021, which is an increase of 23%. At the same time, the vehicle kilometers traveled by light trucks will increase by 25% (from 94881 in 1995 to 118586 in 2021). In terms of transit travel activity, the vehicle kilometers traveled will increase by 35.1% (from 2480 in 1995 to 3351 in 2021). Between 1995 and 2021, GHG emissions will decrease by 8.7% (from 130312 kg in 1995 to 118996 kg in 2021). This reduction in GHG emissions in the Outaouais Region is the result of anticipated fuel efficiency improvements, as well as road improvements, and increased transit ridership due to enhancements in the transit system.

Figure 5.5 GHG emissions and vehicle kilometers traveled in the Outaouais Region during PM peak hour (1995 - 2021)

In order to assess the effectiveness of the proposed scenarios in terms of GHG reduction, each scenario is presented and compared with the base scenario in the following sections.

5.4.1 GREENHOUSE GAS EMISSION ESTIMATES FOR THE SCENARIO WITH A 10% INCREASE IN PARKING COST (SCENARIO 1)

Figure 5.6 depicts the GHG emissions for the Outaouais region for base scenario and Scenario 1, which involves increasing parking costs by 10%.

Figure 5.6 GHG emissions in the Outaouais region for base scenario and Scenario 1

One can see that, when parking cost is increased by 10% in 1995, transit modal split increases by 0.7% (see Table 5.4). This results in a reduction in GHG emissions of 2209 kg during the PM peak hour (Figure 5.6), which is a decrease of 1.7%. This relatively small impact is due to the fact that only some traffic zones charge people for parking. Of the 45 traffic zones in the NCR where parking fees are collected (see Section 4.2.), only five are located in the Outaouais Region: four in the central core (zones 154, 155, 254, 255) and one in the urban area (zone 160). However, these traffic zones have a heavy concentration of jobs, which means that there is great potential for increasing transit ridership when parking cost is increased.

It is interesting to note that there is smaller decrease in GHG emissions in the NCR as a whole (1.1%) due to the fact that, of the 40 traffic zones in the RMOC where people paid for parking, there is a larger range of parking costs (\$0.5 - \$4.8 per day) compared to the Outaouais Region (\$1.5 - \$3.8 per day). People that pay low parking costs in the RMOC (e.g. \$0.5 per day) are less affected by increases in parking costs, causing fewer people to switch to public transit. Different socio-economic characteristics of the population in the Outaouais Region can also contribute to the differences observed.

A smaller reduction in PM peak hour GHG emissions (1007 kilograms or 0.8%) is predicted for the Outaouais Region in 2021. This is due to the fact that, in the base

scenario for 2021, some improvements in favor of transit are already included in the TRANS model (see Appendix S). Thus, an increase in parking costs is less effective in terms of switching people towards using transit. The improvements that are already included in the base scenario for 2021, as well as the extension of the urban transit area (see Appendix T), will cause an increase in the transit modal split of 1.6% compared to the modal split in 1995. This will be an especially large change for the Outaouais Region, in terms of providing transitways and rapid transit lines, since they do not exist now. Thus, many people would be attracted towards using transit due to these changes.

In these circumstances, an increase in parking cost would be less effective in the Outaouais Region than in the NCR as a whole in terms of reducing GHG emissions. This is illustrated by a smaller decrease in GHG emissions in the Outaouais Region (0.8%) compared to the entire NCR (0.9%) in 2021. Reductions in GHG emissions are different for each characteristic area of the Outaouais Region and are presented in Figure 5.7 for 1995.

Figure 5.7 GHG emissions for each characteristic area in the Outaouais Region for base scenario and Scenario 1 in 1995

From this figure, it can be seen that increases in parking cost are more effective, in terms of reducing GHG emissions, in the areas where parking fees are collected. These

reductions are 4.7% in the central core, 2.0% in the urban area, 0.9% in the suburban area and 0.2% in the rural area of the Outaouais Region.

GHG emissions in 2021 for each characteristic area of the Outaouais Region are presented in Figure 5.8. It can be seen that the reduction in GHG emissions is 2.7% in the central core, 0.9% in the urban area, 0.5% in the suburban area and 0.4% in the rural area of the Outaouais Region.

Figure 5.8 GHG emissions for each characteristic area in the Outaouais region for base scenario and Scenario 1 in 2021

5.4.2 GREENHOUSE GAS EMISSION ESTIMATES FOR THE SCENARIO WITH A 50% INCREASE IN PARKING COST (SCENARIO 2)

Figure 5.9 depicts the GHG emission results for the Outaouais region for the base scenario and Scenario 2, which involves increasing parking costs by 50%. One can see that when parking costs are increased by 50%, the transit modal split increases by 3.2% (see Table 5.4), resulting in a reduction in GHG emissions of 7711 kilograms during the PM peak hour in 1995, a decrease of 5.9% compared to the base scenario. The reduction in GHG emissions is smaller for the NCR as a whole (4.3%) due to the same factors discussed for Scenario 1.

Figure 5.9 GHG emissions in the Outaouais region for base scenario and Scenario 2

In 2021, a reduction of 4415 kilograms of GHGs during the PM peak hour is predicted for the Outaouais Region, which is a decrease of 3.7%. This smaller reduction in GHG emissions in 2021 compared to 1995 is due to the smaller proportion of people switching to public transit. Since the base scenario for 2021 includes improvements in transit service, people that would be affected by increased parking costs may have already switched to public transit, as explained in the discussion for Scenario 1.

The 50% increase in parking cost is more effective in the Outaouais Region than in the NCR as a whole, in terms of reducing GHG emissions. In the Outaouais region in 2021, a decrease in GHG's of 3.7% is observed. In the NCR, GHG's drop by only 3.4%. This result may be due to differences in the socio-economic characteristics of the Outaouais Region and RMOC.

Reductions in GHG emissions are different for each characteristic area of the Outaouais Region. These reductions are presented in Figure 5.10 for 1995. It can be seen from this figure that an increase in parking cost is most effective in terms of reducing GHG emissions in areas with parking fees. These reductions are 16.1% in the central core, 6.8% in the urban area, 3.8% in the suburban area and 1.1% in the rural area of the Outaouais Region.

Figure 5.10 GHG emissions for each characteristic area in the Outaouais region for base scenario and Scenario 2 in 1995

For 2021, GHG emissions associated with each characteristic area of the Outaouais Region are presented in Figure 5.11. It can be seen that the reduction in GHG emissions is 11.5% in central core, 3.7% in the urban area, 2.5% in the suburban area and 2.1% in the rural area of the Outaouais Region.

Figure 5.11 GHG emissions for each characteristic area in the Outaouais region for base scenario and Scenario 2 in 2021

5.4.3 GREENHOUSE GAS EMISSION ESTIMATES FOR THE SCENARIO WITH A 100% INCREASE IN PARKING COST (SCENARIO 3)

When parking cost is increased by 100%, the effectiveness of this measure is considerable in terms of increasing transit ridership and reducing GHG emissions. Figure 5.12 depicts these changes in the Outaouais Region. When parking cost is increased by 100%, the transit modal split increases by 5.1% in 1995 (see Table 5.4), resulting in a reduction in GHG emissions of 12394 kilograms during the PM peak hour (Figure 5.12). This represents a decrease of 9.5%. In the traffic zones in the central core of the Outaouais Region, parking fees are relatively high. Since many jobs are concentrated in this area and since this area is relatively well served by buses, a significant number of people switch from their cars when parking costs are increased by 100%. There is a smaller decrease in GHG emissions in the NCR as a whole in 1995 (6.8%) due to the same factors that apply for Scenario 1.

Figure 5.12 GHG emissions in the Outaouais region for base scenario and Scenario 3

A smaller proportion of people are predicted to switch to public transit in 2021. Consequently, there is a smaller reduction in GHG emissions during the PM peak hour in the Outaouais Region (6695 kg). This is due to the fact that some improvements in favor of transit are already included in the model for the 2021 base scenario, and thus, an increase in parking cost is less effective in 2021 than in 1995. There is a smaller decrease

in GHG emissions in the National Capital Region as a whole (5.1%) compared to the Outaouais Region (5.6%) due to the same factors explained for Scenario 2.

Reductions in GHG emissions are different for each characteristic area of the Outaouais Region (see Figure 5.13) for 1995 data. It can be seen that an increase in parking cost is most effective in terms of reducing GHG emissions in areas with high parking fees. The reduction in GHG emissions is predicted to be 25.5% in the central core, 11.0% in the urban area, 6.2% in the suburban area and 1.7% in the rural area.

Figure 5.13 GHG emissions for each characteristic area in the Outaouais region (1995)

For 2021, GHG emissions for each characteristic area of the Outaouais Region are presented in Figure 5.14.

Figure 5.14 GHG emissions for each characteristic area in the Outaouais region (2021)

It can be seen that the reduction in GHG emissions is 17.0% in the central core, 5.8% in the urban area, 3.6% in the suburban area and 3.1% in the rural area of the Outaouais Region, during the PM peak hour in 2021.

5.4.4 GREENHOUSE GAS EMISSION ESTIMATES FOR THE SCENARIO WITH FUEL COST INCREASED BY 1% ABOVE INFLATION (SCENARIO 4)

Figure 5.15 depicts the results of the GHG emission calculations for the base scenario and Scenario 4, which involves an increased fuel cost of 1% above the average inflation rate. It can be seen that the same amount of GHG emissions are produced (130312 kg) during the PM peak hour for both scenarios in 1995. This is due to the fact that the increased fuel costs do not take effect until after 1995.

In 2021, increased fuel costs would cause an increase in the transit modal split of 0.6% (see Table 5.4). As a result, GHG emissions would be reduced by 1477 kilograms during the PM peak hour, which is a decrease of 1.2% compared to the base scenario.

Figure 5.15 GHG emissions in the Outaouais region for base scenario and Scenario 4

The results for the NCR show a decrease in GHG emissions of 1.0%, which is lower than decrease predicted for the Outaouais Region (1.2%) in 2021. This may be due to the different socio-economic characteristics of the Outaouais Region and RMOC.

GHG emissions in 1995 are the same for the both the base scenario and Scenario 4. Consequently, the variation in GHG emissions by surrounding land use is also the same, since the effects of the increased fuel cost appear after 1995 starting point. Figure 5.16 depicts the variation in GHG emissions per characteristic area in 2021.

Figure 5.16 GHG emissions for each characteristic area in the Outaouais region (2021)

One can see that the increase in fuel cost is most effective in the areas where the majority of auto trips occur. The trends in Figure 5.16 may also be partially due to different socio-economic characteristics in each area as well as different levels of transit service. The reduction in GHG emissions is 2.3% in the central core, 1.0% in the urban area, 1.4% in the suburban area and 1.0% in the rural area of the Outaouais Region.

5.4.5 GREENHOUSE GAS EMISSION ESTIMATES FOR THE SCENARIO WITH FUEL COST INCREASED BY 2.5% ABOVE INFLATION (SCENARIO 5)

Figure 5.17 presents the results of the GHG emission calculations for the base scenario and Scenario 5, in which fuel cost is increased by 2.5% above the average inflation rate. As this figure shows, the same quantity of GHG emissions (130312 kilograms) is produced during the PM peak hour for both scenarios in 1995 since the measure is not implemented until later. In 2021, the increased fuel cost would cause an increase in the transit modal split of 1.8% (see Table 5.4). As a result, GHG emissions would be reduced by 4994 kilograms during the PM peak hour, which is a decrease of 4.2%.

Figure 5.17 GHG emissions in the Outaouais region for base scenario and Scenario 5

The results for the NCR show a decrease in GHG emissions of 3.4%, which is lower than the decrease predicted for the Outaouais Region (4.2%) in 2021. As mentioned for Scenario 4, this may be due to different socio-economic characteristics between residents of the Outaouais Region and RMOC. In 1995, GHG emissions are the same for both the base scenario and Scenario 5. This result occurs since the effects of the increased fuel cost appear after the 1995 starting point. In 2021, GHG emissions vary by characteristic area for both the base scenario and Scenario 5 (see Figure 5.18).

Figure 5.18 GHG emissions for each characteristic area in the Outaouais region (2021)

According to these results, the reduction in GHG emissions is 7.0% in the central core, 3.5% in the urban area, 4.7% in the suburban area and 3.9% in rural area of the Outaouais Region. This trend can be explained by the same factors described for Scenario 4.

5.4.6 GREENHOUSE GAS EMISSION ESTIMATES FOR THE SCENARIO WITH FUEL COST INCREASED BY 5% ABOVE INFLATION (SCENARIO 6)

Figure 5.19 depicts the results of the GHG emission calculations for the base scenario and Scenario 6, in which fuel costs are increased by 5% above the average inflation rate.

Figure 5.19 GHG emissions in the Outaouais region for base scenario and Scenario 6

It can be seen in this figure that in 1995, the same quantity of GHG emissions (130312 kilograms) is produced during the PM peak hour for both scenarios, since the effects of the increased fuel cost appear after 1995 starting point. In 2021, increased fuel cost would cause an increase in the transit modal split of 5.7% and, as a result, GHG emissions would be reduced by 15444 kilograms during the PM peak hour, which is a decrease of 13.0%.

In 2021, there is a lower decrease in GHG emissions (10.4%) in the National Capital Region as whole compared to the Outaouais Region (13%), which can be explained by the different socio-economic characteristics of Outaouais Region and RMOC. The results also show that the improvements in transit service that are included in the model for the 2021 base scenario are a good basis for policy changes to reduce GHG emissions, especially in the Outaouais Region.

Since the increased fuel cost does not come into effect until after 1995, GHG emissions in 1995 are the same for both the base scenario and Scenario 6, causing the variation in

GHG emissions by characteristic area to be the same as well. In 2021, GHG emissions vary according to the surrounding land use, as presented in Figure 5.20.

Figure 5.20 GHG emissions for each characteristic area in the Outaouais region (2021)

According to the results in Figure 5.20, the reduction in GHG emissions is 18.0% in the central core, 10.6% in the urban area, 15.2% in the suburban area and 12.9% in the rural area of the Outaouais Region. This trend can be explained by the factors described for Scenario 4.

It should be also pointed out that, by increasing fuel costs by 5% above inflation rates, traffic congestion would be relieved considerably in the central core, since there is relatively good transit service and people would more easily switch from cars. This finding is of importance to transportation planners since congestion problems are particularly high in the downtown core, as well as on the bridges over Ottawa and the Gatineau rivers.

5.4.7. GREENHOUSE GAS EMISSION ESTIMATES FOR THE SCENARIO WITH TRANSIT FARE DECREASED BY 10% (SCENARIO 7)

When transit fare is decreased by 10%, the modal split in the National Capital Region increases by 0.5% (see Table 5.4). As a result, GHG emissions are reduced by 758

kilograms during the PM peak hour in the Outaouais Region in 1995 (Figure 5.21), which is a decrease of 0.6% compared to the base scenario.

Figure 5.21 GHG emissions in the Outaouais region for base scenario and Scenario 7

It is important to note that the reduction of GHG emissions in the Outaouais Region would be greater for the PM peak hour in 2021 (1075 kilograms) than in 1995. This is mainly due to the fact that some improvements in favor of transit are already included in the model for 2021 (base scenario) and these improvements attract more people when transit fare is decreased, especially for shorter trips.

This measure would improve the position of the Outaouais Region within the National Capital Region, since there is a greater decrease in GHG emissions (0.9% compared with 0.6%) in 2021.

The reduction in GHG emissions is different for each characteristic area of the Outaouais Region. These reductions are presented in Figure 5.22 for 1995. In this figure, one can see that a decrease in transit fare is more effective, in terms of reducing GHG emissions, in areas where extensive transit service is provided. These areas are in a better position to attract new riders when transit fare is decreased. The reduction in GHG emissions, compared to the base scenario, is 1.3% in the central core, 0.7% in the urban area, 0.6% in the suburban area and 0.1% in the rural area of the Outaouais Region.

Figure 5.22 GHG emissions for each characteristic area in the Outaouais region (1995)

For 2021, GHG emissions are presented in Figure 5.23 for each characteristic area of the Outaouais Region. It can be seen that the reduction in GHG emissions is 2.6% in central core, 0.8% in the urban area, 0.9% in the suburban area and 0.5% in the rural area of the Outaouais Region.

Figure 5.23 GHG emissions for each characteristic area in the Outaouais region (2021)

Generally, it can be seen that decreasing transit fare is not as effective as other measures, in reducing GHGs. Indeed, increasing fuel and parking costs has a much greater impact on reducing GHG emissions. In addition, it should be noted that transit is already

partially subsidized by the community and that, if transit fare were decreased, more subsidies would be required for covering the cost of transit service.

5.4.8 GREENHOUSE GAS EMISSION ESTIMATES FOR THE SCENARIO WITH TOTAL TRANSIT TRIP TIME DECREASED BY 10% (SCENARIO 8)

Figure 5.24 depicts GHG emissions for the base scenario and Scenario 8, in which total transit trip time was decreased by 10%. One can see that, when transit travel time is decreased by 10% in the National Capital Region, the transit modal share increases by 0.7% (see Table 5.4). As a result, GHG emissions are reduced by 1579 kilograms during the PM peak hour in the Outaouais Region in 1995 (Figure 5.24), which represents a decrease of 1.2% compared to the base scenario.

Figure 5.24 GHG emissions in the Outaouais region for base scenario and Scenario 8

The results show that the decrease in GHG emissions in 1995 is lower for the National Capital Region (0.9%) compared to the Outaouais Region, due to the fact that there is better transit service provided in the RMO. Thus, people in the Outaouais Region are more sensitive to the reduction in transit travel time.

It is also important to note that the reduction in GHG emissions in the Outaouais Region would be smaller for the PM peak hour in 2021 (824 kilograms) than in 1995. This is

mainly due to the fact that some improvements in favor of transit are already included in the model for 2021 (base scenario). Thus, additional improvements in transit service have a smaller impact, causing only a small group of people to switch to transit.

The reduction in GHG emissions is different for each characteristic area of the Outaouais Region. The anticipated reductions for 1995 associated with this scenario are presented in Figure 5.25.

Figure 5.25 GHG emissions for each characteristic area in the Outaouais region (1995)

According to the results in Figure 5.25, the reduction in GHG emissions for Scenario 8 compared to the base scenario is 3.0% in the central core, 1.4% in the urban area, 0.9% in the suburban area and 0.2% in the rural area of the Outaouais Region.

When comparing this scenario (8) to Scenario 7 (decrease in transit fare by 10%), it can be concluded that providing faster transit service attracts more people towards using transit than decreasing the transit fare, particularly in the Outaouais Region.

GHG emissions in 2021 for each characteristic area of the Outaouais Region are presented in Figure 5.26. From this figure, it can be seen that the reduction in GHG emissions is 1.7% in the central core, 0.7% in the urban area, 0.5% in the suburban area and 0.5% in the rural area.

Figure 5.26 GHG emissions for each characteristic area in the Outaouais region (2021)

5.4.9 GREENHOUSE GAS EMISSION ESTIMATES FOR THE SCENARIO WITH TOTAL TRANSIT TRIP TIME DECREASED BY 50% (SCENARIO 9)

When total transit trip time is decreased by 50%, the 1995 transit modal split increases by 3.7% during the PM peak hour in the National Capital Region (see Table 5.4). As a result, GHG emissions in the Outaouais Region are reduced by 4504 kilograms (Figure 5.27), a decrease of 3.5% compared to the base scenario.

The results show that there is a lower decrease in GHG emissions in the NCR (3.3%) compared to the Outaouais Region in 1995. This may be attributed to the same factors that were described for Scenario 8.

It is also important to note that the reduction in GHG emissions in the Outaouais Region would be smaller for the PM peak hour in 2021 (3340 kilograms) than in 1995. This is due to the fact that some improvements in favor of transit are already included in the model for 2021 (base scenario). Thus, the reduction of transit travel time by 50% would attract a smaller fraction of people towards using transit compared to 1995.

Figure 5.27 GHG emissions in the Outaouais region for base scenario and Scenario 9

The reduction in GHG emissions varies depending on the location. This variation is shown in Figure 5.28 for 1995. In this figure, one can see that the reduction in GHG emissions compared to the base scenario is 5.7% in the central core, 4.1% in the urban area, 3.2% in the suburban area and 1.2% in the rural area of the Outaouais Region.

Figure 5.28 GHG emissions for each characteristic area in the Outaouais region (1995)

For 2021, GHG emissions are presented in Figure 5.29 for each characteristic area of the Outaouais Region. It can be seen that the reduction in GHG emissions is 4.4% in the central core, 3.1% in the urban area, 2.3% in the suburban area and 2.4% in the rural area.

Figure 5.29 GHG emissions for each characteristic area in the Outaouais region (2021)

In order to decrease total transit trip time by 50%, transitways with rapid transit service should be provided in the Outaouais Region, which would require a significant investment. Consequently, this measure is not overly attractive in terms of increasing transit ridership and reducing GHG emissions. This measure can be combined with other measures such as increasing the parking and fuel costs in order to attract more people towards using transit. This in turn will help to justify the investment in transit and reduce GHG emissions considerably.

In terms of land use planning, the situation can also be improved in the long term by planning higher density population centers in the Outaouais Region. This would result in shorter walking distances, which would make transit service even more attractive. Also, it is more economical to provide transit service in densely populated areas.

5.4.10 GREENHOUSE GAS EMISSION ESTIMATES FOR THE SCENARIO WITH DIESEL-ELECTRIC HYBRID BUSES IN 2021 (SCENARIO 10)

Concerns about transportation related emissions and the need for preservation of energy have been motivating specialists in their research of new technology vehicles. New technology buses that produce few or no emissions are currently in the testing phase. In the coming years, we can expect to see more of these vehicles on the roads.

In order to investigate the magnitude of GHG reductions that can result from using new technology buses, it is assumed that new technology buses will gradually replace all existing diesel buses from now to 2021. In 1995, GHG emissions from passenger transportation are presented only for 1995 base scenario, since the new technology buses have not yet been introduced (diesel-electric hybrid buses). After 1995, the effects of using the new technology (hybrid) buses increase gradually until full implementation is achieved in 2021.

For Scenario 10, it was assumed that the new buses would be diesel-electric hybrid Nova buses (Volvo. 2000.). Figure 5.30 depicts the results of the GHG emission calculations for Scenario 10 and the base scenario.

Figure 5.30 GHG emissions in the Outaouais region for base scenario and Scenario 10 which involves diesel-electric hybrid buses in 2021

When all diesel buses are replaced with diesel-electric hybrid buses in 2021, the modal split is the same as the base scenario, since these buses have the same operational characteristics. However, GHG emissions would be reduced by 536 kilograms during the PM peak hour in the Outaouais Region. This is due to the lower level of fuel consumption for diesel-electric hybrid buses, estimated as 64-65% of fuel consumption for standard diesel buses (Allen et al. 2000.).

In 2021, GHG emissions in the Outaouais Region for Scenario 10 are decreased by 0.5% compared to the base scenario. The results also show that there would be a higher reduction in GHG emissions in the NCR (0.6%) as a whole due to the fact that people in the RMOC use more transit than people in the Outaouais Region, causing the amount of transit service to be greater.

As discussed earlier, in 1995, GHG emissions from passenger transportation are presented only for 1995 base scenario, since the diesel-electric hybrid buses have not yet been introduced. Thus, the variation in GHG emissions by location can be presented for only base scenario. Figure 5.31 depicts the GHG emissions associated with each characteristic area in the Outaouais Region in 2021. As this figure shows, the variation for Scenario 10 (diesel-electric hybrid buses) is different compared to the base scenario, reflecting areas with higher transit service.

Figure 5.31 GHG emissions for each characteristic area in the Outaouais region, 2021

According to the results from Figure 5.31, the reduction in GHG emissions in 2021 due to the new technology buses is 0.9% in the central core, 0.6% in the urban area, 0.5% in the suburban area and 0.1% in the rural area of the Outaouais Region. Generally, the reduction in GHG emissions is higher in areas where people use more transit. It is important to mention that diesel-electric hybrid Nova buses have been tested on the streets of New York. Thus, results for the New York trials can be used in the scope of any

future analysis concerning the use of these buses in the Outaouais Region, as well as in the NCR as a whole.

Based on the results depicted in Figure 5.30 and Figure 5.31, it should be noted that the reduction in GHG emissions from the adoption of new technology buses in the Outaouais Region is not particularly impressive, due to the fact that there is a small amount of bus travel in the region compared to the total amount of travel from motorized vehicles. Moreover, standard diesel buses already produce much less GHG emissions compared to private automobiles. However, it is important to note that in terms of emissions from public transit vehicles, diesel electric hybrid buses would produce 36% less GHG emissions than diesel buses in 2021 (see Figure 5.32).

Figure 5.32 GHG emissions from transit in the Outaouais region (1995 - 2021)

In addition to reducing GHG emissions, diesel electric hybrid buses have the potential to reduce emissions that affect air quality and human health such as particulate matter (PM) and carbon monoxide (CO). Indeed, it is estimated that PM and CO emissions would be reduced by approximately 80% and 90% respectively through the use of diesel electric hybrid buses (Volvo. 2000.). It can be concluded that hybrid buses are an attractive option from an environmental point of view, particularly when combined with other measures such as increasing parking and fuel costs in order to attract more people towards using transit. This in turn would cause a greater reduction in vehicle emissions. Combining these scenarios into an integrated package of measures can help to justify the investment in new technology buses.

5.4.11 GREENHOUSE GAS EMISSION ESTIMATES FOR THE SCENARIO WITH FUEL CELL BUSES INSTEAD OF DIESEL BUSES IN 2021 (SCENARIO 11)

Ballard fuel cell buses (Ballard. 2000.) represent another new technology with the potential to reduce GHG emissions. Ballard buses use hydrogen as the basic fuel. A process of reverse electrolysis occurs, converting chemical energy into electricity and yielding byproducts of water and heat. In these types of buses, the emissions are practically zero. Although GHGs are produced if hydrogen fuel is produced from the sources other than GHG-free processes, it is assumed in this research that electrolysis is used and electricity is obtained from hydroelectric power plants. Also, in this thesis, the end use of all fuels is taken into account and upstream GHGs are ignored. This practice is common in evaluating transportation technologies. So, the estimation of upstream GHGs for fossil fuel as well as hydrogen fuel is beyond the scope of this research.

It is assumed that diesel buses in the NCR will be replaced gradually by Ballard fuel cell buses from now to 2021. Figure 5.33 depicts the results of the GHG emission calculations for the Outaouais Region during the PM peak hour for both the scenario with fuel cell buses and the base scenario.

Figure 5.33 GHG emissions in the Outaouais region for base scenario and Scenario 11 which involves fuel cell buses in 2021

Ballard buses have been tested in Chicago where public reaction to these buses has been positive. Comments from the public have focused primarily on the smooth ride and lower

noise level compared to diesel buses. However, there are no indications of the ability of these buses to attract additional people towards using transit. Thus, it was assumed that the mode split would be the same as the mode split for the base scenario.

In 1995, GHG emissions from passenger transportation are presented only for 1995 base scenario, since the new technology (fuel cell) buses have not yet been introduced. After 1995, the effects of using these buses increase gradually until full implementation is achieved in 2021. In 2021, GHG emissions would be reduced by 2148 kilograms in the Outaouais Region during the PM peak hour, a decrease of 1.8% compared to the base scenario. The results from Table 5.4 show that there would be a higher reduction in GHG emissions in the NCR as a whole (2.5%) compared to the Outaouais Region due to the fact that people in the RMOC use more public transit than people in the Outaouais Region. The greater the amount of transit service provided, the greater the potential reduction in GHG emissions from adopting new technology vehicles. Figure 5.34 depicts the GHG emissions associated with each characteristic area of the Outaouais Region in 2021. From this figure, it is clear that the variation in GHG emissions is different for these two scenarios, since the use of fuel cell buses has a greater impact in areas where transit use is higher.

Figure 5.34 GHG emissions for each characteristic area in the Outaouais region in 2021

It can be seen in this figure that the reduction in GHG emissions is 3.5% in the central core, 2.4% in the urban area, 1.8% in the suburban area and 0.4% in the rural area of the Outaouais Region. Generally, it can be concluded that the ability of fuel cell buses to

reduce GHG emissions is relatively small. This is due to the fact that the transit travel represents only a small portion of the total amount of motorized travel in the Outaouais region. As a result, transit vehicles produce significantly less GHG emissions compared to private automobiles. However, it is important to note that Ballard fuel cell buses produce no emissions in end use. As a result, GHG emissions from public transit in the Outaouais Region would be reduced by 100% (2518 kilograms) compared to the base scenario which relies on diesel buses in 2021 (see Figure 5.35).

Figure 5.35 GHG emissions from transit in the Outaouais region (1995 - 2021)

The scenario with Ballard fuel cell buses can also be combined with other measures (such as increasing parking and fuel costs) to attract more people towards using transit. This will reduce GHG emissions considerably and will help to justify the investment in new technology buses.

5.4.12 GREENHOUSE GAS EMISSIONS FROM ADDITIONAL BUSES PER PROPOSED SCENARIOS

From the EMME/2 analysis, it became evident that additional buses would be required to accommodate the increased transit demand associated with the various scenarios. During the simulation process in EMME/2, transit trips were assigned to the transit routes assumed to exist in 1995 and 2021 regardless of the bus capacity provided along the route. As additional transit trips were assigned to bus routes, the load factor is increased. However, the EMME/2 program does not calculate the additional number of buses required during the modeling process. Instead, this information must be specified by the user.

In order to calculate the number of additional buses required for each scenario and the associated GHG emissions, EMME/2 transit lines were transferred from the EMME/2 program to MS Excel. In MS Excel, a maximum load factor (0.9) was selected. The headway of each route was then modified and the number of additional buses required to accommodate the increased demand was calculated, as well as the corresponding vehicle kilometers of travel. Assuming that these additional buses operate at the same average speed as other buses in the analyzed scenarios, GHG emissions per vehicle kilometer of travel (kg/km) were calculated from the final simulation results presented in Appendices F to R. These values were then multiplied by the amount of travel associated with the additional buses to determine the GHG emissions produced during the PM peak hour (see Table 5.5).

Scenario	Area	1995				2021			
		Additional number of buses	Additional VKT (km)	GHGs / VKT (kg/km)	Additional GHGs from buses (kg)	Additional number of buses	Additional VKT (km)	GHGs / VKT (kg/km)	Additional GHGs from buses (kg)
Base 0	RMOC	0	0	0	0	0	0	0	0
	Outaouais	0	0	0	0	0	0	0	0
	NCR	0	0	0	0	0	0	0	0
1	RMOC	7	212.42	0.708	150	16	511.59	0.614	314
	Outaouais	3	65.53	0.818	54	9	218.77	0.638	140
	NCR	10	277.95	0.734	204	25	730.36	0.621	454
2	RMOC	30	828.79	0.699	579	40	1401.61	0.608	852
	Outaouais	17	371.31	0.796	296	18	442.3	0.613	279
	NCR	47	1200.1	0.729	875	58	1843.91	0.613	1131
3	RMOC	53	1543.69	0.694	1071	63	2158.2	0.603	1301
	Outaouais	24	561.2	0.777	436	26	624.32	0.625	390
	NCR	77	2104.89	0.716	1507	89	2782.52	0.608	1691
4	RMOC	0	0	0	0	18	603.64	0.614	371
	Outaouais	0	0	0	0	10	235.78	0.638	150
	NCR	0	0	0	0	28	839.42	0.621	521
5	RMOC	0	0	0	0	41	1490.29	0.608	906
	Outaouais	0	0	0	0	14	344.28	0.633	218
	NCR	0	0	0	0	55	1834.57	0.613	1124
6	RMOC	0	0	0	0	124	4753.24	0.597	2838
	Outaouais	0	0	0	0	40	1032.39	0.625	645
	NCR	0	0	0	0	164	5785.63	0.602	3483
7	RMOC	7	212.03	0.709	150	15	496.97	0.616	306
	Outaouais	2	46.03	0.824	38	10	230.05	0.638	147
	NCR	9	258.06	0.729	188	25	727.02	0.623	453
8	RMOC	7	212.24	0.71	151	10	325.15	0.616	200
	Outaouais	4	94.31	0.818	95	9	230.29	0.638	147
	NCR	11	306.55	0.802	246	19	555.44	0.625	347
9	RMOC	17	498.69	0.705	352	20	648.35	0.614	398
	Outaouais	6	132.44	0.813	108	17	407.23	0.637	259
	NCR	23	631.13	0.728	460	37	1055.58	0.623	657
10	RMOC	0	0	0	0	0	0	0	0
	Outaouais	0	0	0	0	0	0	0	0
	NCR	0	0	0	0	0	0	0	0
11	RMOC	0	0	0	0	0	0	0	0
	Outaouais	0	0	0	0	0	0	0	0
	NCR	0	0	0	0	0	0	0	0

One can see that there are no additional GHG emissions produced in the base scenario, since the model was originally calibrated based on an adequate level of travel service. Since no additional buses are required, no additional GHG emissions are produced. The same is true for Scenarios 10 and 11, since it was assumed that the new technology buses have the same operational characteristics as diesel buses and thus, no change in the modal split occurs.

On the basis of the GHG emissions presented in Table 5.4, Table 5.6 was generated, showing the percent change in GHG emissions in 2021 compared to the 1995 base scenario. The values reflect the effectiveness of the various scenarios tested in controlling the growth of GHGs in urban transportation. For example, Scenario 6 (fuel cost increased 5% above inflation) shows that for the National Capital Region, the percent growth in GHGs is only 1.5% between 1995 and 2021 whereas the base (do nothing) scenario results in a 13.3% growth in GHGs.

Table 5.6 Change in GHG emissions in 2021 compared to the 1995 base scenario

Scenario	GHG emissions in Outaouais/NCR during PM peak hour in 1995	GHG emissions in Outaouais/NCR during PM peak hour in 2021	
	GHGs (kg)	GHG (kg)	% of change compared to 1995 base scenario
Base 0	<u>130312</u> 497606	<u>118996</u> 564024	<u>-8.7</u> 13.3
Scenario 1	- -	<u>117989</u> 558814	<u>-9.5</u> 12.3
Scenario 2	- -	<u>114581</u> 544914	<u>-12.1</u> 9.5
Scenario 3	- -	<u>112301</u> 535048	<u>-13.8</u> 7.5
Scenario 4	- -	<u>117519</u> 558174	<u>-9.8</u> 12.2
Scenario 5	- -	<u>114002</u> 544589	<u>-12.5</u> 9.4
Scenario 6	- -	<u>103552</u> 505292	<u>-20.5</u> 1.5
Scenario 7	- -	<u>117921</u> 560593	<u>-9.5</u> 12.7
Scenario 8	- -	<u>118172</u> 560971	<u>-9.3</u> 12.7
Scenario 9	- -	<u>115656</u> 551228	<u>-11.2</u> 10.8
Scenario 10	- -	<u>118460</u> 560560	<u>-9.1</u> 12.7
Scenario 11	- -	<u>116848</u> 550153	<u>-10.3</u> 10.6

5.5 ANNUAL GREENHOUSE GAS EMISSIONS IN THE NATIONAL CAPITAL REGION

Section 5.4 describes the GHG emissions produced during the PM peak hour in 1995 and 2021 that were estimated in this research. In this section, additional statistics for the National Capital Region are presented. Comparing the results obtained in Section 5.4 with previously published estimations (TAC. 1996.) can help in confirming the appropriateness of the methodology used in the GHG calculations.

Daily passenger and commercial vehicle trips in the National Capital Region were recently analyzed to estimate daily fuel consumption and GHG emissions from mobile sources (Armstrong. 2000.). It was found that, on average, passenger vehicles consumed 1,637,800 liters of gasoline per day in 1995, resulting in 4080 tonnes of GHG emissions. When these passenger vehicle emissions are increased by 2.6% (for intrazonal trips that were not calculated during simulation process, see Section 5.4), it results in 4190 tonnes of GHG emissions per day. It was also found that non-passenger vehicles (e.g. light trucks and vans that are used as commercial vehicles) consumed 136,700 liters of gasoline per day. In addition, 232,200 liters of diesel were consumed by heavy trucks and buses. In total, it was estimated that non-passenger vehicles produced 990 tonnes of GHG emissions per day in 1995. Thus, GHG emissions from passenger vehicles in the NCR accounted for approximately 80.9% of daily (5180 tonnes) GHG emissions in 1995. In addition, it was found that 87.6% of GHGs are gasoline based, while 12.4% are diesel based.

Annual GHG emissions from transportation were estimated to be approximately 1,826,000 tonnes (about 2.1 tonnes per capita). This value was obtained by multiplying the average daily GHG production (5180 tonnes) by a factor which accounts for the seasonal variation in traffic (source: Region of Ottawa-Carleton. 2000.). This corresponds approximately to estimates in a 1996 Report (TAC. 1996.) where it is highlighted that about 2 tonnes of CO₂ per capita are produced annually in the RMOC. It is important to mention that carbon dioxide (CO₂) accounted for about 95% of all transportation related GHGs in the National Capital Region in 1995.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

The fact that urban areas in Canada are characterized by an auto dependent travel demand clearly shows that there is a considerable potential for switching people from their cars to transit and, as a result, reducing GHG emissions. On the basis of recent estimates for urban transportation in Canada (CUTA. 2000.), it can be seen that public transit is a more environmentally friendly mode of transportation than private automobiles. It is estimated that a car produces 254 tonnes of GHG emissions (CO₂ equivalent) per million passenger kilometers, while a bus produces only 70 tonnes. From this investigation of GHG emissions in transportation in the National Capital Region in general and the Outaouais Region in particular, several conclusions can be drawn.

6.1 CONCLUSIONS

Travel demand in the Outaouais Region is characterized by high auto dependency. Indeed, car trips accounted for 77.2% of total trips occurring over a 24-hour period in 1995, while transit accounted for only 6.2%. Other motorized and non-motorized modes accounted for 16.6% of total trips. When considering the National Capital Region as a whole, it was found (Section 5.5.) that 80.9% of GHG emissions come from passenger vehicles, while 19.1% can be attributed to non-passenger vehicles. This shows that there is considerable potential for reducing GHG emissions based on a "mode choice strategy".

The "Mode choice strategy" for reducing GHG emissions is based on the fact that a trip maker will choose the mode of transportation with the highest utility value. This strategy represents a set of measures that could be used to make public transit the mode with the highest utility value for a substantial percentage of travellers. This approach for reducing GHG emissions enables urban transportation planners to analyze systems from an environmental point of view, in an innovative way. In addition to the base ("do nothing") scenario, eleven scenarios were proposed in order to show the range of possible measures and their effectiveness in terms of increasing transit ridership and reducing GHG emissions. The effects of the proposed measures were examined for different locations within the study area, including the central core, urban area, suburban area and rural area.

Parking cost was increased by 10% (Scenario 1), 50% (Scenario 2) and 100% (Scenario 3). When parking cost is increased substantially (e.g. 100%), the transit modal split during the PM peak hour in 1995 increased by over 5%, reducing GHG emissions considerably (9.5% reduction). It is important to mention that, according to the 1995 O-D survey, parking fees were only collected in four traffic zones in the central core and one traffic zone in the urban area of the Outaouais Region. This means that the effectiveness of the parking cost variable could be very high if parking policy were revised in favor of transit, for example, by increasing parking costs and extending the area where parking is charged. With this measure, traffic congestion would be relieved, especially in the central core, since there is relatively good transit service and it would be easier for people to switch from cars to public transit in this area.

Fuel cost for auto mode was increased by 1% (Scenario 4), 2.5% (Scenario 5) and 5% (Scenario 6) above the average inflation rate. Since the increase in fuel cost is applied to all auto users, the effectiveness of this measure is considerable. As an example, when fuel cost is increased by 5% above the average inflation rate, the transit modal split increases by 5.7% in 2021. As a result, GHG emissions are reduced by 13.0% during the PM peak hour. This means that increasing the fuel cost is very effective in terms of reducing GHG emissions. With this measure, traffic congestion would also be partially relieved. This is a very important finding since congestion problems are especially high in the downtown core and on the bridges over the Ottawa and Gatineau rivers.

According to the results for Scenario 7, in which transit fare was decreased by 10%, it can be concluded that decreasing the transit fare is not an effective measure, in terms of reducing GHGs, compared to increasing the parking or fuel cost. In addition, it should be pointed out that transit is already partially supported by the community. If transit fare were decreased, more subsidies would be required for covering the cost of transit service.

In Scenarios 8 and 9, transit travel time was decreased by 10% and 50% respectively. The results show that when transit travel time is decreased by 50%, the transit modal share increases by 2.5% during the PM peak hour in 2021, leading to a reduction in GHG emissions of 2.8%. However, to provide transit service with 50% shorter total travel time,

considerable investment in transit infrastructure and services would be required. Thus, other measures such as increasing the parking and fuel costs could be combined with this measure in order to attract more people towards using transit and reduce GHG emissions.

The scenarios with new technology buses were analyzed in order to determine the magnitude of the potential GHG reduction that would occur if standard diesel buses were replaced with hybrid or fuel cell buses. It was assumed that standard diesel buses would be replaced gradually from now to 2021. One proposal is diesel-electric hybrid Nova buses that have been tested on the streets of New York. If diesel-electric hybrid buses were used in the Outaouais Region (Scenario 10), GHG emissions from passenger transportation would be decreased by 0.5% during the PM peak hour in 2021. This relatively small reduction in GHG emissions is due to the fact that the proportion of transit trips in the region is much smaller than the proportion of auto vehicle trips. In conjunction with this, standard diesel buses produce significantly less GHG emissions per passenger transported compared to private automobiles. However, it is important to note (see Figure 5.32) that diesel electric hybrid buses would produce 36% less GHG emissions than diesel buses in 2021. This is in accordance with the preliminary estimation (Allen et al. 2000.) that diesel electric buses consume 35-36% less fuel than standard diesel buses. The scenario with diesel-electric hybrid buses can be combined with other measures (such as increasing parking and fuel costs) to attract more people towards using transit. This will reduce GHG emissions and help to justify the investment in new technology buses.

Another proposal is the use of Ballard fuel cell buses. These buses have been tested in Chicago where public reaction has been positive. The results for the scenario with Ballard fuel cell buses (Scenario 11) are encouraging, since these buses produce no emissions in end use. As previously noted in Section 5.4.11, the upstream GHGs for all fuels are not taken into account. Furthermore, in this research, it is assumed that hydrogen is produced from electrolysis and electricity is obtained from hydroelectric power plants. If fuel cell buses were used, GHG emissions from passenger transportation in the Outaouais Region would be decreased by 1.8% compared to the base scenario in 2021. Since fuel cell buses produce no emissions, GHG emissions from transit in the Outaouais Region would be

reduced by 100% in 2021 if such buses were adopted. In this secondary energy analysis, GHG emissions from the production of hydrogen fuel are not taken into account for the reasons noted earlier. The use of fuel cell buses can also be combined with other measures (such as increasing the parking and fuel costs) to attract more people towards using transit. This integrated package of measures would significantly reduce GHG emissions and help to justify the investment in new technology buses.

Based on the results from this research, it can generally be concluded that bus transportation has the potential to play an important role in reducing GHG emissions, depending on the measures adopted to increase transit ridership. The results and this conclusion are subject to the uncertainties in modeling human behavior regarding mode choice.

6.2 RECOMMENDATIONS

The results from this research form a basis for parking policy changes, transit marketing activities, and the environmentally friendly development of transportation in the context of sustainable development in the Outaouais Region. Only motorized modes of transportation (cars and buses) were analyzed in this research. Thus, there is need to undertake a comprehensive study that would include all modes of transportation in order to identify all possibilities for improving the situation from an environmental point of view.

The scenarios with increased fuel and parking costs are most effective in terms of switching people from cars to buses and reducing GHG emissions. The scenarios with increased fuel cost are in accordance with the objective of preserving energy resources (Prades et al. 1998.), and are reasonable, since experts estimate that in the "...next decade or so we will see the end of cheap conventional oil" (The Centre for Sustainable Transportation. 1999.). The scenarios with increased fuel and parking costs should be analyzed further in terms of possible implications on businesses in the central core. "Park and Ride" services should be also analyzed in this context in order to put people from rural and suburban areas in an equal position with others.

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APPENDIX A:

Population characteristics in terms of labor force activity in CUO area (1986)						
Labor force activity	Aylmer	Hull	Gatineau	Buckingham	Masson	Total CUO
Total - 1986						
Total population 15 years and over	20945	48445	61055	6730	3610	140785
Total labor force 15 years and over	15025	32955	44045	4010	2290	98325
Employed	13690	29035	39480	3515	2000	87720
Unemployed	1335	3920	4565	500	290	10610
Participation rate	71.7%	68.0%	72.1%	59.6%	63.4%	69.8%
Unemployment rate	8.9%	11.9%	10.4%	12.5%	12.7%	10.8%
Men - 1986						
Males 15 years and over	10245	22985	30115	3280	1795	68420
Males 15 years and over in labor force	8465	17835	24765	2370	1380	54815
Employed	7740	15665	22270	2085	1195	48955
Unemployed	720	2170	2495	285	185	5855
Participation rate	82.6%	77.6%	82.2%	72.3%	76.9%	80.1%
Unemployment rate	8.5%	12.2%	10.1%	12.0%	13.4%	10.7%
Women - 1986						
Females 15 years and over	10700	25460	30940	3450	1815	72365
Females 15 years and over in labor force	6560	15120	19280	1640	910	43510
Employed	5950	13370	17210	1430	805	38765
Unemployed	615	1750	2070	215	105	4755
Participation rate	61.3%	59.4%	62.3%	47.5%	50.1%	60.1%
Unemployment rate	9.4%	11.6%	10.7%	13.1%	11.5%	10.9%

APPENDIX A: (continued)

Population characteristics in terms of labor force activity in CUO area (1991)						
Labor force activity	Aylmer	Hull	Gatineau	Buckingham	Masson	Total CUO
Total - 1991						
Total population 15 years and over	23730	50195	70645	8040	4345	156955
Total labor force 15 years and over	17560	34585	52820	5365	3090	113420
Employed	16305	31485	48630	4840	2830	104090
Unemployed	1255	3100	4185	530	260	9330
Participation rate	74.0%	68.9%	74.8%	66.7%	71.1%	72.2%
Unemployment rate	7.1%	9.0%	7.9%	9.9%	8.4%	8.2%
Men - 1991						
Males 15 years and over	11570	23935	34660	3865	2180	76210
Males 15 years and over in labor force	9440	18260	28270	2955	1695	60620
Employed	8720	16510	26050	2690	1540	55510
Unemployed	720	1750	2220	265	155	5110
Participation rate	81.6%	76.3%	81.6%	76.5%	77.8%	79.5%
Unemployment rate	7.6%	9.6%	7.9%	9.1%	8.8%	8.4%
Women - 1991						
Females 15 years and over	12160	26260	35985	4175	2165	80745
Females 15 years and over in labor force	8120	16325	24550	2410	1395	52800
Employed	7585	14975	22580	2150	1290	48580
Unemployed	535	1350	1965	265	105	4220
Participation rate	66.8%	62.2%	68.2%	57.7%	64.4%	65.4%
Unemployment rate	6.6%	8.3%	8.0%	11.0%	7.5%	8.0%

APPENDIX A: (continued)

Population characteristics in terms of labor force activity in CUO area (1996)						
Labor force activity	Aylmer	Hull	Gatineau	Buckingham	Masson	Total CUO
Total - 1996						
Total population 15 years and over	26105	51140	77170	8810	5945	169170
Total labor force 15 years and over	18390	33335	55035	5455	4260	116475
Employed	16810	29875	49895	4815	3850	105245
Unemployed	1580	3460	5140	640	410	11230
Participation rate	70.4%	65.2%	71.3%	61.9%	71.7%	68.8%
Unemployment rate	8.6%	10.4%	9.3%	11.7%	9.6%	9.6%
Men - 1996						
Males 15 years and over	12660	24235	37500	4220	2985	81600
Males 15 years and over in labor force	9700	17190	29125	2905	2380	61300
Employed	8835	15170	26230	2530	2120	54885
Unemployed	865	2020	2895	375	260	6415
Participation rate	76.6%	70.9%	77.7%	68.8%	79.7%	75.1%
Unemployment rate	8.9%	11.7%	9.9%	12.9%	10.9%	10.5%
Women - 1996						
Females 15 years and over	13445	26905	39670	4590	2960	87570
Females 15 years and over in labor force	8690	16145	25910	2550	1880	55175
Employed	7975	14705	23665	2285	1730	50360
Unemployed	715	1440	2245	265	150	4815
Participation rate	64.6%	60.0%	65.3%	55.6%	63.7%	63.0%
Unemployment rate	8.2%	9.0%	8.7%	10.2%	8.2%	8.7%

APPENDIX B:

Labor force 15 years and over by sex and occupation major groups in CUO (1986)							
Sector of the activity	Description	Aylmer	Hull	Gatineau	Buckingham	Masson	Total CUO
Total-1986							
Primary	Primary occupations	180	240	405	45	55	925
	<i>Total</i>	180	240	405	45	55	925
Secondary	Processing and repairing occupations	835	1715	3980	295	325	7150
	Construction trade occupations	980	2080	3740	310	310	7420
	Transport operation occupations	385	930	1685	120	90	3210
	<i>Total</i>	2200	4725	9405	725	725	17780
Tertiary professions	Managerial, administrative and related occupations	2375	3855	5135	310	165	11840
	Teaching and related occupations	740	1840	1770	220	105	4675
	Occupations in medicine and health	535	1630	1720	300	95	4280
	Natural, social, religious and related occupations	1760	3210	3020	245	85	8320
	<i>Total</i>	5410	10535	11645	1075	450	29115
Tertiary service	Clerical and related occupations	3630	7505	10600	930	520	23185
	Sales occupations	1005	2310	3370	315	90	7090
	Service occupations	1740	5310	5655	435	250	13390
	Other occupations	475	1205	1520	135	125	3460
	<i>Total</i>	6850	16330	21145	1815	985	47125
All professions - total		14640	31830	42600	3660	2215	94945
Men-1986							
Primary	Primary occupations	160	225	330	45	45	805
	<i>Total</i>	160	225	330	45	45	805
Secondary	Processing and repairing occupations	725	1415	3545	260	290	6235
	Construction trade occupations	955	1990	3650	310	310	7215
	Transport operation occupations	365	855	1600	115	85	3020
	<i>Total</i>	2045	4260	8795	685	685	16470

Continued							
Tertiary professions	Managerial, administrative and related occupations	1565	2215	3195	245	90	7310
	Teaching and related occupations	285	695	595	80	45	1700
	Occupations in medicine and health	125	470	400	105	15	1115
	Natural, social, religious and related occupations	1215	2085	2095	195	65	5655
	<i>Total</i>	<i>3190</i>	<i>5465</i>	<i>6285</i>	<i>625</i>	<i>215</i>	<i>15780</i>
Tertiary service	Clerical and related occupations	895	1800	2315	170	105	5285
	Sales occupations	630	1465	2000	205	50	4350
	Service occupations	925	2990	3070	250	115	7350
	Other occupations	405	1030	1250	120	115	2920
	<i>Total</i>	<i>2855</i>	<i>7285</i>	<i>8635</i>	<i>745</i>	<i>385</i>	<i>19905</i>
All professions - total		8250	17235	24045	2100	1330	52960
Women-1986							
Primary	Primary occupations	20	15	75	0	10	120
	<i>Total</i>	<i>20</i>	<i>15</i>	<i>75</i>	<i>0</i>	<i>10</i>	<i>120</i>
Secondary	Processing and repairing occupations	110	300	435	35	35	915
	Construction trade occupations	25	90	90	0	0	205
	Transport operation occupations	20	75	85	5	5	190
	<i>Total</i>	<i>155</i>	<i>465</i>	<i>610</i>	<i>40</i>	<i>40</i>	<i>1310</i>
Tertiary professions	Managerial, adm. and related occupations	810	1640	1940	65	75	4530
	Teaching and related occupations	455	1145	1175	140	60	2975
	Occupations in medicine and health	410	1160	1320	195	80	3165
	Natural, social, relig. and relat. occupations	545	1125	925	50	20	2665
	<i>Total</i>	<i>2220</i>	<i>5070</i>	<i>5360</i>	<i>450</i>	<i>235</i>	<i>13335</i>
Tertiary service	Clerical and related occupations	2735	5705	8285	760	415	17900
	Sales occupations	375	845	1370	110	40	2740
	Service occupations	815	2320	2585	185	135	6040
	Other occupations	70	175	270	15	10	540
	<i>Total</i>	<i>3995</i>	<i>9045</i>	<i>12510</i>	<i>1070</i>	<i>600</i>	<i>27220</i>
All professions - total		6390	14595	18555	1560	885	41985

APPENDIX B: (continued)

Labor force 15 years and over by sex and occupation major groups in CUO (1991)							
Sector of the activity	Description	Aylmer	Hull	Gatineau	Buckingham	Masson	Total CUO
Total-1991							
Primary	Primary occupations	225	295	380	70	60	1030
	<i>Total</i>	225	295	380	70	60	1030
Secondary	Processing and repairing occup.	735	1680	3630	600	370	7015
	Construction trade occupations	1115	1870	3875	525	380	7765
	Transport operation occupations	390	980	1945	165	120	3600
	<i>Total</i>	2240	4530	9450	1290	870	18380
Tertiary professions	Managerial, administrative and related occupations	3155	5075	7025	610	310	16175
	Teaching and related occupations	880	1795	1940	210	135	4960
	Occupations in medicine and health	750	1580	2520	380	110	5340
	Natural, social, religious and related occupations	2120	4345	4335	380	150	11330
	<i>Total</i>	6905	12795	15820	1580	705	37805
Tertiary service	Clerical and related occupations	3815	7395	13365	1095	780	26450
	Sales occupations	1410	2390	4110	425	170	8505
	Service occupations	2315	5590	7155	645	370	16075
	Other occupations	385	800	1565	100	85	2935
	<i>Total</i>	7925	16175	26195	2265	1405	53965
All professions - total		17295	33795	51845	5205	3040	111180
Men-1991							
Primary	Primary occupations	190	255	350	40	40	875
	<i>Total</i>	190	255	350	40	40	875
Secondary	Processing and repairing occup.	655	1390	3375	570	330	6320
	Construction trade occupations	1085	1810	3820	515	370	7600
	Transport op. occup.	350	935	1815	155	110	3365
	<i>Total</i>	2090	4135	9010	1240	810	17285

Continued							
Tertiary professions	Managerial, administrative and related occupations	1800	2985	4000	315	180	9280
	Teaching, and related occupations	305	630	630	80	30	1675
	Occupations in medicine and health	180	410	585	100	30	1305
	Natural, social, religious and related occupations	1330	2585	2830	250	120	7115
	<i>Total</i>	<i>3615</i>	<i>6610</i>	<i>8045</i>	<i>745</i>	<i>360</i>	<i>19375</i>
Tertiary service	Clerical and related occupations	990	1815	2940	195	110	6050
	Sales occupations	785	1410	2265	280	95	4835
	Service occupations	1300	3000	3875	300	170	8645
	Other occupations	325	605	1315	80	85	2410
	<i>Total</i>	<i>3400</i>	<i>6830</i>	<i>10395</i>	<i>855</i>	<i>460</i>	<i>21940</i>
All professions - total		9295	17830	27800	2880	1670	59475
Women-1991							
Primary	Primary occupations	35	40	30	30	20	155
	<i>Total</i>	<i>35</i>	<i>40</i>	<i>30</i>	<i>30</i>	<i>20</i>	<i>155</i>
Secondary	Processing and repairing occup.	80	290	255	30	40	695
	Construction trade occupations	30	60	55	10	10	165
	Transport operation occupations	40	45	130	10	10	235
	<i>Total</i>	<i>150</i>	<i>395</i>	<i>440</i>	<i>50</i>	<i>60</i>	<i>1095</i>
Tertiary professions	Managerial, ad. and related occupations	1355	2090	3025	295	130	6895
	Teaching and related occupations	575	1165	1310	130	105	3285
	Occupations in medicine and health	570	1170	1935	280	80	4035
	Natural, social, relig. and rel. occupations	790	1760	1505	130	30	4215
	<i>Total</i>	<i>3290</i>	<i>6185</i>	<i>7775</i>	<i>835</i>	<i>345</i>	<i>18430</i>
Tertiary service	Clerical and related occupations	2825	5580	10425	900	670	20400
	Sales occupations	625	980	1845	145	75	3670
	Service occupations	1015	2590	3280	345	200	7430
	Other occupations	60	195	250	20	0	525
	<i>Total</i>	<i>4525</i>	<i>9345</i>	<i>15800</i>	<i>1410</i>	<i>945</i>	<i>32025</i>
All professions - total		8000	15965	24045	2325	1370	51705

APPENDIX B: (continued)

Labor force 15 years and over by sex and occupation major groups in CUO (1996)							
Sector of the activity	Description	Aylmer	Hull	Gatineau	Buckingham	Masson	Total CUO
Total-1996							
Primary	Primary occupations	205	215	500	55	35	1010
	<i>Total</i>	205	215	500	55	35	1010
Secondary	Processing, manufacturing and utilities	370	540	1340	350	215	2815
	Trade, transport and equipment operators and related occupat.	1610	2705	7250	635	805	13005
	<i>Total</i>	1980	3245	8590	985	1020	15820
Tertiary professions	Management occupations	2070	2770	4600	420	260	10120
	Business, finance and administrative occupations	4390	7555	14565	1285	1145	28940
	Occupations in social science, educ. government service and religion	1920	3625	3390	385	170	9490
	Health occupations	720	1655	2565	365	235	5540
	Natural and applied science and related occupations	1440	2425	3130	255	195	7445
	<i>Total</i>	10540	18030	28250	2710	2005	61535
Tertiary service	Occupations in art, culture, recreation and sport	740	1780	1465	115	75	4175
	Sales and service occupations	4315	8500	14200	1300	955	29270
	Other occupations	610	1565	2020	280	150	4625
	<i>Total</i>	5665	11845	17685	1695	1180	38070
All professions - total		18390	33335	55025	5445	4240	116435
Men-1996							
Primary	Primary occupations	180	195	410	45	35	865
	<i>Total</i>	180	195	410	45	35	865
Secondary	Processing, manuf. and utilities	260	410	1130	330	200	2330
	Trade, transport and equipment operators and related occupat.	1515	2550	6920	620	775	12380
	<i>Total</i>	1775	2960	8050	950	975	14710

Continued							
Tertiary professions	Management occup.	1330	1750	3070	290	195	6635
	Business, finance and adm. occupat.	1285	2340	4485	325	300	8735
	Occupations in soc. science, education, gover. ser. and relig.	815	1500	1330	170	85	3900
	Health occupations	175	395	550	85	55	1260
	Natural and applied sci. and relat. occup.	1210	1840	2485	210	155	5900
	<i>Total</i>	<i>4815</i>	<i>7825</i>	<i>11920</i>	<i>1080</i>	<i>790</i>	<i>26430</i>
Tertiary service	Occupations in art, cult., rec. and sport	370	785	710	70	25	1960
	Sales and ser. occup.	2230	4480	7010	590	445	14755
	Other occupations	330	940	1025	165	100	2560
	<i>Total</i>	<i>2930</i>	<i>6205</i>	<i>8745</i>	<i>825</i>	<i>570</i>	<i>19275</i>
All professions - total		9700	17185	29125	2900	2370	61280
Women-1996							
Primary	Primary occupations	25	20	90	10	0	145
	<i>Total</i>	<i>25</i>	<i>20</i>	<i>90</i>	<i>10</i>	<i>0</i>	<i>145</i>
Secondary	Processing, manuf. and utilities	110	130	210	20	15	485
	Trade, transport and equipment operators and related occupat.	95	155	330	15	30	625
	<i>Total</i>	<i>205</i>	<i>285</i>	<i>540</i>	<i>35</i>	<i>45</i>	<i>1110</i>
Tertiary professions	Management occup.	740	1020	1530	130	65	3485
	Business, finance and adm. occupat.	3105	5215	10080	960	845	20205
	Occupations in soc. science, educ., gov. service and religion	1105	2125	2060	215	85	5590
	Health occupations	545	1260	2015	280	180	4280
	Natural and applied Scien. and rel.occup.	230	585	645	45	40	1545
	<i>Total</i>	<i>5725</i>	<i>10205</i>	<i>16330</i>	<i>1630</i>	<i>1215</i>	<i>35105</i>
Tertiary service	Occupations in art, cult., recr. and sport	370	995	755	45	50	2215
	Sales and service occupations	2085	4020	7190	710	510	14515
	Other occupations	280	625	995	115	50	2065
	<i>Total</i>	<i>2735</i>	<i>5640</i>	<i>8940</i>	<i>870</i>	<i>610</i>	<i>18795</i>
All professions - total		8690	16150	25900	2545	1870	55155

APPENDIX C:

Income characteristics in CUO area in 1986								
City	Number of households in income class							Average household income(\$)
	<10000\$	10000 - 19999\$	20000 - 29999\$	30000 - 39999\$	40000 - 49999\$	50000\$ and over	Total	
Aylmer	835	1025	1300	1600	1465	2925	9150	41273
Hull	4315	4695	4635	3905	2515	4170	24235	30726
Gatineau	2945	3185	4185	4835	4170	6960	26280	37770
Buckingham	640	540	570	440	385	560	3135	30492
Masson	190	255	295	320	315	235	1610	32147
All private household in CUO	8925	9700	10985	11100	8850	14850	64410	35122

City	Males 15 years and over in income class							Males' Average income(\$)
	<5000\$	5000 - 9999\$	10000 - 19999\$	20000 - 29999\$	30000 - 34999\$	35000\$ and over	Total	
Aylmer	1075	940	1715	1970	1080	2755	9535	26430
Hull	2775	3700	5120	4550	1870	3505	21520	20992
Gatineau	3325	3150	5495	6720	3225	5755	27670	23570
Buckingham	420	430	745	590	310	525	3020	21194
Masson	205	195	395	390	215	280	1680	21442
All males in CUO area	7800	8415	13470	14220	6700	12820	63425	22956

City	Females 15 years and over in income class							Females' Average income(\$)
	<5000\$	5000 - 9999\$	10000 - 19999\$	20000 - 29999\$	30000 - 34999\$	35000\$ and over	Total	
Aylmer	2005	1565	2090	1835	490	570	8555	15325
Hull	4310	5465	5960	3890	840	1055	21520	14068
Gatineau	5385	5140	6455	5180	1130	900	24190	14251
Buckingham	670	780	615	405	85	75	2630	11940
Masson	260	300	350	285	25	20	1240	12901
All females in CUO	12630	13250	15470	11595	2570	2620	58135	14208

APPENDIX C: (continued)

Income characteristics in CUO area in 1991								
City	Number of households in income class							Average household income(\$)
	<10000	10000 - 19999	20000 - 29999	30000 - 39999	40000 - 49999	50000 and over	Total	
Aylmer	490	925	985	1210	1270	5720	10600	57569
Hull	2995	4475	4235	3515	3140	8350	26710	41062
Gatineau	2450	2920	3500	4025	4360	14980	32235	50156
Buckingham	370	555	545	565	480	1405	3920	43671
Masson	150	235	255	305	305	750	2000	45143
All private household in CUO	6455	9110	9520	9620	9555	31205	75465	47509

City	Males 15 years and over in income class							Males' average income(\$)
	<5000\$	5000 - 9999\$	10000 - 19999\$	20000 - 29999\$	30000 - 39999\$	40000\$ and over	Total	
Aylmer	1015	830	1485	1775	1880	3930	10915	34650
Hull	1785	2575	4920	4510	3795	5160	22745	28327
Gatineau	2835	2785	4935	6555	6635	9060	32805	30438
Buckingham	230	350	775	730	810	765	3660	28707
Masson	140	170	400	510	385	460	2065	28303
All males in CUO area	6005	6710	12515	14080	13505	19375	72190	30261

City	Females 15 years and over in income class							Females' average income(\$)
	<5000\$	5000 - 9999\$	10000 - 19999\$	20000 - 29999\$	30000 - 39999\$	40000\$ and over	Total	
Aylmer	1610	1490	2385	2000	1815	1380	10680	22192
Hull	2895	4495	6420	4675	3035	2265	23785	19552
Gatineau	4265	5230	7120	6790	4905	2870	31180	20120
Buckingham	525	765	945	720	325	345	3625	18575
Masson	265	285	495	495	185	80	1805	18150
All females in CUO	9560	12265	17365	14680	10265	6940	71075	20112

APPENDIX C: (continued)

Income characteristics in CUO area in 1996								
City	Number of households in income class							Average household income(\$)
	<10000\$	10000 - 19999\$	20000 - 29999\$	30000 - 39999\$	40000 - 49999\$	50000\$ and over	Total	
Aylmer	660	1165	950	1355	1505	6355	11990	58277
Hull	3475	5030	3845	3715	3120	9210	28395	42262
Gatineau	3020	4295	3445	4350	4625	16730	36465	50329
Buckingham	540	580	585	525	460	1715	4405	44413
Masson	170	350	280	405	395	1245	2845	47249
All private household in CUO	7865	11420	9105	10350	10105	35255	84100	48324
City	Males 15 years and over in income class							Males' average income(\$)
	<5000\$	5000 - 9999\$	10000 - 19999\$	20000 - 29999\$	30000 - 39999\$	40000\$ and over	Total	
Aylmer	1480	855	1615	1690	1780	4500	11920	35110
Hull	2790	2860	4790	3650	3160	5935	23185	28058
Gatineau	3935	3285	5850	5245	5855	11425	35595	30663
Buckingham	440	380	685	675	575	1205	3960	30316
Masson	260	290	445	405	555	865	2820	29589
All males in CUO area	8905	7670	13385	11665	11925	23930	77480	30511
City	Females 15 years and over in income class							Females' average income(\$)
	<5000\$	5000 - 9999\$	10000 - 19999\$	20000 - 29999\$	30000 - 39999\$	40000\$ and over	Total	
Aylmer	1705	1415	2515	1955	1925	2230	11745	24113
Hull	3315	3560	6625	3955	3395	4070	24920	22380
Gatineau	5525	5020	8180	6115	5975	4435	35250	21243
Buckingham	655	715	1025	715	475	415	4000	19001
Masson	375	335	650	680	370	185	2595	19552
All females in CUO	11575	11045	18995	13420	12140	11335	78510	21863

Appendix D_95b: Modal split macro for Base scenario in 1995

```
~/ ms_all95.mac %1% %2% modal split model from 95 model calibration
~/ macro name is mode_sp.mac
~/ UTA WORK TRIPS LOGIT.MODEL -- Macro to run Logit Modal Split Model
~/ for PM Work Trips in UTA
~/ Developed by M. Campbell April/98
~/ Modified by Petar Grubor, March 2000
~/ Create (update existing) matrices of:
~/ 1. Auto Person (mf31)
~/ 2. Auto Vehicles (mf32)
~/ 3. Transit Passenger (mf33)
~/ matrices
~/
~o=32
reports=ms_all.txt
~/ Make assemble:gu0=external zones, gu1=uta zones, gu2=outside UTA zones.
3.01
2
1
gu0
186,200

gu1
1,131
134
136
142,145
148,176
178,180
201,211
216,226
231,258

gu2
132,133
135
137,141
146,147
177
181,185
212,215
227,230

/
q

~/ ***** Interzonal Trips - Inside UTA - Work
~/ Step 2: calculate transit modal demand, 0 vehicle homes.
~/ note: still in module 3.21
3.21
1
y
mf33
```

```

y
%1%
%2% Transit Work Trips UTA
y
0
mf33+mf25*md45*(exp(-.009624*(mf14)-
.864061*mf18-.836664*mf17*md20+.909063)/
(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(2)))+ exp(-.009624*(mf14)-
.864061*mf18-.836664*mf17*md20+.909063)))

mf16
l,l,ex
y
gul

gul

l
~/ Now do for 1 vehicle per home
l
l
y
mf33
n
mf33+mf25*md46*(exp(-.009624*(mf14)-.864061*mf18-
.836664*mf17*md20-1.73766+.909063) /
(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(1+.34*(.249-.00259*mf3))))+ exp(-.009624*(mf14)-.864061*mf18-
.836664*mf17*md20-1.73766+.909063)))

mf16
l,l,ex
y
gul

gul

l
~/ Now do for 2+ vehicles per home
l
l
y
mf33
n
mf33+mf25*md47*(exp(-.009624*(mf14)-.864061*mf18-
2*1.73766-.836664*mf17*md20+.909063)/
(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(i+.17*(.249-.00259*mf3))))+ exp(-.009624*(mf14)-.864061*mf18-2*1.73766-
.836664*mf17*md20+.909063)))

mf16
l,l,ex
y
gul

```

```

gul

l
l
~/ Now do modal split equation for auto, 0 vehicles in home.
l
y
mf3l
y
%1%
%2% Auto Person Work Trips UTA
y
0
mf3l+mf25*md45*(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(2))/
(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(2))+ exp(-.009624*(mf14)-
.864061*mf18-.836664*mf17*md20+.909063)))

mf16
l,l,ex
y
gul

gul

l
~/ Now do for auto person mode, 1 vehicle per home.
l
l
y
mf3l
n
mf3l+mf25*md46*(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(1+.34*(.249-.00259*mf3)))/
(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(1+.34*(.249-.00259*mf3)))+exp(-.009624*(mf14)-.864061*mf18-
.836664*mf17*md20-1.73766+.909063)))

mf16
l,l,ex
y
gul

gul

l
l
~/ Now do for auto person mode, 2+ vehicles per home.
l
y
mf3l
n
mf3l+mf25*md47*(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(1+.17*(.249-.00259*mf3)))/
(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/

```

```
(1+.17*(.249-.00259*mf3)))+
exp(-.009624*(mf14)-.864061*mf18-2*1.73766-
.836664*mf17*md20+.909063)))
```

```
mf16
l,l,ex
y
gul
```

```
gul
```

```
l
l
~/ Step _ Calculate auto vehicle trips.
l
y
mf32
y
%1%
%2% Auto Vehicle Work Trips UTA
y
0
mf31/(1.04*(1.249-.00259*mf3))
```

```
mf16
l,l,ex
y
gul
```

```
gul
```

```
l
l
q
~/ ***** Interzonal mode split "Other Trips" inside UTA.
~/ Do for origins and destinations within UTA.
~/ If outside UTA, ratio equals 0.
~/
~/ Step 1A -- Calculate ratio of auto to transit times (mf15=mf2/mf14)
~/ reports=other_sp.txt
3.21
l
y
mf15
y
%1%
%2% Auto/Transit Time Ratio
y
0
mf2/mf14

mf14
0,0,exclude
y
gul
```



```

gul

2
~/ Step 1B -- Set limits to mf15 (0.le.mf1 5.le.1)
~/
~/ Input: mf15 (auto / transit time ratio)
~/ mf28 (simulated Other-Home O-D)
~/ mf30 (simulated Leave-Home O-D)
~/
~/ Step 2: Create Modal Split Factor matrix (mf20)
~/
~/ times 0 to 15 min.
~/ auto person
l
y
mf20
y
%1%
%2% Other Trips mode split factors
y
0
(-.26*mf15+1.052) .min. 1 .max. .85

mf2
0,15,in
n
2
~/ auto time 15 plus
l
y
mf20
n
(-.249*mf15+1.071) .min. 1 .max. .90

mf2
15,99999,in
n
2
~/Calculate trips by mode.
l
y
mf4l
y
%1%
%2% Auto Persons Other Trips UTA
y
0
(mf28+mf29+mf30)*mf20

mf16
l,1,ex
y
gul

gul

```

```

2
~/ auto vehicles
1
y
mf42
y
%1%
%2% Auto Vehicles Other Trips UTA
y
0
mf41/(1.04*(1.25+.001186*mf3))

mf16
l,l,ex
y
gul

gul

2
~/ transit
1
y
mf43
y
%1%
%2% Transit Other Trips UTA
y
0
(mf28+mf29+mf30)*(1-mf20)

mf16
l,l,ex
y
gul

gul

2
q
~/ *****Interzonal Mode split - School Inside UTA.
~/ mode split model school trips in UTA
~/ reports=ms_sch.txt
3.21
1
y
mf38
y
%1%
%2% Transit School Trips UTA
y
0
mf38+(mf26+mf27)*md48*(exp(-.092608*(mf7+mf8+mf10)-
.526521*mf17*md20+2.84939)/
(1+ exp(-.092608*(mf7+mf8+mf10)-
.526521*mf17*md20+2.84939)))

```

```

mf16
l,l,ex
y
gul

gul

2
~/ Now do for 1 vehicle per home
l
y
mf38
n
mf38+(mf26+mf27)*md49*(exp(-.092608*(mf7+mf8+mf10)-
.526521*mf17*md20-1.08305*1+2.84939)/
(1+ exp(-.092608*(mf7+mf8+mf10)-
.526521*mf17*md20-1.08305*1+2.84939))))

mf16
l,l,ex
y
gul

gul

2
~/ Now do for 2+ vehicles per home
l
y
mf38
n
mf38+(mf26+mf27)*md50*(exp(-.092608*(mf7+mf8+mf10)-
.526521*mf17*md20-1.08305*2+2.84939)/
(1+ exp(-.092608*(mf7+mf8+mf10)-
.526521*mf17*md20-1.08305*2+2.84939))))

mf16
l,l,ex
y
gul

gul

2
~/ Now do modal split equation for auto, 0 vehicles in home.
l
y
mf36
y
%1%
%2% Auto Person School trips UTA
y
0
mf36+(mf26+mf27)*md48*(1/
(exp(-.092608*0)+ exp(-.092608*(mf7+mf8+mf10)-

```

.526521*mf17*md20+2.84939)))

mf16
l,l,ex
y
gul

gul

2
~/ Now do for auto person mode, 1 vehicle per home.

l
y
mf36
n
$$\text{mf36} + (\text{mf26} + \text{mf27}) * \text{md49} * (1 / (\exp(-.092608 * 0) + \exp(-.092608 * (\text{mf7} + \text{mf8} + \text{mf10}) - .526521 * \text{mf17} * \text{md20} - 1.08305 * 1 + 2.84939)))$$

mf16
l,l,ex
y
gul

gul

2
~/ Now do for 2+ veh/hh persons Ontario residents

l
y
mf36
n
$$\text{mf36} + (\text{mf26} + \text{mf27}) * \text{md50} * (1 / (\exp(-.092608 * 0) + \exp(-.092608 * (\text{mf7} + \text{mf8} + \text{mf10}) - .526521 * \text{mf17} * \text{md20} - 1.08305 * 2 + 2.84939)))$$

mf16
l,l,ex
y
gul

gul

2
l
~/ Step _ Calculate auto vehicle School trips.

y
mf37
y
%1%
%2% Auto Vehicle School Trips UTA
y
0
$$\text{mf36} / (1.04 * (3.67 - .7481 * \ln(\text{mf3})))$$

mf3

```

0,0,ex
y
gul

gul

2
l
q
~/ *****interzonal trips outside UTA
~/ reports=out_wk_o.txt
3.2l
l
y
mf46
y
%1%
%2% Auto Person Work Trips Non-UTA
y
0
mf25

mf16
l,l,ex
y
*
gu2

2
l
y
mf47
y
%1%
temp
y
0
mf25

mf16

y
gu2

*
2
l
y
mf46
n
mf46+mf47

n
2
l

```

y
mf47
y
%1%
%2% Auto Veh. Work Trips Non-UTA
y
0
 $mf46/(1.04*(1.071+.00275*mf3))$

mf46
0,0,ex
n
2
q
~/ reports=out_sc_o.txt
3.21
l
y
mf48
y
%1%
%2% Auto Person Sch. Trips NON-UTA
y
0
mf26+mf27

mf16
l,l,ex
y
*
gu2

2
l
y
mf49
y
%1%
temp
y
0
mf26+mf27

mf16

y
gu2

*
2
l
y
mf48
n
mf48+mf49

n
2
l
y
mf49
y
%1%
%2% Auto veh. School Trips NON-UTA
y
0
mf48/3

n
2
q
~/reports=out_ot_o.txt
3.21
l
y
mf50
y
%1%
%2% Auto Person Other Trips NON-UTA
y
0
mf28+mf29+mf30

mf16
l,l,ex
y
*
gu2

2
l
y
mf51
y
%1%
temp
y
0
mf28+mf29+mf30

mf16

y
gu2

*
2
l
y
mf50

n
mf50+mf51

n
2
1
y
mf51
y
%1%
%2% Auto Vehicle Other Trip Non-UTA
y
0
$$mf50/(1.04*(1.296-.00187*mf3))$$

mf50
0,0,ex
n
2
q
~/ calculate the total number of Intrazonal trips and save results.
~/ intra.mac intrazonal travel demand macro.
~/ reports=intra.txt
3.21
1
y
mf53
y
%1%
%2% Auto Vehicle Trips- Intrazonal
y
0
$$(mf25+mf26+mf27+mf28+mf29+mf30)*(mf16*(mo-55/mo57))$$

mo57

n
2
1
y
mf52
y
%1%
%2% Auto Person Trips Intrazonal
y
0
$$(mf25+mf26+mf27+mf28+mf29+mf30)*(mf16*mo55)$$

n
2
1
y
mf54
y


```

%1%
%2% Transit Trips Intrazonal
y
0
(mf25+mf26+mf27+mf28+mf29+mf30)*(mf16*mo56)

```

```

n
2
~/ Calculate total trip matrices
l
y
mf57
y
%1%
%2% Auto Person Total Trips
y
0
mf31+mf46+mf52+mf36+mf48+mf41+mf50+mf55*1.2

```

```

n
2
l
y
mf58
y
%1%
%2% Auto Vehicles Total Trips
y
0
mf32+mf47+mf53+mf37+mf49+mf42+mf51+mf55

```

```

n
2
l
y
mf59
y
%1%
%2% Transit Total Trips
y
0
mf33+mf54+mf38+mf43

```

```

n
2
q
~/ end of Macro

```

Appendix D_21b: Modal split macro for Base scenario in 2021

```
~/ ms_all21.mac %1% %2% modal split model from 2021 model run
~/ this macro has different UTA area , see gul.
~/ macro name is mode_sp.mac
~/ UTA WORK TRIPS LOGIT.MODEL -- Macro to run Logit Modal Split Model
~/ for PM Work Trips in UTA
~/ Developed by M. Campbell April/98
~/ Modified by Petar Grubor, March 2000
~/ Create (update existing) matrices of:
~/ 1. Auto Person (mf31)
~/ 2. Auto Vehicles (mf32)
~/ 3. Transit Passenger (mf33)
~/ matrices
~/
~o=32
reports=ms_all.txt
~/ Make assemble:gu0=external zones, gul=uta zones, gu2=outside UTA zones.
3.01
2
1
gu0
186,200

gul
1,131
134,137
140
142,181
201,227
229
231,258

gu2
132,133
138,139
141
182,185
228
230

/
q

~/ ***** Interzonal Trips - Inside UTA - Work
~/ Step 2: calculate transit modal demand, 0 vehicle homes.
~/ note: still in module 3.21
3.21
1
y
mf33
y
%1%
%2% Transit Work Trips UTA
y
0
```

```
mf33+mf25*md45*(exp(-.009624*(mf14)-
.864061*mf18-.836664*mf17*md20+.909063)/
(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(2))+ exp(-.009624*(mf14)-
.864061*mf18-.836664*mf17*md20+.909063)))
```

```
mf16
l,l,ex
y
gul
```

```
gul
```

```
l
~/ Now do for 1 vehicle per home
```

```
l
l
y
mf33
n
mf33+mf25*md46*(exp(-.009624*(mf14)-.864061*mf18-
.836664*mf17*md20-1.73766+.909063) /
(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(1+.34*(.249-.00259*mf3)))+ exp(-.009624*(mf14)-.864061*mf18-
.836664*mf17*md20-1.73766+.909063)))
```

```
mf16
l,l,ex
y
gul
```

```
gul
```

```
l
~/ Now do for 2+ vehicles per home
```

```
l
l
y
mf33
n
mf33+mf25*md47*(exp(-.009624*(mf14)-.864061*mf18-
2*1.73766-.836664*mf17*md20+.909063)/
(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(1+.17*(.249-.00259*mf3)))+ exp(-.009624*(mf14)-.864061*mf18-2*1.73766-
.836664*mf17*md20+.909063)))
```

```
mf16
l,l,ex
y
gul
```

```
gul
```

```
l
l
~/ Now do modal split equation for auto, 0 vehicles in home.
```

```

l
y
mf3l
y
%1%
%2% Auto Person Work Trips UTA
y
0
mf3l+mf25*md45*(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(2))/
(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(2))+ exp(-.009624*(mf14)-
.864061*mf18-.836664*mf17*md20+.909063)))

```

```

mf16
l,l,ex
y
gul

```

```

gul

```

```

l
~/ Now do for auto person mode, 1 vehicle per home.

```

```

l
l
y
mf3l
n
mf3l+mf25*md46*(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(1+.34*(.249-.00259*mf3)))/
(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(1+.34*(.249-.00259*mf3)))+exp(-.009624*(mf14)-.864061*mf18-
.836664*mf17*md20-1.73766+.909063)))

```

```

mf16
l,l,ex
y
gul

```

```

gul

```

```

l
l
~/ Now do for auto person mode, 2+ vehicles per home.

```

```

l
y
mf3l
n
mf3l+mf25*md47*(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(1+.17*(.249-.00259*mf3)))/
(exp(-.009624*mf2-.864061*(mf3*.05+mf17*mo1)/
(1+.17*(.249-.00259*mf3)))+
exp(-.009624*(mf14)-.864061*mf18-2*1.73766-
.836664*mf17*md20+.909063)))

```

```

mf16

```

```

1,1,ex
y
gul

gul

1
1
~/ Step _ Calculate auto vehicle trips.
1
y
mf32
y
%1%
%2% Auto Vehicle Work Trips UTA
y
0
mf31/(1.04*(1.249-.00259*mf3))

mf16
1,1,ex
y
gul

gul

1
1
q
~/ ***** Interzonal mode split "Other Trips" inside UTA.
~/ Do for origins and destinations within UTA.
~/ If outside UTA, ratio equals 0.
~/
~/ Step 1A -- Calculate ratio of auto to transit times (mf15=mf2/(mf14))
~/ reports=other_sp.txt
3.21
1
y
mf15
y
%1%
%2% Auto/Transit Time Ratio
y
0
mf2/(mf14)

mf14
0,0,exclude
y
gul

gul

2
~/ Step 1B -- Set limits to mf15 (0.le.mf15.le.1)
~/

```

```

~/ Input: mf15 (auto / transit time ratio)
~/      mf28 (simulated Other-Home O-D)
~/      mf30 (simulated Leave-Home O-D)
~/
~/ Step 2: Create Modal Split Factor matrix (mf20)
~/
~/ times 0 to 15 min.
~/ auto person
1
y
~/ regression factors increased to account
~/ for more transit trips for other to home.
mf20
y
%1%
%2% Other Trips mode split factors
y
0
(-.26*mf15+1.027) .min. 1 .max. .85

mf2
0,15,in
n
2
~/ auto time 15 plus
1
y
mf20
n
(-.249*mf15+1.05) .min. 1 .max. .90

mf2
15,99999,in
n
2
~/Calculate trips by mode.
1
y
mf41
y
%1%
%2% Auto Persons Other Trips UTA
y
0
(mf28+mf29+mf30)*mf20

mf16
1,1,ex
y
gul

gul

2
~/ auto vehicles
1

```

```

y
mf42
y
%1%
%2% Auto Vehicles Other Trips UTA
y
0
mf41/(1.04*(1.25+.001186*mf3))

mf16
l,l,ex
y
gul

gul

2
~/ transit
l
y
mf43
y
%1%
%2% Transit Other Trips UTA
y
0
(mf28+mf29+mf30)*(1-mf20)

mf16
l,l,ex
y
gul

gul

2
q
~/ *****Interzonal Mode split - School Inside UTA.
~/ mode split model school trips in UTA
~/ reports=ms_sch.txt
3.21
l
y
mf38
y
%1%
%2% Transit School Trips UTA
y
0
mf38+(mf26+mf27)*md48*(exp(-.092608*(mf7+mf8+mf10)-
.526521*mf17*md20+2.84939)/
(1+ exp(-.092608*(mf7+mf8+mf10)-
.526521*mf17*md20+2.84939)))

mf16
l,l,ex

```

```

y
gul

gul

2
~/ Now do for 1 vehicle per home
l
y
mf38
n
mf38+(mf26+mf27)*md49*(exp(-.092608*(mf7+mf8+mf10)-
.526521*mf17*md20-1.08305*1+2.84939)/
(1+ exp(-.092608*(mf7+mf8+mf10)-
.526521*mf17*md20-1.08305*1+2.84939))))

mf16
l,l,ex
y
gul

gul

2
~/ now do for 2+ vehicles per home
l
y
mf38
n
mf38+(mf26+mf27)*md50*(exp(-.092608*(mf7+mf8+mf10)-
.526521*mf17*md20-1.08305*2+2.84939)/
(1+ exp(-.092608*(mf7+mf8+mf10)-
.526521*mf17*md20-1.08305*2+2.84939))))

mf16
l,l,ex
y
gul

gul

2
~/ Now do modal split equation for auto, 0 vehicles in home.
l
y
mf36
y
%1%
%2% Auto Person School trips UTA
y
0
mf36+(mf26+mf27)*md48*(1/
(exp(-.092608*0)+ exp(-.092608*(mf7+mf8+mf10)-
.526521*mf17*md20+2.84939))))

mf16

```



```

l,l,ex
y
gul

gul

2
~/ Now do for auto person mode, 1 vehicle per home.
l
y
mf36
n
mf36+(mf26+mf27)*md49*(1/
(exp(-.092608*0)+ exp(-.092608*(mf7+mf8+mf10)-
.526521*mf17*md20-1.08305*1+2.84939)))

mf16
l,l,ex
y
gul

gul

2
~/ Now do for 2+ veh/hh persons Ontario residents
l
y
mf36
n
mf36+(mf26+mf27)*md50*(1/
(exp(-.092608*0)+ exp(-.092608*(mf7+mf8+mf10)-
.526521*mf17*md20-1.08305*2+2.84939)))

mf16
l,l,ex
y
gul

gul

2
l
~/ Step _ Calculate auto vehicle School trips.
y
mf37
y
%1%
%2% Auto Vehicle School Trips UTA
y
0
mf36/(1.04*(3.67-.7481*ln(mf3)))

mf3
0,0,ex
y
gul

```

```

gul
2
l
q
~/ *****interzonal trips outside UTA
~/ reports=out_wk_o.txt
3.21
l
y
mf46
y
%1%
%2% Auto Person Work Trips Non-UTA
y
0
mf25

mf16
l,l,ex
y
*
gu2

2
l
y
mf47
y
%1%
temp
y
0
mf25

mf16

y
gu2

*
2
l
y
mf46
n
mf46+mf47

n
2
l
y
mf47
y

```

```

%1%
%2% Auto Veh. Work Trips Non-UTA
y
0
mf46/(1.04*(1.071+.00275*mf3))

mf46
0,0,ex
n
2
q
~/reports=out_sc_o.txt
3.21
l
y
mf48
y
%1%
%2% Auto Person Sch. Trips NON-UTA
y
0
mf26+mf27

mf16
l,l,ex
y
*
gu2

2
l
y
mf49
y
%1%
temp
y
0
mf26+mf27

mf16

y
gu2

*
2
l
y
mf48
n
mf48+mf49

n
2

```

l
y
mf49
y
%1%
%2% Auto veh. School Trips NON-UTA
y
0
mf48/3

n
2
q
~/ reports=out_ot_o.txt
3.21
l
y
mf50
y
%1%
%2% Auto Person Other Trips NON-UTA
y
0
mf28+mf29+mf30

mf16
l,l,ex
y
*
gu2

2
l
y
mf51
y
%1%
temp
y
0
mf28+mf29+mf30

mf16

y
gu2

*
2
l
y
mf50
n
mf50+mf51

```

n
2
1
y
mf51
y
%1%
%2% Auto Vehicle Other Trip Non-UTA
y
0
mf50/(1.04*(1.296-.00187*mf3))

mf50
0,0,ex
n
2
q
~/ Calculate the total number of Intrazonal trips and save results.
~/ intra.mac intrazonal travel demand macro.
~/ reports=intra.txt
3.21
1
y
mf53
y
%1%
%2% Auto Vehicle Trips- Intrazonal
y
0
(mf25+mf26+mf27+mf28+mf29+mf30)*(mf16*(mo55/mo57))

mo57

n
2
1
y
mf52
y
%1%
%2% Auto Person Trips Intrazonal
y
0
(mf25+mf26+mf27+mf28+mf29+mf30)*(mf16*mo55)

n
2
1
y
mf54
y
%1%
%2% Transit Trips Intrazonal
y

```

```
0
(mf25+mf26+mf27+mf28+mf29+mf30)*(mf16*mo56)
```

```
n
2
~/ Calculate total trip matrices
1
y
mf57
y
%1%
%2% Auto Person Total Trips
y
0
mf31+mf46+mf52+mf36+mf48+mf41+mf50+mf55*1.2
```

```
n
2
1
y
mf58
y
%1%
%2% Auto Vehicles Total Trips
y
0
mf32+mf47+mf53+mf37+mf49+mf42+mf51+mf55
```

```
n
2
1
y
mf59
y
%1%
%2% Transit Total Trips
y
0
mf33+mf54+mf38+mf43
```

```
n
2
q
~/ end of Macro
```

Appendix D_295: Macro that runs the TRANS model from "level2" for 1995

```
~/ level295.mac %1% %2% %3% %4% %5% %6% %7% %8%
~/ 1995 model run from trip distribution to assignment - 5 cycles.
~/
~/ %1% is matrix 6 letter or number ID
~/ %2% is run ID maximum 8 numbers or letters.
~/ %3% is the auto vehicle matrix for assignment
~/ %4% is the auto person trip matrix for assignment.
~/ %5% is the transit matrix for assignment.
~/ %6% is the max. iterations for auto assignment.
~/ %7% is the auto assig. relative gap
~/ %8% is the auto assig. normal gap.
~/ sample to run the macro would be as follows:
~/ ~<level295.mac 1995 pmpkhr 57 58 59 30 .4 .4
~/
~/ developed by Mark Campbell May 14/99
~/ first full cycle
~<tripdist.mac %1% %2%
~<ms_all95.mac %1% %2%
~<assign.mac %1% %2% %3% %4% %5% %6% %7% %8%
~/ second cycle
~<tripdist.mac %1% %2%
~<ms_all95.mac %1% %2%
~<assign.mac %1% %2% %3% %4% %5% %6% %7% %8%
~/ third cycle
~<tripdist.mac %1% %2%
~<ms_all95.mac %1% %2%
~<assign.mac %1% %2% %3% %4% %5% %6% %7% %8%
~/ fourth cycle
~<tripdist.mac %1% %2%
~<ms_all95.mac %1% %2%
~<assign.mac %1% %2% %3% %4% %5% %6% %7% %8%
~/ fifth and last cycle
~<tripdist.mac %1% %2%
~<ms_all95.mac %1% %2%
~<assign.mac %1% %2% %3% %4% %5% %6% %7% %8%
~<sum.odh %1%
```

Appendix D_221: Macro that runs the TRANS model from "level2" for 2021

```
~/ level221.mac %1% %2% %3% %4% %5% %6% %7% %8%
~/ 2021 model run from trip distribution to assignment - 5 cycles.
~/
~/ %1% is matrix 6 letter or number ID
~/ %2% is run ID maximum 8 numbers or letters.
~/ %3% is the auto vehicle matrix for assignment
~/ %4% is the auto person trip matrix for assignment.
~/ %5% is the transit matrix for assignment.
~/ %6% is the max. iterations for auto assignment.
~/ %7% is the auto assign. relative gap
~/ %8% is the auto assign. normal gap.
~/ sample to run the macro would be as follows:
~/ ~<level221.mac 1995 pmpkhr 57 58 59 30 .4 .4
~/
~/ developed by Mark Campbell May 14/99
~/ first full cycle
~<tripdist.mac %1% %2%
~<ms_all21.mac %1% %2%
~<assign.mac %1% %2% %3% %4% %5% %6% %7% %8%
~/ second cycle
~<tripdist.mac %1% %2%
~<ms_all21.mac %1% %2%
~<assign.mac %1% %2% %3% %4% %5% %6% %7% %8%
~/ third cycle
~<tripdist.mac %1% %2%
~<ms_all21.mac %1% %2%
~<assign.mac %1% %2% %3% %4% %5% %6% %7% %8%
~/ fourth cycle
~<tripdist.mac %1% %2%
~<ms_all21.mac %1% %2%
~<assign.mac %1% %2% %3% %4% %5% %6% %7% %8%
~/ fifth and last cycle
~<tripdist.mac %1% %2%
~<ms_all21.mac %1% %2%
~<assign.mac %1% %2% %3% %4% %5% %6% %7% %8%
~<sum.odh %1%
```


Appendix E: Main macro that calculates vehicle km traveled and link average speed

```
~# *****
~# This macro (VKM_PMPHR.mac) provides an interface between EMME/2 and Mobile5.
~# It is set up to calculate trip data in cases where the trip tables for
~# the analysis period are already stored in EMME/2. If multiple periods
~# are to be analyzed, the user should modify the macro accordingly
~#
~#
~# To call the macro, type: VKM_PMPHR.mac a b c d e f g h i j k l
~#     where  a = scenario number
~#            b = speed increment in km/hr; 999 for link by link analysis
~#            c = area variable -- name of macro to be used to compute link
~#              location, or the name of the link attribute containing the
~#              the relevant information
~#            d = link variable -- name of macro to be used to compute link
~#              type, or the name of the link attribute containing the
~#              relevant information
~#            e = auto vehicle trip table (including external trips)
~#            f = cold start trip table; "none" if operating mode is to be
~#              calculated from look-up tables based on link type and location
~#            g = "transit" if transit output is desired; name of extra link
~#              attribute containing vkt data to be output INSTEAD of transit
~#              data; 999 otherwise
~#            IMPORTANT: IF TRANSIT VKT IS DESIRED, A TRANSIT ASSIGNMENT
~#                      CORRESPONDING TO THE APPROPRIATE TIME PERIOD SHOULD
~#                      BE PERFORMED PRIOR TO USING THE EMISSION MACROS!!!!
~#            h = "background" traffic variable -- name of macro to be used to
~#              compute the background volume (after an initial assignment has
~#              been performed), "none" if the effect of background
~#              traffic is to be ignored, "transit" if only the effect of transit
~#              vehicles is to be considered, or the name of the link variable
~#              containing the relevant information
~#            i = number of regions to analyze
~#            j = number of link types to analyze
~#            k = type of analysis -- 1 if link by link, 2 if data is to be
~#              aggregated into categories
~#            l = output file extension (must be 3 consecutive characters or less)
~#
~#
~# PLEASE NOTE:
~#
~# If macros are used to compute the link location and type of link, the macro
~# must store the information in link attributes called @area and @link, respectively.
~# If a macro is used to calculate the background traffic volume, this volume should be
~# stored in ul1. Note that these macros must be based on information that is found
~# in the EMME/2 databank. Since the background traffic macro is run after the link
~# location and link type are computed, it can incorporate data stored in @area and
~# @link, if desired.
~#
~# Background traffic must be stored as passenger car units per link
~#
~# Since ul1, ul2, and ul3 are used during macro execution, all user-specified link
~# attributes (such as area, link type, and background traffic) MUST be stored in extra
~# link attributes of the form: @_____ (The field "typ" will not be recognized--if the
~# type of link is stored in this field, the data should be copied into an extra link
```

```

~# attribute)
~#
~# The number of transit vehicles per link can only be known if the databank contains
~# transit route information. Therefore, if transit routes have not been specified, "g"
~# should not be set to "transit". In addition, the calculation of background traffic
~# volumes should not require the use of transit headway information, and the "transit"
~# option should not be selected for "h". If transit routes HAVE been specified, the number
~# of transit vehicles per link will be stored in ul2 during macro execution (Note
~# that these values can then be used in any macro used to calculate background traffic
~# volumes, if desired).
~#
~# Note that transit route information can be used to compute background traffic volumes
~# even if data on transit VKT (and speed) is not desired. This situation might arise
~# if the user wishes to accurately model auto travel time, taking into account the effect
~# of transit vehicles, but does not require information on transit vehicle emissions.
~# In this situation, a transit assignment is not required before running the Emission
~# macros, although transit route information must be present in the database. However,
~# if transit VKT is not desired, then the link classification scheme should exclude all
~# transit-only links since travel time information will not be available for these links,
~# causing the Emission Calculator to fail.
~#
~# To compute the volume of transit vehicles using each link, (whether for background
~# traffic calculations or transit vkt calculations) headway information for each transit
~# route is used. A transit assignment is required to compute transit speeds on links
~# which exclude passenger vehicles. For this reason, a transit assignment MUST be
~# performed prior to running the Emission macros if transit emissions are desired. If a
~# valid auto speed exists for the link, the transit speed is assumed to be equal to the
~# auto speed. However, if a valid auto speed does not exist (i.e. because auto vehicles
~# are not permitted on the link), transit travel times are used from the transit
~# assignment. If a valid speed is still not obtained, the links will not be included in
~# the analysis, and should be excluded from the link classification scheme (i.e.
~# pedestrian-only links, "future" links, etc.) For obvious reasons, transit-only links
~# should not be lumped together with arterial/collector streets when performing an
~# aggregated link analysis. Not only do these links have different operating
~# characteristics, but average travel speeds would be based solely on the links allowing
~# automobile traffic.
~#
~# For option "g", an extra link attribute containing vkt data should only be specified
~# in special cases where commercial vehicle volumes are known on a link by link
~# basis, and are not based on averages which correspond to different link classifications.
~# If the volumes are based on averages, the averages can be specified in the Emission
~# Calculator and there is no need to output the data from EMME/2. However, if detailed
~# data is available, this option allows different vehicle classes to be analyzed more
~# accurately than if the volumes were averaged for different facility types. Since transit
~# vkt data is not output in this situation, the analysis must be repeated (and the
~# results added together) if transit output is desired as well.
~#
~# When performing an aggregated link analysis, weighted travel speeds are required.
~# For links which allow automobiles, the average travel speed is weighted by the amount
~# of passenger vehicle travel on each link. Background traffic (trucks and buses) is not
~# considered in the weighting process since its effect is likely to be negligible.
~# For transit only links, the average travel speed is weighted by the amount of transit
~# travel on each link.
~#
~#
~# When specifying the link location, the following naming convention should be used:

```

```

~#          1 = area 1
~#          2 = area 2
~#          etc
~#
~# When specifying the type of link, the following naming convention should be used:
~#          1 = link type 1
~#          2 = link type 2
~#          etc
~#
~# If there is only one region (or link type) to analyze, set i (or j) equal to 1.
~# For the macro to work properly, the links must still be classified by using a macro or
~# storing the information in an extra attribute. In this case, the links to be output
~# should all be assigned a value of 1.
~#
~# To omit certain links from the analysis (i.e. transit-only links, future roads, etc.),
~# exclude them from the link classification scheme. This can be accomplished by assigning
~# them a value of 0 (or any other number greater than the number of link categories). It
~# is extremely important that all links which will have invalid travel time data be
~# excluded from the output. For example, if some links are tagged for future construction
~# by setting the travel time equal to infinity during the assignment process, these roads
~# should be assigned a classification of 0 to exclude them from the analysis. It should
~# be emphasized that roads which do not allow cars, such as pedestrian or transit-only
~# links, will have invalid auto travel times. Pedestrian-only links should not be included
~# in the analysis. Transit-only links should be included only if "transit" is specified for
~# option g (i.e. transit vkt is desired). In this case, transit travel times are used in
~# the calculation of travel speed, requiring a transit assignment to be performed prior to
~# running the Emission macros, as discussed previously.
~#
~# It should be noted that the user does not have the option of specifying which transit
~# vehicles should be included in the analysis (if transit vkt are to be computed). However,
~# careful selection of the link classification scheme will enable the user to know with
~# certainty the type of transit vehicle that the transit vkt corresponds to. For
~# example, if light rail, subway, and bus systems exist within an urban area, the link
~# classification scheme should include light rail and subway classifications. Any transit
~# vkt on a link classified as "light rail" would correspond to light rail transit vehicles.
~# Any transit vkt on a link classified as arterial would correspond to bus vehicles, etc.
~#
~# The number of link type and location categories depends on the level of detail
~# required for computing background traffic volumes, operating mode fractions, and
~# emissions. Based on these requirements, an appropriate scheme should be selected
~# that will work in ALL cases.
~#
~# The file "trvldata.out" must not previously exist, otherwise, the macro will
~# append data to the bottom of this file, rather than create a new file! This in turn
~# will cause the Emission Calculator to fail.
~#
~# Please be aware that the macro will over-write the following:
~#   * ul1, ul2 and ul3
~#   * @start, @speed (also @area and @link if link location and type is
~#     computed using a macro)
~#   * mf: 61, 70
~#   * ms90
~#
~# The following macros are called by the main macro:
~#   al.mac

```

```

~#      a2.mac
~#      a3.mac
~#      a4.mac
~#      speed.mac
~#      rprtl a.mac
~#      rprtl b.mac
~#
~#
~# Developed by Jennifer Armstrong, January 2000
~# Modified by Petar Grubor, March 2000
~#
~# *****
~# Declare variables

~# r11 = region index
~# r12 = road classification index
~# r13 = total number of regions to analyze
~# r14 = total number of regions to analyze plus one
~# r15 = number of link types to analyze
~# r16 = number of link types to analyze plus one
~# r17 = operating mode variable (1 if look-up tables, 2 if assignment)
~# r18 = speed increment
~# r19 = minimum speed for speed category
~# r20 = maximum speed for speed category
~# r21 = additional vkt variable (1 if transit vkt, 2 if user-defined, 3 if none)
~# r75 = average speed
~# r76 = total vkt
~# r77 = start mode vkt
~# r78 = cold start vkt
~# r79 = transit vkt
~# ms90 = scalar matrix used to store results temporarily
~# t1 = output file extension (specified by user)
~# t2 = temporary variable
~# t3 = temporary variable
~# t5 = name of the attribute describing the link location
~# t6 = name of the attribute describing the type of link
~# t7 = matrix containing full trip table
~# t8 = matrix containing cold start trip table
~# t9 = name of link attribute containing additional vkt data to be output

~# *****
~# Initialize variables

reports=nul
~o=32

~r11=0
~r12=0
~r13=%9%
~r14=%r13%
~r14+1
~r15=%10%
~r16=%r15%
~r16+1
~r17=0

```

```

~r18=%2%
~r19=0
~r20=0
~r21=0
~r75=0
~r76=0
~r77=0
~r78=0
~r79=0
~t1=%12%
~t7=%5%
~t8=%6%
~t9=%7%

~?t8=none
~r17=1
~?!t8=none
~r17=2

~?t9=transit
~r21=1
~?t9=999
~r21=3
~?r21=0
~r21=2

~# *****
~# Set current scenario

s=%1%

~# *****
~# Ensure that switch 22 is set to off (no engineering notation allowed!)

off=22

~# *****
~# Prepare scenario for analysis
~# Determine which extra link attributes already exist. Create new link
~# attributes where necessary.

~# Create @speed
2.42
2
2
@speed
~?e
~$ Create @error2
Average Travel Speed
0
q
~$ Create @error

~: Create @error
2.42

```

```

2
2
@error
~?e
~$ Create @start2
Link Error Code
0
q
~$ Create @start

~: Create @error2
@error
~?e
~$ Create @start2
Link Error Code
0
q
~$ Create @start

~: Create @start
2.42
2
2
@start
~?e
~$ Stop2
VKT - Start Mode
0
q
~$ Stop

~: Create @start2
@start
~?e
~$ Stop2
VKT - Start Mode
0
q

~: Stop2

q

~: Stop

~# *****
~# Initialize @error

2.41
l
y
@error
n
999999

```

```

*
2
1
q

~# *****
~# If transit routes have been specified in the databank, compute the
~# transit volume using each link

~# Initialize UI2 to 0 -- Will be used to store hourly transit volumes
2.41
1
y
ul2
0

*
2
1
q

~# Compute the hourly transit volume using each link
2.41
1
y
ul2
60/hdwy
~?e
~$ End of Transit Vehicle Calculation

4
*
*
2
1
q

~: End of Transit Vehicle Calculation

~# *****
~# Call macro to define analysis regions, if required. If a macro is used,
~# the location code for each link MUST be stored in @area.

~t2=%3%
~t3=%t2_1%

~?t3=@
~t5=%3%
~?t3=@
~$ End of Analysis Region Calculation

~# Create @area

```

```

2.42
2
2
@area
~?e
~$ Initialize @area
Link Location
0
q
~$ End Creating @area

```

```

~: Initialize @area

```

```

q
2.41
l
y
@area
n
0
*
2
l
q

```

```

~: End Creating @area

```

```

~< %t2%
~t5=@area

```

```

~: End of Analysis Region Calculation

```

```

~# *****
~# Call macro to define link types, if required. If a macro is used,
~# the link type code for each link MUST be stored in @link.

```

```

~t2=%4%
~t3=%t2_1%

```

```

~?t3=@
~t6=%4%
~?t3=@
~$ End of Link Type Calculation

```

```

~# Create @link

```

```

2.42
2
2
@link

```



```

~?e
~$ Initialize @link
Type of Link
0
q
~$ End Creating @link

```

```

~: Initialize @link

```

```

q
2.4l
l
y
@link
n
0
*
2
l
q

```

```

~: End Creating @link

```

```

~< %t2%
~t6=@link

```

```

~: End of Link Type Calculation

```

```

~# *****
~# Assign traffic volume without background traffic

```

```

~<a1.mac %t7% %t8%

```

```

~# *****
~# Initialize ul1 to 0 (will be used to store background traffic volumes)

```

```

2.4l
l
y
ul1
0
*
2
l
q

```

```

~# *****
~# If required, compute background traffic volume

```

```

~t2=%8%
~t3=%t2_1%

~?t2=none
~$ End of Background Traffic Computation

~?t3=@
~$ Move background traffic from user-defined attribute to ul1

~?t2=transit
~$ Compute Transit Background Traffic Only

~<%t2%
~$ End of Background Traffic Computation

~: Move background traffic from user-defined attribute to ul1

```

```

2.41
l
y
ul1
%t2%

```

```

*
2
l

q

```

```

~$ End of Background Traffic Computation

~$ Compute Transit Background Traffic Only
~# Assume bus = 1.75 pcu

```

```

2.41
l
y
ul1
ul2*1.75

```

```

*
2
l

q

```

```

~$ End of Background Traffic Computation

~: End of Background Traffic Computation

```

```

~# *****
~# Assign traffic volume taking into account background traffic

```

```

~t2=%8%
~?!t2=none
~<a2.mac %t7% %t8%

~# Note that use of a2.mac will require batching function tables in and out

~# *****
~# Initialize UI3 to 0 -- Will be used to store link travel times

2.41
l
y
ul3
0

*
2
l
q

~# *****
~# Store travel time data

2.41
l
y
ul3
timau

*
2
l
q

~# *****
~# Assign trips in start mode to network

~<a3.mac %t7% %t8%

~# Note that use of a3.mac will require batching function tables in and out

~# *****
~# Initialize @start to 0 -- Will be used to store start mode VKT

2.41
l
y
@start
n
0

```

```

*
2
1
q

~# *****
~# Store start mode vkt

2.41
1
y
@start
n
volad*len

*
2
1
q

~# *****
~# Assign cold start trips to network (if desired)

~?r17=2
~< a4.mac %t7% %t8%

~# Note that use of a4.mac will require batching function tables in and out

~# *****
~# Call macro "speed.mac" to compute the average travel speed. This macro
~# can be modified by the user if post-processing of travel speeds is desired

~# speed.mac should begin by initializing @speed to 0!
~# For most links, speed is based on timau (computed by EMME/2 during assignment)
~# For transit-only links, speed should be based on timtr. For this reason,
~# a transit assignment must be performed prior to running the Emission macros
~# if transit travel data is desired. If transit VKT data is not required,
~# transit-only links should be excluded from the output (by excluding them from
~# the link classification scheme). In this situation, there is no need to compute
~# the speed for transit-only links.

~< speed.mac %r21%

~# *****
~# Compute VKT distribution (by trip length in minutes)
~# Note that the full trip matrix is specified by the user and stored in
~# variable t7; mf61 is the corresponding travel time matrix. Also note
~# that speed post-processing will NOT change the travel times used to
~# compute the trip length distribution

~# Intra-zonal trips are NOT included in the VKT distribution (travel time = 0)

```

```

~# Set output file name
reports=E2trip.%t1%

3.16
4
mf61
y
%t7%
n

0,50
10
2
q

~# *****
~# Decide which type of report to generate

~t2=%l1%

~?t2=1
~$ LINK BY LINK

~?t2=2
~$ AGGREGATED DATA

~# *****
~# Write data to output file -- Data aggregated into categories

~: AGGREGATED DATA

~>>trvldata.%t1%
~"Operating mode variable = %r17%
~"Additional vkt variable = %r21%
~"Number of link locations = %r13%
~"Number of link types = %r15%
~"
~"Area, Link, Avg Speed, Total-VKT, Start-VKT, Cold-VKT, Transit-VKT
~"
~>>

~< rpt1a.mac %t1% %t5% %t6% %t9% %r13% %r15% %r17% %r18% %r21%

~$ END WRITING TO OUTPUT FILE

~# *****
~# Write data to output file -- Link by link analysis

~: LINK BY LINK

~>>trvldata.%t1%
~"Operating mode variable = %r17%
~"Additional vkt variable = %r21%
~"Number of link locations = %r13%

```

```

~"Number of link types = %r15%
~"
~"
~"      Vehicle Kilometers Travelled
~"  Node ID      Area  Link Speed Total Start Cold Transit
~"
~>>

~< rpt1b.mac %t1% %t5% %t6% %t9% %r13% %r15% %r17% %r21%
~$ END WRITING TO OUTPUT FILE

~# *****

~: END WRITING TO OUTPUT FILE

q
q
q

```

Appendix E_1: Macro that allocates results per characteristic area in NCR

```
~# *****
~# This macro (region.mac) tags Emme/2 links according to their location. This macro
~# can be modified by the user to create different analysis regions as
~# desired. Note that the location of each link MUST be stored in @area.
~# To specify the location, the following numbering scheme should be used:
~#
~#     1st analysis region = 1
~#     2nd analysis region = 2
~#     and so on...
~#
~#
~# Created by: Jennifer Armstrong, January 2000
~# Modified by: Petar Grubor, March 2000
~# *****
~# This section should be used to document the numbering scheme selected (example for NCR)
~#
~#     1 = Core-RMOC
~#     2 = Urban-RMOC
~#     3 = Suburban-RMOC
~#     4 = Rural-RMOC
~#     5 = Core-OUTAOUAIS
~#     6 = Urban-OUTAOUAIS
~#     7 = Suburban-OUTAOUAIS
~#     8 = Rural-OUTAOUAIS
~#
~# In this macro, links are classified on the basis of their traffic analysis
~# zone, which is stored in @zone
~#
~# *****
~# Initialize @area

2.41
l
y
@area
n
0

*
2
1

q

~# *****
~# Core-RMOC

2.41
l
y
@area
n
```

l

@zone=1,25
@zone=201

2

l

q

~# *****
~# Urban-RMOC

2.41

l

y

@area

n

2

@zone=26,118
@zone=120,128
@zone=232,234

2

l

q

~# *****
~# Suburban-RMOC

2.41

l

y

@area

n

3

@zone=119
@zone=129,131
@zone=136
@zone=140
@zone=142,144
@zone=202,226
@zone=229
@zone=231
@zone=235,247

2

l

q

~# *****

~# Rural-RMOC

2.41

l

y

@area

n

4

@zone=132,135

@zone=137,139

@zone=141

@zone=145

@zone=190,200

@zone=227,228

@zone=230

2

l

q

~# *****

~# Core-OUTAOUAIS

2.41

l

y

@area

n

5

@zone=254

@zone=255

@zone=153,155

2

l

q

~# *****

~# Urban-OUTAOUAIS

2.41

l

y

@area

n

6

@zone=148,152

@zone=156,170

@zone=252,253

```

@zone=256,258

2
1

q

~# *****
~# Suburban-OUTAOUAIS

2.41
1
y
@area
n
7

@zone=171,176
@zone=178
@zone=248,251

2
1

q

~# *****
~# Rural-OUTAOUAIS

2.41
1
y
@area
n
8

@zone=146,147
@zone=177
@zone=179,189

2
1

q

~# *****
~# Return to main macro

```

Appendix E_2: Macro that allocates the results per link type in NCR

```
~# *****
~# This macro (linktype.mac) tags Emme/2 links according to the type of road. This macro
~# can be modified by the user to create different classification schemes
~# as desired. Note that the type of link must be stored in @link. To specify
~# the link type, the following numbering scheme should be used:
~#
~#     1st link type = 1
~#     2nd link type = 2
~#     and so on...
~#
~#
~# Created by Jennifer Armstrong, January 2000
~# Modified by Petar Grubor, March 2000
~#
~# *****
~# This section should be used to document the numbering scheme selected
~#
~#     1 = Local roads
~#     2 = Minor low speed roads
~#     3 = Minor high speed roads
~#     4 = Major low speed roads
~#     5 = Major high speed roads
~#     6 = Freeways and rural highways
~#     7 = Centroid connectors (no external zones)
~#     8 = transit-only links (vdf=70,79)
~#     0 = Links excluded from analysis
~#           roads not yet built - vdf=10
~#           pedestrian-only links
~#
~# In this macro, links are classified primarily on the basis of their
~# volume-delay function (which includes data on the link capacity and
~# posted speed limit)
~#
~# *****
~# Initialize @link

2.41
l
y
@link
n
0

*
2
1

q

~# *****
~# Local Roads

2.41
```

```

l
y
@link
n
l

vdf=20,29
and lan=0,1

2
l

q

~# *****
~# Minor_Low_Speed

2.4l
l
y
@link
n
2

vdf=31,36
or vdf=41,46

2
l

q

2.4l
l
y
@link
n
2

vdf=20,29
and lan=2,999

2
l

q

~# *****
~# Minor_High_Speed

2.4l
l
y
@link
n

```

3

vdf=37,39
or vdf=30
or vdf=47,49
or vdf=40

2

l

q

~# *****
~# Major_Low_Speed

2.4l

l

y

@link

n

4

vdf=51,56
or vdf=61,66

2

l

q

~# *****
~# Major_High_Speed

2.4l

l

y

@link

n

5

vdf=57,59
or vdf=50
or vdf=67,69
or vdf=60

2

l

q

~# *****
~# Freeways and Rural Highways

2.4l

l

y

```

@link
n
6

vdf=80,89
or vdf=90,99

2
1

q

~# *****
~# Centroid Connectors, No External Zones

2.41
1
y
@link
n
7

vdf=11,18

2
1

q

~# *****
~# If cars are not allowed on the link, ensure classification is 0

2.41
1
y
@link
n
0

not mod=c

2
1

q

~# *****
~# Transit-only links (transit-way)
~# Must be classified AFTER non-car links are classified as 0

2.41
1
y
@link
n
8

```

vdf=70,79
and mod=reupi

2
l

q

~# *****
~# Return to main macro

Appendix E_3: Macro that calculates "background" traffic in the NCR

```
#####
~# This macro (bkgd_pm.mac) computes the volume of "background" traffic (heavy trucks, commercial
~# light trucks, taxis, buses, and "other" miscellaneous vehicles using each link
~# Note that buses and trucks are converted to equivalent passenger vehicles
~#
~# Analysis period = PM Peak Period
~# ul1 -- stores background traffic volume in pcu's
~# ul2 -- stores hourly transit volume
~#
~# Macro created by Jennifer Armstrong, Nov. 18, 1999
~# Macro modified by Petar Grubor, March 2000
#####

~# Initialize U12 to 0 -- Will be used to store hourly transit volumes
2.41
1
y
ul2
0

*
2
1
q

~# Compute the hourly transit volume using each link
2.41
1
y
ul2
60/hdwy

4
*
*
2
1
q

~# Initialize ul1 to 0 -- Will be used to store background traffic volumes
2.41
1
y
ul1
0

*
2
1
q
```


~# Core: arterials and collectors

2.41

1

y

u11

$\text{volau} * (0.013 * 2 + 0.2 * 0.218 + 0.04 + 0.005 + 0.009 * 1.75) + \text{ul2} * 1.75$

@area=1

2

1

q

~# Core: arterials and collectors

2.41

1

y

u11

$\text{volau} * (0.013 * 2 + 0.2 * 0.218 + 0.04 + 0.005 + 0.009 * 1.75) + \text{ul2} * 1.75$

@area=5

2

1

q

~# Urban: arterials and collectors

2.41

1

y

u11

$\text{volau} * (0.013 * 2 + 0.2 * 0.236 + 0.019 + 0.003 + 0.005 * 1.75) + \text{ul2} * 1.75$

@area=2

2

1

q

~# Urban: arterials and collectors

2.41

1

y

u11

$\text{volau} * (0.013 * 2 + 0.2 * 0.236 + 0.019 + 0.003 + 0.005 * 1.75) + \text{ul2} * 1.75$

@area=6

2

1

q

~# Suburban: arterials and collectors

2.41

1

y

u11

$\text{volau} * (0.022 * 2 + 0.2 * 0.304 + 0.003 + 0.005 + 0.005 * 1.75) + \text{u12} * 1.75$

@area=3

2

1

q

~# Suburban: arterials and collectors

2.41

1

y

u11

$\text{volau} * (0.022 * 2 + 0.2 * 0.304 + 0.003 + 0.005 + 0.005 * 1.75) + \text{u12} * 1.75$

@area=7

2

1

q

~# Rural: arterials and collectors

2.41

1

y

u11

$\text{volau} * (0.07 * 2 + 0.2 * 0.389 + 0.001 + 0.005 + 0.009 * 1.75) + \text{u12} * 1.75$

@area=4

2

1

q

~# Rural: arterials and collectors

2.41

1

y

u11

$\text{volau} * (0.07 * 2 + 0.2 * 0.389 + 0.001 + 0.005 + 0.009 * 1.75) + \text{u12} * 1.75$

@area=8

2

l

q

~# Freeways and Rural Highways

2.4l

l

y

ul1

volau*(0.039*2+0.2*0.277+0.003+0.003+0.005*1.6)+ul2*1.6

vdf=80,100

2

l

q

~# Core: centroid connectors

2.4l

l

y

ul1

volau*(0.013*2+0.2*0.218+0.04+0.005+0.009*1.75)+ul2*1.75

ci=1

or cj=1

and @area=1

2

l

q

~# Core: centroid connectors

2.4l

l

y

ul1

volau*(0.013*2+0.2*0.218+0.04+0.005+0.009*1.75)+ul2*1.75

ci=1

or cj=1

and @area=5

2

l

q

```

~# Urban: centroid connectors
2.41
l
y
ull
volau*(0.013*2+0.2*0.236+0.019+0.003+0.005*1.75)+ul2*1.75

```

```

ci=1
or cj=1
and @area=2

```

```

2
l

```

```

q

```

```

~# Urban: centroid connectors
2.41
l
y
ull
volau*(0.013*2+0.2*0.236+0.019+0.003+0.005*1.75)+ul2*1.75

```

```

ci=1
or cj=1
and @area=6

```

```

2
l

```

```

q

```

```

~# Suburban: centroid connectors
2.41
l
y
ull
volau*(0.022*2+0.2*0.304+0.003+0.005+0.005*1.75)+ul2*1.75

```

```

ci=1
or cj=1
and @area=3

```

```

2
l

```

```

q

```

```

~# Suburban: centroid connectors
2.41
l
y

```

```
ul1  
volau*(0.022*2+0.2*0.304+0.003+0.005+0.005*1.75)+ul2*1.75
```

```
ci=1  
or cj=1  
and @area=7
```

```
2  
1
```

```
q
```

```
~# Rural: centroid connectors
```

```
2.41
```

```
1
```

```
y
```

```
ul1
```

```
volau*(0.07*2+0.2*0.389+0.001+0.005+0.009*1.75)+ul2*1.75
```

```
ci=1  
or cj=1  
and @area=4
```

```
2  
1
```

```
q
```

```
~# Rural: centroid connectors
```

```
2.41
```

```
1
```

```
y
```

```
ul1
```

```
volau*(0.07*2+0.2*0.389+0.001+0.005+0.009*1.75)+ul2*1.75
```

```
ci=1  
or cj=1  
and @area=8
```

```
2  
1
```

```
q
```

Appendix E_4: Vehicle kilometers traveled and link average speed results for base scenario in 1995 (sample of output results from VKM_PMPHR.mac macro)

Operating mode variable = 1
 Additional vkt variable = 1
 Number of link locations = 8
 Number of link types = 8

Node ID		Area	Link	Speed	Vehicle Kilometers Travelled				
					Total	Start	Cold	Transit	
inode	jnode	@area	@link	@speed	ul1	@start	@error	ul2	result
1	1007	1	7	11.4098	122.91	122.91	999999	0	1000264
1	1014	1	7	12.7659	81.6556	81.6554	999999	0	1000183
1	1022	1	7	9.96031	95.5271	95.5269	999999	0	1000208
1	1031	1	7	13.0976	119.299	119.299	999999	0	1000259
2	1018	1	7	15.8561	81.9946	81.9944	999999	0	1000187
2	1027	1	7	14.0575	58.4286	58.4285	999999	0	1000138
2	1036	1	7	18.1818	.3066	.3066	999999	0	1000026
2	1044	1	7	14.9564	109.748	109.748	999999	0	1000241
3	1037	1	7	15.6958	195.059	195.059	999999	0	1000413
3	1038	1	7	9.75338	125.316	125.315	999999	0	1000267
3	1048	1	7	7.75156	96.1777	96.1775	999999	0	1000207
3	1049	1	7	13.567	200.399	200.399	999999	0	1000421
4	2057	1	7	27.2579	18.9483	18.9482	999999	0	1000072
4	2135	1	7	27.2725	14.5801	14.5801	999999	0	1000063
4	2138	1	7	27.1073	63.0029	63.0028	999999	0	1000160
4	2142	1	7	23.3346	57.877	57.8767	999999	0	1000146
5	1205	1	7	27.231	35.4066	35.4065	999999	0	1000105
5	2003	1	7	26.7026	85.0006	85.0005	999999	0	1000204
6	2068	1	7	16.8643	159.417	159.417	999999	0	1000343
6	2105	1	7	45.3139	79.2174	79.2172	999999	0	1000211
6	3070	1	7	42.8533	70.4553	70.4551	999999	0	1000191
7	2070	1	7	45.1877	91.2193	91.2192	999999	0	1000235
7	2071	1	7	44.5548	63.5527	63.5524	999999	0	1000179
7	2095	1	7	45.4545	0	0	999999	0	1000052
7	2096	1	7	45.4378	56.6065	56.6064	999999	0	1000166
8	2044	1	7	44.6804	103.792	103.791	999999	0	1000259
8	2045	1	7	45.4545	0	0	999999	0	1000052
8	2046	1	7	45.2177	127.587	127.587	999999	0	1000307
8	2120	1	7	43.9742	124.817	124.817	999999	0	1000301
9	2040	1	7	27.2726	28.6343	28.6343	999999	0	1000092
9	2041	1	7	27.2727	0	0	999999	0	1000034
9	3219	1	7	27.1804	109.037	109.037	999999	0	1000252
10	1203	1	7	26.2932	138.104	138.104	999999	0	1000310
.....									
.....									
.....									
9813	9590	4	5	71.7028	1306.35	0	999999	0	1001386
9814	8665	4	5	72.7273	0	0	999999	0	1000081
9814	9591	4	5	72.7273	0	0	999999	0	1000081
9815	4292	4	5	72.7271	237.958	0	999999	0	1000319
9815	9592	4	5	72.7271	88.0477	0	999999	0	1000169
9821	6132	3	5	71.1844	633.518	633.518	999999	0	1001345
9821	9722	4	5	60.7055	733.035	132.031	999999	0	1000934
9901	4170	3	2	29.0186	726.581	275.059	999999	0	1001035
9901	4194	3	2	33.311	86.6209	6.89271	999999	0	1000131
9901	4195	3	5	81.1363	419.724	105.184	999999	4.64	1000618
9901	4217	3	5	79.645	773.038	722.333	999999	9.54	1001592
9902	8393	3	2	38.4615	2.68352	.98393	999999	0	1000046
9902	8556	3	2	38.4615	34.9264	24.2429	999999	0	1000102
9902	9050	3	6	85.4074	2788.41	226.9	999999	0	1003109
9902	9085	3	6	70.6354	6203.46	753.34	999999	0	1007035
9905	111	2	7	45.1116	108.995	41.7458	999999	0	1000204
9905	4095	2	2	21.2295	202.116	202.116	999999	2.22	1000431
9905	9906	1	2	34.7726	258.179	258.179	999999	4.4	1000558
9906	4100	2	2	33.5097	224.576	218.667	999999	.7	1000480
9906	5107	2	2	25.797	514.698	194.314	999999	1.34	1000739
9906	9905	1	2	35.7126	42.9665	22.2182	999999	6.6	1000110

Appendix E_5: Vehicle mix data for National Capital Region (%)

64

3

1 Autos

1 Light trucks

2 Transit

82.56	17.44	100
82.56	17.44	100
82.56	17.44	100
82.56	17.44	100
82.56	17.44	100
77.84	22.16	100
82.56	17.44	100
0	0	100
81.12	18.88	100
81.12	18.88	100
81.12	18.88	100
81.12	18.88	100
81.12	18.88	100
77.84	22.16	100
81.12	18.88	100
0	0	100
75.68	24.32	100
75.68	24.32	100
75.68	24.32	100
75.68	24.32	100
75.68	24.32	100
77.84	22.16	100
75.68	24.32	100
0	0	100
68.88	31.12	100
68.88	31.12	100
68.88	31.12	100
68.88	31.12	100
68.88	31.12	100
77.84	22.16	100
68.88	31.12	100
0	0	100
82.56	17.44	100
82.56	17.44	100
82.56	17.44	100
82.56	17.44	100
82.56	17.44	100
77.84	22.16	100
82.56	17.44	100
0	0	100
81.12	18.88	100
81.12	18.88	100
81.12	18.88	100
81.12	18.88	100
81.12	18.88	100
77.84	22.16	100
81.12	18.88	100
0	0	100
75.68	24.32	100
75.68	24.32	100
75.68	24.32	100
75.68	24.32	100
75.68	24.32	100
77.84	22.16	100
75.68	24.32	100
0	0	100
68.88	31.12	100
68.88	31.12	100
68.88	31.12	100
68.88	31.12	100
68.88	31.12	100
77.84	22.16	100
68.88	31.12	100
0	0	100

Appendix E_95: Fuel consumption equations for 1995

3

8

Autos

Light trucks

Transit

2490.5

2553.9

2763.8

```
if (AvgSpd<4, 0.2968866, if (AvgSpd<104, (0.3790550946-
0.2343923179*(AvgSpd*0.1)+0.0772803044*((AvgSpd*0.1)^2) -
0.0125152243*((AvgSpd*0.1)^3)+0.0009706108*((AvgSpd*0.1)^4) -
0.0000285520*((AvgSpd*0.1)^5)), 0.1030736))
if (AvgSpd<4, 0.5705789, if (AvgSpd<104, (0.7300554499-
0.4557576897*(AvgSpd*0.1)+0.1524461930*((AvgSpd*0.1)^2) -
0.0252463634*((AvgSpd*0.1)^3)+0.0020137458*((AvgSpd*0.1)^4) -
0.0000608289*((AvgSpd*0.1)^5)), 0.2372422))
if (AvgSpd<4, 0.7889759, if (AvgSpd<104, (1.008840431-
0.628403958*(AvgSpd*0.1)+0.210402862*((AvgSpd*0.1)^2) -
0.034973746*((AvgSpd*0.1)^3)+0.002805941*((AvgSpd*0.1)^4) -
0.000085231*((AvgSpd*0.1)^5)), 0.3457916))
if (AvgSpd<4, 0.2968866, if (AvgSpd<104, (0.3790550946-
0.2343923179*(AvgSpd*0.1)+0.0772803044*((AvgSpd*0.1)^2) -
0.0125152243*((AvgSpd*0.1)^3)+0.0009706108*((AvgSpd*0.1)^4) -
0.0000285520*((AvgSpd*0.1)^5)), 0.1030736))
if (AvgSpd<4, 0.5705789, if (AvgSpd<104, (0.7300554499-
0.4557576897*(AvgSpd*0.1)+0.1524461930*((AvgSpd*0.1)^2) -
0.0252463634*((AvgSpd*0.1)^3)+0.0020137458*((AvgSpd*0.1)^4) -
0.0000608289*((AvgSpd*0.1)^5)), 0.2372422))
if (AvgSpd<4, 0.7889759, if (AvgSpd<104, (1.008840431-
0.628403958*(AvgSpd*0.1)+0.210402862*((AvgSpd*0.1)^2) -
0.034973746*((AvgSpd*0.1)^3)+0.002805941*((AvgSpd*0.1)^4) -
0.000085231*((AvgSpd*0.1)^5)), 0.3457916))
if (AvgSpd<4, 0.2968866, if (AvgSpd<104, (0.3790550946-
0.2343923179*(AvgSpd*0.1)+0.0772803044*((AvgSpd*0.1)^2) -
0.0125152243*((AvgSpd*0.1)^3)+0.0009706108*((AvgSpd*0.1)^4) -
0.0000285520*((AvgSpd*0.1)^5)), 0.1030736))
if (AvgSpd<4, 0.5705789, if (AvgSpd<104, (0.7300554499-
0.4557576897*(AvgSpd*0.1)+0.1524461930*((AvgSpd*0.1)^2) -
0.0252463634*((AvgSpd*0.1)^3)+0.0020137458*((AvgSpd*0.1)^4) -
0.0000608289*((AvgSpd*0.1)^5)), 0.2372422))
if (AvgSpd<4, 0.7889759, if (AvgSpd<104, (1.008840431-
0.628403958*(AvgSpd*0.1)+0.210402862*((AvgSpd*0.1)^2) -
0.034973746*((AvgSpd*0.1)^3)+0.002805941*((AvgSpd*0.1)^4) -
0.000085231*((AvgSpd*0.1)^5)), 0.3457916))
if (AvgSpd<4, 0.2968866, if (AvgSpd<104, (0.3790550946-
0.2343923179*(AvgSpd*0.1)+0.0772803044*((AvgSpd*0.1)^2) -
0.0125152243*((AvgSpd*0.1)^3)+0.0009706108*((AvgSpd*0.1)^4) -
0.0000285520*((AvgSpd*0.1)^5)), 0.1030736))
if (AvgSpd<4, 0.5705789, if (AvgSpd<104, (0.7300554499-
0.4557576897*(AvgSpd*0.1)+0.1524461930*((AvgSpd*0.1)^2) -
0.0252463634*((AvgSpd*0.1)^3)+0.0020137458*((AvgSpd*0.1)^4) -
0.0000608289*((AvgSpd*0.1)^5)), 0.2372422))
if (AvgSpd<4, 0.7889759, if (AvgSpd<104, (1.008840431-
0.628403958*(AvgSpd*0.1)+0.210402862*((AvgSpd*0.1)^2) -
0.034973746*((AvgSpd*0.1)^3)+0.002805941*((AvgSpd*0.1)^4) -
0.000085231*((AvgSpd*0.1)^5)), 0.3457916))
```



```

0.034973746*((AvgSpd*0.1)^3)+0.002805941*((AvgSpd*0.1)^4) -
0.000085231*((AvgSpd*0.1)^5)),0.3457916))
if(AvgSpd<4,0.2968866,if(AvgSpd<104,(0.3790550946-
0.2343923179*(AvgSpd*0.1)+0.0772803044*((AvgSpd*0.1)^2) -
0.0125152243*((AvgSpd*0.1)^3)+0.0009706108*((AvgSpd*0.1)^4) -
0.0000285520*((AvgSpd*0.1)^5)),0.1030736))
if(AvgSpd<4,0.5705789,if(AvgSpd<104,(0.7300554499-
0.4557576897*(AvgSpd*0.1)+0.1524461930*((AvgSpd*0.1)^2) -
0.0252463634*((AvgSpd*0.1)^3)+0.0020137458*((AvgSpd*0.1)^4) -
0.0000608289*((AvgSpd*0.1)^5)),0.2372422))
if(AvgSpd<4,0.7889759,if(AvgSpd<104,(1.008840431-
0.628403958*(AvgSpd*0.1)+0.210402862*((AvgSpd*0.1)^2) -
0.034973746*((AvgSpd*0.1)^3)+0.002805941*((AvgSpd*0.1)^4) -
0.000085231*((AvgSpd*0.1)^5)),0.3457916))
if(AvgSpd<4,0.3689833,if(AvgSpd<104,(0.4405972907-
0.1921995414*(AvgSpd*0.1)+0.0337319978*((AvgSpd*0.1)^2) -
0.0020476045*((AvgSpd*0.1)^3) -
0.0000116308*((AvgSpd*0.1)^4)+0.0000036738*((AvgSpd*0.1)^5)),0.0978084)
)
if(AvgSpd<4,0.4278646,if(AvgSpd<104,(0.5258148481-
0.2698340004*(AvgSpd*0.1)+0.0652467134*((AvgSpd*0.1)^2) -
0.0072867052*((AvgSpd*0.1)^3)+0.0004036275*((AvgSpd*0.1)^4) -
0.0000088212*((AvgSpd*0.1)^5)),0.2287104))
if(AvgSpd<4,1.3763866,if(AvgSpd<104,(1.629186798-
0.665156070*(AvgSpd*0.1)+0.082332556*((AvgSpd*0.1)^2)+0.001719648*((Avg
Spd*0.1)^3) -
0.000836586*((AvgSpd*0.1)^4)+0.000037479*((AvgSpd*0.1)^5)),0.3240435))
if(AvgSpd<4,0.2968866,if(AvgSpd<104,(0.3790550946-
0.2343923179*(AvgSpd*0.1)+0.0772803044*((AvgSpd*0.1)^2) -
0.0125152243*((AvgSpd*0.1)^3)+0.0009706108*((AvgSpd*0.1)^4) -
0.0000285520*((AvgSpd*0.1)^5)),0.1030736))
if(AvgSpd<4,0.5705789,if(AvgSpd<104,(0.7300554499-
0.4557576897*(AvgSpd*0.1)+0.1524461930*((AvgSpd*0.1)^2) -
0.0252463634*((AvgSpd*0.1)^3)+0.0020137458*((AvgSpd*0.1)^4) -
0.0000608289*((AvgSpd*0.1)^5)),0.2372422))
if(AvgSpd<4,0.7889759,if(AvgSpd<104,(1.008840431-
0.628403958*(AvgSpd*0.1)+0.210402862*((AvgSpd*0.1)^2) -
0.034973746*((AvgSpd*0.1)^3)+0.002805941*((AvgSpd*0.1)^4) -
0.000085231*((AvgSpd*0.1)^5)),0.3457916))
0
0
if(AvgSpd<4,0.7889759,if(AvgSpd<104,(1.008840431-
0.628403958*(AvgSpd*0.1)+0.210402862*((AvgSpd*0.1)^2) -
0.034973746*((AvgSpd*0.1)^3)+0.002805941*((AvgSpd*0.1)^4) -
0.000085231*((AvgSpd*0.1)^5)),0.3457916))

```

Appendix E_21: Fuel consumption equations for 2021

3

8

Autos

Light trucks

Transit

2490.5

2553.9

2763.8

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if (AvgSpd<4, 0.2968866*0.767, if (AvgSpd<104, (0.3790550946-
0.2343923179*(AvgSpd*0.1)+0.0772803044*((AvgSpd*0.1)^2) -
0.0125152243*((AvgSpd*0.1)^3)+0.0009706108*((AvgSpd*0.1)^4) -
0.0000285520*((AvgSpd*0.1)^5))*0.767, 0.1030736*0.767))
if (AvgSpd<4, 0.5705789*0.767, if (AvgSpd<104, (0.7300554499-
0.4557576897*(AvgSpd*0.1)+0.1524461930*((AvgSpd*0.1)^2) -
0.0252463634*((AvgSpd*0.1)^3)+0.0020137458*((AvgSpd*0.1)^4) -
0.0000608289*((AvgSpd*0.1)^5))*0.767, 0.2372422*0.767))
if (AvgSpd<4, 0.7889759*0.853, if (AvgSpd<104, (1.008840431-
0.628403958*(AvgSpd*0.1)+0.210402862*((AvgSpd*0.1)^2) -
0.034973746*((AvgSpd*0.1)^3)+0.002805941*((AvgSpd*0.1)^4) -
0.000085231*((AvgSpd*0.1)^5))*0.853, 0.3457916*0.853))
if (AvgSpd<4, 0.2968866*0.767, if (AvgSpd<104, (0.3790550946-
0.2343923179*(AvgSpd*0.1)+0.0772803044*((AvgSpd*0.1)^2) -
0.0125152243*((AvgSpd*0.1)^3)+0.0009706108*((AvgSpd*0.1)^4) -
0.0000285520*((AvgSpd*0.1)^5))*0.767, 0.1030736*0.767))
if (AvgSpd<4, 0.5705789*0.767, if (AvgSpd<104, (0.7300554499-
0.4557576897*(AvgSpd*0.1)+0.1524461930*((AvgSpd*0.1)^2) -
0.0252463634*((AvgSpd*0.1)^3)+0.0020137458*((AvgSpd*0.1)^4) -
0.0000608289*((AvgSpd*0.1)^5))*0.767, 0.2372422*0.767))
if (AvgSpd<4, 0.7889759*0.853, if (AvgSpd<104, (1.008840431-
0.628403958*(AvgSpd*0.1)+0.210402862*((AvgSpd*0.1)^2) -
0.034973746*((AvgSpd*0.1)^3)+0.002805941*((AvgSpd*0.1)^4) -
0.000085231*((AvgSpd*0.1)^5))*0.853, 0.3457916*0.853))
if (AvgSpd<4, 0.2968866*0.767, if (AvgSpd<104, (0.3790550946-
0.2343923179*(AvgSpd*0.1)+0.0772803044*((AvgSpd*0.1)^2) -
0.0125152243*((AvgSpd*0.1)^3)+0.0009706108*((AvgSpd*0.1)^4) -
0.0000285520*((AvgSpd*0.1)^5))*0.767, 0.1030736*0.767))
if (AvgSpd<4, 0.5705789*0.767, if (AvgSpd<104, (0.7300554499-
0.4557576897*(AvgSpd*0.1)+0.1524461930*((AvgSpd*0.1)^2) -
0.0252463634*((AvgSpd*0.1)^3)+0.0020137458*((AvgSpd*0.1)^4) -
0.0000608289*((AvgSpd*0.1)^5))*0.767, 0.2372422*0.767))
if (AvgSpd<4, 0.7889759*0.853, if (AvgSpd<104, (1.008840431-
0.628403958*(AvgSpd*0.1)+0.210402862*((AvgSpd*0.1)^2) -
```

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0.034973746*((AvgSpd*0.1)^3)+0.002805941*((AvgSpd*0.1)^4) -
0.000085231*((AvgSpd*0.1)^5))*0.853,0.3457916*0.853))
if (AvgSpd<4,0.2968866*0.767,if (AvgSpd<104,(0.3790550946-
0.2343923179*(AvgSpd*0.1)+0.0772803044*((AvgSpd*0.1)^2) -
0.0125152243*((AvgSpd*0.1)^3)+0.0009706108*((AvgSpd*0.1)^4) -
0.0000285520*((AvgSpd*0.1)^5))*0.767,0.1030736*0.767))
if (AvgSpd<4,0.5705789*0.767,if (AvgSpd<104,(0.7300554499-
0.4557576897*(AvgSpd*0.1)+0.1524461930*((AvgSpd*0.1)^2) -
0.0252463634*((AvgSpd*0.1)^3)+0.0020137458*((AvgSpd*0.1)^4) -
0.0000608289*((AvgSpd*0.1)^5))*0.767,0.2372422*0.767))
if (AvgSpd<4,0.7889759*0.853,if (AvgSpd<104,(1.008840431-
0.628403958*(AvgSpd*0.1)+0.210402862*((AvgSpd*0.1)^2) -
0.034973746*((AvgSpd*0.1)^3)+0.002805941*((AvgSpd*0.1)^4) -
0.000085231*((AvgSpd*0.1)^5))*0.853,0.3457916*0.853))
if (AvgSpd<4,0.3689833*0.767,if (AvgSpd<104,(0.4405972907-
0.1921995414*(AvgSpd*0.1)+0.0337319978*((AvgSpd*0.1)^2) -
0.0020476045*((AvgSpd*0.1)^3) -
0.0000116308*((AvgSpd*0.1)^4)+0.0000036738*((AvgSpd*0.1)^5))*0.767,0.09
78084*0.767))
if (AvgSpd<4,0.4278646*0.767,if (AvgSpd<104,(0.5258148481-
0.2698340004*(AvgSpd*0.1)+0.0652467134*((AvgSpd*0.1)^2) -
0.0072867052*((AvgSpd*0.1)^3)+0.0004036275*((AvgSpd*0.1)^4) -
0.0000088212*((AvgSpd*0.1)^5))*0.767,0.2287104*0.767))
if (AvgSpd<4,1.3763866*0.853,if (AvgSpd<104,(1.629186798-
0.665156070*(AvgSpd*0.1)+0.082332556*((AvgSpd*0.1)^2)+0.001719648*((Avg
Spd*0.1)^3) -
0.000836586*((AvgSpd*0.1)^4)+0.000037479*((AvgSpd*0.1)^5))*0.853,0.3240
435*0.853))
if (AvgSpd<4,0.2968866*0.767,if (AvgSpd<104,(0.3790550946-
0.2343923179*(AvgSpd*0.1)+0.0772803044*((AvgSpd*0.1)^2) -
0.0125152243*((AvgSpd*0.1)^3)+0.0009706108*((AvgSpd*0.1)^4) -
0.0000285520*((AvgSpd*0.1)^5))*0.767,0.1030736*0.767))
if (AvgSpd<4,0.5705789*0.767,if (AvgSpd<104,(0.7300554499-
0.4557576897*(AvgSpd*0.1)+0.1524461930*((AvgSpd*0.1)^2) -
0.0252463634*((AvgSpd*0.1)^3)+0.0020137458*((AvgSpd*0.1)^4) -
0.0000608289*((AvgSpd*0.1)^5))*0.767,0.2372422*0.767))
if (AvgSpd<4,0.7889759*0.853,if (AvgSpd<104,(1.008840431-
0.628403958*(AvgSpd*0.1)+0.210402862*((AvgSpd*0.1)^2) -
0.034973746*((AvgSpd*0.1)^3)+0.002805941*((AvgSpd*0.1)^4) -
0.000085231*((AvgSpd*0.1)^5))*0.853,0.3457916*0.853))
0
0
if (AvgSpd<4,0.7889759*0.853,if (AvgSpd<104,(1.008840431-
0.628403958*(AvgSpd*0.1)+0.210402862*((AvgSpd*0.1)^2) -
0.034973746*((AvgSpd*0.1)^3)+0.002805941*((AvgSpd*0.1)^4) -
0.000085231*((AvgSpd*0.1)^5))*0.853,0.3457916*0.853))

```

Appendix F: Base scenario 0 (GHG emission estimates for 1995)

Vehicle Type Descriptions

Vehicle Type 1: Autos
Vehicle Type 2: Light trucks
Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	2748.817	950706.735	2179.07	460.307	109.44	244.548	98.951	32.183
	2	71130.452	23867246.26	57214.36	12085.979	1830.113	6365.387	2573.61	521.567
	3	13398.218	3698406.388	11027.046	2329.357	41.815	1042.716	419.738	10.693
	4	6637.31	2497150.904	5473.175	1156.155	7.98	707.366	285.819	1.992
	5	4598.817	1226701.596	3796.783	802.034	0	348.855	140.13	0
	6	48753.813	11689270.91	37935.382	10798.693	18.739	3113.997	1528.587	3.527
	7	10348.755	3963599.345	8543.932	1804.823	0	1124.943	454.962	0
	8	986.147	887011.122	0	0	986.147	0	0	241.338
TOTAL 1 (Central Core-RMOC):		158802.329	48540083.26	126189.748	29438.348	2994.234	12947.812	5501.897	811.3
	2	22762.487	8485572.617	17593.498	4094.739	1074.25	2112.761	942.12	295.847
	2	182884.135	55901912.07	146194.958	34025.651	2663.526	14882.769	6618.404	699.629
	2	33452.195	9586401.075	26977.933	6278.888	195.375	2607.163	1158.249	48.922
	2	75221.401	21243787.32	60615.637	14107.781	497.983	5768.062	2558.19	124.852
	2	55575.913	14709539.4	44679.548	10398.79	497.574	3962.735	1766.928	118.601
	2	199574.983	47217764.91	154641.738	44024.421	908.824	12360.294	6206.994	210.728
	2	59313.853	17088865.56	48115.398	11198.456	0	4716.006	2092.35	0
	2	1810.943	1089577.308	0	0	1810.943	0	0	394.232
TOTAL 2 (Urban Area-RMOC):		630395.91	175323420.3	498818.71	124128.726	1448.475	48408.79	21343.235	1892.811
	3	9349.52	3798826.78	6600.374	2121.05	628.096	814.808	501.709	176.652
	3	35766.145	11047314.67	26584.284	8542.941	638.92	2610.931	1601.378	164.586
	3	20264.338	5673289.529	15240.8	4897.678	125.86	1377.717	845.749	29.715
	3	7647.999	2276499.809	5759.777	1850.922	37.3	554.816	340.2	9.368
	3	41642.294	11235321.33	31431.602	10100.642	110.05	2741.97	1697.233	26.008
	3	93790.167	23449437.3	72447.55	20624.842	717.775	5966.254	3194.557	156.271
	3	27905.905	8166003.069	21119.189	6786.716	0	2014.01	1233.451	0
	3	4.888	3774.573	0	0	4.888	0	0	1.366
TOTAL 3 (Suburban Area-RMOC):		236371.254	6343087.06	179183.576	54924.791	2262.887	16080.586	8414.277	563.966
	4	102.357	33482.972	70.503	31.853	0	7.126	6.162	0
	4	966.432	306793.347	663.819	299.913	2.7	64.939	56.05	0.694
	4	9603.433	2915863.036	6613.164	2987.829	2.44	620.269	536.248	0.564
	4	8404.399	2539171.885	5788.95	2615.449	0	541.682	465.998	0
	4	92010.415	25527635.17	63354.381	28623.524	32.51	5383.06	4738.035	7.474
	4	133984.098	35575930.67	104293.222	29690.876	0	8941.736	5210.282	0
	4	37496.076	10881443.02	25827.297	11668.779	0	2308.956	2009.041	0
	4	0	0	0	0	0	0	0	0
TOTAL 4 (Rural Area-RMOC):		282587.21	77780320.1	208811.336	75918.223	37.65	17867.808	13021.816	8.732
	5	1450.026	715212.973	1131.663	239.053	79.31	184.077	74.578	23.99
	5	17969.477	8371251.294	14562.202	3076.124	331.151	2268.34	918.336	136.266
	5	97.573	23758.554	80.556	17.017	0	6.699	2.77	0
	5	4872.025	1602497.611	4001.704	845.321	25	446.871	181.275	7.825
	5	6048.284	2003360.777	4992.58	1054.634	1.07	567.983	230.256	0.262
	5	1843.737	462302.36	1434.41	408.357	0.97	129.009	55.012	0.185
	5	1940.738	979931.446	1602273	338.465	0	277.933	112.667	0
	5	0	0	0	0	0	0	0	0
TOTAL 5 (Central Core-OUTAOUAIS):		34221.88	14158315.02	27805.388	5978.971	437.501	3882.922	1574.894	168.528
	6	9150.303	3290419.772	7141.369	1662.094	346.84	831.112	370.584	99.175
	6	49539.113	16130614.98	39590.891	9214.401	734.02	4289.95	1910.343	205.395
	6	30194.628	8860166.443	24281.048	5651.21	262.37	2391.487	1061.777	69.649
	6	7058.131	2494776.805	5689.425	1324.166	44.54	677.813	301.808	12.988
	6	25264.031	6860046.167	20457.029	4761.202	45.8	1871.021	846.514	12.03
	6	63150.219	17741203.4	49059.882	13966.688	123.65	4739.309	2273.74	47.477
	6	19479.348	5475901.55	15801.647	3677.701	0	1511.141	670.506	0
	6	0.81	618.784	0	0	0.81	0	0	0.224
TOTAL 6 (Urban Area-OUTAOUAIS):		203836.583	60653747.9	162021.081	40257.462	1558.03	16311.833	7437.272	448.878
	7	1104.1	458213.048	782.373	251.418	70.31	99.519	61.277	19.489
	7	5970.434	1916132.772	4451.251	1430.423	88.76	456.176	280.342	23.179
	7	17153.581	5013974.89	12900.762	4145.699	107.12	1217.456	747.399	26.456
	7	1448.222	428152.488	1091.981	350.911	5.33	104.666	64.151	1.319
	7	10428.589	2728910.042	7847.599	2521.85	59.14	644.811	424.556	14.015
	7	49470.749	13274050.4	38489.73	10957.508	23.51	3324.72	1949.807	5.147
	7	6220.904	1822124.651	4707.98	1512.924	0	449.432	275.193	0
	7	0	0	0	0	0	0	0	0
TOTAL 7 (Suburban Area-OUTAOUAIS):		91796.578	2841588.29	10271.878	21170.733	354.17	828.678	3882.725	88.605
	8	247.451	191416.127	150.641	68.06	28.75	36.151	31.36	7.705
	8	8778.746	3336710.437	6020.929	2720.257	37.56	703.487	608.075	11.475
	8	3714.82	1092292.268	2551.205	1152.635	10.98	231.579	199.025	2.624
	8	10565.489	3243760.042	7259.607	3279.892	25.99	687.796	592.285	6.574
	8	16673.036	4695008.141	11473.139	5183.567	16.33	990.184	868.634	3.818
	8	47283.005	1274547.223	36797.019	10475.616	10.37	3191.614	1875.354	2.637
	8	14762.692	4353655.08	10188.542	4594.15	0	927.08	800.643	0
	8	0	0	0	0	0	0	0	0
TOTAL 8 (Rural Area-OUTAOUAIS):		102026.239	28636314.33	74421.062	27474.177	129.06	6767.897	4876.378	34.833
TOTAL (1-4) RMOC:		1307936.703	367294306.7	1010783.37	284410.088	12743.246	93305.976	49281.225	3276.809
TOTAL (5-8) OUTAOUAIS:		431889.281	130311935.3	334516.237	94881.343	2478.681	33258.428	17790.267	738.844
TOTAL NATIONAL CAPITAL REGION:		1739826.984	497606242.0	1345300.607	379291.431	15222.927	126565.402	67071.492	4016.653

Appendix F: Base scenario - Fuel efficiency improved by 14.7% - buses and 23.3% - cars and light trucks (GHG emissions for 2021)

Vehicle Type Descriptions

Vehicle Type 1: Autos
Vehicle Type 2: Light trucks
Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	4075.781	1045413.995	3273.315	691.456	111.01	275.265	111.375	27.291
	2	86472.46	22866725.75	69672.22	14717.581	2082.658	6072.962	2456.271	531.494
	3	16599.399	3661324.549	13672.629	2888.21	38.56	1033.318	416.559	8.683
	4	13477.481	3381664.26	11120.42	2319.081	7.98	958.573	387.408	1.765
	5	5216.542	1092327.772	4306.777	909.765	0	310.485	124.933	0
	6	54128.472	10318457.28	42119.016	11990.717	18.739	2833.212	1273.97	3.165
	7	13942.817	4564385.663	11511.19	2431.627	0	1295.199	524.176	0
	8	1499.805	884744.526	0	0	1499.805	0	0	312.665
TOTAL 1 (Central Core-RMOC):		195412.557	47784443.78	155875.587	35978.437	3758.552	12779.074	5294.692	885.085
	2	31636.228	10005343.28	24724.168	5754.343	1157.717	2541.484	1133.744	262.332
	2	235998.875	56737539.05	188880.613	43960.379	3157.883	15090.674	6714.656	725.687
	3	49821.972	10957154.89	40211.918	9358.987	251.067	2981.076	1323.953	54.831
	4	119228.277	26272310.59	96258.766	22403.421	566.09	7154.38	3176.491	123.702
	5	90685.413	18895497.05	72962.15	16981.329	741.934	5089.493	2264.352	158.184
	6	242057.473	44676184.46	187254.954	53308.964	1493.555	11914.59	5569.352	281.977
	7	76868.325	16996459.45	62355.585	14512.74	0	4689.801	2081.722	0
	8	2670.008	1548808.995	0	0	2670.008	0	0	560.391
TOTAL 2 (Urban Area-RMOC):		848966.571	186089297.8	672648.154	168280.163	10038.254	49461.498	22264.27	2187.104
	3	14761.41	4948033.31	10549.365	3390.071	821.974	1077.289	653.487	206.442
	3	69301.849	16780632.22	51504.488	16551.125	1246.236	3944.212	2419.898	281.277
	3	53913.201	12098061.9	40386.384	12978.288	548.528	2902.41	1179.694	117.392
	4	24239.869	5730559.577	18139.405	5829.154	271.31	1373.026	842.197	57.946
	5	104789.319	22465503.61	78826.615	25331.174	631.53	5431.92	3360.242	128.658
	6	137436.256	25837803.52	106183.151	30228.913	1024.192	6681.891	3340.366	240.825
	7	79760.431	19440528.73	60362.695	19397.737	0	4791.974	2939.08	0
	8	236.18	133709.847	0	0	236.18	0	0	48.379
TOTAL 3 (Suburban Area-RMOC):		484438.495	107434832.5	365952.103	113708.482	4779.93	28202.722	15344.964	1080.919
	4	255.749	65181.846	176.16	79.589	0	13.869	11.998	0
	4	5986.616	1448498.605	4111.569	1857.608	17.44	306.367	264.276	3.82
	4	25299.954	5778541.19	17422.613	7871.541	5.8	1230.166	1061.73	1.179
	4	16021.584	3814466.64	11015.031	4976.593	29.96	809.662	697.272	6.238
	4	177181.83	38155738.04	121772.828	55016.992	372.01	8021.835	7033.967	77.181
	6	214995.53	40963293.67	167352.521	47643.009	0	10472.92	5826.574	0
	7	57379.145	13483144.04	39522.755	17856.39	0	2865.916	2484.663	0
	8	0	0	0	0	0	0	0	0
TOTAL 4 (Rural Area-RMOC):		497100.408	103708864	361373.477	135301.722	425.21	23720.735	17380.48	88.418
	5	1571.237	578021.175	1232.528	260.36	78.35	147.575	57.769	20.928
	5	20148.513	6613088.65	16348.595	3453.482	346.436	1787.236	723.429	113.76
	5	734.066	155559.983	606.045	128.021	0	42.816	17.2	0
	5	4991.479	1191393.644	4100.325	886.154	25	333.279	134.556	6.412
	5	6159.943	1360714.602	5084.765	1074.107	1.07	385.953	156.194	0.216
	5	1783.059	308453.176	1387.178	394.911	0.97	83.651	39.033	0.157
	5	2638.987	1042917.953	2178.748	460.239	0	295.793	119.913	0
	5	4.2	2300.475	0	0	4.2	0	0	0.832
TOTAL 5 (Central Core-Outsiders):		38031.484	11247448.96	30938.184	6637.274	456.026	3076.303	1250.094	142.303
	6	8479.68	2397524.43	6597.36	1535.48	346.64	556.419	265.941	84.289
	6	46451.702	11030195.47	37086.184	8631.498	734.02	2912.981	1296.328	168.165
	6	31658.929	6799637.248	25468.889	5927.67	262.37	1834.992	813.624	54.679
	6	7344.751	1722648.722	5921.932	1378.28	44.54	467.097	207.764	10.397
	6	32544.359	6510499.249	26362.831	6135.728	45.8	1779.667	803.417	9.55
	6	61873.681	12661264.11	48066.224	13683.807	123.65	3295.272	1708.75	32.713
	6	23363.413	5095144.236	18952.401	4411.012	0	1405.936	624.011	0
	8	224.37	122978.799	0	0	224.37	0	0	44.496
TOTAL 6 (Urban Area-Outsiders):		211940.885	48339892.27	168455.821	41703.475	1781.59	12292.344	5718.835	404.489
	7	1232.761	359639.776	679.743	282.708	70.31	77.299	47.579	16.504
	7	8523.425	2041364.385	6383.354	2051.31	88.76	489.356	300.67	19.806
	7	20078.88	4531796.363	15114.628	4857.132	107.12	1101.353	675.652	22.914
	7	1923.695	443700.134	1451.818	466.546	5.33	108.583	66.628	1.126
	7	16218.486	3302289.495	12229.393	3929.953	59.14	797.228	502.99	11.652
	7	67292.502	13374251.84	52362.184	14906.809	23.51	3406.469	1910.424	4.128
	7	8349.085	1862471.917	6318.588	2030.498	0	459.43	281.241	0
	7	493.2	270141.444	0	0	493.2	0	0	97.743
TOTAL 7 (Suburban Area-Outsiders):		124112.034	26185835.35	84739.708	28524.958	647.37	6438.718	3785.184	173.973
	8	630.7	273885.157	412.432	186.337	31.93	53.927	46.751	7.302
	8	10246.856	2935364.207	7033.568	3177.768	35.52	619.564	535.427	9.014
	8	7162.609	1626194.11	4925.042	2225.587	10.98	345.696	297.212	2.239
	8	14860.909	3640235.331	10218.292	4616.627	25.99	772.101	666.094	5.854
	8	15388.411	3337408.732	10588.29	4783.792	16.33	702.941	617.643	3.377
	8	86313.522	17737705.87	67178.374	19124.778	10.37	4449.895	2603.759	1.991
	8	24437.377	5598264.949	16832.465	7604.912	0	1192.976	1028.685	0
	8	135.12	74009.554	0	0	135.12	0	0	26.778
TOTAL 8 (Rural Area-Outsiders):		169176.504	3522397.81	117189.483	41718.801	268.24	8137.1	5785.573	56.555
TOTAL (1-8) RMOC:		2025918.031	445027438.1	1555649.301	451266.784	19001.946	112163.969	60284.406	4241.526
TOTAL (8-9) OUTSIDERS:		833288.967	11896668.2	411325.776	118985.806	3361.226	23945.488	16550.684	777.222
TOTAL NATIONAL CAPITAL REGION:		2559177.936	564023503.3	1966972477	569852.26	22353.172	142108.434	76835.09	5018.748

Appendix G: Scenario 1 - parking cost increased by 10% (GHG emission estimates for 1995)

Vehicle Type Descriptions

Vehicle Type 1: Autos
Vehicle Type 2: Light trucks
Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	2627.615	906961.936	2079.006	439.17	109.44	232.2	93.95	32.103
	2	68453.592	23061689.91	55829.944	11793.535	1830.113	6139.629	2482.059	518.132
	3	13291.533	3658832.119	10938.967	2310.751	41.815	1031.545	415.191	10.643
	4	6548.359	2410961.205	5399.737	1140.642	7.98	682.943	275.887	1.991
	5	4570.944	1218262.837	3773.771	797.173	0	346.452	139.169	0
	6	48850.402	11576595.93	38010.566	10821.096	18.739	3083.422	1522.225	3.518
	7	10121.723	3823847.099	8356.494	1765.228	0	1085.299	438.902	0
	8	986.147	667011.122	0	0	986.147	0	0	241.338
TOTAL 1 (Central Core-ROWC):		158450.315	47324182.16	124388.485	29087.595	2994.234	12607.49	5367.383	807.725
	2	22512.681	8378335.071	17390.855	4047.576	1074.225	2083.269	928.962	295.78
	2	181160.73	55233413.19	144796.932	33700.272	2663.526	14699.475	6536.476	698.626
	2	33514.981	9574283.673	27028.864	6290.742	195.375	2603.897	1156.745	48.87
	2	74827.735	21113454.48	60296.295	14033.457	497.983	5732.238	2542.167	124.783
	2	55034.932	14550527.8	44240.705	10296.653	497.574	3918.799	1747.752	118.378
	2	199115.916	46959142.25	154284.4	43922.692	908.824	12277.068	6190.636	207.265
	2	58953.029	16970139.28	47822.697	11130.332	0	4683.275	2077.78	0
	2	1810.943	1069577.308	0	0	1810.943	0	0	394.232
TOTAL 2 (Urban Area-ROWC):		826730.947	173068473	495860.745	123421.724	7448.475	45998.021	21180.518	1887.934
	3	9216.042	3730108.925	6499.357	2088.588	628.096	798.086	491.413	176.372
	3	35617.068	10994732.05	26471.463	8506.686	638.92	2598.09	1593.406	164.553
	3	20179.47	5641454.107	15176.572	4877.038	125.86	1369.893	840.931	29.698
	3	7594.226	2253394.471	5719.082	1837.844	37.3	549.168	336.67	9.361
	3	41427.909	11164594.95	31269.355	10048.503	110.05	2724.366	1686.721	25.995
	3	93773.446	23375303.47	72434.534	20621.137	717.775	5943.435	3190.758	153.52
	3	77274.877	8113311.513	20982.187	6742.69	0	2001.026	1225.481	0
	3	4.886	3774.573	0	0	4.886	0	0	1.368
TOTAL 3 (Suburban Area-ROWC):		235537.924	63276674.06	178552.55	54722.486	2262.887	15984.084	9385.39	560.865
	4	102.639	33575.173	70.698	31.941	7.145	6.179	0	0
	4	961.266	305113.931	860.261	298.306	2.7	64.581	55.741	0.694
	4	9541.421	2887858.139	6570.45	2968.531	2.44	614.326	531.078	0.564
	4	8402.622	2538412.005	5767.726	2614.896	0	541.521	465.858	0
	4	91741.985	2543922.81	63169.486	28539.989	32.51	5364.045	4722.234	7.473
	4	133627.857	35492172.11	104015.924	29611.933	0	8919.457	5199.211	0
	4	37450.54	10864147.36	25795.932	11654.608	0	2305.271	2005.9	0
	4	0	0	0	0	0	0	0	0
TOTAL 4 (Rural Area-ROWC):		281828.33	77561201.32	206070.477	75720.204	37.85	17816.348	12986.207	8.731
	5	1415.584	684058.875	1103.228	233.046	79.31	175.335	71.029	23.875
	5	17545.468	7930153.518	14212.14	3002.177	331.151	2145.788	868.619	133.042
	5	88.257	21489.551	72.865	15.392	0	6.059	2.506	0
	5	4790.458	1560835.705	3934.362	831.096	25	437.053	176.491	7.82
	5	5951.119	1902719.033	4912.361	1037.689	1.07	539.436	218.697	0.262
	5	1817.39	444621.108	1413.901	402.519	0.97	123.402	53.556	0.185
	5	1912.395	946417.303	1578.973	333.522	0	268.438	108.803	0
	5	0	0	0	0	0	0	0	0
TOTAL 5 (Central Core-Outsiders):		33520.671	13490295.08	27227.73	5655.441	437.501	3995.577	1499.707	165.194
	6	8941.513	3195429.649	6971.999	1622.674	346.84	805.091	356.975	98.981
	6	48764.641	15783989.11	38962.439	9068.181	734.02	4195.132	1867.997	204.549
	6	29872.527	8725203.177	24019.759	5590.398	262.37	2354.636	1045.199	69.343
	6	6941.353	2409483.509	5594.695	1302.118	44.54	654.404	291.378	12.859
	6	24856.3	6707987.021	20126.277	4684.222	45.8	1828.762	830.289	11.934
	6	62283.874	17355920.9	48385.518	13774.706	123.65	4617.995	2242.752	45.966
	6	19312.653	5422753.935	15666.425	3646.229	0	1496.506	663.967	0
	6	0.81	618.784	0	0	0.81	0	0	0.224
TOTAL 6 (Urban Area-Outsiders):		200973.871	66601388.08	169727.112	39688.528	1658.03	15862.528	7300.557	443.858
	7	1080.011	450035.379	764.142	245.559	70.31	97.511	60.041	19.483
	7	5861.643	1873281.671	4368.918	1403.965	88.76	445.638	273.858	23.162
	7	17022.779	4961235.238	12801.771	4113.888	107.12	1204.494	739.458	26.391
	7	1423.444	420087.318	1073.229	344.885	5.33	102.684	62.926	1.319
	7	10229.532	2678344.088	7696.953	2473.439	59.14	632.336	416.889	14.045
	7	49076.668	13218842.16	38182.978	10870.18	23.51	3307.463	1944.933	5.225
	7	6145.827	1796571.738	4651.162	1494.665	0	443.144	271.319	0
	7	0	0	0	0	0	0	0	0
TOTAL 7 (Suburban Area-Outsiders):		80639.904	25396387.89	69534.163	20946.581	354.17	8233.27	3768.424	88.825
	8	249.887	194939.621	152.319	68.818	28.75	36.898	32.01	7.705
	8	8686.971	3274465.78	5957.714	2691.697	37.56	690.304	596.643	11.396
	8	3809.802	1119644.086	2616.628	1182.193	10.98	237.417	204.042	2.624
	8	10553.75	3237236.293	7251.521	3276.239	25.99	686.43	591.073	6.564
	8	16587.83	4667994.133	11414.449	5157.051	16.33	984.411	863.689	3.815
	8	47356.897	12767845.24	36854.537	10491.99	10.37	3197.109	1878.755	2.639
	8	14758.464	4350537.919	10165.63	4592.834	0	926.42	800.067	0
	8	0	0	0	0	0	0	0	0
TOTAL 8 (Rural Area-Outsiders):		102003.601	29612863.07	74412.796	27480.822	129.08	6784.989	4968.279	34.747
TOTAL (1-8) ROWC:		1369547.516	384030810.3	1004872.28	262932.008	12743.246	92396.821	48490.442	3285.259
TOTAL (9-8) OUTAQUARI:		487397.847	126182741.3	336966.783	39851.372	2478.861	32840.296	17835.361	733.406
TOTAL NATIONAL CAPITAL REGION:		1727845.363	492133632.6	1335779.063	376883.381	15222.927	125040.217	66335.443	3998.665

Appendix G: Scenario 1 - parking cost increased by 10% (GHG emissions estimates for 2021)

Vehicle Type Descriptions

Vehicle Type 1: Autos
Vehicle Type 2: Light trucks
Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	3885.638	996797.95	3116.333	658.295	111.01	261.559	105.827	27.178
	2	84964.124	2222527.292	68426.938	14454.528	2082.658	5894.71	2384.009	526.803
	3	16384.966	3589534.586	13495.592	2850.813	38.56	1013.036	408.296	8.618
	4	13319.381	3290249.269	10989.893	2321.508	7.98	932.667	376.891	1.773
	5	5166.782	1078642.41	4265.695	901.087	0	306.626	123.337	0
	6	54033.602	1013537.02	42045.17	11969.694	18.739	2774.312	1259.781	3.097
	7	13645.422	4394984.99	11265.66	2379.762	0	1247.161	504.691	0
	8	1499.805	864144.528	0	0	1499.805	0	0	312.665
TOTAL 1 (Central Core-RMOC):		182899.52	4857483.87	153605.281	35535.687	3758.552	12430.071	5162.832	880.134
	2	31353.42	9918394.82	24494.754	5700.949	1157.717	2517.764	1123.163	282.024
	2	233534.802	55935134.11	186881.757	43495.162	3157.883	14871.426	6616.688	723.456
	2	49660.744	10903080.91	40081.13	9328.547	251.067	2966.232	1317.289	54.8
	2	118330.754	26021628.65	95530.695	22233.968	566.09	7085.623	3145.689	123.421
	2	90101.267	187337.1243	72488.291	16871.042	741.934	5045.396	2244.619	157.617
	2	241664.437	44157388.91	186949.015	53221.867	1493.555	11748.997	5533.751	276.382
	2	76464.363	16893121.36	62027.891	14436.472	0	4661.307	2069.046	0
	2	2870.008	1548808.995	0	0	2870.008	0	0	560.391
TOTAL 2 (Urban Area-RMOC):		843779.795	18411127.02	668453.533	165288.007	10038.254	48896.745	22030.245	2178.097
	3	14639.468	4678134.122	10457.079	3360.415	821.974	1060.45	653.09	205.933
	3	68751.639	16632184.84	51088.089	16417.314	1246.236	3907.652	2397.529	281.001
	3	53755.285	12047657.3	40266.874	12939.883	548.528	2890.01	1772.084	117.361
	3	24095.435	5678809.14	18030.098	5794.027	271.31	1360.314	834.362	57.916
	3	104487.846	22385123.41	78598.46	25257.856	631.53	5412.136	3348.126	128.598
	3	137195.711	25646826.36	105995.91	30175.609	1024.192	6624.351	3328.475	234.564
	3	79416.643	19326824.34	60102.515	19314.128	0	4764.002	2921.836	0
	3	236.16	133709.847	0	0	236.16	0	0	48.379
TOTAL 3 (Suburban Area-RMOC):		482578.187	106729269.2	384539.025	113259.232	4779.93	26019.175	15255.502	1073.752
	4	256.263	65307.173	176.514	79.749	0	13.896	12.021	0
	4	6168.037	1495256.034	4235.154	1913.443	17.44	316.306	272.892	3.82
	4	24953.772	5894247.159	17184.163	7763.809	5.8	1212.155	1046.289	1.179
	4	15942.222	3793898.902	10960.366	4951.896	29.96	805.284	693.488	6.238
	4	176088.83	37926419.89	121033.746	54683.074	372.01	7972.934	6991.886	77.156
	4	214785.781	40928862.55	167189.252	47596.529	0	10463.368	5822.407	0
	4	57358.408	13505409.45	39508.471	17849.937	0	2870.31	2489.096	0
	4	0	0	0	0	0	0	0	0
TOTAL 4 (Rural Area-RMOC):		495551.313	103409401.2	380287.688	134838.437	425.21	23654.253	17328.079	88.395
	5	1527.456	563049.883	1196.382	252.724	78.35	143.41	58.077	20.828
	5	19883.621	6388607.448	16129.9	3407.285	346.436	1725.362	698.354	111.464
	5	740.759	152288.554	611.571	129.188	0	43.304	17.401	0
	5	4972.729	1177561.707	4084.845	862.884	25	329.424	132.992	6.326
	5	6105.718	1332288.974	5039.997	1064.651	1.07	377.907	152.909	0.216
	5	1787.025	305694.897	1390.265	395.79	0.97	82.512	39.064	0.157
	5	2587.191	1014759.375	2135.985	451.206	0	287.81	116.672	0
	5	4.2	2300.475	0	0	4.2	0	0	0.832
TOTAL 5 (Central Core-OUTAOUAIS):		37608.689	10838891.31	30688.946	8863.728	458.026	2389.729	1215.469	139.823
	6	8390.938	2366570.738	6525.372	1518.726	346.84	587.966	262.17	84.191
	6	46049.404	10903305.37	36759.84	8555.545	734.02	2878.132	1280.784	168.002
	6	31380.787	6733910.25	25243.26	5875.157	262.37	1816.905	805.579	54.83
	6	7288.524	1696536.873	5876.32	1367.664	44.54	459.974	204.577	10.312
	6	32394.151	6463924.25	26240.982	6107.369	45.8	1766.665	797.89	9.521
	6	6156.255	12585905	47834.707	13617.897	123.65	327.2422	1701.823	32.438
	6	23242.261	5060172.462	18854.122	4398.139	0	1396.3	619.714	0
	6	224.37	122978.789	0	0	224.37	0	0	44.496
TOTAL 6 (Urban Area-OUTAOUAIS):		210643.68	45833303.74	167334.603	41430.497	1781.59	12178.364	5672.537	403.79
	7	1211.402	354218.086	863.578	277.514	70.31	75.96	46.756	16.51
	7	8450.513	2020444.165	6328.174	2733.578	88.76	484.218	297.501	17.955
	7	19982.524	4500907.333	15041.706	4833.698	107.12	1093.779	670.992	22.868
	7	1925.173	443884.368	1452.937	466.906	5.33	108.629	66.656	1.128
	7	16196.15	3296035.725	12212.489	3924.521	59.14	795.64	502.098	11.648
	7	66939.141	13318050.45	52087.127	14828.504	23.51	3389.878	1904.595	4.13
	7	8277.926	1845703.144	6264.735	2013.192	0	455.298	278.704	0
	7	493.2	270141.444	0	0	493.2	0	0	97.743
TOTAL 7 (Suburban Area-OUTAOUAIS):		123476.029	26048384.72	94250.746	28377.913	847.37	6403.402	3767.302	173.818
	8	607.132	268425.045	396.199	179.003	31.93	52.765	45.747	7.301
	8	10171.583	2917146.889	6981.72	3154.343	35.52	615.696	532.081	9
	8	7019.576	1593520.964	4827.521	2181.075	10.98	338.725	291.217	2.239
	8	14780.905	3609307.279	10163.185	4591.729	25.99	765.545	660.402	5.832
	8	15348.893	3328926.638	10561.062	4771.49	16.33	701.15	616.07	3.376
	8	86111.957	17701934.89	67021.476	19080.112	10.37	4440.22	2599.189	1.989
	8	24366.766	5576432.124	16783.829	7582.938	0	1188.328	1024.669	0
	8	135.12	74009.554	0	0	135.12	0	0	26.778
TOTAL 8 (Rural Area-OUTAOUAIS):		158541.922	39088783.19	116734.992	41540.89	286.24	8702.429	5789.373	58.515
TOTAL (1-8) RMOC:		2014806.815	44062494.2	1546885.505	448921.363	19001.946	111000.184	59786.658	4220.372
TOTAL (9-8) OUTAOUAIS:		930173.34	117888843	406888.288	117812.828	3351.226	28873.324	16424.683	773.948
TOTAL NATIONAL CAPITAL REGION:		2544982.155	558513847.1	1953794.791	566334.191	22353.172	140674.108	76221.341	4994.316

Appendix H: Scenario 2 - parking cost increased by 50% (GHG emission estimates for 1995)

Vehicle Type Descriptions

Vehicle Type 1: Autos
Vehicle Type 2: Light trucks
Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	2311.349	805796.164	1817.896	384.013	109.44	203.688	82.413	31.854
	2	64817.634	21096954.78	52002.497	10985.024	1830.113	5590.365	2259.483	507.873
	3	12826.84	3506549.655	10555.317	2229.708	41.815	988.517	397.705	10.475
	4	6144.64	2152378.981	5066.426	1070.233	7.98	609.636	246.128	1.988
	5	4322.742	1147316.961	3568.856	753.886	0	326.248	131.092	0
	6	48258.953	11212244.53	37550.183	10690.031	18.739	2960.499	1499.403	3545
	7	9373.526	3436916.174	7738.783	1634.743	0	975.517	394.452	0
	8	986.147	867011.122	0	0	986.147	0	0	241.338
TOTAL 1 (Central core-RMOC):		149041.831	44025164.36	118299.358	27747.638	2994.234	11654.47	5010.876	197.073
	2	21851.285	8112684.61	16854.331	3922.704	1074.25	2010.5	896.513	295.22
	2	175002.079	53003666.51	139801.034	32537.519	2663.526	14087.663	6263.137	695.751
	2	32811.198	8237700.417	26457.955	6157.867	195.375	2511.398	1115.51	48.543
	2	72847.155	20498360.33	58689.648	13659.524	497.983	5563.059	2466.657	124.454
	2	52962.503	13951053.48	42559.55	9905.379	497.574	3752.867	1675.469	117.794
	2	197191.91	46055465.68	152786.754	43496.332	906.824	11979.322	6140.568	194.864
	2	57732.797	16590384.37	46832.845	10899.952	0	4578.565	2031.195	0
	2	1810.943	1089577.308	0	0	1810.943	0	0	394.232
TOTAL 2 (Urban area-RMOC):		612009.87	18853882.7	483982.117	120579.277	7448.475	44483.374	20589.049	1870.858
	3	8967.774	3621072.779	6311.468	2028.21	628.096	771.45	474.599	176.089
	3	34532.405	10616390.19	25650.589	8242.895	638.92	2505.17	1536.202	164.251
	3	19607.8	5456196.535	14743.933	4738.008	125.86	1324.315	812.883	29.658
	3	4747.141	2130739.956	5456.407	1753.433	37.3	519.094	318.001	9.332
	3	40489.978	10865950.08	30559.53	9820.398	110.05	2649.98	1642.368	25.954
	3	93212.048	23071040.7	71997.542	20496.731	717.775	5844.343	3179.758	142.891
	3	27136.245	7923922.298	20536.711	6599.535	0	1954.393	1196.8	0
	3	4.886	3774.573	0	0	4.886	0	0	1.366
TOTAL 3 (Suburban area-RMOC):		231198.277	8368987.1	175256.179	53679.21	2262.887	13588.745	9161.011	549.547
	4	100.279	32800.69	69.072	31.207	0	6.981	6.036	0
	4	995.532	316030.082	683.862	308.969	2.7	66.906	57.749	0.694
	4	9419.899	2847036.056	6486.746	2930.713	2.44	605.627	523.577	0.564
	4	8348.395	2522978.323	5750.374	2598.02	0	538.221	463.032	0
	4	91472.098	25351445.22	62983.588	28456	32.51	5345.152	4706.015	7.472
	4	132932.736	35343853.1	103474.841	29457.894	0	8877.883	5181.678	0
	4	37724.229	10957838.21	25984.449	11739.78	0	2324.98	2023.366	0
	4	0	0	0	0	0	0	0	0
TOTAL 4 (RMOC area-OUTAOUAIS):		280993.168	7737198.88	205432.932	75622.583	37.65	17765.75	12961.433	8.73
	5	1241.975	580286.25	959.896	202.769	79.31	146.422	59.299	23.221
	5	16677.998	6915390.385	13495.957	2850.89	331.151	1864.989	754.742	124.141
	5	88.406	21526.03	72.988	15.418	0	6.069	2.51	0
	5	4605.931	1434336.476	3782.016	798.914	25	401.426	162.067	7.483
	5	5786.922	1716568.055	4776.799	1009.053	1.07	486.671	197.263	0.261
	5	1836.27	427214.484	1428.598	406.702	0.97	116.874	53.107	0.185
	5	1768.032	786919.25	1459.687	308.345	0	223.245	90.422	0
	5	0	0	0	0	0	0	0	0
TOTAL 5 (Central core-OUTAOUAIS):		32005.634	11822240.93	25975.941	6592.091	437.601	3245.896	1319.47	155.291
	6	8546.283	3014549.106	6651.388	1548.055	346.84	755.677	336.926	98.437
	6	46696.228	14794386.14	37284.543	8677.665	734.02	3924.302	1747.025	202.324
	6	29023.273	8371940.199	23330.845	5430.059	262.37	2258.361	1002.027	68.173
	6	6738.218	2207448.549	5429.912	1263.766	44.54	599.008	266.647	12.529
	6	24251.247	6435957.764	19635.459	4569.988	45.8	1753.309	797.661	11.649
	6	61123.895	16669037.56	47482.59	13517.654	123.65	4397.38	2192.695	42.491
	6	18674.926	5223216.737	15149.1	3525.826	0	1441.568	639.411	0
	6	0.81	618.784	0	0	0.81	0	0	0.224
TOTAL 6 (Urban area-OUTAOUAIS):		195054.88	66717154.84	154963.837	38533.013	1568.03	15129.805	6982.392	435.827
	7	1008.289	40497.3948	709.862	228.116	70.31	86.537	53.275	19.32
	7	5432.366	1713247.825	4044.041	1299.585	88.76	406.279	249.634	23.109
	7	16477.553	4745785.685	12389.144	3981.289	107.12	1151.537	707.024	26.128
	7	1487.896	438716.002	1122.006	360.56	5.33	107.28	65.738	1.319
	7	9993.358	2618633.737	7518.216	2416.002	59.14	617.841	407.62	14.068
	7	47964.904	13017050.21	37317.581	10623.813	23.51	3249.707	1922.066	5.386
	7	5949.91	1733896.353	4502.892	1447.018	0	427.703	261.835	0
	7	0	0	0	0	0	0	0	0
TOTAL 7 (Suburban area-OUTAOUAIS):		88314.276	24872303.76	67603.742	20356.383	354.17	6048.884	3667.192	88.332
	8	249.6	195326.978	152.121	68.728	28.75	36.98	32.082	7.705
	8	8456.113	3127544.75	5798.7	2619.854	37.56	659.193	569.629	11.234
	8	3606.304	1060743.137	2476.459	1118.865	10.98	224.844	193.24	2.624
	8	10311.897	3158394.678	7084.933	3200.974	25.99	669.66	576.56	6.56
	8	16777.679	4725170.56	11545.217	5216.132	16.33	996.618	874.17	3.818
	8	47166.899	12727315.77	36706.642	10449.887	10.37	3186.446	1873.276	2.646
	8	14705.829	4334762.418	10129.375	4576.454	0	923.016	797.209	0
	8	0	0	0	0	0	0	0	0
TOTAL 8 (RMOC area-OUTAOUAIS):		101274.321	28328298.28	73893.447	27250.894	129.98	6896.757	4970.766	34.587
TOTAL (1-8) RMOC:		1273243.146	353625129.3	982971.186	277528.708	12743.246	89472.339	47722.189	3226.202
TOTAL (5-8) OUTAOUAIS:		416648.911	122800887.8	322436.987	81732.361	2479.881	31118.942	16885.16	715.037
TOTAL NATIONAL CAPITAL REGION:		1689892.157	476226017.1	1305408.153	388261.069	15222.927	120591.281	64607.349	3941.239

Appendix H: Scenario 2 - parking cost increased by 50% (GHG emission estimates for 2021)

Vehicle Type Descriptions

Vehicle Type 1: Autos
Vehicle Type 2: Light trucks
Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	3407.442	870368.226	2721.534	574.898	111.01	225.935	91.411	26.855
	2	80498.86	20529712.43	64740.416	13675.785	2082.658	5424.97	2193.588	512.563
	3	15749.626	3396329.062	12971.056	2740.01	38.56	958.392	386.049	9.512
	4	12811.009	3037833.642	10570.18	2232.848	7.98	861.151	347.827	1.745
	5	4981.357	1031745.907	4112.608	868.749	0	293.364	117.907	0
	6	53851.915	9706147.185	41903.744	11929.432	18.739	2637.901	1224.909	2.952
	7	12768.272	3963273.227	10541.485	2226.787	0	1124.714	455.058	0
	8	1499.805	884144.526	0	0	1499.805	0	0	312.665
TOTAL 1 (Central core-RMOC):		185588.086	4339834.21	147581.023	34248.51	3758.552	11528.427	4816.749	865.292
	1	30487.756	9624500.038	23792.527	5537.511	1157.717	2437.513	1087.364	281.082
	2	227222.615	53889733.16	181761.311	42303.421	3157.883	14312.548	6366.882	171.835
	3	49165.152	10727898.3	39679.106	9234.979	251.067	2918.334	1295.668	54.556
	4	118021.781	25362316.39	93657.656	21798.034	566.09	6904.861	3064.58	122.705
	5	88036.58	18174049.08	70813.417	16481.229	741.934	4892.418	2176.567	155.853
	6	240766.444	43009359.83	186250.017	53022.872	1493.555	11378.741	5457.539	265.069
	7	75234.595	16585997.73	61030.303	14204.291	0	4576.678	2031.317	0
	8	2870.008	1548808.995	0	0	2870.008	0	0	580.391
TOTAL 2 (Urban area-RMOC):		829604.931	178922683.5	656984.337	182582.337	10038.254	47421.093	21479.917	2157.497
	1	14475.327	4827405.378	10332.858	3320.495	821.974	1047.537	645.143	206.558
	2	67260.899	16220641.08	49959.696	16054.766	1246.236	3807.121	2335.51	280.175
	3	52776.287	11763360.15	39527.482	12702.277	548.528	2820.298	1729.363	116.791
	4	23754.983	5558266.779	17772.444	5711.229	271.31	1330.722	816.093	57.849
	5	103307.182	22018362.45	77704.934	24970.719	631.53	5322.477	3292.514	128.078
	6	136904.542	25475260.07	105769.264	30111.086	1024.192	6573.237	3315.314	229.785
	7	78308.681	18977867.83	59264.01	19044.671	0	4678.099	2868.97	0
	8	236.16	133709.647	0	0	236.16	0	0	48.379
TOTAL 3 (Suburban area-RMOC):		477026.061	104974873.4	380330.888	111915.243	4779.93	25579.491	15003.907	1067.615
	1	243.19	61944.633	167.51	75.681	0	13.18	11.402	0
	2	6006.072	1452458.773	4124.97	1863.682	17.44	307.221	264.994	3.82
	3	24850.859	5649202.298	17113.139	7731.72	5.8	1202.586	1037.982	1.179
	4	15893.811	3780878.563	10927.02	4936.83	29.96	802.519	691.091	6.234
	5	176077.264	37877588.34	121025.779	54679.475	372.01	7962.252	6983.501	76.863
	6	213333.563	40751016.51	166058.845	47274.718	0	10408.068	5806.697	0
	7	57632.13	13463471.06	39697.011	17935.119	0	2861.462	2481.282	0
	8	0	0	0	0	0	0	0	0
TOTAL 4 (Rural area-RMOC):		494036.889	103038506.2	359114.274	134497.205	425.21	23557.288	17276.549	88.096
	1	1336.105	468561.568	1038.402	219.352	78.35	117.403	47.536	19.816
	2	18990.899	5707781.604	15392.869	3251.594	346.436	1537.47	622.22	104.792
	3	726.326	148970.591	599.655	126.671	0	42.345	17.037	0
	4	4840.731	1123908.732	3975.867	839.863	25	314.376	126.869	6.113
	5	6003.43	1272424.003	4955.548	1046.812	1.07	361.019	145.936	0.217
	6	1789.953	299482.911	1392.544	356.439	0.97	79.88	39.199	0.157
	7	2420.435	924087.83	1998.311	422.124	0	262.103	106.237	0
	8	4.2	2300.475	0	0	4.2	0	0	0.832
TOTAL 5 (Central core-Outsiders):		381120.78	8947517.74	29353.186	8302.855	456.026	2714.596	1105.054	137.927
	1	8099.795	2285748.095	6289.197	1463.758	346.84	565.764	252.259	84.112
	2	44862.447	10551907.18	35796.98	8331.447	734.02	2781.702	1237.733	167.535
	3	30430.455	6509684.453	24472.35	5695.734	262.37	1755.234	778.131	54.637
	4	7088.781	1622249.616	5714.288	1329.953	44.54	439.705	195.497	10.089
	5	32105.07	6364653.418	26006.48	6052.79	45.8	1738.73	786.347	9.442
	6	60193.444	12225552.51	46758.327	13311.466	123.65	3162.836	1668.906	31.221
	7	22764.153	4936692.024	18466.281	4297.872	0	1362.272	604.547	0
	8	224.37	122878.799	0	0	224.37	0	0	44.496
TOTAL 6 (Urban area-Outsiders):		205788.515	44819486.08	163503.903	40483.02	1781.59	11806.243	5523.42	407.532
	1	1164	335633.042	827.704	265.985	70.31	71.433	43.965	16.443
	2	8045.624	1916547.305	6021.755	1935.109	88.76	458.669	281.772	19.761
	3	19637.383	4397406.276	14780.503	4749.76	107.12	1068.391	655.387	22.717
	4	1880.149	426750.283	1403.727	451.092	5.33	104.416	64.055	1.126
	5	15914.105	3220828.262	11999.038	3855.927	59.14	776.537	491.338	11.591
	6	65983.667	13179926.69	51343.386	14616.771	23.51	3345.576	1893.673	4.167
	7	8064.17	1796485.713	6102.964	1961.206	0	443.165	271.266	0
	8	493.2	270141.444	0	0	493.2	0	0	97.743
TOTAL 7 (Suburban area-Outsiders):		121182.298	25543720.02	92479.077	27835.85	847.37	6268.187	3707.456	173.548
	1	555.166	255358.362	360.405	162.831	31.93	49.986	43.343	7.3
	2	10001.751	2846773.33	6864.74	3101.491	35.52	600.795	519.158	8.907
	3	6725.127	1527263.413	4624.704	2089.443	10.98	324.582	279.065	2.239
	4	14558.477	3532426.581	10010.666	4522.821	25.99	749.248	646.237	5.789
	5	15340.548	3323825.79	10555.321	4768.897	16.33	700.066	615.135	3.371
	6	84864.091	17448975.78	66050.137	18803.585	10.37	4374.668	2564.072	1.983
	7	23918.287	5461489.867	16474.916	7443.371	0	1163.914	1003.47	0
	8	135.12	74009.554	0	0	135.12	0	0	26.778
TOTAL 8 (Rural area-Outsiders):		158099.567	34479122.88	114940.889	40892.439	286.24	7883.259	5670.48	58.387
TOTAL (1-4) RMOC:		1986235.767	43033597.3	1523990.522	443243.295	19001.946	108084.299	58577.522	4178.494
TOTAL (5-8) OUTSIDERS:		818142.888	11488026.3	400277.085	118514.184	3351.226	28782.285	16800.41	763.374
TOTAL NATIONAL CAPITAL REGION:		2804378.655	54521623.6	1924267.607	561757.479	22353.172	136866.584	75377.932	4941.868

Appendix I: Scenario 3 - parking cost increased by 100% (GHG emission estimates for 1995)

Vehicle Type Descriptions

Vehicle Type 1: Autos
Vehicle Type 2: Light trucks
Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	2116.42	733358.875	1656.963	350.017	109.44	183.462	74.225	31.436
	2	6147.3.61	19702378.05	49241.671	10401.826	1830.113	5199.31	2101.097	502.027
	3	12611.284	3435973.732	10377.353	2192.115	41.815	968.584	389.576	10.413
	4	5873.26	1954975.201	4842.375	1022.905	7.98	553.653	223.429	1.986
	5	4167.726	1102772.659	3440.875	726.851	0	313.569	126.015	0
	6	47805.628	11010060.78	37197.314	10589.575	18.739	2892.294	1486.703	3.586
	7	8863.2	3212705.961	7317.458	1545.742	0	911.888	368.71	0
	8	986.147	667011.122	0	0	986.147	0	0	241.338
TOTAL 1 (Central core-RMOC):		143897.275	41819238.38	114074.009	26829.031	2894.234	11022.78	4789.735	790.786
	2	21358.674	7888070.041	16454.724	3829.699	1074.25	1949.05	869.098	294.658
	2	169430.422	51098117.41	135281.306	31485.59	2863.528	13564.16	6029.492	693.92
	3	32371.711	9045417.359	26101.444	6074.892	195.375	2458.581	1091.943	48.343
	4	71559.611	20098489.73	57645.192	13416.435	497.983	5453.063	2417.567	124.253
	5	51058.404	13415671.87	41014.945	9545.885	497.574	3604.729	1610.693	117.428
	6	196255.043	45605621.17	152057.497	43288.722	908.824	11828.03	6120.893	186.614
	7	56776.059	16310109.01	46056.739	10719.32	0	4501.266	1996.83	0
	8	1810.943	1089577.308	0	0	1810.943	0	0	394.232
TOTAL 2 (Urban area-RMOC):		800420.887	16453107.33	474811.847	118380.543	7448.475	43358.879	20136.316	1859.446
	3	8813.011	3550317.955	6194.344	1990.571	628.096	754.29	464.425	175.723
	3	33866.766	10383503.74	25146.834	8081.012	638.92	2448.015	1500.987	164.032
	3	19252.367	5345987.264	14474.941	4651.567	125.86	1297.208	796.187	29.636
	4	6994.286	2046386.208	5265.047	1691.939	37.3	498.395	305.176	9.315
	5	39945.344	10703209.83	30147.35	9687.943	110.05	2609.482	1616.155	25.938
	6	92295.587	22773265.59	71284.169	20293.643	717.775	5751.399	3160.742	136.474
	7	26758.472	7798434.767	20250.811	6507.66	0	1923.508	1177.782	0
	8	4.886	3774.573	0	0	4.886	0	0	1.368
TOTAL 3 (Suburban area-RMOC):		227930.719	62604879.93	172763.496	52904.335	2262.887	15282.297	9023.454	542.484
	4	86.977	29093.558	61.287	27.69	0	6.192	5.354	0
	4	1004.316	318777.73	689.913	311.703	2.7	67.491	58.254	0.694
	4	9157.655	2770402.685	6306.112	2849.103	2.44	589.32	509.473	0.564
	4	8255.497	2494832.587	5686.386	2569.111	0	532.213	457.871	0
	5	90844.74	25169165.15	62551.464	28260.766	32.51	5306.602	4672.236	7.472
	6	132585.118	35255146.86	103204.256	29380.862	0	8856.645	5167.654	0
	7	37672.931	10936252.64	25949.115	11723.816	0	2320.378	2019.402	0
	8	0	0	0	0	0	0	0	0
TOTAL 4 (Rural area-RMOC):		279609.234	78973671.21	204448.533	75123.051	37.65	17678.847	12890.244	8.73
	5	1102.685	490677.419	844.899	178.477	79.31	121.34	45.126	22.802
	5	15732.056	6044815.845	12714.987	2685.918	331.151	1625.48	657.705	114.641
	5	88.58	21568.158	73.131	15.448	0	6.081	2.515	0
	5	4428.501	1320465.108	3635.53	767.971	25	369.536	149.139	6.965
	5	5611.212	1586263.222	4631.734	978.409	1.07	449.796	182.201	0.262
	5	1792.173	402689.883	1394.272	396.931	0.97	108.845	51.326	0.185
	5	1648.117	674542.481	1360.685	287.432	0	191.387	77.487	0
	5	0	0	0	0	0	0	0	0
TOTAL 5 (Central core-Outsiders):		30403.324	10541002.12	24855.238	5310.586	437.501	2872.485	1169.499	144.255
	6	8093.33	2820220.752	6283.952	1462.537	346.84	702.474	313.182	98.007
	6	2	44883.36	14019601.1	35813.944	8335.395	734.02	3712.205	200.656
	6	3	28055.299	8016595.002	22545.624	5247.305	262.37	2161.105	958.537
	6	4	6492.318	2034108.449	5230.437	1217.34	44.54	551.824	245.523
	6	5	23614.084	6204640.119	19118.592	4449.692	45.8	1689.398	769.67
	6	6	59897.036	16064367.41	46527.603	13245.782	123.65	4202.09	2149.665
	6	7	17991.24	5018038.472	14594.494	3396.746	0	1385.04	614.196
	6	8	0.81	618.784	0	0	0.81	0	0.224
TOTAL 6 (Urban area-Outsiders):		169027.477	54178190.08	150114.646	37354.787	1558.03	14404.136	6703.062	429.028
	7	902.814	361202.329	630.039	202.465	70.31	75.84	46.671	19.241
	7	2	5144.874	1606015.905	3826.467	1229.647	88.76	379.927	233.391
	7	3	15968.96	4565785.459	12004.24	3657.599	107.12	1107.223	679.944
	7	4	1436.147	422296.92	1082.842	347.975	5.33	103.243	63.246
	7	5	9992.718	2618674.491	7517.732	2415.646	59.14	617.979	407.493
	7	6	46841.87	12812486.33	36443.411	10374.949	23.51	3191.956	1898.074
	7	7	5705.802	1656153.226	4318.151	1387.651	0	408.562	250.061
	7	8	0	0	0	0	0	0	0
TOTAL 7 (Suburban area-Outsiders):		85993.185	26042614.96	65822.882	19816.132	354.17	3884.71	357.848	89.247
	8	1	249.508	195365.699	152.058	68.7	28.75	36.989	32.089
	8	2	8344.224	3031174.592	5721.63	2585.034	37.56	638.821	551.923
	8	3	3457.038	1017553.988	2373.645	1072.413	10.98	215.624	185.32
	8	4	10106.187	3090324.395	6943.24	3136.957	25.99	655.189	564.028
	8	5	16874.487	4752323.859	11611.899	5246.259	16.33	1002.413	879.149
	8	6	47215.26	12745217.14	36744.287	10460.604	10.37	3190.703	1876.129
	8	7	14676.816	4324344.909	10109.391	4567.425	0	920.771	795.319
	8	8	0	0	0	0	0	0	0
TOTAL 8 (Rural area-Outsiders):		100823.52	28198306.18	73656.15	27137.392	129.98	6860.57	4883.957	34.433
TOTAL 1-8) RMOC:		1251858.085	345948861.4	965897.885	273216.96	12743.248	87342.777	46819.969	3201.446
TOTAL (5-8) OUTSIDERS:		406347.308	117818112	314248.316	89618.367	2473.681	29821.821	16335.398	687.555
TOTAL NATIONAL CAPITAL REGION:		1658205.601	463868973.5	1280146.801	362835.357	15222.927	117164.598	63155.367	3898.001

Appendix I: Scenario 3 - parking cost increased by 100% (GHG emission estimates for 2021)

Vehicle Type Descriptions

Vehicle Type 1: Autos
Vehicle Type 2: Light trucks
Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	3167.246	806334.522	2523.229	533.008	111.01	207.983	84.146	26.576
	2	77220.716	19428721.42	62033.981	13104.077	2082.658	5118.075	2069.218	505.674
	3	15334.31	3279976.652	12628.171	2667.579	38.56	925.499	372.666	8.42
	4	12473.846	2894487.425	10291.819	2174.047	7.98	820.534	331.317	1.735
	5	4857.596	1001758.289	4010.431	847.165	0	284.862	114.456	0
	6	53446.436	9413894.676	41588.119	11839.578	18.739	2543.262	1202.833	2.89
	7	12184.916	3735068.197	10059.867	2125.049	0	1059.974	428.836	0
	8	1499.605	864144.526	0	0	1499.605	0	0	312.665
TOTAL 1 (Central core-RMOC):		180184.671	41424383.7	143135.617	33290.503	3758.552	10980.189	4803.472	257.98
	2	29922.995	9425749.39	23334.393	5430.884	1157.717	2383.401	1063.216	280.245
	2	221958.309	52335714.71	177490.906	41309.52	3157.883	13687.408	6176.944	714.171
	2	48823.124	10612730.61	39401.652	9170.404	251.067	2886.845	1281.501	54.352
	2	114233.478	24876372.92	92206.984	21460.403	566.09	6771.52	3004.816	122.261
	2	86739.979	17838988.52	69761.614	16236.431	741.934	4800.741	2135.885	154.826
	2	239470.996	42219766.33	185241.64	52735.801	1493.555	11121.054	5407.685	257.651
	2	74186.55	16336320.32	60180.13	14006.421	0	4507.842	2000.681	0
	2	2670.008	1548808.995	0	0	2670.008	0	0	560.391
TOTAL 2 (Urban Area-RMOC):		818005.439	175194451.8	647817.319	160349.884	10038.254	48358.811	21070.728	2743.897
	3	14291.608	4773216.558	10193.819	3275.815	821.974	1034.654	637.218	205.883
	3	66119.393	15909023.22	49098.005	15777.152	1246.236	3730.76	2288.504	279.672
	3	52184.955	11604267.03	39078.448	12557.979	548.528	2781.24	1705.461	116.511
	3	23416.644	5453140.02	17516.389	5628.945	271.31	1304.901	800.155	57.808
	3	102282.349	21728286.97	76929.34	24721.479	631.53	5251.35	3248.63	127.767
	3	136115.931	25163225.37	105155.41	29936.329	1024.192	6480.062	3293.714	221.729
	3	77510.945	18743541.9	58660.284	18850.662	0	4620.401	2833.483	0
	3	238.18	133709.647	0	0	238.18	0	0	48.379
TOTAL 3 (Suburban Area-RMOC):		472157.985	103508416.7	358628.695	110748.361	4779.93	25203.368	14407.165	1057.749
	4	233.192	59218.119	160.622	72.369	0	12.601	10.9	0
	4	5748.157	1386401.955	3947.318	1783.399	17.44	293.179	252.821	3.62
	4	24627.141	5602715.936	16959.18	7662.161	5.8	1192.597	1029.522	1.178
	4	15802.57	3758316.201	10864.173	4908.436	29.96	797.706	686.952	6.231
	4	174885.06	37615627.76	120204.589	54308.461	372.01	7906.059	6935.704	76.884
	4	212676.215	40898223.11	165547.166	47129.049	0	10388.379	5805.225	0
	4	57427.171	13499683.99	39555.835	17871.336	0	2868.876	2488.252	0
	4	0	0	0	0	0	0	0	0
TOTAL 4 (Rural Area-RMOC):		491399.506	102620187.1	357238.883	133735.411	425.21	23459.397	17209.376	88.113
	5	1272.967	436764.849	986.276	208.341	78.35	108.666	44.002	19.432
	5	18281.63	5288224.275	14807.296	3127.896	346.436	1421.655	575.302	100.705
	5	705.626	144136.444	582.565	123.061	0	40.959	16.496	0
	5	4685.332	1070008.733	3847.57	812.762	25	299.238	120.748	5.926
	5	5917.039	1235942.405	4884.224	1031.745	1.07	350.753	141.662	0.218
	5	1786.241	296699.286	1389.655	395.616	0.97	78.705	39.255	0.156
	5	2305.791	859746.774	1903.661	402.13	0	243.866	98.829	0
	5	4.2	2300.475	0	0	4.2	0	0	0.832
TOTAL 5 (Central core-OUTSIDE):		34958.826	8333823.241	28401.247	6101.553	456.026	2543.862	1036.294	127.269
	6	7842.001	2217688.911	6080.075	1415.086	346.84	547.068	243.915	84.045
	6	43919.253	10282554.7	35031.861	8153.372	734.02	2707.728	1204.703	167.258
	6	29808.159	6365991.651	23967.544	5578.245	262.37	1715.725	760.544	54.499
	6	6964.644	1579793.727	5613.588	1306.516	44.54	428.15	190.3	9.992
	6	31653.446	6244846.296	25640.123	5967.524	45.8	1705.009	772.369	9.396
	6	59208.664	11989730.18	45991.775	13093.239	123.65	3091.674	1646.646	30.591
	6	22481.641	4867602.99	18237.107	4244.534	0	1343.226	596.068	0
	6	224.37	122978.799	0	0	224.37	0	0	44.496
TOTAL 6 (Urban Area-OUTSIDE):		202102.178	43671167.26	160582.073	39758.516	1781.59	11536.58	5414.545	400.227
	7	1146.477	325585.585	814.443	261.724	70.31	69.006	42.469	16.377
	7	7767.426	1845842.292	5811.214	1867.451	88.76	441.282	271.066	19.739
	7	19440.912	4332976.892	14631.814	4701.978	107.12	1052.599	645.679	22.606
	7	1781.502	409703.385	1344.51	432.062	5.33	100.209	61.483	1.126
	7	15573.409	3135363.186	11741.199	3773.07	59.14	754.778	479.139	11.547
	7	65232.248	13082498.7	50758.482	14450.256	23.51	3314.772	1885.499	4.228
	7	7932.518	1765780.076	6003.33	1929.189	0	435.598	266.621	0
	7	493.2	270141.444	0	0	493.2	0	0	97.743
TOTAL 7 (Suburban Area-OUTSIDE):		119366.092	25167891.36	91104.992	27415.729	847.37	6168.244	3651.958	173.365
	8	535.101	250405.528	346.584	156.587	31.93	48.932	42.432	7.3
	8	9890.784	2801281.069	6788.306	3066.958	35.52	591.158	510.8	8.854
	8	6646.811	1508000.96	4570.76	2065.071	10.98	320.482	275.521	2.239
	8	14377.979	3476790.092	9885.65	4466.339	25.99	737.438	635.958	5.8
	8	15240.767	3299986.465	10486.592	4737.845	16.33	694.988	610.761	3.364
	8	84230.349	17325712.57	65556.831	18663.147	10.37	4342.109	2547.561	1.98
	8	23643.58	5391545.557	16285.698	7357.882	0	1149.019	990.608	0
	8	135.12	74000.554	0	0	135.12	0	0	26.778
TOTAL 8 (Rural Area-OUTSIDE):		154700.491	34127731.8	113820.421	40613.829	286.24	7854.128	5813.647	38.315
TOTAL (1-8) RMOC:		1961747.601	422747435.3	1504821.574	438124.139	19001.946	105981.765	57690.741	4147.719
TOTAL (8-9) OUTSIDE:		811128.967	112306633.9	383988.734	113788.827	3351.266	28134.838	15716.438	757.177
TOTAL NATIONAL CAPITAL REGION:		2772876.568	535054069.1	1888810.247	551913.768	22353.172	134116.577	73407.177	4904.896

Appendix J: Scenario 4 - fuel cost increased 1% above inflation rate (GHG emission estimates for 2021)

Vehicle Type Descriptions

Vehicle Type 1: Autos
Vehicle Type 2: Light trucks
Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	3986.467	1021721.955	3199.577	675.88	111.01	268.6	108.676	27.218
	2	85694.913	22527309.51	69030.277	14581.977	2082.658	5978.215	2417.856	529.561
	3	16417.385	3601952.14	13522.358	2856.467	38.56	1016.557	409.725	8.619
	4	13391.146	3331769.31	11049.141	2334.024	7.98	944.43	381.668	1.781
	5	5192.857	1085967.567	4287.223	905.634	0	308.689	124.194	0
	6	54132.512	10221626.66	42122.161	11991.612	18.739	2801.77	1266.755	3.131
	7	13773.894	4478095.342	11371.727	2402.167	0	1270.723	514.256	0
	8	1499.805	884144.528	0	0	1499.805	0	0	312.665
TOTAL 1 (Central core-RMOC):		194088.779	47132587	154582.484	35747.761	3758.552	12588.984	5223.173	882.975
	1	31348.98	9904542.702	24491.152	5700.11	1157.717	2514.008	1121.482	281.95
	2	233487.572	55933634.53	186843.443	43486.245	3157.883	14870.785	6616.421	723.738
	3	49595.683	10883754.56	40028.352	9316.263	251.067	2960.991	1314.94	54.701
	4	118072.204	25966625.46	95320.959	22185.154	566.09	7070.441	3138.951	123.426
	5	89704.408	18644208.8	72166.359	16796.115	741.934	5020.604	2233.714	157.65
	6	241302.113	44174241.1	186666.982	53141.576	1493.555	11754.388	5534.444	276.981
	7	76419.096	16880766.49	61991.171	14427.925	0	4657.906	2067.525	0
	8	2870.008	1548808.995	0	0	0	2870.008	0	580.391
TOTAL 2 (Urban Area-RMOC):		842800.064	163836582.6	687508.418	165053.388	10038.254	48849.123	22027.477	2178.837
	1	14576.642	4854776.53	10409.533	3345.135	821.974	1054.686	649.543	205.953
	2	68514.899	16560662.28	50908.924	16359.739	1246.236	3891.735	2387.586	280.788
	3	53438.647	11963034.76	40027.242	12862.877	548.528	2869.217	1759.36	117.237
	4	23927.688	5644645.419	17903.147	5753.231	271.31	1351.885	829.203	57.918
	5	103973.095	22253794.44	78208.896	25132.669	631.53	5379.752	3326.417	128.474
	6	136999.193	25631812.46	105842.941	30132.06	1024.192	6619.527	3326.634	235.18
	7	79105.972	19214684.85	59667.4	19238.572	0	4736.393	2904.851	0
	8	236.18	133709.647	0	0	0	236.18	0	48.379
TOTAL 3 (Suburban Area-RMOC):		480772.296	106262520.2	383188.083	112824.283	4779.93	23903.193	15185.594	1073.929
	1	256.533	65299.342	176.7	79.833	0	13.894	12.019	0
	2	6007.813	1452842.471	4126.169	1864.204	17.44	307.299	265.067	3.82
	3	24997.902	5701180.057	17214.56	7777.542	5.8	1213.667	1047.529	1.179
	4	15847.258	3768328.637	10894.955	4922.343	29.96	799.855	886.773	6.236
	5	176211.546	37937743.5	121118.272	54721.263	372.01	7975.209	6994.354	76.924
	6	214671.519	40898940.47	167100.31	47571.209	0	10456.214	5817.667	0
	7	57366.431	13499252.74	39513.998	17852.433	0	2888.075	0	0
	8	0	0	0	0	0	0	0	0
TOTAL 4 (Rural Area-RMOC):		495399.002	103323987.2	380144.964	134788.827	425.21	23635.023	17313.484	88.139
	1	1542.986	564665.423	1209.203	255.433	78.35	143.859	58.26	20.839
	2	19904.052	6431502.532	16146.768	3410.848	346.436	1737.172	703.138	111.923
	3	740.74	152281.064	611.555	129.185	0	43.303	17.399	0
	4	4940.05	1169930.216	4057.865	857.185	25	327.257	132.117	6.325
	5	6117.341	1339132.691	5049.593	1066.678	1.07	379.843	153.701	0.216
	6	1781.46	305810.72	1385.933	394.557	0.97	82.677	38.948	0.157
	7	2602.429	1025638.856	2148.566	453.864	0	290.894	117.924	0
	8	42	2300.475	0	0	4.2	0	0	0.832
TOTAL 5 (Central core-OUTAOUAIS):		37833.258	10991281.36	30809.483	6587.75	458.028	3005.005	1221.487	140.292
	1	8422.877	2377570.592	6551.281	1524.756	346.84	590.939	263.495	84.266
	2	45943.953	10881560.53	35674.298	8535.635	734.02	2872.142	1278.114	167.999
	3	31292.885	6713544.494	25171.954	5858.561	262.37	1811.301	803.079	54.822
	4	7271.119	1696696.347	5862.201	1364.378	44.54	459.983	204.587	10.353
	5	32445.668	6479328.971	26282.773	6117.095	45.8	1770.943	799.739	9.531
	6	61254.696	12529799.73	47584.406	13546.64	123.65	3256.055	1695.848	32.409
	7	23205.038	5053484.112	18823.927	4381.111	0	1394.454	618.896	0
	8	224.37	122978.799	0	0	224.37	0	0	44.496
TOTAL 6 (Urban Area-OUTAOUAIS):		210060.806	45834863.58	188950.84	41328.176	1781.59	12155.817	5663.758	403.876
	1	1208.671	352311.062	861.511	276.849	70.31	75.503	46.474	16.493
	2	8339.251	1993493.479	6243.972	2006.519	88.76	477.584	293.421	19.792
	3	19857.052	4464963.754	14946.748	4803.183	107.12	1084.951	665.573	22.826
	4	1869.811	431708.299	1411.039	453.442	5.33	105.624	64.818	1.126
	5	15954.561	3234235.452	12029.655	3865.766	59.14	780.026	493.171	11.604
	6	66420.549	13234632.03	51683.455	14713.584	23.51	3364.952	1896.229	4.139
	7	8218.377	1832288.522	6219.667	1998.709	0	451.993	276.679	0
	8	493.2	270141.444	0	0	493.2	0	0	97.743
TOTAL 7 (Suburban Area-OUTAOUAIS):		122361.472	25813784.04	93396.047	28118.052	847.37	6340.633	3736.365	173.723
	1	543.64	252721.301	352.466	159.244	31.93	49.424	42.858	7.3
	2	10176.663	2929598.389	6985.219	3155.924	35.52	618.339	534.368	9.01
	3	6951.409	1577782.234	4780.567	2159.861	10.98	335.369	288.328	2.239
	4	14617.269	3557457.523	10050.473	4540.806	25.99	754.544	650.936	5.823
	5	15351.097	3331038.055	10562.588	4772.18	16.33	701.591	616.46	3.383
	6	85562.583	17601886.82	66593.842	18958.37	10.37	4413.624	2585.953	1.986
	7	24201.072	5534245.197	16669.698	7531.374	0	1179.366	1016.889	0
	8	135.12	74009.554	0	0	135.12	0	0	26.776
TOTAL 8 (Rural Area-OUTAOUAIS):		157638.853	34898738.07	115994.853	41277.759	268.24	8062.257	6735.692	58.679
TOTAL (1-8) RMOC:		2012820.141	440855277	1545403.929	448414.259	19001.946	110976.325	59749.685	4223.9
TOTAL (6-8) OUTAOUAIS:		827984.189	117916748.7	408981.223	117281.737	4351.226	28653.112	16357.302	174.41
TOTAL NATIONAL CAPITAL REGION:		2540414.33	558174025.7	1952353.152	585705.998	22353.172	140530.037	76106.987	4998.31

Appendix K: Scenario 5 - fuel cost increased 2.5% above inflation rate (GHG emission estimates for 2021)

Vehicle Type Descriptions

Vehicle Type 1: Autos
Vehicle Type 2: Light trucks
Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	3741.665	958554.721	2997.469	633.186	111.01	250.737	101.447	27.14
	2	83617.383	21710169.12	67315.068	14219.656	2082.858	5751.093	2325.803	523.627
	3	16137.793	3514042.455	13291.527	2807.706	38.56	991.708	399.615	8.545
	4	13109.01	3193382.25	10816.21	2284.82	7.98	905.214	365.74	1.767
	5	5030.51	1045657.667	4153.189	877.321	0	297.273	119.542	0
	6	53700.984	9957913.43	41786.26	11895.986	18.739	2716.639	1246.615	3.037
	7	13486.787	4325902.909	11134.692	2352.096	0	1227.565	496.751	0
	8	1499.805	864144.528	0	0	1499.805	0	0	312.665
TOTAL 1 (Central core-RMOC):		100323.737	43988767.08	151494.415	35070.771	3758.552	12140.229	5053.513	878.781
	1	30743.431	9670781.345	23999.931	5585.783	1157.717	2450.012	1092.921	281.43
	2	227227.731	54097122.25	181765.46	42304.387	3157.883	14368.015	6391.894	719.779
	3	48802.525	10643666.17	39384.943	9166.515	251.067	2895.141	1285.491	54.382
	4	115231.433	25219486.24	93016.526	21648.817	566.09	6865.2	3047.164	122.858
	5	87581.819	18105102.56	70444.515	16395.37	741.934	4872.604	2168.243	156.453
	6	238975.972	43138347.5	184856.313	52626.104	1493.555	11418.13	5466.526	267.94
	7	75361.057	16611945.05	61132.889	14228.168	0	4583.83	2034.503	0
	8	2670.008	154808.995	0	0	2670.008	0	0	560.391
TOTAL 2 (Urban Area-RMOC):		826593.976	170035280.1	654600.577	181955.144	10038.254	47452.932	21486.742	2183.233
	1	14327.354	4755168.027	10220.871	3284.508	821.974	1030.388	634.57	205.644
	2	66028.535	15912462.23	49027.243	15755.055	1246.236	3731.538	2289.056	279.704
	3	52213.652	11628129.83	39100.166	12564.958	548.528	2786.933	1708.98	116.762
	4	23025.141	5390651.202	17220.099	5533.732	271.31	1289.413	790.775	57.822
	5	102120.092	21750391.97	76806.544	24682.018	631.53	5256.099	3252.413	127.99
	6	135908.379	25259721.11	104993.851	29890.336	1024.192	6510.94	3296.354	226.379
	7	77551.03	18672255.45	58690.619	18860.41	0	4602.881	2822.655	0
	8	236.16	133709.847	0	0	236.16	0	0	48.379
TOTAL 3 (Suburban Area-RMOC):		471410.343	103502489.5	358059.393	110571.017	4779.93	25208.192	14794.803	1062.68
	1	247.544	63053.031	170.508	77.036	0	13.416	11.606	0
	2	5698.854	1373275.507	3913.358	1768.056	17.44	290.389	250.402	3.82
	3	24335.338	5524532.161	16758.186	7571.352	5.8	1175.996	1015.097	1.178
	4	15578.278	3659811.665	10709.682	4838.637	29.96	785.269	676.172	6.232
	5	174350.89	37494270.09	119836.653	54142.228	372.01	7880.457	6913.387	76.667
	6	213943.899	40851942.56	166533.931	47409.968	0	10442.159	5812.971	0
	7	57476.897	13472594.86	39590.087	17886.81	0	2863.047	2483.33	0
	8	0	0	0	0	0	0	0	0
TOTAL 4 (Rural Area-RMOC):		491631.7	102479479.9	357512.405	133694.087	425.21	23450.733	17162.985	87.897
	1	1442.445	516252.201	1126.197	237.898	78.35	130.519	52.852	20.34
	2	19398.22	6071049.532	15729.153	3322.631	346.436	1637.329	662.674	108.864
	3	724.228	148103.775	597.923	126.305	0	42.113	16.924	0
	4	4866.877	1143930.078	3997.453	844.423	25	319.962	129.164	6.22
	5	5992.31	1288654.127	4946.367	1044.872	1.07	365.541	147.883	0.216
	6	1757.167	297920.301	1367.024	389.173	0.97	80.101	38.37	0.157
	7	2537.188	992814.145	2094.702	442.486	0	281.587	114.148	0
	8	4.2	2300.475	0	0	4.2	0	0	0.832
TOTAL 5 (Central core-Outsides):		36722.835	10461024.83	29858.819	8407.789	458.026	2857.152	1162.015	136.629
	1	8217.158	2313664.092	6384.402	1485.916	346.84	573.437	255.685	84.132
	2	44864.767	10586155.81	35798.862	8331.885	734.02	2790.99	1241.916	167.692
	3	30397.341	6506869.985	24445.489	5689.483	262.37	1754.39	777.782	54.701
	4	7102.965	1641675.806	5725.794	1332.631	44.54	444.941	197.863	10.214
	5	31990.053	6361375.558	25913.178	6031.075	45.8	1738.067	785.666	9.48
	6	59783.51	12232522.58	46439.235	13220.625	123.65	3168.382	1665.551	31.846
	7	22819.077	4956838.929	18510.835	4308.242	0	1367.82	607.026	0
	8	224.37	122978.789	0	0	224.37	0	0	44.496
TOTAL 6 (Urban Area-Outsides):		206398.241	44722681.36	163217.785	40399.857	1781.59	11838.027	5531.491	402.581
	1	1126.21	324209.317	799.105	256.795	70.31	68.646	42.25	16.406
	2	7962.425	1898980.863	5958.79	1914.875	88.76	454.337	279.114	19.765
	3	19321.743	4321989.352	14541.626	4672.996	107.12	1049.824	644.016	22.669
	4	1753.538	401701.272	1323.044	425.164	5.33	98.246	60.264	1.126
	5	15397.561	3099205.48	11608.117	3730.304	59.14	745.729	473.81	11.543
	6	63988.216	12865530.42	49790.127	14174.579	23.51	3257.557	1856.364	4.203
	7	7982.981	1778031.437	6041.52	1941.461	0	438.618	268.473	0
	8	493.2	270141.444	0	0	493.2	0	0	97.743
TOTAL 7 (Suburban Area-Outsides):		118025.874	24938788.39	90062.329	27116.174	847.37	8112.957	3624.291	173.455
	1	470.94	232771.926	302.39	136.62	31.93	45.18	39.186	7.299
	2	9948.916	2838498.61	6828.347	3085.049	35.52	599.011	517.619	8.942
	3	6607.925	1499728.836	4543.976	2052.969	10.98	318.713	274.007	2.239
	4	14161.056	3407449.68	9736.233	4398.832	25.99	722.761	623.167	5.756
	5	15123.357	3276521.523	10405.727	4701.31	16.33	690.02	605.408	3.373
	6	83049.962	17147267.81	64638.019	18401.574	10.37	4293.604	2524.991	1.98
	7	23607.178	5382606.006	16260.624	7346.554	0	1147.032	989.046	0
	8	135.12	74009.554	0	0	135.12	0	0	26.778
TOTAL 8 (Rural Area-Outsides):		163104.464	33656853.94	112715.316	40122.908	266.24	7816.321	857.424	58.387
TOTAL (1-8) RMOC:		1979959.756	43058998.5	1519666.79	441291.019	19001.946	108252.086	58500.023	4190.591
TOTAL (5-8) OUTSIDE:		813232.214	114001746.7	393984.288	114086.727	3361.226	28624.457	18882.221	768.012
TOTAL NATIONAL CAPITAL REGION:		2493211.97	54458748.3	1915521.086	555377.746	22353.172	136876.543	74392.244	4959.603

Appendix L: Scenario 6 - fuel cost increased 5% above inflation rate (GHG emission estimates for 2021)

Vehicle Type Descriptions

Vehicle Type 1: Autos

Vehicle Type 2: Light trucks

Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	3187.098	817924.828	2539.618	536.47	111.01	211.032	85.379	26.883
	2	78199.674	19813683.29	62842.208	13274.807	2082.658	5223.327	2111.915	510.662
	3	15297.829	3274413.633	12598.052	2661.216	38.56	923.985	372.033	8.357
	4	12296.268	2875020.178	10145.211	2143.077	7.98	815	329.087	1.74
	5	4616.923	947523.509	3811.732	805.191	0	269.427	108.272	0
	6	52135.719	9317864.348	40567.857	11549.123	18.739	2505.328	1202.247	2.868
	7	12734.936	3991255.68	10513.963	2220.973	0	1132.641	458.285	0
	8	1499.805	864144.526	0	0	1499.805	0	0	312.665
TOTAL 1 (Central Core-RMOC):		179968.052	41901830	143018.641	33190.857	3758.552	11080.74	4667.218	863.175
	2	28774.809	8888455.644	22402.984	5214.107	1157.717	2236.407	997.56	278.969
	2	209174.549	49028929.42	167120.72	38895.947	3157.883	12979.495	5772.029	710.005
	2	45646.966	9779015.198	36825.153	8570.746	251.067	2657.617	1179.518	53.495
	2	105786.803	22906034.58	85355.042	19865.67	566.09	6229.04	2763.127	121.522
	2	79915.219	16309302.69	64225.369	14947.916	741.934	4378.215	1950.344	153.547
	2	230369.67	40612134.87	178157.168	50718.947	1493.555	10583.168	5313.976	247.266
	2	71744.788	1572718.58	58199.372	13545.416	0	4339.96	1925.897	0
	2	2870.008	1548808.995	0	0	2870.008	0	0	560.391
TOTAL 2 (Urban Area-RMOC):		774082.812	164799900	612285.808	151758.749	10038.254	43403.902	19902.451	2125.195
	3	13159.891	4329729.721	9337.336	3000.581	821.974	926.694	570.68	204.19
	3	59810.6	14308282.88	44321.511	14242.853	1246.236	3338.186	2047.173	217.247
	3	48180.03	10591072.27	36047.52	11583.981	548.528	2532.228	1552.976	115.208
	3	20227.005	4661007.08	15102.47	4853.225	271.31	1109.984	680.3	57.593
	3	94579.37	19928890.01	71099.725	22848.115	631.53	4808.633	2976.724	126.903
	3	131399.732	24110860.95	101484.32	28891.22	1024.192	6164.955	3210.312	201.977
	3	72578.159	17127119.88	54927.15	17651.008	0	4222.567	2588.519	0
	3	238.16	133709.647	0	0	238.16	0	0	48.379
TOTAL 3 (Suburban Area-RMOC):		440170.947	85190672.43	332320.032	103070.983	4779.93	23103.247	13626.844	1031.497
	4	219.768	55654.958	151.376	68.392	0	11.843	10.243	0
	4	4772.527	1148516.551	3275.304	1479.783	17.44	242.516	209.081	3.82
	4	22215.431	5000319.009	15297.994	6911.637	5.8	1064.172	918.887	1.177
	4	14766.736	3495510.789	10150.691	4586.085	29.96	741.989	638.787	6.219
	4	168159.022	36061092.52	115571.694	52215.318	372.01	7575.001	6650.927	75.891
	4	211800.844	40637371.09	184865.777	46935.067	0	10374.734	5794.705	0
	4	57452.866	13448903.41	39573.534	17879.332	0	2857.639	2479.327	0
	4	0	0	0	0	0	0	0	0
TOTAL 4 (Rural Area-RMOC):		479387.194	98848368.33	348886.37	130075.614	425.21	22867.894	16701.957	87.107
	5	1290.103	444858.638	1000.423	211.33	78.35	44.915	19.485	0
	5	17993.628	5207957.164	14569.522	3077.67	346.436	1399.288	566.239	100.193
	5	676.48	136390.126	558.502	117.978	0	38.764	15.603	0
	5	4512.236	1034377.092	3704.662	782.574	25	289.095	116.663	5.948
	5	5727.184	1194776.757	4727.479	998.634	1.07	338.994	137.013	0.216
	5	1693.163	282276.195	1317.203	374.99	0.97	75.12	37.102	0.157
	5	2379.234	922232.782	1964.296	414.938	0	261.574	106.027	0
	5	4.2	2300.475	0	0	4.2	0	0	0.832
TOTAL 5 (Central Core-Outside):		34276.228	9225169.228	27842.087	6978.114	458.026	2313.773	1023.582	126.831
	6	7544.606	2120179.674	5838.828	1358.938	346.84	520.293	231.97	83.928
	6	41530.719	9718772.112	33094.282	7702.417	734.02	2552.533	1135.587	166.985
	6	27456.856	5846299.509	22060.167	5134.319	262.37	1572.426	696.977	54.332
	6	6640.193	1505745.641	5350.394	1245.259	44.54	407.693	181.2	9.993
	6	30239.113	5946404.129	24492.815	5700.497	45.8	1621.929	736.549	9.378
	6	56005.309	11497162.59	43498.283	12383.376	123.65	2952.63	1589.008	30.925
	6	21605.853	4668983.883	17526.668	4079.185	0	1288.468	571.696	0
	6	224.37	122978.799	0	0	224.37	0	0	44.496
TOTAL 6 (Urban Area-Outside):		191247.019	41426526.34	151881.437	37603.991	1781.59	10915.972	5142.987	400.037
	7	964.079	266719.125	676.405	217.365	70.31	54.67	33.646	16.15
	7	6740.867	1604987.105	5034.314	1617.792	88.76	381.969	234.623	19.715
	7	17710.937	3906497.249	13322.569	4281.248	107.12	947.656	581.395	22.265
	7	1524.444	344941.004	1149.665	369.448	5.33	84.29	51.649	1.125
	7	13391.221	2678264.263	10089.719	3242.362	59.14	638.658	413.264	11.67
	7	55508.211	11515108.04	43189.292	12295.41	23.51	2881.962	1693.374	4.658
	7	7327.711	1628866.544	5545.612	1782.099	0	401.842	245.93	0
	7	493.2	270141.444	0	0	493.2	0	0	97.743
TOTAL 7 (Suburban Area-Outside):		103860.87	22219524.78	79007.576	23905.724	847.37	5397.047	3253.881	173.326
	8	364.392	197062.858	229	103.462	31.93	37.587	32.608	7.299
	8	9230.022	2533643.509	6333.173	2861.329	35.52	534.339	461.586	8.694
	8	6161.149	1394585.332	4236.236	1913.932	10.98	296.298	254.696	2.239
	8	11982.925	2827523.955	8235.937	3720.998	25.99	599.562	516.374	5.625
	8	14248.924	3071119.359	9803.411	4429.183	16.33	646.423	568.54	3.331
	8	75331.739	15700741.06	58630.154	16691.215	10.37	3919.14	2323.736	2.002
	8	21637.079	4885823.47	14903.62	6733.459	0	1040.928	897.996	0
	8	135.12	74009.554	0	0	135.12	0	0	26.778
TOTAL 8 (Rural Area-Outside):		139081.36	30884308.1	102371.531	36453.578	266.24	7074.277	5055.836	53.988
TOTAL (1-8) RMOC:		1873609.005	401140770.7	1438510.851	418096.203	19001.946	100455.783	54898.31	4106.974
TOTAL (6-8) OUTAQUAS:		488278.287	103881728.4	361082.831	103841.407	3361.226	25885.071	14475.966	786.182
TOTAL NATIONAL CAPITAL REGION:		2341864.272	505292900.2	1797593.482	521937.61	22353.172	126350.854	69374.276	4863.196

Appendix M: Scenario 7 - transit fare decreased by 10% (GHG emission estimates for 1995)

Vehicle Type Descriptions

Vehicle Type 1: Autos
Vehicle Type 2: Light trucks
Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	2684.185	933197.364	2125.709	449.036	109.44	239.481	96.9	32.309
	2	70436.984	23555209.11	56641.832	11965.038	1830.113	6277.801	2538.09	520.413
	3	13330.895	3673763.747	10971.464	2317.615	41.815	1035.767	416.902	10.659
	4	6653.654	2478290.85	5486.668	1159.006	7.98	702.033	283.635	1.991
	5	4579.009	1220997.283	3780.43	798.579	0	347.231	139.481	0
	6	48717.629	11603912.7	37907.216	10791.674	18.739	3092.324	1524.231	3.526
	7	10235.364	3900716.767	8450.316	1785.047	0	1107.104	447.737	0
	8	986.147	867011.122	0	0	986.147	0	0	241.338
TOTAL 1 (Central core-RMOC):		157623.387	48033088.95	125363.635	29265.995	2994.234	12801.741	5448.976	810.236
	2	22613.44	8407524.573	17472.591	4066.599	1074.25	2091.367	932.576	295.705
	2	181358.968	55365950.33	144957.742	33737.699	2663.526	14735.714	6552.745	696.893
	2	33418.668	9543325.479	26950.736	6272.558	195.375	2595.383	1152.96	46.838
	2	74704.219	21082439.3	60196.098	14010.137	497.983	5723.669	2538.37	124.791
	2	55117.243	14575147.9	44307.476	10312.194	497.574	3925.568	1750.686	118.476
	2	198966.376	46995819.17	154167.998	43889.554	908.824	12288.989	6192.954	207.657
	2	58971.706	16972436.46	47837.848	11133.858	0	4683.9	2078.07	0
	2	1610.943	1089577.308	0	0	1610.943	0	0	394.232
TOTAL 2 (Urban Area-RMOC):		626761.583	174032220.5	495890.489	123422.589	7448.475	46044.39	21198.381	1888.586
	3	9264.769	3771636.607	6536.234	2100.439	628.096	808.101	497.578	176.676
	3	35507.186	10958824.48	26388.304	8479.962	638.92	2589.257	1589.009	164.507
	3	20134.228	5628396.623	15142.333	4866.035	125.86	1366.661	838.967	29.701
	3	7604.706	2257128.707	5727.013	1840.393	37.3	550.083	337.237	9.363
	3	41430.547	11167248.73	31271.352	10649.145	110.05	2725.084	1687.059	25.996
	3	93604.25	23366721.72	72302.832	20583.643	717.775	5539.875	3190.696	153.682
	3	27713.687	8112321.21	20973.718	6739.969	0	2000.772	1225.341	0
	3	4.886	3774.573	0	0	4.886	0	0	1.368
TOTAL 3 (Suburban Area-RMOC):		235264.259	65268052.85	178341.786	54659.586	2262.887	15879.833	9364.887	561.297
	4	101.913	33336.882	70.198	31.715	0	7.095	6.135	0
	4	963.027	305677.75	661.473	298.854	2.7	64.701	55.845	0.694
	4	9522.519	2884576.632	6557.43	2962.649	2.44	613.617	530.485	0.564
	4	8380.79	2531700.815	5772.688	2608.102	0	540.088	464.627	0
	4	91825.611	25475335.2	63227.088	28566.013	32.51	5371.946	4728.396	7.473
	4	133126.197	35365092.88	103625.431	29500.765	0	8887.612	5180.506	0
	4	37452.782	10867837.77	25797.476	11655.306	0	2306.022	2006.614	0
	4	0	0	0	0	0	0	0	0
TOTAL 4 (Rural Area-RMOC):		281372.839	77463557.93	205711.784	75623.404	37.65	17791.087	12972.808	8.737
	5	1458.403	713110.528	1138.579	240.514	79.31	183.513	74.345	23.953
	5	17832.965	8251589.42	14449.497	3052.316	331.151	2234.924	904.776	135.612
	5	96.836	23579.212	79.948	16.888	0	6.648	2.75	0
	5	4853.58	1592227.744	3986.475	842.104	25	445.932	180.084	7.858
	5	6013.386	1965499.691	4963.768	1048.548	1.07	557.25	225.906	0.263
	5	1828.625	454806.67	1422.647	405.008	0.97	126.702	54.326	0.185
	5	1931.226	967730.412	1594.42	336.806	0	274.475	111.261	0
	5	0	0	0	0	0	0	0	0
TOTAL 5 (Central core-Outer Sub):		34015.021	13988543.66	27635.334	5942.184	437.501	3829.444	1533.448	167.871
	6	9083.662	3240539.396	7087.31	1649.512	346.84	617.582	364.546	98.899
	6	49248.726	15995111.52	39355.129	9159.576	734.02	4252.894	1893.796	205.048
	6	30115.734	8835280.536	24217.049	5636.315	262.37	2384.473	1058.599	69.901
	6	7027.347	2467263.69	5664.453	1318.354	44.54	670.24	298.432	12.977
	6	25113.685	6810745.837	20335.068	4732.817	45.8	1857.134	842.757	12.025
	6	62990.826	17638482.31	48935.81	13931.366	123.65	4706.027	2266.489	46.942
	6	19408.928	5452483.371	15744.522	3664.406	0	1504.695	667.623	0
	6	0.81	818.784	0	0	0.81	0	0	0.224
TOTAL 6 (Urban Area-Outer Sub):		202989.718	60440525.44	161339.341	40092.348	1558.03	16193.045	7392.242	446.076
	7	1104.573	460908.214	782.73	251.533	70.31	100.179	61.686	19.492
	7	5853.348	1873100.641	4362.64	1401.948	88.76	445.588	273.83	23.168
	7	17081.335	4974732.76	12846.086	4128.129	107.12	1207.807	741.522	26.382
	7	1427.239	42167.95	1076.101	345.808	5.33	103.073	63.17	1.319
	7	10327.08	2703494.937	7770.777	2497.163	59.14	638.495	420.738	14.04
	7	49357.942	13260321.89	38401.922	10932.51	23.51	3320.157	1948.853	5.172
	7	6158.123	1801795.78	4660.467	1497.655	0	444.426	272.114	0
	7	0	0	0	0	0	0	0	0
TOTAL 7 (Suburban Area-Outer Sub):		81309.64	25196033.72	69900.723	21054.746	354.17	6298.725	3781.913	89.573
	8	249.608	195047.42	152.127	68.731	28.75	36.921	32.03	7.705
	8	8722.497	3305454.247	5982.185	2702.752	37.56	696.857	602.333	11.446
	8	3705.148	1089577.848	2544.543	1149.625	10.98	231	198.528	2.624
	8	10536.036	3232657.496	7239.319	3270.726	25.99	685.488	590.271	6.57
	8	16704.306	4703748.662	11494.678	5193.298	16.33	992.042	870.246	3.817
	8	47377.409	12770340.57	36870.503	10496.536	10.37	3197.884	1878.976	2.639
	8	14755.951	4351863.878	10163.899	4592.052	0	926.692	800.32	0
	8	0	0	0	0	0	0	0	0
TOTAL 8 (Rural Area-Outer Sub):		102050.955	2964888.12	74447.254	27473.72	129.98	6768.884	4972.708	34.807
TOTAL (1-8) RMOC:		1301022.528	364754830	1005307.884	282971.584	12743246	92617245	48982.832	3268.844
TOTAL (9-8) Outer Sub:		430386.334	129563993	333322.832	84862.996	2470.681	33048.096	17700.307	738.281
TOTAL NATIONAL CAPITAL REGION:		1731408.862	494318823	1338630.716	377534.58	15222.927	125865.943	66683.139	4007.105

Appendix M: Scenario 7 - transit fare decreased by 10% (GHG emission estimates for 2021)

Vehicle Type Descriptions

Vehicle Type 1: Autos
Vehicle Type 2: Light trucks
Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	3965.726	10154.38.228	3182.454	672.263	111.01	266.827	107.959	27.205
	2	85680.989	22528991.2	69018.782	14579.549	2082.658	5979.015	2418.184	529.146
	3	16573.46	3644883.362	13651.213	2883.686	38.56	1028.691	414.657	8.66
	4	13371.201	3324455.723	11032.675	2330.546	7.98	942.36	380.826	1.779
	5	5160.299	1078774.69	4260.343	899.956	0	306.64	123.375	0
	6	54318.423	10286077.74	42266.874	12032.81	18.739	2823.039	1271.214	3.165
	7	13788.418	4483893.879	11383.718	2404.7	0	1272.372	514.919	0
	8	1499.805	884144.526	0	0	1499.805	0	0	312.665
TOTAL 1 (Central Core-RMOC):		194358.121	47228859.39	154798.059	35803.51	3758.552	12618.944	5231.134	882.62
	2	31368.453	9924971.159	24506.949	5703.787	1157.717	2519.499	1123.937	282.125
	2	234280.59	56166335.15	187486.74	43635.967	3157.893	14934.478	6644.658	724.252
	2	49772.593	10934816	40171.862	9349.664	251.067	2975.035	1321.187	54.748
	2	4	118705.615	26114449.79	95834.782	22304.742	566.09	7111.102	3157.083
	2	5	90433.486	18822407.09	72757.787	16933.765	741.934	5069.463	2255.491
	2	6	242196.571	44544258.74	187363.228	53339.788	1493.555	11873.053	5559.34
	2	7	76427.947	16885385.3	61998.35	14429.596	0	4659.188	2068.083
	2	8	2670.008	1548808.995	0	0	2670.008	0	580.391
TOTAL 2 (Urban Area-RMOC):		845855.263	18481432.2	670119.898	165697.309	10038.254	49141.818	22129.989	2183.934
	3	1	14642.491	4866230.319	10459.367	3361.15	821.974	1057.061	650.998
	3	2	68883.368	16664339.23	51187.781	16449.35	1246.236	3915.825	2402.418
	3	3	53773.296	12049375.09	40280.504	12944.263	548.528	2890.5	1172.364
	3	4	24125.387	5697257.321	18052.766	5801.312	271.31	1364.832	837.159
	3	5	104288.888	22337872.28	78447.889	25209.47	631.53	5400.443	3341.064
	3	6	137635.822	25850754.21	106338.493	30273.137	1024.192	6687.277	3340.674
	3	7	79311.643	19275200.45	60023.051	19288.592	0	4751.304	2914.006
	3	8	236.18	133708.847	0	0	236.18	0	48.379
TOTAL 3 (Suburban Area-RMOC):		482897.055	108474734.3	384789.851	113327.274	4779.93	28067.242	15258.663	1080.079
	4	1	255.265	65049.162	175.826	79.438	0	13.841	11.973
	4	2	6018.932	1456006.202	4133.828	1867.664	17.44	307.969	265.653
	4	3	24959.386	5686576.374	17188.03	7765.556	5.8	1210.581	1044.82
	4	4	15977.225	3798994.75	10984.476	4962.789	29.96	806.394	694.402
	4	5	177112.573	38131950.3	121738.9	55001.663	372.01	8015.88	7703.565
	4	6	215176.195	40941416.8	167493.15	47683.045	0	10467.785	5823.015
	4	7	57775.779	13549371.42	39795.956	17979.822	0	2879.382	2497.463
	4	8	0	0	0	0	0	0	0
TOTAL 4 (Rural Area-RMOC):		497275.355	103628385	361510.166	135339.977	425.21	23701.832	17367.897	88.379
	5	1	1535.01	562917.15	1202.618	254.042	78.35	143.433	58.086
	5	2	19855.497	6396504.758	18106.681	3402.38	346.436	1727.686	699.295
	5	3	735.725	151053.281	607.415	128.31	0	42.953	17.259
	5	4	4947.888	1172191.088	4064.172	858.517	25	327.908	132.381
	5	5	6112.195	1340507.933	5045.345	1065.78	1.07	380.227	153.866
	5	6	1781.223	306548.78	1385.749	394.504	0.97	82.966	38.955
	5	7	2606.7	1026995.448	2152.091	454.608	0	291.278	118.081
	5	8	4.2	2300.475	0	0	4.2	0	0.832
TOTAL 5 (Central Core-Outsiders):		375782.38	10859018.89	30584.071	6558.141	456.026	2998.431	1217.925	139.626
	6	1	8416.76	2373842.726	6546.319	1523.601	346.84	589.979	263.065
	6	2	46129.657	10939658.63	36824.941	8570.696	734.02	2888.123	1285.243
	6	3	31329.215	6723763.362	25201.425	5865.42	262.37	1814.092	804.335
	6	4	7291.414	1701974.056	5878.664	1368.21	44.54	461.434	205.236
	6	5	32484.914	6490653.781	26314.609	6124.505	45.8	1774.127	801.073
	6	6	61473.141	12568077.97	47754.444	13595.047	123.65	3267.425	1699.722
	6	7	23217.97	5056325.607	18834.417	4383.553	0	1395.236	619.243
	6	8	224.37	122978.799	0	0	224.37	0	44.498
TOTAL 6 (Urban Area-Outsiders):		210587.441	45977274.32	167354.819	41431.032	1781.59	12190.478	5877.917	403.867
	7	1	1204.591	352805.615	858.424	275.857	70.31	75.613	46.542
	7	2	8400.594	2008526.095	6290.396	2021.438	88.76	481.285	295.698
	7	3	19932.522	4488827.666	15003.864	4821.538	107.12	1090.813	669.169
	7	4	1893.917	436391.867	1429.283	459.304	5.33	106.783	65.522
	7	5	16036.155	3256903.484	12091.405	3885.61	59.14	785.83	496.366
	7	6	66784.674	13293553.3	51966.89	14794.274	23.51	3381.591	1903.08
	7	7	8248.469	1839256.411	6242.441	2006.028	0	453.707	277.731
	7	8	493.2	270141.444	0	0	493.2	0	97.743
TOTAL 7 (Suburban Area-Outsiders):		122694.122	25946405.88	93882.703	28264.049	847.37	6375.822	3754.108	173.788
	8	1	570.312	259368.861	370.838	167.545	31.93	50.839	44.081
	8	2	10226.452	2937757.892	7019.514	3171.418	35.52	620.077	535.868
	8	3	7074.33	1605978.314	4865.235	2198.114	10.98	341.384	293.502
	8	4	14720.368	3593317.723	10121.488	4572.89	25.99	762.152	657.45
	8	5	15357.293	3332971.544	10566.856	4774.108	16.33	701.988	616.63
	8	6	85981.089	17677031.77	66919.608	19051.111	10.37	4433.478	2596.014
	8	7	24296.984	5558232.171	16735.762	7561.221	0	1184.445	1021.329
	8	8	135.12	74009.554	0	0	135.12	0	26.778
TOTAL 8 (Rural Area-Outsiders):		156361.948	39036667.82	116999.301	41496.407	286.24	8094.783	5785.074	56.528
TOTAL (1-4) RMOC:		2020385.794	442672195.1	1551215.774	450168.07	19001.946	111529.836	59987.697	4234.952
TOTAL (5-8) OUTSIDERS:		628901.748	117821367.3	408400.884	117748.829	3381.226	29698.854	16415.024	773.805
TOTAL NATIONAL CAPITAL REGION:		2549287.543	560493562.3	1859616.658	567917.899	22383.172	141188.69	76402.721	5008.757

Appendix N: Scenario 8 - total transit time decreased by 10% (GHG emission estimates for 1995)

Vehicle Type Descriptions

Vehicle Type 1: Autos
Vehicle Type 2: Light trucks
Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	2679.469	925836.34	2121.816	448.213	109.44	237.541	96.114	32.12
	2	70153.283	23452192.09	56407.609	11915.561	1830.113	6248.652	2526.295	520.305
	3	13259.608	3654453.735	10912.61	2305.183	41.815	1030.269	414.698	10.664
	4	6578.886	2463847.037	5424.924	1145.963	7.98	697.922	281.988	1.991
	5	4515.497	1201623.503	3727.994	787.503	0	341.727	137.262	0
	6	48744.743	11647475.21	37928.322	10797.683	18.739	3106.385	1527.573	3.529
	7	10237.165	3910147.041	8451.804	1785.362	0	1109.777	448.823	0
	8	986.147	887011.122	0	0	986.147	0	0	241.338
TOTAL 1 (Central Core-RMOC):		157154.778	47922586.07	124975.079	29185.468	2994.234	12772.273	5432.733	809.947
	2	22501.262	8378758.81	17381.592	4045.42	1074.25	2083.493	929.063	295.638
	2	180801.108	55190397.2	144505.207	33632.375	2663.526	14687.281	6531.216	698.911
	3	33162.983	9482528.385	26743.324	6224.284	195.375	2578.589	1145.543	48.828
	4	74482.094	21016626.8	60015.911	13968.2	497.983	5705.545	2530.311	124.759
	5	55019.959	14553523.02	44228.558	10293.826	497.574	3919.782	1747.876	116.462
	6	199097.397	47070266.97	154269.985	43918.588	908.824	12313.778	6196.794	208.702
	7	58745.656	16901540.18	47654.476	11091.18	0	4664.338	2069.386	0
	8	1810.943	1089577.308	0	0	1810.943	0	0	394.232
TOTAL 2 (Urban Area-RMOC):		625421.402	173883226.5	494799.053	123173.873	7448.475	45952.806	21150.789	1889.532
	3	9169.053	3720163.272	6463.796	2077.161	628.096	795.624	489.895	176.394
	2	35526.914	10972771.75	26403.234	8484.76	638.92	2592.642	1590.106	164.565
	3	20169.203	5644783.452	15168.802	4874.541	125.86	1370.69	841.448	29.707
	4	7606.675	2260357.886	5728.503	1840.872	37.3	550.863	337.74	9.363
	5	41384.787	11160968.53	31236.721	10038.016	110.05	2723.683	1685.959	26.002
	6	93605.137	23391424.41	72303.523	20583.839	717.775	5948.839	3190.997	155.095
	7	27673.284	8098335.038	20943.141	6730.143	0	1997.33	1223.221	0
	8	4.886	3774.573	0	0	4.886	0	0	1.366
TOTAL 3 (Suburban Area-RMOC):		235139.939	63252576.91	178247.72	54829.332	2262.887	15979.671	8358.486	562.692
	4	101.24	33116.332	69.734	31.506	0	7.048	6.094	0
	2	959.705	304714.486	659.185	297.82	2.7	64.495	55.668	0.694
	3	9505.927	2881840.556	6546.002	2957.485	2.44	613.03	529.986	0.564
	4	8435.133	2548825.78	5810.12	2625.014	0	543.741	467.77	0
	5	91781.502	25461157.63	83196.706	28552.286	32.51	5368.662	4726.046	7.474
	6	133810.029	35549405.1	104157.726	29652.302	0	8934.803	5206.656	0
	7	37581.845	10901683.57	25886.375	11695.47	0	2313.232	2012.835	0
	8	0	0	0	0	0	0	0	0
TOTAL 4 (Rural Area-RMOC):		282175.381	77680743.46	206325.848	75811.883	37.65	17445.011	13005.053	8.732
	5	1439.676	690023.286	1123.118	237.248	79.31	177.033	71.715	23.869
	2	17607.676	8067867.698	14263.499	3013.026	331.151	2184.475	884.327	133.493
	3	90.411	22014.351	74.643	15.768	0	6.207	2.567	0
	4	4788.792	1553935.576	3932.987	830.805	25	435.116	175.709	7.792
	5	5998.958	1968894.341	4951.856	1046.032	1.07	558.211	226.299	0.262
	6	1834.947	463263.516	1427.568	408.409	0.97	129.501	54.908	0.185
	7	1930.346	970839.724	1593.694	336.652	0	275.355	111.621	0
	8	0	0	0	0	0	0	0	0
TOTAL 5 (Central Core-Outside):		33690.806	13736834.68	27367.386	5885.94	437.501	3765.899	1527.746	185.607
	6	9067.056	3252159.545	7073.839	1646.377	346.84	820.813	365.989	98.859
	2	48829.089	15798451.35	39014.72	9080.349	734.02	4198.961	1869.72	204.74
	3	29959.328	8769255.731	24090.173	5606.786	262.37	2366.587	1050.618	69.504
	4	6969.12	2434270.453	5617.219	1307.361	44.54	661.164	294.391	12.952
	5	24894.922	6723314.588	20157.608	4691.514	45.8	1833.108	831.999	11.983
	6	62624.494	17576307.53	48650.657	13850.187	123.65	4688.249	2259.391	47.025
	7	19297.42	5420828.272	15654.067	3643.353	0	1495.964	663.742	0
	8	0.81	618.784	0	0	0.81	0	0	0.224
TOTAL 6 (Urban Area-Outside):		20164.239	58978206.45	60258.283	39825.927	1558.03	16064.846	7335.85	445.287
	7	1087.533	449662.72	769.834	247.389	70.31	97.431	59.99	19.466
	2	5842.575	1865807.244	4354.487	1399.328	88.76	443.798	272.724	23.163
	3	16991.291	4951712.528	12777.941	4106.23	107.12	1202.142	738.029	26.386
	4	1428.489	421954.586	1077.046	346.112	5.33	103.141	63.211	1.319
	5	10318.509	2701221.815	7764.29	2495.079	59.14	638.027	420.311	14.033
	6	49175.441	13216841.72	38259.863	10892.068	23.51	3308.737	1942.956	5.18
	7	6167.838	1804898.698	4667.819	1500.018	0	445.185	272.589	0
	8	0	0	0	0	0	0	0	0
TOTAL 7 (Suburban Area-Outside):		91011.876	25412096.31	68871.28	20986.224	354.17	6238.461	3769.81	89.547
	8	250.68	195995.08	152.865	69.065	28.75	37.122	32.205	7.705
	2	8722.166	3280966.27	5981.956	2702.649	37.56	693.808	599.667	11.417
	3	3775.722	1109880.496	2593.154	1171.588	10.98	235.334	202.251	2.624
	4	10516.567	3225864.547	7225.909	3264.667	25.99	684.006	586.979	6.569
	5	16544.225	4655264.841	11384.414	5143.481	16.33	981.715	861.334	3.815
	6	47333.217	12760235.06	36836.104	10486.743	10.37	3195.272	1877.567	2.639
	7	14830.124	4370589.773	10214.99	4615.135	0	930.63	803.812	0
	8	0	0	0	0	0	0	0	0
TOTAL 8 (Rural Area-Outside):		101972.701	28868786.07	74389.392	27453.326	129.96	8757.885	4983.875	34.769
TOTAL (1-8) RMOC:		1298891.5	364539128.3	1004347.7	282800.556	12743.246	92548.761	48946.463	3270.703
TOTAL (9-8) OUTAQUARI:		428337.422	128732840.3	331886.32	94181.419	32827.821	17896.821	17896.821	735.204
TOTAL NATIONAL CAPITAL REGION:		1726208.922	493272069.2	1336234.02	376951.975	15222.927	125376.851	66843.684	4005.907

Appendix N: Scenario 8 - total transit time decreased by 10% (GHG emission estimates for 2021)

Vehicle Type Descriptions

Vehicle Type 1: Autos
Vehicle Type 2: Light trucks
Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	4008.056	1027088.199	3217.401	679.645	111.01	270.119	109.292	27.222
	2	85772.272	22605346.24	69094.145	14595.469	2082.658	6000.215	2426.791	529.717
	3	16559.799	3643095.245	13639.935	2881.304	38.56	1028.196	414.456	8.645
	4	13428.857	3357436.786	11080.276	2340.601	7.98	951.708	384.622	1.781
	5	5163.777	1079575.222	4263.214	900.563	0	306.867	123.467	0
	6	54115.712	10300015.91	42109.084	11987.889	18.739	2826.774	1273.036	3.158
	7	13814.634	4510926.416	11405.362	2409.272	0	1280.031	518.034	0
	8	1499.605	884144.528	0	0	1499.605	0	0	312.665
TOTAL 1 (Central Core-RMOC):		194382.712	47387628.35	154809.417	35794.743	3758.552	12683.91	5249.899	883.788
	2	31393.912	9913346.554	24527.601	5708.594	1157.717	2516.362	1122.529	282.047
	2	234217.622	56214332.26	187435.661	43624.079	3157.883	14947.321	6650.683	724.673
	2	49724.754	10939302.94	40133.055	9340.632	251.067	2976.174	1321.765	54.811
	2	118535.587	26090618.26	95696.856	22272.641	566.09	7104.46	3154.175	123.567
	2	90221.151	18779432.67	72585.541	16893.676	741.934	5057.561	2250.167	158.07
	2	241790.717	44572554.5	187047.311	53249.851	1493.555	11881.302	5561.774	281.481
	2	76230.686	16830953.73	61838.333	14392.354	0	4644.158	2061.427	0
	2	2870.008	1548808.995	0	0	2870.008	0	0	560.391
TOTAL 2 (Urban Area-RMOC):		844784.437	18488348.3	689264.358	165481.827	10038.254	49127.338	22122.52	2185.04
	3	14631.256	4889732.443	10450.865	3358.417	821.974	1062.997	654.675	206.37
	3	69013.723	16710113.48	51286.434	16481.053	1246.236	3927.07	2409.363	280.944
	3	53732.248	12054145.15	40249.439	12934.281	548.528	2891.631	1773.081	117.326
	3	24065.274	5697790.28	18007.272	5786.692	271.31	1364.945	837.252	57.941
	3	104276.669	22352078.59	78438.641	25206.498	631.53	5403.902	3343.168	128.642
	3	137503.511	25880018.34	106235.502	30243.817	1024.192	6894.522	3342.82	242.451
	3	79111.466	19239080.49	59871.558	19239.909	0	4742.371	2908.573	0
	3	236.16	133709.647	0	0	236.16	0	0	48.379
TOTAL 3 (Suburban Area-RMOC):		482570.307	10695868.4	384539.711	113250.667	4779.93	26087.438	15268.932	1082.053
	4	252.504	64313.605	173.925	78.579	0	13.684	11.838	0
	4	6108.652	1479412.228	4195.627	1895.585	17.44	312.943	269.968	3.82
	4	25083.649	5719021.723	17273.622	7804.227	5.8	1217.492	1050.784	1.179
	4	15981.543	3802717.196	10987.45	4964.133	29.96	807.165	695.107	6.237
	4	17647.237	38008288.87	121298.181	54802.546	372.01	7990.294	7007.151	77.032
	4	215096.553	40976315.96	167431.157	47665.396	0	10475.609	5829.051	0
	4	7328.552	13515366.1	39487.907	17840.645	0	2872.431	2490.926	0
	4	0	0	0	0	0	0	0	0
TOTAL 4 (Rural Area-RMOC):		496324.19	103565435.8	360847.869	135051.111	425.21	23689.818	17354.825	88.288
	5	1548.175	569200.081	1213.488	256.337	78.35	145.061	58.749	20.944
	5	19932.553	6470770.196	16170.298	3415.819	346.436	1747.992	707.524	112.327
	5	733.579	150388.223	805.643	127.936	0	42.766	17.181	0
	5	4968.302	1180778.222	4081.19	862.112	25	330.302	133.351	6.367
	5	6103.96	1340713.218	5038.546	1064.344	1.07	380.276	153.897	0.216
	5	1770.358	304655.289	1377.292	392.096	0.97	82.456	38.711	0.157
	5	2618.33	1034042.094	2161.694	456.637	0	293.276	118.892	0
	5	4.2	2300.475	0	0	4.2	0	0	0.832
TOTAL 5 (Central Core-OUTAOUAIS):		37679.457	11032647.76	30648.151	6575.281	458.026	3022.129	1228.305	140.843
	6	8445.348	2361762.58	6569.509	1528.998	346.84	592.118	264.02	84.236
	6	46051.285	10926358.47	36761.365	8555.9	734.02	2884.41	1283.594	168.089
	6	31413.078	6742946.847	25269.454	5881.254	262.37	1819.362	806.684	54.865
	6	7300.218	1707489.751	5885.806	1369.872	44.54	462.926	205.905	10.388
	6	32377.272	6469209.566	26227.29	6104.182	45.8	1768.188	798.459	9.534
	6	61635.665	12606458.38	47880.953	13631.063	123.65	3279.151	1703.161	32.575
	6	23145.075	5040519.541	18775.284	4369.79	0	1390.878	617.306	0
	6	224.37	122978.789	0	0	224.37	0	0	44.496
TOTAL 6 (Urban Area-OUTAOUAIS):		210692.311	43887723.83	167369.661	41441.059	1781.59	12197.033	5679.129	404.183
	7	1207.206	353371.01	860.403	276.493	70.31	75.752	46.627	16.51
	7	8422.628	2015182.475	6307.071	2026.797	88.76	482.92	296.707	19.796
	7	19948.294	4495627.558	15015.8	4825.373	107.12	1092.47	670.195	22.875
	7	1900.703	437353.096	1434.418	460.955	5.33	107.023	65.684	1.126
	7	16186.757	3292540.761	12205.381	3922.236	59.14	794.756	501.595	11.642
	7	67076.496	13342161.94	52195.601	14859.385	23.51	3395.987	1908.078	4.131
	7	8256.562	1841013.759	6248.566	2007.996	0	454.141	277.996	0
	7	493.2	270141.444	0	0	493.2	0	0	97.743
TOTAL 7 (Suburban Area-OUTAOUAIS):		123493.848	26047382.04	84267.24	28379.236	847.37	6403.049	3768.852	173.823
	8	596.498	265271.117	388.874	175.694	31.93	52.095	45.167	7.301
	8	10200.261	2925052.388	7001.474	3163.267	35.52	617.372	533.529	9.013
	8	7043.888	1598866.685	4844.267	2188.641	10.98	339.867	292.196	2.239
	8	14875.475	3641476.726	10228.326	4621.16	25.99	772.374	666.345	5.825
	8	15373.889	3338503.701	10578.287	4779.272	16.33	702.756	617.463	3.384
	8	85994.538	17678068.83	66930.076	19054.092	10.37	4433.957	2595.952	1.988
	8	24287.072	5554446.807	16728.935	7558.137	0	1183.632	1020.639	0
	8	135.12	74009.554	0	0	135.12	0	0	26.778
TOTAL 8 (Rural Area-OUTAOUAIS):		158506.741	3507388.81	116700.239	41540.263	268.24	8102.053	5771.291	58.528
TOTAL (1-8) RMOC:		2018041.646	442799082.4	1549461.355	449578.348	19001.946	111568.304	59995.975	4238.549
TOTAL (1-8) OUTAOUAIS:		530272.388	11817180.8	406985.291	117835.834	3391.228	28724.264	16445.387	778.377
TOTAL NATIONAL CAPITAL REGION:		2548314.061	560970742	1956446.646	567514.186	22393.172	141292.568	76441.362	5013.926

Appendix O: Scenario 9 - total transit time decreased by 50% (GHG emission estimates for 1995)

Vehicle Type Descriptions

Vehicle Type 1: Autos
Vehicle Type 2: Light trucks
Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	2553.29	882020.546	2017.642	426.207	109.44	225.223	91.125	31.977
	2	68188.714	22678016.71	54785.661	11572.94	1830.113	6032.12	2438.574	516.372
	3	12959.843	3563023.092	10665.124	2252.904	41.815	1004.361	404.232	10.599
	4	6492.386	2397983.816	5353.525	1130.88	7.98	679.257	274.402	1.989
	5	4528.635	1205530.623	3738.841	789.794	0	342.837	137.709	0
	6	48057.266	11436546.57	37393.189	10645.338	18.739	3036.957	1512.667	3.548
	7	9858.101	3736315.598	8138.848	1719.253	0	1060.449	428.661	0
	8	986.147	887011.122	0	0	986.147	0	0	241.338
TOTAL 1 (Central core-RMOC):		153824.382	48588448.07	122092.83	28537.316	2994.234	12391.204	5287.57	805.823
	2	21520.535	7956343.111	16586.026	3860.259	1074.25	1967.688	877.396	294.896
	2	174088.008	52991744.61	139059.54	32364.942	2663.526	14083.023	6261.817	696.838
	2	32362.175	9196100.798	26093.708	6073.092	135.375	2499.776	1110.51	48.584
	2	72384.81	20386271.83	58314.594	13572.233	497.983	5531.978	2453.018	124.509
	2	53358.009	14092170.08	42880.385	9980.05	497.574	3792.12	1691.91	118.288
	2	197026.066	46558848.79	152659.22	43460.024	908.824	12148.863	6161.466	204.895
	2	56194.801	16105654.76	45585.223	10609.579	0	4444.848	1971.792	0
	2	1810.943	1089577.308	0	0	1810.943	0	0	394.232
TOTAL 2 (Urban area-RMOC):		808547.349	188376711.3	481178.696	119920.179	7448.475	44468.378	20527.909	1882.242
	3	8853.337	3585731.182	6224.862	2000.379	628.096	763.06	469.83	175.638
	3	34036.78	10496585.49	25275.501	8122.36	638.92	2475.5	1518.123	164.338
	3	19457.428	5432257.691	14630.131	4701.437	125.86	1318.335	809.323	29.674
	3	7340.224	2174234.694	5526.853	1776.071	37.3	529.686	324.685	9.349
	3	40498.896	10905217.89	30566.279	9822.567	110.05	2660.569	1647.38	25.989
	3	92793.201	23179592.68	71671.512	20403.914	717.775	5884.597	3173.722	151.471
	3	26459.93	7731933.484	20024.875	6435.055	0	1907.017	1167.825	0
	3	4.888	3774.573	0	0	4.888	0	0	1.366
TOTAL 3 (Suburban area-RMOC):		229444.882	83508307.88	173920.013	53261.783	2262.887	15538.784	9170.888	557.825
	4	100.906	33006.829	69.504	31.402	0	7.024	6.074	0
	4	921.059	292409.515	632.566	285.793	2.7	61.875	53.406	0.693
	4	9383.162	2831187.831	6461.442	2919.281	2.44	602.269	520.646	0.564
	4	8378.779	2531675.264	5771.303	2607.476	0	540.082	464.624	0
	4	90925.927	25207516.25	62607.386	28286.032	32.51	5314.871	4679.188	7.472
	4	133097.079	35374001.35	103602.766	29494.313	0	8888.805	5182.831	0
	4	37504.499	10888609.8	25833.099	11671.4	0	2310.318	2010.557	0
	4	0	0	0	0	0	0	0	0
TOTAL 4 (Rural area-RMOC):		280311.411	77158406.83	204978.968	75295.697	37.85	17725.244	12917.326	8.729
	5	1413.87	711246.415	1101.813	232.747	79.31	163.031	74.161	23.882
	5	17352.389	7839375.788	14052.734	2968.504	331.151	2120.909	858.54	131.929
	5	93.974	22882.28	77.585	16.389	0	6.452	2.668	0
	5	4721.088	1520700.942	3877.09	816.998	25	425.726	171.91	7.74
	5	5881.059	1886154.002	4854.519	1025.47	1.07	534.731	216.8	0.261
	5	1803.292	445211.573	1402.927	399.395	0.97	123.893	53.308	0.185
	5	1863.016	926724.647	1538.105	324.91	0	262.85	106.542	0
	5	0	0	0	0	0	0	0	0
TOTAL 5 (Central core-Outsiders):		33128.688	13352295.85	26904.774	6786.413	437.501	3657.392	1483.929	163.997
	6	8632.352	3068051.971	6721.207	1564.305	346.64	770.34	343.477	98.529
	6	47491.541	15296904.68	37929.701	8827.82	734.02	4061.404	1808.368	203.917
	6	29440.024	8580154.515	23668.913	5508.741	262.37	2314.806	1027.512	69.096
	6	8869.701	2364837.201	5536.571	1288.59	44.54	642.109	285.895	12.85
	6	24441.378	6575465.624	19789.693	4605.885	45.8	1792.277	814.023	11.892
	6	61781.51	17236936.92	47994.478	13663.382	123.65	4585.664	2227.777	45.887
	6	18588.814	5211785.569	15079.246	3509.568	0	1438.327	638.096	0
	6	0.81	618.784	0	0	0.81	0	0	0.224
TOTAL 6 (Urban area-Outsiders):		197246.13	58334757.27	158719.809	38968.291	1558.03	15804.927	7145.748	442.395
	7	1031.996	426290.572	727.804	233.882	70.31	91.704	56.462	19.431
	7	5565.25	1765847.335	4144.608	1331.882	88.76	419.206	257.598	23.134
	7	16627.487	4828236.629	12502.614	4017.753	107.12	1171.749	719.412	26.301
	7	1411.749	416656.58	1064.378	342.041	5.33	101.838	62.407	1.319
	7	10200.841	2671188.921	7675.239	2466.462	59.14	630.706	415.673	14.049
	7	48192.787	12998119.74	37494.965	10674.312	23.51	3250.481	1914.034	5.263
	7	5868.029	1713831.031	4440.924	1427.105	0	422.741	258.818	0
	7	0	0	0	0	0	0	0	0
TOTAL 7 (Suburban area-Outsiders):		68896.139	24820170.81	69050.532	20493.437	354.17	8098.425	3684.404	89.497
	8	248.904	193393.211	151.642	68.512	28.75	36.57	31.724	7.705
	8	8554.257	3206676.297	5866.301	2650.396	37.56	675.933	564.183	11.333
	8	3626.018	1066534.222	2490.038	1125	10.98	226.08	194.302	2.624
	8	10320.791	3163952.347	7091.059	3203.742	25.99	670.82	577.605	6.56
	8	16736.655	4712365.612	11516.96	5203.365	16.33	993.89	871.817	3.817
	8	46842.335	12633977.14	36454.001	10377.963	10.37	3163.3	1859.3	2.646
	8	14668.749	4324306.153	10103.834	4564.915	0	920.804	795.271	0
	8	0	0	0	0	0	0	0	0
TOTAL 8 (Rural area-Outsiders):		100997.709	29301286.38	73673.636	27193.893	129.98	8887.397	4914.202	34.665
TOTAL (1-8) RMOC:		1271927.824	355610873.7	942188.805	277014.975	12743.248	90113.528	47643.693	3254.619
TOTAL (9-8) OUTSIDE:		428276.898	128806928.7	323348.98	12442.834	2473.661	32038.341	17227.883	730.574
TOTAL NATIONAL CAPITAL REGION:		1802196.48	484419802.4	1307516.555	389457.009	15222.927	122151.869	65071.376	3985.193

Appendix O: Scenario 9 - total transit time decreased by 50% (GHG emission estimates for 2021)

Vehicle Type Descriptions

Vehicle Type 1: Autos

Vehicle Type 2: Light trucks

Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	3879.764	99447.114	3111.484	657.271	111.01	260.924	105.57	27.126
	2	84398.424	22108589.59	67959.896	14355.869	2082.658	5862.039	2370.792	526.237
	3	16327.054	3576291.86	13447.781	2840.713	38.56	1009.296	406.78	8.599
	4	13224.774	3270825.472	10911.785	2305.009	7.98	927.156	374.656	1.776
	5	5139.254	1073376.407	4242.968	896.286	0	305.114	122.749	0
	6	53915.245	10188327.83	41953.04	11943.466	18.739	2790.253	1264.947	3.132
	7	13509.23	4384752.261	11153.221	2356.01	0	1244.24	503.533	0
	8	1499.805	864144.528	0	0	1499.805	0	0	312.665
TOTAL 1 (Central core-RMOC):		191893.35	46480725.06	152780.175	35354.624	3758.552	12399.022	5749.027	879.535
	1	30632.941	9666395.517	23910.302	5564.922	1157.717	2448.782	1092.386	281.446
	2	229277.295	54832842.71	183428.067	42691.345	3157.883	14568.503	6481.669	722.267
	3	49029.816	10743904.34	39569.322	9209.428	251.067	2922.511	1297.86	54.557
	4	116419.931	25554017.62	93980.636	21873.205	566.09	6956.944	3088.282	123.231
	5	89227.116	18532799.51	71779.18	16706.002	741.934	4989.783	2220.102	157.692
	6	240713.323	44152849.7	186208.667	52011.101	1493.555	11746.044	5533.218	277.893
	7	74277.135	16357746.5	60253.612	14023.523	0	4513.7	2003.358	0
	8	2870.008	1548808.995	0	0	2870.008	0	0	580.397
TOTAL 2 (Urban area-RMOC):		832247.565	181389384.3	659129.788	163079.526	10038.254	48146.367	21718.875	2177.477
	1	14211.976	4739242.462	10133.553	3256.448	821.974	1026.597	632.25	205.442
	2	67332.514	16269014.58	50014.095	16072.183	1246.236	3819.09	2342.961	280.007
	3	52517.244	11746717.37	39329.924	12638.792	548.528	2816.079	1726.822	116.919
	4	23320.242	5514616.898	17443.432	5605.5	271.31	1319.826	809.574	57.898
	5	102614.596	21938877.47	77180.784	24802.282	631.53	5302.324	3280.781	128.34
	6	136541.492	25642513.07	105486.666	30030.634	1024.192	6624.864	3322.157	238.38
	7	76831.952	18635329.22	58146.421	18685.531	0	4593.664	2817.185	0
	8	238.18	133709.647	0	0	238.18	0	0	48.379
TOTAL 3 (Suburban area-RMOC):		473808.178	104620020.7	357734.875	111091.37	4779.93	25302.444	14931.71	1075.365
	1	251.368	64116.592	173.143	78.226	0	13.642	11.802	0
	2	5954.793	1440526.919	4089.649	1847.704	17.44	304.672	262.807	3.82
	3	24610.119	5608154.663	16947.455	7656.864	5.8	1193.789	1030.488	1.179
	4	15812.02	3758040.151	10870.683	4911.377	29.96	797.669	686.875	6.236
	5	175956.419	37870089.65	120942.541	54641.868	372.01	7960.65	6982.049	76.936
	6	214310.726	40855940.62	166819.469	47491.257	0	10442.396	5814.305	0
	7	57409.419	13504468.86	39543.608	17865.811	0	2870.155	2488.879	0
	8	0	0	0	0	0	0	0	0
TOTAL 4 (Rural area-RMOC):		494304.884	103101337.4	359386.548	134493.107	425.21	23582.973	17277.205	38.177
	1	1508.446	548370.7	1180.688	249.409	78.35	139.461	56.478	20.553
	2	19607.228	6293445.275	15901.71	3359.082	346.436	1698.755	687.571	110.973
	3	712.888	145266.764	588.56	124.328	0	41.308	16.597	0
	4	4883.2	1154581.433	4010.93	847.27	25	322.906	130.359	6.318
	5	6012.07	1307804.775	4962.682	1048.318	1.07	370.943	150.114	0.215
	6	1746.63	299205.819	1358.822	386.838	0.97	80.639	38.154	0.157
	7	2553.048	1005088.159	2107.797	445.252	0	285.064	115.563	0
	8	4.2	2300.475	0	0	4.2	0	0	0.832
TOTAL 5 (Central core-OUTSOURC):		37027.71	1079808.54	30111.189	8460.497	456.026	2839.276	1194.836	139.048
	1	8149.67	2300991.995	6329.656	1473.174	346.84	569.965	254.139	84.105
	2	44760.534	10590999.78	35714.308	8312.206	734.02	2792.192	1242.485	167.836
	3	30673.321	6576078.558	24669.363	5741.587	262.37	1773.401	786.262	54.775
	4	7144.582	1663569.505	5759.554	1340.488	44.54	450.871	200.528	10.329
	5	31866.092	6351357.646	25812.621	6007.671	45.8	1735.507	784.203	9.516
	6	60828.448	12443824.52	47252.615	13452.183	123.65	3232.153	1685.649	32.262
	7	22433.686	4871567.61	18198.206	4235.48	0	1344.301	596.572	0
	8	224.37	122878.799	0	0	224.37	0	0	44.496
TOTAL 6 (Urban area-OUTSOURC):		208080.703	44821368.41	163738.323	40562.789	1761.69	17896.39	5549.838	403.319
	1	1156.628	340042.017	822.125	264.192	70.31	72.478	44.612	16.499
	2	8114.792	1936785.748	6074.101	1951.931	88.76	463.641	284.837	19.772
	3	19608.442	4400566.99	14758.601	4742.722	107.12	1069.106	655.855	22.764
	4	1837.995	422053.829	1386.961	445.704	5.33	103.257	63.346	1.126
	5	16025.217	3254453.325	12083.127	3882.95	59.14	785.108	496.112	11.621
	6	66196.047	13199628.75	51508.702	14663.834	23.51	3356.141	1891.117	4.137
	7	7954.648	1771971.554	6020.077	1934.57	0	437.121	267.56	0
	8	493.2	270141.444	0	0	493.2	0	0	97.743
TOTAL 7 (Suburban area-OUTSOURC):		121386.969	2589643.65	92653.894	27885.903	647.37	6286.852	3703.439	173.682
	1	555.017	255005.714	360.302	162.785	31.93	49.911	43.276	7.3
	2	9984.895	2863206.705	6853.13	3096.246	35.52	604.234	522.156	8.983
	3	6580.75	1492931.478	4525.258	2044.513	10.98	317.267	272.756	2.239
	4	14590.836	3554162.752	10032.266	4532.58	25.99	753.848	650.258	5.793
	5	15151.692	3285157.605	10425.237	4710.125	16.33	691.852	607.999	3.376
	6	84886.732	17478014.06	66067.76	18808.602	10.37	4381.289	2568.983	1.966
	7	23560.204	5380831.009	16228.269	7331.936	0	1146.672	988.702	0
	8	135.12	74009.554	0	0	135.12	0	0	26.778
TOTAL 8 (Rural area-OUTSOURC):		155445.246	34383318.87	114492.222	40686.787	268.24	7845.073	5854.132	58.455
TOTAL (1-4) RMOC:		1992051.955	435571448.1	1529931.384	444018.627	19001.946	109630.806	59074.817	4220.548
TOTAL (5-8) OUTSOURC:		819848.828	119883384.3	2649883.428	118086.976	3331.226	23068.381	18102.245	772.594
TOTAL NATIONAL CAPITAL REGION:		2511902.583	551227832.4	1830024.812	559614.603	22333.172	136700.397	75177.062	4993.052

Appendix P: Scenario 10 - diesel electric hybrid buses in 2021 (GHG emission estimates for 2021)

Vehicle Type Descriptions

Vehicle Type 1: Autos
Vehicle Type 2: Light trucks
Vehicle Type 3: Transit

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	VKT-Veh 3	Fuel-Veh 1	Fuel-Veh 2	Fuel-Veh 3
	1	4075.781	1026579.525	327.3315	691.456	111.01	275.265	111.375	20.476
	2	86472.46	22499920.58	69672.22	14717.581	2082.658	6072.962	2456.271	398.776
	3	16599.399	3655332.323	13672.629	2888.21	38.56	1033.318	416.559	6.515
	4	13477.481	3380431.606	11120.42	2349.081	7.98	958.573	387.408	1.34
	5	5216.542	1092327.772	4306.777	909.765	0	310.485	124.933	0
	6	54128.472	10316272.21	42119.016	11990.717	18.739	2833.212	1273.97	2.376
	7	13942.817	4564385.663	11511.19	2431.627	0	1295.199	524.176	0
	8	1499.805	648381.861	0	0	1499.805	0	0	234.591
TOTAL 1 (CAREX CORE-RIPOC):		195412.557	4718381.34	155875.587	35978.437	3758.552	12779.014	3244.892	664.074
	1	31636.228	9810494.79	24724.168	5754.343	1157.717	2541.484	1133.744	211.832
	2	235998.875	56236713.17	188880.613	43960.379	3157.883	15090.674	6714.656	544.478
	3	49821.972	10919313.78	40211.918	9358.987	251.067	2981.076	1323.953	41.139
	4	119228.277	26186939.17	96258.766	22403.421	566.09	7154.38	3176.491	92.812
	5	90685.413	18786328.21	72982.15	16981.329	741.934	5089.493	2264.352	178.684
	6	242057.473	44481580.58	187254.954	53308.964	1493.555	11914.59	5569.352	211.566
	7	76868.325	16996459.45	62355.585	14512.74	0	4689.801	2081.722	0
	8	2870.008	1162080.678	0	0	2870.008	0	0	420.458
TOTAL 2 (URBAN AREA-RIPOC):		848968.571	16457688.3	672648.154	166280.163	10038.254	49481.498	22264.27	1640.969
	1	14761.41	4805559.636	10549.365	3390.071	821.974	1077.289	663.487	154.892
	2	69301.849	16586511.4	51504.488	16551.125	1246.236	3944.212	2419.898	211.041
	3	53913.201	12017044.89	40386.384	12976.288	548.528	2902.41	1779.694	86.079
	4	24239.869	5690568.641	18139.405	5829.154	271.31	1373.026	842.197	43.477
	5	104789.319	22376711.39	78826.615	25331.174	631.53	5431.92	3360.242	96.531
	6	137436.256	25671600.65	106183.151	30228.913	1024.192	6681.891	3340.366	180.689
	7	79760.431	19440528.73	60362.695	19397.737	0	4791.974	2939.08	0
	8	236.16	100321.424	0	0	236.16	0	0	36.298
TOTAL 3 (SUBURBAN AREA-RIPOC):		484438.495	10688888.3	365952.103	113708.462	4779.93	26202.722	15344.564	817.007
	1	255.749	65181.846	176.16	79.589	0	13.869	11.998	0
	2	5986.616	1445861.981	4111.569	1857.608	17.44	306.367	264.276	2.866
	3	25299.954	5777727.205	17422.613	7871.541	5.8	1230.166	1061.73	0.885
	4	16021.584	3810161.432	11015.031	4976.593	29.96	809.662	697.272	4.68
	5	177161.83	3810247.261	121772.828	55016.992	372.01	8021.835	7033.967	57.908
	6	214995.53	40963293.67	167352.521	47643.009	0	10472.92	5826.574	0
	7	57379.145	13483144.04	39522.755	17856.39	0	2865.916	2484.663	0
	8	0	0	0	0	0	0	0	0
TOTAL 4 (RURAL AREA-RIPOC):		497100.408	103647642.8	381373.477	135301.722	425.21	23720.735	17380.48	66.339
	1	1571.237	563577.594	1232.528	260.36	78.35	147.575	59.769	15.702
	2	20149.513	6534578.25	16348.595	3453.482	346.436	1787.236	723.429	85.353
	3	734.066	150559.983	606.045	128.021	0	42.816	17.2	0
	4	4991.479	1186968.555	4100.325	866.154	25	333.279	134.556	4.811
	5	6159.943	1360565.594	5084.765	1074.107	1.07	385.953	156.194	0.162
	6	1783.059	308344.653	1387.178	394.911	0.97	83.651	39.033	0.118
	7	2638.987	1042917.953	2178.748	460.239	0	295.793	119.913	0
	8	4.2	1728.03	0	0	4.2	0	0	0.625
TOTAL 5 (CAREX CORE-OUTAQUAM):		38031.484	11148238.67	30038.184	8637.274	458.026	3078.393	1250.094	106.777
	1	8479.68	2339353.411	6597.36	1535.48	346.84	596.419	265.941	63.241
	2	46451.702	10914137.95	37086.184	8631.498	734.02	2912.961	1296.328	126.173
	3	31658.929	6761762.86	25468.889	5927.67	262.37	1834.992	813.624	41.176
	4	7344.751	1715473.123	5921.932	1378.28	44.54	467.097	207.764	7.801
	5	32544.359	6503908.701	26362.831	6135.728	45.8	1779.667	803.417	7.165
	6	61873.681	12638687.54	48066.224	13683.807	123.65	3295.272	1708.75	24.544
	7	23363.413	5095144.236	18952.401	4411.012	0	1405.936	624.011	0
	8	224.37	82270.142	0	0	224.37	0	0	33.385
TOTAL 6 (URBAN AREA-OUTAQUAM):		211940.686	48060737.97	168455.821	41703.475	1781.59	12292.344	5718.835	303.485
	1	1232.761	348249.461	879.743	282.708	70.31	77.299	47.579	12.383
	2	8523.425	2027695.291	6383.354	2051.31	88.76	489.356	300.67	14.861
	3	20078.88	4515982.387	15114.628	4857.132	107.12	1101.353	675.652	17.192
	4	1923.695	442922.78	1451.818	466.546	5.33	108.583	66.626	0.845
	5	16218.486	3294247.737	12229.393	3929.953	59.14	797.228	502.99	8.743
	6	67292.502	13371402.95	52362.184	14906.809	23.51	3406.469	1910.424	3.097
	7	8349.065	1862471.917	6318.588	2030.498	0	459.43	281.241	0
	8	493.2	202885.257	0	0	493.2	0	0	73.336
TOTAL 7 (SUBURBAN AREA-OUTAQUAM):		124112.034	28063637.78	94738.708	28524.958	847.37	6439.718	3785.184	130.437
	1	630.7	268845.463	412.432	186.337	31.93	53.927	46.751	5.479
	2	10246.856	2929143.403	7033.568	3177.768	35.52	619.564	535.427	6.763
	3	7162.609	1624649.177	4926.042	2225.587	10.98	345.696	297.212	1.68
	4	14860.909	3636195.028	10216.292	4616.627	25.99	772.101	666.094	4.392
	5	15388.411	3335077.857	10588.29	4783.922	16.33	702.941	617.643	2.534
	6	86313.522	17736331.54	67178.374	19124.778	10.37	4449.895	2603.759	1.494
	7	24437.377	5598264.949	16832.465	7604.912	0	1192.976	1026.685	0
	8	135.12	55528.856	0	0	135.12	0	0	20.091
TOTAL 8 (RURAL AREA-OUTAQUAM):		159175.504	35164938.27	117188.463	41719.801	288.24	8137.1	5785.571	42.433
TOTAL (1-8) RIPOC:		2025918.031	442100190.7	1555649.301	451266.784	19001.946	112163.969	60284.406	3182.389
TOTAL (1-8) OUTAQUAM:		533298.387	116486076.8	411323.176	118988.306	3381.226	29645.483	16596.844	883.748
TOTAL NATIONAL CAPITAL REGION:		2559177.338	560596867.5	1966972477	569452.29	22333.172	142108.434	76835.09	3765.535

Appendix R: Scenario 11 - fuel cell Ballard buses in 2021 (GHG emission estimates for 2021)

Vehicle Type Descriptions

Vehicle Type 1: Autos

Vehicle Type 2: Light trucks

Area	Link	Total VKT	Greenhouse Gas	VKT-Veh 1	VKT-Veh 2	Fuel-Veh 1	Fuel-Veh 2
	1	3964.771	969987.689	3273.315	691.456	275.265	111.375
	2	84389.802	21397782.98	69672.22	14717.581	6072.962	2456.271
	3	16560.839	3637327.512	13672.629	2888.21	1033.318	416.559
	4	13469.501	3376727.858	11120.42	2349.081	958.573	387.408
	5	5216.542	1092327.772	4306.777	909.765	310.485	124.933
	6	54109.733	10309706.76	42119.016	11990.717	2833.212	1273.97
	7	13942.817	4564385.663	11511.19	2431.627	1295.199	524.176
	8	0	0	0	0	0	0
TOTAL 1 (Central core-RMOC):		191654.005	45348246.24	155675.567	35978.437	12779.014	5294.692
	2	30478.511	9225034.525	24724.168	5754.343	2541.484	1133.744
	2	232840.992	54731884.21	188880.613	43960.379	15090.674	6714.656
	3	49570.905	10805612.8	40211.918	9358.987	2981.076	1323.953
	2	118662.186	25930424.08	96258.766	22403.421	7154.38	3176.491
	2	89943.479	18458309.15	72962.15	16981.329	5089.493	2264.352
	2	240563.918	43896855.29	187254.954	53308.964	11914.59	5569.352
	2	76868.325	18996459.45	62355.585	14512.74	4689.801	2081.722
	2	0	0	0	0	0	0
TOTAL 2 (Urban area-RMOC):		838928.316	180044579.3	672648.154	166280.163	49461.498	22264.27
	3	13939.436	4377469.722	10549.365	3390.071	1077.289	663.487
	3	68055.613	16003237.57	51504.488	16551.125	3944.212	2419.898
	3	53364.672	11773613.51	40386.384	12978.288	2902.41	1779.694
	3	23968.559	5570408.081	18139.405	5829.154	1373.026	842.197
	3	104157.789	22109917.84	78826.615	25331.174	5431.92	3360.242
	3	136412.064	25172211.75	106183.151	30228.913	6681.891	3340.366
	3	79760.431	19440528.73	60362.695	19397.737	4791.974	2939.08
	3	0	0	0	0	0	0
TOTAL 3 (Suburban area-RMOC):		479658.564	104447387.2	365952.103	113706.462	26202.722	15344.964
	4	255.749	65181.846	176.16	79.589	13.869	11.998
	4	5969.176	1437939.733	4111.569	1857.608	306.367	264.276
	4	25294.154	5775281.428	17422.613	7871.541	1230.166	1061.73
	4	15991.624	3797225.595	11015.031	4976.593	809.662	697.272
	4	176789.82	37942426.27	121772.828	55016.992	8021.835	7033.967
	4	214995.53	40963293.67	167352.521	47643.009	10472.92	5826.574
	4	57379.145	13483144.04	39522.755	17856.39	2865.916	2484.663
	4	0	0	0	0	0	0
TOTAL 4 (Rural area-RMOC):		498675.198	103464492.8	361373.477	135301.722	23720.735	17380.48
	5	1492.887	520179.039	1232.528	260.36	147.575	59.769
	5	19802.077	6298678.457	16348.595	3453.482	1787.236	723.429
	5	734.066	150559.983	606.045	128.021	42.816	17.2
	5	4966.479	1173672.512	4100.325	866.154	333.279	134.556
	5	6158.873	1360117.868	5084.765	1074.107	385.953	156.194
	5	1782.089	308018.574	1387.178	394.911	83.651	39.033
	5	2638.987	1042917.953	2178.748	460.239	295.793	119.913
	5	0	0	0	0	0	0
TOTAL 5 (Central core-OUTAOUAIS):		37575.458	10854144.38	30936.184	6837.274	3078.303	1250.094
	6	8132.84	2164567.25	6597.36	1535.48	596.419	265.941
	6	45717.682	10565420.53	37086.184	8631.498	2912.961	1296.328
	6	31396.559	6647961.883	25468.889	5927.67	1834.992	813.624
	6	7300.211	1693912.638	5921.932	1378.28	467.097	207.764
	6	32498.559	6484106.115	26362.831	6135.728	1779.667	803.417
	6	61750.031	12570851.83	48066.224	13683.807	3295.272	1708.75
	6	23363.413	5095144.236	18952.401	4411.012	1405.936	624.011
	6	0	0	0	0	0	0
TOTAL 6 (Urban area-OUTAOUAIS):		210159.295	45221964.48	168455.821	41703.475	12292.344	5719.835
	7	1162.451	314025.042	879.743	282.708	77.299	47.579
	7	8434.665	1986623.832	6383.354	2051.31	489.356	300.67
	7	19971.76	4468466.212	15114.628	4857.132	1101.353	675.652
	7	1918.365	440587.067	1451.818	466.546	108.583	66.628
	7	16159.346	3270084.709	12229.393	3929.953	797.228	502.99
	7	67268.992	13362842.92	52362.184	14906.809	3406.469	1910.424
	7	8349.085	1862471.917	6318.588	2030.498	459.43	281.241
	7	0	0	0	0	0	0
TOTAL 7 (Suburban area-OUTAOUAIS):		123264.884	28705101.7	94739.708	28524.956	8439.718	3785.184
	8	598.77	253702.722	412.432	186.337	53.927	46.751
	8	10211.336	2910451.785	7033.568	3177.768	619.564	535.427
	8	7151.629	1620007.125	4926.042	2225.587	345.696	297.212
	8	14834.919	3624055.148	10218.292	4616.627	772.101	666.094
	8	15372.081	3328074.289	10588.29	4783.792	702.941	617.643
	8	86303.152	17732202.11	67178.374	19124.778	4449.895	2603.759
	8	24437.377	5598264.949	16832.465	7604.912	1192.976	1028.685
	8	0	0	0	0	0	0
TOTAL 8 (Rural area-OUTAOUAIS):		158909.264	35068758.15	117189.465	41719.801	8737.7	3785.571
TOTAL (1-8) RMOC:		2008918.083	433304705.3	1555649.301	451266.784	112163.968	60284.408
TOTAL (6-8) OUTAOUAIS:		829608.881	18847988.7	411323.176	116886.506	28945.485	16550.864
TOTAL NATIONAL CAPITAL REGION:		2538824.764	550152674.2	1966972477	569852.29	142109.434	76835.08

Appendix S: Major Transit Route Changes Between 1995 and 2021

Route Additions	
Route Number	Description
2s	Downtown (Bank and Somerset) - Blair Station via Montreal Road
8n	Heron Gate Mall - Hull via Alta Vista Drive / Transitway
8s	Hull - Heron Gate Mall via Alta Vista Drive / Transitway
418	South Keys Station - Kanata via Barhaven
425	Hurdman Station - Orleans South via Transitway / Innes Road / Blackburn Hamlet Bypass
463	Kanata - Lebreton Station via Queensway / Ottawa River Pkwy / Transitway
47	Lebreton - Gloucester (Conroy and Leitrim) via Transitway
495	Kanata - Orleans Station via Queensway / Transitway / Innes Road / Blackburn Hamlet Bypass / Trim Road
496	Stittsville (Main Street) - Barhaven (Jockvale Road) via Fallowfield Road
83	Hull - Heron Gate Mall via Transitway / Walkley Road
86e	Lebreton - Southvale Crescent via Transitway / Industrial Avenue / Russell Road
86w	Hurdman Station - Baseline Station via Transitway / Fisher Avenue / Meadowlands Road
94	Hull - Airport via Transitway / Airport Parkway
142	Gloucester South, local route (Greenboro Station / Hwy 31 / Conroy Road)
142d	Gloucester South, local route (Greenboro Station / Hwy 31 / Conroy Road)
146w	Gloucester South, local route (Billings Bridge Station - Greenboro Station)
156x	Lincoln Fields - Britannia, local route
174x	Carlingwood Mall - Greenbank and Canfield Road via Woodroffe Avenue
178	Nepean Centre, local loop along Woodroffe Avenue
180	Hawthorne Road (near Hunt Club Road) - Hurdman Station via Russell Road / Elmvale Mall / St. Laurent
182x	Kanata - Shirleys Bay via March Road / Carling Avenue
194	Cite College - Hurdman Station via St. Laurent Blvd / Elmvale Mall / Transitway
199x	Blair Station - Hurdman Station via Industrial Avenue / Star Top Road / Cyrville Road / Blair Road
441	Alta Vista Transitway along Leitrim Road between Conroy Road and Alert Road
900	Rapid Transit Line from Ottawa South (Leitrim Road) - Ottawa River (CP Alignment)
902	Rapid Transit Line from Ottawa - East Quebec
910	Rapid Transit Line from North Kanata - VIA Train Station (CN Alignment)

Cancelled Routes	
Route Number	Description
8	Heron Gate Mall - Hull via Alta Vista Drive / Transitway
42	Lebreton Station - Ottawa South (Hunt Club Road) via Transitway
95x	Baseline Station - Blair Station via Transitway
96	Carlingwood Mall - Airport via Transitway
112	Billings Bridge Station - Hurdman Station via Walkley Road / St. Laurent Blvd / Transitway
112x	Don Reid Drive - Hurdman Station via St. Laurent Blvd / Transitway
117	St. Laurent Station - Billings Bridge Station via Transitway / Walkley Road / St. Laurent Blvd
142n	Gloucester South, local route (starting and ending at Greenboro Station)
142s	Gloucester South, local route (starting and ending at Greenboro Station)
146	Greenboro Station - Billings Bridge Station, local route
177	Baseline Station - Nepean South, along Woodroffe Avenue
189	Lebreton Station - Riverside Drive via Bronson Avenue
192	Elmvale Mall - Hurdman Station via Sheffield Road / Transitway
192x	Hawthorne Road - Hurdman Station via Sheffield Road / Elmvale Mall / Transitway
193	Orleans, local route (along Queensway and St. Joseph Blvd)
196	Airport - Greenboro Station via Airport Parkway / Transitway
197	Local Route between Bank Street and Riverside Drive (starting and ending at Billings Bridge Station)

Note: These routes do not include routes with minor changes between 1995 and 2021
(virtually all routes are affected by new bus lanes, transitway extensions
along existing roads, etc.)

Source: (Region of Ottawa-Carleton. 1999.).

Appendix T: Urban Transit Area in NCR for 1995 and 2021 (Source: Region of Ottawa-Carleton, 1999.)