NEW GENERATION WIDE BASE SINGLE (NGWBS) TIRES STUDY

COST-BENEFIT ANALYSIS OF THE REMOVAL OF THE WEIGHT LIMITATION FOR NGWBS TIRES

FINAL REPORT

WSP

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FINAL REPORT

Project nº: 141-21595-00
Date: SEPTEMBER 2015

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EXECUTIVE SUMMARY

In 2014, Michelin North America contracted WSP to conduct a cost-benefits analysis (CBA) in order to evaluate the impacts of the elimination of the weight limitation for new generation wide base single (NGWBS) tires. The CBA was conducted for the provinces of Newfoundland and Labrador, Prince Edward Island, Nova Scotia, New Brunswick, Manitoba, Saskatchewan, Alberta and British Columbia. The aim of this report is to present the parameters used and the results of the CBA.

The following items were considered in the cost-benefit analysis:

- → Additional pavement damage under two different assessment scenarios
- → Reduction in fuel consumption
- → Differences in retread costs
- → Cost to neutralize emissions
- → Savings on vehicle maintenance
- → Reduction in injuries and fatalities
- → Differences in disposal costs

This study is based on a 20-year analysis and covers the years 2014-2033. All of the amounts in this study are expressed in 2014 Canadian dollars unless otherwise specified. For this study, an 8% discount rate was used as recommended by the Treasury Board of Canada (2007) guidelines for cost-benefit analysis.

The cost-benefit analysis on the elimination of the weight limitations for NGWBS tires is positive for both costs scenarios. Overall, the benefits offset the costs in every scenario analysed. Table 1summarizes the results for the provinces under the scope of work.

This analysis demonstrates that the elimination of the weight limitations for NGWBS tires could lead to an increase in economic competiveness through lower fuel consumption and lower maintenance costs. It also benefits the society through a significant reduction in greenhouse gas emissions, pollutants and a decrease in road fatalities and injuries. Table 2 presents the impacts of the elimination of the weight limitation for NGWBS tires.

The results are consistent with the results that have been published in previous studies for the Government of Quebec and the Government of Ontario. Overall, the benefits offset the costs in every scenario analysed.

Table 1 Summary of the CBA results

Province / M$ 2014 disc. 8%	Cost scenario	NL	PEI	NS	NB	MB	SK	AB	BC	TOTAL
Cost scenarios	A	4.7	0.9	11.4	3.1	57.9	52.2	237	40.6	**407.8**
	B	3.1	0.5	7.4	1.9	24.9	16.7	65	10.8	**130.3**
Benefits (M$):										
Fuel savings		8.6	1.6	19.6	5.4	67.6	60.9	277	44.6	**485.3**
Reduction in vehicle emissions		1.2	0.2	3	0.8	9.2	8.3	37.7	6.5	**66.9**
Reduction in accidents		0.3	0.1	0.9	0.3	3.2	3.9	10.1	2.7	**21.5**
Saving on maintenance		0.8	0.1	2	0.5	5.5	5	22.7	3.9	**40.5**
Reduction in environmental fees		0.1	0.2	0.3	0.1	0.7	0.6	2.8	0.5	**5.3**
Retread costs		0	-0.1	-1	-0.3	-3.5	-3.1	-14.1	-2.4	**-24.5**
Total benefits:		**11**	**2.1**	**24.6**	**6.9**	**82.7**	**75.6**	**336.2**	**55.8**	**594.9**
NPV (M$)	A	6.3	1.1	13.3	3.8	24.8	23.5	99.1	15.1	**187**
NPV (M$)	B	7.9	1.4	17.2	4.9	57.8	59	271.1	44.9	**464.2**
B/C ratio	A	2.4	2.2	2.2	2.2	1.4	1.5	1.4	1.4	**1.5**
B/C ratio	B	3.6	3.7	3.3	3.5	3.3	4.5	5.2	5.2	**4.6**

Table 2 Summary of the impacts of the elimination of the NGWBS tires weight limitation

CATEGORY	NL	PEI	NS	NB	MB	SK	AB	BC	TOTAL
Fuel savings (Litres)	▼14.8M	▼2.8M	▼35.9M	▼9.7M	▼111.5M	▼101M	▼457M	▼78M	▼811M
Fatality accident (Number)	▼0.064	▼0.015	▼0.185	▼0.084	▼0.586	▼0.94	▼2.2	▼0.576	▼5
Injury accidents (Number)	▼ 4.74	▼ 1.04	▼ 12.8	▼ 3.1	▼ 12.8	▼ 36.7	▼ 116	▼ 33.1	▼ 220
Maintenance (Hours)	▼115.8K	▼22.0K	▼280.8K	▼75.0K	▼847.8K	▼764.8K	▼3.4M	▼594.2K	▼6.1M
Tire environmental fee ($, disc)	▼$79.0K	▼$18.8K	▼$287.0K	▼$287K	▼$ 691K	▼$624K	▼$2.8M	▼$ 484.5K	▼$ 5.3M
Retread of tires costs ($, disc)	▲$15.0K	▲$74.9K	▲$953.0K	▲$953K	▲$3.5M	▲$3.1M	▲$14.1M	▲$2.4M	▲$25M
CO_2 Emissions (Tonnes)	▼ 40.6K	▼ 7.7K	▼ 98.2K	▼ 26.6K	▼ 304.5K	▼ 274.7K	▼ 1.2.M	▼ 213.4K	▼ 2.2M
NO_X emissions (Tonnes)	▼142.8	▼27.1	▼345.2	▼93.4	▼1071	▼965.8	▼4,383	▼750.5	▼7779
VOC (Tonnes)	▼144.3	▼27.4	▼348.8	▼94.4	▼1082	▼975.9	▼4,429	▼758.3	▼7860

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Reference to be cited:

WSP. 2015. *NGWBS TIRES STUDY. Final Report.* Report produced for Michelin Canada. 51 pages.

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1 INTRODUCTION

1.1 BACKGROUND

In 2004, WSP Canada Inc. (WSP) has been given the mandate to conduct a cost-benefit analysis for the province of Quebec. This mandate was given by the Ministry of Transportation and its goal was to calculate the private and social costs and benefits of the elimination of the axle weight limitation for new generation wide base (NGWBS) tires.

The results of this study helped to support the government's decision to maintain or remove the NGWBS tires weight limits. The government proceeded with the elimination of the weight limits for NGWBS tires.

The government of Ontario commissioned Knowles Consultancy Services and Synectics Transportation Consultants to complete a similar study, in 2009. The results of this study were used by the Ontario government in its decision regarding the elimination of the weight limitation in Ontario.

In 2014, Michelin North America contracted WSP to conduct a similar study for the Maritimes and Western provinces. This document will present the parameters used and the results of the cost-benefit analysis for those provinces. This study will focus on NGWBS single tires and exclude old generation super single tires.

1.2 PARAMETERS TO CONSIDER

This study is based on a 20-year analysis and covers the years 2014-2033. All the amounts in this study are expressed in 2014 Canadian dollars unless otherwise specified. For this study, an 8% discount rate was used as recommended by the Treasury Board of Canada (2007) guidelines for cost-benefit analysis.

The following items will be considered in the cost-benefit analysis:

- → Reduction in fuel consumption
- → Differences in retread costs
- → Cost to neutralize emissions
- → Savings on vehicle maintenance
- → Reduction in injuries and fatalities
- → Differences in disposal costs
- → Additional pavement damage under two different assessment scenarios

1.2.1 TOTAL ANNUAL KILOMETRES OF THE HEAVY TRUCKING INDUSTRY

The total annual kilometres of the trucking industry were obtained from Transport Canada via the Canadian Vehicle Survey (2010) and adjusted to 2014. The latest update was completed in 2009. The data has been adjusted using the GDP growth of the trucking industry in each of the provinces.

It is important to keep in mind that these numbers are estimates. Using the growth factor in the trucking industry does not take into account structural changes that could have impacted the origin-destination transportation networks in the provinces.

Table 1.1 Annual Million Vehicle Kilometres (MVeh-km) by the trucking industry in selected provinces

MILLION VEHICLE KILOMETRES, HEAVY TRUCKING INDUSTRY, 2014	10 TONNES TO 15	15 TONNES AND OVER	TOTAL
Maritimes			
Newfoundland and Labrador	12	225	**237**
Prince Edward Island	3	42	**45**
Nova Scotia	53	519	**573**
New Brunswick	17	137	**155**
Western Provinces			
Manitoba	50	1.685	**1.735**
Saskatchewan	172	1.394	**1.565**
Alberta	859	6.243	**7.102**
British Columbia	583	633	**1.216**

Source: Statistics Canada, table 405-0058 – Canadian Vehicle Survey

In order to assess future MVeh-km, a compound annual growth rate (CAGR) of 2.5% equivalent to the long term GDP growth rate was used.

1.2.2 NGWBS TIRE INDUSTRY UPTAKE

The NGWBS tire uptake is below what was used in the previous studies. In the Ontario and Quebec studies, a NGWBS tire uptake of 75% and 100% was used. However, it appears that these percentages, based on consultation with the industry, were too high. The actual uptake of NGWBS tires is around 7%. In order to assess the future NGWBS tires uptake, discussions with provincial associations, such as the AMTA, were completed. The total industry uptake should increase another 17% over the next 20 years to reach 25% in 2034. This estimation is also based on industry uptake projections in the US. Sensitivity analysis using high and low NGWBS tire penetration rates tests the robustness of the CBA. Figure 1.1 presents the industry uptake scenarios.

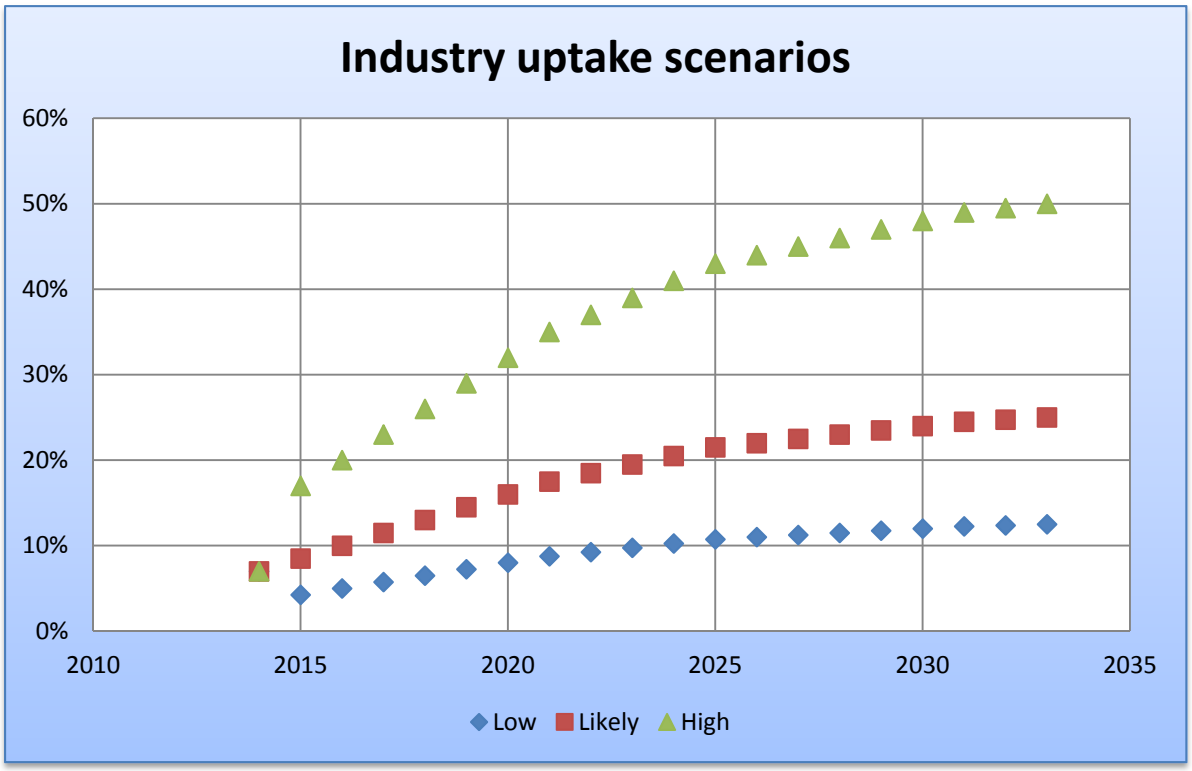


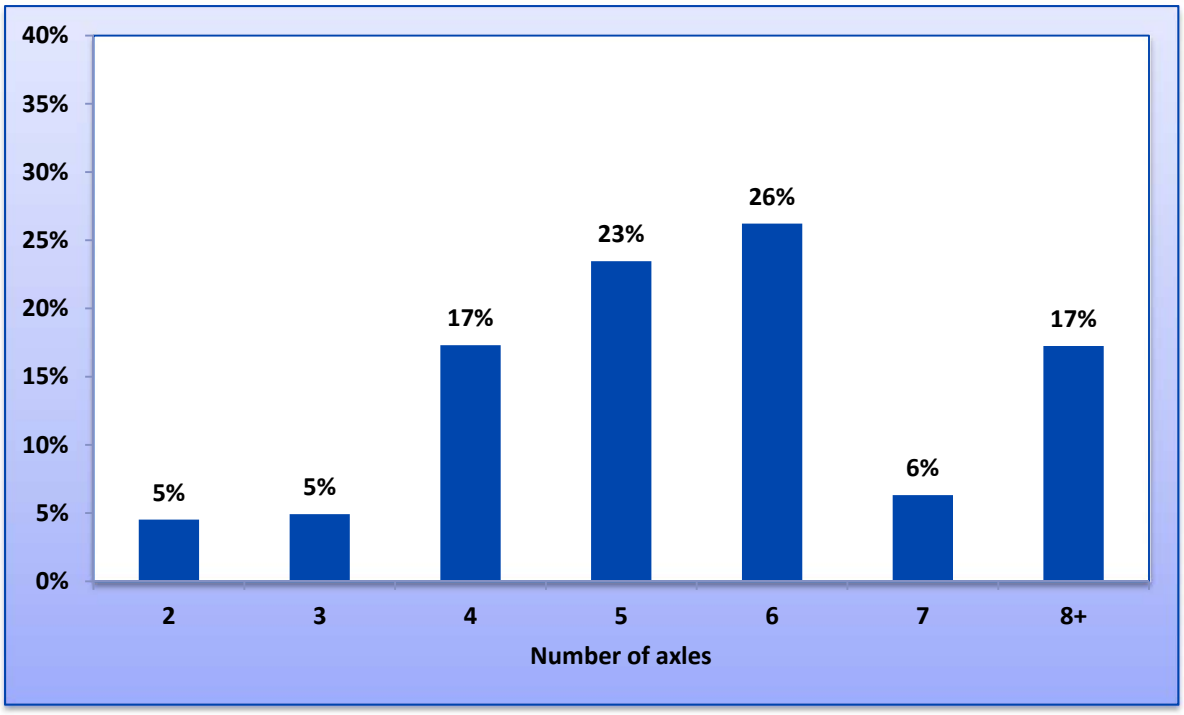
Figure 1.1 Industry uptake scenarios

1.2.3 AXLE CONFIGURATION OF THE HEAVY TRUCKING INDUSTRY

Data for axle configuration in the Western provinces was available for Alberta but it was not possible to obtain specific data configuration for Manitoba, Saskatchewan and British Columbia. Thus, for the Western provinces, the data from Alberta Transportation will be extrapolated to the other provinces and used as a baseline for the study. The data was collected through the six weighing stations in Alberta in 2013.

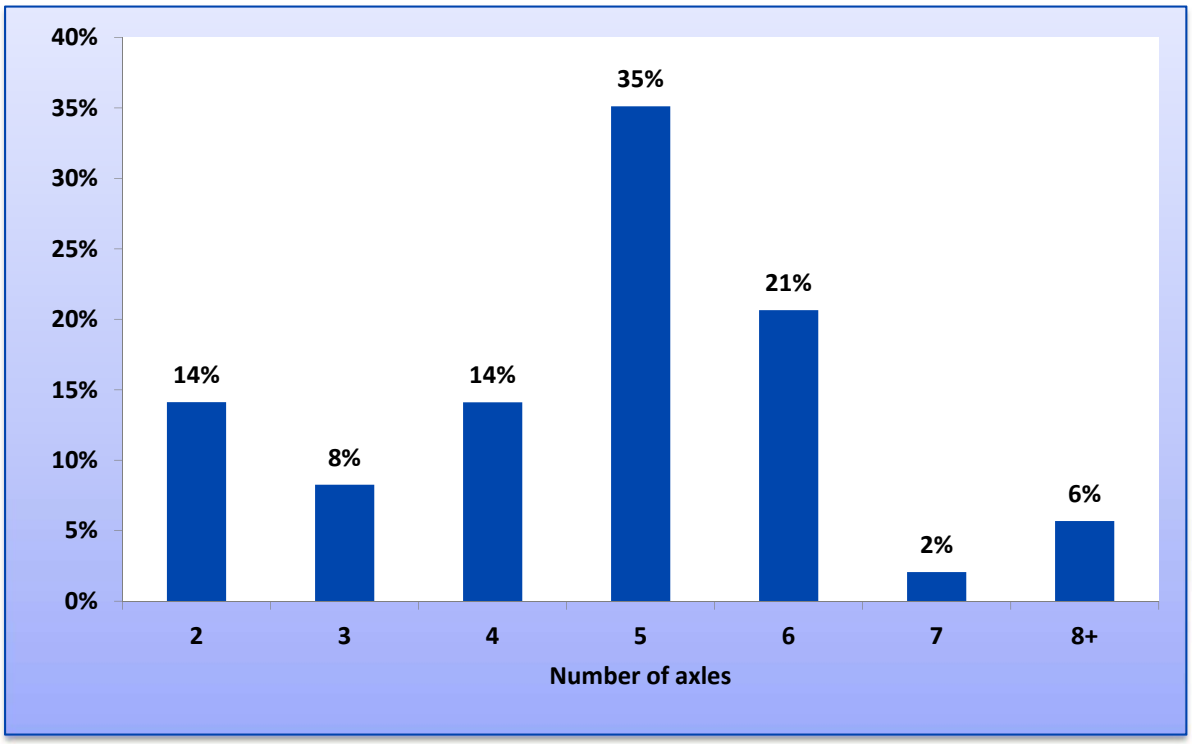
The data has been transmitted to WSP by Alberta Transportation. The calculations were made by WSP. The data contained in the 2014 Canadian Vehicle Survey was used to segregate between 2-axle vehicles that sit in class 6 and 7, weighing between 10 and 15 tonnes and the 2-axle vehicles that weigh less than 10 tonnes.

The results show that vehicles with 4, 5, 6 and 8+ axles account for over 80% of the heavy trucking fleet (Figure 1.2).



Source: Alberta Transportation, Leduc 1, Leduc 2a, Fort Macleod, Edson, Villeneuve and Red Deer weighting stations.

Figure 1.2 Average axle configuration in Alberta



Source: Nova Scotia Transportation, Kelly Lake weighting station

Figure 1.3 Average vehicle configuration at the Kelly Lake Scale in Nova Scotia

In the Eastern provinces, Nova Scotia has transmitted some data regarding the average axle configuration in the province. The data focuses on the average count of vehicles by axle types at the Kelly Lake Scale. The main differences between data from Alberta and those from Nova Scotia are that the percentage of trips by 2-axle vehicles in Nova Scotia is significantly higher than in Alberta, the proportion of 5-axle vehicles are a bit higher, while the proportion of other axle configurations are lower (Figure 1.3). The available configurations of vehicles by axle type in Nova Scotia will be used as a baseline for the Maritimes.

1.2.4 AXLE WEIGHT DISTRIBUTION

Another parameter to consider is the percentage of vehicles rolling with a weight capacity below the NGWBS limit. This parameter is important because it is assumed that vehicles using NGWBS tires rolling below the NGWBS tire limit will cause road damages similar to a vehicle using dual tires.

The other weight factor to consider is the percentage of vehicles travelling with axle weights that are above the NGWBS maximum limit. It is assumed that those vehicles will benefit from the additional weight capacity if they switch to NGWBS tires because of the reduction in their unloaded weight (the single axles being lighter).

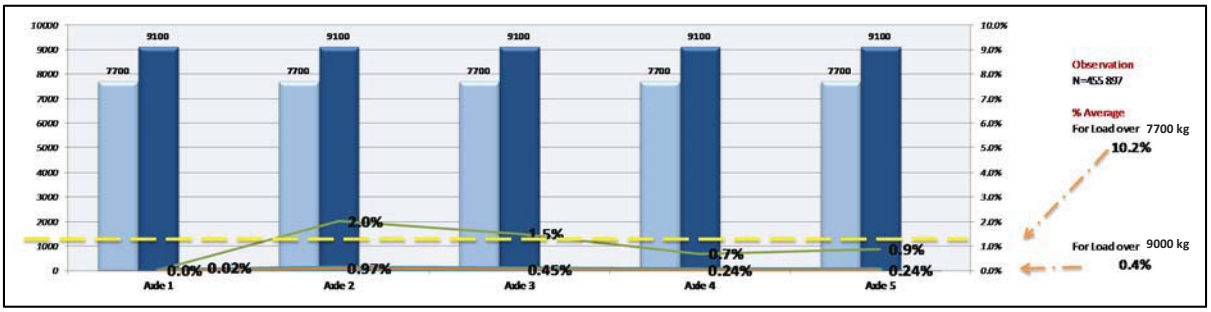
The average weight limits were derived from the Alberta Transport dataset. They consist of the total axle weight for different axle configurations. The data allowed WSP to identify, by axle type, the percentage of the vehicles running under the NGWBS tire limit, under the dual limit and those that were overweight. The findings from the Red Deer weighing station are presented in Table 1.2.

Table 1.2 Average weight distribution by axle configuration

NUMBER OF AXLES	UNDER NGWBS LIMIT (7,700 KG) (%)	OVER NGWBS LIMIT AND UNDER DUAL LIMIT (7,700-9,000) (%)	OVER DUAL LIMIT (%) (9,000 +)
2	93.9	4.0	2.1
3	89.1	9.3	1.6
4	99.2	0.6	0.2
5	90.3	6.3	3.4
6	71.4	21.6	6.9
7	66.0	17.6	16.4
8+	54.3	16.8	28.9

Source: Red Deer weighing station, Lane 1, 2013

This data is in accordance with the results from the New Brunswick Ministry of Transportation. They found that in a sample of 455,897 5-axle vehicle observations at weighing stations, only 10.2% of them were reporting a load over the NGWBS tires limits. Moreover, only 0.4% of the vehicles were reported overloaded (Figure 1.4). Therefore, data from Table 1.2 will be used as a baseline scenario.



Source: Transportation New Brunswick, special compilation

Figure 1.4 % of weight over the US load (7,700 kg per axle for category 9) - 5 axles

1.2.5 FUEL PRICES

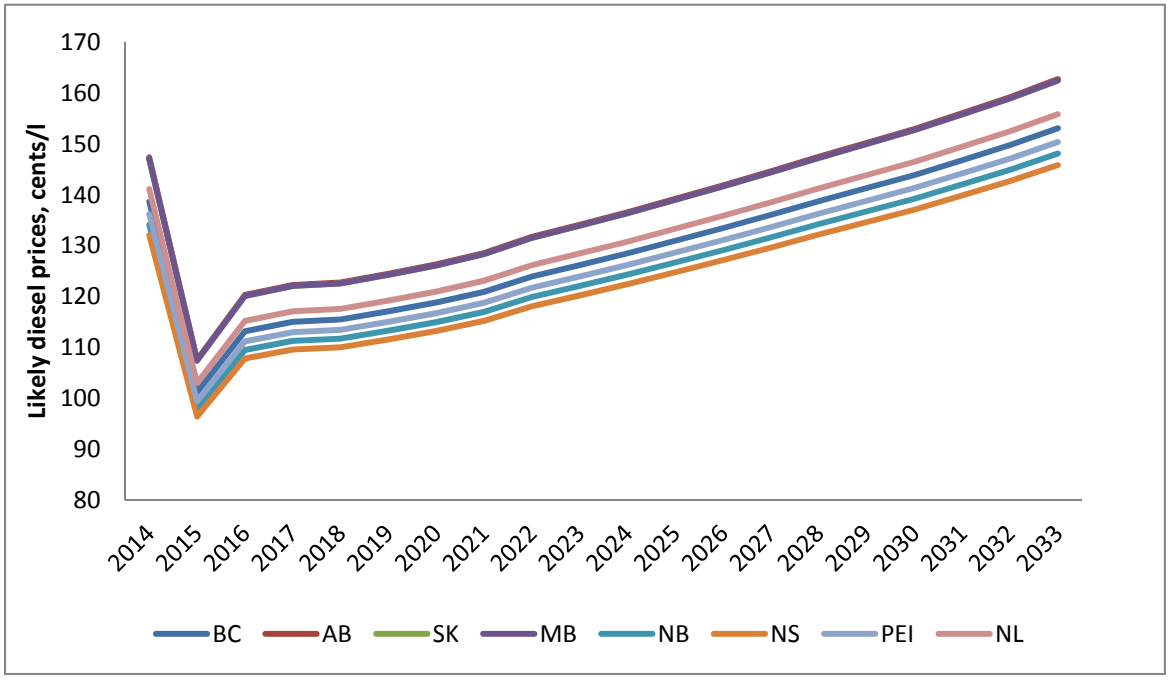
The average retail price for diesel was extracted from Natural Resources Canada database for diesel, in March 2015. This database provides information for weekly retail prices for various cities across Canada, including the amount of taxes. The tax amount was subtracted from the retail prices to be able to use tax exempt prices. Cities' results have been used as proxy for provincial prices.

Table 1.3 Average March 2015 gas prices in selected cities

PROVINCE	TAX EXEMPT DIESEL PRICE, CENTS PER LITRE
BC (average of Victoria and Vancouver)	101.18
AB (average of Calgary and Edmonton)	107.55
SK (average of Regina and Saskatoon)	107.38
MB (Winnipeg)	107.40
NB (Saint John)	97.89
NS (Halifax)	96.40
PEI (Charlottetown)	99.39
NL (Saint John's)	103.01

Source: Natural Resources Canada

In order to estimate the fuel prices over a 20-year period, the annual growth rate for the price of fuel from the Energy Information Administration was applied to the provincial numbers. Figure 1.5 shows the forecast of gas prices in the selected provinces for 2014-2033.



Source: Energy Information Administration, EIA, 2014

Figure 1.5 Tax exempt diesel prices forecast, 2014-2033

1.3 ADDITIONNAL PAVEMENT DAMAGE

The existence of additional pavement damages from the use of NGWBS tires is disputed. Studies focusing on older generation single tires demonstrate that they tend to do more damage than duals. However, the effect on roads of NGWBS tires versus dual tires is disputed. Some studies and stakeholders consider that the NGWBS tires would not cause more road damage than duals while others consider that the damage would not be equivalent.

The study commissioned by the Ontario Ministry of Transportation (MTO) in 2008 to assess the costs and benefits of the elimination of the weight limits for NGWBS tires did not take into account the potential additional road damage that could be caused by the elimination of the limit, regarding them as marginal.

The Florida Department of Transportation (2009) conducted an analysis of the potential damage of the NGWBS single tires versus dual tires. It concluded that “the 455-mm NGWBS performed as well as the dual tire.”

However, the present study will take consideration of the additional road damage caused by NGWBS tires. It will consider two different costs scenarios from the increased use of NGWBS tires. The first scenario is based on the study conducted by the Government of Quebec. The second scenario is based on the United States Department of Transportation (USDOT) University Transportation Center Final Report (2009) that assessed the additional road damages caused by NGWBS tires versus dual tires.

1.3.1 SCENARIO A

Scenario A will assess the additional road damage based on the study conducted by the Ministère des Transports du Québec (MTQ, 2005). This study has estimated additional costs of the elimination of the 10% axle load limitation for NGWBS tires in 2004. This estimation was based on a study conducted by the Direction du Laboratoire des chaussées [Pavement Laboratory Branch] of the MTQ, Phase II (September 2004). The overall results per axle type and millions of vehicle kilometres are found in Table 1.4.

In this study, it is assumed that the heavy vehicles operating under the NGWBS tire limits don't cause additional road damage.

Table 1.4 Additional road damage by axle configuration per million of kilometres

ADDITIONAL DAMAGE $/MVEH-KM	2 AXLES	3 AXLES	4 AXLES	5 AXLES	6 AXLES	7 AXLES	8 AXLES OR MORE
Low	3.071	3.071	3.071	2.505	11.700	18.877	36.491
Likely	4.095	4.095	4.095	3.340	15.600	25.169	48.655
High	5.119	5.119	5.119	4.175	19.500	31.461	60.819

Source: MTQ 2004

In addition, a sensitivity analysis of the additional costs of the use of NGWBS tires will be conducted to compare the low, likely and high costs scenarios with the likely benefits scenarios.

1.3.2 SCENARIO B

Scenario B will use the costs assessment for NGWBS based on the USDOT University Transportation Center Final Report (2009). This scenario is based on the assumption that the NGWBS tires will cause more damage to the roads at any given load.

In scenario B, WSP used the data prescribed by the USDOT (2014) in the completion of cost-benefit analyses as a reference. All costs scenarios were converted to 2014 Canadian dollars.

Road Damage per Veh-km Traveled

According to a study conducted by the Federal Highway Administration (FHWA 2000), on average, a heavy truck will cause $19,980 in road damage per million miles traveled ($12,488 per million km) in an urban environment. In a rural environment, this number falls to $8,890 ($5,556 per million km). The vehicle kilometres data was adjusted based on the urban to rural proportions of each province using the 2011 census.

Table 1.5 Rural vs. urban environment in selected provinces

2011 CENSUS	URBAN (%)	RURAL (%)
Newfoundland and Labrador	59	41
Prince Edward Island	47	53
Nova Scotia	57	43
New Brunswick	53	48
Manitoba	72	28
Saskatchewan	67	33
Alberta	83	17
British Columbia	86	14

Source: Statistics Canada 2011, Census of the population

These numbers translate into a cost per million kilometres traveled presented in the Table 1.6.

Table 1.6 Baseline heavy truck road damage per million vehicle kilometres traveled

BASELINE HEAVY TRUCK DAMAGE	$ PER MVEH-KM
Newfoundland and Labrador	9,646
Prince Edward Island	8,814
Nova Scotia	9,507
New Brunswick	9,285
Manitoba	10,547
Saskatchewan	10,200
Alberta	11,309
British Columbia	11,517

Source: FHWA (2000), WSP

Additional Damage Caused by NGWBS Tires

A 2009 USDOT study, The Pavement Damage Due to Different Tire and Loading Configurations on Secondary Roads, concluded that "in general, the results shows that using the 455 NGWBS tire results in 1.12 (low), 1.25 (likely) and 1.38 (high) more damage compared to the dual-tire assembly and thus greater rehabilitation costs."

Using these numbers, the additional damage caused by NGWBS tires is presented in the Table 1.7.

Table 1.7 Additional damage from the use of NGWBS tires

ADDITIONAL NGWBS DAMAGE $ PER MVEH-KM	LOW	LIKELY	HIGH
Newfoundland and Labrador	1,158	2,412	3,665
Prince Edward Island	1,058	2,204	3,349
Nova Scotia	1,141	2,377	3,613
New Brunswick	1,114	2,321	3,528
Manitoba	1,266	2,637	4,008
Saskatchewan	1,224	2,550	3,876
Alberta	1,357	2,827	4,297
British Columbia	1,382	2,879	4,376

Source: US DOT 2009, WSP 2015

1.4 BENEFITS

1.4.1 DIFFERENCES IN RETREAD COSTS

Two dual tires and one NGWBS tire have a similar initial purchasing cost. However, the duals can be retread twice while the NGWBS tires only once. Over a tire life, considering the number and the costs of retreads, the NGWBS tire has a slight disadvantage when compared to duals. The costs data was obtained from Michelin Canada via their National Client Account Database. The assumptions retained for this study are found in in Table 1.8.

Table 1.8 Assumptions regarding retread and purchase cost

ASSUMPTIONS	DUAL TIRES (BOTH TIRES)	NGWBS TIRES
Longevity (km)	425,000	425,000
Retread	Twice	Once
Purchase cost	1,104	1,115
Retread cost	604	640
Total costs	2,312	1,755
Total number of uses (Initial+retread)	3	2
Average cost per use	771	878

Source: Michelin National Client Account Database, treatment by WSP.

1.4.2 REDUCTION IN FUEL CONSUMPTION

The reduction in fuel consumption is derived from the MTQ study, which surveyed heavy trucking operators to assess the real fuel savings resulting from the uptake of the NGWBS technology.

The use of NGWBS tires can reduce fuel consumption. According to information obtained from Michelin, rolling resistance accounts for 35% of a vehicle's fuel consumption, while aerodynamic resistance accounts for 40% and mechanical factors account for 25%.

When Michelin ran analyses to compare its NGWBS tire with its XDA Energy and XT-1 conventional tires (275/80R22.5), it found that the use of NGWBS can reduce a vehicle's rolling resistance by about 12% and thus reduce its fuel consumption by about 4%.

This impact of super single tires on fuel consumption also emerged from our 2004 survey of Québec trucking firms that use them. Six of the seven firms questioned in the survey stated that they had observed reductions in fuel consumption ranging from 3.5% to 12%.

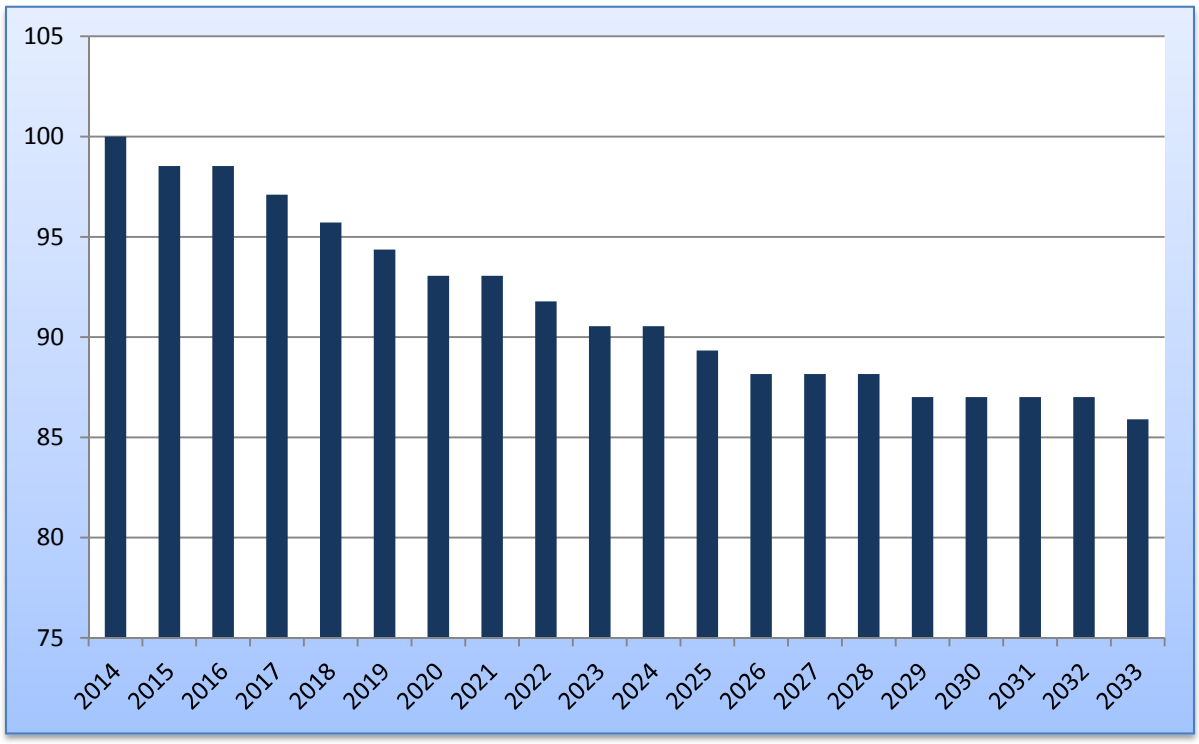
For the purposes of this analysis, we have used the average percentage reduction in fuel consumption provided by NGWBS tires which is 3.2%, the most conservative figure. The data is presented in Table 1.9.

Table 1.9 Fuel economy by tire and axle configuration

CONSUMPTION L/100 KM	2 AXLES	3 AXLES	4 AXLES	5 AXLES	6 AXLES	7 AXLES	8 AXLES OR +
Dual	40	40	40	46	50	50	51
NGWBS	38.72	38.72	38.72	44.24	47.92	48.69	49.17
Economy (L/100km)	1.28	1.28	1.28	1.46	1.58	1.61	1.63

Source: WSP truck operator survey

In order to assess the forecasted improvement in engine and truck efficiency, WSP used the Energy Information Administration to integrate the parameter in the cost-benefit analysis. The next figure presents, on a 100 index scale, the forecasted fuel efficiency improvement for heavy duty trucks (Figure 1.6).



Source: Energy Information Administration, EIA, 2014
Note: 2014=100

Figure 1.6 Fuel consumption of heavy trucks per km traveled, 2014-2033

1.4.3 SOCIAL COSTS TO NEUTRALIZE EMISSIONS

The fuel economy resulting from the increase in the uptake of the NGWBS tires will result in a decrease in emissions. According to the USDOT Final Regulatory Impact analysis, the National Highway Traffic Safety Administration (NHTSA, 2012), the following quantities of pollutants are emitted for every litre of fuel burnt:

CO_2 – 2,730 g/l

NO_x – 9.6g g/l

VOC – 9.7g g/l

The costs for mitigating nitrogen oxides (NO_x) and volatile organic compound (VOC) emissions are estimated by NHTSA (2012), and carbon dioxide (CO_2) mitigation data is based on the Alberta $15 per ton calculation. The results are shown in Table 1.10.

Table 1.10 Emissions mitigation costs, $/L, 2014$

MITIGATION COSTS	LOW	LIKELY	HIGH
CO_2	0.031	0.041	0.051
No_x	0.050	0.066	0.083
VOC	0.035	0.047	0.059
Total	**0.122**	**0.163**	**0.203**

Source: Government of Alberta, EIA (2014)

The mitigation cost of CO_2 is based on the $15 per tonne offset used in Alberta for 2014-2015, $20 per tonne for 2016 and $30 per tonne for 2017. A 2% annual compound growth rate was applied for the years 2018-2033. The value for NOx and VOC is based on NHSTA (2012).

1.4.4 SAVINGS IN VEHICLE MAINTENANCE

The switch from dual tires to NGWBS tires will result in a decrease in the time required for tire maintenance because of the requirement to only inspect 2 wheels per axles instead of 4. Moreover, it will further enhance the inspection efficiency by the limitation of the additional effort required to inspect the inner tire and ease the overall inspection in terms of air pressure checking, replacement tire time and idle time. It will also limit the required time to mount and unmount tires, facilitate the storage management, and install two valves per axle instead of four. Given these facts, the switch from duals to NGWBS should cut the maintenance time by half.

Table 1.11 Assumptions for the differences in maintenance costs

ASSUMPTIONS	
Maintenance interval	10,000 km
Maintenance for dual tires	30 mins per vehicle
Maintenance for single tires	15 mins per vehicle
Average cost per hour ($)	60

Source: WSP survey of truck operators, MTQ 2004

1.4.5 VALUE OF LIFE AND INJURIES

The methodology proposed for this study component borrows from a previous report prepared by Knowles and Synectics (2008) for the Ontario Ministry of Transportation to evaluate the costs and benefits of NGWBS.

More specifically, the methodology used by Knowles and Synetics involved a review and discussion of the data used in previous studies, as well as computer simulations of six different vehicle configurations, ranging from semi-trailer with a “standard spread” tandem to an 8-axle B-train double trailer with a “standard spread” tandem pup trailer.

This study involved several steps and report on the following relationships:

- → Collision rate, according to the trailer class
- → Expected future tractor-trailer collision rates, if compliant with proposed regulation
- → Societal costs of collisions, per severity of the consequences (fatality, injury, property damage only)

They concluded that the use of NGWBS tires is estimated to save 0.96% of the baseline number of collisions.

The difference between the current and expected number of tractor-trailer collisions is then used to estimate the aggregate benefits in terms of a reduction on societal costs of collision. This study will use the data from MTO (2009) to assess the value of the potential of NGWBS tires to reduce incidents. The retained values are summarized in Table 1.12.

Table 1.12 Fatality and injury values

	FATALITY VALUE	INJURY VALUE
Low	$5,325,000	$48,750
Likely	$7,100,000	$65,000
High	$8,875,000	$81,250

Source: MTO 2009

The accident data was collected from Transportation Canada. The accident rates per million vehicle-kilometres are presented in Table 1.13 and Table 1.14.

Table 1.13 Fatalities and injuries per million vehicle kilometres

PROVINCE	PER MILLION VEHICLE-KILOMETRES	
	FATALITIES	INJURIES
N.L.	0.0058	0.4262
P.E.I.	0.0069	0.4937
N.S.	0.0069	0.4769
N.B.	0.0115	0.4259
MB.	0.0072	0.5839
SK.	0.0128	0.4995
AB.	0.0066	0.3495
B.C.	0.0101	0.5793

Source: Transportation Canada, Canadian Motor Vehicle Traffic Collision Statistics, 2010

Table 1.14 Reduced fatalities and injury rates from the use of NGWBS tires (-0.96%)

PROVINCE	PER MILLION VEHICLE-KILOMETRES	
	FATALITIES	INJURIES
N.L.	0.0057	0.4221
P.E.I.	0.0068	0.4890
N.S.	0.0068	0.4723
N.B.	0.0114	0.4218
MB.	0.0071	0.5783
SK	0.0127	0.4947
AB	0.0065	0.3461
B.C.	0.0100	0.5737

Source: MTO 2009

1.4.6 DISPOSAL COSTS OF USED TIRES

For the purpose of the study, a review of the fees imposed to buyers all across the selected provinces was completed. Overall, the imposed fees for the purchase of heavy trucks tires (excluding off road and farm equipment) ranges from $9.00 to $13.50. When using NGWBS tires, the operator has to only pay for two tires per axles. When using duals, the operator has to pay for four tires per axle. Table 1.15 presents the tire purchasing fees per provinces.

Table 1.15 Environmental fees for tire recycling

PROVINCE	PRICE PER TIRES ($)
Newfoundland and Labrador	9.00
Prince Edward Island	11.25
Nova Scotia	13.50
New Brunswick	13.50
Manitoba	9.00
Saskatchewan	9.00
Alberta	9.00
British Columbia	9.00

Source: Environment Canada, Managing and reducing waste

2 RESULTS BY PROVINCE

The cost-benefit analysis (CBA) converts potential gains (benefits) and losses (costs) from the project into monetary units and compares them. The following common benefit-cost evaluation measures are included in this CBA.

Net Present Value (NPV): NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms

Benefit Cost (B/C) Ratio: The evaluation also estimates the benefit-cost ratio; the present value of incremental benefits is divided by the present value of incremental costs to yield the benefit-cost ratio. The B/C ratio expresses the relation of discounted benefits to discounted costs as a measure of the extent to which a project's benefits either exceed or fall short of their associated costs.

To test the robustness of the estimated NPV and B/C ratio, a sensitivity analysis will be conducted in the next chapter. It will present the NPV and B/C ratios for a low, likely and high cost to pavement scenario.

2.1 NEWFOUNDLAND AND LABRADOR

2.1.1 SUMMARY OF THE RESULTS

Over the 20-year period, the total discounted costs for scenario A are $4,698,614 while the total cost for scenario B is $3,107,654. The benefits, in both scenarios amount to $11,022,878.

The benefit-cost analysis for Newfoundland and Labrador yields a net present value of $6,324,264 for cost scenario A and of $7,915,224 for cost scenario B.

The benefit to costs ratio is 2.35 for scenario A and 3.55 for scenario B. The summary of the results are presented in Table 2.1.

Table 2.1 Summary of the results for Newfoundland and Labrador

SCENARIO	TOTAL COSTS (2014 $ MILLIONS DISC.)	TOTAL BENEFITS (2014 $ MILLIONS DISC.)	NET PRESENT VALUE (2014 $ MILLIONS DISC.)	BENEFIT COST RATIO
Cost Scenario A	4.7	11.02	6.3	2.35
Cost Scenario B	3.1	11.02	7.9	3.55

Source: WSP 2015

2.1.2 IMPACTS OF THE REGULATORY CHANGE

The overall impact of the elimination of the weight limitation for NGWBS tires can be seen in Table 2.2, which shows the magnitude of change and direction of the various impact categories.

The regulatory change will have a major impact on fuel consumption. In fact, over the 20-year analysis, there is a decrease in fuel consumption by 20.3 million litres. The new regulation will also reduce the province's Co_2 emissions by 40,605 tonnes. Finally, the new regulation will also decrease fatalities and injury accidents as well as the emissions of NOx and VOC (Table 2.2).

Table 2.2 Impact of the elimination of the weight limitation for NGWBS tires in Newfoundland and Labrador 2014-2033

CATEGORY	QUANTITY
Fuel savings (Litres)	▼14.9 Million
Fatality accident (Number)	▼0.064
Injury accidents (Number)	▼ 4.74
Maintenance (Hours)	▼115,816
Tire environmental fee ($, disc)	▼$ 79,000
Retread of tires costs ($, disc)	▲$15,000
CO_2 Emissions (Tonnes)	▼ 40,605
NO_X emissions (Tonnes)	▼142.8
VOC (Tonnes)	▼144.3

Source: WSP, 2015

2.1.3 BENEFITS BY CATEGORY

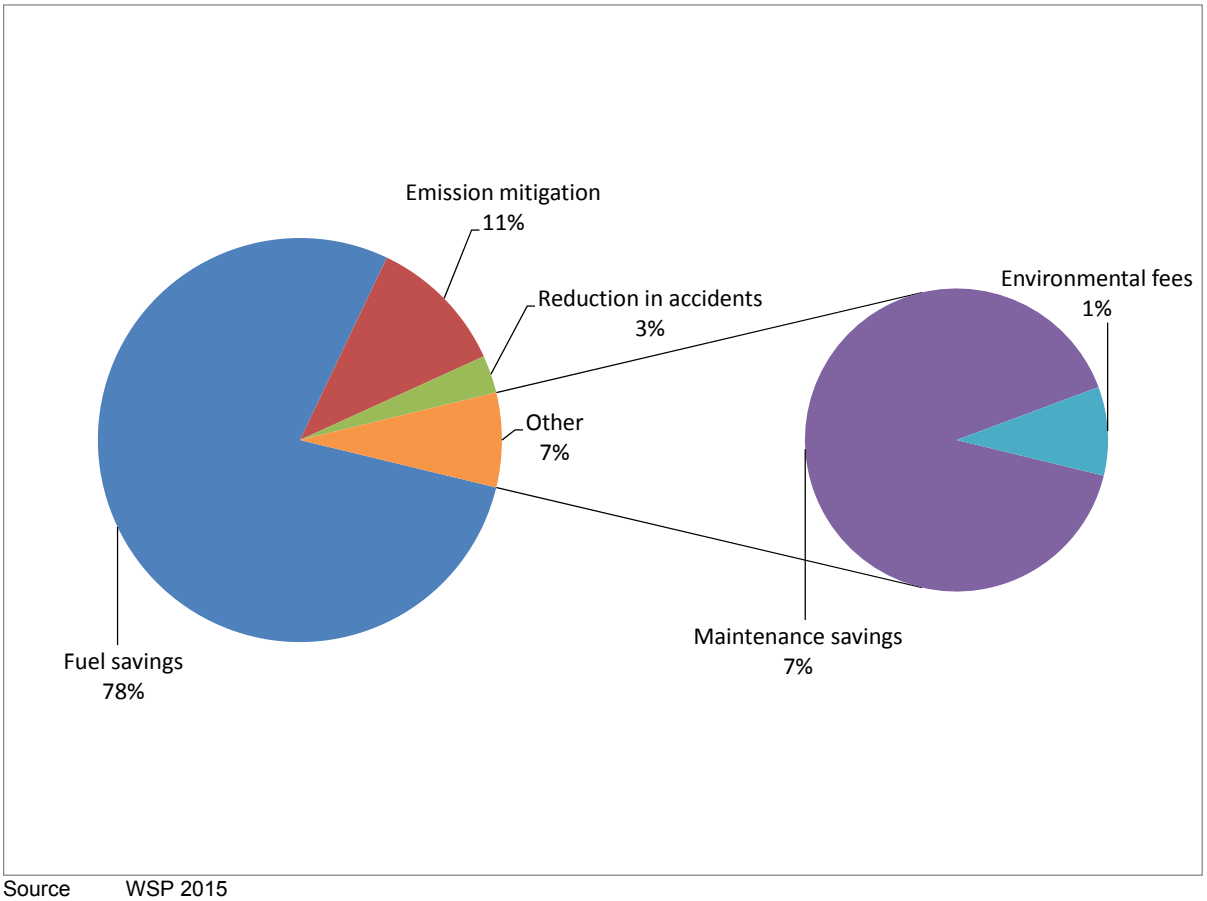
Converted into monetary units, the total savings from fuel consumption in discounted 2014 dollars amount to $8,642,390 and are by far the most important component in terms of benefits and represents a gain in economic competitiveness. The reduction of vehicle emissions is valued at $1,228,371 and the reduction of fatalities and injuries at $332,889. These also represent significant benefits for the society and the surrounding communities.

The next table and figure presents the benefits by category (Table 2.3 & Figure 2.1). Finally, Figure 2.2 presents the cumulative costs and benefits for both costs scenarios, A and B, for the 20-year analysis.

Table 2.3 Summary of the benefits by category, Newfoundland and Labrador

TYPE OF IMPACT	POPULATION AFFECTED BY IMPACT	ECONOMIC BENEFIT	SUMMARY OF RESULTS (AT 8% DISCOUNT RATE) ($)
Economic competiveness	Heavy truck owners and operators	Fuel savings	8.6M
Sustainability	Society and surrounding communities	Reduction in vehicle emissions	1.23M
Safety	All drivers in study region and society	Changes in accidents	333K
Economic competiveness	Heavy truck owners and operators	Saving on maintenance	755K
Economic competiveness	Heavy truck owners and operators	Reduction in environmental fees	79K

Source WSP 2015



Source WSP 2015

Figure 2.1 Benefits by category, Newfoundland and Labrador

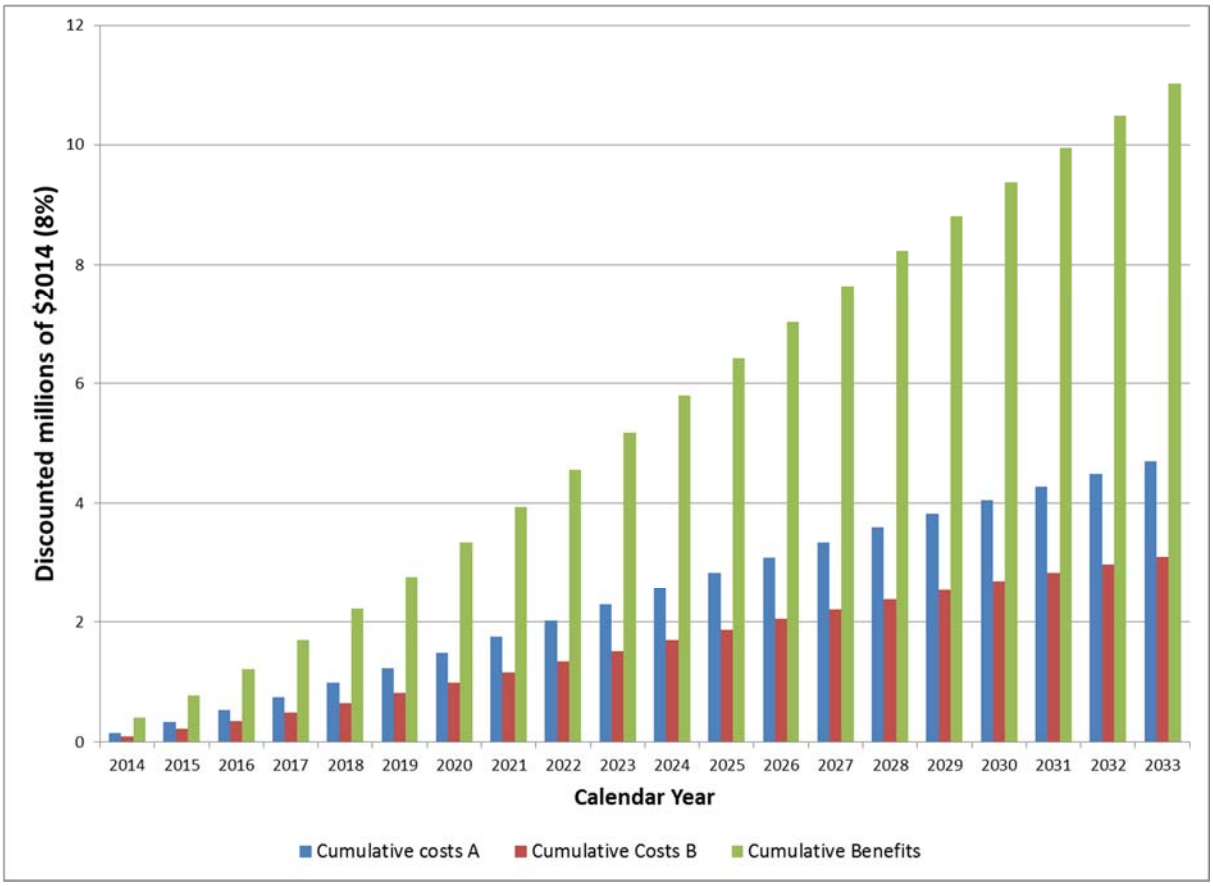


Figure 2.2 Cumulative costs and benefits, Newfoundland and Labrador

2.2 RESULTS FOR PRINCE EDWARD ISLAND

2.2.1 SUMMARY OF THE RESULTS

Over the 20-year period, the total discounted costs for scenario A are $892,142 while the total costs for scenario B are $539,181. The benefits, in both scenarios amount to $1,978,209.

The benefit-cost analysis for Prince Edward Island yields a net present value of $1,086,067 for cost scenario A and $1,439,028 for cost scenario B.

The benefit to costs ratio is 2.22 for scenario A and 3.67 for scenario B. The summary of the results are presented in Table 2.4.

Table 2.4 Summary of the results, Prince Edward Island

SCENARIO	TOTAL COSTS (2014 $ MILLIONS DISC.)	TOTAL BENEFITS (2014 $ MILLIONS DISC.)	NET PRESENT VALUE (2014 $ MILLIONS DISC.)	BENEFIT COST RATIO
Cost Scenario A	0.892	2.0	1.1	2.22
Cost Scenario B	0.539	2.0	1.4	3.67

2.2.2 IMPACTS OF THE REGULATORY CHANGE

The overall impact of the elimination of the weight limitation for NGWBS tires can be seen in Table 2.5, which shows the magnitude of change and direction of the various impact categories.

The regulatory change will have a major impact on fuel consumption. In fact, over the 20-year analysis, there is a decrease of 3.7 million litres of fuel consumed. The new regulation will also reduce the Co_2 emission of the province by 7,710 tonnes. Finally, the new regulation will also decrease fatalities and injury accidents as well as the emissions of NOx and VOC (Table 2.5).

Table 2.5 Impact of the elimination of the weight limitation for NGWBS tires in Prince Edward Island 2014-2033

CATEGORY	QUANTITY
Fuel savings (Litres)	▼2.8 Million
Fatality accident (Number)	▼0.015
Injury accidents (Number)	▼ 1.04
Maintenance (Hours)	▼21,990
Tire environmental fee ($, disc)	▼$18,800
Retread of tires costs ($, disc)	▲$74,900
CO_2 Emissions (Tonnes)	▼ 7,710
NO_X emissions (Tonnes)	▼27.1
VOC (Tonnes)	▼27.4

Source: WSP, 2015

2.2.3 BENEFITS BY CATEGORY

Converted into monetary units, the total savings from fuel consumption in discounted 2014 dollars amount to $1,583,293 and are by far the most important component in terms of benefits and represents a gain in economic competitiveness. The reduction in vehicle emissions, with a value of $233,235, and the reduction in fatalities and injuries, at $74,399, represents significant benefits for the society and the surrounding communities.

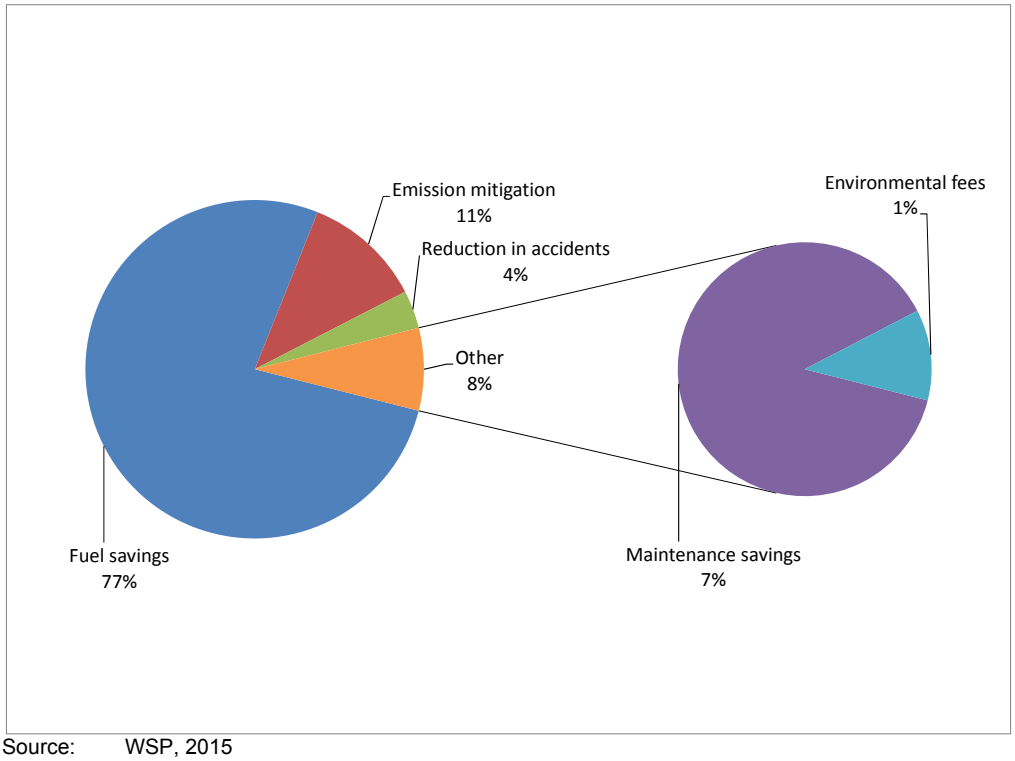
The next table and figure present the benefits by category (Table 2.6 & Figure 2.3).

Table 2.6 Summary of the benefits by category, Prince Edward Island

TYPE OF IMPACT	POPULATION AFFECTED BY IMPACT	ECONOMIC BENEFIT	SUMMARY OF RESULTS (AT 8% DISCOUNT RATE) ($)
Economic competiveness	Heavy truck owners and operators	Fuel savings	1.6M
Sustainability	Society and surrounding communities	Reduction in vehicle emissions	233K
Safety	All drivers in study region and society	Changes in accidents	74K
Economic competiveness	Heavy truck owners and operators	Saving on maintenance	143K
Economic competiveness	Heavy truck owners and operators	Reduction in environmental fees	19K

Source: WSP, 2015

Finally, Figure 2.4 presents the cumulative costs and benefits for both costs scenarios, A and B, for the 20year analysis.



Source: WSP, 2015

Figure 2.3 Benefits by category, Prince Edward Island

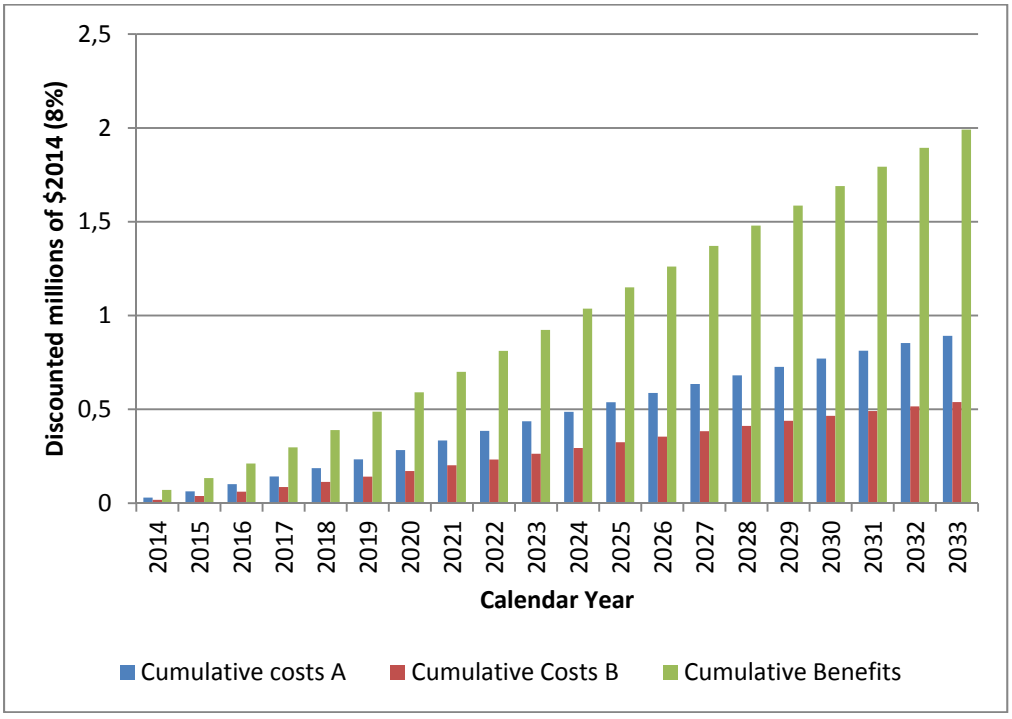


Figure 2.4 Cumulative costs and benefits, Prince Edward Island

2.3 RESULTS FOR NOVA SCOTIA

2.3.1 SUMMARY OF THE RESULTS

Over the 20year period, the total discounted costs for scenario A are $11,359,941 while the total costs for scenario B are $7,405,462. The benefits in both scenarios amount to $24,617,690.

The benefit-cost analysis for Nova Scotia yields a net present value of $13,257,749 for cost scenario A and $17,212,227 for cost scenario B.

The benefit to costs ratio is 2.17 for scenario A and 3.32 for scenario B. The summary of the results are presented in Table 2.7.

Table 2.7 Summary of the results for Nova Scotia

SCENARIO	TOTAL COSTS (2014 $ MILLIONS DISC.)	TOTAL BENEFITS (2014 $ MILLIONS DISC.)	NET PRESENT VALUE (2014 $ MILLIONS DISC.)	BENEFIT COST RATIO
Cost Scenario A	11.4	24.6	13.3	2.17
Cost Scenario B	7.4	24.6	17.2	3.32

2.3.2 IMPACTS OF THE REGULATORY CHANGE

The overall impact of the elimination of the weight limitation for NGWBS tires can be seen in Table 2.8, which shows the magnitude of change and direction of the various impact categories.

The regulatory change will have a major impact on fuel consumption. In fact, over the 20-year analysis, there is a decrease of 45.9 million litres of fuel consumed. The new regulation will also reduce the province's Co_2 emission by 98,172 tonnes. Finally, the new regulation will also decrease fatalities and injury accidents as well as the emissions of NOx and VOC (Table 2.8).

Table 2.8 Impact of the elimination of the weight limitation for NGWBS tires in Nova Scotia 2014-2033

CATEGORY	QUANTITY
Fuel savings (Litres)	▼36 Million
Fatality accident (Number)	▼0.185
Injury accidents (Number)	▼ 12.8
Maintenance (Hours)	▼280,816
Tire environmental fee ($, disc)	▼$287,000
Retread of tires costs ($, disc)	▲$953,000
CO_2 Emissions (Tonnes)	▼ 98,172
NO_X emissions (Tonnes)	▼345.2
VOC (Tonnes)	▼348.8

Source: WSP, 2015

2.3.3 BENEFITS BY CATEGORY

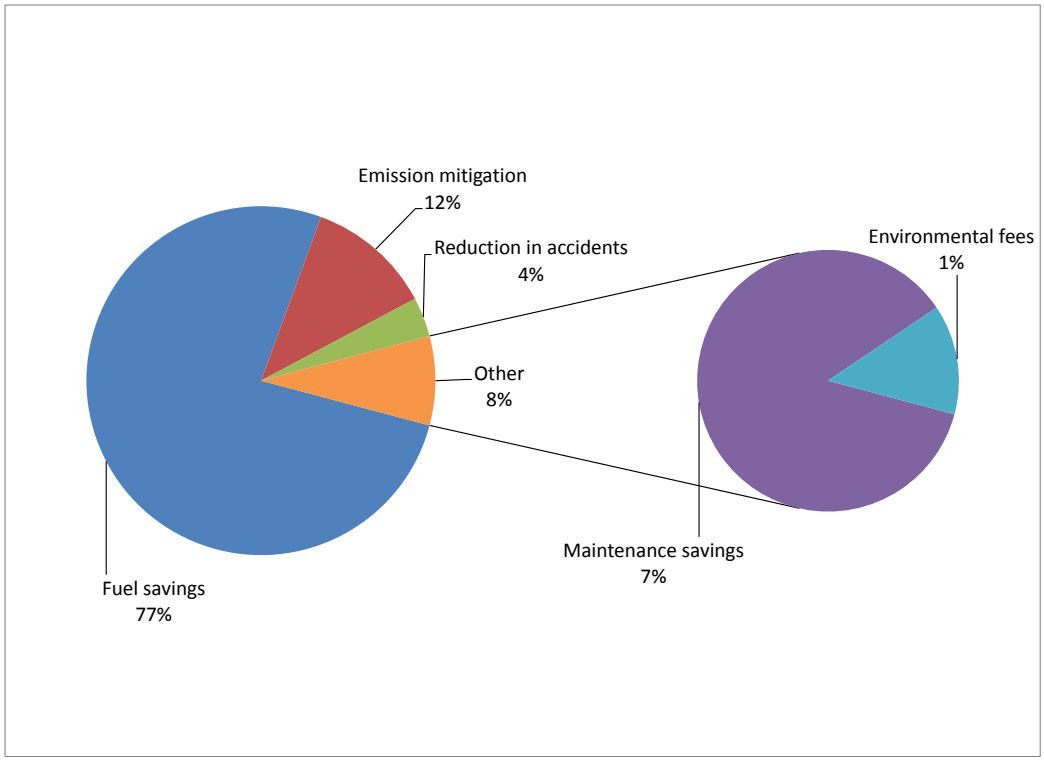
Converted into monetary units, the total savings from fuel consumption in discounted 2014 dollars amount to $19,554,097 and are by far the most important component in terms of benefits and represents a gain in economic competitiveness. The reduction in vehicle emissions, with a value of $2,969,858, and the reduction in fatalities and injuries, at $934,591, represents significant benefits for the society and the surrounding communities.

The next table and figure present the benefits by category (Table 2.9 & Figure 2.5). Finally, Figure 2.6 presents the cumulative costs and benefits for both cost scenarios, A and B, for the 20-year analysis.

Table 2.9 Summary of the benefits by category, Nova Scotia

TYPE OF IMPACT	POPULATION AFFECTED BY IMPACT	ECONOMIC BENEFIT	SUMMARY OF RESULTS (AT 8% DISCOUNT RATE) ($)
Economic competiveness	Heavy truck owners and operators	Fuel savings	19.6M
Sustainability	Society and surrounding communities	Reduction in vehicle emissions	3.0M
Safety	All drivers in study region and society	Changes in accidents	935K
Economic competiveness	Heavy truck owners and operators	Saving on maintenance	2.0M
Economic competiveness	Heavy truck owners and operators	Reduction in environmental fees	287K

Source: WSP, 2015



Source: WSP, 2015

Figure 2.5 Benefits by category, Nova Scotia

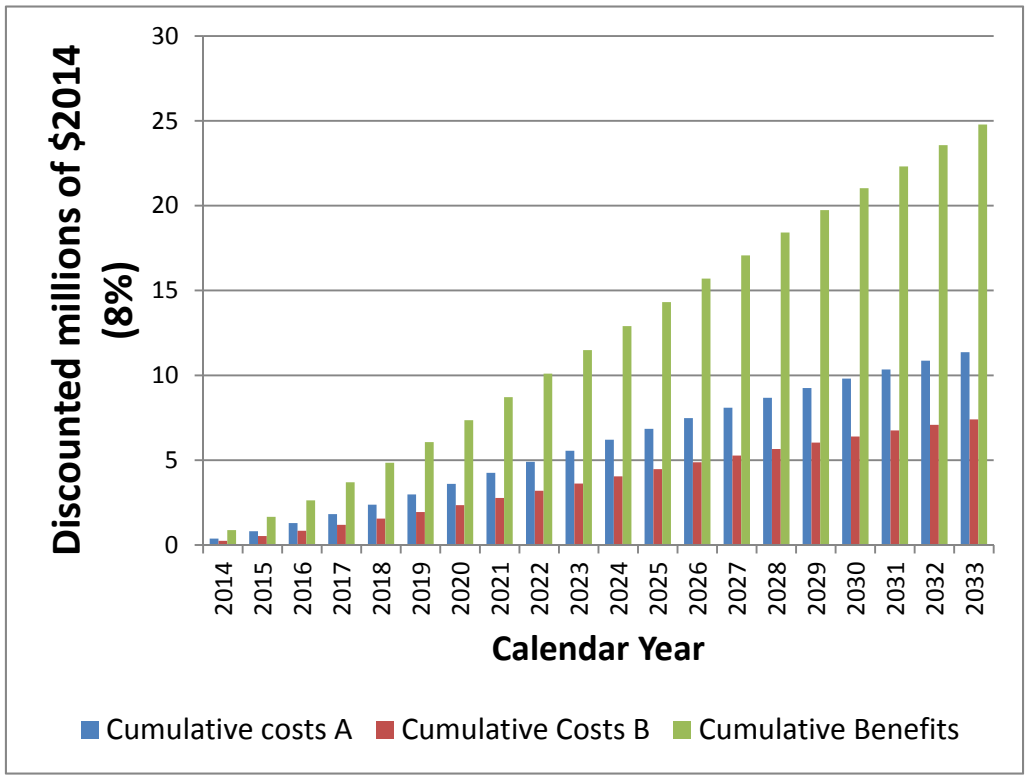


Figure 2.6 Cumulative costs and benefits, Nova Scotia

2.4 RESULTS FOR NEW BRUNSWICK

2.4.1 SUMMARY OF THE RESULTS

Over the 20-year period, the total discounted costs for scenario A are $3,072,933 while the total costs for scenario B are $1,930,201. The benefits, in both scenarios amount to $6,833,740.

The benefit-cost analysis for New Brunswick yields a net present value of $3,760,807 for cost scenario A and $4,903,540 for cost scenario B.

The benefit to costs ratio is 2.22 for scenario A and 3.54 for scenario B. The summary of results are presented in Table 2.10.

Table 2.10 Summary of the results for New Brunswick

SCENARIO	TOTAL COSTS (2014 $ MILLIONS DISC.)	TOTAL BENEFITS (2014 $ MILLIONS DISC.)	NET PRESENT VALUE (2014 $ MILLIONS DISC.)	BENEFIT COST RATIO
Cost Scenario A	3.1	6.8	3.8	2.22
Cost Scenario B	1.9	6.8	4.9	3.54

2.4.2 IMPACTS OF THE REGULATORY CHANGE

The overall impact of the elimination of the weight limitation for NGWBS tires can be seen in Table 2.11, which shows the magnitude of change and direction of the various impact categories.

The regulatory change will have a major impact on fuel consumption. In fact, over the 20-year analysis, there is a decrease of 12.6 million litres of fuel consumed. The new regulation will also reduce the province's Co_2 emissions by 26,556 tonnes. Finally, the new regulation will also decrease fatalities and injury accidents as well as the emissions of NOx and VOC (Table 2.11).

Table 2.11 Impact of the elimination of the weight limitation for NGWBS tires in New Brunswick 2014-2033

CATEGORY	QUANTITY
Fuel savings (Litres)	▼9.7 Million
Fatality accident (Number)	▼0.084
Injury accidents (Number)	▼ 3.1
Maintenance (Hours)	▼75,000
Tire environmental fee ($, disc)	▼$ 287k,000
Retread of tires costs ($, disc)	▲$953,000
CO_2 Emissions (Tonnes)	▼ 26,556
NO_X emissions (Tonnes)	▼93.4
VOC (Tonnes)	▼94.4

Source: WSP, 2015

2.4.3 BENEFITS BY CATEGORY

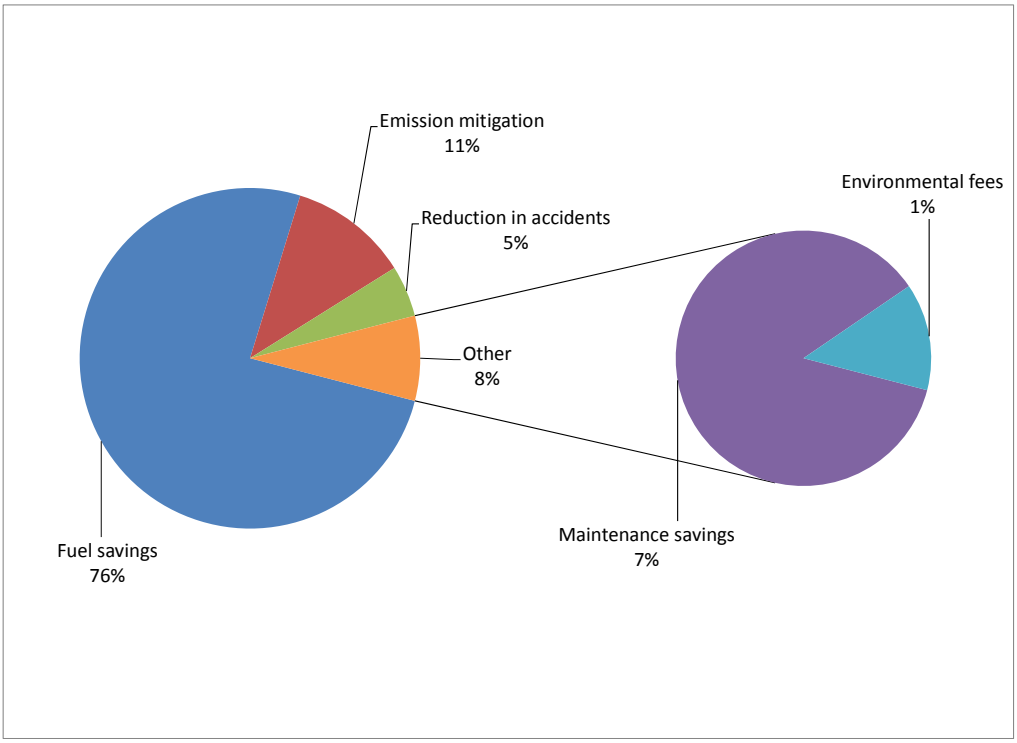
Converted into monetary units, the total savings from fuel consumption in discounted 2014 dollars amount to $5,371,259 and are by far the most important component in terms of benefits and represents a gain in economic competitiveness. The reduction in vehicle emissions, with a value of $803,365 and the reduction in fatalities and injuries, at $345,561 represents significant benefits for the society and the surrounding communities.

The next table and figure present the benefits by category (Table 2.12, Figure 2.7). Finally, Figure 2.8 presents the cumulative costs and benefits for both cost scenarios, A and B, for the 20year analysis.

Table 2.12 Summary of the benefits by category, New Brunswick

TYPE OF IMPACT	POPULATION AFFECTED BY IMPACT	ECONOMIC BENEFIT	SUMMARY OF RESULTS (AT 8% DISCOUNT RATE) ($)
Economic competiveness	Heavy truck owners and operators	Fuel savings	5.4M
Sustainability	Society and surrounding communities	Reduction in vehicle emissions	803k
Safety	All drivers in study region and society	Changes in accidents	346K
Economic competiveness	Heavy truck owners and operators	Saving on maintenance	494K
Economic competiveness	Heavy truck owners and operators	Reduction in environmental fees	78K

Source: WSP, 2015



Source: WSP, 2015

Figure 2.7 Benefits by category, New Brunswick

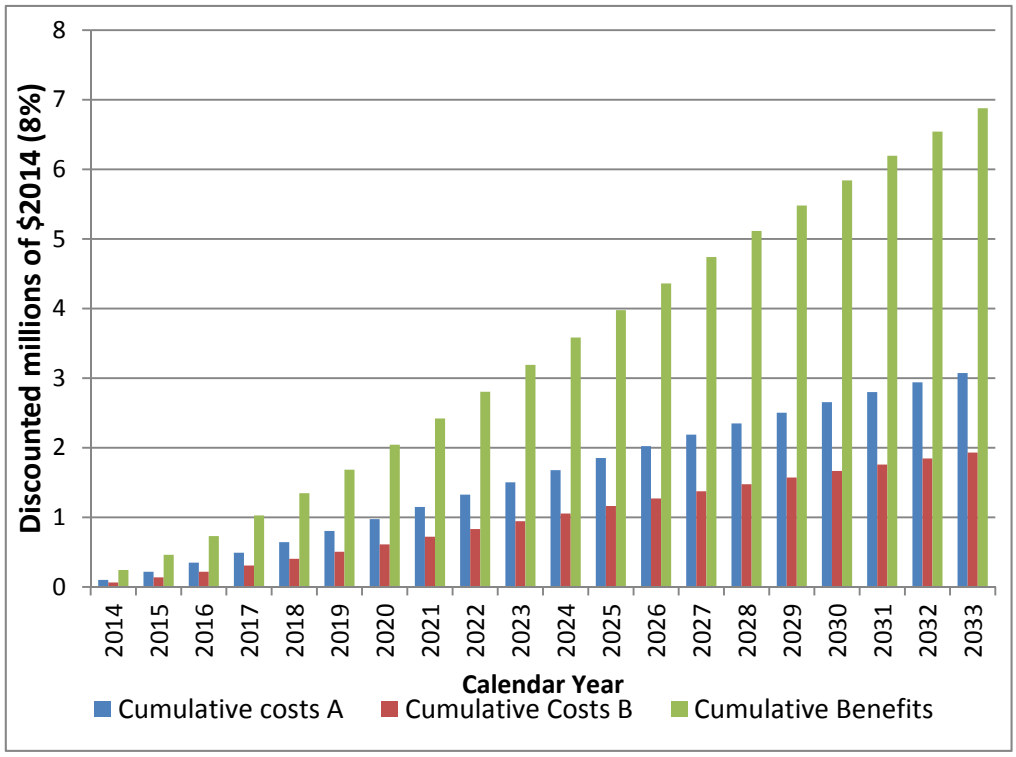


Figure 2.8 Cumulative costs and benefits, New Brunswick

2.5 RESULTS FOR MANITOBA

2.5.1 SUMMARY OF THE RESULTS

Over the 20-year period, the total discounted costs for scenario A are $57,900,295 while the total costs for scenario B are $24,875,305. The benefits in both scenarios amount to $82,703,995.

The benefit-cost analysis for Manitoba yields a net present value of $24,803,700 for cost scenario A and $57,828,690 for cost scenario B.

The benefit to costs ratio is 1.43 for scenario A and 3.32 for scenario B. The summary of the results are presented in Table 2.13.

Table 2.13 Summary of the results for Manitoba

SCENARIO	TOTAL COSTS (2014 $ MILLIONS DISC.)	TOTAL BENEFITS (2014 $ MILLIONS DISC.)	NET PRESENT VALUE (2014 $ MILLIONS DISC.)	BENEFIT COST RATIO
Cost Scenario A	57.9	82.7	24.8	1.43
Cost Scenario B	24.9	82.7	57.8	3.32

2.5.2 IMPACTS OF THE REGULATORY CHANGE

The overall impact of the elimination of the weight limitation for NGWBS tires can be seen in Table 2.14, which shows the magnitude of change and direction of the various impact categories.

The regulatory change will have a major impact on fuel consumption. In fact, over the 20-year analysis, there is a decrease of 158,612,531 litres of fuel consumed. The new regulation will also reduce the province's Co_2 emission by 847,848 tonnes. Finally, the new regulation will also decrease fatalities and injury accidents as well as the emissions of NOx and VOC (Table 2.14).

Table 2.14 Impact of the elimination of the weight limitation for NGWBS tires in Manitoba 2014-2033

CATEGORY	QUANTITY
Fuel savings (Litres)	▼111.5 Million
Fatality accident (Number)	▼0.586
Injury accidents (Number)	▼ 12.8
Maintenance (Hours)	▼847,848
Tire environmental fee ($, disc)	▼$ 691,000
Retread of tires costs ($, disc)	▲$3.5 Million
CO_2 Emissions (Tonnes)	▼ 304,497
NO_X emissions (Tonnes)	▼1,071
VOC (Tonnes)	▼1,082

Source: WSP, 2015

2.5.3 BENEFITS BY CATEGORY

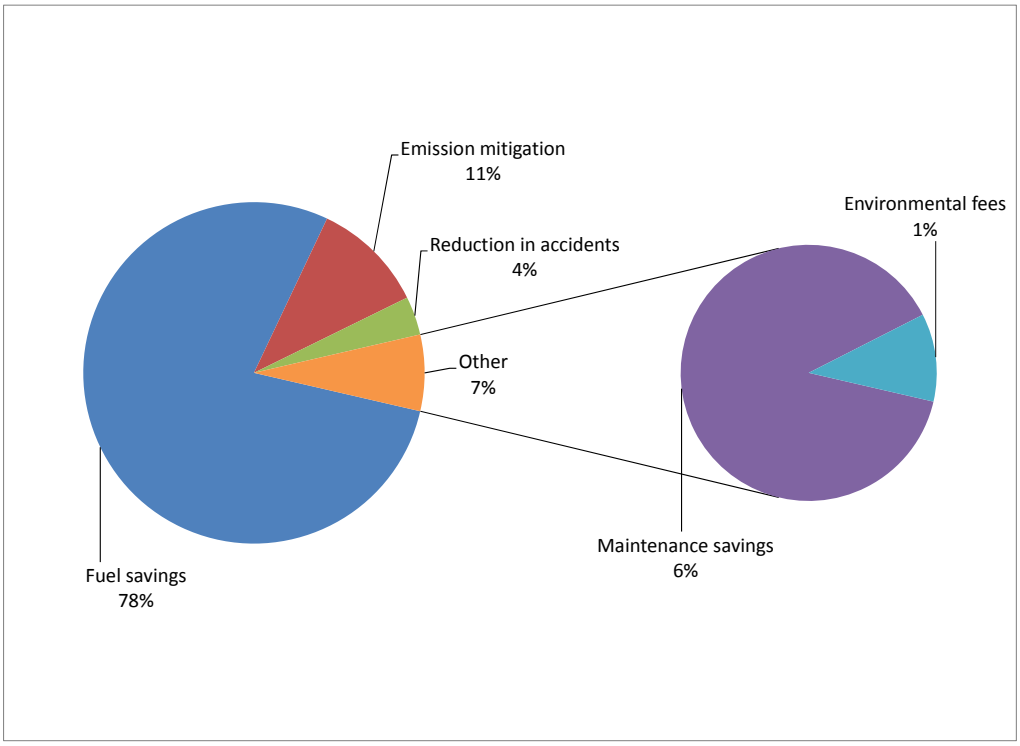
Converted into monetary units, the total savings from fuel consumption in discounted 2014 dollars amount to $67,571,326 and are by far the most important component in terms of benefits and represents a gain in economic competitiveness. The reduction in vehicle emissions, with a value of $9,211,558, and the reduction in fatalities and injuries, at $3,151,282, represents significant benefits for the society and the surrounding communities.

The next table and figure present the benefits by category (Table 2.15 & Figure 2.9). Finally, Figure 2.10 presents the cumulative costs and benefits for both cost scenarios, A and B, for the 20-year analysis.

Table 2.15 Summary of the benefits by category, Manitoba

TYPE OF IMPACT	POPULATION AFFECTED BY IMPACT	ECONOMIC BENEFIT	SUMMARY OF RESULTS (AT 8% DISCOUNT RATE) ($)
Economic competiveness	Heavy truck owners and operators	Fuel savings	67.6M
Sustainability	Society and surrounding communities	Reduction in vehicle emissions	9.2M
Safety	All drivers in study region and society	Changes in accidents	3.2M
Economic competiveness	Heavy truck owners and operators	Saving on maintenance	5.5M
Economic competiveness	Heavy truck owners and operators	Reduction in environmental fees	691K

Source: WSP, 2015



Source: WSP, 2015

Figure 2.9 Benefits by category, Manitoba

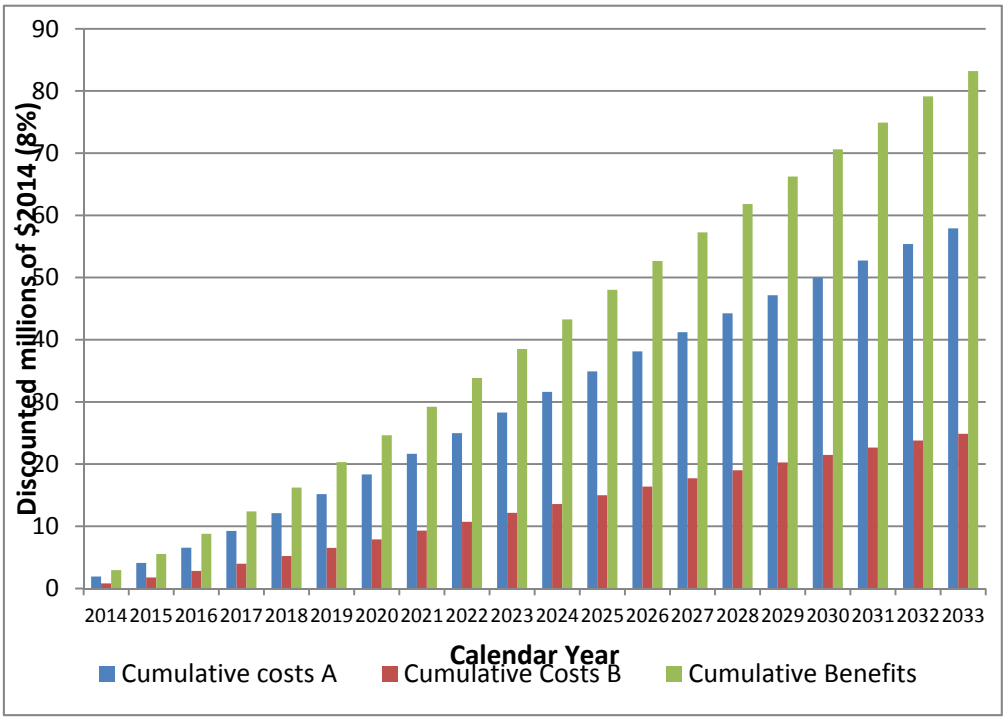


Figure 2.10 Cumulative costs and benefits, Manitoba

2.6 RESULTS FOR SASKATCHEWAN

2.6.1 SUMMARY OF THE RESULTS

Over the 20-year period, the total discounted costs for scenario A are $52,227,067 while the total costs for scenario B are $16,687,102. The benefits, in both scenarios amount to $75,682,834.

The benefit-cost analysis for Saskatchewan yields a net present value of $23,455,767 for cost scenario A and $58,995,732 for cost scenario B.

The benefit to costs ratio is 1.45 for scenario A and 4.54 for scenario B. The summary of results is presented in Table 2.16.

Table 2.16 Summary of the results for Saskatchewan

SCENARIO	TOTAL COSTS (2014 $ MILLIONS DISC.)	TOTAL BENEFITS (2014 $ MILLIONS DISC.)	NET PRESENT VALUE (2014 $ MILLIONS DISC.)	BENEFIT COST RATIO
Cost Scenario A	52.2	75.7	23.9	1.45
Cost Scenario B	16.7	75.7	59.4	4.54

2.6.2 IMPACTS OF THE REGULATORY CHANGE

The overall impact of the elimination of the weight limitation for NGWBS tires can be seen in Table 2.17, which shows the magnitude of change and direction of the various impact categories.

The regulatory change will have a major impact on fuel consumption. In fact, over the 20-year analysis, we see a decrease of 143 million litres of fuel consumed. The new regulation will also reduce the province's Co_2 emissions by 274,662 tonnes. Finally, the new regulation will also decrease fatalities and injury accidents as well as the emissions of NOx and VOC (Table 2.17).

Table 2.17 Impact of the elimination of the weight limitation for NGWBS tires in Saskatchewan

CATEGORY	QUANTITY
Fuel savings (Litres)	▼ 100.6Million
Fatality accident (Number)	▼0.94
Injury accidents (Number)	▼ 36.7
Maintenance (Hours)	▼764,773
Tire environmental fee ($, disc)	▼$ 624.000
Retread of tires costs ($, disc)	▲$3.1 Million
CO_2 Emissions (Tonnes)	▼ 274,662
NO_X emissions (Tonnes)	▼965.8
VOC (Tonnes)	▼975.9

Source: WSP, 2015

2.6.3 BENEFITS BY CATEGORY

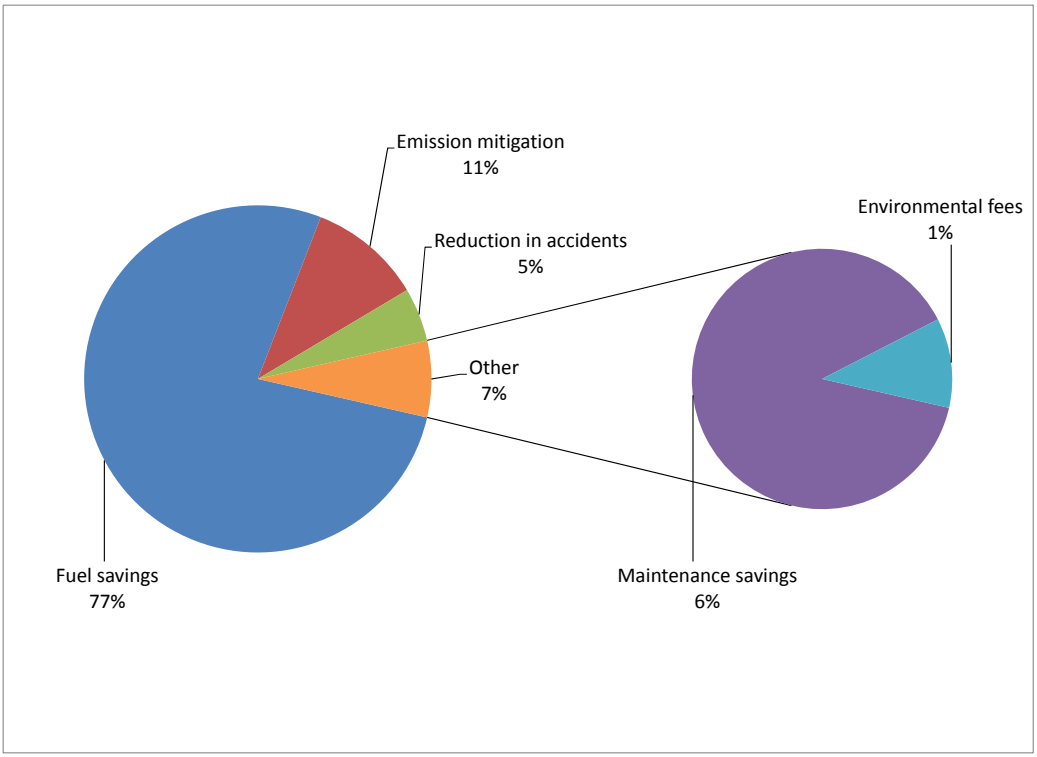
Converted into monetary units, the total savings from fuel consumption in discounted 2014 dollars amount to $60,939,154 and are by far the most important component in terms of benefits and represents a gain in economic competitiveness. The reduction in vehicle emissions, with a value of $8,308,985, and the reduction in fatalities and injuries, at $3,936,262, represents significant benefits for the society and the surrounding communities.

The next table and figure present the benefits by category (Table 2.18 & Figure 2.11). Finally, Figure 2.12 presents the cumulative costs and benefits for both costs scenarios, A and B, for the 20-year analysis.

Table 2.18 Summary of the benefits by category, Saskatchewan

TYPE OF IMPACT	POPULATION AFFECTED BY IMPACT	ECONOMIC BENEFIT	SUMMARY OF RESULTS (AT 8% DISCOUNT RATE) ($)
Economic competiveness	Heavy truck owners and operators	Fuel savings	60.9M
Sustainability	Society and surrounding communities	Reduction in vehicle emissions	8.3M
Safety	All drivers in study region and society	Changes in accidents	3.9M
Economic competiveness	Heavy truck owners and operators	Saving on maintenance	5.0M
Economic competiveness	Heavy truck owners and operators	Reduction in environmental fees	624K

Source: WSP, 2015



Source: WSP, 2015

Figure 2.11 Benefits by category, Saskatchewan

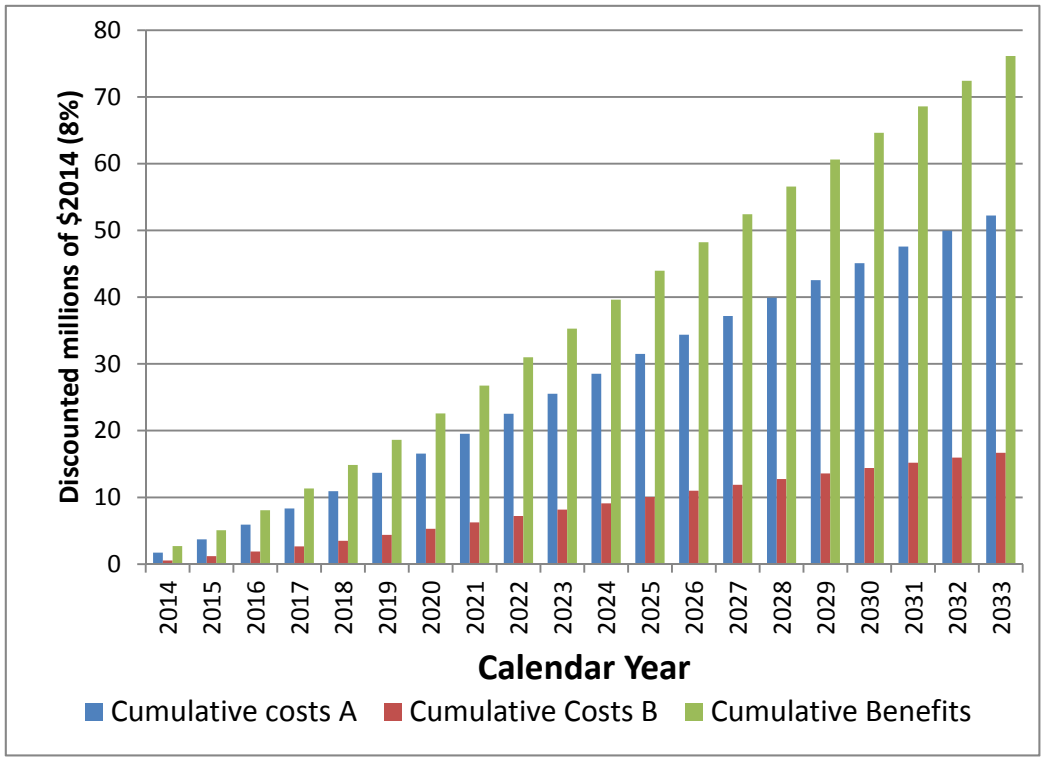


Figure 2.12 Cumulative costs and benefits, Saskatchewan

2.7 RESULTS FOR ALBERTA

2.7.1 SUMMARY OF THE RESULTS

Over the 20-year period, the total discounted costs for scenario A are $237,007,433 while the total costs for scenario B are $65,019,728. The benefits, in both scenarios amount to $336,101,147.

The benefit-cost analysis for Alberta yields a net present value of $99,093,714 for cost scenario A and $271,081,419 for cost scenario B.

The benefit to costs ratio is 1.42 for scenario A and 5.17 for scenario B. The summary of the results are presented in Table 2.19.

Table 2.19 Summary of the results for Alberta

SCENARIO	TOTAL COSTS (2014 $ MILLIONS DISC.)	TOTAL BENEFITS (2014 $ MILLIONS DISC.)	NET PRESENT VALUE (2014 $ MILLIONS DISC.)	BENEFIT COST RATIO
Cost Scenario A	237.0	336.1	99.1	1.42
Cost Scenario B	65.0	336.1	271.1	5.17

2.7.2 IMPACTS OF THE REGULATORY CHANGE

The overall impact of the elimination of the weight limitation for NGWBS tires can be seen in Table 2.20, which shows the magnitude of change and direction of the various impact categories.

The regulatory change will have a major impact on fuel consumption. In fact, over the 20-year analysis, there is a decrease of 45.9 million litres of fuel consumed. The new regulation will also reduce the province's Co_2 emission by 98,172 tonnes. Finally, the new regulation will also decrease fatalities and injury accidents as well as the emissions of NOx and VOC (Table 2.20).

Table 2.20 Impact of the elimination of the weight limitation for NGWBS tires in Alberta 2014-2033

CATEGORY	QUANTITY
Fuel savings (Litres)	▼456.7 M
Fatality accident (Number)	▼2.2
Injury accidents (Number)	▼ 116
Maintenance (Hours)	▼3.4M
Tire environmental fee ($, disc)	▼$2.8M
Retread of tires costs ($, disc)	▲$14.1M
CO_2 Emissions (Tonnes)	▼ 1.2M
NO_X emissions (Tonnes)	▼4,383
VOC (Tonnes)	▼4,429

Source: WSP, 2015

2.7.3 BENEFITS BY CATEGORY

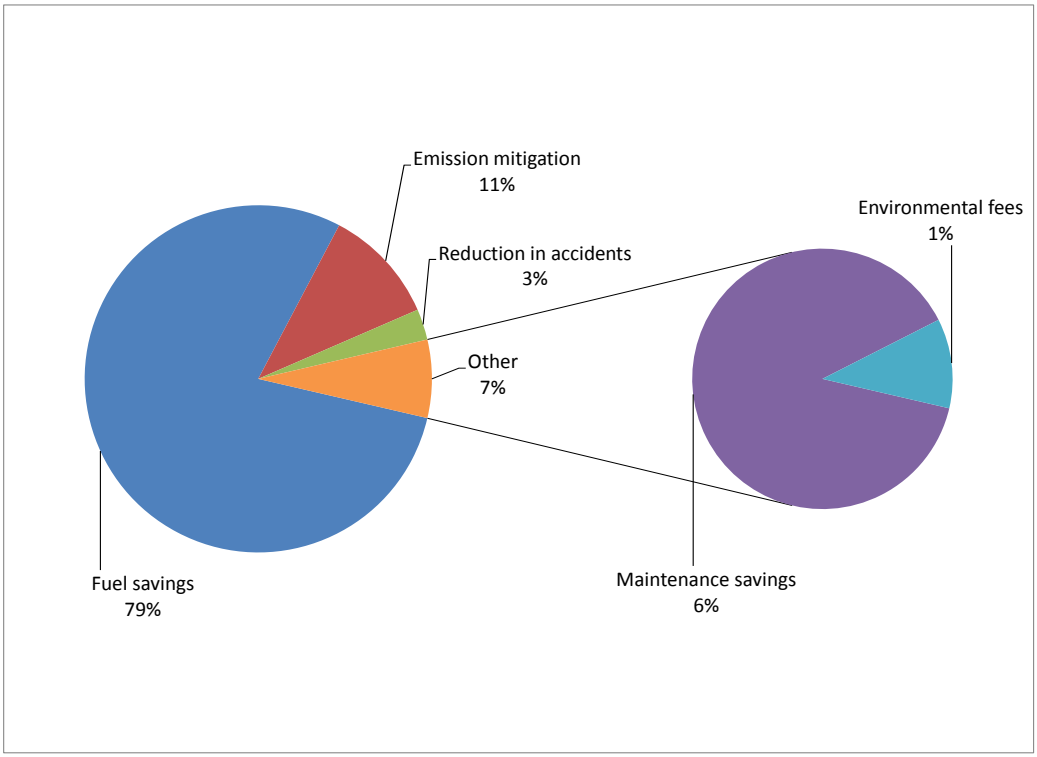
Converted into monetary units, the total savings from fuel consumption in discounted 2014 dollars amount to $276,980,862 and are by far the most important component in terms of benefits and represents a gain in economic competitiveness. The reduction in emission of pollutants, with a value of $37,706,332, and the reduction in fatalities and injuries, at $10,076,015, represents significant benefits for the society and the surrounding communities.

The next table and figure present the benefits by category (Table 2.21 & Figure 2.13). Finally, Figure 2.14 presents the cumulative costs and benefits for both cost scenarios, A and B, for the 20-year analysis.

Table 2.21 Summary of the benefits by category, Alberta

TYPE OF IMPACT	POPULATION AFFECTED BY IMPACT	ECONOMIC BENEFIT	SUMMARY OF RESULTS (AT 8% DISCOUNT RATE) ($)
Economic competiveness	Heavy truck owners and operators	Fuel savings	277.0M
Sustainability	Society and surrounding communities	Reduction in vehicle emissions	37.7M
Safety	All drivers in study region and society	Changes in accidents	10.1M
Economic competiveness	Heavy truck owners and operators	Saving on maintenance	22.7M
Economic competiveness	Heavy truck owners and operators	Reduction in environmental fees	2.8M

Source: WSP, 2015



Source: WSP, 2015

Figure 2.13 Benefits by category, Alberta

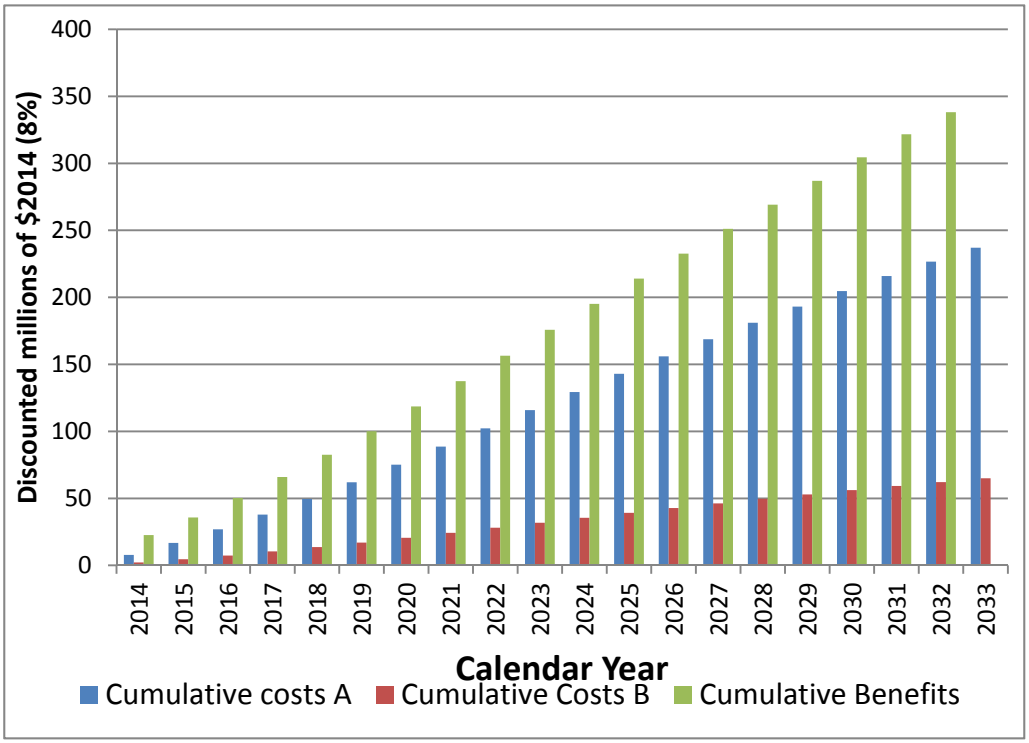


Figure 2.14 Cumulative costs and benefits, Alberta

2.8 RESULTS FOR BRITISH COLUMBIA

2.8.1 SUMMARY OF THE RESULTS

Over the 20-year period, the total discounted costs for scenario A are $40,580,264 while the total costs for scenario B are $10,788,915. The benefits in both scenarios amount to $55,724,967.

The benefit-cost analysis for British Columbia yields a net present value of $15,144,432 for cost scenario A and $44,935,782 for cost scenario B.

The benefit to costs ratio is 1.37 for scenario A and 5.16 for scenario B. The summary of the results are presented in (Table 2.22).

Table 2.22 Summary of the results for British Columbia

SCENARIO	TOTAL COSTS (2014 $ MILLIONS DISC.)	TOTAL BENEFITS (2014 $ MILLIONS DISC.)	NET PRESENT VALUE (2014 $ MILLIONS DISC.)	BENEFIT COST RATIO
Cost Scenario A	40.6	55.7	15.1	1.37
Cost Scenario B	10.8	55.7	44.9	5.16

2.8.2 IMPACTS OF THE REGULATORY CHANGE

The overall impact of the elimination of the weight limitation for NGWBS tires can be seen in Table 2.23, which shows the magnitude of change and direction of the various impact categories.

The regulatory change will have a major impact on fuel consumption. In fact, over the 20-year analysis, there is a decrease of 104,727,801 litres of fuel consumed. The new regulation will also reduce the province's Co_2 emission by 213,411 tonnes. Finally, the new regulation will also decrease fatalities and injury accidents as well as the emissions of NOx and VOC (Table 2.23).

Table 2.23 Impact of the elimination of the weight limitation for NGWBS tires in British Columbia 2014-2033

CATEGORY	QUANTITY
Fuel savings (Litres)	▼78.1M
Fatality accident (Number)	▼0.576
Injury accidents (Number)	▼ 33.1
Maintenance (Hours)	▼594,226
Tire environmental fee ($, disc)	▼$484,500
Retread of tires costs ($, disc)	▲$2.4M
CO_2 Emissions (Tonnes)	▼ 213,411
NO_X emissions (Tonnes)	▼750.5
VOC (Tonnes)	▼758.3

Source: WSP, 2015

2.8.3 BENEFITS BY CATEGORY

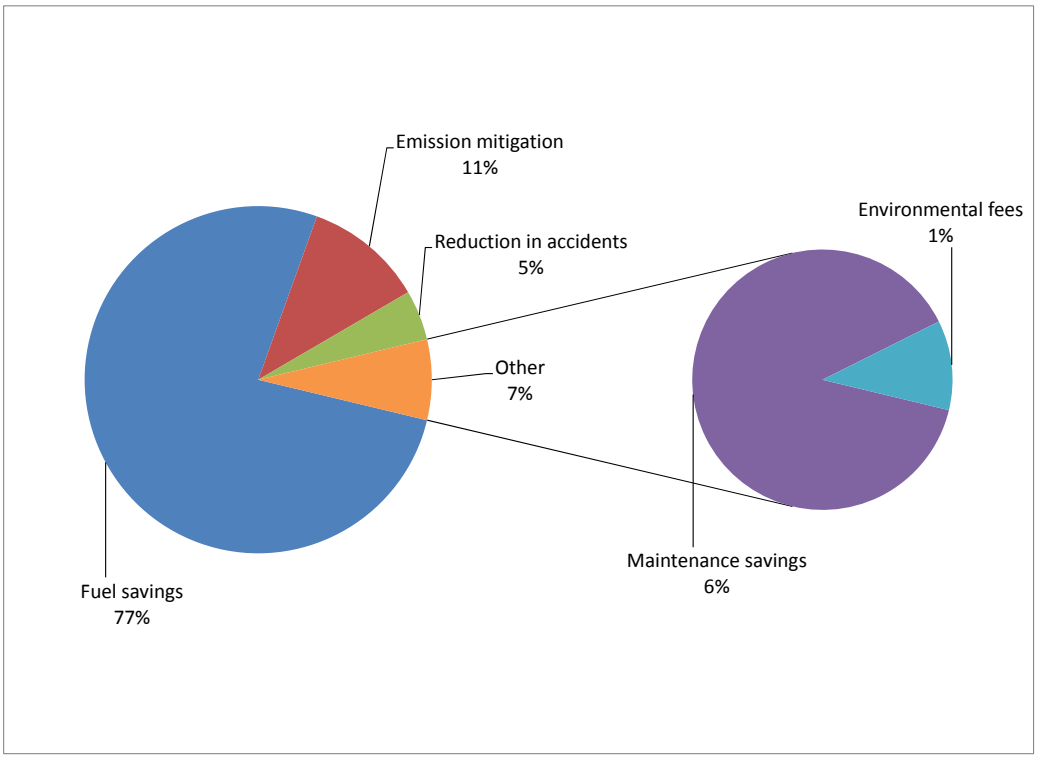
Converted into monetary units, the total savings from fuel consumption in discounted 2014 dollars amount to $44,615,620 and are by far the most important component in terms of benefits and represents a gain in economic competitiveness. The reduction in vehicle emissions, with a value of $6,456,055, and the reduction in fatalities and injuries, at $2,711,748, represents significant benefits for the society and the surrounding communities.

The next table and figure present the benefits by category (Table 2.24 & Figure 2.15). Finally, Figure 2.16 presents the cumulative costs and benefits for both cost scenarios, A and B, for the 20-year analysis.

Table 2.24 Summary of the benefits by category, British Columbia

TYPE OF IMPACT	POPULATION AFFECTED BY IMPACT	ECONOMIC BENEFIT	SUMMARY OF RESULTS (AT 8% DISCOUNT RATE) ($)
Economic competiveness	Heavy truck owners and operators	Fuel savings	44.6M
Sustainability	Society and surrounding communities	Reduction in vehicle emissions	6.5M
Safety	All drivers in study region and society	Changes in accidents	2.7M
Economic competiveness	Heavy truck owners and operators	Saving on maintenance	3.9M
Economic competiveness	Heavy truck owners and operators	Reduction in environmental fees	484K

Source: WSP, 2015



Source: WSP, 2015

Figure 2.15 Benefits by category, British Columbia

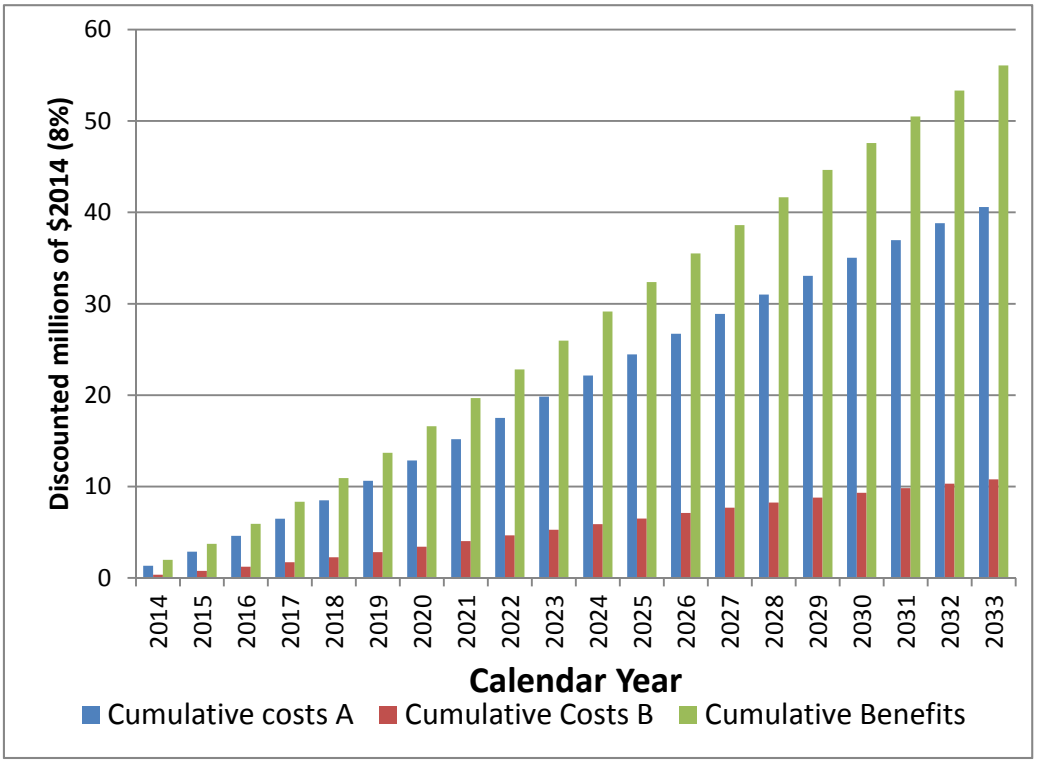


Figure 2.16 Cumulative costs and benefits, British Columbia

3 SENSITIVITY ANALYSIS

The aim of this chapter is to test the robustness of the estimated NPV and B/C ratio against different variations of the input in the model. This section will test the CBA model for 3 different parameters. First, it will test the robustness of the CBA against a low cost and a high cost scenario. Second, the model will be tested for different discount rates. Finally, the model will be tested by adjusting the NGWBS uptake in the trucking industry.

3.1 SENSITIVITY TO COSTS

In order to test the robustness of the analysis, cost scenario A will be tested using a ± 25% range to the baseline model. Scenario B will use the lowest and highest multipliers for the additional damages in the USDOT NGWBS study of 1.12 and 1.38 versus the 1.25 baseline scenario, which represents a ±10% variation.

In both scenarios, the sensitivity analysis showed that under the high costs scenario the benefit to cost ratio remained positive in all of the provinces covered by the study. The benefit to costs ratio under the high cost scenario ranged from 1.11 in British Columbia to 1.89 in Newfoundland and Labrador for scenario A. In scenario B, under the high cost scenario, it varies from 1.75 in Nova Scotia to 2.74 in Alberta and British Columbia.

It is important to keep in mind that the baseline costs under scenario A are higher than what could reasonably be expected in scenario B. Moreover, the scenario A uses a ± 25% range while the scenario B range is around ± 10%[1]. Therefore, it is reasonable to conclude that the cost-benefit analysis is robust under every cost scenario. The next table presents the benefit to costs ratio and the net present value for each the low, likely and high cost scenario (Table 3.1).

[1] WSP decided to use the damage range found in the DOT study for Scenario B to be consistent. However, the calculation was made using a ±25% range and the results for Scenario B are still higher than the results for scenario A under the low, likely and high scenarios.

Table 3.1 Costs sensitivity analysis

PROVINCE	COST SCENARIO	LOW		LIKELY		HIGH	
		B/C Ratio	NPV (M$)	B/C Ratio	NPV (M$)	B/C Ratio	NPV (M$)
Newfoundland and Labrador	A	3.15	7.57	2.35	6.32	1.89	5.22
	B	9.91	9.97	3.55	7.92	1.88	5.19
Prince Edward Island	A	2.98	1.32	2.22	1.09	1.79	0.88
	B	10.26	1.80	3.67	1.44	1.94	0.97
Nova Scotia	A	2.91	16.26	2.17	13.26	1.75	10.58
	B	9.30	22.12	3.32	17.21	1.76	10.71
New Brunswick	A	2.98	4.57	2.22	3.76	1.79	3.04
	B	9.90	6.18	3.54	4.90	1.88	3.21
Manitoba	A	1.92	39.79	1.43	24.80	1.15	10.84
	B	9.29	74.26	3.32	57.83	1.76	35.95
Saskatchewan	A	1.94	36.97	1.45	23.46	1.17	10.86
	B	12.68	70.14	4.54	59.00	2.40	44.44
Alberta	A	1.90	160.44	1.42	99.09	1.14	41.94
	B	14.45	314.79	5.17	271.08	2.74	214.66
British Columbia	A	1.84	25.65	1.37	15.14	1.11	5.36
	B	14.44	52.20	5.16	44.94	2.74	35.58

3.2 SENSITIVITY TO DISCOUNT RATE

The analysis is based on an 8% discount rate. In order to test the robustness of the model to different discount rates, a rate of 3% and 15 % was included in the parameters. The CBA model was tested for three different discount rates. The analysis remains positive for each of the discount rates tested. Therefore, it is reasonable to conclude that the cost-benefit analysis is robust under different discount rates.

For the three discount rate scenarios, the benefit to costs ratio is positive. With the 3% discount rate, the B/C ratio goes from 1.40 in British Columbia to 2.39 in Newfoundland and Labrador in scenario A. For scenario B, it ranges from 3.40 in Nova Scotia to 5.28 in Alberta and British Columbia.

In scenario A, with the 15% discount rate, the B/C ratio ranges from 1.36 in British Columbia to 2.33 in Newfoundland and Labrador. For scenario B, it ranges from 3.28 Manitoba to 5.10 in Alberta and British Columbia. The next table presents the benefit to costs ratio and the net present value for each the low, likely and high costs scenario (Table 3.2).

Table 3.2 Sensitivity to discount rate

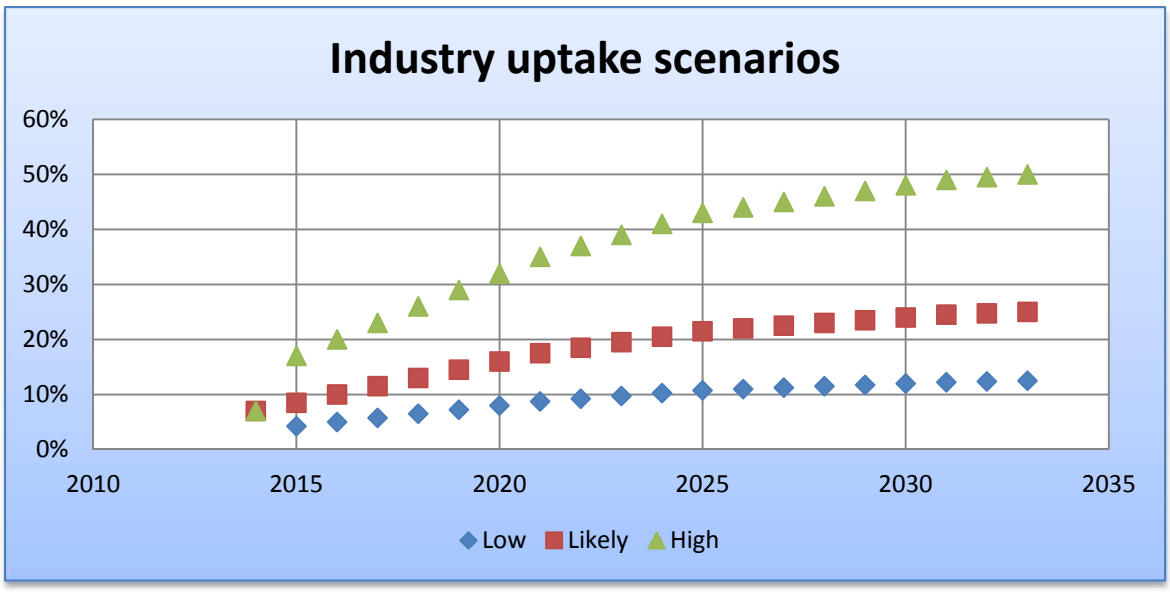
PROVINCE	COST SCENARIO	3%		8%		15%	
		B/C Ratio	NPV (M$)	B/C Ratio	NPV (M$)	B/C Ratio	NPV (M$)
Newfoundland and Labrador	A	2.39	10.68	2.35	6.32	2.33	3.60
	B	3.61	13.28	3.55	7.92	3.52	4.51
Prince Edward Island	A	2.27	1.85	2.22	1.09	2.19	0.61
	B	3.75	2.43	3.67	1.44	3.63	0.82
Nova Scotia	A	2.21	22.59	2.17	13.26	2.14	7.47
	B	3.40	29.07	3.32	17.21	3.29	9.74
New Brunswick	A	2.27	6.40	2.22	3.76	2.20	2.12
	B	3.62	8.27	3.54	4.90	3.50	2.78
Manitoba	A	1.46	43.55	1.43	24.80	1.41	13.68
	B	3.40	97.64	3.32	57.83	3.28	32.69
Saskatchewan	A	1.48	41.06	1.45	23.46	1.43	12.96
	B	4.63	99.26	4.54	59.00	4.48	33.42
Alberta	A	1.45	174.29	1.42	99.09	1.40	54.59
	B	5.28	455.94	5.17	271.08	5.10	153.58
British Columbia	A	1.40	26.80	1.37	15.14	1.36	8.32
	B	5.28	75.59	5.16	44.94	5.10	25.47

3.3 SENSITIVITY TO NGWBS TIRES UPTAKE PERCENTAGE

The last component tested for the sensitivity analysis is the uptake percentage of NGWBS tires in the industry. This sensitivity test aims to determine whether a lower or higher percentage of fleets using NGWBS tires could impact the B/C ratio of the CBA.

In order to assess the robustness of the CBA to the NGWBS tires uptake, the following penetration rates were used (Figure 3.1).

Figure 3.1 NGWBS tires industry penetration percentage



Under every uptake scenarios, the benefit to costs ratio is positive. The highest values are found on the high uptake scenario while the lowest values are found in the low uptake scenario. Table 3.3 summarizes the sensitivity analysis results.

Table 3.3 Sensitivity to uptake percentage

PROVINCE	COSTS SCENARIO	LOW		LIKELY		HIGH	
		NPV (M$)	B/C Ratio	NPV (M$)	B/C Ratio	NPV (M$)	B/C Ratio
Newfoundland and Labrador	A	2.36	4.85	2.35	6.32	2.36	7.93
	B	3.57	6.06	3.55	7.92	3.57	9.91
Prince Edward Island	A	2.21	0.82	2.22	1.09	2.25	1.38
	B	3.65	1.08	3.67	1.44	3.72	1.82
Nova Scotia	A	2.16	9.97	2.17	13.26	2.20	16.87
	B	3.31	12.97	3.32	17.21	3.37	21.78
New Brunswick	A	2.21	2.83	2.22	3.76	2.25	4.78
	B	3.53	3.70	3.54	4.90	3.59	6.20
Manitoba	A	1.42	18.45	1.43	24.80	1.45	32.18
	B	3.31	43.49	3.32	57.83	3.37	73.19
Saskatchewan	A	1.44	17.46	1.45	23.46	1.47	30.37
	B	4.51	44.41	4.54	59.00	4.60	74.50
Alberta	A	1.41	73.68	1.42	99.09	1.44	128.69
	B	5.14	204.09	5.17	271.08	5.24	342.26
British Columbia	A	1.36	11.23	1.37	15.14	1.39	19.78
	B	5.13	33.82	5.16	44.94	5.24	56.77

4 CONCLUSION

The cost-benefit analysis on the elimination of the weight limitations for NGWBS tires is positive for both costs scenarios. It showed robustness of three sensitivity analyses conducted on the costs, the discount rate and the industry uptake.

This analysis demonstrates that the elimination of the weight limitations for NGWBS tires could lead to an increase in economic competiveness through lower fuel consumption, lower maintenance costs and lower tire recycling costs. It also benefits the society through a significant reduction in greenhouse gas emissions, pollutants and a decrease in road fatalities and injuries. Table 4.1 below summarises the impacts of the regulatory change.

Table 4.1 Summary of the impacts of the elimination of the NGWBS tires weight limitation

CATEGORY	NL	PEI	NS	NB	MB	SK	AB	BC
Fuel savings (Litres)	▼14.8M	▼2.8M	▼35.9M	▼9.7M	▼111.5M	▼101M	▼457M	▼78M
Fatality accident (Number)	▼0.064	▼0.015	▼0.185	▼0.084	▼0.586	▼0.94	▼2.2	▼0.576
Injury accidents (Number)	▼ 4.74	▼ 1.04	▼ 12.8	▼ 3.1	▼ 12.8	▼ 36.7	▼ 116	▼ 33.1
Maintenance (Hours)	▼115.8K	▼22.0K	▼280.8K	▼75.0K	▼847.8K	▼764.8K	▼3.4M	▼594.2K
Tire environmental fee ($, disc)	▼$79.0K	▼$18.8K	▼$287.0K	▼$287K	▼$ 691K	▼$624K	▼$2.8M	▼$ 484.5K
Retread of tires costs ($, disc)	▲$15.0K	▲$74.9K	▲$953.0K	▲$953K	▲$3.5M	▲$3.1M	▲$14.1M	▲$2.4M
CO_2 Emissions (Tonnes)	▼ 40.6K	▼ 7,710	▼ 98.2K	▼ 26.6K	▼ 304.5K	▼ 274.7K	▼ 1.2.M	▼ 213.4K
NO_X emissions (Tonnes)	▼142.8	▼27.1	▼345.2	▼93.4	▼1071	▼965.8	▼4,383	▼750.5
VOC (Tonnes)	▼144.3	▼27.4	▼348.8	▼94.4	▼1082	▼975.9	▼4,429	▼758.3

Overall, the benefits offset the costs in every scenario analysed. This is consistent with the results that have been published in previous studies for the Government of Quebec and the Government of Ontario.

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