Technical Review

of the

AirCare® Program

Program Year Three - September 1994 to August 1995

Prepared by:

S.J.Stewart PhD., P.Eng. Project Engineer, Emissions and Data Analysis

Executive Summary by:

D.I.Gourley P.Eng. Manager, Emissions Testing and Standards

March 1996

FOREWORD

The Program Year Three Technical Review confirms that AirCare continues to be a most effective emissions inspection and maintenance programs in terms of vehicle repair and air quality benefits.

To remain effective, AirCare must maintain strong partnerships between diverse agencies and organizations. Of particular importance are the relationships between the Provincial regulating and environmental agencies, the program contractor and the certified repair industry. Each of which are critical to success in ultimately improving our community's air quality.

AirCare must also meet the tests of public acceptance, social and economic value. It is necessary to identify automobile-related emission reductions and to ensure that this program operates in partnership with other air quality initiatives.

I am pleased to advise that AirCare meets those challenges and remains the single-most significant contributor to the region's Air Quality Management Plan. And as such, continues to provide an important element to the growth, development and success of the Lower Mainland of British Columbia.

M. A. (Martin) Lay
Director,
AirCare® Program

March, 1996

EXECUTIVE SUMMARY

In April of 1995, the results of an independent audit of the British Columbia AirCare program performed by Radian Corporation were released to the public. This independent audit, performed by Radian Corporation, dealt with the first two years of the program's operation, covering the period from September 1, 1992 to August 31, 1993 . It included an estimate of the impact of the program on the regional air emission inventory as well as an evaluation of the program design and its operating policies relative to other programs in North America.

An analysis for the period September 1, 1994 to August 31, 1995 has been completed as a logical continuation of this effectiveness monitoring process. The analysis was performed by engineering staff in the AirCare Program Administration Office (PAO) utilizing Radian's methodology as much as possible. Where new or more complete data were available to replace or supplement assumptions made by Radian in their report, they have been used. Major findings of the analysis were as follows:

- As a result of the AirCare program, almost 54,000 tonnes of Hydrocarbons, Carbon Monoxide and Oxides of Nitrogen were prevented from being released into the Lower Fraser Valley airshed. Total benefits since testing began on September 1, 1992 exceed 165,000 tonnes. Yearly reductions by emission type are shown in the table below.

Pollutant	Emission Reductions 1992-1993 (tonnes/yr)	Emission Reductions 1993-1994 (tonnes/yr)	Emission Reductions 1994-1995 (tonnes/yr)	Total (tonnes)
HC	2900	4800	3500	11,200
CO	36000	68000	50000	154,000
NOx	95	460	225	780
Total	38,995	73,260	53,725	165,980

- The program continues to be very effective in terms of repairs. Analysis of 248 matched pairs of "before" and "after" HOT 505 test results conducted in the AirCare Constant Volume Sampling (CVS) facility confirms that 87% of the vehicles experienced a reduction in the emission(s) that initially resulted in the failure.

- The effectiveness of AirCare-related repairs is reflected in the fact that a greater percentage of vehicles passed the inspection in 1994-95 compared to 1993-94, suggesting that repairs made to failing vehicles were sufficient to allow many of them to pass their next AirCare inspection on the initial attempt. The decline in the failure rate from 14% to 10.4% reduced the number of vehicles required to have corrective maintenance performed and thereby reduced the tonnage of emissions reduction relative to the previous Program Year. This underscores the need to adjust the cut points periodically to address the ever-improving condition of the in-use vehicle fleet.

- Based on the above sample, the average reduction in fuel consumption as a result of repair was sufficient to account for a 0.73% reduction for the entire fleet. This is estimated to represent a savings of just under 12 million litres of gasoline, which translates to savings of over seven million dollars, and is equivalent to reducing CO_2 emissions by 28,000 tonnes.

- Changes recommended in the Radian study were not fully implemented during the reporting period described in this report. Significantly, changes to the cut points and repair cost limits were not implemented until the beginning of the fourth program year. It is anticipated that the benefits of the program in terms of tonnes of pollution prevented will increase substantially as a result of these changes.

Operating Statistics

- There were 1,002,566 individual vehicles inspected during the 12 month period. This was 11,331 fewer than the previous program year. Within the total, there were 283,176 vehicles identified as trucks (28.2%).

- There were 104,373 vehicles that experienced a failed test result. This represents an overall failure rate of 10.41%. There was a higher failure rate for trucks at 11.81% vs. 9.86% for passenger cars.

- The median model year of vehicles tested was 1988. Due to a trend towards higher sales of trucks in recent years, the median model year for trucks was newer, at 1989, than for passenger cars at 1988.

- Overall, 96.2% of vehicles tested were gasoline-powered. There were 17,177 diesel powered vehicles tested, 16,636 vehicles capable of operating on propane and 3945 vehicles capable of operating on natural gas. Trucks were found to be most likely to be operated on fuels other than gasoline with 12.4% running on diesel or alternative fuels. Only 1.6% of the passenger cars tested used diesel or alternative fuels.

- Despite the fact that there were 104, 373 vehicles that recorded a failed inspection, only 43,552 Repair Data Forms were submitted at the time of reinspection. No repair information was available for the remaining vehicles, although the data indicate that 85% of the failed vehicles recorded a reinspection result at some subsequent date. The remainder must be assumed to have been removed from the program area, voluntarily de-licensed or scrapped.

- Of the 1,013,897 vehicles inspected in the second year of the program (September 1, 1993 to August 31, 1994), 112,020 did not reappear in the third year of the program. Although some portion of this number may be assumed to have been scrapped, it is likely that motorists choices of combinations of short term insurance and licensing allowed the remaining vehicles to extend the period between tests to more than one year. There were 56,125 vehicles tested in Program Year 1 that were not tested in Program Year 2 but reappeared in Program Year 3, suggesting that the owners of these vehicles were able to obtain more than one year's operation from their AirCare inspection.

- In Program Year 3, there were 141,569 vehicles tested for the first time. This number includes approximately 18,725 vehicles of 1993 model year and 55,985 vehicles of the 1994 model year that would have been tested for the first time as a result of having being exempt from the program for the first licensing period. The remaining 66,859 vehicles were likely introduced to the fleet as a result of migration from other areas.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PART 1. - FLEET COMPOSITION AND FAILURE RATES IN PROGRAM YEAR 3.

The analyses explained in PART 1. are all concerned with characterising certain specific variables with respect to individual vehicles. This is not an operations report. Where numbers of vehicles, numbers of failures, and percentage fail rates are discussed, each vehicle is only counted once regardless of how many times it may have gone through inspection.

The overall fail rate for Program Year 3 was 10.41% (based on individual vehicles). 1,002,566 individual vehicles were inspected, comprising 719,390 passenger vehicles, and 283,176 trucks. Of these, 70,927 passenger vehicles (9.86%) and 33,446 trucks (11.81%) experienced a failed inspection.

Vehicle Type and Model Year

Figure 1. shows the number of vehicles inspected by model year, and by vehicle type. All vehicles are categorised as either Passenger Vehicles or Trucks. It is possible that a small number of trucks may have been incorrectly identified as vtype=P, because of the particular details of how passenger vehicles are defined. All pre-1969 vehicles are grouped together. No 1996 model year vehicles are shown even though a few 1996 passenger vehicles were actually inspected.

The median model year of the total fleet is 1988. Trucks are slightly newer than passenger vehicles, with a median model year of 1989 compared to 1988 for passenger vehicles. It should be noted that for the reporting period, 1995 and 1996 vehicles were not subject to the AirCare Program and therefore the median ages of the total in-use fleet will actually be less than those indicated by this analysis of AirCare inspections. The effects of the economic recession in 1982 and 1983 are still evident in the numbers of vehicles still in use.

Figure 2. is equivalent to Figure 1. except that it shows the number of vehicles that failed.

Figure 3. combines the information in the previous two charts to give percentage fail rates by model year and vehicle type. The failure rates for vehicles over 20 years old are very variable. There are few of these vehicles as a proportion of the fleet (3.4% of the fleet), and their failure rates are more likely to depend on such factors as maintenance history than on their particular age.

Vehicle Type and Fuel Code

Figure 4. shows a numbers of vehicles by fuel code, and by vehicle type. There are a number of different fuel codes used, with the defaults for almost all new vehicles being 'G' for gasoline and 'D' for diesel. Any conversions to alternative fuel require a change in fuel code. Most common alternative fuels are Compressed Natural Gas (CNG) and

Liquified Petrolem Gas (LPG) which in Canada is more commonly known as Propane. Gasoline is by far the most common fuel. 87.6% of all trucks, 98.4% of passenger vehicles, and 96.2% of all vehicles use gasoline. By comparison, the 20,581 vehicles capable of using CNG or LPG only account for 2.05% of the fleet. There are almost as many diesels as CNG and LPG combined. The numbers of non-gasoline vehicles by fuel code are shown in Figure 5..

Figure 6. shows the percentage fail rates by fuel code and vehicle type. Gasoline trucks and passenger vehicles have slightly lower failure rates than the overall fleet averages. Diesel failure rates are very low, but these vehicles undergo a different type of test than other vehicles and so their performance cannot be directly compared. Highest failure rates are for the alternative fuels. Overall, LPG vehicles are about 3 times more likely, and CNG vehicles are about twice as likely, to experience failure than gasoline. Figure 7. shows that the model year distributions for alternative fuel vehicles indicate a somewhat older fleet than the gasoline fleet; the median model year for all alternative fuel vehicles is 1985.

Inspection Centre

Figure 8. shows numbers of vehicles and number of failed vehicles by Inspection Centre. The table includes percentage failure rates. The number of vehicles inspected at each centre varies more or less in proportion to the number of inspection lanes at each centre. The different failure rates at each centre is attributable to differences in fleet composition in different geographic areas.

Inspection Month

Figure 9. shows numbers of vehicles and number of failed vehicles by inspection month. The table includes percentage failure rates. The number of vehicles inspected in each month is primarily influenced by the expected number of licence and insurance renewals. Failure rates in each month may indicate different types of vehicle being used at different times of year. However, there is also a general downwards trend in failure rate which continues the trend experienced during Program Year 2, and is a natural consequence of an effective improvement in levels of vehicle maintenance and longevity of repairs, and of the more effective and reliable technology used in newer vehicles.

PART 2. - THE REPAIR INDUSTRY IN PROGRAM YEAR 3.

Results of Certified Repairs

Figure 10. shows the numbers of vehicles reinspected by model year, and the numbers achieving each of the three possible results. All reinspections after certified repairs either pass or conditionally pass. There are two types of conditional pass: cost waivers are where the Repair Data Form (RDF) indicates that it would have cost more than the Repair Cost Limit (RCL) to completely correct the emissions problem; qualified waivers are where the RDF indicates no remaining emissions related defects on the vehicle, but it still fails.

The distribution of certified repairs by model year is the same shape as the distribution of failures by model year, as shown in Figure 2.. However the total number of certified repairs is only 43,552 which represents only 41.7% of the 104,373 vehicles that failed inspection. The natural time lag between failure and reinspection will always cause the number of failures and number of repairs in any given period to differ, but it appears that over half the failed vehicles are either being repaired at non-certified shops, or by their owners, or are being removed from use in the AirCare area.

Overall 67.6% of certified repairs pass the reinspection completely. A further 22.9% receive a cost waiver which indicates that these vehicles could have been repaired if the RCL did not exist. 1.1% of the reinspections were void or aborted inspections. The remaining 8.3% indicate vehicles that should be investigated further to establish what types of repair problem have been encountered. Vehicle model year does not seem to exert any significant influence on the success rate of certified repairs.

A measure of the rate of succesful repair can also be derived from the sample of vehicles which were subjected to CVS mass emissions testing. As a result of repairs, 215 of the 248 vehicles in this sample, experienced a reduction in the emission(s) that initially caused the failure. This effective repair rate, 87%, is consistent with the figure of 88% stated by Radian.

Average Emissions Reductions as a Result of Repairs

Table 1. and Figure 11 (a), (b) and (c) show the emissions in grams/kilometre before and after repair for vehicles in the different model year groups that were tested in the CVS testing program. These vehicles failed the AirCare inspection and were procured for CVS testing. Significant reductions of HC, CO and NOx emissions were achieved, and these reductions are in line with those indicated in the Radian report.

Cost of Certified Repairs

The cost shown in the following charts is the actual repair cost, equal to labour cost plus parts cost. Figure 12. shows the cost distribution for all repairs together with the distributions by reinspection result achieved. The mean, median, and upper quartile cost levels are indicated in the accompanying table. The mean cost of all repairs is $204.00. The mean cost of successful repairs is $208.00.

The Repair Cost Limits in effect during Program Year 3 are indicated in Figure 13., together with the cost distribution of all repairs broken down into the vehicle groups to which the RCLs apply. The table not only shows the mean, median, and upper quartile cost levels, but also the number of repairs done for more than the relevant RCL, and the percentage of repairs done for more than the relevant RCL.

Frequency of Certified Repair Actions

The Repair Data Form includes 29 different emissions control components or systems which can be involved in an emissions repair. Each item must be marked as OK, Not Applicable, Replaced, Repaired Cleaned or Adjusted, Reconnected, or Still Defective. Table 2. shows how many of each item received each type of repair action as part of certified repairs in each of the three Program Years.

PART 3. - STRATEGIC OBSERVATIONS

Profile of the Certified Repair Industry in Program Years 1; 2; and 3.

Table 3(b) shows the total number of active certified technicians and repair facilities in each Program Year. There has been a steady increase in both technicians and facilities as the program has progressed. Only active technicians and facilities are tabulated, meaning those that actually submitted at least one RDF during the Program Year.

Table 3(a) shows the number of technicians at repair facilities. This is the total number that were there at some time in the Program Year, they were not necessarily all there at the same time.

Number of technicians at repair facility	Number of active repair facilities with specified number of active technicians		
	92-93	93-94	94-95
1	227	202	220
2	159	184	183
3	73	91	84
4	44	46	53
5	18	27	21
6	8	14	13
7	5	11	6
8	0	2	1
9	0	0	1
10	1	0	1

(a)

Total number of active repair facilites	535	577	583
Total number of active technicians	1123	1339	1302

(b) TABLE 3.

Chronology of Vehicles Inspected in Program Years 1; 2; and 3.

The information presented in Table 4. is not self explanatory. It calls into question some of the basic assumptions upon which the calculations of overall achieved emissions reductions are based.

Immediately apparent questions include:

How did 56,125 of the vehicles that were inspected in Program Year 1, completely miss being inspected in Program Year 2 but come back again in Program Year 3?

Where did the 88,473 vehicles go that were not seen since Program Year 1?

Why did we inspect 141,569 vehicles for the first time in Program Year 3, considering that this number far exceeds the number of new registrations annually?

Possible contributing factors to an explanation include:

Vehicles taken off the road or moved outside the AirCare territory.

Short term policy (eleven months or less) taken out after inspection, converted to annual policy thereby missing one complete inspection Program Year.

Vehicle re-licensed with GVW over 5,000kg.

Vehicles registered for the first time in the AirCare territory , both new and used vehicles.

Vehicles relicensed after a period of non-use.

Vehicles that licensed during the Ebco-Hamilton labour dispute, April to July 1993.

AirCare program data is a complete record of all vehicles inspected. However, in order to quantify how significant each of the various possible factors listed above, actually is in practice, it will be necessary to analyse vehicle registration information. This analysis will form part of the continuing development of the overall emissions reduction calculation method.

CHRONOLOGY OF VEHICLES INSPECTED					in Program Years 1, 2 and 3 (Sep 01, 92 to Aug 31, 95)
552768	vehicles inspected in PY1				
	309466	of the	**552768**	were also inspected in PY2 and PY3	
	98704	of the	**552768**	were inspected again in PY2 but did not reappear in PY3	
	56125	of the	**552768**	were not inspected in PY2 but were inspected again in PY3	
	88473	of the	**552768**	were never inspected again	
1013897	vehicles inspected in PY2				
	605727	of the	**1013897**	were inspected for the first time	
	803173	of the	**1013897**	were inspected again in PY3	
	210724	of the	**1013897**	did not reappear in PY3	
1002566	vehicles inspected in PY3				
	141569	of the	**1002566**	were inspected for the first time	

TABLE 4.

Chronology of Conditional Passes in Program Years 1; 2; and 3.

The significance of the information presented in Table 5. is in identifying vehicles that receive multiple conditional passes, ie. they continue for periods exceeding one year without being repaired. The most significant group are those which have received a conditional pass in every year of the program. There are 524 such vehicles.

CHRONOLOGY OF CONDITIONAL PASSES					in Program Years 1, 2 and 3 (Sep 01, 92 to Aug 31, 95)
19932 got conditional pass in PY1					
2611	of the	**19932**	got another conditional pass in PY2		
	2087	of the	**2611**	must have passed or retired or been removed from the AirCare area in PY3	
	524	of the	**2611**	went on to get another conditional pass in PY3	
835	of the	**19932**	went through to PY3 before getting another conditional pass		
16486	of the	**19932**	must have passed or retired or been removed from the AirCare area in PY2 and still don't show up as a problem in PY3		
21736 got conditional pass in PY2					
19125	of the	**21736**	were first time conditional passes		
16925	of the	**21736**	must have passed or retired or been removed from the AirCare area in PY3		
2200	of the	**21736**	went on to get another conditional pass in PY3		
13663 got conditional pass in PY3					
10104	of the	**13663**	were first time conditional passes		

TABLE 5.

Vehicles That Failed But Were Not Reinspected, in Program Year 3.

The calculation described in PART 4. assumes that vehicles failing in Program Year 3. are also repaired and therefore achieve an emissions reduction benefit in Program Year 3. The time lag between failure and repair should approximately cancel out from one Program Year to the next. It is usually assumed that this time lag is about three months, which corresponds to the period for which a short term license can be obtained after failing the inspection. This assumption would indicate that almost all of the Program Year 3 failures would have been repaired by a date three months into Program Year 4. In fact 104,373 vehicles failed in Program Year 3. , and 84.3% of these failed vehicles had returned for a succesful inspection or reinspection by December 31, 1995 which is four months into Program Year 4. However, there were still 16,352 vehicles which had not returned for a succesful reinspection, (see Table 6.). Some of the various explanations mentioned in relation to the chronology of inspections, can no doubt be applied to the non-return of these vehicles. This situation confirms the need to quantify the importance of each contributing explanatory factor.

Vehicles that failed but were not reinspected	from Program Year 3 (Sep 01, 94 to Aug 31, 95)
1002567 vehicles inspected in PY3	
104373 of the **1002567** failed the inspection	
16352 of the **104373** had still not achieved a pass or conditional pass as of December 31, 1995	

TABLE 6.

PART 4. - BENEFITS ACHIEVED IN PROGRAM YEAR 3.

Overall Emissions Reductions in Program Year 3.

The cornerstone of the calculation method introduced by Radian and, for the sake of continuity, retained for this report, is to estimate percentage differences in fleet emissions rates between the non-I/M situation and the I/M situation, and then apply these percentages to the GVRD emission inventory forecasts for 1995, to give a reduction expressed as tonnes of emissions. Figure 14. reproduces Table 3. from the Radian Report to show how their percentage reductions were calculated

Table 3

Estimated Emission Reduction per Vehicle From AirCare Program Comparison of Radian's Calculated Emission Reduction with MOBILE5a Predictions

Observed Reductions	Non I/M (g/km)			I/M (g/km)			% Reduction		
Model Year Group	HC	CO	NO_x	HC	CO	NO_x	HC	CO	NO_x
< 1981	2.4	22	2.0	1.9	17	1.8	23	24	6.2
1981-1987	1.5	16	1.4	1.2	12	1.5	18	25	--.6
1988 +	0.31	3.9	0.54	0.24	2.9	0.51	23	24	5.8
Overall	1.03	11	1.3	.82	8.1	1.25	20	24	2.7
MOBILE5A Predictions (Overall)	1.34	16.4	1.71	1.07	13.2	1.68	20	20	1.0

.

Emission rates are derived from the results of before-and-after-repair CVS tests performed at the AirCare Research Centre. Radian only distinguished two types of vehicle condition from these results: the before-repair result was used to characterise failing vehicles; and the after-repair result was used to describe passing vehicles as well as those that have been repaired. Radian also introduced the super-emitter vehicle condition description. The present analysis separates first-time-passing vehicles from repaired-vehicles, thus giving four possible vehicle conditions. A distinction is also made between failures for HC and/or CO, and failures for NOx. The emission rates used for the four possible vehicle conditions are shown in Table 7.. The 'Failed Condition' and 'After - Repair' condition rates are taken from Table 1.; 'First Time Pass' rates are derived from CVS data and from original certification standards; 'Super Emitter' was defined by Radian as HC and CO twenty times the certification standard.

EMISSIONS RATES (gram/km)

Age Group	**First Time Pass**			**Failed Condition**			**After Repair**			**Super Emitter**		
	HC	CO	NOx	HC	CO	NOx	HC	CO	NOx	HC	CO	NOx
< 1981	1.25	9.89	1.94	3.73	36.67	3.21	1.92	22.75	2.02	-	-	-
'81 - '87	1.25	9.90	1.94	1.79	29.31	2.99	1.16	14.89	2.35	-	-	-
≥ 1988	0.26	2.13	0.63	0.65	12.00	1.59	0.37	5.37	0.85	5.12	42.5	-

TABLE 7.

Radian split the fleet into three age groups, and this very simple split has been retained for the present. Within each age group the numbers of passing-first-time; failing; and repaired vehicles is calculated from an analysis of all the inspection records for the Program Year. It is assumed (following Radian) that 1% of all 1988 and newer vehicles are actually super-emitters.

The overall emission rates for each age group are calculated by performing an average of the different vehicle condition emission rates, weighted by the number of vehicles corresponding to each condition. The distinction between HC and/or CO failures, and NOx failures carries through this calculation. Radian applied the repaired-vehicle HC and CO emissions rates to all repaired vehicles including those that only failed for NOx. The present analysis has applied repaired-vehicle HC and CO emissions rates to vehicles that were repaired for failing HC and/or CO, and the repaired-vehicle NOx emission rates to vehicles that were repaired for failing NOx. Where a vehicle failed both for HC and/or CO and NOx, the repaired-vehicle HC, CO and NOx emission rates have been applied.

AGE GROUP	VEHICLE COUNT	Non I/M (gram/km)			I/M (gram/km)			% Reduction		
		HC	CO	NOx	HC	CO	NOx	HC	CO	NOx
< 1981	130036	1.81	15.84	1.99	1.40	12.78	1.94	22.47	19.32	2.27
'81 - '87	338992	1.32	12.27	1.98	1.24	10.51	1.95	5.87	14.36	1.15
≥ 1988	533539	0.31	2.73	0.63	0.26	2.22	0.63	17.02	18.6	0.92
OVERALL	1002567	0.85	7.66	1.26	0.74	6.40	1.25	12.35	16.45	1.25

TABLE 8.

The averaging calculation is performed twice. The first time through establishes the non-I/M typical emissions rates for the age group by treating all failures as remaining that way. The second time through assumes that all the failed vehicles are changed into repaired vehicles. The differences between the two sets of results is the difference between having the AirCare Program and not having the AirCare Program.
The percentage differences for the three age groups are then combined to give overall percentage differences for the fleet. The average is weighted by the number of vehicles in each age group and by the amount of use those vehicles experience. (Table 8.) Radian gave no details of the weighting factors they used, but they appear to have only considered the number of vehicles and ignored the usage.

	HC	CO	NOx
Emissions reduction achieved by applying % changes to GVRD mobile source inventory	tonnes 3249	tonnes 46063	tonnes 213
AirCare Inventory Reduction	3523	49960	231

TABLE 9.

The overall percentage differences are applied to the GVRD mobile source emissions inventory to give tonnes reduction. Then an additional HC reduction is included for evaporative emissions. The present calculation has assumed the same reduction (840 tonnes) in evaporative emissions as Radian published last year. To adjust from the GVRD geographic are to the AirCare area a multiplying factor of 1.085 is applied to the result. (The GVRD light-duty vehicle inventory only includes 92.2% of the inventory affected by AirCare). Radian did not make this adjustment.

The results of this analysis are shown in Table 9. The overall reductions achieved are less than those published by Radian for Program Year 2 (see Figure 15. which reproduces Radian Table 4.), the main reason for which is the lower failure rates experienced in Program Year 3. Radian applied the August 1993 failure rate of 14% to the whole of Program Year 2, even though the rate had dropped to 11% by August 1994. The overall failure rate for Program Year 3, as used in the present analysis, was 10.41%.

Table 4

Estimated Tonnes per Year Benefits for AirCare Program

	HC		CO	NO_x
	Exhaust	Evaporative		
GVRD Light-duty vehicle emissions inventory (1995)	19,500	8,000	280,000	17,000
Radian's percent reduction estimate	20%	10%	24%	2.7%
Current Estimated Emission Reduction (tonnes/yr 1995)	3,900	840	68,000	460
GVRD Emission Reduction Estimates(tonnes/yr 1995)	6,865		84,000	500
Current Reductions (% of Design)	69%		81%	91%

Note: Exhaust and evaporative emission inventory was determined by multiplying GVRD VOC inventory by exhaust and evaporative fractions from MOBILE5C.

Overall Fuel Consumption Reduction in Program Year 3.

Fuel consumption savings have been calculated in much the same way as the emissions reduction calculation. The overall fuel consumption reduction is almost 12 million litres, as shown in Table 10., which is equivalent to reducing CO_2 emissions by 28,000 tonnes.

	AGE GROUP	
Percentage Change in Fuel Consumption	1 2 3	0.65 1.85 0.17
	OVERALL	0.73
Fuel consumption reduction		

achieved by applying % change to total Vkmt	litres	11,933,176

TABLE 10.

PART 5. - DEVELOPMENTS TO BE IMPLEMENTED IN PROGRAM YEAR 4.

Using analyses based on data from Program Year 3 there were a number major developments to the program, to be implemented at the start of Program Year 4. These will be briefly described here, and their impact on the program during Program Year 4 will be reviewed thoroughly in the next annual report.

Changes to Maximum Allowable Inspection Readings

A stricter standard means a standard more closely matched to how a particular vehicle should perform when it is running properly. So because of the wide range of different vehicles affected, it was necessary to increase the number of categories that the inspection uses to determine the appropriate cut-point for any particular vehicle. Up to the end of Program Year 3 there were only 12 categories. At the start of Program Year 4 these were replaced with 46 new category definitions. The category to which a vehicle is assigned depends on three things: Model Year; Engine Size; and Vehicle Type.The cut-points were decided after analysing the results of all the inspections done between Dec 01, 94 and Apr 31, 95 (about 500,000 inspections). The actual distributions of how many vehicles achieved what emissions levels were examined for each part of the tailpipe test. This allowed the cut points to be chosen so that only high emitting vehicles would fail, and so that properly running vehicles would consistently pass. It also allowed identification of what a typical good result would be. The results of CVS mass emissions tests were correlated with the inspection data to confirm that the chosen cut-points would not produce undesirable errors of comission, and that errors of omission would be minimised.

Information Re. 'Good' Readings

'Good Reading' information now appears on every Vehicle Inspection Record . The definition of a good reading has been kept simple. 25% of all the vehicles in the category will be able to achieve a reading as good as, or better than, the suggested good reading.

Implementation of a Repair Effectiveness Index (REI), and Report

The major revisions of vehicle category definitions, and reductions in maximum allowable readings indicated a need for more sophistication in the feedback reports provided to technicians. The new reports include much more comprehensive information than previous reports, and will be issued quarterly.

For each vehicle the report includes the vehicle make, model year and engine size; the initial inspection readings; the reinspection readings; the reinspection result; and the REI for the repair. Previous reports only gave information about numbers of reinspection passes, conditional passes, and qualified waivers. It is hoped that technicians will find the actual vehicle readings useful in reviewing their own assessments of how effective each repair was. The REI is the PAO's assessment of how effective the repair was.

The report includes a count of the total number of repairs in the quarter, and the Technician Effectiveness Index, TEI which is equal to the average REI.

Increasing the Repair Cost Limits

The Repair Cost Limits were scheduled to be increased by between $50 an $100 on January 01, 1996. This will increase the number of certified repairs that can be completed within the RCL and therefore result in an increased repair effectiveness.

Introduction of Full Emission Components Inspection

Also scheduled for implementation during Program Year 4 was the introduction of a full inspection for tampered, missing, or faulty emission control components. This will increase the number of vehicles which fail the inspection, and because the Repair Cost Limit for such failures is either set at $1000 or is non-existent, it is intended to result in all such failures being repaired completely.

Re-Certification of Technicians

Technician certification is valid for three years, so Program Year 4 will see the re-certification of the majority of technicians. The re-certification process has been designed to be more demanding than original certification so as to reflect the practical experience that has been accumulated through three years of practice and also the more difficult repairs which may be required as a result of cut-point changes. The ongoing professional development of technician competence will result in improved repair effectiveness.

Validation of Reductions Calculation Method

The validity of the GVRD inventory is hypostatic to the Radian method of calculating the tonnes of emissions reduction . Other calculation methods are also possible which instead of applying a percentage reduction to an accepted inventory level, rely on totalling all the emissions reductions that are achieved for all the vehicles affected by the Program. However, this approach requires accurate data on annual vehicle-kilometres-travelled and individual vehicle emissions rates. It is intended to continue refining and validating the alternative approaches as a means of providing input to GVRD inventory validation. As the inventory is improved and validated, the different approaches to the reduction calculation will converge to give coincident answers.

Future calculations of emission reductions will implement greater sophistication in the way the total light-duty fleet is modelled. For example, splitting the light-duty vehicle fleet into just three groups dependent on model year is the most basic split that could be used. As explained in SAE 950482 it is more valid to split Canadian specification vehicles by emissions control technology than by model year. Ibidem described 4 technology groups. This should be expanded to 5, so as to distinguish MPFI TWC vehicles from other TWC vehicles. There should also be a split for different vehicle types: Passenger vehicles; light-duty trucks; and heavy-duty trucks.

Further distinctions are desirable to distinguish the five possible components of any particular failure, and recent work on Repair Effectiveness Index is also leading to a much more sophisticated model of how much emissions improvement is achieved by actual repair actions. The REI work has only examined certified repairs. A common assumption is that all other failed vehicles are repaired completely so as to pass the inspection eventually. The present analysis continued this assumption, but has assumed the same average after-repair emissions from both certified and non-certified repairs. The information presented in PART 3. of this report indicates that the assumptions about how many vehicles are repaired; or taken off the road; etc. need much more thorough examination.

The overall vehicle fleet can only be modelled adequately with all the desired distinctions of technology level; failure mode; repair effectiveness; and retirement/usage pattern, if each subgroup is also represented by a significant sample of vehicles that have been through the before-and-after-repair CVS testing program. CVS testing is the only way we can confidently assign true emissions rates to each subgroup. The present group of just over 250 complete before-and-after-repair cases is still far too few to make all the distinctions that should be made.

Future calculations of program effectiveness in terms of tonnes of emissions reduced, and fuel consumption saved, will benefit from the continued efforts to improve the accuracy and resolution of the modelling on which the calculation relies. This is an ongoing activity.