Secondary Benefits of GHG Regulations for Toxic Air Pollutants

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Abstract. In 2010, Canada introduced the Passenger Automobile and Light Truck Greenhouse Gas Emissions Regulations, aligning with similar U.S. standards. In 2011, the U.S. EPA announced new standards to reduce GHG's from heavy-duty trucks and buses, and Canada followed with its Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations in 2012. These new standards will affect not only GHG emissions from the on-road fleet, but also emissions of various toxic air pollutants, such as oxides of nitrogen, respirable particulate matter and various hydrocarbons.

The toxic pollutants have direct implications on the quality of the air we breathe, human health and the health of the environment. In order to understand how fuel efficiency standards for light and heavy duty vehicles will affect air quality, it is first necessary to understand the overall effect that vehicle emissions have on the toxic pollutants. An overview of vehicle emissions and air quality is provided, based on the authors' three decades of involvement in the assessment of traffic-related air quality and its implications.

INTRODUCTION

The road transportation sector is a significant source of greenhouse gas (GHG) emissions and air pollutants. For example, road transportation accounts for approximately 20% of Canada's GHG emissions (Environment Canada, 2012a). It accounts for 16% of Canada's emissions and 25% of Ontario's emissions of oxides of nitrogen (NO_X), an important pollutant for both local and regional air quality (Environment Canada, 2012a; Government of Ontario, 2013). This paper looks at the scale and magnitude of the effects that vehicle emissions have on air quality and health, and at how regulations are affecting the emissions, including recent regulations dealing with greenhouse gas emissions from vehicles.

RECENT TRENDS

Vehicle traffic continues to grow in Canada. In Ontario, for example, the total amount of road travel increased from about 72 billion kilometres to 129 billion kilometres between 1987 and 2010 (Ontario Ministry of Transportation, 2011). In spite of this growth in traffic, the levels of traffic-related pollutants have been decreasing rather than increasing. In Ontario, the average concentration of nitrogen dioxide (NO_2) in the outside air declined by approximately 40% from 2001 to 2010 (Government of Ontario, 2013). A similar trend can be seen for carbon monoxide, fine particulate matter and sulphur dioxide, which are three other key pollutants that have been routinely monitored. The estimated provincial NO_X emissions from road vehicles decreased by

50% over the same time period (Figure 1) – a period when annual road travel grew by 12%, from 116 billion to 130 billion kilometres (Figure 2).

Figure 1 – Trend in Ontario's NO_X Emissions (Government of Ontario, 2013)

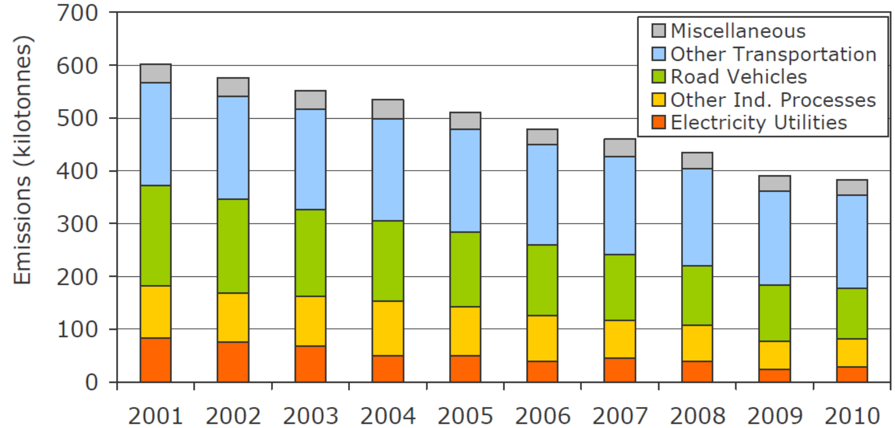
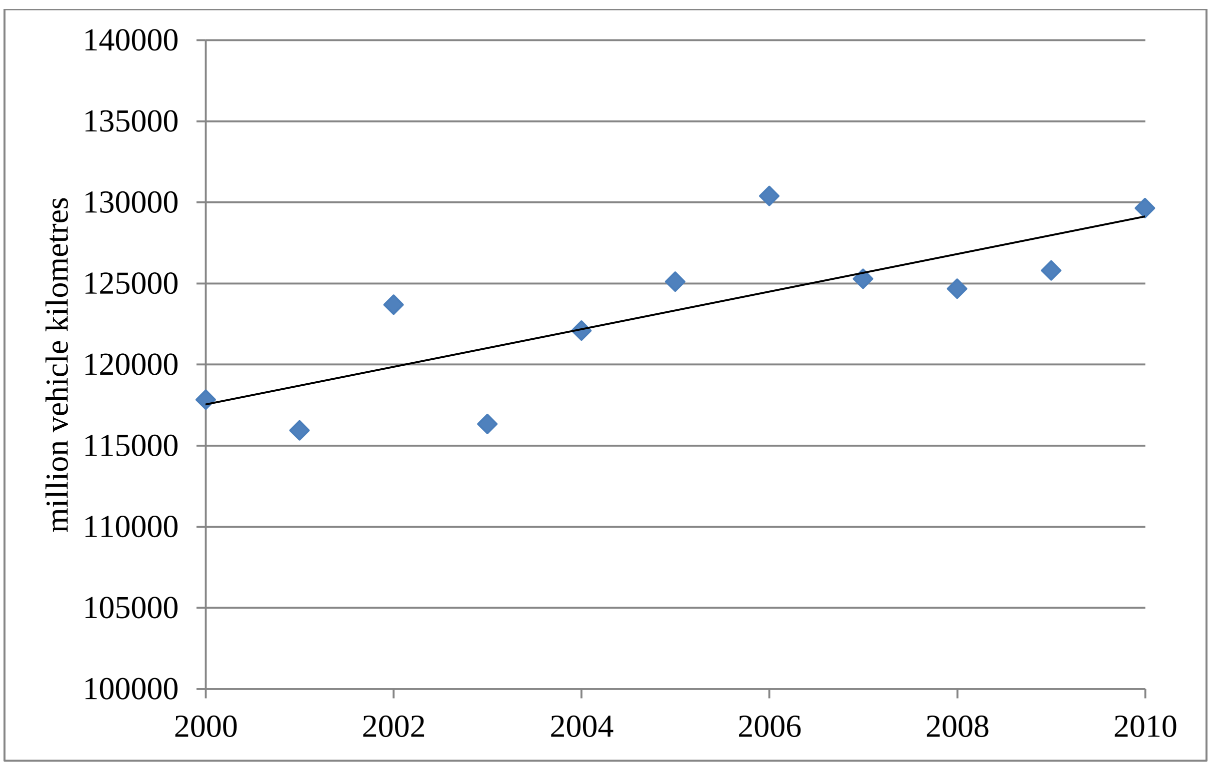


Figure 2 – Trend in Road Vehicle Travel in Ontario (Ontario Ministry of Transportation, 2011)



The decreasing trend in air pollutants is thanks in a large part to the ongoing effect of Federal regulations dealing with motor vehicle exhaust emissions. Canada's On-Road Vehicle and Engine Emission Regulations came into effect in 2004, replacing earlier regulations. At that time, the regulation was projected to achieve a 73% reduction in average NO_X emissions from road vehicles by the year 2020, with significant reductions in other pollutants as well (Government of Canada, 2003). The observed decline in concentrations of NO_2 and other pollutants shows that this and other regulations are more than compensating for the growth in traffic.

More recently, the Federal government set its sights on greenhouse gas emissions from vehicles, introducing the Passenger Automobile and Light Truck Greenhouse Gas Emission Regulations in 2010, and the Heavy-Duty Vehicle and Engine Greenhouse Gas Emission Regulations in 2012. The 2010 regulations targets an average fuel consumption rate of 6.7 L/100 km by the 2016 model, which is about a 22% reduction from the 2011 on-road average fuel consumption of 8.6 L/100 km in Canada. The regulation for heavy duty vehicles targets 10-20% reductions in fuel consumption by the 2018 model year, depending on the vehicle category (U.S. EPA, 2011). Not only will these regulations reduce GHG emissions, but they will also affect toxic air pollutants in the vehicle exhausts, since the emissions of these pollutants are related to fuel consumption.

TRANSPORTATION CORRIDORS AND LOCAL AIR QUALITY

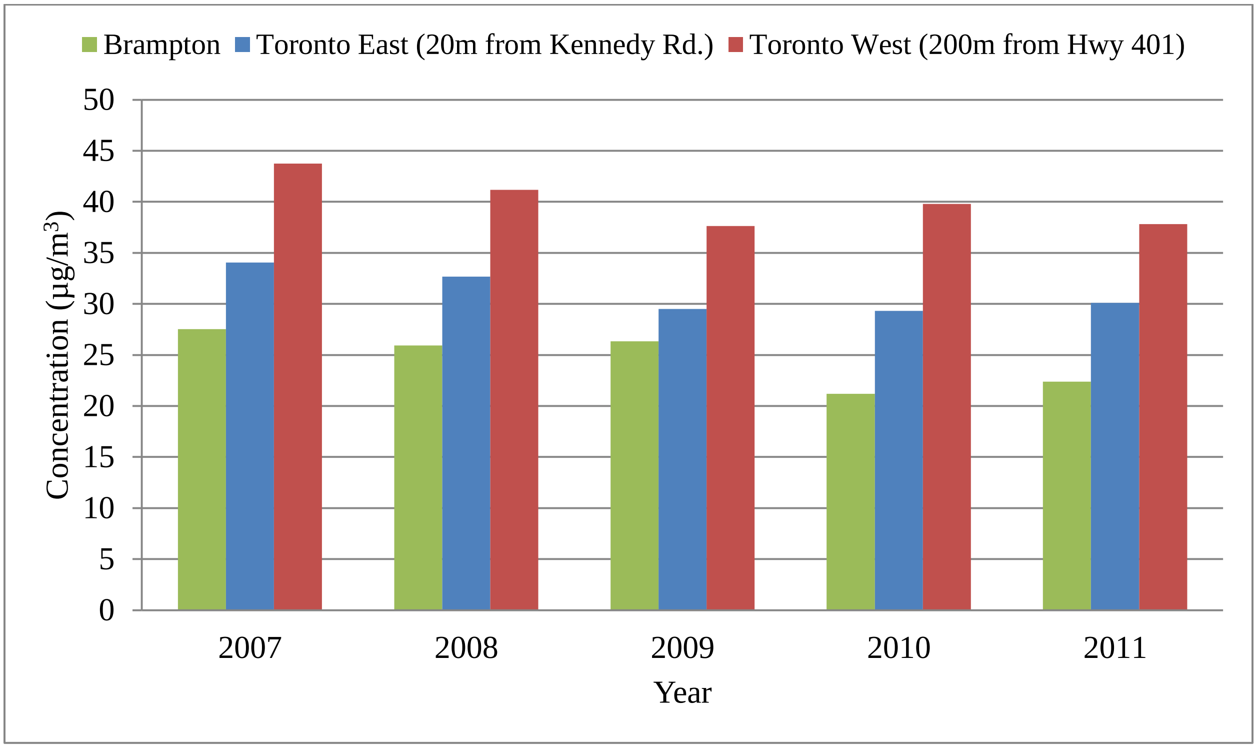
Vehicle emissions have implications for regional air quality in urban areas, affecting region-wide levels of certain pollutants during smog events, including fine particulate matter and ground-level ozone. They also have implications for the local air quality experienced daily by populations living near major roadways. Here we focus on the latter, a topic of growing interest in recent years.

Many investigations of health effects in populations living near major arteries have been conducted throughout the world over the past two decades. Increased odds of various respiratory and cardiovascular effects have been identified for people living or spending substantial time near highways, ranging from reduced lung function to asthma, bronchitis, lung cancer and cardio pulmonary mortality (Brugge et al., 2007). In general, the effects are found to be localized. Studies have found increased odds of pulmonary disease, increased hospitalization due to asthma and higher risk of stroke mortality for populations living within 100-200m of main roads (Schikowksi, et al., 2005; Maheswaran and Elliot, 2003; Lin et al., 2000). Other studies have found effects to lung function in children living within 300-500m from highways (Van Vliet et al., 1997; Gauderman et al., 2007).

These findings are consistent with recent near-roadway measurements of vehicle-related air pollutants, which show the levels of most of these pollutants decrease rapidly with distance from the roadside, decaying to background levels within 115 to 570m from the road edge (Lurmann et al., 2013).

Figure 3 illustrates a Canadian example of the relationship between pollutant levels and proximity to roadways. Ambient air quality data are provided from three urban monitoring stations in the Greater Toronto Area. The Brampton monitoring station is well removed from large roadways and can be thought of as an urban background site. The Toronto East site is 20m away from Kennedy Road, near Lawrence Avenue – two busy arterial roads. The Toronto West site is 200m from Highway 401 near Islington Avenue – the busiest stretch of highway in Canada with an AADT of over 400,000. The measured NO_2 Concentrations near Highway 401 were 40% to 90% higher than at the Brampton site, and those near Kennedy Road lie in between.

Figure 3 - Annual Mean Concentrations of NO_2 Measured at Ontario Ministry of Environment Monitoring Sites



The present authors have engaged in numerous computer simulations of air quality near major roadways in Ontario over the past three decades. Examples of model results for NO_2 from several of those studies are shown in Figure 4. A U.S. EPA model known as MOVES was used to estimate the on-road fleet emission characteristics, and a computer dispersion model known as CAL3QHCR was used to predict off-site concentrations as a function of meteorology and distance from the roadway.

The model results in Figure 4 are very similar in magnitude to those in Figure 3, which were based on field measurements. The model results, however, show more clearly the relationships between NO_2 levels and distance from the roadway as well as traffic volume. These data suggest that vehicle-related pollutants decay to near background levels (approximately 27 $\mu g/m^3$) within 150 to 500m of the roadway edge, similar to the range of distances cited by Lurmann et al. (2013), with the actual distance depending on the traffic volume. The shorter distance of 150m applies to lower traffic arterial roads (AADT of about 26,000) and the distance of 500m applying to a super highway (AADT > 400,000).

Figure 4 also shows that, for the busier roadways, the predicted annual mean NO_2 concentrations are in excess of the World Health Organization (WHO) guideline (40 µg/m^3) within distances ranging from 100 to 300m from the roadway edge.

Figure 4 – Modelled Annual Mean NO_2 Concentrations for Various Roadways, Based on Present-Day Fleet Emission Characteristics

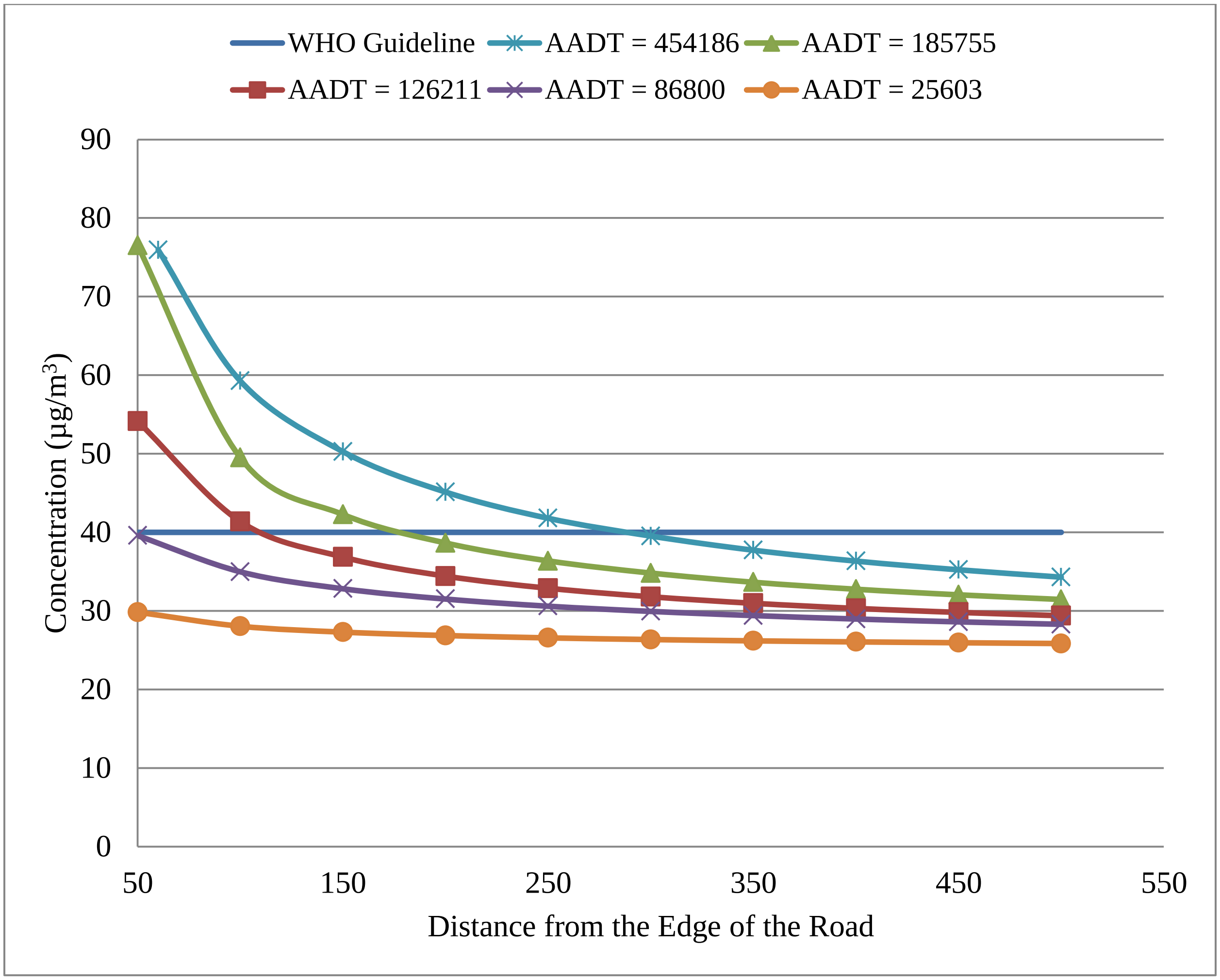
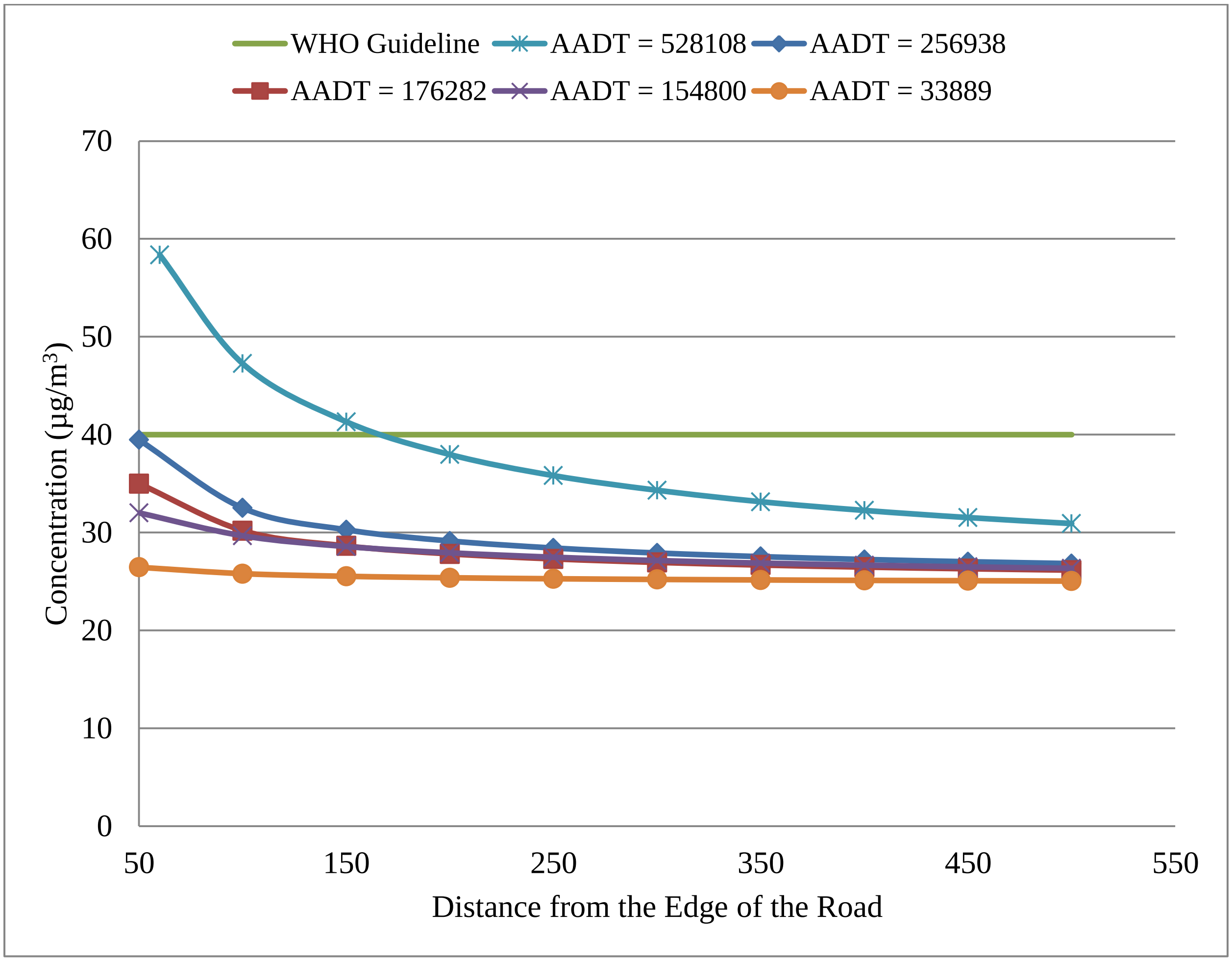


Figure 5 shows the same plot as Figure 4, but projected to the year 2031, taking into account traffic growth and the ongoing effect of the On-Road Vehicle and Engine Emission Regulations, but not accounting for the more recent greenhouse gas emission regulations. Figure 5 also does not account for any change in background levels of NO_2 between now and 2031 (they are likely to decline somewhat into the future due to the ongoing effect of vehicle emission regulations).

By 2031, the predicted annual NO_2 levels are significantly reduced compared to the present day values, and are within the WHO guideline beyond 50m from the roadway edge for all roadways except the super highway, where the levels fall below the guideline at a distance of about 160m. The recent greenhouse gas regulations will have an additional effect that further reduces the levels.

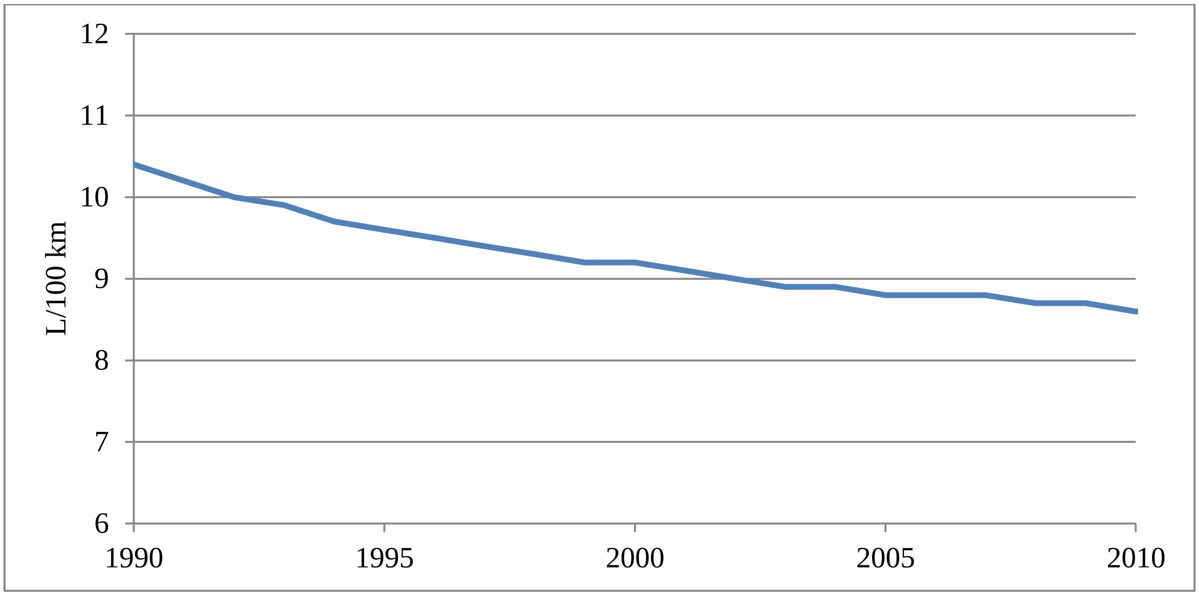
Figure 5 - Modelled Annual Mean NO_2 Concentrations for Various Roadways, Based on 2031 Fleet Emission Characteristics



IMPACT OF GREENHOUSE GAS REGULATIONS

Like the exhaust pollutants, fuel consumption and GHG emissions from the average vehicle have been declining. However, Figure 6 shows that, across Canada, fuel consumption declined by about 7% from 2000 to 2010; whereas, the amount of vehicle travel in Ontario has increased by 12%, as shown previously in Figure 2. Thus, the decline in average fuel consumption has not offset the growth in traffic and overall GHG emissions from road vehicles have not been reduced.

Figure 6 – Car On-Road Average Fuel Consumption in Canada (Natural Resources Canada, 2012)



The Federal government's recently introduced Passenger Automobile and Light Track Greenhouse Gas Regulations mandate an eventual further reduction in average car fuel consumption to 6.7 L/100 km, as already mentioned, which is 22% lower than the 2011 on-road average and 46% lower than the 1990 average. The 2016 new vehicle fleet will need to achieve this average level of fuel consumption, but it will be many years later before older vehicle models go out of service. As result, the on-road average fuel consumption probably will not fall to 6.7 L/100 km until sometime between 2020 and 2030. If the annual amount of vehicle travel continues to grow as it has in the past, it will grow by 15-20% over that time period. Since reduced fuel consumption makes travel more economical, the regulations themselves may, in fact, stimulate a further increases in vehicle travel. As a result, the new legislation may only slightly more than offset the effect of traffic growth. Overall GHG emissions from road vehicles will decrease only slightly from present day levels, if at all.

The legislation will also affect toxic exhaust pollutants, such as NO_X, carbon monoxide and hydrocarbons. Assuming that these emissions will have a roughly linear relationship with fuel consumption, then the GHG legislation will have a similar impact to that on GHG emissions, i.e., slightly more than offseting the effects of traffic growth. That effect will be over and above the ongoing effect of the 2004 On-Road Engine and Vehicle Emissions Regulations that can be seen in the comparison of Figure 4 to Figure 5. Overall, we conclude that the recent GHG regulations will result in no more than a slight further improvement in toxic pollutant emissions, compared to the significant ongoing improvement expected from the On-Road Engine and Vehicle Emissions Regulations.

CONCLUSION

Numerous studies have found an increased risk of various health effects for populations living within a few hundred metres of major roadways and this has been the subject of growing concern. Consistent with these findings, the present authors and other researchers have found that concentrations of vehicle exhaust pollutants drop off rapidly with distance from the roadway edge, and are indistinguishable from background levels beyond distances on the order of a few hundred metres (varying according to the traffic volume).

The Federal government regulations dealing with toxic vehicle exhaust pollutants are resulting in continued significant decreases in these pollutants, despite the fact that the overall amount of vehicle travel grows yearly. The recently introduced greenhouse gas regulations for light-duty and heavy-duty road vehicles may be slightly more than enough to offset further growth in vehicle travel in the coming years, contributing a slight net benefit to GHG emissions. It may also contribute a further benefit to toxic pollutant emissions, over and above the significant ongoing improvement in toxic pollutants expected from the 2004 On-Road Engine and Vehicle Emissions Regulations, but the effect will be very slight.

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