Greenhouse Gas Emissions

Baseline

For

The City of Winnipeg

May 31, 2007

Winnipeg, Manitoba

CENTRE FOR SUSTAINABLE TRANSPORTATION
CENTRE POUR UN TRANSPORT DURABLE

CST

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1. Executive Summary

The purpose of this report is to develop baseline transportation greenhouse gas emissions for the city of Winnipeg as an initiating part of the larger WinSmart Project. This report provides the information gathered, assumptions taken, and methodology used in creating the baseline. The report also provides the results, sensitivity analysis and outlines suggestions for the future. The WinSmart project will be evaluated, in part, by the ability of the various measures, to reduce greenhouse gas emissions from transportation activities.

The baseline for Manitoba is 4.776 Mt. of Greenhouse Gas, Carbon Dioxide Equivalent (GHG CO_2e) emissions, while the baseline calculated for Winnipeg is 2.383 Mt. of GHG CO_2e emissions.

The data used in this study is representative of different years (*See 7. Assumptions and Limitations*).

- Vehicle Registration, 2007
- VKT, 2005
- Fuel Efficiencies, 2006
- Canadian Vehicle Survey, 2005

Key findings of this study:

- The GHG emissions baseline for Winnipeg is derived from fuel use. (Calculation: Appendix E)
- Winnipeg comprises 52% of all registered vehicles in Manitoba
- 52% of provincial VKTs occur in Winnipeg
- During 2005 vehicles in Winnipeg traveled 5.7 billion kms.
- A significant portion; 27% of vehicle travel in Winnipeg is spent idling.
- 46% of all provincial on-road transportation fuel is used on Winnipeg streets and roads
- 60% of provincial gasoline is used in Winnipeg
- 21% of provincial diesel fuel is used in Winnipeg
- The total amount of gasoline used in Winnipeg is 793,697,532 litres and the total amount of diesel fuel used is 146,195,911 litres.
- Light duty passenger vehicles use 70% of the gasoline used in Winnipeg
- Heavy duty commercial vehicles use 61% of the diesel fuel used in Winnipeg
- 50% of Manitoba's on-road GHG, CO_2e emissions are generated within the city of Winnipeg

Given the range of the various data sources used in this report, it is assumed that these results are representative of the year 2006.

2. List of Tables

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4. Research Team & Acknowledgements

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- Jeff Babb, M.Sc., Chair of the Mathematics/Statistics Department
- Dr. Danny Blair, PARC-MB Hydro Climate Change Research Professor

Acknowledgements

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The CST also appreciates the information and guidance provided by Manitoba Public Insurance, Manitoba Infrastructure and Transportation, Transport Canada, Environment Canada, and Statistics Canada.

Photographic credits provided by Jodi Binder, Joey Pankiw and Justyna Swistak.

5. Research Terminology

- LDPV-A: Light Duty Passenger Vehicles (automobiles) - regular passenger vehicles (cars)
- LDPV-T: Light Duty Passenger Vehicles (trucks) - passenger vehicles (vans, SUVs, trucks)
- LDCV: Light Duty Commercial Vehicles - commercial trucks under 4.5 tonnes
- HDCV: Heavy Duty Commercial Vehicles - commercial trucks over 4.5 tonnes (inclusive), including public school buses
- BUS: buses (Transit, Greyhound, Beaver)
- Territory 1: Winnipeg, including St. Norbert, Headingley, East and West St. Paul. (MPI)
- GHG: Greenhouse gas
- UTEC: Urban Transportation Emissions Calculator (Transport Canada)
- VKT: Vehicle Kilometres Travelled
- CO_2e: Carbon Dioxide equivalents
- MPI: Manitoba Public Insurance Corporation
- CST: Centre for Sustainable Transportation at the University of Winnipeg
- Mt: Megatonnes
- P_{idle}: time spent idling
- P_{low}: distance travelled under posted speed limit
- P_{limit}: distance travelled at posted limit

6. Objective/Purpose

The City of Winnipeg and Transport Canada have agreed to cost-share the WinSmart Project in the Urban Transport Showcase Program. The Province of Manitoba is also a funding partner. The WinSmart project is an innovative approach to implementing sustainable urban transportation initiatives focusing on the Pembina corridor. Its success will be assessed, in part, by the ability of the various proposed strategies to reduce greenhouse gas emissions from transportation activities*. This project provides an estimate of baseline transportation greenhouse gas emissions in the city of Winnipeg, which may be used to evaluate the effectiveness of the WinSmart project in the Pembina corridor and city wide.

*Only on-road fuel use by registered vehicles is considered in this report.

7. Assumptions and Limitations

This project was predicated on the allocation of existing data as there was no mandate to collect data. As a result, data was collected from existing sources. Typical of this type of data collection, the data was found to be of varying quality, formatted in different ways and was representative of different years. To formulate an association between the different data collected, the following variables were considered.

Vehicle Registrations (2007)

Vehicle registrations were taken from data collected from Manitoba Public Insurance. Historical records show that there are minimal changes from year to year in the number of vehicles registered in Manitoba. From 2005 to 2007 there was a 2.7% increase in the number of vehicles registered in Manitoba.

Fuel Efficiency (2006)

Fuel efficiency data was gathered from Transport Canada GHG Urban Transport Emissions Calculator. The changes in efficiency would be due to the entering of newer, more fuel efficient, vehicles into the market, replacing older, less efficient, vehicles. Annually these changes would not greatly affect the baseline, however over a 5 year period a slight change may be evident.

VKT (2005)

VKT data was collected both from the Canadian Vehicle Survey and the City of Winnipeg. Changes in the annual kilometres driven by each vehicle in a year would be very minimal. Factors that may influence changes in the amount of kilometres driven are changes in fuel prices, the improvement of sustainable forms of transportation and the distribution of people within the city from the core areas to the suburbs.

GHG Emission Rates (2006)

GHG emissions rates were collected from Transport Canada. The emission rates are held constant from year to year.

Taking these variables into account, it is reasonable to assume that the estimated GHG baseline in this report would be representative of current 2007 emission levels.

Other Assumptions and Limitations:

- Winnipeg is defined as MPI rating Territory 1 (See Map in Appendix C). This definition of Winnipeg is necessitated by the data format.

- Vehicles registered in St. Norbert, Headingley, East and West St. Paul are also included in this analysis as being a part of Winnipeg, based on Manitoba Public Insurance Corporation's registration configuration.

- Vehicles are either gasoline or diesel fuel operated.

- Ethanol and bio-diesel blended fuels are not factored in this report.
    - There is no or incomplete bio-diesel data available and ethanol fuel sales are assumed to be proportionately small.

- As per the Transport Canada model, it is assumed that vehicles operating at posted speed limits and over the posted speed limit have the same fuel efficiency factor.

- The vehicles were categorized into one of five specific classes: (LDPV-A, LDPV-T, LDCV, HDCV, BUS). In order to use the tables and rates from the GHG Urban Transportation Emissions Calculator from Transport Canada.

- All streets in Winnipeg have posted speed limits between 50 and 90 km/h.

- The proportions of vehicles using gasoline and diesel fuel in Winnipeg are the same as the proportions for provincial vehicles.

- The average annual VKTs for a passenger vehicle in Winnipeg is 14,500 km[1]. An average commercial vehicle travels 23,000 km in a year, and a bus travels 47,000 km in a year[2].

- A vehicle in Winnipeg travels at posted speed limit for 45% of a trip, 27.5% of a trip is spent at lower speeds, and 27.5% of a trip is spent idling.

- Fuel use is increasing at a steady rate per annum.
    - Fuel use fluctuates from year to year, with an overall gradual increase.

- The data limits the ability to estimate the amount of VKTs that rural vehicles travel within the city of Winnipeg. The data also limits the ability to estimate the VKTs of Winnipeg based vehicles travelling outside of Winnipeg.

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[1] Transport Canada *Canadian Vehicle Survey*, 2005
[2] City of Winnipeg

8. Methodology: Fuel Use

Objective

The objective was to calculate gasoline and diesel fuel use in order to determine baseline emissions within the City of Winnipeg. To do this requires an estimate of the vehicle population and classification into heavy and light duty vehicles as well as buses. Manitoba Public Insurance provided data for vehicle registration in Winnipeg.

Data

To calculate fuel use in the city of Winnipeg the following data was used:

1. Total Cars – Manitoba Public Insurance
2. Km per year – Transport Canada and City of Winnipeg
3. Fuel Efficiency – Transport Canada GHG Urban Transport Emissions Calculator (UTEC)
4. VKT weighting factor – Research Advisors and Assistants
5. Emissions Rate (g/L) – Transport Canada

The vehicles were classified into five classes with specific sub classes within each:

1. LDPV - A
   - Gasoline
   - Diesel
2. LDPV - T
   - Gasoline
   - Diesel
3. LDCV
   - Gasoline
   - Diesel
4. HDCV
   - Medium use, Heavy use, Public Bus
   - Gasoline and Diesel
5. BUS
   - Urban Buses
   - Gasoline and Diesel

Methodology

Each of the five classes was broken down into gasoline and diesel fuel use and any other sub categories found within each class. The five classes had their VKTs broken down into the percentages of time that vehicles spent idling (P_{idle}), driving under the speed limit (P_{low}) and driving at posted speed limit (P_{limit}). From the fuel use calculations, emissions were calculated, producing a baseline emissions number for greenhouse gas emissions within the city of Winnipeg.

The first step in finding the amount of fuel used was to find the total VKT for each of the classes and fuel types. To calculate the VKT for each of the categories, the number of vehicles in each category was multiplied by the average annual kilometres for each category. For the two LDPV classes the average annual VKT was 14,500 km, for both of the LDCV and HDCV (less Public Buses) classes, the average yearly VKT was 23,000 km, and for the BUS class and Public Buses (HDCV) annual VKT average was 47,000 km.

The second step was to break down the VKT for each of the classes into P_{idle}, P_{low}, and P_{limit}. A weight of 27.5% of the VKTs was allocated to both P_{idle} and P_{low}. The remaining 45% of the VKTs was allocated to P_{limit}. Sensitivity analysis was performed to analyze how changes in time at Pidle and distance travelled at P_{low} and P_{limit} would affect outputs of GHG emissions. The weighting factors were altered to add and subtract ten and five percent to P_{limit}. Changes in the weight applied to P_{limit} were then evenly distributed to the weight spent at P_{idle} and P_{low}, to maintain the sum of the weights to equal to one. (See: Table 11.1)

The last step was to find the fuel used in each class by fuel type and weighting factor. Each of the speeds had their own fuel efficiencies, as an example, passenger cars (gasoline use) had fuel efficiencies of 22.54 L/100 km at idle, 12.74 L/100 km under speed limit and 9.8 L/100 km at the posted speed limit (dividing each by 100 gives the fuel efficiency in L/km). This was then multiplied by the corresponding VKT (km) producing an amount of fuel in litres.

(For the complete calculation for finding fuel use within the city of Winnipeg, *See Appendix E*).

The CO_2e Emissions (g/yr) was calculated by multiplying the CO_2e emission rate (g/l) by the VKT (km/yr).

By adding up the totals for each category we find that the total annual CO_2e emissions for Winnipeg are 2.383 Mt.

Results

When all the totals for all categories and classes are added up, an estimate for transportation fuel use can be found. In the city of Winnipeg the total use of gasoline was found to be 793,697,532 litres and the total use of diesel found to be 146,195,911 litres. These result fits reasonably well when compared to the total fuel used in Manitoba and also were compared to vehicle survey data. These values are estimated to be accurate within + or – 5%.

Originally raw fuel sales data was to be used in this methodology. Unfortunately due to the lack of availability of accurate raw fuel sales data, the fuel use in the city was calculated based on VKTs and fuel efficiencies.

9. Findings-Results

This section summarizes the research findings – the analysis indicates the baseline GHG emissions from on road transportation in Winnipeg is 2.383 Mt.

The results indicate urban transportation in Winnipeg represents 50% of Manitoba transportation emissions.

9.1 Vehicles

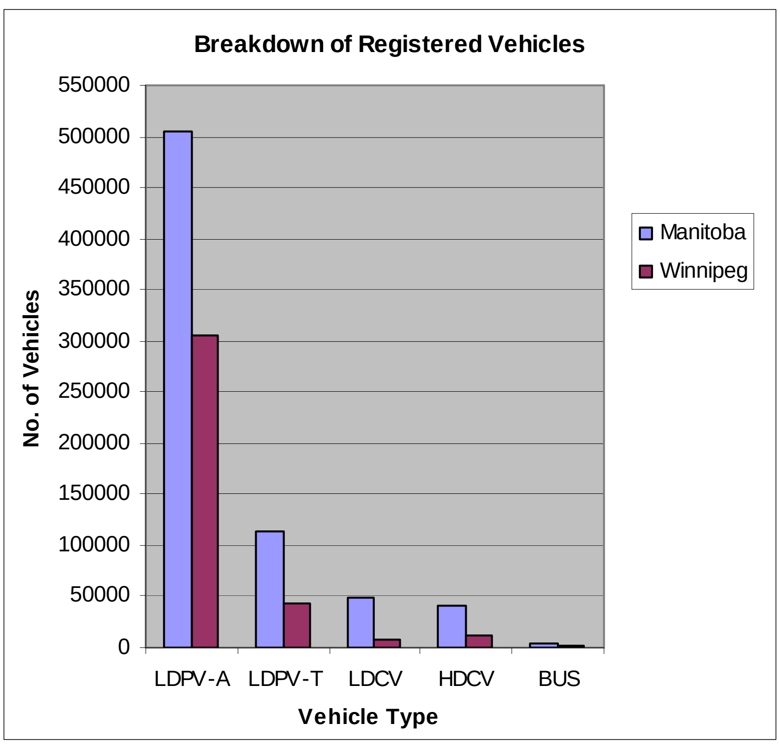
Winnipeg accounts for 52% of all registered vehicles in Manitoba. Within Manitoba, passenger vehicles make up 87% of registered vehicles.

Table 9.11: Registered Vehicles: Winnipeg

Vehicle Class	Manitoba	Winnipeg
LDPV-A	505,289	305,617
LDPV-T	114,437	43,776
LDCV	49,260	7,571
HDCV	40,973	11,386
BUS	3,040	1,164
Total	**712,999***	**369,514***

*Source: Manitoba Public Insurance

Figure 9.11 Manitoba Register Vehicles



*Source: Manitoba Public Insurance

9.2 Vehicle Kilometres Travelled (VKT)

Table 9.21: Manitoba VKT

VKT (billions)	
Winnipeg	5.7
Rural	5.3
Manitoba*	**11.0**

* Source: Canadian Vehicle Survey

In the province of Manitoba 52% (5.7 billion) of the total VKTs occur in the city of Winnipeg, while rural areas account for the remaining 48% (5.3 billion) of the VKTs.

Figure 9.21: Manitoba VKT

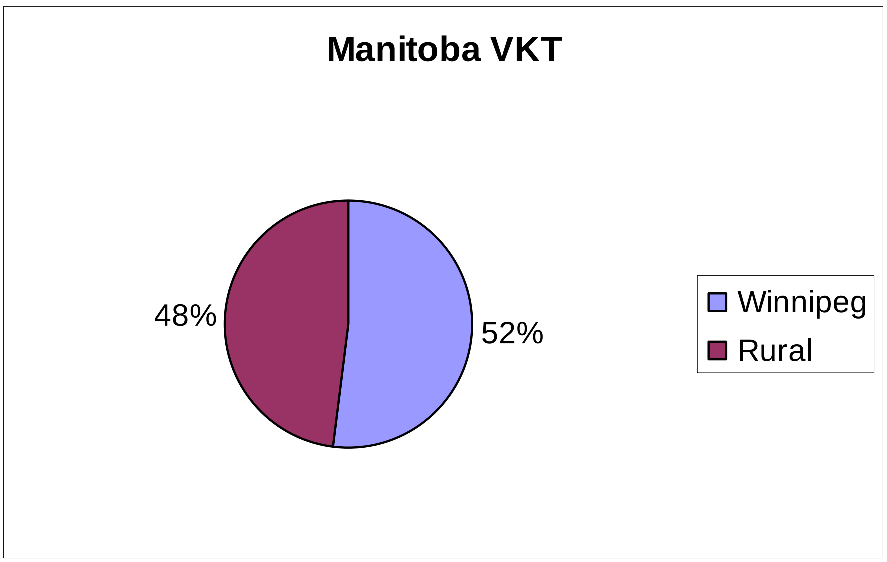


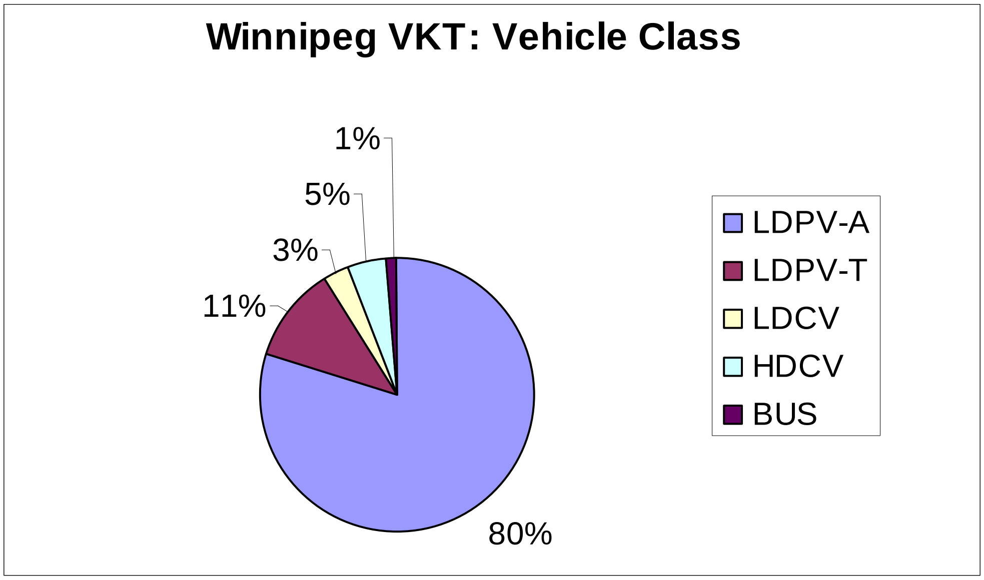
Table 9.22: Winnipeg VKT: Vehicle Class

Vehicle Class	VKT
LDPV-A	4,540,000,000
LDPV-T	650,000,000
LDCV	180,000,000
HDCV	270,000,000
BUS	60,000,000
Total*	5,700,000,000

*Source: City of Winnipeg Traffic Flow Map

The LDPV-A and LDPV-T vehicles account for 91% of the total kilometers traveled within the city of Winnipeg.

Figure 9.22: Winnipeg VKT: Vehicle Class



9.3 Fuel Use

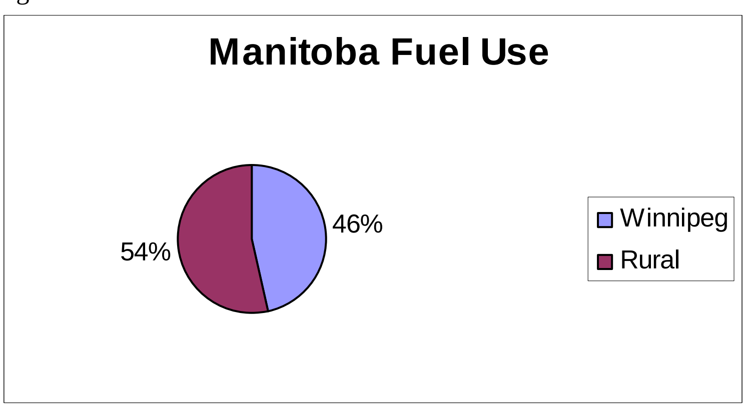
Table 9.31: Manitoba Fuel Use

Fuel Use (L)	Gasoline	Diesel
Winnipeg	794,300,264	145,292,754
Rural	530,388,374	556,498,190
Manitoba	**1,324,688,638***	**701,790,944***

*Source: Province of Manitoba

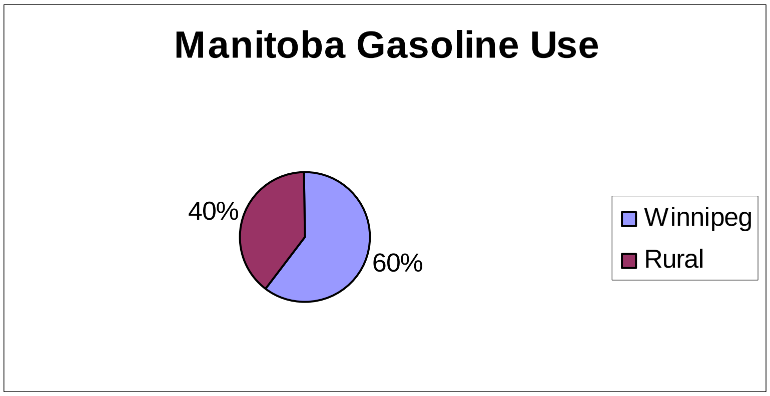
Rural areas use 54% of the total fuel in Manitoba. Rural areas use more fuel than Winnipeg due to large numbers of HDCV which use high levels of diesel fuel.

Figure 9.31: Manitoba Fuel Use



Winnipeg accounts for 60% of the total gasoline used in Manitoba. The high level of gasoline use in Winnipeg is due to the high numbers of LDPV in the city.

Figure 9.32: Manitoba Gasoline Use



Rural areas account for the majority (79%) of the total diesel fuel used in Manitoba. The high level of diesel fuel use in rural areas of Manitoba is due to the high numbers of HDCV.

Figure 9.33 Manitoba Diesel Use

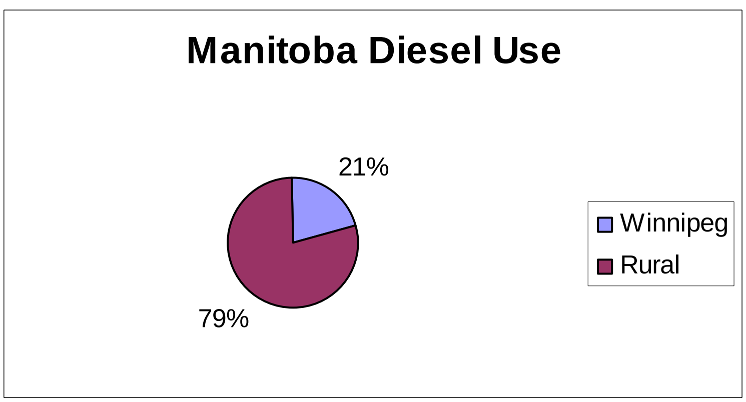


Table 9.32: Fuel Use Winnipeg: Vehicle Class

Fuel Use (L)	Gasoline	Diesel
LDPV-A	619,112,073	5,552,935
LDPV-T	110,562,627	3,875,542
LDCV	38,244,622	2,369,602
HDCV	26,380,942	90,053,514
BUS		43,441,161
Total	**794,300,264**	**145,292,754**

Gasoline fuel use by LDPV-A accounts for the largest percentage (76%) of total fuel used within Winnipeg, while HDCV accounts for the largest percentage (61%) of total diesel fuel used in Winnipeg.

Figure 9.34: Winnipeg Gasoline Use

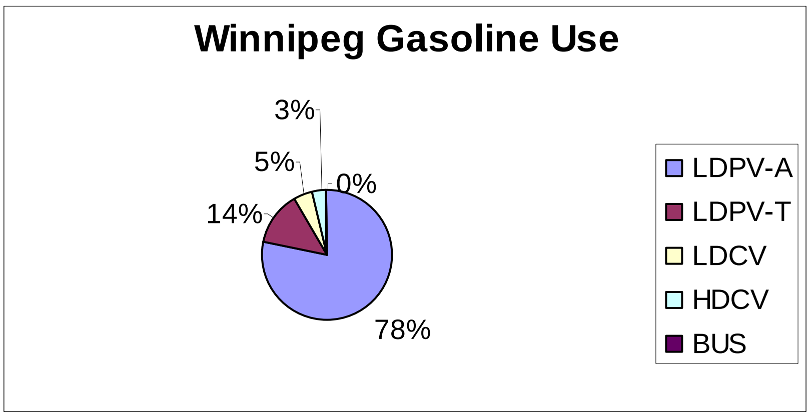
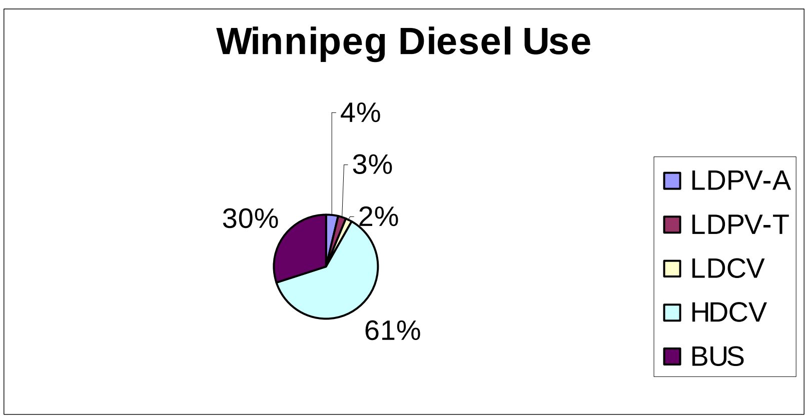


Figure 9.35: Winnipeg Diesel Use



9.4 Emissions

Table 9.41: Manitoba GHG Emissions

GHG Emissions	
Rural	2.383
Winnipeg	2.383
Manitoba	4.776*

*Source: Environment Canada, 2007

Greenhouse Gas emissions are evenly divided between Winnipeg and Rural areas. Even though less than 50% of the total fuel is used in Winnipeg, GHG emissions are evenly divided between Winnipeg and rural areas due to the large percentage of passenger vehicle in Winnipeg.

Figure 9.41: Manitoba GHG Emissions

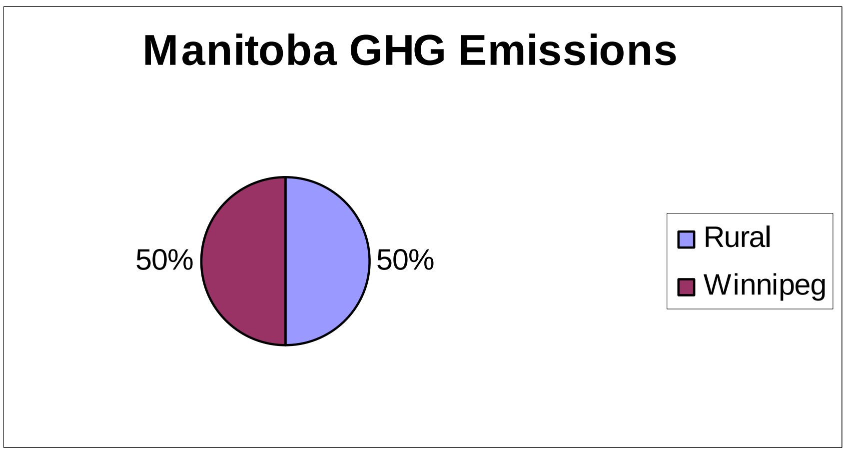


Table 9.42: Winnipeg GHG Emissions: Vehicle Class

	Winnipeg CO_2e Emissions (g)		
	Gasoline	Diesel	
LDPV-A	1,534,778,828,967.00	15,509,347,455.00	
LDPV-T	282,598,074,612.00	10,824,388,806.00	
LDCV	97,753,253,832.00	6,618,298,386.00	
HDCV	67,587,973,404.00	248,277,538,098.00	
BUS	-	119,767,280,877.00	**Total Gas & Diesel**
Total	**1,982,718,130,815.00**	**400,996,853,622.00**	**2,383,714,984,437.00**

The vehicle class which contributes the largest amount of GHG emissions in Winnipeg is the LDPV-A class, contributing 1.539 Mt. The fuel type which produces the most GHG emissions within Winnipeg is gasoline, producing 1.983 Mt.

Figure 9.42: Winnipeg GHG Emissions

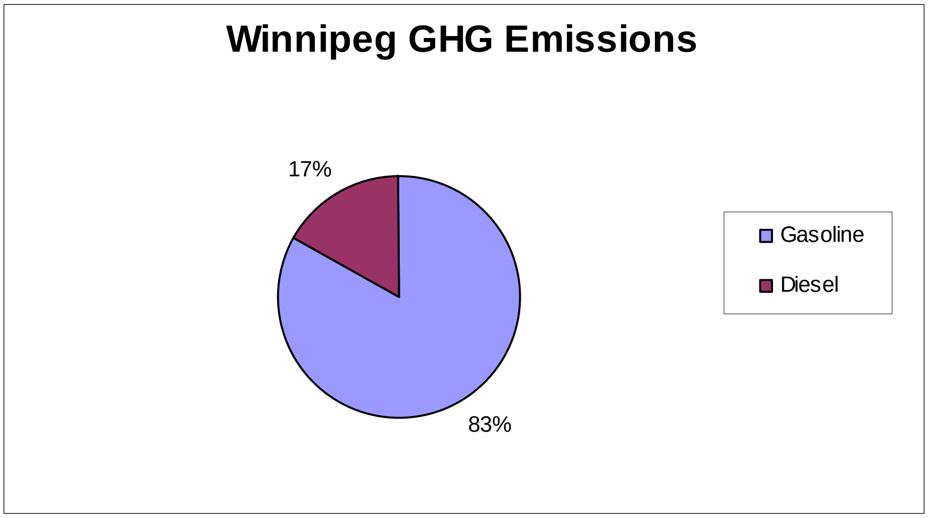


Figure 9.43: Winnipeg Gasoline GHG Emissions: Vehicle Class

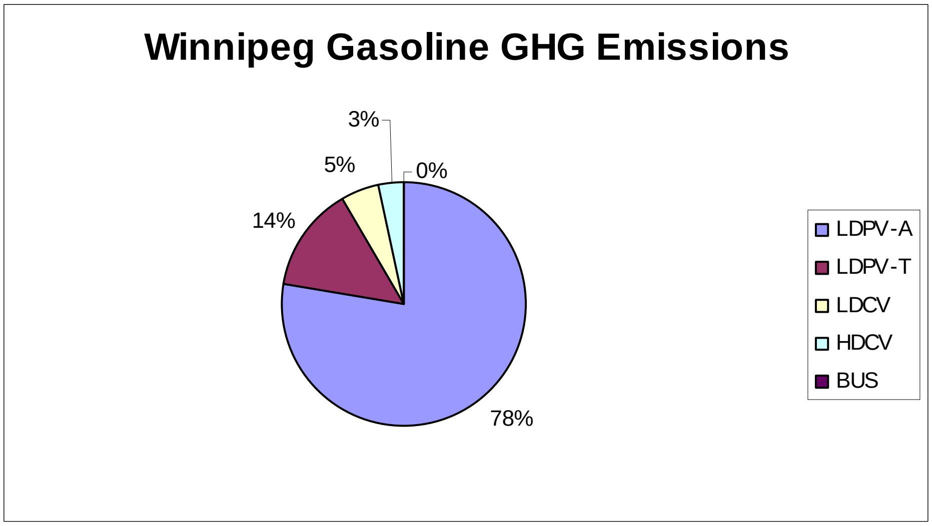
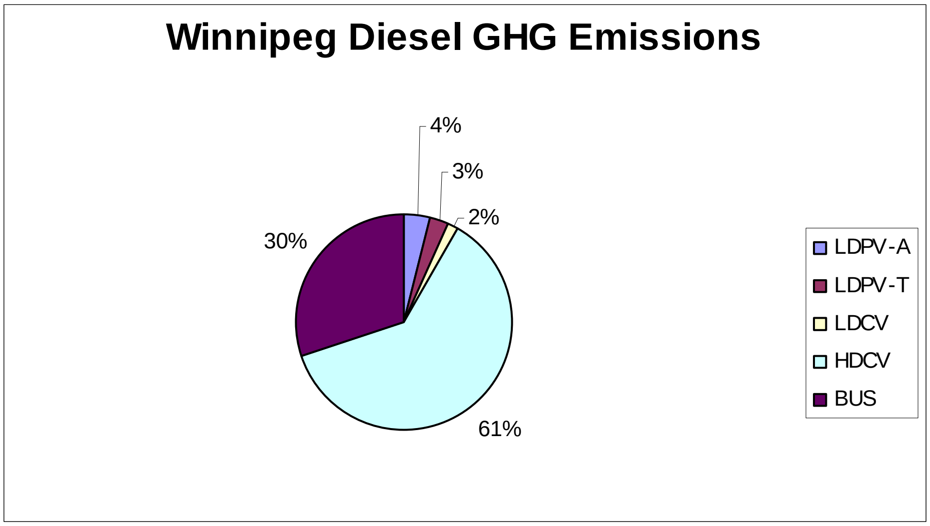


Figure 9.44: Winnipeg Diesel GHG Emissions



10. Check Methodology (VKT Method)

Many factors contributed to the final calculation of the GHG emissions baseline for Winnipeg, some of which were given to us in the form of tables and data, whereas others had to be assumptions which were estimated

These factors are:

Collected/Given

- Fuel efficiency (L/km)
- CO_2e Emission rate (g/km)
- VKTs

Assumptions

- Travelling Speed (At Limit, Under Limit, Idling)
- Vehicle Class (LDPV-A, LDPV-T, LDCV, HDCV, BUS)
- Type of fuel (gasoline, diesel)

The annual VKT was found by multiplying the average VKT of each vehicle class by the number of vehicles in each class. The annual VKT average for the LDPV-A and LDPV-T classes was taken from, *Transportation in Canada Annual Report 2005*[3]. In the report, it was found that LDPV-A and LDPV-T classes had annual VKT averages of 14,500 kms. The annual VKT average for the LDCV and HDCV classes was taken from the average annual VKT of the City of Winnipeg fleet. The average for the City of Winnipeg fleet was 23,000 km for both LDCV and HDCV classes. The BUS class and Public Buses (HDCV) annual VKT average was taken from the City of Winnipeg Transit web site. It was found that the annual VKT average for the BUS class and Public Buses (HDCV) was 47,000 km.

The VKT for each vehicle class was then broken down into gasoline or diesel vehicles, using the fuel ratios as calculated in the fuel sales method.

The VKT values were then weighted by the designated speed categories. It was calculated that 45% of a trip is spent driving at the posted speed limit, 27.5% of a trip is spent driving below the speed limit (by a factor of about 2.25), and the other 27.5% of a trip is spent idling. These weights are based upon averages that were the product of experiences, as there was a lack of this type of data. For 5 and 10 percent adjustments on the weights see Sensitivity Analysis.

The total VKTs for Winnipeg were 5.56 billion kms as calculated using this method.

[3] Transport Canada, *Transportation in Canada Annual Report 2005*, 2005.

Table 10.1: VKT Winnipeg: Vehicle Class, Fuel Type and Duty Cycle

VKT (kms/year)					
Vehicle Class	**Fuel**	**Idling**	**Under Limit**	**At Limit**	**Total**
LDPV-A	**Gasoline**	1,206,461,310	1,206,461,310	1,974,209,416	4,387,132,035
	Diesel	12,186,478	12,186,478	19,941,509	44,314,465
LDPV-T	**Gasoline**	167,574,528	167,574,528	274,212,864	609,361,920
	Diesel	6,982,272	6,982,272	11,425,536	25,390,080
LDCV	**Gasoline**	44,534,515	44,534,515	72,874,661	161,943,690
	Diesel	3,352,060	3,352,060	5,485,190	12,189,310
HDCV	**Gasoline**	19,489,195	19,489,195	31,891,410	70,869,800
	Diesel	52,757,980	52,757,980	86,331,240	191,847,200
BUS	**Gasoline**	-	-	-	0
	Diesel	16,582,775	16,582,775	27,135,450	60,301,000
					5,563,349,500

The fuel efficiency for each of the specified speed categories was calculated by multiplying the corresponding adjustment factor by the fuel efficiency. Next, the fuel efficiency in L/km for each category of vehicle classes and speed categories was multiplied by the CO_2e emission rate in g/L, in order to get a CO_2e emission rate in g/km.

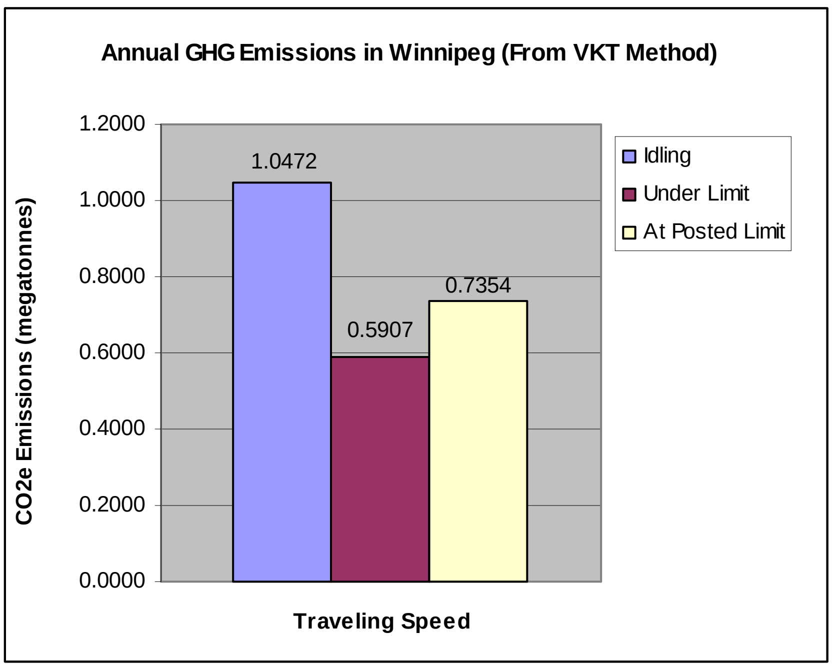
The annual CO_2e emissions in grams were calculated by multiplying the CO_2e emission rate (g/km) by the annual VKTs.

Summing the totals of the categories gave an annual total of CO2e emissions for Winnipeg as 2.373Mt. This number falls right in the middle of the emissions range calculated by the fuel use method. (See Sensitivity Analysis)

Table10.2: 2006 GHG Emissions: Winnipeg

CO_2e Emissions (Megatonnes/year)					
Vehicle Class	**Fuel**	**Idling**	**Under Limit**	**At Limit**	**Total**
LDPV-A	**Gasoline**	0.6741	0.3810	0.4796	1.5348
	Diesel	0.0057	0.0032	0.0041	0.0130
LDPV-T	**Gasoline**	0.1241	0.0702	0.0883	0.2826
	Diesel	0.0068	0.0027	0.0034	0.0129
LDCV	**Gasoline**	0.0429	0.0243	0.0305	0.0978
	Diesel	0.0029	0.0016	0.0021	0.0066
HDCV	**Gasoline**	0.0294	0.0166	0.0128	0.0588
	Diesel	0.1024	0.0579	0.0728	0.2331
BUS	**Gasoline**	-	-	-	-
	Diesel	0.0588	0.0332	0.0418	0.1339
					2.3734

Figure 10.1 2006 GHG Emissions: Winnipeg



11. Sensitivity Analysis

The following results are subject to changes in assumptions regarding the idling time (P_{idle}), the distance travelled at low speed (P_{low}), and the distance travelled at posted speed limits (P_{limit}). Adjustments plus and minus 5 and 10 percent to P_{limit} are used. Due to the nature of Transport Canada's GHG model, decreasing P_{idle} and P_{low} does not influence the result by a large factor. However, increasing the P_{idle} and P_{low} do noticeably influence the results. Increasing the P_{idle} and P_{low} generates results that fit better with provincial data, fuel use and emissions. Decreasing P_{limit} in Winnipeg by 10% generates a more realistic result of 52% of Manitoba's total on-road transportation emissions.

The sensitivity analysis is illustrated in the following tables and figures.

Table 11.1: Sensitivity Weights

Weights	P_{idle}	P_{low}	P_{limit}
Normal Level	0.275	0.275	0.450
10% Decrease	0.325	0.325	0.350
10% Increase	0.225	0.225	0.550
5% Decrease	0.300	0.300	0.400
5% Increase	0.250	0.250	0.500

*Sensitivity adjustment Weight of P_{limit}

Table 11.2: Sensitivity GHG Emissions

GHG emissions	
Normal Level	2.383
10% Decrease	2.515
10% Increase	2.316
5% Decrease	2.494
5% Increase	2.338

* GHG emissions are in Megatonnes

* Emissions with +/- 5 & 10 % P_{idle}, P_{low}, P_{limit}.

12. Discussion

This analysis addresses several variables and incorporates assumptions regarding transportation fuel use and GHG emissions in the city of Winnipeg. The assumptions used appear to be reasonable because cross-checking estimates with other known data yields consistent results.

It is estimated that the total GHG emissions in 2005 are 4.776 Mt in Manitoba.[4] Based on the transportation fuel levels in Winnipeg the total GHG emissions in Winnipeg are 2.383 Mt. The breakdown of GHG between Winnipeg and the rural areas of the province was divided evenly. However when looking at the sensitivity analysis the lowering of the P_{limit} is a better reflection of actually GHG emissions within the city. With a 10% decrease to P_{limit} it is found that 2.515 Mt of GHG emissions where produced. The breakdown of GHG emissions between Winnipeg and rural areas is 53% produced in Winnipeg and 47% produced in rural Manitoba.

Since 70% of gasoline is used by light duty passenger vehicles, this is the segment where efficiency gains and trip and congestion reduction strategies can produce the largest potential reductions in emissions.

The findings in the report point to idling and slow speed in heavy traffic as the principle factors that greatly increase GHG emissions. An effective way to reduce GHG emissions within Winnipeg would be to improved traffic flow, which has the added benefit of reducing congestion and the costs associated with that. With reduced congestion vehicles will be operating at higher efficiency rate for a larger period of time thereby reducing their emissions.

There are numerous strategies to reduce congestion from building new infrastructure, to coordinating lights and removing or redesigning traffic bottlenecks, most of which involve significant expense. Over the longer term the best strategy is to reduce the number of cars using the roads by creating disincentives for vehicle use, particularly unnecessary trips and low occupancy, and by providing incentives for fully fledged alternatives to private vehicle use.

Such alternatives include safe routes and facilities for walking and cycling, well priced and timely transit that has a full range of quality service features such as real time transit information. Certainly the WinSmart project features such approaches and it becomes critical to monitor the impacts of the various initiatives by analysing changes in vehicle counts, ridership and user attitudes.

Such data collection is presumably part of the WinSmart initiative and we re-iterate that base-lining such information becomes critical to measuring the success of the project and tracking improvements or changes.

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[4] Environment Canada, 2007.

13. Suggestions for the Future

Fuel data for the City of Winnipeg was not available for use in calculation emissions and this complicated and challenged the analysis. A collection of fuel data for the City of Winnipeg, both on and off-road sales would be useful for tracking emissions.

As well vehicle-kilometres-travelled (VKT) could be obtained by MPI each time a registered vehicle owner renews his/her insurance. This would help in converting the VKTs into fuel used and in turn into GHG emissions.

Sample of vehicles of all classes within Winnipeg could be conducted and tracked as to find a more accurate speed data, trip data, and duty cycle. **These types of data collection should be considered a priority for the Pembina corridor as such data is incomplete and will be essential for base-lining improvements from the WinSmart initiative.** This should be considered a key part of tracking improvements in sustainable transportation pilot projects.

The report should be updated yearly or when updated data relating to the variables and assumptions within the report become available.

A regional study of GHG emissions which would include different corridors within the city should be done.

The city should consider a range of incentives and disincentives to stimulate and encourage sustainable transportation resulting in the reduction of GHG emissions

In the future it will be necessary to account for ethanol and bio-diesel fuel in the fuel use mix, as well as the use of electric and other alternative fuel vehicles. This will become especially pertinent, provincially and city-wide, when biofuel market penetration increases and if ethanol and biodiesel are mandated into the fuel mix. While the emissions from biofuels are technically carbon neutral they include upstream emissions from biofuel production which can be closely equivalent to fossil fuels. Biofuel tracking, in concert with collection of gasoline and diesel sales will provide a knowledge base for understanding fuel use and developing policies and strategies for improving climate change emissions, criteria pollutants and for lowering the relative dependence of Winnipeggers on fossil fuels.

14. Sources/References

-City of Winnipeg

- Alec Stuart
  - astuart@winnipeg.ca
    - City Fleet data (vehicle makes, weight)
    - Traffic Flow (VKT numbers, maps)

-MPI

- Jamie Thould
  - JThould@mpi.mb.ca
    - Vehicle Counts for Territory 1 to 5
    - Commuter counts

-Transport Canada

- David MacIsaac
  - macisad@tc.gc.ca
- Alain Paquet
  - PAQUETA@tc.gc.ca
- Urban Transportation Emissions Calculator
  - http://www.tc.gc.ca/programs/environment/UTEC/Default.aspx
    - Fuel Efficiencies (GHG Urban Calculator)
    - GHG Rates (GHG Urban Calculator)
- TC Website
  - Fuel Conversion Table
  - Transportation in Canada Annual Reports

-Statistics Canada

- Population Figures for Winnipeg and Capital Region
- Manitoba Motor Vehicle Registrations
- Canadian Vehicle Survey Annual 2005 (revised)

-Natural Resources Canada – Office of Energy Efficiency Web Site

- MB GHG database

15. Appendices

Appendix A: Classification of Vehicles

The vehicles needed to be classified into one of the 5 categories specified by the GHG UTEC from Transport Canada (Which uses the Mobile6.2C Table) in order to properly make use of their emission rates.
The total vehicles registered in Winnipeg (and commuting to Winnipeg) were given to us by Manitoba Public Insurance Corporation (MPI).

MPI classified its vehicles as follows:

- **Passenger Vehicles:**
  A1 - Passenger Car
  P4 - Public Service Vehicle
  X2 - Livery (TA) (City)
  X3 - Limousine
  X4 - Livery (HTA) (Country)
  A5 1 - Passenger Trucks (trucks under 4.5 tonnes)

- **Trucks:**
  A5 2 - Between 4,541 and 16,330 kg
  A5 3 - Greater Than 16,330 kg
  A6 1 - Agricultural Trucks <= 4,540
  A6 2 - Agricultural Trucks between 4,541 and 16,330 kg
  A6 3 - Agricultural Trucks Greater Than 16,330 kg
  C1 1 - Commercial Trucks <= 4,540
  C1 2 - Commercial Trucks between 4,541 and 16,330 kg
  C1 3 - Commercial Trucks Greater Than 16,330 kg
  P4 - Public Service Trucks

- **Buses:**
  A1 - <=20 passengers
  A1 - 21-35 passengers
  A1 - 36-50 passengers
  A1 - >=50 passengers
  P2 - Public Service <=20 passengers
  P2 - Public Service 21-35 passengers
  P2 - Public Service 36-50 passengers
  P2 - Public Service >=50 passengers
  X2 - Livery <=20 passengers
  X2 - Livery 21-35 passengers

The Mobile6.2C Table, as well as the Table from TC was used (http://www.tc.gc.ca/programs/environment/UTEC/UserGuideFactors.aspx#1.1 : Exhibit 3 1: Vehicle Classification in order to categorize the vehicles.)
MPI data on registered vehicles was adjusted to fit into the Mobile6 categories, and then these were transformed into one of the five GHG UTEC classes.

Appendix B: Yearly VKT Average

The yearly VKT average for the Light Duty Passenger Vehicles – Cars (LDPV-A) and Light Duty Passenger Vehicles – Trucks (LDPV-T) was taken from Transport Canada's, Transportation in Canada Annual Report 2005. In the report it was found that LDPV-A and LCDV-T both had yearly VKT averages of 14,500 kms. The yearly VKT average for Light Duty Commercial Vehicles (LDCV) and Heavy Duty Commercial Vehicles (HDCV) were taken from the average yearly VKT of the City of Winnipeg fleet. The average for the City of Winnipeg fleet was 23,000 km for both LDCV and HDCV. The BUS yearly VKT average was taken from City of Winnipeg Transit web site. It was found that the yearly VKT average for BUS vehicles was 47,000 km.

Appendix C: Gasoline and Diesel Vehicle Breakdown Method

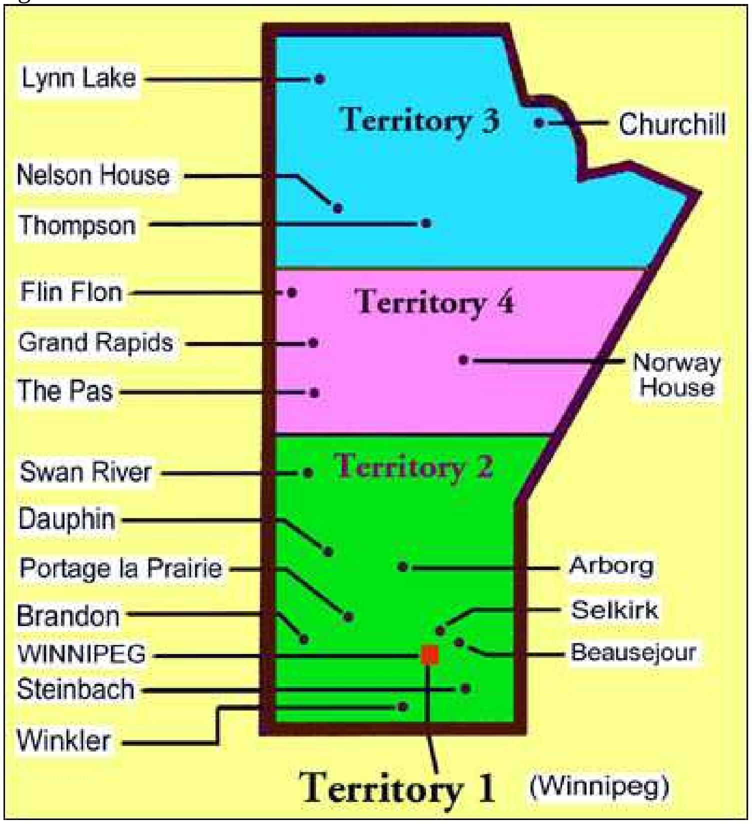
Natural Resources Canada– Office for Energy Efficiency's, Comprehensive Energy Use Database provides a breakdown of gasoline and diesel emissions by vehicle class. In the data base GHG emissions for all the vehicle classes and fuel type were looked at and a percentage of gasoline and diesel GHG emissions were found for each class.

Table 15.1: Vehicle Fuel Percentages: Gasoline And Diesel

Vehicle Class	Subclass	Gasoline	Diesel
LDPV-A		99%	1%
LDPV-T		96%	4%
LDCV		93%	7%
HDCV			
	Medium	72%	28%
	Heavy	0%	100%
BUS			
	Urban	0%	100%
	Public	20%	80%

Winnipeg - Defined as Territory 1 as stated by MPI: (including Headingly, St. Norbert, East and West St. Paul)

Figure 15.1: Manitoba Public Insurance: Territories



*Source: Manitoba Public Insurance

Appendix D: Sensitivity Analysis

GHG emissions for all Weights and Vehicle Classes

Table 15.21: 10% Increase P_{limit}

	CO2e Emissions (g)		
	Gasoline	**Diesel**	
LDPV-A	1,491,080,263,904.00	15,376,255,419.00	
LDPV-T	274,551,878,628.00	10,516,195,221.00	
LDCV	94,867,759,872.00	6,429,860,262.00	
HDCV	65,803,227,840.00	241,382,383,107.00	
BUS	-	116,448,321,567.00	**Total Gas & Diesel**
Total	**1,926,303,130,244.00**	**390,153,015,576.00**	**2,316,456,145,820.00**

Table 15.22: 10% Decrease P_{limit}

	CO2e Emissions (g)		
	Gasoline	**Diesel**	
LDPV-A	1,620,044,319,052.00	16,123,866,108.00	
LDPV-T	298,297,967,220.00	11,425,744,050.00	
LDCV	103,183,989,588.00	6,985,980,078.00	
HDCV	71,157,464,532.00	262,067,845,323.00	
BUS	-	126,405,307,020.00	**Total Gas & Diesel**
Total	**2,092,683,740,392.00**	**423,008,742,579.00**	**2,515,692,482,971.00**

Table 15.23: 5% Increase P_{limit}

	CO2e Emissions (g)		
	Gasoline	**Diesel**	
LDPV-A	1,492,146,082,685.00	15,202,086,732.00	
LDPV-T	274,748,125,752.00	10,523,711,184.00	
LDCV	95,037,884,676.00	6,434,457,540.00	
HDCV	65,888,757,648.00	262,067,845,323.00	
BUS	-	116,362,747,044.00	**Total Gas & Diesel**
Total	**1,927,820,850,761.00**	**410,590,847,823.00**	**2,338,411,698,584.00**

Table 15.24: 5% Decrease P_{limit}

	CO2e Emissions (g)		
	Gasoline	**Diesel**	
LDPV-A	1,492,146,082,685.00	15,202,086,732.00	
LDPV-T	274,748,125,752.00	10,523,711,184.00	
LDCV	95,037,884,676.00	6,434,457,540.00	
HDCV	65,888,757,648.00	262,067,845,323.00	
BUS	-	116,362,747,044.00	**Total Gas & Diesel**
Total	**1,927,820,850,761.00**	**410,590,847,823.00**	**2,338,411,698,584.00**

Appendix E: Equations

$$\text{Total Fuel Used (L/year)} = \sum_{i=1}^{5} \left(A_i \times B_i \times \begin{Bmatrix} P_{idle} \\ P_{low} \\ P_{limit} \end{Bmatrix} \times \begin{Bmatrix} F_{idle} \\ F_{low} \\ F_{limit} \end{Bmatrix} \right)$$

Where i = Classes 1, 2, 3, 4, 5.

Class 1 = LDPV-A
Class 2 = LDPV-T
Class 3 = LDCV
Class 4 = HDCV
Class 5 = BUS

A_i = Number of vehicles in class i
B_i = Annual VKT of class i (km/year)
P_{idle}, P_{low}, P_{limit} are the weighting factors for idling, driving at lower than the speed limit and driving at the posted speed limit (where $\sum$ P's = 1).
F_{idle}, F_{low}, F_{limit} are the fuel efficiencies for idling, driving at lower than the speed limit and driving at the posted speed limit (L/km)