

AirCare[®]

Evaluation of Benefits

Program Year Six

September 1997 to August 1998

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Abstract

This report represents an analysis of the cumulative benefits of 6 years of operation of the AirCare program, spanning the period between September 1, 1992 and August 31, 1998. During this period, over 6 million inspections were performed on a total of over 1.5 million individual vehicles. Inspections were performed at centralized, test-only inspection centres according to an ASM 2525/Idle test procedure. Measurements of HC, CO under loaded and idle conditions as well as NOx emissions under loaded operation were compared to program-specific cut points to assess whether vehicles passed or failed. Almost half a million vehicles failed an AirCare inspection at least once in the first 5 years of operation. While some of these vehicles have been retired from use or removed from the area, the vast majority have received repairs which resulted in reduced emissions for at least two years. The cumulative effects of these repairs represent a reduction in emissions of over 30% relative to the pre-AirCare baseline. A further reduction of 25% due to the replacement of older vehicles with newer, lower-emitting vehicles can be added to this benefit, resulting in a total reduction in vehicle-related emissions of over 50% since 1992. The estimated fuel savings since 1992 are 29 million litres. This amount of gasoline would have produced 73 thousand tonnes of carbon dioxide and represents a significant contribution to reducing greenhouse gas emissions.

This addendum supplements the previously-released report entitled 'Program Review and Evaluation of Benefits – Program Years One to Five'. It contains information specific to the program year 6, which commenced September 1, 1997 and concluded August 31, 1998.

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Emissions Reductions

The methodology used to calculate emission reductions was described in the report entitled 'AirCare Program Review and Evaluation of benefits – Program Years One to Five'. The same approach has been retained. The increased amount of data available from one further year of laboratory testing enabled the emission factors used in the calculation to be reviewed. Although the review suggested that some small adjustments could be made, it was decided to keep the same factors. This allows direct comparison of the achievements of each year's contribution to overall emission reductions. It is intended that the factors will be completely updated at the expiration of the current program in 1999.

Tables 1, 2 and 3 summarize the emission reductions that have been achieved after six years.

Light-Duty Vehicle Emissions Benefits as a Result of AirCare Program

AirCare attributable benefits	HC	CO	NOx	HC+CO+NOx	HC+(CO/7)+NOx
Percentage reduction from Pre-AirCare	27.6%	31.5%	8.6%	30.1%	25.9%
GVRD tonnes/year reduction	9,788	107,647	1,640	119,065	
LFV tonnes/year reduction	10,620	116,797	1,780	129,197	

TABLE 1

Light-Duty Vehicle Emissions Benefits as a Result of Vehicle Fleet Turnover

Vehicle fleet turnover reductions	HC	CO	NOx	HC+CO+NOx	HC+(CO/7)+NOx
Percentage reduction from Pre-AirCare	31.7%	25.8%	14.5%	25.8%	25.7%
GVRD tonnes/year reduction	11,242	88,131	2,766	102,139	
LFV tonnes/year reduction	12,197	95,622	3,001	110,820	

TABLE 2

Combined AirCare and Fleet Turnover Benefits

Total	HC	CO	NOx	HC+CO+NOx	HC+(CO/7)+NOx
Percentage reduction from Pre-AirCare	59.2%	57.3%	23.1%	55.9%	51.7%
GVRD tonnes/year reduction	21,030	195,778	4,406	220,214	
LFV tonnes/year reduction	22,817	212,419	4,781	240,017	

TABLE 3

The emissions reduction calculation process yields an overall cumulative emissions benefit from six years of the AirCare program of **27.6%** for **HC**, **31.5%** for **CO** and **8.6%** for **NOx** relative to the pre-AirCare baseline level.

The cumulative reduction of combined HC, CO and NOx emissions directly attributable to the AirCare program is 30.1% compared to the pre-AirCare baseline of 1992. The contribution of new vehicle emission technology is estimated at 25.8% yielding a total reduction of 55.9% in light duty vehicle emissions since 1992.

These percentage reductions have been applied to the GVRD Light-Duty Vehicle Inventory to give tonnage reductions. Multiplying the GVRD inventory by a factor of 1.085 gives an indication of the entire Lower Fraser Valley inventory.

After discounting the reductions in carbon monoxide by a factor of 7, the weighted total emission reduction of VOC's, CO and NOx amounts to 29,085 tonnes/year directly attributable to the AirCare program and 28,858 tonnes/year from the replacement of older vehicles with new vehicles with better emissions control technology.

Figures 6 to 10 start in 1992, and each sub-figure shows two lines. The upper line is how the inventory would have changed if the AirCare program had not existed. The lower line shows the actual case with AirCare included. Tonnages shown in Figure 7 are for the GVRD inventory. Figure 8 shows the tonnage reductions for the Lower Fraser Valley.

The percentage reduction charts in Figures 9 and 10 also include vertical columns indicating the growth in vehicle kilometres traveled per year (annual Vkmt).

Fuel Savings

The previous report included an explanation and analysis of how fuel consumption can be affected by emission repairs. Using the same method for estimating the amount of fuel savings achieved, up to the end of August 1998, results in total fuel savings of 29 million litres in six years. These fuel savings translate directly into a reduction of greenhouse gas emissions of 73,000 tonnes of carbon dioxide.

Vehicle Fleet Inspected

1,022,874 individual vehicles were inspected in program year six, comprising 689,058 passenger vehicles, and 333,816 trucks

The vehicle fleet subject to AirCare testing appears to be shrinking slightly with 1,022, 874 vehicles tested in Year 6 compared to 1,060,344 in Program Year 5. Table 4 shows the number of individual vehicles tested in each Program Year. An initial fleet size of 950,000 was assumed for 1992-1993. Based on an expected fleet growth of 3% per annum, a 'projected' figure is shown. Beside the projected figure is the actual number of vehicles inspected. Lower numbers of vehicles were tested in Program Years 1 and 4 due to strikes that closed the inspection centres temporarily.

Program Year	Projected	Actual
1992-1993	950,000	507,616
1993-1994	978,500	1,016,528
1994-1995	1,007,855	1,002,566
1995-1996	1,038,091	550,668
1996-1997	1,069,233	1,060,344
1997-1998	1,101,310	1,022,874

TABLE 4

Figures 1 and 2 show the growth in the total number of vehicles that have been inspected up to the end of each program year. Even in the sixth year of operation there were still significant numbers of older vehicles that were tested for the first time. It is assumed that these vehicles are mostly brought in from out of the region, and therefore the fleet growth in the region does not entirely comprise new vehicles.

Approximately 58,523 1997 model year vehicles were added to the program in the first 8 months of 1998. These vehicles were exempt from testing in Program Year 5. However, given that there were 37,470 fewer vehicles tested in total in Program Year 6 compared to Program Year 5, it appears that over 90,000 vehicles were removed from the fleet. The historical rate of attrition or retirement is between 40,000 and 50,000 vehicles per year, suggesting that, either a greater number of vehicles were retired from use during the period, or motorists are finding ways of skipping inspections.

Relatively few vehicles have received more than an expected number of inspections. Table 5 shows the number of inspections per vehicle. Vehicles that have simply passed every year have up to six inspections (depending of their model year). The number with seven or more inspections drops off very rapidly.

Figure 11 shows the number of vehicles inspected in year six by model year, and by vehicle type. All vehicles are categorised as either Passenger Vehicles or Trucks. All pre-1969 vehicles are grouped together.

The median model year of the inspected fleet was 1990 in program year six. Truck median model year was 1991, whereas passenger vehicle median model year was slightly older at 1990. It should be noted that the median ages of the total in-use fleet will actually be less than those indicated by this analysis of AirCare inspections, because AirCare inspection is not required until a vehicles second year.

Trucks made up 32.6% of the vehicles tested, up from 28% in Year 5 and 23% in Year 1. This trend reflects the growth in sales of trucks, which now represent about half of the new vehicles sold each year.

Among car manufacturers, General Motors had the greatest representation with 177,649 vehicles tested. General Motors accounted for a further 95,538 trucks, bringing their total share to 273,187, or 26.7% of the fleet. Ford is next with 177,617 vehicles, or 17.4% of the fleet. Chrysler accounted for 157,240 vehicles, or 15.4% of the total. Import manufacturers were led by Toyota with 101,408 vehicles, followed by Honda with 99,579. Vehicles built by these 5 manufacturers comprise 79% of the vehicles tested in Program Year 6.

Number of Inspections or Failures	Number of Vehicles with Specified Number of:	
	Inspections	Failures
1	257330	245117
2	250533	113244
3	232026	54241
4	282121	26975
5	318336	13372
6	151004	6550
7	66563	3215
8	33506	1596
9	17254	864
10	8884	484
11	4569	247
12	2386	127
13	1227	76
14	673	53
15	348	28
16	216	16
17	111	14
18	70	6
19	46	3
20	21	2
21	15	1
22	9	1
23	9	
24	2	1
25	2	1
26	2	1
27	0	2
30	2	
31	1	
32	1	
34	1	
49	1	
120	1	
2012	1	

TABLE 5

Figure 14 shows 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 Liquefied Petroleum Gas (LPG or propane). Gasoline is by far the most common fuel. Vehicles capable of using CNG or LPG now account for less than 2.0% of the fleet. There are now more diesels than CNG and LPG combined. The numbers of non-gasoline vehicles by fuel code are shown in Figure 15.

Since 1992, the total number of diesel vehicles in the light-duty fleet has remained fairly constant. However, there has been a distinct change in the profile of the light-duty diesel fleet. In 1992-93, over half (54%) of all diesels were passenger cars. In 1998-99, passenger cars only account for 34% of diesels. There has been a corresponding increase in the number of light-duty diesel trucks, with almost all the growth occurring in trucks

which are classed as heavy light-duty. These are trucks with a gross vehicle weight rating (GVWR) of 8500lbs or more.

There have been very few new diesel passenger cars added to the fleet. The total number of diesel passenger cars has dropped from 9626 in 1992-93 to 6381 in 1998-99. This number is made up almost completely of only three makes: Mercedes, Volkswagen and Volvo. The number of diesel Volvos is decreasing steadily because they have not been available since model year 1986. The number of new Mercedes diesels sold each year is very small. Even Volkswagens annual sales have not even approached 200 new diesels since 1986.

There are now two very distinct groups of vehicles within the light-duty diesel fleet. The first group comprises heavy light-duty trucks manufactured by Ford, GMC and Chrysler and accounts for 54% of all light-duty diesels. Most are less than 10 years old (42% of fleet). The second group (30% of fleet) comprises passenger cars manufactured by Mercedes, Volkswagen, and Volvo. Most of these are over ten years old (21.5% of fleet). The remaining diesel vehicles are a variety of smaller diesel trucks, and some cars and heavy light-duty trucks, by other manufacturers (16% of fleet).

Failure Statistics

Figures 3 and 4 show the growth in the total number of vehicles that have failed (once or more times) up to the end of each program year. The number of newer vehicles which have experienced failure is still small, but for older vehicles the consistent pattern is an indication that different vehicles fail each year, and that an emissions inspection failure is almost an expected event at some time. Of the total of 1,627,054 unique vehicles inspected to the end of year six, there were 466,237 that had experienced failure once or more times.

Table 5 shows that most vehicles that have failed have only failed once. The numbers with two or more failures drops off very rapidly.

Figure 12 shows the number of vehicles that failed in program year six. Figure 13 combines the information from Figures 11 and 12 to give percentage fail rates by model year and vehicle type

The overall failure rate in Program Year 6 was 10.7%, representing 109,535 vehicles. This compares with 13.53% in Program Year 5 and 14.49% in Program Year 4. The decline in failure rate over the years is expected as the stringency of the cut points used has not changed since 1995 and because the program has been effective at identifying and correcting problems with excess emitting vehicles. This has caused the number of high emitters in the fleet to continually decline. In a mature program, such as AirCare, the failure rate represents the number of vehicles that have developed new emission related defects since their last inspection or re-inspection.

The failure rate for passenger cars and trucks was almost exactly the same, at 10.61% (73,106 passenger vehicles) and 10.91% (36,429 trucks) respectively.

As expected, the failure rate increases with age. New vehicles have shown very good performance in AirCare testing and appear to be less susceptible to developing problems in their first years of use. Vehicles that have been subject to AirCare testing since new have maintained a low failure rate. Of the 109,535 vehicles that failed, only 4,821 of the passenger cars, and 3,350 of the trucks were from model year 1992 or later.

The largest number of failed vehicles is found for the 1988 model year for both cars (7909 failed vehicles) and trucks (3166 failures). This is due to the fact that a large number of these vehicles remain in service, but have reached the age and mileage where emission-related defects are likely to occur.

More 1981 model year vehicles have failed the inspection than any other year. The number of failures per model year drops off significantly for vehicles older than 1980 (because there are very few vehicles), or newer than 1991 (because they are much less likely to fail).

Table 6 is derived from the vehicle technology group analysis performed in order to calculate emission reductions. The analysis distinguishes between vehicles that passed at their first attempt and those which had previous failures. This requires data from the previous year to be taken into account as well, and therefore the total numbers shown in this table are not exactly the same as simple Year Six numbers as stated elsewhere in this report.

There is a clear relation between vehicle technology and failure rate. Pre-control vehicles have the highest failure rate, although there are not very many failed vehicles. The largest group of vehicles are 1988 and newer passenger vehicles, and these have the lowest failure rate at only 6%. Trucks with three-way catalysts are almost all from model year 1988 or newer, and their failure rate is also low at 7%.

PROGRAM YEAR SIX Sep 01, 1997 to Aug 31, 1998

Vehicle Group	Number of Vehicles			Percentage of Vehicles in Group	
	Number of Vehicles in Group	Passed at First Attempt	Failed	Passed at First Attempt	Failed
Pre control basic mixture	9277	6370	2907	69%	31%
Oxidation	67594	49792	17802	74%	26%
Pre 88 TWC	91443	67318	24125	74%	26%
Trucks with TWC	122799	103877	18922	85%	15%
88 and later TWC	275894	256917	18977	93%	7%
	448775	424021	24754	94%	6%

TABLE 6

Due to the fact that the fleet is inspected every year and failing vehicles are directed for repair, vehicles that fail one year are likely to pass the next while others that passed the previous year may fail. Since the AirCare program began in 1992, over 1.6 million unique vehicles have been tested. Although the number of vehicles failed in a single program year has never exceeded 160,000, there have been 330,755 passenger cars and 135,482 trucks that have failed an inspection at some point in the first 6 years, or about 30% of the vehicles that have ever been inspected.

Figure 16 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. Highest failure rates are for the alternative fuels. Overall, LPG vehicles are about 4 times more likely, and CNG vehicles are about 3 times more likely, to fail than gasoline. Figure 17 shows that the model year distribution for alternative fuel vehicles indicate a somewhat older fleet than the gasoline fleet; the median model year for all alternative fuel vehicles is still 1985.

The failure rate for diesel vehicles continues to be extremely low. This is partly because these vehicles are subject to a different type of test than all other vehicles.

Figure 18 shows number 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 rate at each centre is attributable to differences in fleet composition in different geographic areas.

Figure 19 shows numbers of vehicles and number of failed vehicles by inspection month. The table includes percentage failure rates.

Certified Repairs

Since the program started in 1992, one recurring concern has been the possibility that the provisions for conditional pass might be abused. Of particular concern are vehicles which receive a conditional pass (or waiver) every year, and are therefore never actually repaired. Table 7 shows the numbers of vehicles that have received different numbers of re-inspections and waivers. Only 15 vehicles have actually received a waiver six times. The vast majority of vehicles that ever need a waiver, only receive one. The implication is that for the

most part, the system is working as it was intended. Thus, the conditional pass, or waiver, is being used to allow time for completion of necessary repairs, before inspection is required again in the next annual cycle.

Figure 20 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.

Overall 67.7% of certified repairs in year 6, passed the reinspection completely. A further 18.1% received a cost waiver. 1.9% of reinspections were void or aborted inspections. 12.7% received qualified waivers

TABLE 7

The actual repair cost is equal to labour cost plus parts cost. Figure 21 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 tables. The mean cost of all repairs was \$254 in year 6. The mean cost of successful repairs was \$256.

The Repair Cost Limits in effect during each program year are shown in Figure 22 together with the cost distribution of all repairs broken down into the vehicle groups to which the RCLs apply. The associated table not only shows the mean, median, and upper quartile cost levels, but also the number of repairs that exceeded the relevant RCL, and the corresponding percentages.

Model Year	Number of reinspections or waivers	Number of vehicles from model year or group of model years with specified number of reinspections or waivers			
		Reinspection	Waiver	Cost Waiver	Qualified Waiver
all	1	176317	67710	40858	37672
	2	41944	11728	5795	3240
	3	10271	2472	990	266
	4	2425	540	182	38
	5	506	115	32	4
	6	68	15		
pre 1986	1	108753	43680	26510	24342
	2	26772	7274	3533	1893
	3	6705	1526	619	149
	4	1590	338	113	19
	5	355	80	23	1
	6	52	13		
1986-1991	1	59926	22159	13634	12018
	2	13991	4197	2176	1229
	3	3361	919	364	105
	4	800	195	68	18
	5	145	34	9	3
	6	14	2		
1992	1	3408	943	418	636
	2	616	145	48	56
	3	129	17	6	8
	4	24	6	1	
	5	4			
	6	2			
1993	1	2230	524	192	365
	2	301	66	28	27
	3	52	4	1	1
	4	9	1		1
	5	2	1		
1994	1	1051	261	77	194
	2	140	26	7	17
	3	19	5		3
	4	2			
1995	1	603	99	24	76
	2	56	12	2	11
	3	3	1		
1996	1	265	31	1	30
	2	37	3	1	2
	3	2			
1997	1	80	13	2	11
	2	31	5		5
1998	1	1			

Table 8 shows the number of certified technicians per repair centre for each year of the program. The numbers have remained very stable. Most repair centres have only one or two certified technicians.

Since the start of program year 4 the Repair Data Form has included 33 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.

number of technicians at repair facility	Number of active repair facilities with specified number of active technicians					
	92-93	93-94	94-95	95-96	96-97	97-98
1	227	202	220	218	201	227
2	159	184	183	160	174	157
3	73	91	84	82	88	92
4	44	46	53	48	36	41
5	18	27	21	16	20	17
6	8	14	13	10	11	10
7	5	11	6	4	6	3
8	0	2	1	2	2	3
9	0	0	1	0	0	0
10	1	0	1	0	1	1
Total number of active repair facilities	535	577	583	540	539	551
Total number of active technicians	1123	1339	1302	1160	1191	1181

TABLE 8

Table 10 shows how many of each item received each type of repair action as part of certified repairs in program year 6.

AirCare Research Centre

During program year six the AirCare Research Centre continued to perform mass emission tests, both to support regular operations and for special projects. The IM240 cycle has become a frequent component in the overall testing strategy for newer vehicles. Its use will provide data that will support future decisions regarding appropriate test cycles and standards for the inspection program. The number of each type of test performed for various purposes is shown in Table 9.

AirCare Research Centre Activities and Projects

Reason for Test	epa75	Hot505	im240	Total
After Repair	7	633		640
Before Repair	13	964		977
Compliance Referee	25	30		55
Demonstration / Training	10	111		121
Diagnostic Support	206	290		496
Industry Support	149	191		340
Miscellaneous	93	422		515
Research	323	793	94	1210
Total	826	3434	94	4354

TABLE 9

INCIDENCE OF CERTIFIED REPAIR ACTIONS IN PROGRAM YEAR 6

C= reconnect
 D = defective and not repaired
 M = data missing from RDF
 N = not applicable
 O = item is OK
 R = replaced
 S = repaired, cleaned or adjusted

ITEM	ITEM #	C	D	M	N	O	R	S	Total
splugs	1	3	200	685	4664	28206	8426	635	42819
igwire	2	81	256	685	5012	33808	2969	8	42819
distr	3	1	158	685	7685	30090	3580	620	42819
spaadv	4	75	385	685	5115	33953	278	2328	42819
spatim	5	1	109	685	4099	26290	20	11615	42819
vaclea	6	438	763	685	114	33585	193	7041	42819
idlmix	7	1	631	685	6467	14317	39	20679	42819
idlspe	8	0	229	685	5526	17414	35	18930	42819
carinj	9	10	4120	685	6626	23675	1306	6397	42819
airfil	10	0	144	685	4006	29051	8205	728	42819
choke	11	17	356	685	17515	22856	179	1211	42819
tac	12	225	939	685	15094	24927	203	746	42819
pcv	13	55	163	685	6695	31216	2633	1372	42819
airinj	14	193	1332	685	23523	16196	227	663	42819
egr	15	605	1729	685	14611	20913	2225	2051	42819
evap	16	82	494	685	10727	30441	156	234	42819
gascap	17	2	64	685	15070	26925	71	2	42819
catcon	18	25	6764	685	10949	20245	4132	19	42819
ffr	19	1	230	685	17595	24184	106	18	42819
O2sens	20	72	675	685	21336	12239	7452	360	42819
tps	21	5	98	685	24984	16491	195	361	42819
wot	22	1	25	685	31428	10596	26	58	42819
map	23	32	45	685	27926	13940	128	63	42819
maf	24	6	105	685	35140	6641	62	180	42819
cts	25	12	62	685	22140	19584	270	66	42819
tvS	26	52	384	685	22274	19138	233	53	42819
othsen	27	16	257	685	21748	19845	193	75	42819
prom	28	9	587	685	24173	17056	241	68	42819
engine	29	1	4912	685	15398	21032	11	780	42819
pvalve	30	2	1631	726	25742	12897	672	1149	42819
cfloat	31	0	1218	717	25251	13652	651	1330	42819
egrpas	32	11	1290	717	17583	20874	14	2330	42819
egrctl	33	242	1061	720	17529	21518	563	1186	42819
other	34	16	706	773	20764	18643	1006	911	42819
Total		2292	32122	23518	534509	732438	46700	84267	

TABLE 10

Total number of unique passenger vehicles inspected up to end of each program year

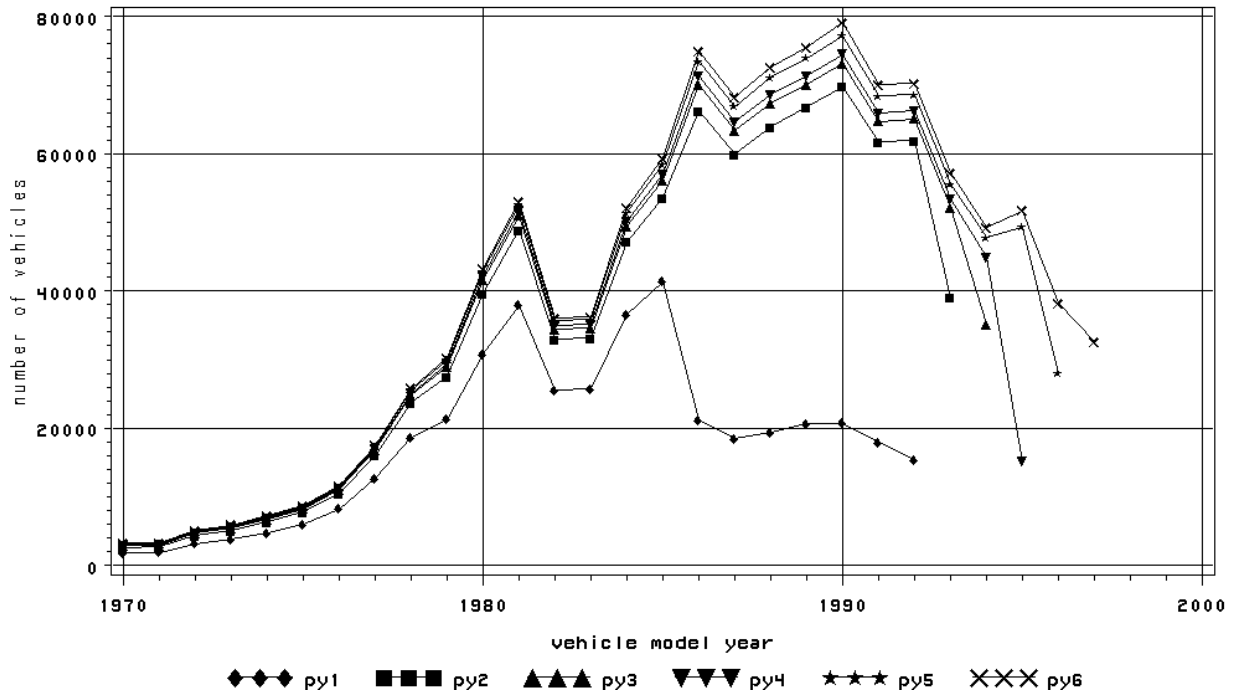


Figure 1

Total number of unique trucks inspected up to end of each program year

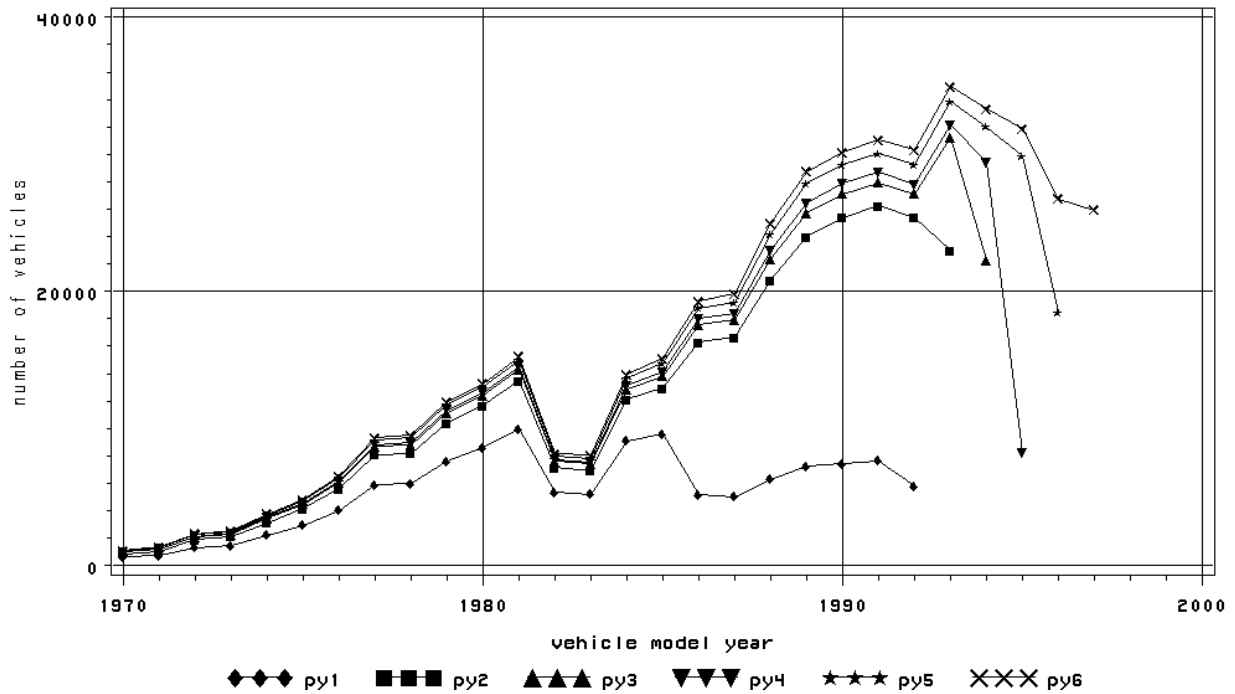


Figure 2

Total number of unique passenger vehicles failed up to end of each program year

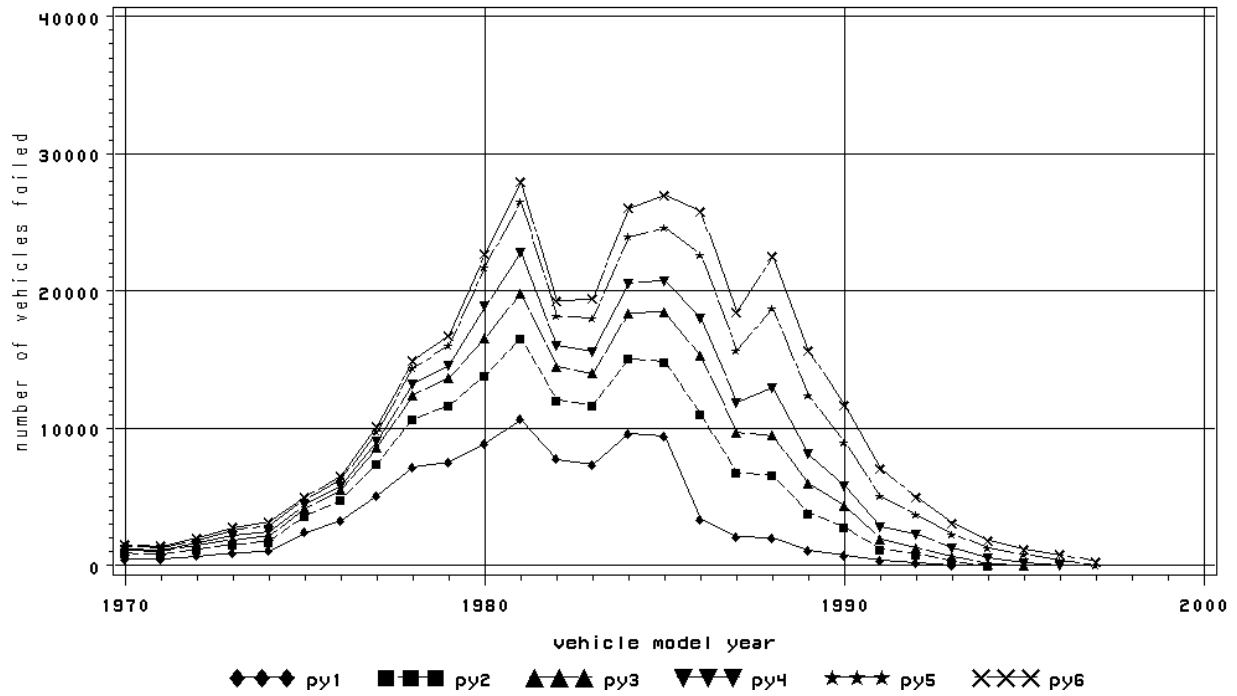


Figure 3

Total number of unique trucks failed up to end of each program year

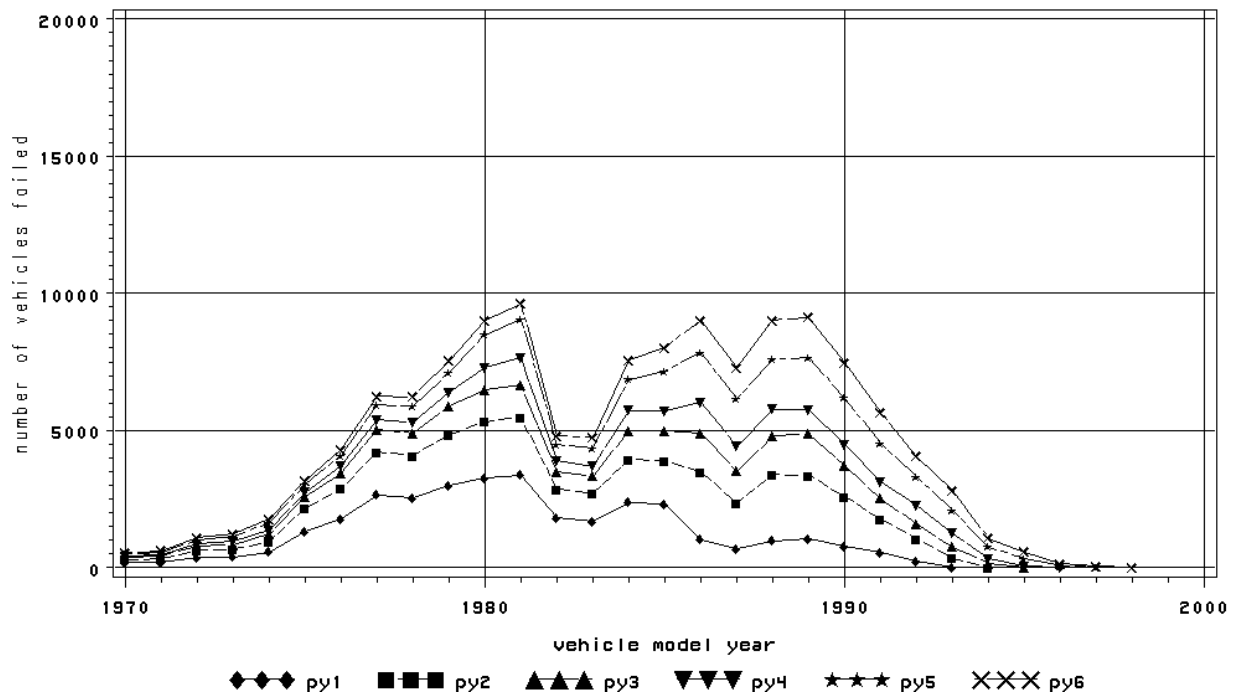


Figure 4

Distribution of Certified Repair Costs by Program Year

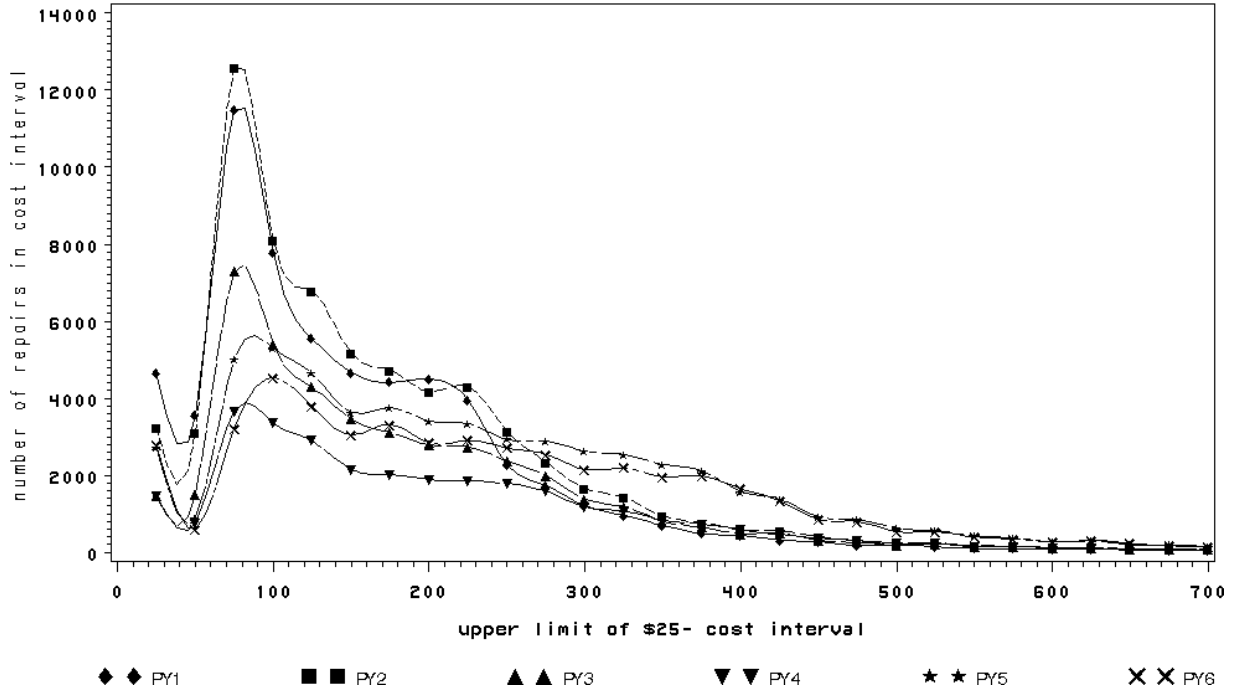
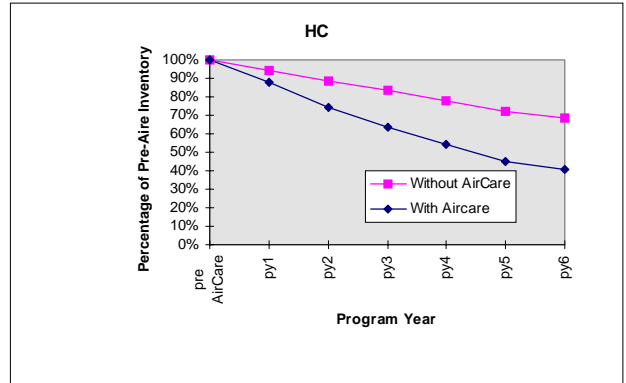


Figure 5

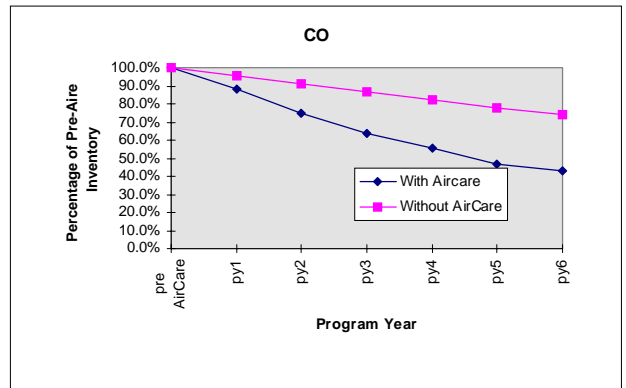
Percentage Reduction in Light-Duty Vehicle Annual Emissions Since Start of AirCare Program

HC					
	With AirCare	Without AirCare	Cumulative aircare attributable benefits	vehicle turnover inventory reduction	Total inventory reduction since pre AirCare
pre AirCare	100.0%	100%			
py1	88.1%	95%	6.4%	5.5%	11.9%
py2	74.5%	89%	14.0%	11.5%	25.5%
py3	63.6%	83%	19.9%	16.5%	36.4%
py4	54.2%	78%	23.9%	21.9%	45.8%
py5	45.0%	72%	27.3%	27.7%	55.0%
py6	40.8%	68%	27.6%	31.7%	59.2%



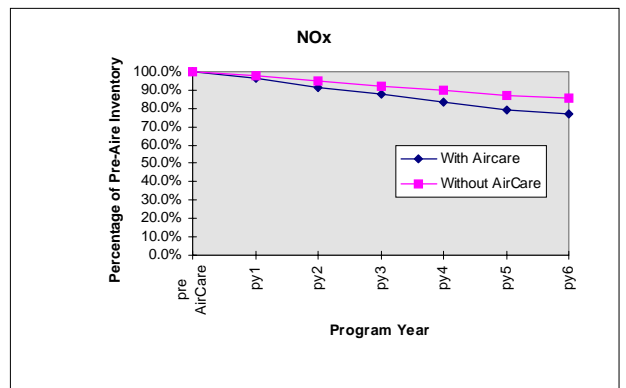
(a)

CO					
	With AirCare	Without AirCare	Cumulative aircare attributable benefits	vehicle turnover inventory reduction	Total inventory reduction since pre AirCare
pre AirCare	100.0%	100.0%			
py1	88.3%	95.5%	7.2%	4.5%	11.7%
py2	74.7%	90.7%	16.0%	9.3%	25.3%
py3	63.9%	86.7%	22.8%	13.3%	36.1%
py4	55.3%	82.4%	27.2%	17.6%	44.7%
py5	46.5%	77.5%	31.0%	22.5%	53.5%
py6	42.7%	74.2%	31.5%	25.8%	57.3%



(b)

NOx					
	With AirCare	Without AirCare	Cumulative aircare attributable benefits	vehicle turnover inventory reduction	Total inventory reduction since pre AirCare
pre AirCare	100.0%	100.0%			
py1	96.1%	97.5%	1.5%	2.5%	4.0%
py2	91.5%	94.7%	3.3%	5.3%	8.5%
py3	87.6%	92.4%	4.8%	7.6%	12.4%
py4	83.5%	90.0%	6.5%	10.0%	16.5%
py5	79.1%	87.2%	8.0%	12.8%	20.9%
py6	76.9%	85.5%	8.6%	14.5%	23.1%

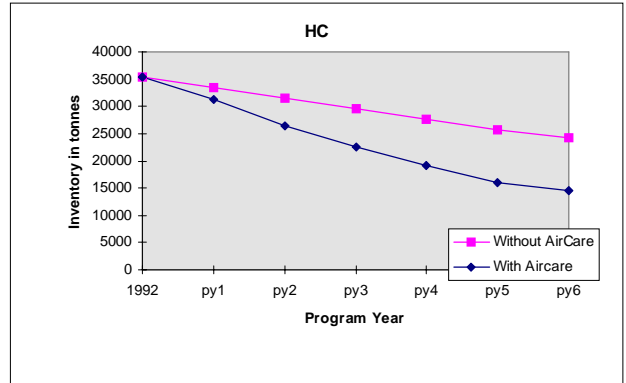


(c)

Figure 6

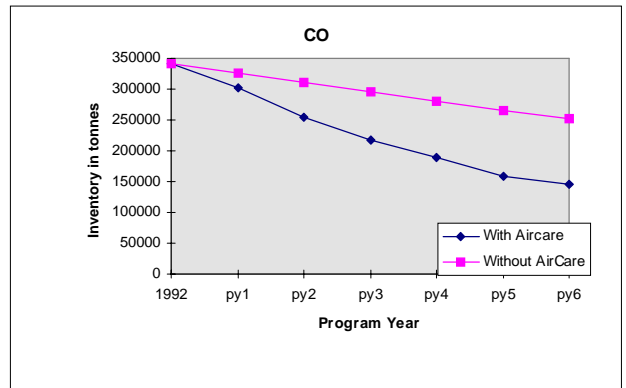
GVRD Light-Duty Vehicle Emissions Annual Tonnage Since Start of AirCare Program

HC					
	With AirCare	Without AirCare	Cumulative aircare attributable benefits	vehicle turnover inventory reduction	Total inventory reduction since 1992
1990	-	40109	-		
1991	-	37903	-		
1992	35515	35515	-		
py1	31289	33562	2273	1953	4226
py2	26467	31447	4981	4068	9048
py3	22571	29645	7074	5870	12944
py4	19251	27739	8488	7776	16264
py5	15967	25670	9703	9845	19548
py6	14485	24273	9788	11242	21030



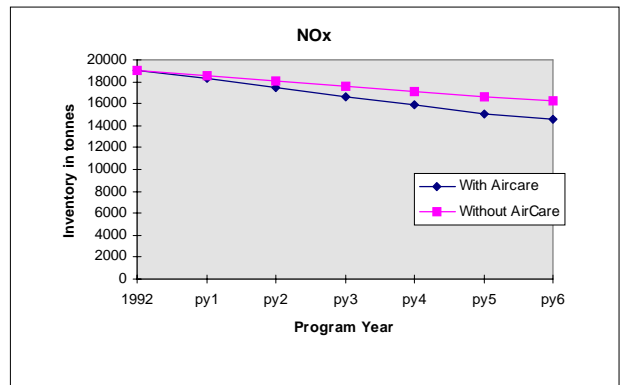
(a)

CO					
	With AirCare	Without AirCare	Cumulative aircare attributable benefits	vehicle turnover inventory reduction	Total inventory reduction since 1992
1990	-	376211	-		
1991	-	359282	-		
1992	341389	341389	-		
py1	301583	326027	24443	15363	39806
py2	255162	309791	54628	31599	86227
py3	218265	295974	77709	45415	123125
py4	188706	281471	92765	59918	152683
py5	158669	264555	105886	76834	182720
py6	145612	253258	107647	88131	195778



(b)

NOx					
	With AirCare	Without AirCare	Cumulative aircare attributable benefits	vehicle turnover inventory reduction	Total inventory reduction since 1992
1990	-	20099	-		
1991	-	19597	-		
1992	19038	19038	-		
py1	18286	18562	276	476	752
py2	17413	18033	620	1005	1625
py3	16684	17597	913	1441	2354
py4	15896	17137	1241	1901	3142
py5	15066	16592	1527	2446	3972
py6	14632	16272	1640	2766	4406

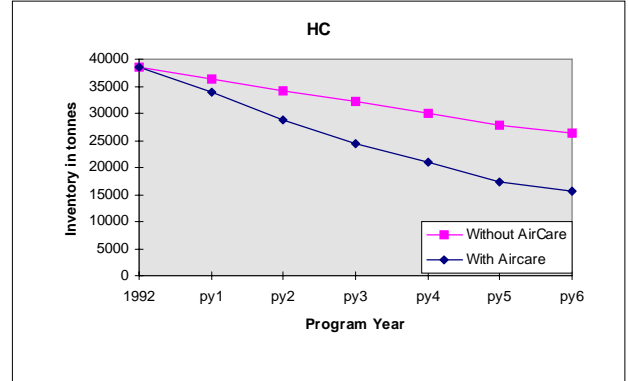


(c)

Figure 7

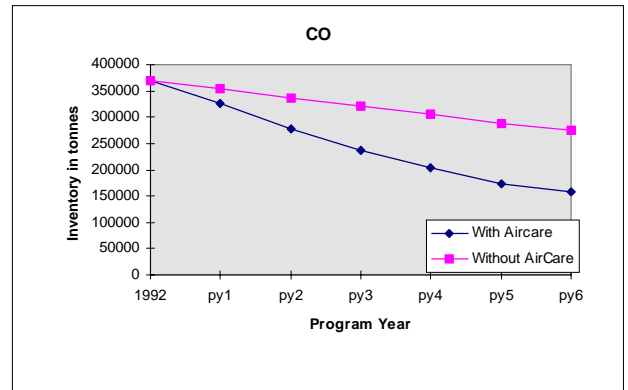
Lower Fraser Valley Light-Duty Vehicle Emissions Annual Tonnage Since Start of AirCare Program

HC					
	With AirCare	Without AirCare	Cumulative aircare attributable benefits	vehicle turnover inventory reduction	Total inventory reduction since 1992
1990	-	43518	-		
1991	-	41125	-		
1992	38534	38534	-		
py1	33948	36415	2466	2119	4586
py2	28716	34120	5404	4413	9818
py3	24490	32165	7675	6369	14044
py4	20887	30097	9210	8437	17647
py5	17324	27852	10528	10682	21210
py6	15716	26337	10620	12197	22817



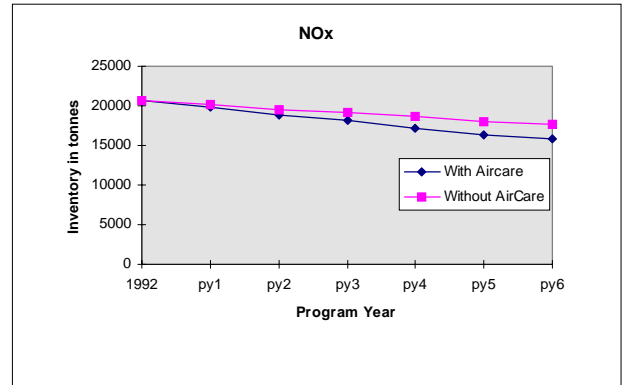
(a)

CO					
	With AirCare	Without AirCare	Cumulative aircare attributable benefits	vehicle turnover inventory reduction	Total inventory reduction since 1992
1990	-	408189	-		
1991	-	389820	-		
1992	370407	370407	-		
py1	327218	353739	26521	16688	43189
py2	276851	336123	59272	34285	93556
py3	236817	321132	84315	49276	133590
py4	204746	305396	100650	65011	165661
py5	172156	287042	114886	83365	198252
py6	157989	274785	116797	95622	212419



(b)

NOx					
	With AirCare	Without AirCare	Cumulative aircare attributable benefits	vehicle turnover inventory reduction	Total inventory reduction since 1992
1990	-	21807	-		
1991	-	21262	-		
1992	20656	20656	-		
py1	19840	20140	300	516	816
py2	18893	19566	673	1090	1763
py3	18102	19092	991	1564	2554
py4	17248	18594	1347	2062	3409
py5	16346	18003	1657	2653	4310
py6	15876	17655	1780	3001	4781

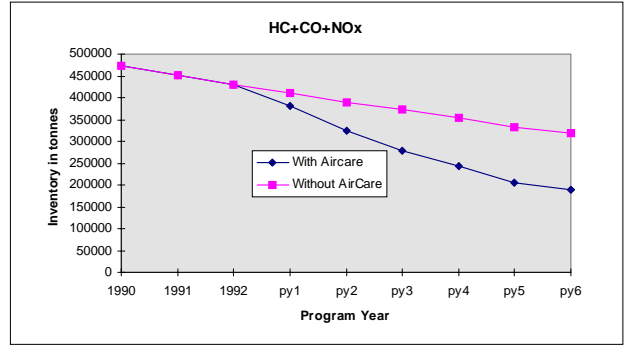


(c)

Figure 8

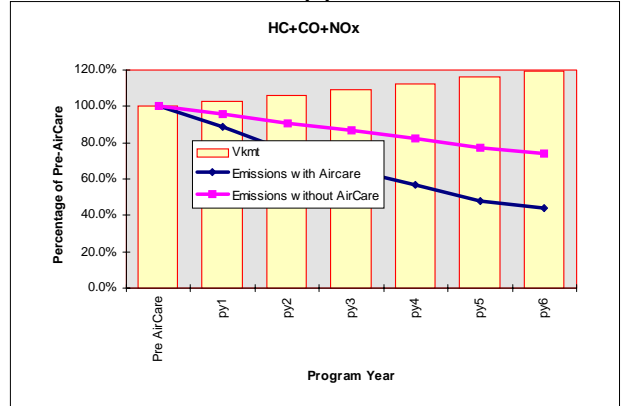
Lower Fraser Valley Combined HC, CO and NOx Annual Emissions Since Start of AirCare program

HC+CO+NOx					
	With AirCare	Without AirCare	Cumulative aircare attributable benefits	vehicle turnover inventory reduction	Total inventory reduction since 1992
1990	473515	473515	-		
1991	452207	452207	-		
1992	429598	429598	-		
py1	381007	410293	29287	19304	48591
py2	324460	389809	65349	39788	105137
py3	279409	372389	92981	57208	150189
py4	242881	354087	111207	75510	186717
py5	205826	332897	127070	96701	223771
py6	189581	318777	129197	110820	240017



(a)

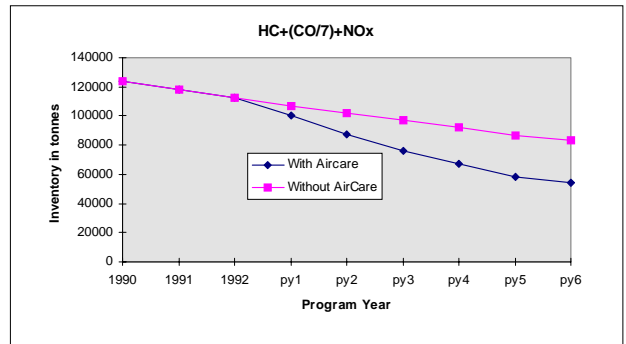
HC+CO+NOx					
	Emissions with AirCare	Emissions without AirCare	Cumulative aircare attributable benefits	vehicle turnover inventory reduction	Total inventory reduction since 1992
Pre AirCare	100.0%	100.0%	-		
py1	88.7%	95.5%	6.8%	4.5%	11.3%
py2	75.5%	90.7%	15.2%	9.3%	24.5%
py3	65.0%	86.7%	21.6%	13.3%	35.0%
py4	56.5%	82.4%	25.9%	17.6%	43.5%
py5	47.9%	77.5%	29.6%	22.5%	52.1%
py6	44.1%	74.2%	30.1%	25.8%	55.9%



(b)

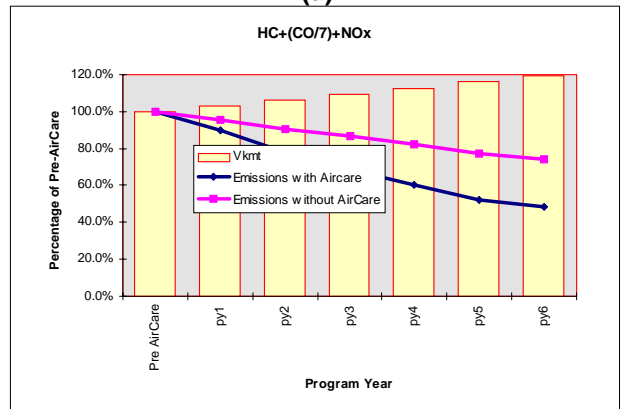
Figure 9

HC+(CO/7)+NOx					
	With AirCare	Without AirCare	Cumulative aircare attributable benefits	vehicle turnover inventory reduction	Total inventory reduction since 1992
1990	123638	123638	-		
1991	118076	118076	-		
1992	112105	112105	-		
py1	100534	107089	6554	5017	11571
py2	87159	101704	14544	10402	24946
py3	76423	97134	20711	14972	35683
py4	67384	92319	24935	19786	44721
py5	58264	86861	28596	25245	53841
py6	54162	83247	29085	28858	57944



(a)

HC+(CO/7)+NOx					
	Emissions with AirCare	Emissions without AirCare	Cumulative aircare attributable benefits	vehicle turnover inventory reduction	Total inventory reduction since 1992
Pre AirCare	100.0%	100.0%	-		
py1	89.7%	95.5%	5.8%	4.5%	10.3%
py2	77.7%	90.7%	13.0%	9.3%	22.3%
py3	68.2%	86.6%	18.5%	13.4%	31.8%
py4	60.1%	82.4%	22.2%	17.6%	39.9%
py5	52.0%	77.5%	25.5%	22.5%	48.0%
py6	48.3%	74.3%	25.9%	25.7%	51.7%



(b)

Figure 10

INSPECTIONS

Model Year	Trucks	Passenger	All Vehicles
pre '69	1135	5036	6171
1969	364	1137	1501
1970	338	901	1239
1971	446	845	1291
1972	713	1324	2037
1973	737	1404	2141
1974	1136	1586	2722
1975	1456	1855	3311
1976	2002	2464	4466
1977	3143	3781	6924
1978	3423	5991	9414
1979	4469	8081	12550
1980	5283	12339	17622
1981	6700	17749	24449
1982	3753	13342	17095
1983	4011	15815	19826
1984	7632	25484	33116
1985	9424	31049	40473
1986	13627	44221	57848
1987	14625	43804	58429
1988	18616	48406	67022
1989	22769	52252	75021
1990	25187	56479	81666
1991	26243	50753	76996
1992	26584	50692	77276
1993	27340	43587	70927
1994	26388	39133	65521
1995	27023	44006	71029
1996	23213	32838	56051
1997	25902	32621	58523
1998	134	83	217
ALL	333816	689058	1022874

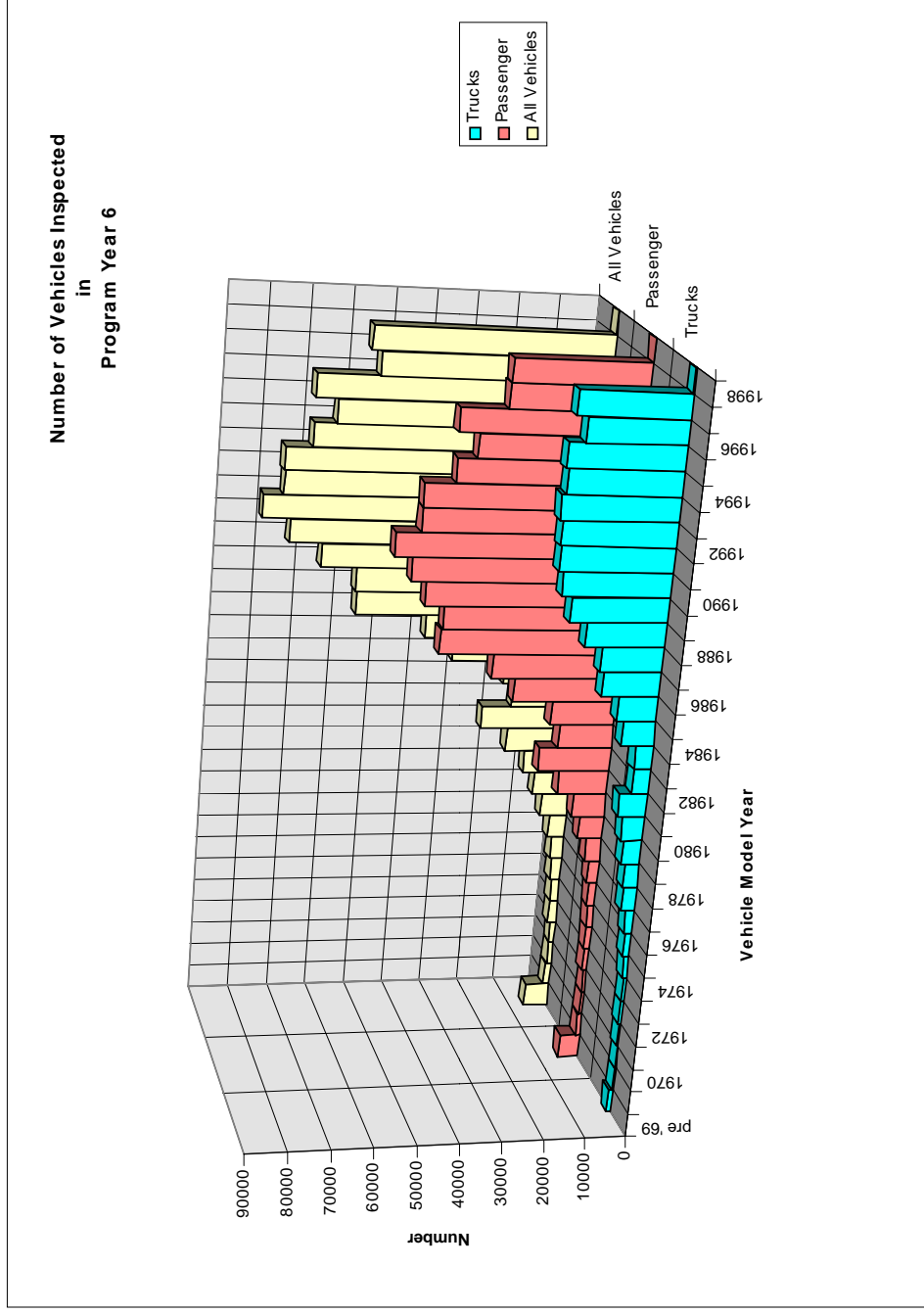


Figure 11

FAILURES

Model Year	Trucks	Passenger	All Vehicles
pre '69	352	1770	2122
1969	109	339	448
1970	93	231	324
1971	107	215	322
1972	155	262	417
1973	191	489	680
1974	285	565	850
1975	501	559	1060
1976	662	692	1354
1977	1012	1009	2021
1978	1003	1651	2654
1979	1263	2080	3343
1980	1783	3108	4891
1981	2060	4283	6343
1982	1169	3428	4597
1983	1251	4026	5277
1984	2160	5573	7733
1985	2555	5911	8466
1986	2981	6268	9249
1987	2554	5120	7674
1988	3166	7909	11075
1989	3103	5574	8677
1990	2561	4339	6900
1991	2003	2884	4887
1992	1416	1810	3226
1993	1057	1122	2179
1994	441	698	1139
1995	303	453	756
1996	93	441	534
1997	36	297	333
1998	4	0	4
ALL	36429	73106	109535

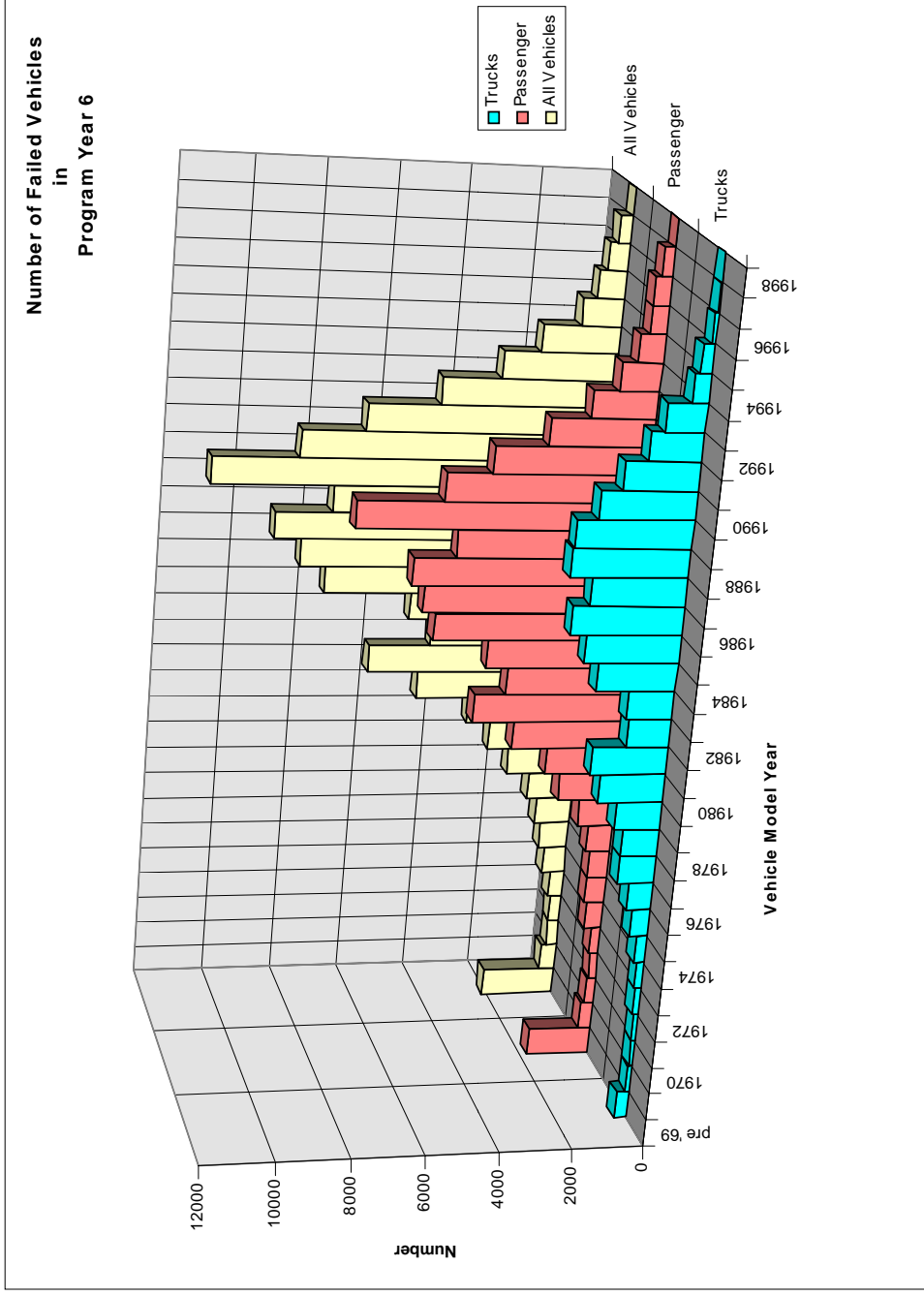


Figure 12

FAIL RATES (%)

Model Year	Trucks	Passenger	All Vehicles
pre '69	31.0%	35.1%	34.4%
1969	29.9%	29.8%	29.8%
1970	27.5%	25.6%	26.2%
1971	24.0%	25.4%	24.9%
1972	21.7%	19.8%	20.5%
1973	25.9%	34.8%	31.8%
1974	25.1%	35.6%	31.2%
1975	34.4%	30.1%	32.0%
1976	33.1%	28.1%	30.3%
1977	32.2%	26.7%	29.2%
1978	29.3%	27.6%	28.2%
1979	28.3%	25.7%	26.8%
1980	33.7%	25.2%	27.8%
1981	30.7%	24.1%	25.9%
1982	31.1%	25.7%	26.9%
1983	31.2%	25.5%	26.6%
1984	28.3%	21.9%	23.4%
1985	27.1%	19.0%	20.9%
1986	21.9%	14.2%	16.0%
1987	17.5%	11.7%	13.1%
1988	17.0%	16.3%	16.5%
1989	13.6%	10.7%	11.6%
1990	10.2%	7.7%	8.4%
1991	7.6%	5.7%	6.3%
1992	5.3%	3.6%	4.2%
1993	3.9%	2.6%	3.1%
1994	1.7%	1.8%	1.7%
1995	1.1%	1.0%	1.1%
1996	0.4%	1.3%	1.0%
1997	0.1%	0.9%	0.6%
1998	3.0%	0.0%	1.8%
ALL	10.9%	10.6%	10.7%

Fail Rates by Model Year
in
Program Year 6

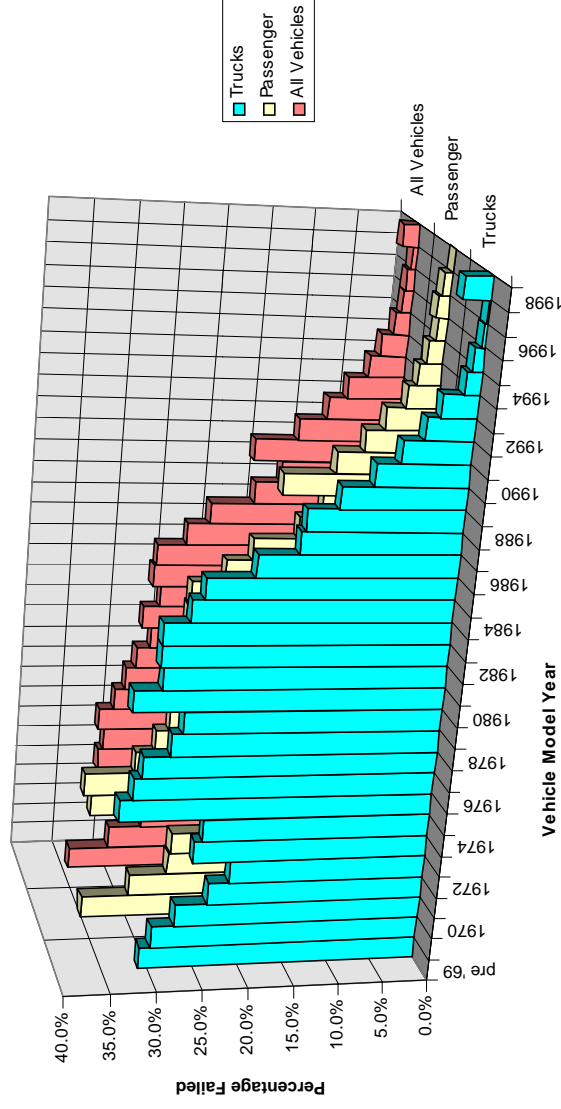


Figure 13

NUMBER OF VEHICLES

FUEL	Trucks	Passenger	All Vehicles
Other	60	122	182
CNG	263	124	387
LPG/Gasoline	1869	184	2053
CNG/Gasoline	2191	745	2936
LPG	10690	1870	12560
Diesel	11905	6197	18102
Gasoline	306838	679816	986654
ALL	333816	689058	1022874

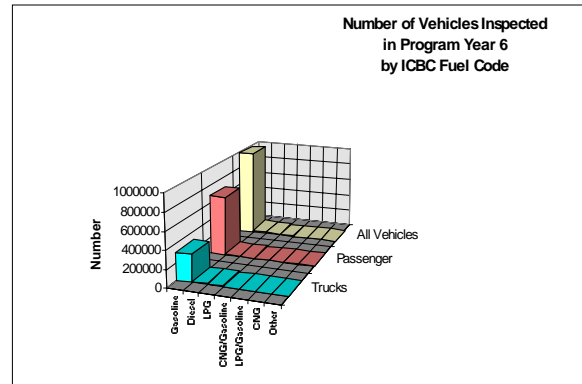


Figure 14

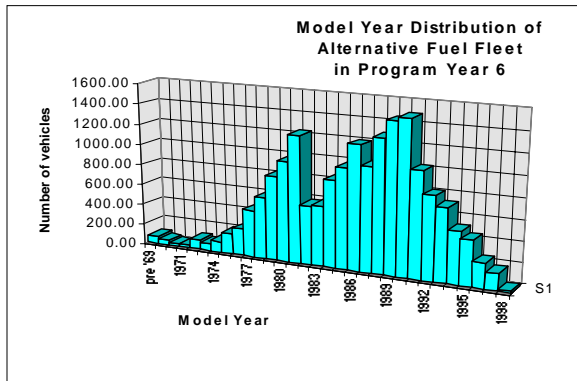


Figure 17

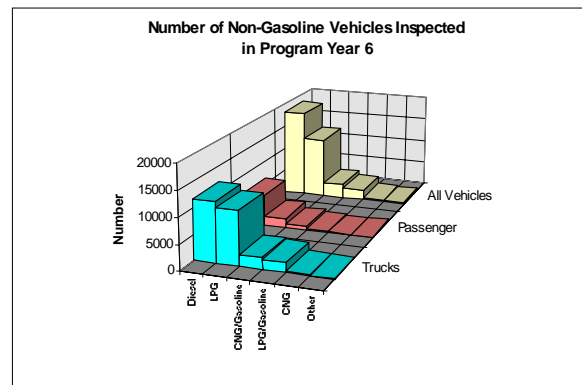


Figure 15

FAIL RATES (%)

FUEL	Trucks	Passenger	All Vehicles
Other	8.3%	10.7%	9.9%
CNG	20.5%	35.5%	25.3%
LPG/Gasoline	30.9%	33.7%	31.1%
CNG/Gasoline	26.8%	39.9%	30.1%
LPG	41.5%	47.9%	42.5%
Diesel	0.2%	0.5%	0.3%
Gasoline	10.0%	10.6%	10.4%
ALL	10.9%	10.6%	10.7%

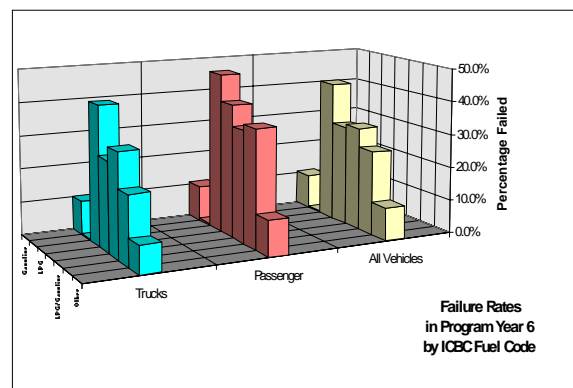


Figure 16

Centre	Number of Vehicles	Number Failed	Fail Rate (%)
North Vancouver	95714	8073	8.4%
East Vancouver	100759	11264	11.2%
Richmond	103477	9204	8.9%
Burnaby	68836	6672	9.7%
Coquitlam	107326	11008	10.3%
North Surrey	111659	15291	13.7%
South Surrey	53366	5511	10.3%
Maple Ridge	46878	5504	11.7%
Langley	79165	9717	12.3%
Abbotsford	73538	9500	12.9%
Chilliwack	39286	4924	12.5%
South Vancouver	142870	12867	9.0%
ALL	1022874	109535	10.7%

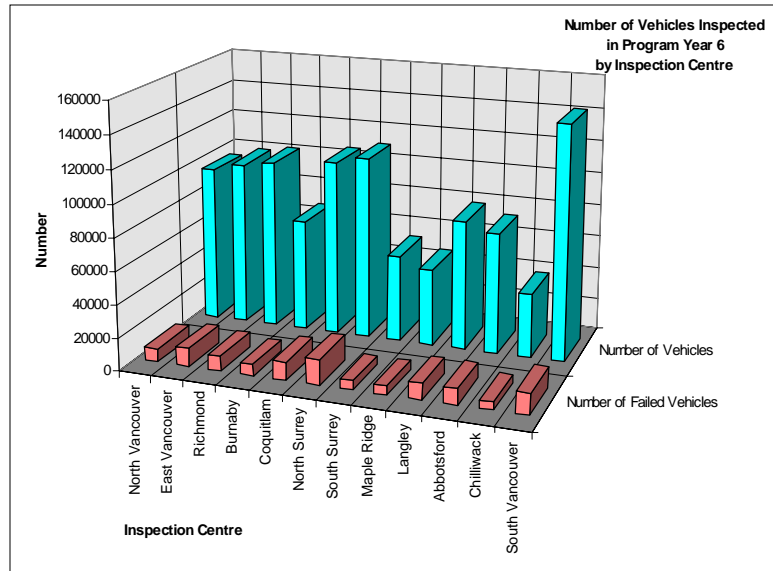


Figure 18

Month	Number of Vehicles	Number Failed	Fail Rate (%)
Sep-97	92834	10247	11.0%
Oct-97	98436	11138	11.3%
Nov-97	84608	10039	11.9%
Dec-97	66641	7405	11.1%
Jan-98	96443	9762	10.1%
Feb-98	102802	11145	10.8%
Mar-98	84973	9187	10.8%
Apr-98	81380	8738	10.7%
May-98	79877	8578	10.7%
Jun-98	79950	7984	10.0%
Jul-98	79677	7822	9.8%
Aug-98	75253	7490	10.0%
ALL	1022874	109535	10.7%

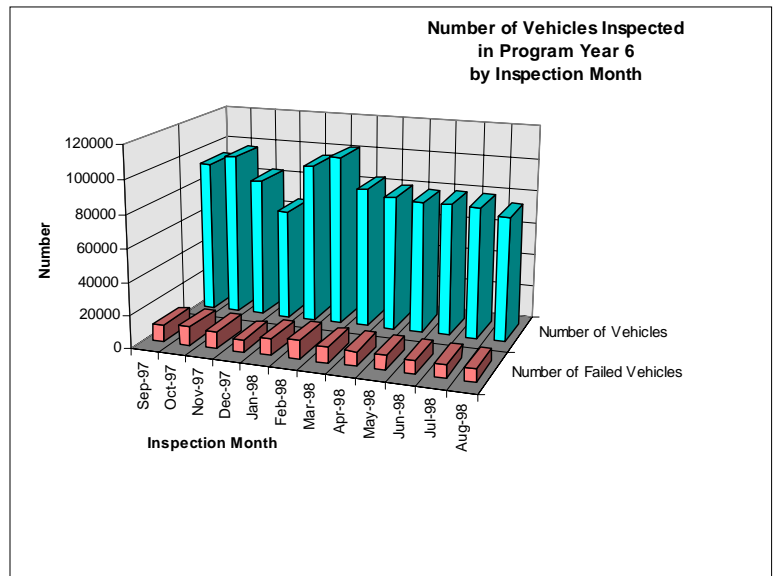
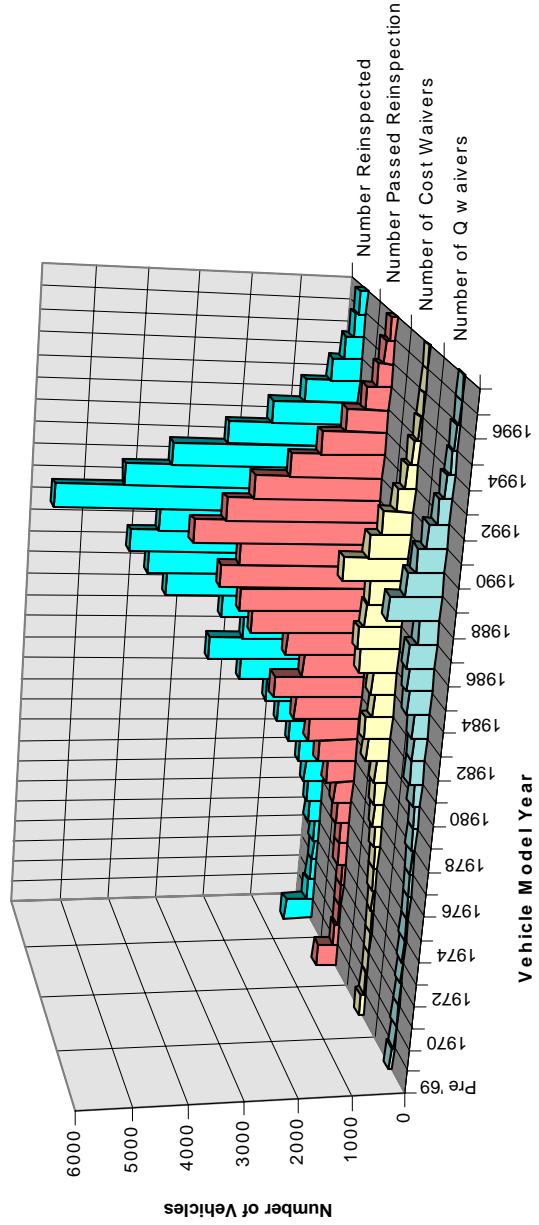


Figure 19

**Certified Repairs
in Program Year 6**



Model Year	# Reinsp	# Pass	# C pass	# Q waiv
Pre '69	561	404	81	64
1969	132	96	19	12
1970	98	59	15	19
1971	84	64	14	4
1972	105	70	17	13
1973	244	161	45	28
1974	303	181	82	33
1975	405	274	85	40
1976	560	366	133	50
1977	787	545	178	56
1978	1063	753	202	82
1979	1342	984	238	88
1980	1899	1298	430	138
1981	2559	1739	521	242
1982	1898	1213	394	243
1983	2376	1566	467	281
1984	3506	2274	735	420
1985	3883	2528	809	464
1986	4255	2935	708	498
1987	3716	2594	666	363
1988	5749	3511	1200	939
1989	4423	2927	767	661
1990	3544	2434	549	514
1991	2493	1770	329	365
1992	1673	1237	201	219
1993	1066	801	124	137
1994	574	454	40	78
1995	350	287	15	48
1996	206	187	2	16
1997	142	119	2	21
ALL	49996	33831	9068	6136

Figure 20

Distribution of Certified Repair Costs
in Program Year 6
by Reinspection Result Achieved

upper limit of cost interval	number of repairs giving P	number of repairs giving C	number of repairs giving Q	All repairs
\$25	1684	315	386	2405
\$50	160	28	217	217
\$75	989	270	181	1440
\$100	2689	960	469	4118
\$125	2089	604	447	3140
\$150	1973	635	317	2925
\$175	1888	533	374	2795
\$200	1777	425	324	2526
\$225	1762	473	343	2578
\$250	1507	430	273	2210
\$275	1654	462	310	2426
\$300	1246	336	223	1805
\$325	1372	368	258	1998
\$350	1089	278	175	1542
\$375	1347	348	243	1938
\$400	901	236	153	1290
\$425	995	268	151	1414
\$450	605	136	93	834
\$475	489	123	90	712
\$500	370	82	58	510
\$525	371	76	57	504
\$550	264	45	60	369
\$575	252	55	33	340
\$600	188	35	23	246
\$625	198	47	30	275
\$650	145	37	21	203
\$675	119	33	18	170
\$700	154	29	27	210
\$725	70	17	10	97
\$775	462	102	67	631
\$1,025	284	100	50	434
\$2,025	98	45	10	153

	repairs giving P	repairs giving C	repairs giving Q	All repairs
MEAN	\$256	\$256	\$239	\$254
MEDIAN	\$207	\$200	\$198	\$204
UPPER QUARTILE	\$339	\$322	\$320	\$333

P = Pass
C = Conditional Pass where estimated cost > Repair Cost Limit
Q = Conditional Pass where no remaining defects according to Repair Data Form

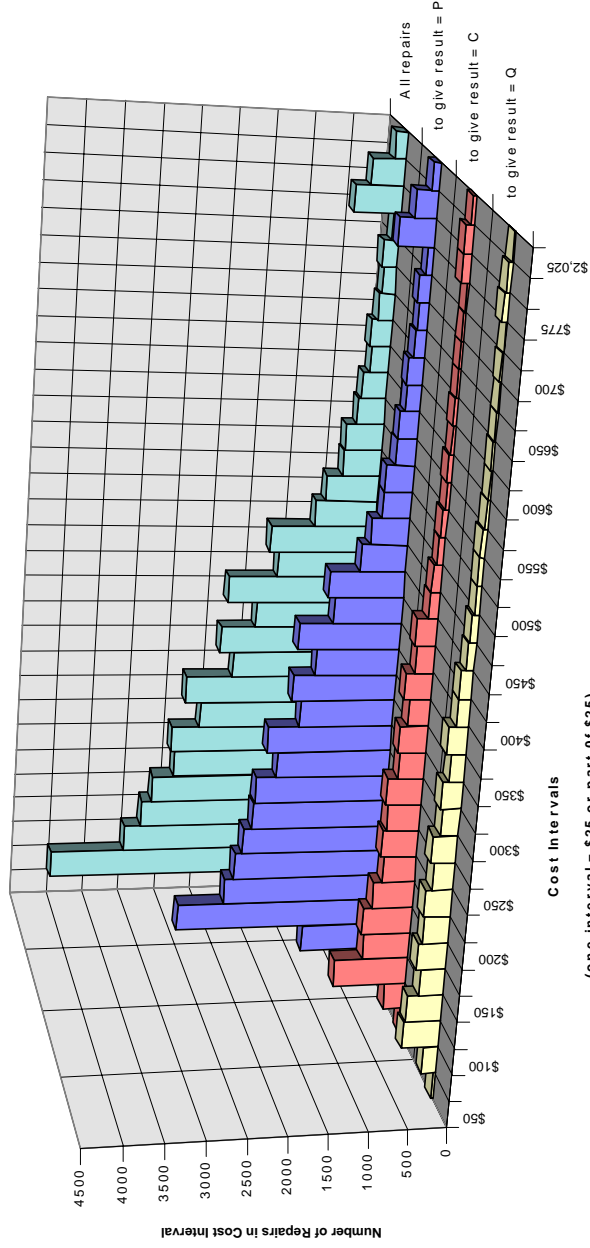
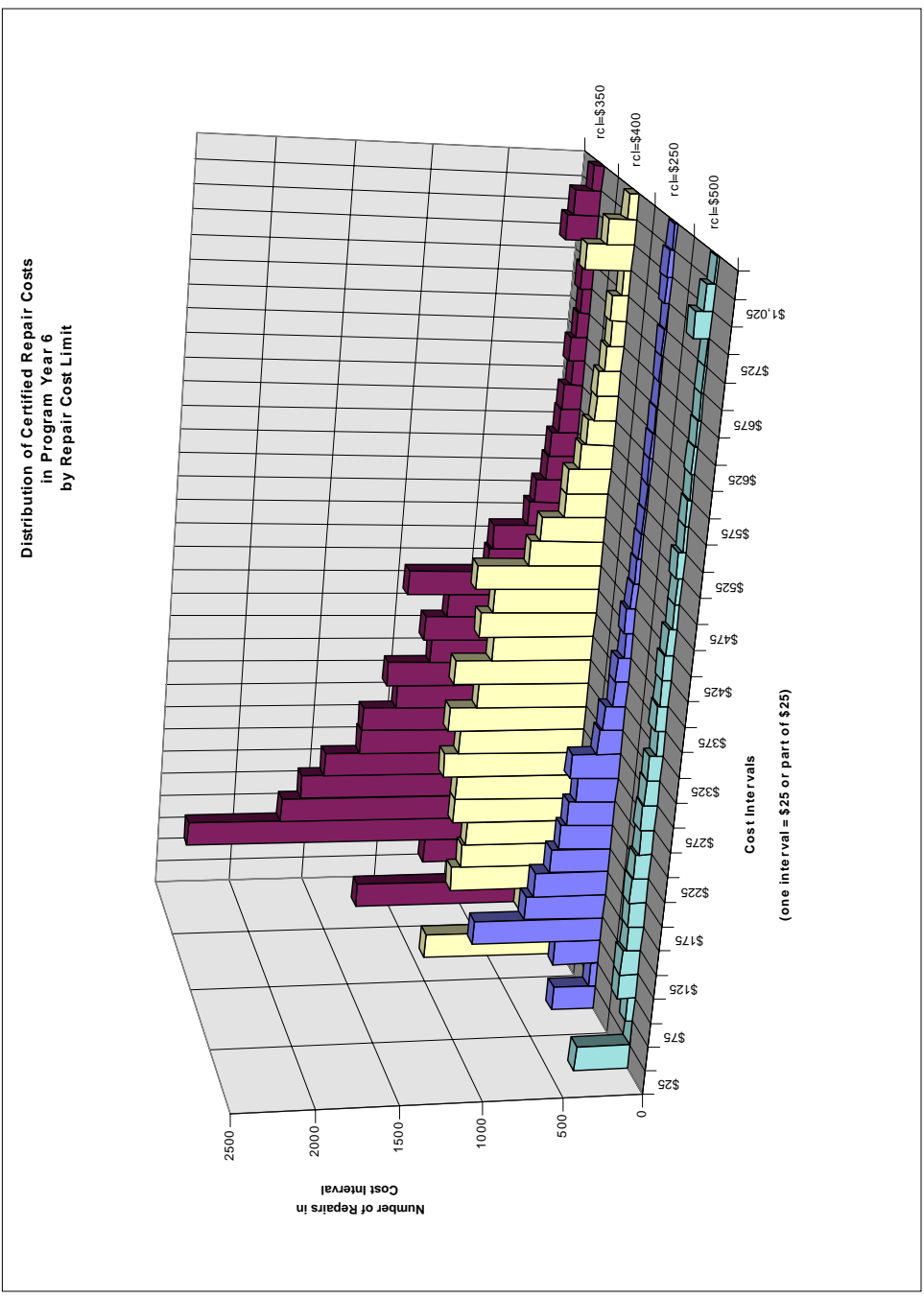


Figure 21



upper limit of cost interval	numb where rcl=250	numb where rcl=350	numb where rcl=400	numb where rcl=500
\$25	273	1220	926	342
\$50	45	128	39	5
\$75	293	785	315	47
\$100	831	2380	793	115
\$125	514	1773	738	115
\$150	470	1647	714	94
\$175	382	1502	812	99
\$200	333	1275	812	107
\$225	301	1271	905	101
\$250	256	1086	819	80
\$275	306	1130	900	90
\$300	151	851	723	82
\$325	131	904	885	79
\$350	81	761	657	43
\$375	83	1037	753	65
\$400	46	516	674	54
\$425	58	498	801	59
\$450	36	278	471	49
\$475	27	242	412	31
\$500	20	184	275	31
\$525	14	174	272	44
\$550	11	131	207	20
\$575	16	123	178	23
\$600	15	78	138	15
\$625	10	105	140	20
\$650	5	73	109	16
\$675	11	58	89	12
\$700	14	76	105	15
\$725	3	38	45	11
\$775	28	208	294	101
\$1,025	32	171	176	55
\$2,025	15	64	62	12
	4811	20737	15239	2032
MEAN	\$185	\$232	\$299	\$302
MEDIAN	\$138	\$183	\$260	\$212
UPPER QUARTILE	\$230	\$303	\$388	\$393
total # repairs	4811	20737	15239	2032
# > RCL	1113	4054	3774	344
% > RCL	23.13	19.55	24.77	16.93

RCL = Repair Cost Limit

Figure 22

