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Economic Evaluation of the Introduction of Lower Rural Default and National Highway Speed Limits in Tasmania

Max Cameron

Monash University Accident Research Centre

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Economic evaluation of the introduction of lower rural default and national highway speed limits in Tasmania

Authors

Max Cameron

Performing Organisation

Monash University Accident Research Centre

Building 70, Monash University, Victoria 3800, Australia

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Abstract

The objective of this project was to explore the potential economic costs and benefits of reducing the rural speed limits on Tasmanian roads. The report includes an analysis of the benefits and costs for lowering:

a) the default speed limit on sealed rural roads from 100km/h to 90km/h, while retaining a 100km/h limit on higher standard rural roads;
b) the default speed limit on unsealed (gravel) rural roads from 100km/h to 80km/h; and
c) the speed limit on lower standard National Highways from 110km/h to 100km/h, whilst retaining the current speed limit (110km/h) on higher standard dual carriageway sections. [Lowering the speed limit on divided 110km/h roads was also analysed.]

The economic evaluation considered the effect of the lowering of these speed limits on travel time costs, including costs for the freight industry; vehicle operating costs; crash costs (generally based on the “human capital” method of valuing road trauma); and air pollution costs. It was concluded that:

1. The envisaged reduction in the 110 km/h speed limit to 100 km/h on Category 1 (National Highways) roads in Tasmania would be economically justified on both the divided and undivided sections under consideration.
2. The economic justification is even greater on the undivided Category 1 roads when (a) the saving in road trauma is valued by “willingness to pay” estimates; or (b) the high proportion of road environments with frequent sharp curves, at-grade intersections, and occasional stops in towns traversed by these roads is recognised. A 90 km/h limit on undivided Category 1 roads could be considered, particularly through curvy road environments.
3. The envisaged reduction in the default 100 km/h speed limit to 90 km/h on sealed rural roads would be economically justified when it is recognised that a high proportion of Category 2-5 roads are through road environments with frequent sharp curves, at-grade intersections, and occasional stops in towns. The optimum speed on these roads through curvy environments is below 90 km/h for all classes of vehicle.
4. The envisaged reduction in the default 100 km/h speed limit to 80 km/h on unsealed (gravel) roads would be economically justified. The optimum speed on these roads on the State Road Network is close to the proposed new speed limit for all classes of vehicle.
5. If mean free speeds were reduced by 5 km/h on each category of road in response to the envisaged reduced speed limit applicable in each case, there would be an estimated total economic benefit exceeding $35 million per annum to Tasmania. It is estimated that there would be 25% reduction in fatal crashes, 15% reduction is serious injury crashes, and nearly 12% reduction in minor injury crashes on the roads with the speed limit reductions.

Keywords

Speed, rural roads, road trauma, travel time, vehicle operating costs, emissions

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Contents

Figures

EXECUTIVE SUMMARY

OBJECTIVES

The objective of this project was to explore the potential economic costs and benefits of reducing the rural speed limits on Tasmanian roads. The report includes an analysis of the benefits and costs for lowering:

a) the default speed limit on sealed rural roads from 100km/h to 90km/h, while retaining a 100km/h limit on higher standard rural roads;

b) the default speed limit on unsealed (gravel) rural roads from 100km/h to 80km/h; and

c) the speed limit on lower standard National Highways from 110km/h to 100km/h, whilst retaining the current speed limit (110km/h) on higher standard dual carriageway sections. [Lowering the speed limit on divided 110km/h roads was also analysed.]

The economic evaluation considered the effect of the lowering of these speed limits on:

- Travel time costs, including costs for the freight industry;
- Vehicle operating costs;
- Crash costs (generally based on the "human capital" method of valuation); and
- Air pollution costs.

RESULTS

The economic analysis considered 3,002 km of rural roads on Tasmania's State Road Network for which a reduction in the speed limit was envisaged (Table 1). A reduction in the speed limit on divided Category 1 (National Highway) roads with 110 km/h limits was included in the analysis, though this was not initially proposed. The analysed roads represent about 85% of the State Road Network, which in turn represents about 18% of Tasmania's rural road system. The majority of vehicle travel occurs on State Roads. On local roads the traffic volume is much smaller – around 25% of the level on State Roads.

Of the estimated 10,300 km of unsealed gravel roads, only 206 km are part of the State Road Network. Thus the analysis of the reduction of the speed limit on unsealed roads would underestimate the total impact on such roads in Tasmania, but the relative economic impact should be indicative of the overall impact on this class of road.

Initial results of the economic analysis

It was not expected that mean free speeds would drop to the same extent as the reduction in speed limit on each category of rural road. This is especially the case on the Category 2-5 roads where the mean free speeds in 2009 were already lower than the envisaged lower limits. The economic analyses considered the impacts of a hypothetical 5 km/h reduction in the mean free speed of each vehicle type as being the likely maximum reduction which would result. Lower speeds in 2 km/h steps were also analysed to determine the speed which minimises the total economic impact ("optimum speed") for each general class of vehicle. This is the speed which balances the social costs and benefits of increased travel time with decreased road trauma, vehicle operating costs, emissions and other costs.

Table 1: State Road Network roads designated for speed limit reductions. Traffic parameters and mean speeds for each road category.

	Traffic parameters		**Mean free speed 2009** (km/h)		
Road category and current speed limit	Length (km)	AADT 2007	Cars & LCVs	Rigid heavy vehicles	Artic. heavy vehicles
Rural roads with 110 km/h speed limits					
Divided Category 1 Trunk Roads	67.3	9,058	110	109	100
Undivided Cat. 1 Trunk Roads	238	7,030	105	100	99
Undivided rural roads with 100 km/h speed limits					
Category 2 Regional Freight Roads	263	2,714	85	81	78
Category 3 Regional Access Roads	572	2,012	87	82	82
Category 4 Feeder Roads	825	1,349	91	85	75
Category 5 "Other" Roads[1]	1,037	712	84	76	82
Unsealed rural roads (100 km/h speed limit)					
Category 5 "Other" Roads	206	140	85	80	80

[1] Includes unsealed gravel roads on SRN. Estimated 18% of length and 3% of travel on Category 5 roads

Using the "human capital" approach to value road trauma costs, there would be overall economic benefits from reducing speed limits on divided and undivided Category 1 roads from 110 km/h to 100km/h (Table 2). The optimum speed for all vehicle types combined on these roads is no more than 100 km/h, so this would support a reduction in the limit to 100 km/h in each case.

If it is assumed that the majority of the Tasmanian State Road Network consists of straight, unimpeded road sections, then for the undivided roads in each of Categories 2-5, the hypothesised 5 km/h reduction in mean free speeds due to a reduction in their current 100 km/h limits would appear to result in an overall economic loss. The optimum speeds on these roads are generally about the same as the envisaged lower limit proposed for each class of road (90 km/h for sealed Category 2-5 roads and 80 km/h for the unsealed Category 5 roads), but the hypothesised reduced mean speeds are substantially less. However these economic analysis results assume that road trauma (crashes and serious injuries) should be valued by conservative "human capital" costs; and that vehicles travel on Category 2-5 roads at their mean free speeds throughout their length without slowing for sharp curves and stopping occasionally.

Table 2: Economic impacts of speed reductions, and estimated optimum speeds. Straight, unimpeded road environment. "Human capital" costs of road trauma.

	Effect of 5 km/h mean speed reductions on total economic cost		**Optimum Speed (km/h)** (speed which minimises total economic cost)		
Road category and current speed limit	Change p.a. ($ million)	Percentage change	All vehicles combined	Cars & LCVs	Heavy vehicles
Rural roads with 110 km/h speed limits					
Divided Category 1 Trunk Roads	-1.083	-0.8%	100	102	94
Undivided Cat. 1 Trunk Roads	-1.870	-0.4%	98	100	92
Undivided rural roads with 100 km/h speed limits					
Category 2 Regional Freight Roads	+3.291	+1.7%	90	92	88
Category 3 Regional Access Roads	+2.593	+0.9%	88	90	86
Category 4 Feeder Roads	+2.261	+0.8%	90	92	86
Category 5 "Other" Roads[1]	+2.722	+1.4%	88	88	84
Unsealed rural roads (100 km/h speed limit)					
Category 5 "Other" Roads[2]	+0.027	+0.3%	82	82	82

[1] Includes unsealed gravel roads on State Road Network. Crash data 2004-2008 not provided separately.
[2] Casualty crash rate per 100 million vehicle-kilometres from AGPE04/08 Table 4.1, not real crash data.

Willingness to pay valuation of road trauma

"Willingness to pay" valuations of road trauma are more consistent with the Safe System approach embodied in the federal government's *National Road Safety Strategy 2001-2010*, and the *Tasmanian Road Safety Strategy 2007-2016*. Fatal crashes are valued more than 2.5 times their "human capital" costs and injury crashes are also valued higher. On this basis, the economic benefits of reducing speed limits on Category 1 roads from 110 km/h to 100km/h would be even greater, especially on the undivided Category 1 roads (Table 3).

Using "willingness to pay" valuations of road trauma, the reduction in mean free speeds on Category 3-5 roads would result in overall economic benefits and the apparent economic loss on the Category 2 roads would be substantially reduced. The optimum speeds would be substantially lower than the envisaged lower limits for each of the Category 2-5 roads, including the unsealed Category 5 roads. The optimum speed on the undivided Category 1 roads is no more than 90 km/h for each class of vehicle, suggesting that the 90 km/h limit envisaged for the sealed Category 2-5 roads could be considered for these roads as well.

Table 3: Economic impacts of speed reductions, and estimated optimum speeds. Straight, unimpeded road environment. "Willingness to pay" values of road trauma.

Road category and current speed limit	**Effect of 5 km/h mean speed reductions on total economic cost**		**Optimum Speed (km/h)** (speed which minimises total economic cost)		
	Change p.a. ($ million)	Percentage change	All vehicles combined	Cars & LCVs	Heavy vehicles
Rural roads with 110 km/h speed limits					
Divided Category 1 Trunk Roads	-3.098	-2.0%	92	92	90
Undivided Cat. 1 Trunk Roads	-8.537	-1.8%	90	90	86
Undivided rural roads with 100 km/h speed limits					
Category 2 Regional Freight Roads	+0.565	+0.3%	82	82	80
Category 3 Regional Access Roads	-2.907	-0.9%	80	80	78
Category 4 Feeder Roads	-1.831	-0.6%	82	84	80
Category 5 "Other" Roads	-0.486	-0.2%	78	80	78
Unsealed rural roads (100 km/h speed limit)					
Category 5 "Other" Roads	-0.172	-1.9%	74	74	74

Curvy road environments requiring slowing and stops

Much of Tasmania's rural road system has frequent curved alignments and passes through intersections and towns often requiring vehicles to slow substantially and occasionally stop. On these types of road the average journey speed over a whole trip is lower than the cruise speeds that vehicles would do on straight unimpeded road sections. This increases the travel time and the slowing and stopping increases the fuel consumption and air pollution emissions of vehicles using the road section. The crash rate also increases because of the curved alignment and because of the increased crash risk associated with cross roads. Adjustments to the economic analyses were made to take into account the impact of increased road trauma, operating costs, emissions and travel times, except for divided Category 1 roads where slowing for sharp curves and stopping is less common.

Assuming that the curvy road environment with frequent slowing and occasional stops applies along the full length of each of the undivided Category 1-5 roads, the economic analysis using "human capital" costs of road trauma showed that there were overall economic benefits from a 5 km/h reduction in cruise speeds (average free speeds) on most classes of road (Table 4). The exceptions were the undivided Category 2 Regional Freight Roads and the Category 5 "Other" Roads (but not including the separately analysed unsealed Category 5 roads). However, the optimum speeds on these two classes of road were below the envisaged 90 km/h limit suggesting that the reduced limit would still be justified even if the hypothesised 5 km/h reduction in cruise speeds did not result.

The greatest economic benefit was from a reduction in cruise speeds on undivided Category 1 roads with current 110 km/h speed limit. In curvy road environments, the optimum speed on these roads was estimated to be 86 km/h for all classes of vehicle. This supports a lower speed limit than the 100 km/h limit envisaged, at least on the undivided Category 1 roads through curvy road environments where a 90 km/h limit could be considered.

Table 4: Economic impacts of speed reductions, and estimated optimum speeds. Curvy road environment with frequent slowing and occasional stops along full length of the road category (except divided Category 1 roads). "Human capital" costs of road trauma.

	Effect of 5 km/h mean speed reductions on total economic cost		**Optimum Speed (km/h)** (speed which minimises total economic cost)		
Road category and current speed limit	Change p.a. ($ million)	Percentage change	All vehicles combined	Cars & LCVs	Heavy vehicles
Rural roads with 110 km/h speed limits					
Divided Category 1 Trunk Roads[1]	-1.083	-0.8%	100	102	94
Undivided Cat. 1 Trunk Roads	-32.853	-5.9%	86	86	86
Undivided rural roads with 100 km/h speed limits					
Category 2 Regional Freight Roads	+1.566	+0.8%	86	86	86
Category 3 Regional Access Roads	-0.929	-0.3%	82	82	82
Category 4 Feeder Roads	-3.021	-1.0%	86	86	82
Category 5 "Other" Roads	+1.000	+0.5%	82	82	82
Unsealed rural roads (100 km/h speed limit)					
Category 5 "Other" Roads	-0.049	-0.6%	80	80	80

[1] Assumed to be primarily freeway standard roads with high design speeds and controlled access, not requiring frequent slowing due to sharp curves and stops for towns and intersections, and hence not analysed for a curvy road environment. Results assumed to be same as in Table 2 for straight unimpeded road environment.

Overall benefits and costs of reduced speed limits

The seven road environments summarised in Table 4 were considered in aggregate to be representative of rural State Roads in Tasmania. Ignoring the double-counting of the economic benefit on unsealed Category 5 roads, the combined results suggest that there would be a total economic benefit to Tasmania of $35.37 million per annum if the envisaged reduced speed limits were introduced and a 5 km/h reduction in current free speeds on the targeted roads were to result. Even if the full 5 km/h reduction in current speeds was not achieved, the optimum speeds for each road class and vehicle type suggest that limiting vehicle free speeds to the envisaged speed limits would result in a net economic benefit.

Table 5 shows the estimated crash savings if the 5 km/h reductions in mean free speeds were to result from the speed limit reductions in each road environment. Again ignoring the double-counting on unsealed Category 5 roads, it is estimated that there would be 25% reduction in fatal crashes, 15% reduction is serious injury crashes, and nearly 12% reduction in minor injury crashes associated with the speed limit reductions. Nearly one-third of the fatal crashes savings would come from the reduction in the limit on existing 110 km/h undivided Category 1 roads.

Table 5: Estimated crash reductions per year. Curvy road environment with frequent slowing and occasional stops along full length of the road category (except divided Category 1 roads).

	Estimated crash savings due to 5 km/h mean speed reductions				
Road category and current speed limit	Fatal crashes p.a.	Serious injury crashes p.a.	Other injury crashes p.a.	Annual casualty crashes (estimate)	Casualty crash saving (% p.a.)
Rural roads with 110 km/h speed limits					
Divided Category 1 Trunk Roads	0.44	0.83	5.54	65.7	10.4%
Undivided Cat. 1 Trunk Roads	2.20	2.08	5.53	81.2	12.1%
Undivided rural roads with 100 km/h speed limits					
Category 2 Regional Freight Roads	0.72	2.07	6.08	64.2	13.8%
Category 3 Regional Access Roads	1.45	3.77	12.51	132.3	13.4%
Category 4 Feeder Roads	1.01	4.25	12.38	137.6	12.8%
Category 5 "Other" Roads[1]	0.80	3.12	9.32	95.7	13.8%
Unsealed rural roads on SRN (100 km/h speed limit)					
Category 5 "Other" Roads	0.05	0.18	0.35	4.1	14.1%
TOTAL CRASH SAVINGS p.a.	**6.67**	**16.30**	**51.71**	580.8	**12.9%**
Annual crashes by severity (est.)	26.7	108.1	446.0		
PERCENT CRASH SAVINGS	**25.0%**	**15.1%**	**11.6%**		

[1] Includes unsealed gravel roads on State Road Network, representing 4.3% of casualty crashes on Cat. 5 roads.

CONCLUSIONS

1. The envisaged reduction in the 110 km/h speed limit to 100 km/h on Category 1 (National Highways) roads in Tasmania would be economically justified on both the divided and undivided sections under consideration.

2. The economic justification is even greater on the undivided Category 1 roads when (a) the saving in road trauma is valued by "willingness to pay" estimates; or (b) if the high proportion of road environments with frequent sharp curves, at-grade intersections, and occasional stops in towns traversed by these roads is recognised. A 90 km/h limit on undivided Category 1 roads could be considered, particularly through curvy road environments.

3. The envisaged reduction in the default 100 km/h speed limit to 90 km/h on sealed rural roads would be economically justified when it is recognised that a high proportion of Category 2-5 roads are through road environments with frequent sharp curves, at-grade intersections, and occasional stops in towns. The optimum speed on these roads through curvy environments is below 90 km/h for all classes of vehicle.

4. The envisaged reduction in the default 100 km/h speed limit to 80 km/h on unsealed (gravel) roads would be economically justified. The optimum speed on these roads on the State Road Network is close to the proposed new speed limit for all classes of vehicle.

5. If mean free speeds were reduced by 5 km/h on each category of road in response to the envisaged reduced speed limit applicable in each case, there would be an estimated total economic benefit exceeding $35 million per annum to Tasmania. It is estimated that there would be 25% reduction in fatal crashes, 15% reduction is serious injury crashes, and nearly 12% reduction in minor injury crashes on the roads with the speed limit reductions.

6. It is possible that the relationships developed by Nilsson (1984), linking crashes and their injury severity with changes in mean free speeds, may not adequately represent the expected changes in casualty crashes if speed limits are reduced in rural road environments where free speeds are already substantially below the current (and reduced) limits on many targeted roads. A change in the distribution of speeds, instead of, or in addition to a reduction in mean speed, may be expected to produce a reduction in casualty crashes. It is recommended that an alternative method of estimating the changes in the numbers of casualty crashes on the Category 2-5 roads be investigated and if feasible, incorporated in further analysis of the economic benefits of the envisaged speed limit reductions.

ECONOMIC EVALUATION OF THE INTRODUCTION OF LOWER RURAL DEFAULT AND NATIONAL HIGHWAY SPEED LIMITS IN TASMANIA

1. INTRODUCTION

The objective of this project was to explore the potential economic costs and benefits of reducing the rural speed limits on Tasmanian roads. The report includes an analysis of the benefits and costs for lowering:

a) the default speed limit on sealed rural roads from 100km/h to 90km/h, while retaining a 100km/h limit on higher standard rural roads;

b) the default speed limit on unsealed (gravel) rural roads from 100km/h to 80km/h; and

c) the speed limit on lower standard National Highways from 110km/h to 100km/h, whilst retaining the current speed limit (110km/h) on higher standard dual carriageway sections. [Lowering the speed limit on divided 110km/h roads was also analysed.]

The economic evaluation considered the effect of the lowering of these speed limits on:

- Travel time costs, including costs for the freight industry;
- Vehicle operating costs;
- Crash costs; and
- Air pollution costs.

Previous research in Europe suggested that there is sufficient knowledge relating road trauma, vehicle operating costs, air pollution emissions, noise and travel time to vehicle speeds to indicate that the project was feasible (Nilsson 1984; Andersson et al 1991; Peters et al 1996; Rietveld et al 1996; Carlsson 1997; Toivanen and Kallberg 1998; Elvik 1998). Subsequent Australian research built on the European experience and calibrated the relationships with vehicle speeds using Australian data (Cameron 2000, 2001, 2003, 2004).

2. PREVIOUS RESEARCH ON IMPACTS OF SPEEDS

Much of the previous research was concerned with estimating the optimum speed of vehicle travel on various classes of road in different road environments. The optimum speed is defined as one which balances the social costs and benefits of increased travel time with decreased road trauma, vehicle operating costs, emissions, and other costs.

Nilsson (1984) reported separate relationships between the increase in the numbers of killed, seriously injured, and slightly injured car occupants, and the increase in the median speed relative to baseline conditions. He built on these relationships to estimate the total injury cost for car occupants per million vehicle kilometres travelled as a function of median speed, for each of six rural road environments in Sweden.

Some roads had much higher median speeds than would be expected if they had the same 'accepted' balance between speed and injury cost rate which was displayed on other roads. Nilsson argued that speeds on these roads would need to be reduced (in the order of 5-10 km/h) if the same balance of speed and injury costs were to be achieved on all roads. While Nilsson's proposals may not have achieved the optimum balance, they were aimed in this direction.

Andersson et al (1991) calculated optimal speeds on different classes of Swedish roads on the basis of socio-economic costs. The optimal speed was defined as the speed where the sum of crash costs (injuries and material damage), vehicle operating costs, and travel time costs was lowest. The prices or values used were the same as those normally used in official transport economic calculations in Sweden.

They found that the optimal speeds on three types of urban roads, presently speed-zoned with 50 km/h limits, was in the range 47-58 km/h. However, in the rural road environments, the optimal speeds were considerably lower than the current mean speeds and the speed limits.

Plowden and Hillman (1996) calculated optimal speed limits for UK main roads, both outside and inside towns. The calculations took into account the speed-related impacts on and economic values of fuel, other vehicle operating costs, travel time and crashes. The results were considered to be the upper boundaries of the speed limits because all the impacts left out of the calculations were negative, and increase with speed (e.g. noise pollution). The calculations were made with and without the assumption of an effect whereby reduced speed limits influence how much road users travel.

For motorways and 'A' roads outside towns, in general they found that optimal speed limits were up to 15 mph lower than existing limits, depending on the road class and assumptions on fuel taxation. Their analysis of urban roads had greater difficulties determining the effects of speed changes, but they concluded that the urban speed limit should normally be 20 mph (32 km/h). However, it appears that some of their assumptions may have been extreme, so this figure could be viewed as a lower limit for optimal speeds in urban areas. They made a number of suggestions for further work to refine this area.

Rietveld et al (1996) calculated the socially optimal speed for passenger cars on different roads types in the Netherlands, with and without the assumption that total travel is independent of changes in speed. The calculations made a distinction between fatal and other serious crashes, and also included the speed-related impacts on travel time, energy use, and CO_2 and NO_X emissions. Further information on their methods and data is given by Peeters et al (1996) and Coesel and Rietveld (1998).

The researchers had to rely on general estimates of the elasticity between travelling time and vehicle travel when estimating the speed-related impacts. They noted that a full network model would have been necessary to provide a more realistic estimate of the effects of speed changes on travel demand. They also stated that their analysis was incomplete because they were not able to consider the effects on noise pollution and costs.

Rietveld et al noted that vehicles seldom travel at constant speed and that actual average speeds are considerably lower than speed limits and desired speeds, especially in urban areas. On urban roads with a 50 km/h limit, they found that the average speed was 38 km/h on major urban through roads and 27 km/h on other urban roads. The average speed was 15 km/h in residential streets, which have a 30 km/h limit. They also found that the optimal speed on the urban roads/streets was close to (or a little less than) the average speed in each case, whereas on the higher speed limited rural roads the optimal speeds were considerably less than the corresponding averages. In the urban areas in the Netherlands, it appears that desired speed behaviour is generally consistent with the current speed limits and produces average speeds which are close to socially optimal.

Elvik (1998) undertook a similar analysis to calculate the optimal speed in urban areas in Norway, considering in addition the speed-related impacts on noise pollution and feelings of insecurity towards children. He found that the optimal speed on urban main roads was 50 km/h, on collector roads it was 40 km/h, and on residential access roads it was 30 km/h.

Carlsson (1997) calculated the optimum speeds of passenger cars on different types of rural roads in Sweden. The speed-related effects on fatalities, serious injuries, slight injuries, property damage, travel time, fuel consumption, tyre wear, and CO_2 , NO_X and HC emissions were all included. He found that the present travel speeds in Sweden were 15-25 km/h higher than the optimum speed for each type of road.

Kallberg and Toivanen (1998) described a framework for assessing the impacts of speed, developed as part of the European project MASTER (Managing Speeds of Traffic on European Roads). While they did not use this to calculate optimum speeds, the framework was a valuable basis for the project described here. The framework aimed to provide a comprehensive coverage of all the impacts, both direct and indirect, and quantifiable and non-quantifiable.

Kallberg and Toivanen drew an important distinction between the impacts of speed at the level of the individual road section or link, viewed in isolation, and at the level of the transport network. It is possible that changes in speeds or speed limits on individual links can have impacts on perceived accessibility, transport modal split, and broader socio-economic impacts, all of which can have feedback effects on travel speeds. They also noted that speed management can have objectives related to *efficiency* (where socio-economic cost-benefit analysis is an important tool) and *equity* (where the distribution of the costs and benefits of speed needs to be considered). Speeds which are desirable from an efficiency point-of-view may not be acceptable because of real or perceived inequities to some parts of society. However, the inequities are usually difficult to quantify.

The MASTER project developed a computer spreadsheet to allow all the impacts of a change in speed management policy to be recorded, and analysed where appropriate. A copy of the output from the spreadsheet (without data entered) is given in Appendix A to illustrate its structure. Kallberg and Toivnanen (1998) gave a detailed description, and illustrated its use by applying it to speed policy issues in Finland, Hungary and Portugal. The spreadsheet provided a useful computational basis (with modifications) for the calculation of the impacts of different travel speeds for the project described here (Appendix B onwards).

Cameron (2000, 2001) used the MASTER framework to estimate the optimum speed on urban residential streets in Australia. He found that the optimum speed depended on the method used to value road trauma. When the ‘human capital’ valuations of road trauma costs (BTE 2000) were used, the analysis suggested that the optimum speed on residential streets is 55 km/h. When the analysis was repeated making use of road trauma costs valued by the ‘willingness to pay’ approach (BTCE 1997), the analysis suggested that the optimum speed on residential streets is 50 km/h. Noise costs in urban areas could not be valued in the analysis, but the travel time on residential streets was (using the value per hour for private car travel, since most travel in residential areas is for non-business purposes).

Cameron (2003, 2004) also used the modified MASTER framework to aggregate the economic costs and benefits of changes to speed limits on rural roads in Australia. Net costs and benefits were estimated over a range of mean travel speeds (80 to 130 km/h) for the following road classes:

- freeway standard rural roads
- other divided rural roads (not of freeway standard)
- two-lane undivided rural roads (with and without shoulder sealing).

The effects of speed on road trauma levels were calculated using relationships linking changes in average free speed with changes in numbers of fatal, serious injury and minor injury crashes on rural roads, developed in Sweden by Nilsson (1981, 2004). Vehicle operating costs for cars, light commercial vehicles and rigid and articulated trucks were based on Austroads published models linking these costs with speed (Thoresen, Roper and Michel 2003). Emission rates of air pollutants of each type were derived from research conducted as part of the MASTER project for the European Commission (Robertson, Ward and Marsden 1998, Kallberg and Toivanen 1998). Increased fuel consumption and emission rates associated with deceleration from cruise speeds for sharp curves (and occasional stops) on undivided rural roads, and then acceleration again, were estimated from mathematical models calibrated for this purpose in the USA (Ding 2000). The analysis also provided estimates of average speeds over 100 km sections of curvy undivided roads. Air pollution cost estimates were provided by Cosgrove (1994).

It was assumed that travel time = link length / speed of traffic flow. This was considered to be a reasonable assumption on rural roads where traffic congestion, and hence constrained speeds, are a rarity. Kallberg and Toivanen (1998) noted that, in urban conditions, a considerable part of the travel time may be spent not moving at all or moving at very low speeds. Travel time was valued by Austroads estimates of time costs reflecting the vehicle type and trip purposes (Thoresen, Roper and Michel 2003). Road trauma was valued by standard ‘human capital’ unit costs related to the injury severity of crash outcomes (BTE 2000), and also by ‘willingness to pay’ values (BTCE 1997) to test the sensitivity of the key results to this assumption.

The study also involved a number of key assumptions, as follows:

1. Vehicles of each type cruise at their speed limit, so that their average speed was the same as the limit, unless their speed was reduced by slowing for curves or stopping in some parts of the road section.

2. The rural roads were considered to be relatively straight without intersections and towns, allowing vehicles to travel at cruise speed throughout the whole road section. Significant variations to this assumption, on road sections requiring vehicles to slow frequently for curves and occasionally stop, were also analysed.

3. Crashes involving material damage only, and no personal injury, were not included in the analysis of crash changes with speed. Material damage crashes represented about 16.3% of total crash costs in Australia during 1996 (BTE 2000).

4. The changes in speed limits were assumed not to increase or reduce travel demand and traffic flows of each vehicle type on the road sections.

5. The travel time savings on the rural road sections were of sufficient magnitude to be aggregated and valued.

6. The economic valuations of travel time, road trauma, and air pollution emissions provided an appropriate basis for analysis which summated their values, together with vehicle operating costs, in a way which represented the total social costs of each speed.

Many of these assumptions are equally applicable to the analysis described in this report.

3. IMPACTS OF SPEED

3.1 ROAD TRAUMA

3.1.1 Kloeden et al's relationship between speed and casualty crashes

It would seem that the most relevant research linking travelling speed with road trauma on rural roads in Australia was that carried out by Kloeden et al (2001). They estimated the relative risk of passenger car involvement in a casualty crash[1] for travelling speeds (free speeds, unimpeded by other traffic) ranging from 10 km/h less than average speed, to 30 km/h more than average, in 5 km/h intervals. Rural speed zones ranging from 80 km/h to 110 km/h limits were considered, with 52% of crashes occurring in 100 km/h zones and most of the remainder split between 80 km/h and 110 km/h zones.

The estimated relative risk for a car travelling at 130 km/h in a 100 km/h speed zone was 17.9 (assuming the average speed was the same as the speed limit), with 95% confidence limits ranging from 8.5 to 60.2. This relative risk corresponds to the 11th power of the speed ratio (1.3). The implied 11th power relationship is considerably greater than the more modest power laws linking increases in crash frequencies with changes in average speeds (Nilsson 1984; see below). However, it should be noted that Kloeden et al's relationship links the travel speed of an individual vehicle with the risk of casualty crash involvement. It does not link changes in average speeds with this risk.

Kallberg and Toivanen (1998) considered that a correct assessment of the effects of speed on road trauma requires that the impacts on crash injury severity, as well as crash frequency, be addressed. This is due to the fact that as speed increases, the effect on the risk of fatal and serious injury crashes is greater than the effect on injury crashes in general. It is possible that in the crashes analysed by Kloeden et al (2001), the proportion of the casualty crashes resulting in death or serious injury may have increased for travelling speeds above average speeds. This effect is not included in their relationship, which provides the relative risks of involvement in a casualty crash (albeit a relatively severe casualty crash; see footnote below).

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[1] Crashes in which at least one person was treated at hospital or killed. Thus the injury was more severe than one requiring any form of medical treatment, the usual minimum criterion for defining a casualty crash resulting in death or injury.

3.1.2 Nilsson's relationships between speed and crashes of different injury severity

Nilsson (1984) developed relationships of the following form linking changes in mean or median speeds with the number of crashes:

$$\mathbf{n_A = (v_A/v_B)^p * n_B}$$

where $\mathbf{n_A}$ = number of crashes after the speed change

$\mathbf{n_B}$ = number of crashes before the speed change

$\mathbf{v_A}$ = mean or median speed after

$\mathbf{v_B}$ = mean or median speed before

$\mathbf{p}$ = exponent depending on the injury severity of the crashes:

- **p** = 4 for fatal crashes
- **p** = 3 for serious injury crashes
- **p** = 2 for minor injury crashes.

These relationships were based on research linking changes in median speeds (free speeds measured in traffic surveys) with changes in crash frequencies at various injury severities, as a result of a large number of changes in speed limits on Swedish rural roads. A potential problem with the fatal crash relationship is that a poor estimate of the fatal crash frequency before the speed change can give an inaccurate estimate of the impact on fatal crash costs, due to the fourth-power effect of the exponent in this case, and the relatively high unit costs normally attached to fatal outcomes.

3.1.3 Elvik et al's meta-analysis of Nilsson's relationships

Elvik, Christensen and Amundsen (2004) conducted a meta-analysis study of a large number (98) of evaluation studies in which 460 estimates of the effects of changes in travel speed on road trauma have been assessed. They combined the estimates of effect in groups of estimates depending on whether the effect was measured as a change in crash numbers (at each level of severity) or victim numbers (again, at each severity level). Each estimate of effect, together with the change in mean speed associated with it, was initially interpreted as a power estimate, i.e. the power to which the speed change needed to be raised to produce the change in crashes or victims. The available individual power estimates were then combined using meta-analysis techniques giving greatest weight to the most reliable estimates to produce an overall power estimate.

Based on a number of different meta-analysis techniques and some smoothing of the results, Elvik et al (2004) produced the final power estimates shown in Table 1. The estimated exponents for crashes at each level of injury severity are lower than those given in section 3.1.2, but the estimation intervals include Nilsson's original exponents.

Table 1: Final power estimates (exponents) produced by Elvik et al (2004)

Accident or injury severity	exponent	interval
Fatalities	4.5	(4.1 – 4.9)
Seriously injured road user	3.0	(2.2 – 3.8)
Slightly injured road user	1.5	(1.0 – 2.0)
All injured road users (severity not stated)	2.7	(0.9 – 4.5)
Fatal accidents	3.6	(2.4 – 4.8)
Serious injury accidents	2.4	(1.1 – 3.7)
Slight injury accidents	1.2	(0.1 – 2.3)
All injury accidents (severity not stated)	2.0	(1.3 – 2.7)
Property-damage-only accidents	1.0	(0.2 – 1.8)

Source: TØI report 740/2004

3.1.4 Power estimates for rural speeds and crashes

Cameron and Elvik (2008) re-analysed Elvik et al's (2004) data to produce separate power estimates for each road environment and each injury severity level. There were too few studies of changes in crash numbers (rather than victims) to allow a conventional meta-analysis. However, the power estimates for changes in crash victims at each severity level on rural highways are given below (together with the standard error of the estimate):

- Fatalities 4.71 (s.e. = 0.49)
- Seriously injured 1.81 (s.e. = 0.30)
- Slightly injured 1.55 (s.e. = 0.24)

It can be seen that on rural highways, the exponent linking fatalities with mean speeds is somewhat higher than that averaged across all road environments (Table 1), but the exponent for seriously injured road users is substantially lower.

An alternative, meta-regression analysis produced estimates of the exponents linking crash numbers with mean speeds on rural highways (albeit with larger standard errors), as follows:

- Fatal crashes 4.36
- Serious injury crashes 2.78
- Slight injury crashes 2.22

These power estimates were considered the most appropriate for use in Nilsson's (1984) relationships when applied to changes in mean speeds on rural highways.

Crashes in rural areas are relatively severe in terms of injury outcome, especially when trucks are involved in the crash. For this reason it was considered necessary to make use of a set of relationships linking speeds with each level of crash injury severity outcome. Nilsson (1984) type relationships are able to represent this better than Kloeden et al's (2001) estimates of relative risk on rural roads. Nilsson's relationships were also more appropriate than Kloeden et al's (2001) estimates of risk associated with speed because of their links with average speed rather than individual speeds. The objectives of the project required that the road trauma impacts of a range of average speeds be estimated.

3.1.5 Crash rates by road type

The application of Nilsson (1984) type relationships requires estimates of the number of casualty crashes, by injury severity level, on each type of road under existing conditions. These estimates can be derived from estimates of the casualty crash rate per million vehicle-kilometres of travel (VKT). Disaggregating the crashes by injury level will be discussed in the following section.

Mclean (2001) estimated casualty crash rates on different classes of rural roads and examined other factors which influence these rates. For a standard two-lane undivided 7.0 m sealed rural road (with traffic mix: 85% cars and light trucks, 7.5% rigid trucks and 7.5% articulated trucks), the estimated rate was 25 casualty crashes per 100 million VKT.

Perovic et al (2008) updated these casualty crash rates per 100 million VKT and provided estimates for various classes of rural road which are relevant to this study, as follows:

- Divided rural road 20.0
- Undivided sealed road > 11.6 m 19.38
- Undivided sealed road 7.61-8.2 m 21.25
- Undivided sealed road 6.41-7.0 m 25.0
- Unsealed gravel road 35.0

Mclean (2001) found that the base casualty crash rates needed to be adjusted for the number and length of horizontal curves with design speeds below 90 km/h (size of adjustment depending on tightness of the curve), but not for the vertical curves. Taylor, Buraya and Kennedy (2002) have confirmed this finding for rural roads in England.

Mclean (2001) reviewed the evidence for different rural crash rates related to vehicle type involved, but was unable to find consistent evidence that trucks were under- or over-represented in casualty crashes. (Their over-representation in fatal crashes was clear; see section 3.1.7.) Cox (1997) also found that trucks do not appear to be involved in crashes at any greater rate than other vehicles but they are more likely to be involved in a fatality or serious injury crash. For this reason, the casualty crash rates per million VKT (i.e., as provided by Mclean, or obtained from direct Tasmanian sources: see section 5.2) were taken to be the same rate for each type of vehicle on each particular class of rural road considered in this study.

3.1.6 Crash rates on curvy roads with crossroads and towns

Curvy roads with bends requiring slowing and other features requiring traffic to stop occasionally will reduce the average speed on the 100 km section below the cruise speed. This will increase the travel time and the slowing and stopping will increase the fuel consumption and air pollution emissions of vehicles using the road section. The crash rate will also increase because of the curved alignment and because of the increased crash risk associated with cross roads.

The density of curves and crossroads on rural two-lane undivided roads has been found to increase the crash rate per million VKT. The U.K. Transport Research Laboratory, in a comprehensive analysis of crash rates on rural roads with 60 mph limits in England, found that the casualty crash rate was increased by 13% per additional sharp bend per kilometre of road, and by 33% per additional crossroad per kilometre (Taylor, Baruya and Kennedy

2002). A sharp bend was defined as one with a bend warning sign, implying that the advisory speed is less than the speed limit. They also found that the risk of a casualty crash increases according to the 2.5^{th} power of the increase in average speed (and that the effect of speed increases on the risk of a fatal or serious injury crash was stronger).

On the English rural roads studied, Taylor et al (2002) found that the density of sharp bends was 0.50 per kilometre and that of crossroads was 0.14 per kilometre. For the purpose of illustrating the effects of bends and crossroads on crash rates on a Tasmanian rural road section, these densities were taken as the same in Tasmania. Thus it was estimated that sharp bends would increase the basic casualty crash rate by 13% x 0.50 = 6.5% and crossroads would increase it by 33% x 0.14 = 4.62%. These increases had been found to be cumulative, implying that the crash rate would increase by 11.42%. Thus, for example, the casualty crash rate on curvy unsealed gravel roads with crossroads was taken as 35.0 x 111.42% = 39.0 casualty crashes per 100 million VKT for this analysis.

For the purpose of calculating the change in crash rate, at each level of crash injury severity, this was based on the Nilsson (1984) relationships (with exponents as in section 3.1.4) using the change in cruise speed, not the change in average travel speed over a given road section. This was because Nilsson's relationships had been developed based on measurements of free, unimpeded speeds (typically measured in speed surveys) on rural roads, and this type of speed is representative of mean speeds under cruise conditions, not the average speed over a whole section (especially where significant slowing and stopping is involved).

3.1.7 Crash severity by vehicle type involved

Mclean (2001) found that the outcome of a casualty crash involving a truck was more likely to be fatal or, to a somewhat lesser extent, result in serious injury, compared with crashes involving lighter vehicles only. Specific information on casualty crash severity on rural roads was provided for Victoria, as follows:

- Car involved 3.8% fatal, 29.4% serious injury outcome
- Rigid truck involved 8.0% fatal, 34.0% serious injury outcome
- Articulated truck involved 11.4% fatal, 35.2% serious injury outcome.

Since the severity of crash outcome is unlikely to be due to the road type or jurisdiction in which occurred and most likely due to the vehicle types involved, these estimates of casualty crash severity were taken as applicable to crashes on rural roads in Tasmania as well as Victoria.

3.2 VEHICLE OPERATING COSTS

Austroads have published models for calculating vehicle operating costs as a function of travel speeds under free-running conditions typical of rural highways (Perovic et al 2008). The 'freeway vehicle operating cost model' is proposed for use on such roads.

The estimated vehicle operating cost, c (cents/km resource cost in June 2007 prices), for a given average link speed, V (km/h), is:

$$c = A + B/V + C*V + D*V^2$$

Perovic et al (2008) provide the parameters of this model for passenger cars, light commercial vehicles, and heavy commercial vehicles separately. For example, the values, A = -16.262, B = 1553.78, C = 0.23531, and D = 0.0000501 applicable to passenger cars, have been used in this study.

An adjustment to these parameters to allow for additional fuel consumption on rural roads with curvy alignments requiring slowing, and intersections in towns requiring stopping, (and the consequent acceleration to normal travelling speeds in each case) will be described in section 3.4 because the same procedures apply to additional air pollution emissions.

3.3 AIR POLLUTION EMISSIONS

Speed of a vehicle has considerable effect on the air pollutants it emits. There are pollutants directly related to fuel consumption (e.g. carbon dioxide, lead, and oxides of nitrogen) as well as those resulting from incomplete combustion (e.g. carbon monoxide, hydrocarbons, and particulates). The amount of pollutant emitted at a given speed depends on whether the vehicle is accelerating or travelling at a steady speed (Ward et al 1998). Hence the total pollution emitted from a vehicle is related to whether it is driven smoothly or aggressively.

The MASTER project (Robertson, Ward and Marsden 1998) has provided estimates of the levels of emissions from a typical stream of vehicles travelling at steady speeds at 80 and 90 km/h on flat roads. The traffic mix consisted of 15% trucks, of which 2/3 were heavy trucks, and 80% of the cars were fitted with catalytic converters. This traffic composition was considered to be reasonably representative of rural traffic in Tasmania.

No estimates of emission rates for each type of vehicle individually (e.g. cars, rigid trucks, articulated trucks) could be readily found. For this reason, this study treated the emission rate of each type of pollutant, at a given speed, as being the same per kilometre of travel of each type of vehicle. This is likely to under- or over-estimate the pollution from some types of vehicle when examined separately. However, the estimated impact from air pollutants resulting from the total mix of traffic is probably close to being correct in aggregate.

Robertson et al's estimates have been extrapolated to estimate the air pollution emission impacts (in grams per km) for carbon monoxide, hydrocarbons, oxides of nitrogen, and particulates at each travel speed (section D4 of Appendix B onwards). They did not present information to estimate the impacts of carbon dioxide related to travel speed. Kallberg and Toivanen (1998) have provide emission rates for carbon dioxide at speeds of 85 and 98 km/h for a similar mix of traffic. For each pollutant, information presented by Ward et al (1998) suggested that it was reasonable to extrapolate its emission rate as a linear function of speed in the range from 80 to 110 km/h.

Since these estimates relate to travel at steady speeds on flat roads, they probably represent the lower bounds of the impacts observed in practice. An adjustment to emission rates to allow for rural roads with curvy alignments requiring slowing, and intersections in towns requiring stopping, (and the consequent acceleration to normal travelling speeds in each case) will be described in the following section 3.4.

3.4 EMISSIONS AND FUEL CONSUMPTION ON CURVY ROADS

Traffic slowing for sharp bends would need to decelerate then accelerate to normal cruising speeds, resulting in increased emissions of air pollutants and increased fuel consumption. On the basis of the English densities in such road environments (Taylor et al 2002), 100 kilometres of rural road would include 50 sharp bends. For the purpose of illustration, it was taken that each sharp bend would require vehicles to decelerate to 70 km/h and then accelerate by the same amount. It was also assumed that there would be three occasions per 100 kilometres where vehicles would be required to stop (perhaps at intersections in towns or for other reasons), requiring deceleration to zero and then acceleration to cruise speed again.

The impact of variations in traffic speed on fuel consumption and emissions, due to acceleration and deceleration, has been examined and modelled by the Virginia Polytechnic Institute and State University in the USA (Ding 2000). They found that emission rates rise substantially with each stop, but fuel consumption is principally related to the cruise speed and secondly to the number of stops. A key parameter is the variance in speeds over the whole road section. Ding (2000) developed statistically-based mathematical models linking the rate of fuel consumption and pollutant emitted (HC, CO and NO_x) per kilometre to the average speed, the average speed squared, the variance of speeds, the number of stops, and parameters reflecting the variation in acceleration rates and kinetic energy. The models had an accuracy of 88%-96% when compared with instantaneous microscopic models (Ahn et al 1999). These models were used to estimate the increases in fuel consumption and emission rates for vehicles travelling at a given cruise speed encountering 50 sharp bends and stopping three times, to illustrate the influence of curved alignments and towns, compared with the straight, featureless road section considered in the base scenario.

For each cruise speed, ranging from 80 to 110 km/h, the average and variance of the travel speeds was calculated for a vehicle decelerating at 5.4 km/h per second to zero and then accelerating at 60% of the maximum possible acceleration back to the cruise speed. These illustrative acceleration and deceleration rates are typical of normal driving and well below the maximum performance of modern cars. The maximum possible acceleration was based on findings by Virginia University relating it linearly to the travel speed, falling to zero at the maximum speed (Ahn et al 1999). The average and variance of travel speeds was also calculated for a vehicle slowing from the cruise speed to 70 km/h (simulating slowing for a curve) and then accelerating again. In each case, the distance over which deceleration/acceleration occurred was also calculated. This allowed the remaining length of the 100 km section in which the vehicle was able to travel at cruise speed to be estimated (Table 2).

Table 2: Distances and average speeds associated with deceleration from given cruise speed and acceleration back to cruise speed in 100 km section.

	Stopping (No. stops: 3)		**Slowing to 70 km/h** (No. curves: 50)		**Cruising**	
Cruise speed (km/h)	Distance decelerating-accelerating per stop (km)	Average speed over distance (km/h)	Distance decelerating-accelerating per curve (km)	Average speed over distance (km/h)	Distance (km)	Average speed over distance (km/h)
80	0.366	49.223	0.097	75.232	94.055	80
82	0.387	50.576	0.119	76.279	92.903	82
84	0.413	52.122	0.141	77.309	91.723	84
85	0.424	52.774	0.156	77.986	90.946	85
86	0.436	53.420	0.167	78.489	90.352	86
88	0.462	54.904	0.189	79.482	89.140	88
90	0.485	56.150	0.216	80.619	87.736	90
92	0.512	57.574	0.243	81.733	86.303	92
94	0.543	59.165	0.271	82.826	84.843	94
95	0.555	59.752	0.286	83.440	84.021	95
96	0.571	60.525	0.302	84.047	83.183	96
98	0.603	62.045	0.334	85.240	81.494	98
100	0.635	63.527	0.366	86.406	79.789	100
105	0.720	67.254	0.452	89.340	75.250	105
110	0.820	71.239	0.551	92.480	69.968	110

Together this information was used to estimate the average speed and speed variance associated with three stops and 50 sharp curves over a 100 km section, given each particular desired cruise speed. Ding's (2000) models were then used to estimate the fuel consumption and emission rates for each cruise speed, first including the speed variance and number of stops, and second excluding these factors to simulate straight roads without stopping. (The factors related to variation in acceleration rates and kinetic energy were excluded from both modelling calculations as no estimates of these variables related to speed were available.) The relative rate of fuel consumption and emissions on curvy roads with stops, relative to straight roads without stops, was calculated for each cruise speed

(Table 3). The relative rates for particulates and CO_2 emissions were assumed to be the same as for fuel consumption because these pollutants are strongly related to the volume of fuel consumed.

Table 3: Relative rates of fuel consumption and air pollutant emissions due to slowing for curves and stops from given cruise speeds.

	Speed over full 100 km rural road section		Relative rates on curvy road with stops, compared to straight road without stops			
Cruise speed (km/h)	Average speed (km/h)	Speed variance (per km)	Fuel consump-tion	HC	CO	NO_x
80	79.43	28.25	1.053	1.085	1.099	1.105
82	81.30	28.83	1.054	1.085	1.100	1.106
84	83.13	35.56	1.076	1.122	1.144	1.152
85	84.04	34.79	1.073	1.115	1.136	1.144
86	84.95	34.50	1.071	1.110	1.131	1.139
88	86.73	44.89	1.107	1.169	1.202	1.215
90	88.49	52.44	1.133	1.211	1.254	1.270
92	90.22	57.29	1.149	1.234	1.284	1.302
94	91.92	69.27	1.193	1.307	1.374	1.400
95	92.76	73.62	1.209	1.332	1.406	1.435
96	93.59	78.46	1.227	1.360	1.443	1.476
98	95.22	85.51	1.252	1.397	1.493	1.531
100	96.82	100.51	1.312	1.497	1.623	1.673
105	100.65	147.38	1.517	1.861	2.109	2.214
110	104.22	195.77	1.757	2.299	2.736	2.929

The increases in emission rates were applied to the emissions coefficients for each cruise speed, given in section D4 in the spreadsheets in Appendix B onwards, to estimate the increased emissions expected on curvy rural roads with occasional stops. The increase in fuel consumption at each cruise speed was applied to the fuel consumption rate per kilometre for each vehicle type (based on the fuel consumption models in Perovic et al 2008), multiplied by the resource cost of fuel in Hobart in June 2007 (Perovic et al 2008), and added to the fixed cost parameter (A) of the Austroads vehicle operating cost model for each vehicle type (see section 3.2).

3.5 TRAVEL TIME

It was assumed that travel time = link length / speed of traffic flow. This was considered to be a reasonable assumption on rural roads where traffic congestion, and hence constrained speeds, are a rarity. Kallberg and Toivanen (1998) noted that, in urban conditions, a considerable part of the travel time may be spent not moving at all or moving at very low speeds. Thus the average of all actual speeds on urban roads may be considerably less than the desired or maximum speed, and the travel time on the link may be considerably greater than that suggested by the free speeds of traffic on the road.

3.5.1 Travel times on curvy roads requiring slowing and stopping

The travel time for each type of vehicle and cruise speed on the curvy roads with stops was calculated from the average speed over the whole 100 km road section, which in turn was calculated as described in section 3.4 (i.e. it reflected the speeds below cruise speed in parts of the road during which the vehicle was decelerating and then accelerating again). In the analysis of scenarios on straight roads without stopping, the cruise speed and the average travel speed were considered to be equal.

3.6 NOISE POLLUTION

The impact of noise pollution from vehicles relates to the number of the human population living in the vicinity of roads such that they are exposed to noise in excess of 55 decibels. This can be a substantial impact in urban areas, but was considered to be small in rural areas because of the negligible population living in vicinity of Tasmanian rural roads outside towns where current speed limits of 100 or 110 km/h apply. For this reason, noise pollution was ignored in this study.

3.7 EFFECT ON TRAFFIC VOLUMES AND TRAFFIC DISTRIBUTION

The analysis in this study was confined to a link-level examination of changes in travel speed. It was assumed that there was no change in traffic volumes as a result of any constraints on speeds on rural roads, and hence that there was no change in consumer surplus (Kallberg and Toivanen 1998) associated with the changes in speed. Given that there are few alternative options associated with a given rural trip of reasonable distance in Tasmania, it is believed that the assumption is reasonable.

4. VALUATION OF COSTS AND BENEFITS

4.1 ROAD TRAUMA

There are two basic approaches to valuing road trauma (Steadman and Bryan 1988):

- the ‘ex-post’ approach, which examines the costs of road trauma which has already occurred (also known as the ‘human capital’ approach)

- the ‘ex-ante’ approach, which seeks to determine the amount the community would pay to prevent road trauma in the future (also known as ‘willingness to pay’)

BTE (2000) has provided estimates of the human capital cost of a road crash in Australia during 1996 at each level of injury severity. A 4% discount rate was used to value future earnings of killed and disabled road trauma victims. These estimates have been updated to year 2007 values by Perovic et al (2008) using the appropriate pricing index for each component of the cost. The updated estimates of the human capital cost of a road crash in rural Tasmania in year 2007 A$ were:

- fatal crashes $2,155,000
- serious injury crashes $455,000
- other injury crashes $21,700.

The human capital costs were used to value the estimated road crashes, by injury severity outcome, at each level of average speed. To test the sensitivity of the analysis to this choice of crash values, analysis was also conducted using 'willingness to pay' values.

BTCE (1997) derived 'willingness to pay' values of road trauma in Victoria during 1992, based on 'willingness to pay' approaches in the USA and human capital costs for Australia at that time. They provided high and low estimates of the 'willingness to pay' values of road trauma per person, at each level of injury severity, which differed only in the cases of serious and medically treated injury. The high estimates were chosen for this study.

The 'willingness to pay' estimates per person were combined according to the average number of persons injured to each level of severity in fatal, serious injury and other injury crashes, respectively (Corben et al 1994). These estimates were then updated to year 2007 A$ using the Consumer Price Index to provide the following estimates of the 'willingness to pay' values of road crashes:

- fatal crashes $5,679,660
- serious injury crashes $460,470
- other injury crashes $102,375.

It was noted that the 'willingness to pay' estimate of the value of a serious injury crash was only marginally greater than the human capital cost based on BTE (2000), whereas for the fatal and minor injury crashes the estimated value was much greater than the human capital cost. This was considered likely to be due to methodological differences between BTCE (1997) and BTE (2000), but it was beyond the scope of this study to rationalise these differences.

4.2 TRAVEL TIME

Austroads have published values per occupant hour and per freight hour (in June 2007 prices) for travel times in rural areas (Perovic et al 2008). These values differ by type of vehicle, reflecting the different values of the time for occupants and freight carried in these vehicles and their trip purposes. The values per vehicle hour were calculated by multiplying the occupant hour values by average occupancy rates and (where applicable) adding the freight hour value (section E2a of Appendix B onwards).

In the analysis, the value per hour for business trips was taken as that associated with business car use. Private car use values were used as the value per hour for personal business and commuting trips, and also for leisure trips. There is a view that the value of time on leisure trips should be set to zero when time savings are compared to crash cost estimates based on human capital methodology (Cameron 2003), however that was not done in the analysis described here.

The values per hour for rigid trucks were taken as those pertaining to heavy, 3-axle trucks and the values per hour for articulated trucks were those for 6-axle trucks (Perovic et al 2008). These were the highest values given for truck travel times and reflected the magnitude and importance of heavy freight traffic in Tasmania.

4.3 AIR POLLUTION EMISSIONS

The unit costs of air pollution emissions were provided by Perovic et al (2008) in year 2007 A$, namely:

- Carbon monoxide $ 3 per tonne
- Hydrocarbons $ 958 per tonne
- Oxides of nitrogen $ 1,912 per tonne
- Particulates (PM10) $ 304,298 per tonne
- Carbon dioxide $ 48 per tonne.

These estimates were used in this study (section E5a of Appendix B onwards).

5. RURAL ROAD USE AND CRASH RATES

5.1 ROAD LENGTHS AND TRAFFIC

DIER provided information on 414 road links on the State Road Network (SRN) covering 3,511 kilometres. Detailed information is not held on the remaining nearly 16,000 kilometres of Council roads in Tasmania, of which over 10,000 kilometres is estimated to be unsealed (NRTC 1991 and Austroads *Road Facts 2005)*. The SRN appears to be mainly rural roads, but some links had speed limits below 100 km/h, possibly on the approaches to urban areas. An estimated 206 km of the SRN is unsealed gravel roads.

The links were classified according to whether a reduction in speed limit is envisaged or not. The links were also classified into one five road categories (Trunk; Regional Freight; Regional Access; Feeder; and Other roads), whether they had divided or undivided carriageways, and the predominant speed limit on the link (110 km/h; 100 km/h; or lower).

Table 5.1 shows the lengths of road on the SRN which were envisaged as potentially having a reduction in speed limit and which were the focus of the economic analyses reported in Chapters 6-8 (shown in bold). The divided road lengths with 100 km/h speed limits envisaged for limit reductions were considered too short for the economic analysis to be reliable. The lower speed limit links are parts of routes ear-marked for speed limit reductions, but the reductions in the rural speed limits are not applicable to them.

Table 5.1: Lengths of links on State Road Network by current speed limits and whether reduced limits are envisaged. Bolded lengths were the focus of economic analysis of the effects of speed reductions.

		Divided roads Speed limit (km/h)			Divided Total	**Undivided roads** Speed limit (km/h)			Un-divided Total	**Grand Total**
Status	**Category**	100	110	Lower		100	110	Lower		
No change in limit	1	23.64	5.02		28.66	80.48	4.51		84.99	113.65
	2					133.89			133.89	133.89
	3	10.54			10.54	93.62			93.62	104.16
Total		34.18	5.02		39.2	307.99	4.51		312.5	351.70
Reduced limit envisaged	1	2.78	**67.31**	10.81	80.9		**238**	19.48	257.48	338.38
	2					**262.66**		17.63	280.29	280.29
	3	9.81		2.74	12.55	**571.94**		31.03	602.97	615.52
	4					**824.99**		20.88	845.87	845.87
	5					**1037.07**[3]	*4.46*[2]	31.67	1073.2	1073.2
Total		12.59	67.31	13.55	93.45	2696.66	242.46	120.69	3059.81	3159.19[1]
Grand Total		46.77	72.33	13.55	132.65	3004.65	246.97	120.69	3372.31	3510.89[1]

[1] Includes 5.93 km of road with unknown road category and unknown carriageway type
[2] Apparently mis-coded road category or speed limit for this road link
[3] Includes approximately 206 km of unsealed gravel road not separately identified in Category 5 links

DIER separately provided information on traffic level and mix (proportion of commercial vehicles: Austroads classes 3-12) on SRN roads categorised in the same way as the road lengths in Table 5.1, except that the traffic levels were not specific to the speed limit on each class of rural road (Table 5.2). However the divided and undivided Category 1 roads envisaged for a speed limit reduction were virtually all 110 km/h roads, so the traffic levels are relevant to Category 1 roads with this speed limit for the economic analysis.

Table 5.2: Annual Average Daily Traffic (AADT) on links on the State Road Network during 2003. Estimates by speed limit within each category not available.

		Divided roads Speed limit (km/h)			**Undivided roads** Speed limit (km/h)		
Status	**Category**	100	110	Lower	100	110	Lower
No change in limit	1	11547	11547		4919	4919	
	2				2669		
	3	6029			1656		
Reduced limit envisaged	1	7997	7997			6206	
	2				2396		
	3	8886			1776		
	4				1191		
	5				629		

5.2 CRASH RATES AND SEVERITY

A key input to the economic analysis of the effects of changes in speed associated with speed limit reductions is the casualty crash rate on the analysed roads and the severity of injury outcome of the crashes, under the existing speed conditions on the classes of road analysed. It is better to use actual crash rates rather than the typical crash rates by road class given by Perovic et al (2008) and listed in section 3.1.5, where actual data is available. This is because the actual crash rates and/or crash injury severity on the Tasmanian road sections nominated for speed limit reduction may be higher than is typical.

Table 5.3: Casualty crashes during 2004-2008 on the State Road Network

		Divided roads Speed limit (km/h)			Divided Total	**Undivided roads** Speed limit (km/h)			Un-divided Total	**Grand Total**
Status	**Category**	100	110	Lower		100	110	Lower		
No change in limit	1	122	17		139	145	10		155	294
	2					169			169	169
	3	45			45	51			51	96
Total		167	17		184	365	10		375	559
Reduced limit envisaged	1	16	**290**	215	521		**291**	113	404	925
	2					**254**		62	316	316
	3	78		6	84	**524**		147	671	755
	4					**545**		58	603	603
	5					**379**	0	26	405	405
Total		94	290	221	605	1702	291	406	2399	3024
Grand Total		261	307	221	789	2067	301	406	2774	3583

Table 5.3 shows the five-year casualty crash frequencies on SRN roads categorised in the same way as the road lengths in Table 5.1. Table 5.4 shows the casualty crash rate per 100 million vehicle-kilometres of travel, based on the length and AADT data in Tables 5.1-5.2. The road sections envisaged for speed limit reductions and economic analysis are indicated by the bold crash frequencies and rates.

Table 5.4: Casualty crash rates per 100 million vehicle-kilometres on the SRN

		Divided roads Speed limit (km/h)			**Undivided roads** Speed limit (km/h)		
Status	**Category**	100	110	Lower	100	110	Lower
No change in limit	1	24.49	16.07		20.07	24.70	
	2				25.91		
	3	38.80			18.03		
Reduced limit envisaged	1	39.44	**29.52**			**10.80**	
	2				**22.12**		
	3	49.03			**28.27**		
	4				**30.39**		
	5				**31.84**		

The Category 1 divided 110 km/h limit roads envisaged for speed limit reduction have relatively high casualty crash rates compared with roads of the same class where no change in the limit is planned. In contrast, the Category 1 undivided 110 km/h limit roads have a relatively low crash rate compared with the same class of roads where no change is planned. However, the proportion of casualty crashes resulting in fatal outcome on these Category 1 undivided 110 km/h roads is more than three times as high as the divided 110 km/h roads in the same category (Table 5.5). The proportion of casualty crashes resulting in serious injury on Category 1 undivided 110 km/h roads is also nearly twice as high as the same class of roads where no change in speed limit is planned (Table 5.6).

Table 5.5: Fatal crash proportion of casualty crashes during 2004-2008 on the SRN

		Divided roads Speed limit (km/h)			Divided Total	**Undivided roads** Speed limit (km/h)			Un-divided Total	**Grand Total**
Status	**Category**	100	110	Lower		100	110	Lower		
No change in limit	1	1.64%	5.88%		2.16%	8.97%	10.00%		9.03%	5.78%
	2					2.37%			2.37%	2.37%
	3	2.22%			2.22%	7.84%			7.84%	5.21%
Total		1.80%	5.88%		2.17%	5.75%	10.00%		5.87%	4.65%
Reduced limit envisaged	1	0.00%	**3.45%**	1.40%	2.50%		**11.68%**	1.77%	8.91%	5.30%
	2					**3.94%**		9.68%	5.06%	5.06%
	3	0.00%		16.67%	1.19%	**4.39%**		1.36%	3.73%	3.44%
	4					**2.94%**		1.72%	2.82%	2.82%
	5					**3.17%**		0.00%	2.96%	2.96%
Total		0.00%	3.45%	1.81%	2.31%	3.58%	11.68%	2.71%	4.42%	3.97%
Grand Total		1.15%	3.58%	1.81%	2.28%	3.97%	11.63%	2.71%	4.61%	4.07%

Table 5.6: Serious injury crash proportion of casualty crashes during 2004-2008 on the SRN

		Divided roads Speed limit (km/h)			Divided Total	**Undivided roads** Speed limit (km/h)			Un-divided Total	**Grand Total**
Status	**Category**	100	110	Lower		100	110	Lower		
No change in limit	1	11.48%	5.88%		10.79%	16.55%	10.00%		16.13%	13.61%
	2					17.75%			17.75%	17.75%
	3	13.33%			13.33%	17.65%			17.65%	15.63%
Total		11.98%	5.88%		11.41%	17.26%	10.00%		17.07%	15.21%
Reduced limit envisaged	1	6.25%	**10.34%**	8.37%	9.40%		**19.59%**	11.50%	17.33%	12.86%
	2					**20.08%**		14.52%	18.99%	18.99%
	3	10.26%		0.00%	9.52%	**18.51%**		17.01%	18.18%	17.22%
	4					**20.73%**		13.79%	20.07%	20.07%
	5					**20.32%**		19.23%	20.25%	20.25%
Total		9.57%	10.34%	8.14%	9.42%	19.86%	19.59%	14.78%	18.97%	17.13%
Grand Total		11.11%	10.10%	8.14%	9.89%	19.40%	19.27%	14.78%	18.71%	16.83%

5.3 TRAFFIC MIX AND GROWTH

Only limited information on the mix of traffic by vehicle type on the SRN was available from DIER (namely, the proportion of commercial vehicles in each road category). The ABS Survey of Motor Vehicle Usage (SMVU) in 2007 provided the following classification of the total vehicle-kilometres in the State by vehicle type:

- Passenger vehicles (including motorcycles) 68.01%
- Light commercial vehicles 24.18%
- Rigid heavy vehicles (including buses) 4.95%
- Articulated heavy vehicles 2.86%

Permanent traffic counters at 20 representative sites on the SRN provided the separate proportions of rigid and articulated vehicles in the traffic passing each site within each road category. Coupled with information on the total proportion of commercial vehicles within each road category on the SRN, the estimated full traffic mix was calculated (Table 5.7).

Table 5.7: Estimated traffic mix by road category on the SRN during 2007

		Passenger vehicles	Light commercial vehicles	Rigid heavy vehicles	Articulated heavy vehicles	TOTAL
Divided	Category 1	69.77%	24.81%	4.86%	0.56%	100.00%
Undivided	Category 1	65.15%	23.16%	4.45%	7.24%	100.00%
	Category 2	63.75%	22.67%	7.59%	5.99%	100.00%
	Category 3	68.76%	24.45%	5.38%	1.41%	100.00%
	Category 4	67.91%	24.15%	4.92%	3.02%	100.00%
	Category 5	67.38%	23.96%	7.69%	0.97%	100.00%

The ABS Surveys of Motor Vehicle Usage (SMVU) conducted in 2003 and 2007 found that travel in ‘other areas’ of Tasmania (outside Hobart and outside urban areas with more than 40,000 population) grew by 13.3% between those two years. Information for rural Tasmania was not available by vehicle type. For the economic analysis, it was assumed that the AADTs during 2007 on each class of road were 13.3% greater than those shown in Table 5.2.

5.4 PURPOSE OF TRAVEL

Information on purpose of travel in Tasmania by vehicle type was not available, apart from estimates of business travel by vehicle type in the ABS SMVU in 2007.

Information on the purpose of travel for each vehicle type was available for Australia as a whole, but not for rural roads separately. ABS have advised that because of the way respondents were asked to record their travel by area of trip and purpose of trip separately, it is not possible to obtain information on trip purposes on rural roads. For this reason, it needed to be assumed that the categorisation of trip purposes within each vehicle type was the same on urban and rural roads.

The Australia-wide information was used to estimate the distribution of purpose of trip for total vehicle kilometres travelled by each type of vehicle in Tasmania (Table 5.8).

Table 5.8: Purpose of trip on travel on Tasmanian roads. (Information for rural roads not available.) Source: ABS Survey of Motor Vehicle Usage, 2007.

Purpose	Passenger vehicles	Light commercial vehicles	Rigid heavy vehicles	Articulated heavy vehicles	Total all vehicles
TRAVEL (million veh-km)					
Business use	584	585	231	143	1542
To and from work	1006	311	16		913
Personal and other	1805	311			2537
TOTAL	3395	1207	247	143	4992
DISTRIBUTION					
Business use	17.2%	48.5%	93.5%	100.0%	30.9%
To and from work	29.6%	25.7%	6.5%	0.0%	18.3%
Personal and other	53.2%	25.8%	0.0%	0.0%	50.8%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

5.5 SPEEDS

DIER provided the results of recent (March 2009) free speed observations collected at 19 representative sites on the SRN, classified into the 12 Austroads classes of type of vehicle. These results were aggregated into three general classes of vehicle:

- Light vehicles (passenger cars and light commercial vehicles): Classes 1 and 2
- Rigid heavy vehicles: Classes 3 to 5
- Articulated heavy vehicles: Classes 6 to 12

The mean free speeds recorded at the 13 sites in the road categories envisaged for speed limit reductions were averaged within each category, weighting each by the number of speed observations, to provide representative mean speeds for each class of vehicle (Table 5.9). These mean speeds provide the baseline speeds for the economic analysis of the hypothesised changes in free speeds which would result if speed limits were reduced in each respective road environment.

There were no representative speed survey sites on gravel roads on the SRN, and the speed observations made at four gravel road sites as part of the evaluation of the Kingborough Safer Speeds Demonstration (Langford 2009) were not considered to be representative of gravel roads on the SRN throughout Tasmania because of the limited number of sites and the proximity of Kingborough to Hobart. For this reason, the baseline speeds on Category 5 unsealed roads on the SRN for the economic analysis were taken to be similar to those on the sealed Category 5 roads, as shown in Table 5.9 (see Chapter 8 for details).

It is understood that travel speeds on gravel roads not part of the SRN and the responsibility of Local Councils could be as low as 60 km/h.

Table 5.9: Speed survey sites, vehicles observed, and the weighted-average mean free speeds for each road category envisaged for a speed limit reduction

	Speed surveys		Mean free speed 2009 (km/h)		
Road category and current speed limit	No. of sites	Speed observations	Cars & LCVs	Rigid heavy vehicles	Artic. heavy vehicles
Rural roads with 110 km/h speed limits					
Divided Category 1 Trunk Roads	2	50,769	109.7	108.8	100.3
Undivided Cat. 1 Trunk Roads	1	44,467	104.7	99.9	99.0
Undivided rural roads with 100 km/h speed limits					
Category 2 Regional Freight Roads	3	134,374	85.3	80.8	77.7
Category 3 Regional Access Roads	5	114,538	87.2	81.6	82.3
Category 4 Feeder Roads	1	18,079	90.7	84.9	75.1
Category 5 "Other" Roads[1]	1	32,215	83.6	76.2	82.2

[1] Sites on sealed roads only. No sites on unsealed gravel roads on State Road Network.

6. RURAL ROADS WITH 110 KM/H SPEED LIMITS

Analysis of the total economic cost from road trauma, air pollutants, travel time, and vehicle operating costs was conducted for those links of Tasmanian rural road with current speed limits of 110 km/h where it is anticipated that a reduced speed limit of 100 km/h may be introduced. These links are all on Category 1 Trunk Roads and included both divided (67.3 km) and undivided (238 km) carriageways. The divided and undivided 110 km/h roads were analysed separately because of their very different current speed profiles and their casualty crash rates and crash injury severity patterns (see sections 5.2 and 5.5).

This analysis does not include road links currently signed at 110km/h that will retain this speed limit. Again these are Category 1 Trunk Roads, including both divided (5.02 km) and undivided (4.51 km) carriageways.

6.1 DIVIDED CATEGORY 1 TRUNK ROADS

6.1.1 Base scenario

The economic impact of reducing the speed limit from 110 to 100 km/h was estimated by assuming that the average free speed for each type of vehicle would decrease by 5 km/h. The base scenario valued road trauma using the "human capital" method (see section 4.1). Details of the analysis are given in Appendix B.

It is estimated that there would be a saving of 0.4 fatal crashes, 0.8 serious injury crashes and 5.5 less-serious injury crashes per year (Appendix B). Annual vehicle operating costs would decrease by $1.83 million (2.4%), crash costs by $1.46 million (15.3%) and air pollution costs by $135,000 (2.4%) on these roads (Table 6.1.1). Travel time costs would increase by $2.33 million per year (4.8%). The total economic impact was estimated to decrease by $1.08 million per annum, or 0.8% of the total impact with the 110 km/h speed limit.

Table 6.1.1: Economic impact of reducing speed limit on divided Category 1 roads from 110 km/h (before) to 100 km/h (after), assuming 5 km/h reduction in mean free speeds for each vehicle type. "Human capital" crash costs.

$'000/year	Before	After	Change	
Vehicle operating costs	76,949	75,123	-1826	-2.4 %
Time costs	48,915	51,248	2333	4.8 %
Crash costs	9,542	8,087	-1,456	-15.3%
Air pollution costs	5,669	5,534	-135	-2.4 %
Total	**141,075**	**139,992**		
Change			**-1,083**	**-0.8 %**

The analysis considered the impacts of different average free speeds below 110 km/h by modifying the 'after' average speed in the spreadsheet, in 2 km/h increments between 80 and 110 km/h, and recording each result (section H3 of Appendix B). In this way, the effect of the reduced speed limit if different average free speeds were to result can be seen (Table 6.1.2). The contribution to the total economic impact by cars and light commercial vehicles (LCVs), in contrast to the contribution by heavy vehicles (both rigid and articulated), was also calculated by analysing their impacts separately (foot of Table 6.1.2).

Table 6.1.2: Economic impact of different mean speeds on divided Category 1 roads

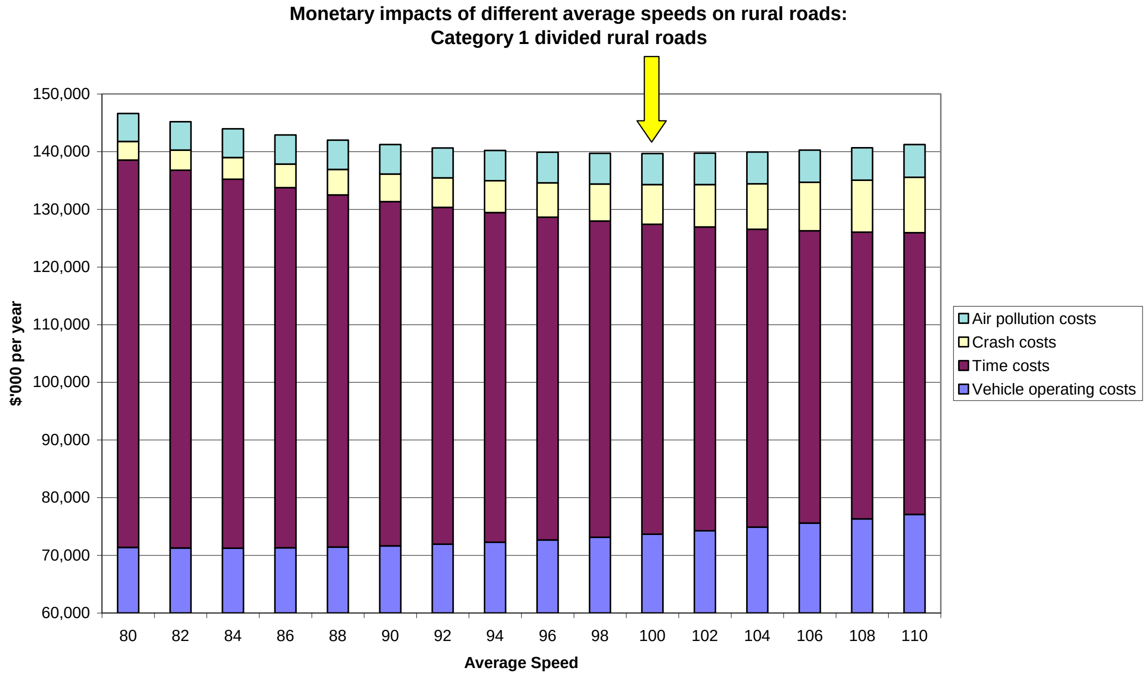
$'000/year	80 km/h	82 km/h	84 km/h	86 km/h	88 km/h	90 km/h	92 km/h	94 km/h
Vehicle op. costs	71,379	71,263	71,235	71,291	71,427	71,636	71,916	72,263
Time costs	67,158	65,520	63,960	62,473	61,053	59,696	58,399	57,156
Crash costs	3,209	3,484	3,777	4,088	4,419	4,771	5,144	5,539
Air pollution costs	4,861	4,915	4,969	5,023	5,077	5,131	5,185	5,239
Total	**146,608**	**145,182**	**143,941**	**142,876**	**141,976**	**141,235**	**140,644**	**140,198**
of which:								
Cars & LCVs	127,466	126,195	125,082	124,117	123,293	122,602	122,039	121,597
Heavy vehicles	19,142	18,987	18,859	18,759	18,684	18,633	18,606	**18,601**

Table 6.1.2 (cont.): Economic impact of different mean speeds on divided Category 1 roads

$'000/year	96 km/h	98 km/h	100 km/h	102 km/h	104 km/h	106 km/h	108 km/h	110 km/h
Vehicle op. costs	72,673	73,143	73,671	74,253	74,887	75,571	76,303	77,080
Time costs	55,965	54,823	53,727	52,673	51,660	50,686	49,747	48,843
Crash costs	5,957	6,399	6,867	7,361	7,882	8,431	9,009	9,619
Air pollution costs	5,293	5,348	5,402	5,456	5,510	5,564	5,618	5,672
Total	**139,889**	**139,714**	**139,666**	**139,742**	**139,938**	**140,251**	**140,677**	**141,213**
of which:								
Cars & LCVs	121,272	121,058	120,952	**120,951**	121,049	121,246	121,537	121,921
Heavy vehicles	18,618	18,655	18,714	18,792	18,889	19,005	19,140	19,292

The speed which minimises the total economic impact, as valued in this base scenario for divided Category 1 roads, is 100 km/h. This is also apparent in Figure 6.1.1. (Only impacts above $60 million are shown in the Figure because of the substantial level of fixed vehicle operating costs.)

Figure 6.1.1: Divided Category 1 roads – Base scenario.



However, the optimum speed differs substantially by vehicle type (shown in bold at the foot of Table 6.1.2). It was estimated as 102 km/h for cars and LCVs (Figure 6.1.2), as for all vehicle types combined, but 94 km/h for heavy vehicles (Figure 6.1.3).

Figure 6.1.2: Divided Category 1 roads – Car and LCV-related costs.

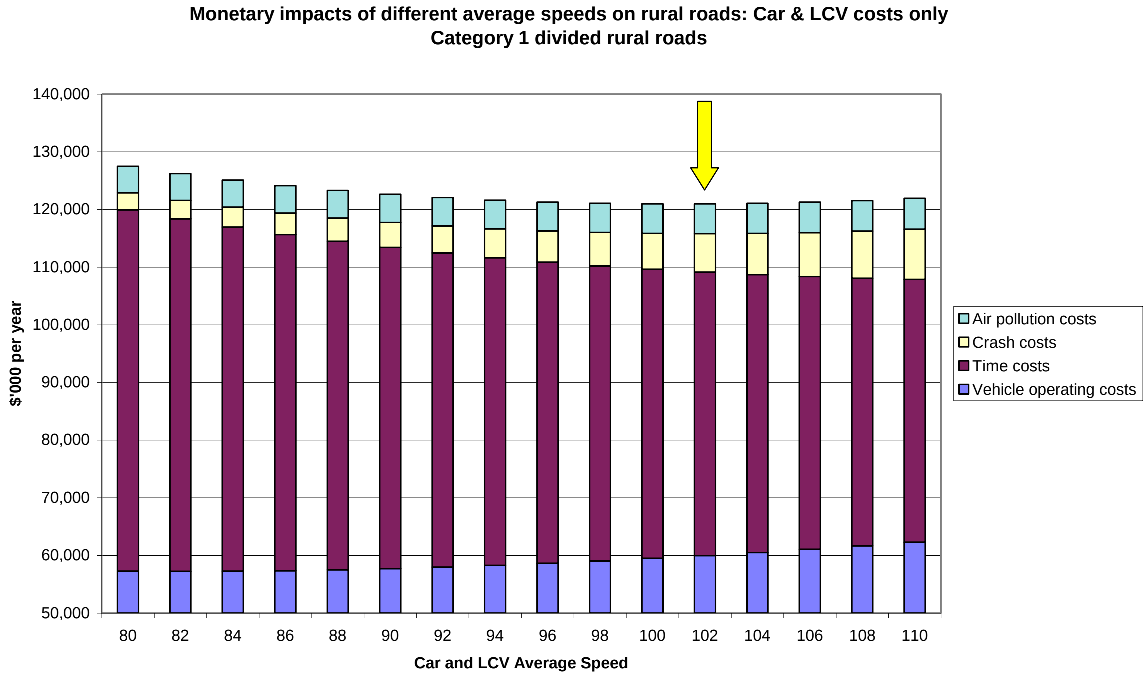
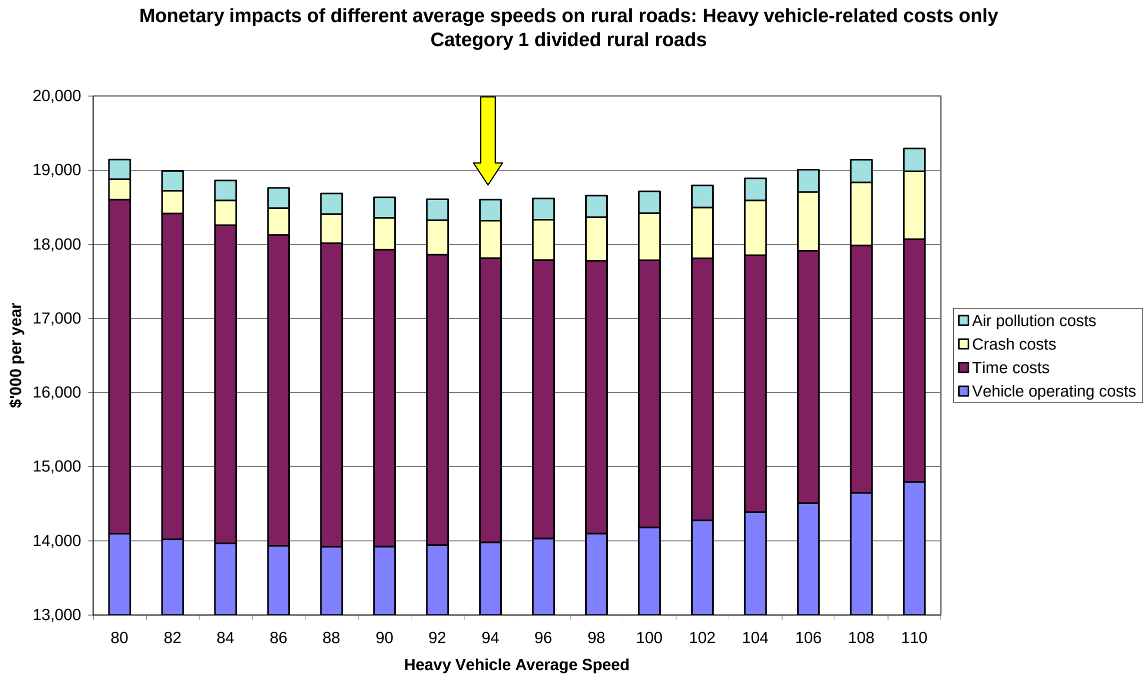


Figure 6.1.3: Divided Category 1 roads – Heavy vehicle-related costs.



6.1.2 Willingness to pay valuation of road trauma

The base scenario was modified by using 'willingness to pay' valuations of road trauma (BTCE 1997), updated to 2007 prices, instead of human capital costs (BTE 2000) to test the sensitivity of the total economic impact to this assumption (Appendix C).

Under this scenario, the annual crash costs would decrease by $3.47 million on divided Category 1 roads (Table 6.1.3), compared with an estimated decrease of $1.46 million per annum using human capital costs. The total economic benefit associated with the decrease in speed limit would then be about $3.098 million per year, or 2.0% of the total impact with the 110 km/h speed limit.

Table 6.1.3: Economic impact of reducing speed limit on divided Category 1 roads from 110 km/h (before) to 100 km/h (after), assuming 5 km/h reduction in mean free speeds. "Willingness to pay" valuations of crash costs.

$'000/year	**Before**	**After**	**Change**	
Vehicle operating costs	76,949	75,123	-1826	-2.4 %
Time costs	48,915	51,248	2333	4.8 %
Crash costs	22,615	19,144	-3,470	-15.3%
Air pollution costs	5,669	5,534	-135	-2.4 %
Total	**154,147**	**151,049**		
Change			**-3,098**	**-2.0 %**

When a range of average speeds was considered, the speed which minimised the total economic impact was 92 km/h (Table 6.1.4 and Figure 6.1.4). Using the "willingness to pay" valuations of road trauma, the optimum speed for cars and LCVs was estimated to be 92 km/h and that for heavy vehicles was estimated to be 90 km/h. The economic impact related to heavy vehicles reflected the higher valuation of the crash costs associated with their use (Figure 6.1.5).

Comparison of these results with those in section 6.1.1, using human capital costs of the road trauma saved by speed reductions, shows the sensitivity of the estimated economic impacts to the assumptions about the values society is prepared to place on preventing casualty crashes, especially those resulting in death and serious injury. The high severity of injury outcome associated with crashes involving heavy vehicles, compared with light vehicle crashes, together with their high operating costs, results in lower optimum speeds for this class of vehicle.

Table 6.1.4: Economic impact of different mean speeds on divided Category 1 roads. "Willingness to pay" valuations of crash costs.

$'000/year	80 km/h	82 km/h	84 km/h	86 km/h	88 km/h	90 km/h	92 km/h	94 km/h	96 km/h	98 km/h	100 km/h
Vehicle op. costs	71,379	71,263	71,235	71,291	71,427	71,636	71,916	72,263	72,673	73,143	73,671
Time costs	67,158	65,520	63,960	62,473	61,053	59,696	58,399	57,156	55,965	54,823	53,727
Crash costs	7,610	8,256	8,945	9,679	10,459	11,288	12,169	13,103	14,093	15,141	16,250
Air pollution costs	4,861	4,915	4,969	5,023	5,077	5,131	5,185	5,239	5,293	5,348	5,402
Total	**151,009**	**149,954**	**149,110**	**148,466**	**148,016**	**147,752**	**147,669**	**147,761**	**148,025**	**148,455**	**149,049**
of which:											
Cars & LCVs	131,485	130,549	129,792	129,207	128,786	128,525	**128,417**	128,459	128,646	128,975	129,444
Heavy vehicles	19,524	19,405	19,318	19,259	19,230	**19,227**	19,252	19,303	19,379	19,480	19,605

Figure 6.1.4: Divided Category 1 roads – 'Willingness to pay' valuations of road trauma.

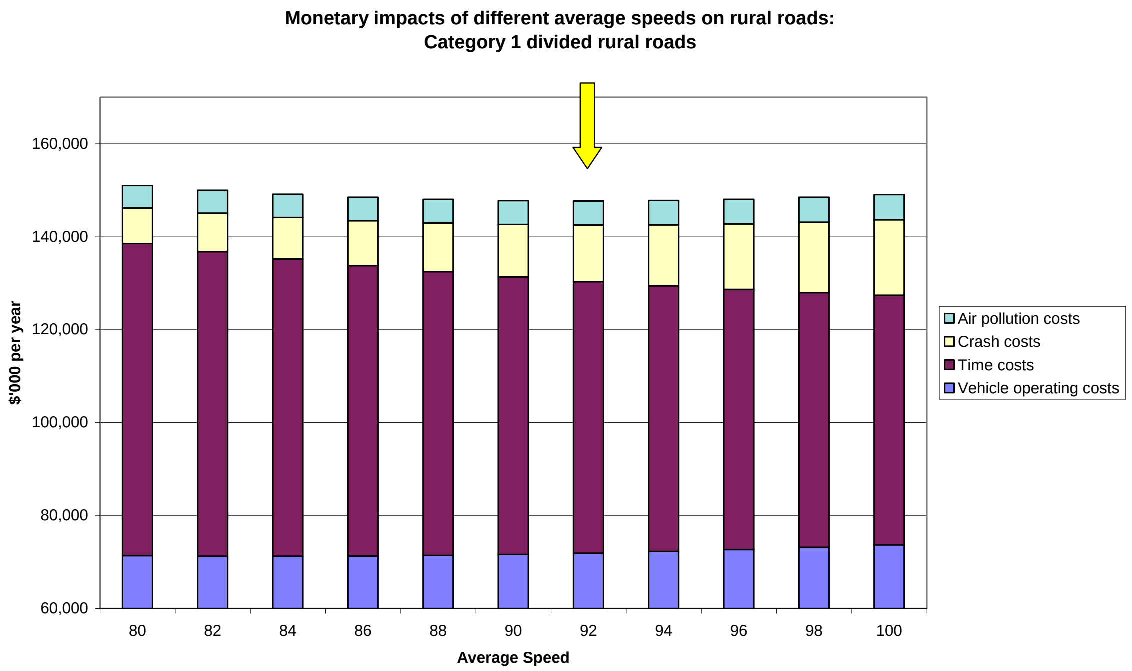
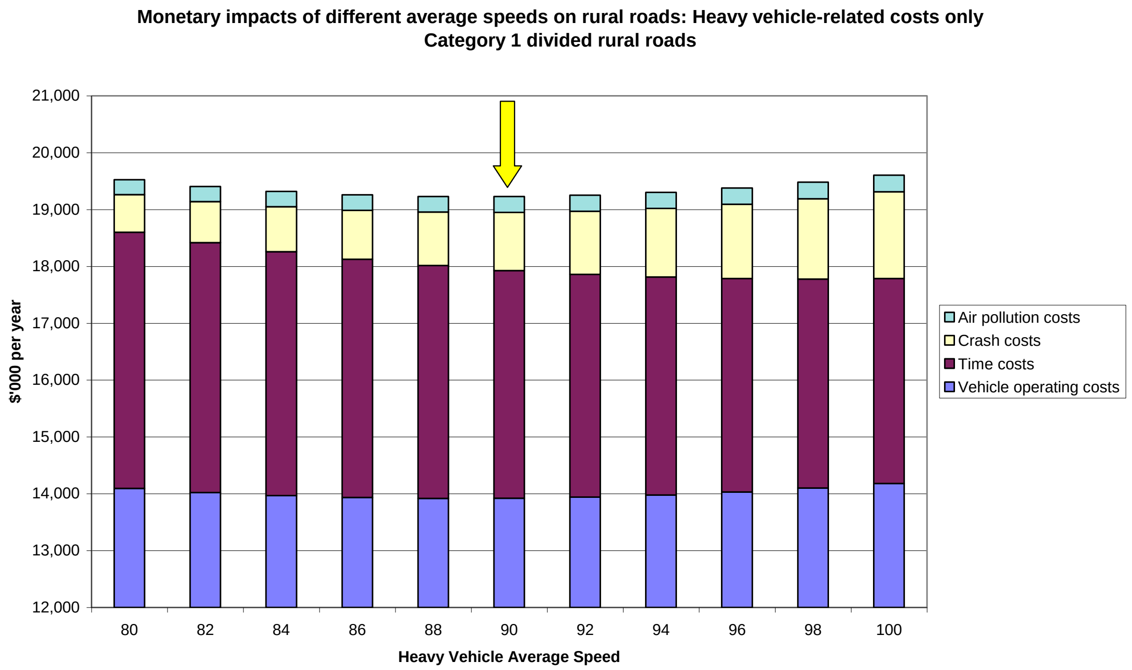


Figure 6.1.5: Divided Category 1 roads – 'Willingness to pay' valuations of road trauma. Heavy vehicle-related costs.



6.2 UNDIVIDED CATEGORY 1 TRUNK ROADS

6.2.1 Base scenario

The economic impact of reducing the speed limit from 110 to 100 km/h on the 238 km of undivided Category 1 rural roads was estimated by assuming that the average free speed for each type of vehicle (see Table 5.9) would decrease by 5 km/h. The average speeds were lower on these undivided roads than the divided roads in the same category, but the proportion of articulated heavy vehicle traffic was much higher. The base scenario valued road trauma using the “human capital” method (see section 4.1). Details of the analysis are given in Appendix D.

It is estimated that there would be a saving of 1.8 fatal crashes, 1.7 serious injury crashes and 4.5 less-serious injury crashes per year (Appendix D). Annual vehicle operating costs would decrease by $4.28 million (1.8%), crash costs by $4.71 million (17.6%) and air pollution costs by $371,000 (2.4%) on these roads (Table 6.2.1). Travel time costs would increase by $7.50 million per year (5.1%). The total economic impact was estimated to decrease by $1.87 million per annum, or 0.4% of the total impact with the 110 km/h speed limit.

Table 6.2.1: Economic impact of reducing speed limit on undivided Category 1 roads from 110 km/h (before) to 100 km/h (after), assuming 5 km/h reduction in mean free speeds for each vehicle type. “Human capital” crash costs.

$’000/year	**Before**	**After**	**Change**	
Vehicle operating costs	239,519	235,240	-4280	-1.8 %
Time costs	148,325	155,820	7495	5.1 %
Crash costs	26,769	22,055	-4,714	-17.6%
Air pollution costs	15,146	14,775	-371	-2.4 %
Total	**429,759**	**427,889**		
Change			**-1,870**	**-0.4 %**

When a range of average speeds was considered as possible “after” speeds following the speed limit reduction, the speed which minimised the total economic impact for all vehicle types combined was 98 km/h (Table 6.2.2 and Figure 6.2.1).

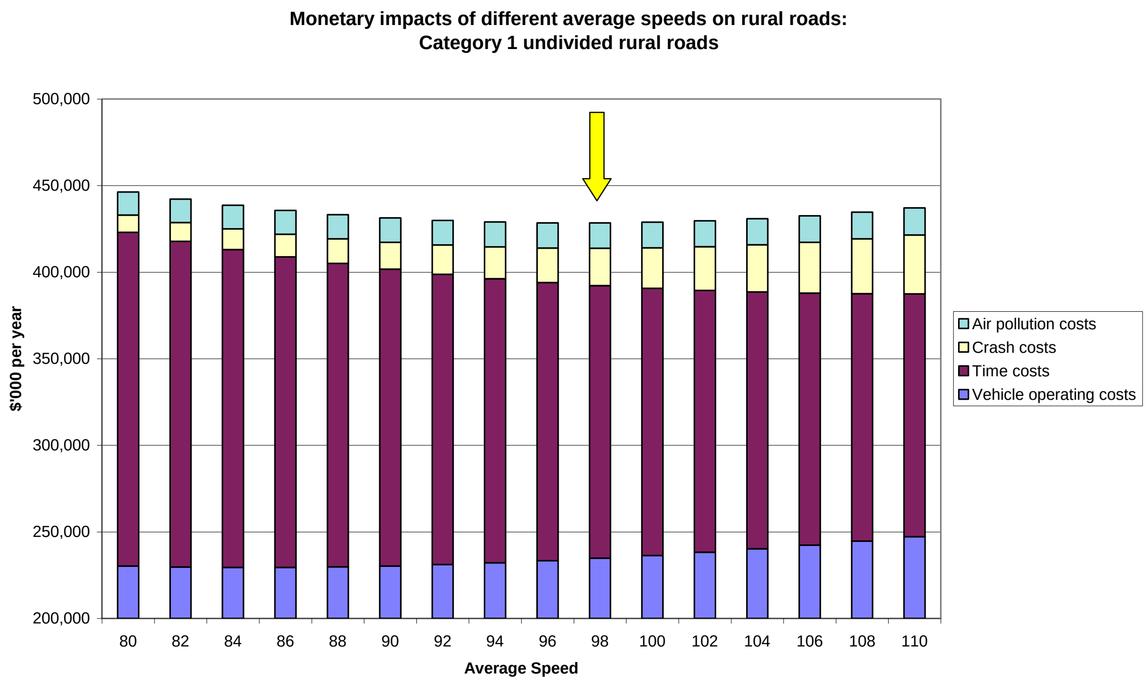
Table 6.2.2: Economic impact of different mean speeds on undivided Category 1 roads

$'000/year	80 km/h	82 km/h	84 km/h	86 km/h	88 km/h	90 km/h	92 km/h	94 km/h
Vehicle op. costs	230,220	229,672	229,422	229,454	229,750	230,298	231,084	232,096
Time costs	192,823	188,120	183,641	179,370	175,294	171,398	167,672	164,105
Crash costs	9,895	10,867	11,912	13,034	14,237	15,525	16,901	18,372
Air pollution costs	13,341	13,489	13,638	13,786	13,934	14,083	14,231	14,379
Total	**446,279**	**442,149**	**438,613**	**435,644**	**433,215**	**431,304**	**429,889**	**428,951**
of which:								
Cars & LCVs	326,508	323,323	320,552	318,173	316,168	314,518	313,210	312,228
Heavy vehicles	119,772	118,826	118,062	117,471	117,048	116,785	**116,679**	116,723

Table 6.2.2 (cont.): Economic impact of different mean speeds on undivided Category 1 roads

$'000/year	96 km/h	98 km/h	100 km/h	102 km/h	104 km/h	106 km/h	108 km/h	110 km/h
Vehicle op. costs	233,322	234,754	236,381	238,195	240,188	242,353	244,683	247,172
Time costs	160,686	157,407	154,259	151,234	148,326	145,527	142,832	140,235
Crash costs	19,940	21,611	23,389	25,280	27,287	29,417	31,674	34,065
Air pollution costs	14,527	14,676	14,824	14,972	15,120	15,269	15,417	15,565
Total	**428,476**	**428,447**	**428,852**	**429,680**	**430,921**	**432,566**	**434,607**	**437,037**
of which:								
Cars & LCVs	311,562	311,199	**311,131**	311,349	311,845	312,612	313,646	314,941
Heavy vehicles	116,914	117,248	117,721	118,332	119,077	119,953	120,961	122,097

Figure 6.2.1: Undivided Category 1 roads – Base scenario.



However, the optimum speed differs substantially by vehicle type (shown in bold at the foot of Table 6.2.2). It was estimated as 100 km/h for cars and LCVs (Figure 6.2.2), but 92 km/h for heavy vehicles (Figure 6.2.3).

Figure 6.2.2: Undivided Category 1 roads – Car and LCV-related costs.

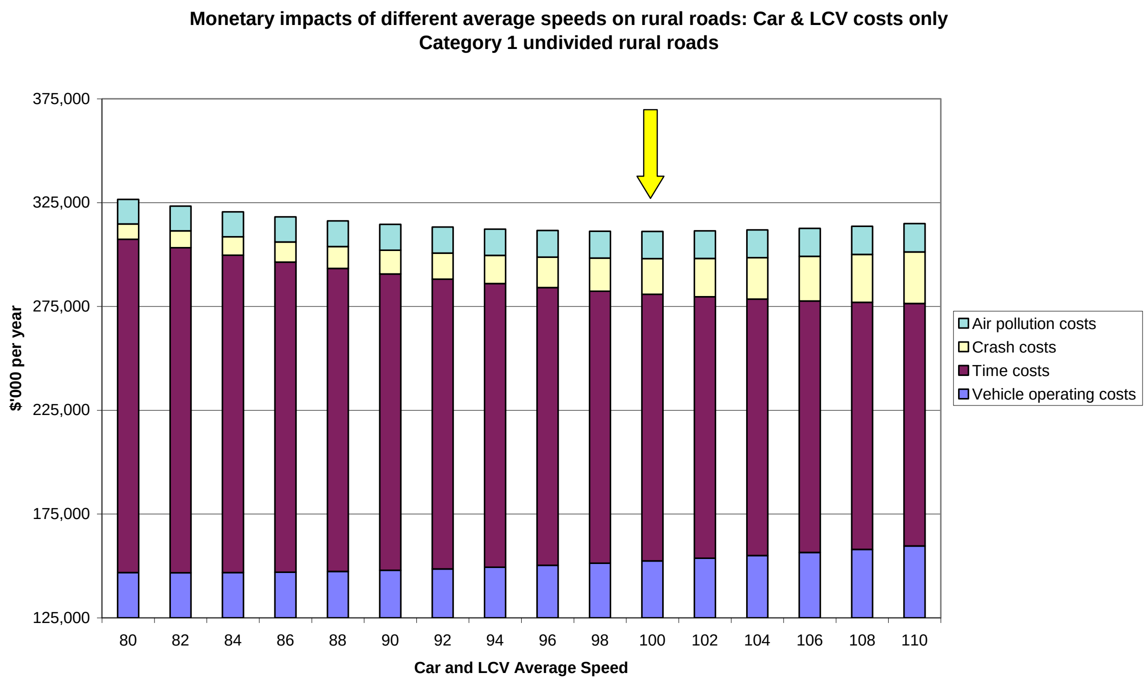
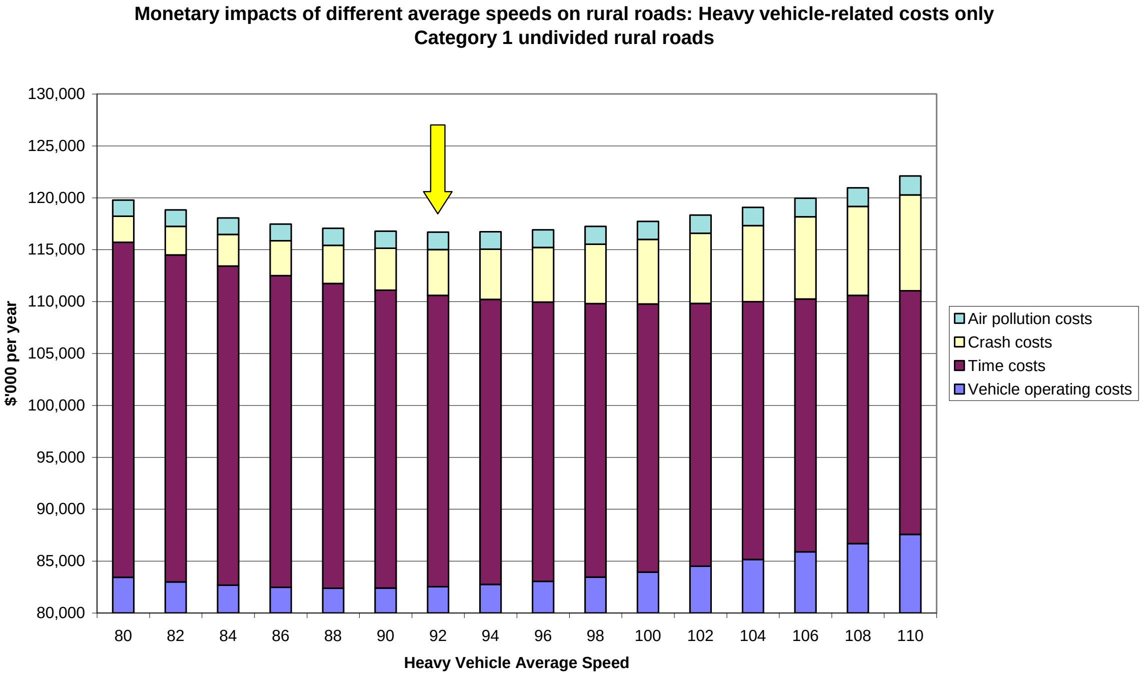


Figure 6.2.3: Undivided Category 1 roads – Heavy vehicle-related costs.



6.2.2 Willingness to pay valuation of road trauma

As for the analysis of divided Category 1 roads, the base scenario was modified by using 'willingness to pay' valuations of road trauma (Appendix E).

Under this scenario, the annual crash costs would decrease by $11.38 million on undivided Category 1 roads (Table 6.2.3), compared with an estimated decrease of $4.71 million per annum using human capital costs. The total economic benefit associated with the decrease in speed limit would then be about $8.54 million per year, or 1.8% of the total impact with the 110 km/h speed limit.

Table 6.2.3: Economic impact of reducing speed limit on undivided Category 1 roads from 110 km/h (before) to 100 km/h (after), assuming 5 km/h reduction in mean free speeds. "Willingness to pay" valuations of crash costs.

$'000/year	**Before**	**After**	**Change**	
Vehicle operating costs	239,519	235,240	-4280	-1.8 %
Time costs	148,325	155,820	7495	5.1 %
Crash costs	62,754	51,373	-11,381	-18.1%
Air pollution costs	15,146	14,775	-371	-2.4 %
Total	**465,744**	**457,207**		
Change			**-8,537**	**-1.8 %**

When a range of average speeds was considered, the speed which minimised the total economic impact for all vehicle types combined was 90 km/h (Table 6.2.4 and Figure 6.2.4). Using the "willingness to pay" valuations of road trauma, the optimum speed for cars and LCVs was estimated to be 90 km/h and that for heavy vehicles was estimated to be 86 km/h (Figure 6.2.5).

Table 6.2.4: Economic impact of different mean speeds on undivided Category 1 roads. "Willingness to pay" valuations of crash costs.

$'000/year	80 km/h	82 km/h	84 km/h	86 km/h	88 km/h	90 km/h	92 km/h	94 km/h	96 km/h	98 km/h	100 km/h
Vehicle op. costs	230,220	229,672	229,422	229,454	229,750	230,298	231,084	232,096	233,322	234,754	236,381
Time costs	192,823	188,120	183,641	179,370	175,294	171,398	167,672	164,105	160,686	157,407	154,259
Crash costs	22,477	24,767	27,237	29,895	32,754	35,822	39,112	42,634	46,399	50,420	54,709
Air pollution costs	13,341	13,489	13,638	13,786	13,934	14,083	14,231	14,379	14,527	14,676	14,824
Total	**458,861**	**456,048**	**453,938**	**452,505**	**451,732**	**451,602**	**452,099**	**453,213**	**454,935**	**457,256**	**460,173**

of which:

Cars & LCVs	335,619	333,368	331,605	330,313	329,476	**329,083**	329,123	329,586	330,465	331,754	333,450
Heavy vehicles	123,242	122,680	122,333	**122,193**	122,256	122,518	122,976	123,628	124,470	125,502	126,723

Figure 6.2.4: Undivided Category 1 roads – 'Willingness to pay' valuations of road trauma.

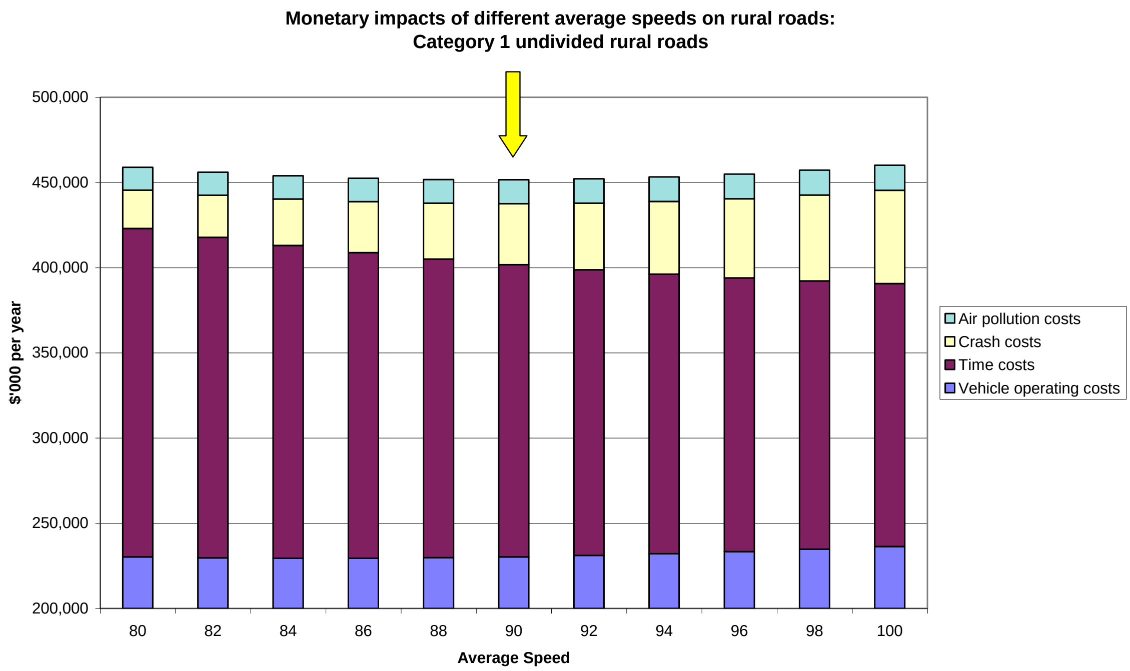
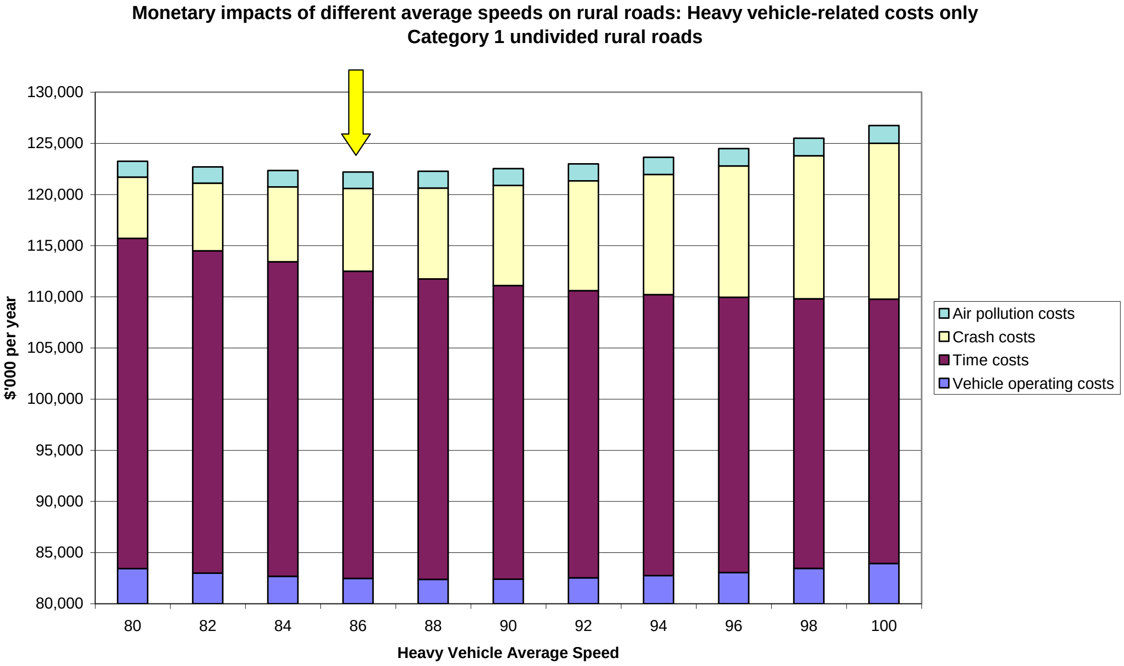


Figure 6.2.5: Undivided Category 1 roads – 'Willingness to pay' valuations of road trauma. Heavy vehicle-related costs.



7. UNDIVIDED RURAL ROADS WITH 100 KM/H SPEED LIMITS

The economic analysis of rural roads with 100 km/h speed limits envisaged for a speed limit reduction to 90 km/h focused on the undivided roads. The divided roads with 100 km/h limits in Category 1 (2.78 km) and in Category 3 (9.81 km) were considered too short for the analysis to be reliable (Table 5.1). There were substantial lengths of undivided 100 km/h limit roads envisaged in Categories 2 to 5, but no undivided 100 km/h roads in Category 1 were candidates for the speed limit reduction. The undivided 110 km/h Category 1 roads were analysed in section 6.2.

7.1 CATEGORY 2 REGIONAL FREIGHT ROADS

7.1.1 Base scenario

The economic impact of reducing the speed limit from 100 to 90 km/h on the 263 km of undivided Category 2 rural roads was estimated by assuming that the average free speed for each type of vehicle (see Table 5.9) would decrease by 5 km/h.[2] The average speeds were lower than the undivided roads in Category 1, and were already lower than the envisaged reduced limit. The proportion of heavy vehicle traffic on Category 2 roads was relatively high, especially rigid heavy vehicles. The base scenario valued road trauma using the "human capital" method. Details of the analysis are given in Appendix F.

If average speeds were reduced by 5 km/h, it is estimated that there would be a saving of 0.6 fatal crashes, 1.9 serious injury crashes and 5.5 less-serious injury crashes per year (Appendix F). Annual crash costs would decrease by $2.36 million (19.3%) and air pollution costs by $158,000 (2.7%) on these roads (Table 7.1.1). Annual vehicle operating costs would increase by $842,000 (0.8%) and travel time costs would increase by $4.96 million per year (6.3%). The total economic impact was estimated to increase by $3.29 million per annum, or 1.7% of the total impact with the 100 km/h speed limit.

Table 7.1.1: Economic impact of reducing speed limit on undivided Category 2 roads from 100 km/h (before) to 90 km/h (after), assuming 5 km/h reduction in mean free speeds. "Human capital" crash costs.

$'000/year	**Before**	**After**	**Change**	
Vehicle operating costs	102,715	103,557	842	0.8 %
Time costs	78,239	83,201	4962	6.3 %
Crash costs	12,214	9,859	-2,355	-19.3%
Air pollution costs	5,827	5,669	-158	-2.7 %
Total	**198,995**	**202,286**		
Change			**3,291**	**1.7 %**

[2] Note there are 134km of undivided Category 2 rural roads where it is envisaged that the current speed limit will be retained.

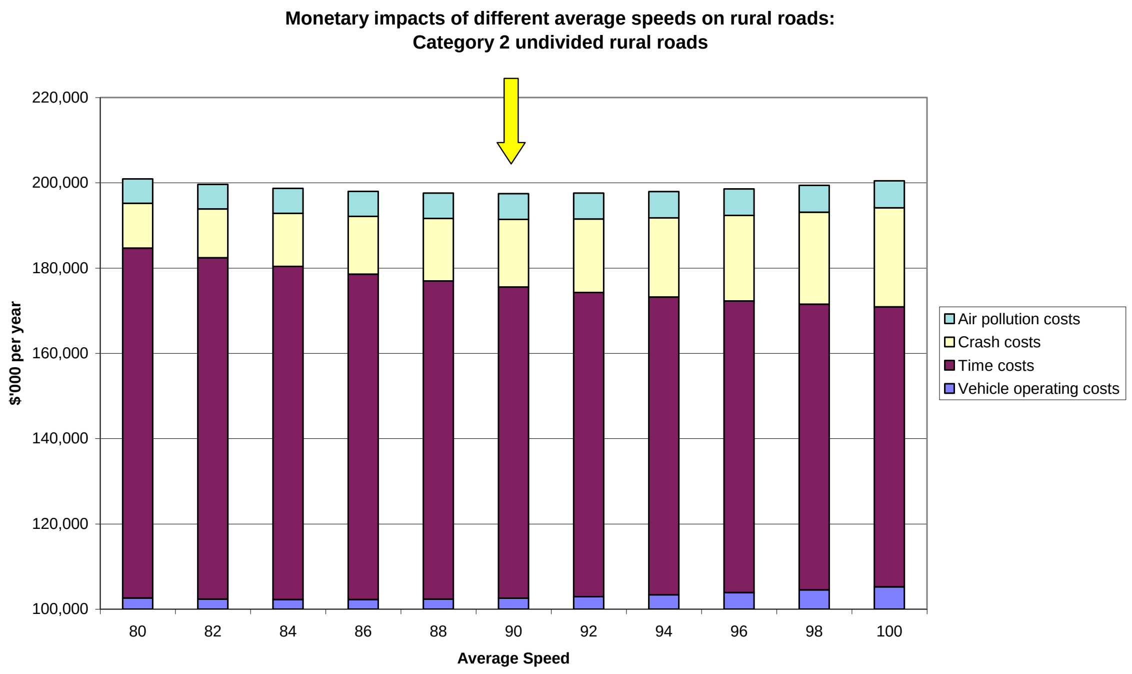
The increased economic impact was apparently due to the hypothesised reduced average speeds after the speed limit reduction being lower than the optimum speed for each class of vehicle (based on human capital valuation of crash costs). The assumption that average speeds substantially lower than existing speed limits would decrease further following the envisaged speed limit reductions is questionable, as is the application of Nilsson-type relationships linking road trauma reductions only to average free speeds in such circumstances. An alternative methodology which may be superior is discussed in section 10.4 and recommended for further consideration.

When a range of average speeds was considered as possible "after" speeds following the speed limit reduction, the speed which minimised the total economic impact for all vehicle types combined was 90 km/h (Table 7.1.2 and Figure 7.1.1).

Table 7.1.2: Economic impact of different mean speeds on undivided Category 2 roads

$'000/year	80 km/h	82 km/h	84 km/h	86 km/h	88 km/h	90 km/h	92 km/h	94 km/h	96 km/h	98 km/h	100 km/h
Vehicle op. costs	102,634	102,371	102,242	102,239	102,356	102,587	102,924	103,363	103,900	104,528	105,246
Time costs	82,065	80,063	78,157	76,339	74,604	72,947	71,361	69,842	68,387	66,992	65,652
Crash costs	10,497	11,442	12,452	13,530	14,678	15,900	17,200	18,581	20,046	21,599	23,244
Air pollution costs	5,692	5,755	5,818	5,882	5,945	6,008	6,071	6,135	6,198	6,261	6,324
Total	**200,887**	**199,631**	**198,669**	**197,990**	**197,584**	**197,441**	**197,556**	**197,921**	**198,531**	**199,380**	**200,466**
of which:											
Cars & LCVs	141,040	140,097	139,350	138,791	138,412	138,209	**138,174**	138,305	138,596	139,045	139,648
Heavy vehicles	59,847	59,535	59,320	59,200	**59,171**	59,233	59,382	59,616	59,934	60,335	60,818

Figure 7.1.1: Undivided Category 2 roads – Base scenario.



However, the optimum speed differs by vehicle type (shown in bold at the foot of Table 7.1.2). It was estimated as 92 km/h for cars and LCVs (Figure 7.1.2), but 88 km/h for heavy vehicles (Figure 7.1.3).

Figure 7.1.2: Undivided Category 2 roads – Car and LCV-related costs.

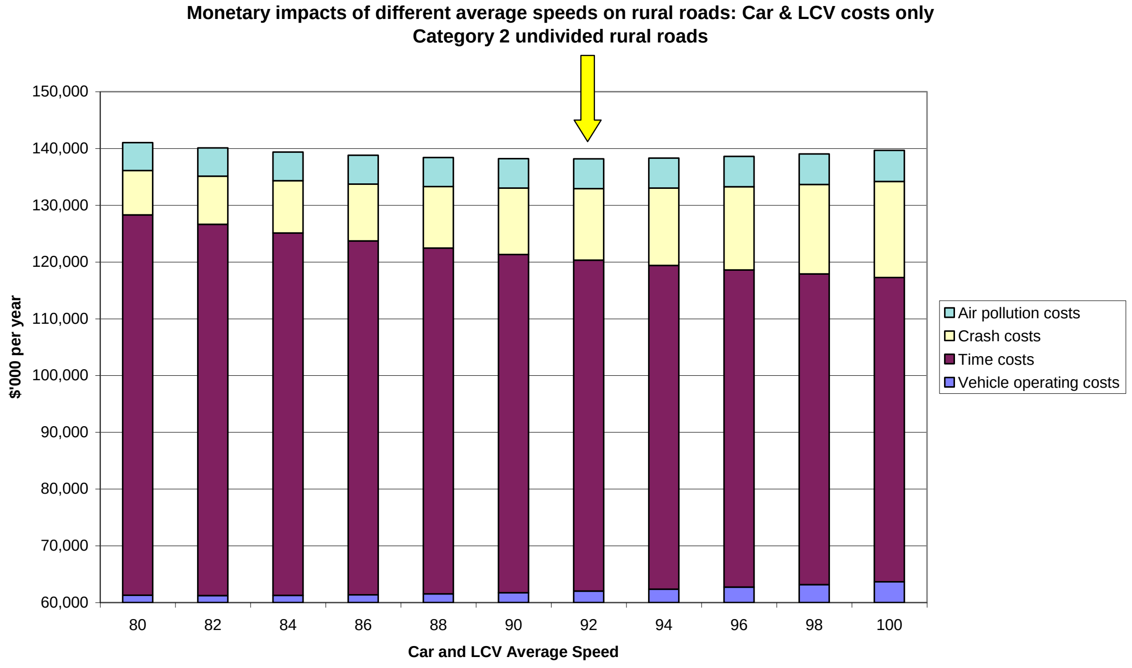
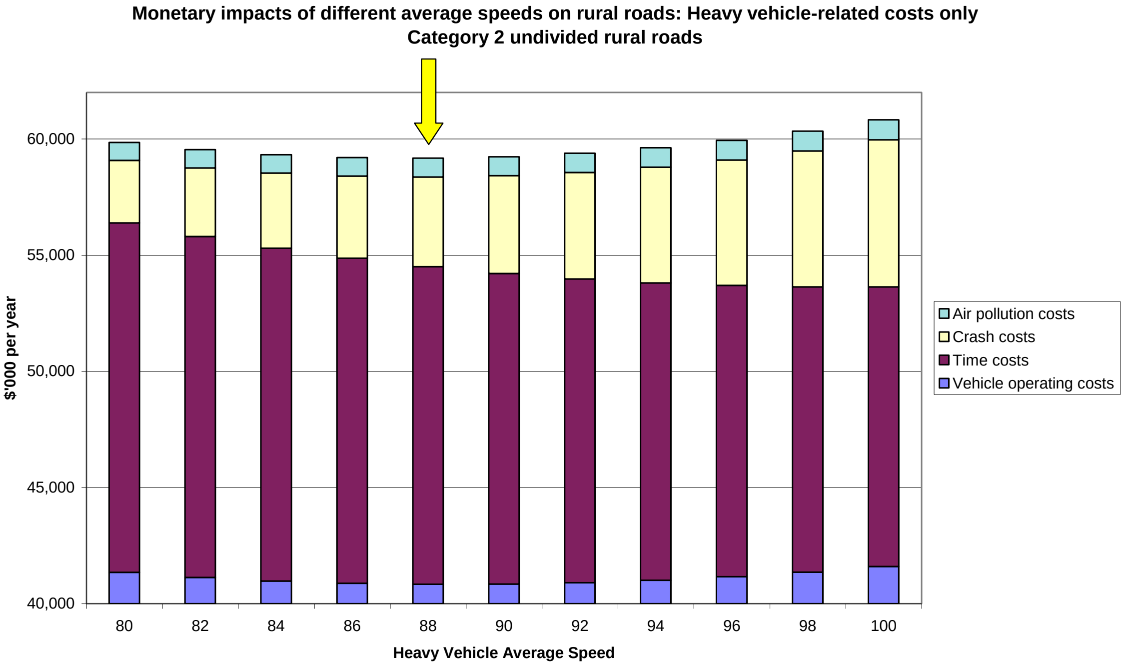


Figure 7.1.3: Undivided Category 2 roads – Heavy vehicle-related costs.



7.1.2 Willingness to pay valuation of road trauma

The base scenario was modified by using 'willingness to pay' valuations of road trauma (Appendix G). Under this scenario, the annual crash costs would decrease by $5.08 million on undivided Category 2 roads (Table 7.1.3), compared with an estimated decrease of $2.36 million per annum using human capital costs. The total economic cost associated with the decrease in speed limit would then be about $565,000 per year, or 0.3% of the total impact with the 100 km/h speed limit.

Table 7.1.3: Economic impact of reducing speed limit on undivided Category 2 roads from 100 km/h (before) to 90 km/h (after), assuming 5 km/h reduction in mean speeds. "Willingness to pay" valuations of crash costs.

$'000/year	**Before**	**After**	**Change**	
Vehicle operating costs	102,715	103,557	842	0.8 %
Time costs	78,239	83,201	4962	6.3 %
Crash costs	25,365	20,284	-5,081	-20.0%
Air pollution costs	5,827	5,669	-158	-2.7 %
Total	**212,145**	**212,710**		
Change			**565**	**0.3 %**

The optimum speed for cars and LCVs was estimated to be 82 km/h (Figure 7.1.4) and that for heavy vehicles was estimated to be 80 km/h (Figure 7.1.5).

Figure 7.1.4: Undivided Category 2 roads – 'Willingness to pay' valuations of road trauma. Car and LCV-related costs.

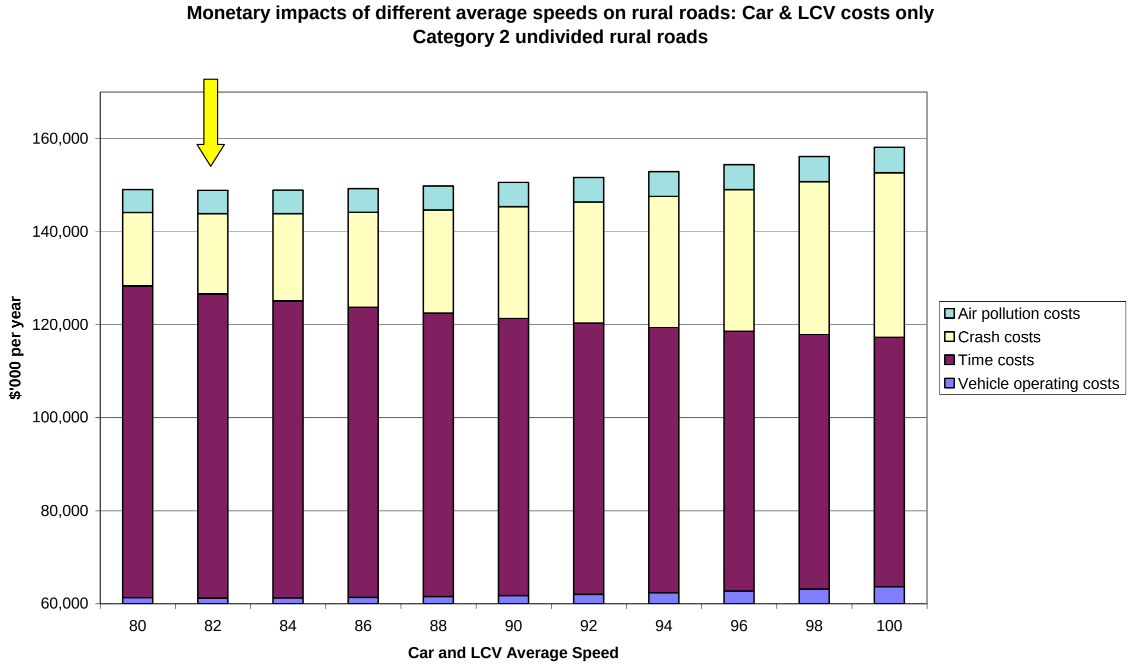
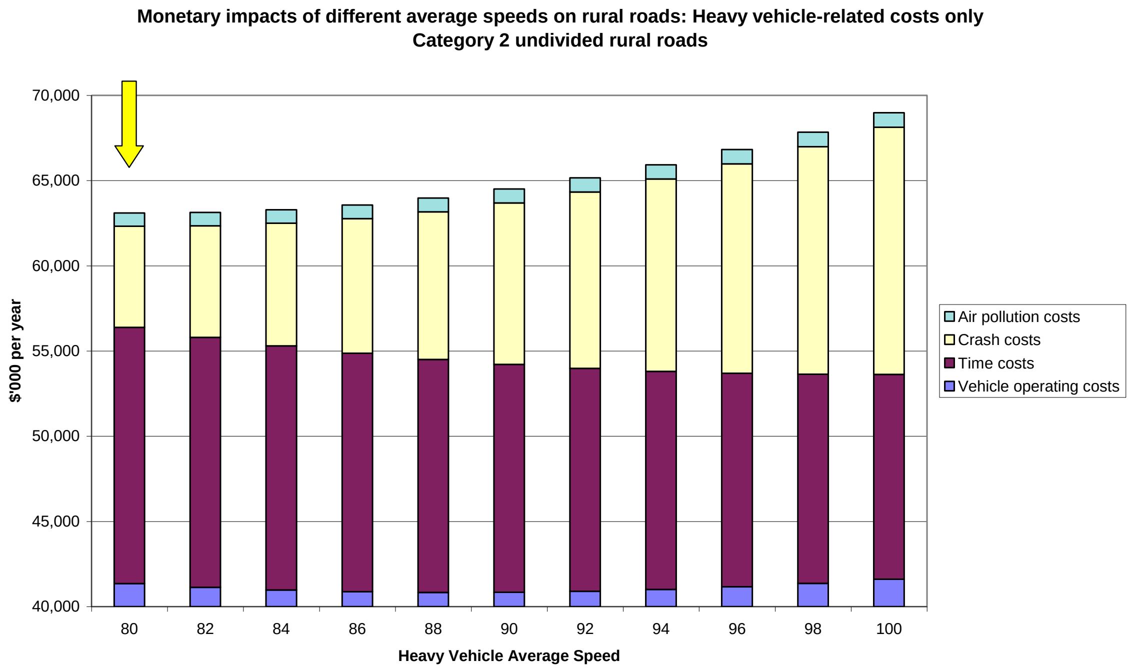


Figure 7.1.5: Undivided Category 2 roads – 'Willingness to pay' valuations of road trauma. Heavy vehicle-related costs.



Thus the hypothesised reduced average speeds on Category 2 roads after the speed limit reduction to 90 km/h are closer to (but still lower than) the optimum speeds based on the willingness-to-pay valuations of road trauma than the optima based on human capital costs. If willingness-to-pay valuation of crash cost savings is supported, then the reduction in current average speeds to a level even further below the envisaged 90 km/h limits for these Category 2 roads would have economic justification, notwithstanding that current average free speeds are below the envisaged limit. However, an alternative methodology to link road trauma changes with reductions in speed limits when average free speeds are already substantially below existing limits is discussed in section 10.4.

7.2 ROAD CATEGORIES 3 TO 5 WITH 100 KM/H LIMITS

7.2.1 Base scenarios

The economic impacts of reducing the speed limit from 100 to 90 km/h on undivided rural roads in Categories 3 to 5 were estimated by assuming that the average free speed for each type of vehicle (see Table 5.9) would decrease by 5 km/h. The detailed results are given in Appendices H, J, and L and are summarised in Table 7.2.1 together with the results of the analysis of undivided Category 2 roads from section 7.1.1 above.

The optimum speeds for each class of vehicle on each of Categories 3 to 5 roads are shown in Figures 7.2.1 to 7.2.3, based on human capital costs of road crashes.

Table 7.2.1: Economic impacts of speed reductions on undivided roads with 100 km/h speed limits. "Human capital" costs of road trauma.

	Effect of 5 km/h mean speed reductions on total economic cost		**Optimum Speed (km/h)** (speed which minimises total economic cost)		
Road category	Change p.a. ($ million)	Percentage change	All vehicles combined	Cars & LCVs	Heavy vehicles
Category 2 Regional Freight Roads	+3.291	+1.7%	90	92	88
Category 3 Regional Access Roads	+2.593	+0.9%	88	90	86
Category 4 Feeder Roads	+2.261	+0.8%	90	92	86
Category 5 "Other" Roads	+2.722	+1.4%	88	88	84

Figure 7.2.1: Undivided Category 3 roads

Figure 7.2.2: Undivided Category 4 roads

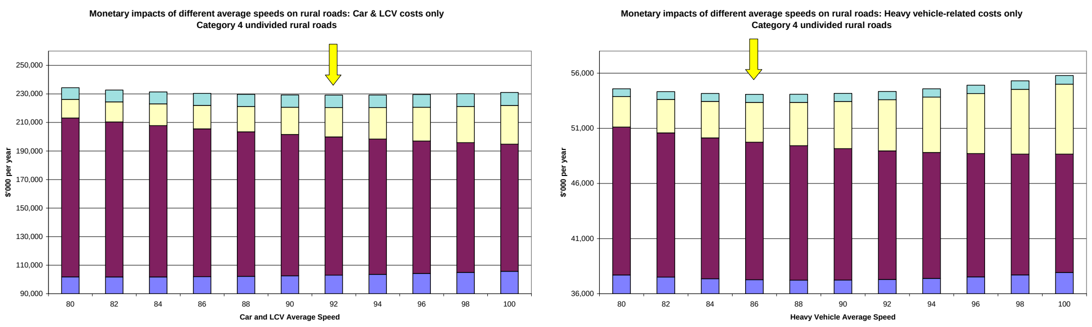
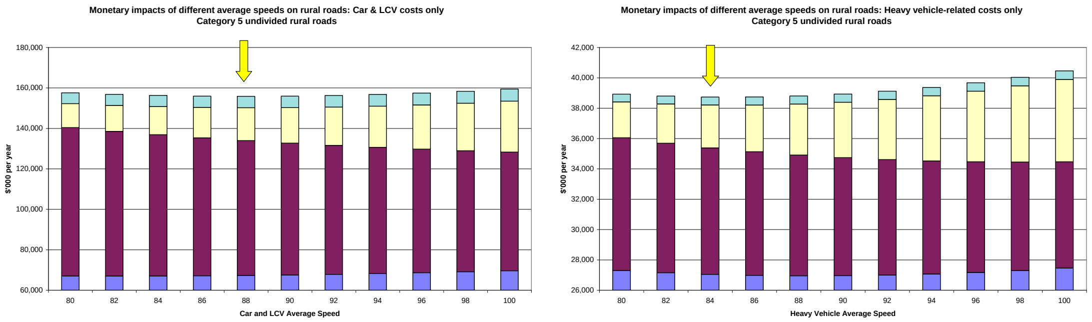


Figure 7.2.3: Undivided Category 5 roads



7.2.2 Willingness to pay valuation of road trauma

The base scenarios were modified by using ‘willingness to pay’ valuations of road trauma (Appendices I, K and M). The detailed results are summarised in Table 7.2.2 together with the results for undivided Category 2 roads. The optimum speeds for each class of vehicle on each of Categories 3 to 5 roads are shown in Figures 7.2.4 to 7.2.6. Where an optimum speed is indicated as being below 80 km/h in a figure, the estimated optimum (to 2 km/h) is shown in Table 7.2.2 (78 km/h in each case below 80 km/h).

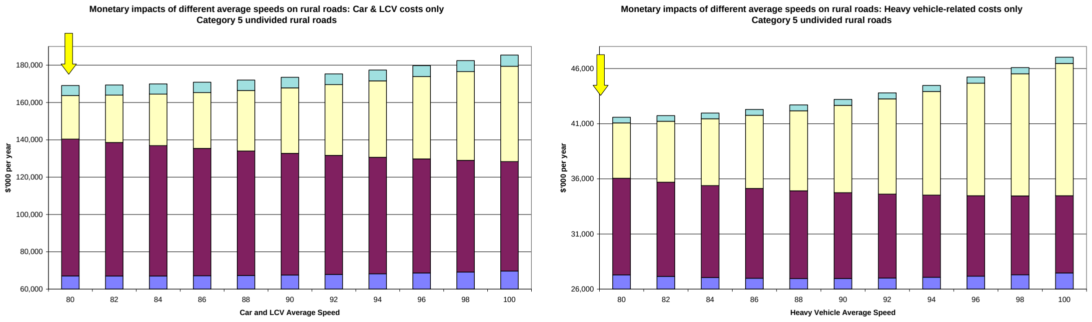
Table 7.2.2: Economic impacts of speed reductions on undivided roads with 100 km/h speed limits. “Willingness to pay” valuations of crash costs.

	Effect of 5 km/h mean speed reductions on total economic cost		**Optimum Speed (km/h)** (speed which minimises total economic cost)		
Road category	Change p.a. ($ million)	Percentage change	All vehicles combined	Cars & LCVs	Heavy vehicles
Category 2 Regional Freight Roads	+0.565	+0.3%	82	82	80
Category 3 Regional Access Roads	-2.907	-0.9%	80	80	78
Category 4 Feeder Roads	-1.831	-0.6%	82	84	80
Category 5 “Other” Roads	-0.486	-0.2%	78	80	78

Figure 7.2.4: Undivided Category 3 roads – 'Willingness to pay' valuations of crashes

Figure 7.2.5: Undivided Category 4 roads – 'Willingness to pay' valuations of crashes

Figure 7.2.6: Undivided Category 5 roads – 'Willingness to pay' valuations of crashes



8 UNSEALED RURAL ROADS

The economic analysis of unsealed rural roads with 100 km/h speed limits envisaged for a speed limit reduction to 80 km/h was focused on the subset of those roads on the State Road Network. There was an estimated 10,300 km of unsealed roads in Tasmania, and all but 206 km of these roads were the responsibility of Local Councils. The unsealed rural roads on the State Road Network were included in the Category 5 “Other” roads analysed in section 7.2 because crash data could not be separately provided for the unsealed road links. The unsealed roads in Category 5 represented 18% of their length but only 3% of the vehicle-kilometres travelled on Category 5 roads. Thus the results in section 7.2 pertain predominantly to sealed Category 5 roads.

No crash data was available for the unsealed rural roads and only limited estimates of the traffic levels could derived from NRTC (1996). About 34 vehicles per day use each unsealed road in Tasmania, resulting in a total of about 128 million vehicle-kilometres per year and representing about 6.4% of total rural travel in Tasmania. The unsealed rural roads on the State Road Network that are analysed in this chapter carry about 10.5 million vehicle-kilometres per year, representing about 8.2% of travel on rural gravel roads although they constitute only 2% of the total length. It is understood that gravel roads not part of the State Road Network remain the responsibility of Local Councils and the road environment generally requires vehicle speeds as low as 60 km/h.

8.1 BASE SCENARIO

The economic impact of reducing the speed limit from 100 to 80 km/h on the 206 km of unsealed Category 5 rural roads was estimated by assuming that the average free speed for each type of vehicle would decrease by 5 km/h. Based on the speed surveys on sealed Category 5 roads during 2009 (Table 5.9), it was estimated that on unsealed roads the average free speed of light vehicles (passenger cars and light commercial vehicles) was 85 km/h and that of heavy vehicles was 80 km/h. There were no permanent speed survey sites on unsealed roads during 2009, and the baseline speed surveys carried out at four sites on gravel roads as part of the Kingborough Safer Speeds Demonstration (Langford 2009) were not considered representative of speeds on unsealed roads throughout Tasmania because of the limited number of sites and the proximity of Kingborough to Hobart.

The rate of casualty crashes per 100 million vehicle-kilometres of travel on unsealed roads was taken as that provided by Perovic et al (2008) for this road type in Australia, namely 35.0 per 100 million vehicle-kilometres. Perovic et al’s estimates that 5.0% of these casualty crashes would result in fatal outcome and 27.6% in serious injury were also used in the absence of real crash data for unsealed roads in Tasmania. The base scenario valued road trauma using the “human capital” method. Details of the analysis are given in Appendix N.

If average speeds were reduced by 5 km/h, it is estimated that there would be a saving of about one casualty crash every two years (Appendix N). Annual crash costs would decrease by $187,000 (19.1%) and air pollution costs by $6,000 (2.7%) on these roads (Table 8.1.1). Annual vehicle operating costs would increase by $26,000 (0.7%) and travel time costs would increase by $194,000 per year (6.3%). The total economic impact was estimated to increase by $27,000 per annum, or 0.3% of the total impact with the 100 km/h speed limit.

Table 8.1.1: Economic impact of reducing speed limit on unsealed Category 5 roads from 100 km/h (before) to 80 km/h (after), assuming 5 km/h reduction in mean free speeds for each vehicle type. "Human capital" crash costs.

$'000/year	Before	After	Change	
Vehicle operating costs	3,918	3,944	26	0.7 %
Time costs	3,069	3,263	194	6.3 %
Crash costs	977	790	-187	-19.1%
Air pollution costs	236	230	-6	-2.7 %
Total	**8,200**	**8,227**		
Change			**27**	**0.3 %**

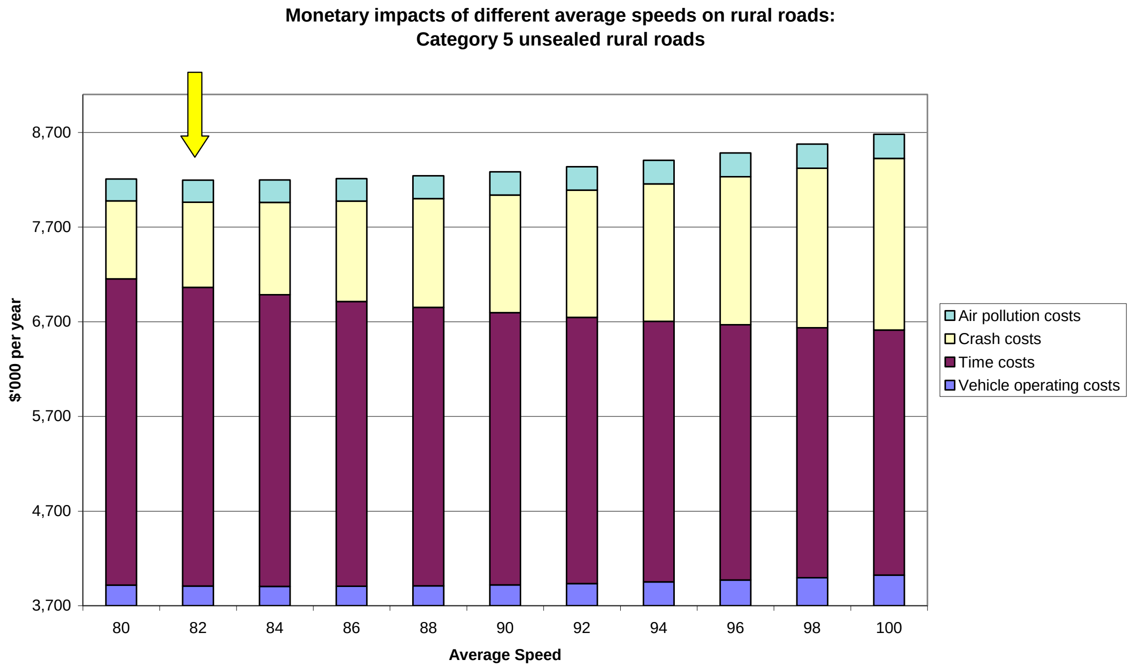
The increased economic impact was apparently due to the hypothesised reduced average speeds after the speed limit reduction being lower than the optimum speed for each class of vehicle (based on human capital valuation of crash costs).

When a range of average speeds was considered as possible "after" speeds following the speed limit reduction, the speed which minimised the total economic impact for all vehicle types combined was 82 km/h (Table 8.1.2 and Figure 8.1.1).

Table 8.1.2: Economic impact of different mean speeds on unsealed Category 5 roads

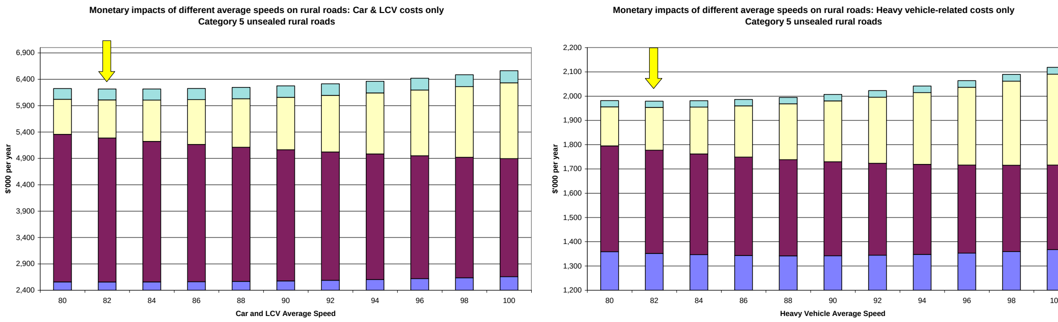
$'000/year	80 km/h	82 km/h	84 km/h	86 km/h	88 km/h	90 km/h	92 km/h	94 km/h	96 km/h	98 km/h	100 km/h
Vehicle op. costs	3,917	3,908	3,904	3,905	3,910	3,920	3,933	3,951	3,972	3,996	4,024
Time costs	3,234	3,155	3,080	3,008	2,940	2,874	2,812	2,752	2,695	2,640	2,587
Crash costs	824	898	976	1,060	1,149	1,244	1,345	1,452	1,565	1,685	1,812
Air pollution costs	231	233	236	238	241	244	246	249	251	254	256
Total	**8,206**	**8,194**	**8,196**	**8,211**	**8,240**	**8,282**	**8,336**	**8,403**	**8,483**	**8,575**	**8,680**
of which:											
Cars & LCVs	6,225	**6,215**	6,215	6,225	6,245	6,275	6,313	6,362	6,419	6,485	6,561
Heavy vehicles	1,981	**1,979**	1,981	1,986	1,995	2,007	2,023	2,042	2,064	2,090	2,119

Figure 8.1.1: Unsealed Category 5 roads – Base scenario.



On unsealed roads the optimum speed did not differ by vehicle type and was estimated as 82 km/h for each class of vehicle (Figure 8.1.2).

Figure 8.1.2: Unsealed Category 5 roads – Optimum speeds by vehicle class.



8.2 WILLINGNESS TO PAY VALUATION OF ROAD TRAUMA

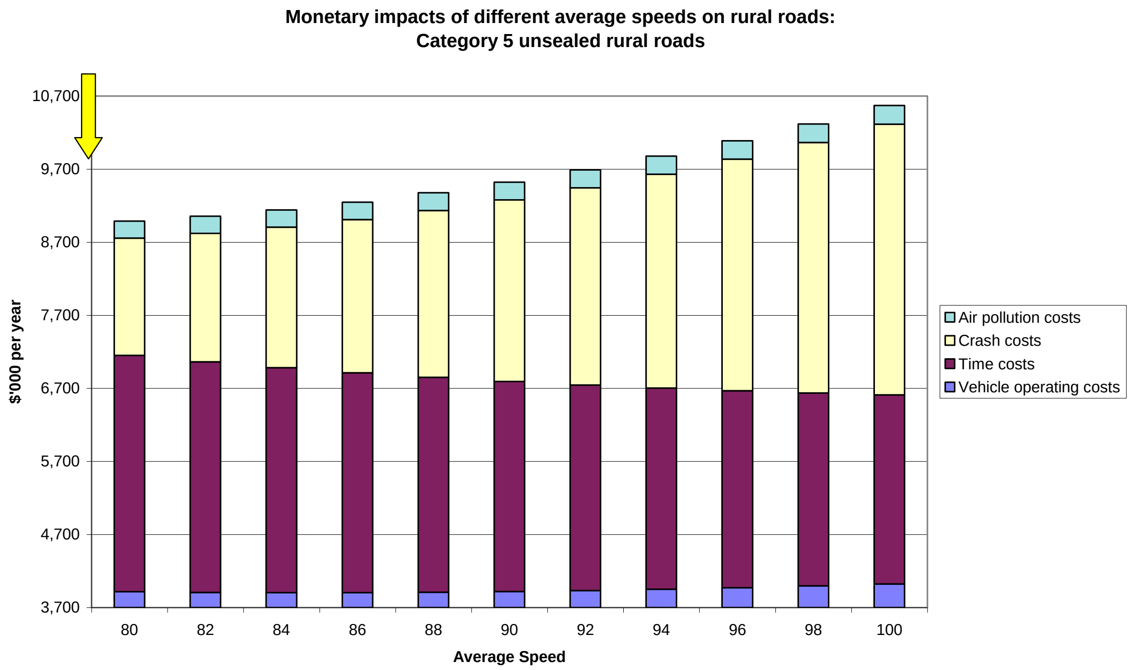
The base scenario was modified by using 'willingness to pay' valuations of road trauma (Appendix O). Under this scenario, the annual crash costs would decrease by $386,000 on unsealed Category 5 roads (Table 8.2.1), compared with an estimated decrease of $187,000 per annum using human capital costs. The total economic impact associated with the decrease in speed limit would then be about $172,000 per year, or 1.9% of the total impact with the 100 km/h speed limit.

Table 8.2.1: Economic impact of reducing speed limit on unsealed Category 5 roads from 100 km/h (before) to 80 km/h (after), assuming 5 km/h reduction in mean speeds. "Willingness to pay" valuations of crash costs.

$'000/year	Before	After	Change	
Vehicle operating costs	3,918	3,944	26	0.7 %
Time costs	3,069	3,263	194	6.3 %
Crash costs	1,917	1,531	-386	-20.1%
Air pollution costs	236	230	-6	-2.7 %
Total	**9,140**	**8,968**		
Change			**-172**	**-1.9 %**

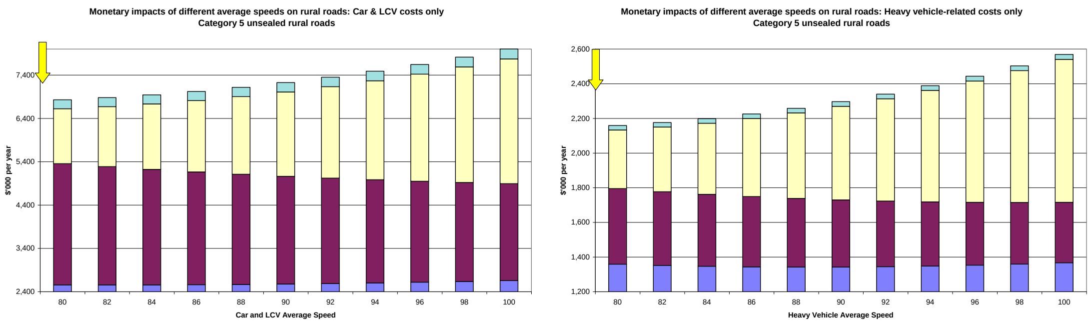
When a range of average speeds was considered as possible "after" speeds following the speed limit reduction, the speed which minimised the total economic impact for all vehicle types combined was 74 km/h. This optimum speed is outside the range of analysed speeds shown in Figure 8.2.1, but is implied by the continuing decrease in total monetary impact at 80 km/h compared with higher average speeds.

Figure 8.2.1: Unsealed Category 5 roads – 'Willingness to pay' valuations of road trauma.



The estimated optimum speed for each of the two classes of vehicle was also 74 km/h, as implied by Figure 8.2.2.

Figure 8.2.2: Unsealed Category 5 roads – 'Willingness to pay' valuations of road trauma.



Thus the hypothesised reduced average speeds for heavy vehicles on unsealed Category 5 roads after the speed limit reduction to 80 km/h are closer to (but still 1 km/h higher than) the optimum speed based on the willingness-to-pay valuations of road trauma (74 km/h) than the optimum based on human capital costs (82 km/h). If willingness-to-pay valuation of crash cost savings is supported, then the reduction in heavy vehicle average speeds to a level below the envisaged 80 km/h limits for these unsealed roads would have economic justification.

9 CURVY ROADS WITH CROSSROADS AND TOWNS

The *Tasmanian Speed Zoning Review 2005* indicates that much of Tasmania's rural road system has frequent curved alignments and passes through intersections and towns often requiring vehicles to slow substantially and stop. On these types of road the average journey speed over a whole trip will be lower than the cruise speeds that vehicles would do on straight unimpeded road sections. The average free speeds measured in speed surveys (see section 5.9) are representative of cruise speeds. The economic analysis in the previous three chapters has examined the impacts of reducing average free speeds (by 5 km/h in each case) in response to envisaged reductions in speed limits on each category of road.

Curvy roads with bends requiring slowing and other features requiring traffic to stop occasionally will reduce the average speed on a given road section below the cruise speed. This will increase the travel time and the slowing and stopping will increase the fuel consumption and air pollution emissions of vehicles using the road section. The crash rate will also increase because of the curved alignment and because of the increased crash risk associated with cross roads. Adjustments to the base scenarios in Chapters 6-8 to take into account the economic impact of increased road trauma, operating costs, emissions and travel times, associated with each cruise speed, have been outlined in sections 3.1.6, 3.4 and 3.5.1.

It was assumed, for the purpose of illustration, that the undivided Category 1-5 rural roads in Tasmania have 50 sharp bends requiring vehicles to decelerate to 70 km/h, 14 at-grade crossroads, and three occasions in towns requiring stopping, per 100 kilometres of road, following the densities of such features recorded on English rural roads (Taylor et al 2002). It is not known to what extent such road environments occur in Tasmania, nor the proportion of each rural road category on the State Road Network with such features or similar. In the following illustrative analyses, it was assumed that 100% of undivided roads in each road category are through such a road environment. The exception to this assumption was divided Category 1 roads with current 110 km/h speed limits, where it was expected that these are primarily freeway standard roads with high design speeds and controlled access, hence not requiring frequent slowing due to sharp curves and occasional stops for towns and intersections.

9.1 UNDIVIDED CATEGORY 1 TRUNK ROADS WITH 110 KM/H LIMITS

Assuming the density of sharp curves, at-grade intersections, and stopping points as outlined above, vehicles travelling on undivided Category 1 roads at the cruise speeds equal to the average free speeds shown in Table 5.9 are estimated to achieve the following average journey speeds:

- Cars and LCVs 100.65 km/h (based on cruise speed of 105 km/h)
- Rigid heavy vehicles 96.82 km/h (based on cruise speed of 100 km/h)
- Articulated heavy vehicles 96.02 km/h (based on cruise speed of 99 km/h).

These slower average journey speeds have important implications for the travel times and their costs for each class of vehicle. If the cruise speeds were reduced by 5 km/h in response to a reduction in the speed limit to 100 km/h, average journey speeds would also reduce, but not by the full 5 km/h because the penalty derived from each vehicle type needing to slow for the frequent sharp curves and occasional stops, and then accelerate again, would not be so severe. Appendix P shows the estimated average journey speeds associated with each cruise speed 5 km/h lower than current average free speeds, namely:

- Cars and LCVs 96.82 km/h (based on new cruise speed of 100 km/h)
- Rigid heavy vehicles 92.76 km/h (based on new cruise speed of 95 km/h)
- Articulated heavy vehicles 91.92 km/h (based on new cruise speed of 94 km/h).

The reduction in average journey speeds is no more than 3-4 km/h.

However, the need for vehicles to decelerate from high cruise speeds for sharp curves and stops, and then accelerate again, has a substantial impact on vehicle operating costs on undivided Category 1 roads through curvy environments compared with straight roads of the same type on which vehicles can generally always travel at or close to cruise speed. Comparing Table 9.1.1 with Table 6.2.1 shows that annual vehicle operating costs in a curvy road environment ($323.5 million) are estimated to be 35% higher than on straight undivided Category 1 roads ($239.5 million). Air pollution costs ($26.9 million) are also estimated to be 77% higher, and crash costs ($33.0 million) 23% higher. As expected from the lower average journey speeds due to the curvy road environment, travel time costs ($170.2 million) were estimated to be 15% higher than on straight undivided Category 1 roads.

As in previous chapters, Nilsson-type relationships have been used to link crashes and their injury severity with reductions in cruise speeds (represented by average free speeds). It should be noted that these relationships connect road trauma with average free speeds, not with average journey speeds. Nilsson-type relationships may be questionable in this context where cruise speeds are already below existing speed limits (and, for heavy vehicles, below the envisaged reduced limit). An alternative methodology to link road trauma changes with reductions in speed limits when average free speeds are already substantially below existing limits is discussed in section 10.4.

The economic impact of reducing cruise speeds by 5 km/h on the undivided Category 1 roads envisaged for reduction in speed limits from 110 km/h is shown in Table 9.1.1. Details of the analysis are given in Appendix P. In this and other economic analyses associated with illustrating the effects of curvy road environments with occasional stops, road trauma was valued using the “human capital” method. Valuation using the “willingness to pay” method would result in even higher savings in crash costs and greater economic benefits associated with speed limit reductions in these road environments.

Table 9.1.1: Economic impact of reducing speed limit on undivided Category 1 roads in curvy road environments from 110 km/h (before) to 100 km/h (after), assuming 5 km/h reduction in cruise speeds for each vehicle type. "Human capital" crash costs.

$'000/year	Before	After	Change	
Vehicle operating costs	323,532	294,295	-29237	-9.0 %
Time costs	170,185	177,057	6872	4.0 %
Crash costs	32,959	27,155	-5,805	-17.6%
Air pollution costs	26,855	22,172	-4,684	-17.4 %
Total	**553,531**	**520,679**		
Change			**-32,853**	**-5.9 %**

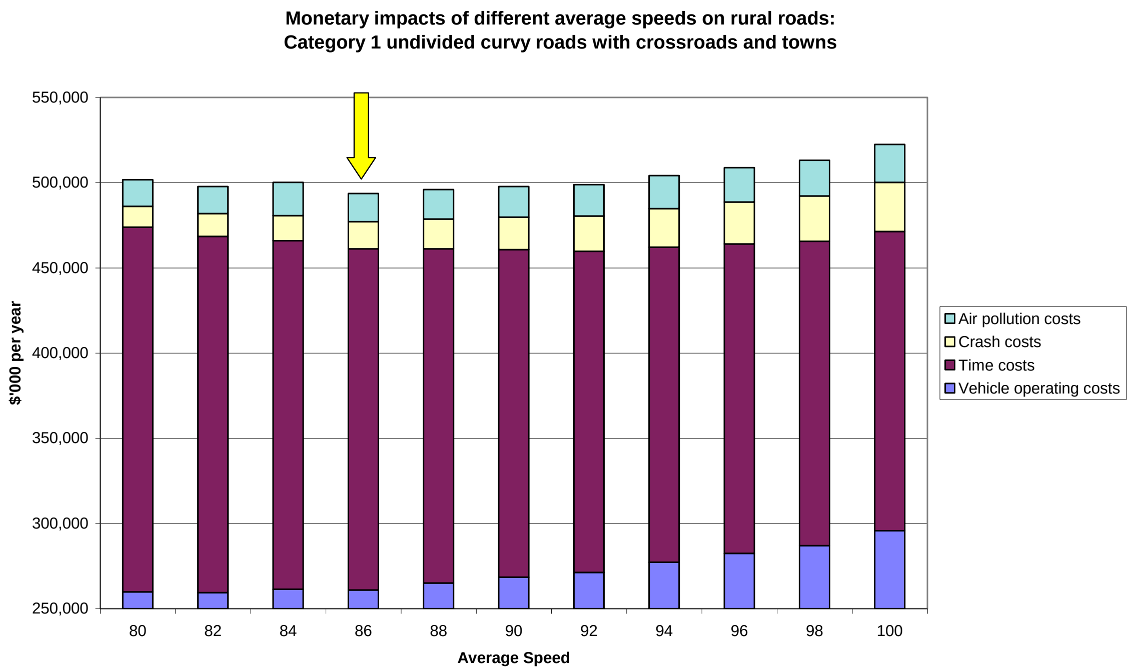
If cruise speeds were reduced by 5 km/h, it is estimated that there would be a saving of 2.2 fatal crashes, 2.1 serious injury crashes, and 5.5 less-serious injury crashes per year (Appendix P). Annual crash costs would decrease by $5.81 million (17.6%) and air pollution costs by $4.68 million (17.4%) on these roads (Table 9.1.1). Annual vehicle operating costs would decrease by $29.24 million (9.0%) and travel time costs would increase by $6.87 million per year (4.0%). The total economic impact was estimated to decrease by $32.85 million per annum, or 5.9% of the total impact with the 110 km/h speed limit. This compares with the estimated total economic benefit of only $1.87 million per year if all undivided Category 1 roads envisaged for the speed limit reduction from 110 km/h were straight and unimpeded along their entire length.

When a range of cruise speeds was considered as possible "after" speeds following the speed limit reduction, the speed which minimised the total economic impact for all vehicle types combined was 86 km/h (Table 9.1.2 and Figure 9.1.1).

Table 9.1.2: Economic impact of different mean speeds on undivided Category 1 roads in curvy road environments with crossroads and towns

$'000/year	80 km/h	82 km/h	84 km/h	86 km/h	88 km/h	90 km/h	92 km/h	94 km/h	96 km/h	98 km/h	100 km/h
Vehicle op. costs	259,850	259,362	261,452	260,980	265,113	268,547	271,229	277,199	282,424	287,054	295,804
Time costs	214,035	209,112	204,508	200,127	196,020	192,121	188,437	184,952	181,652	178,542	175,592
Crash costs	12,184	13,380	14,667	16,048	17,529	19,115	20,810	22,620	24,551	26,608	28,798
Air pollution costs	15,623	15,812	19,489	16,457	17,269	17,918	18,391	19,389	20,214	20,887	22,243
Total	**501,691**	**497,665**	**500,116**	**493,612**	**495,931**	**497,701**	**498,866**	**504,160**	**508,841**	**513,092**	**522,436**
of which:											
Cars & LCVs	367,672	364,571	366,684	**361,253**	362,779	363,875	364,496	368,161	371,345	374,183	380,791
Heavy vehicles	134,020	133,094	133,432	**132,358**	133,152	133,827	134,371	135,999	137,496	138,909	141,646

Figure 9.1.1: Undivided Category 1 roads in curvy road environments



On the undivided Category 1 roads in curvy road environments, the optimum speed did not differ by vehicle type and was estimated as 86 km/h for each class of vehicle (Figure 9.1.2).

Figure 9.1.2: Undivided Category 1 roads in curvy road environments – Optimum speeds by vehicle class.

9.2 UNDIVIDED CATEGORY 2 ROADS WITH 100 KM/H LIMITS

The economic impact of reducing the speed limit from 100 to 90 km/h on the 263 km of undivided Category 2 rural roads was estimated by assuming that the cruise speeds represented by the average free speed for each type of vehicle (see Table 5.9) would decrease by 5 km/h. The average journey speeds associated with each "before" and "after" cruise speed on these roads through curvy road environments with occasional stops are shown in Appendix Q together with details of the economic analysis

If cruise speeds were reduced by 5 km/h, it is estimated that there would be a saving of 0.7 fatal crashes, 2.1 serious injury crashes and 6.1 less-serious injury crashes per year (Appendix Q). Annual crash costs would decrease by $2.62 million (19.3%) and air pollution costs by $324,000 (5.1%) on these roads (Table 9.2.1). Annual vehicle operating costs would decrease by $148,000 (0.1%), but travel time costs would increase by $4.66 million per year (5.9%). The total economic impact was estimated to increase by $1.57 million per annum, or 0.8% of the total impact with the 100 km/h speed limit.

Table 9.2.1: Economic impact of reducing speed limit on undivided Category 2 roads in curvy road environments from 100 km/h (before) to 90 km/h (after), assuming 5 km/h reduction in cruise speeds for each vehicle type. "Human capital" crash costs.

$'000/year	Before	After	Change	
Vehicle operating costs	105,738	105,590	-148	-0.1 %
Time costs	78,574	83,234	4659	5.9 %
Crash costs	13,609	10,989	-2,620	-19.3%
Air pollution costs	6,333	6,009	-324	-5.1 %
Total	**204,255**	**205,821**		
Change			**1,566**	**0.8 %**

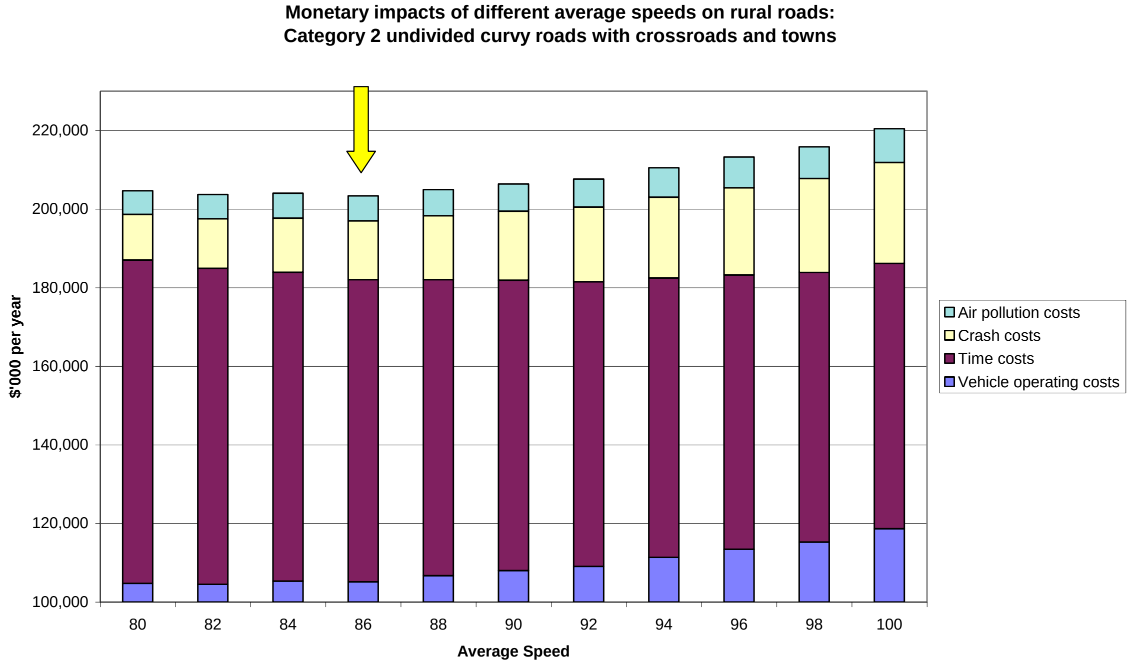
The increased economic cost of $1.57 million can be compared with the estimated increased cost of $3.29 million per year (Table 7.1.1) if the undivided Category 2 roads were straight and traffic was unimpeded along their full length, allowing vehicles to cruise at their average free speed throughout. The higher vehicle operating costs and air pollution costs on the curvy roads requiring frequent deceleration and acceleration represented greater potential for these costs to be reduced by the 5 km/h reduction in cruise speeds.

When a range of average speeds was considered as possible "after" speeds following the speed limit reduction, the speed which minimised the total economic impact for all vehicle types combined was 86 km/h (Table 9.2.2 and Figure 9.2.1).

Table 9.2.2: Economic impact of different mean speeds on undivided Category 2 roads in curvy road environments

$'000/year	80 km/h	82 km/h	84 km/h	86 km/h	88 km/h	90 km/h	92 km/h	94 km/h	96 km/h	98 km/h	100 km/h
Vehicle op. costs	104,744	104,526	105,315	105,116	106,708	108,035	109,076	111,396	113,434	115,245	118,659
Time costs	82,277	80,385	78,615	76,931	75,352	73,854	72,437	71,098	69,829	68,634	67,499
Crash costs	11,613	12,658	13,773	14,964	16,232	17,582	19,017	20,542	22,160	23,875	25,691
Air pollution costs	6,032	6,105	6,322	6,354	6,667	6,918	7,100	7,486	7,804	8,064	8,588
Total	**204,666**	**203,674**	**204,026**	**203,364**	**204,959**	**206,388**	**207,631**	**210,522**	**213,227**	**215,818**	**220,438**
of which:											
Cars & LCVs	144,174	143,433	143,649	**143,120**	144,207	145,162	145,967	147,954	149,792	151,532	154,732
Heavy vehicles	60,492	60,241	60,376	**60,245**	60,752	61,227	61,664	62,568	63,435	64,286	65,705

Figure 9.2.1: Undivided Category 2 roads in curvy road environments



On the undivided Category 2 roads in curvy road environments, the optimum speed did not differ by vehicle type and was estimated as 86 km/h for each class of vehicle (Figures 9.2.2 and 9.2.3).

Figure 9.2.2: Undivided Category 2 roads in curvy road environments – Car and LCV-related costs.

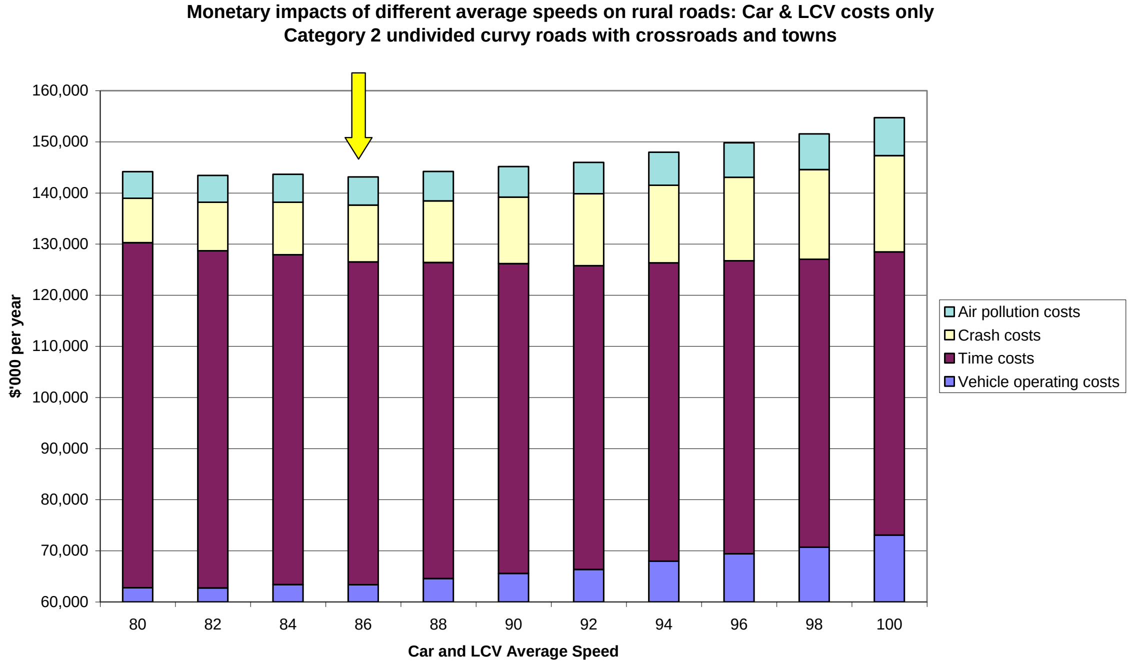
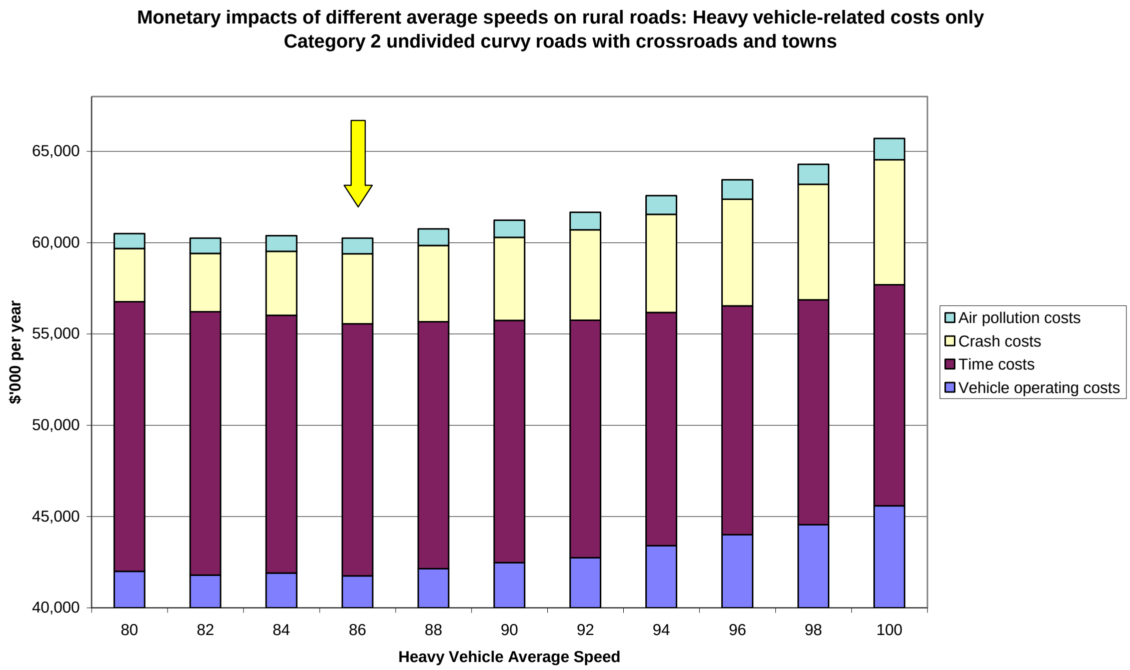


Figure 9.2.3: Undivided Category 2 roads in curvy road environments – Heavy vehicle-related costs.



9.3 UNDIVIDED ROAD CATEGORIES 3 TO 5 WITH 100 KM/H LIMITS

The economic impacts of reducing the speed limit from 100 to 90 km/h on undivided rural roads in Categories 3 to 5 through curvy road environments were estimated by assuming that the cruise speeds represented by the average free speed for each type of vehicle (see Table 5.9) would decrease by 5 km/h. Although it was envisaged that the speed limit on unsealed 100 km/h roads would reduce to 80 km/h, the economic analysis of these roads through curvy road environments also assumed that cruise speeds would decrease by 5 km/h. The detailed results are given in Appendices R, S, T and U and are summarised in Table 9.3.1 together with the results of the analysis of undivided Category 2 roads from section 9.2.1 above.

Table 9.3.1: Economic impacts of speed reductions on undivided roads in curvy road environments with 100 km/h speed limits. "Human capital" costs of road trauma.

	Effect of 5 km/h mean speed reductions on total economic cost		**Optimum Speed (km/h)** (speed which minimises total economic cost)		
Road category	Change p.a. ($ million)	Percentage change	All vehicles combined	Cars & LCVs	Heavy vehicles
Category 2 Regional Freight Roads	+1.566	+0.8%	86	86	86
Category 3 Regional Access Roads	-0.929	-0.3%	82	82	82
Category 4 Feeder Roads	-3.021	-1.0%	86	86	82
Category 5 "Other" Roads	+1.000	+0.5%	82	82	82
Unsealed Category 5 "Other" roads	-0.049	-0.6%	80	80	80

The optimum speeds for each class of vehicle travelling on each of the Category 3 to 5 roads are shown in Figures 9.2.1 to 9.2.4, based on human capital costs of road crashes. Generally the optimum speed was the same for each class of vehicle within a road category, the exception being Category 4 roads through curvy road environments where it was found that the optimum for light vehicles was 86 km/h, but for heavy vehicles it was 82 km/h.

Figure 9.3.1: Undivided Category 3 roads in curvy road environments

Figure 9.3.2: Undivided Category 4 roads in curvy road environments

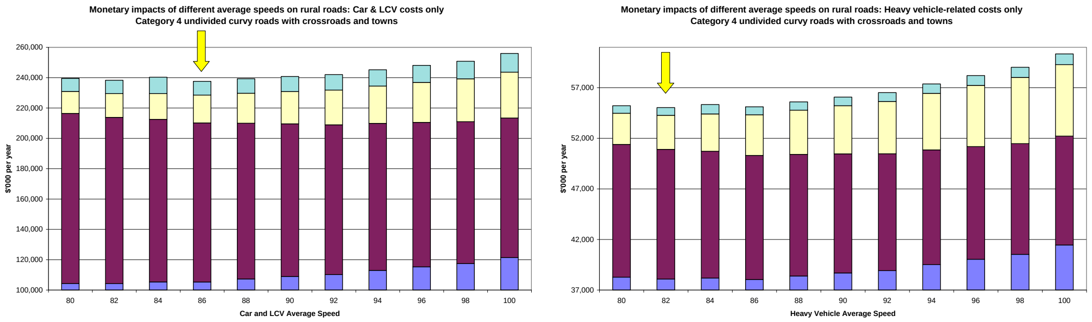
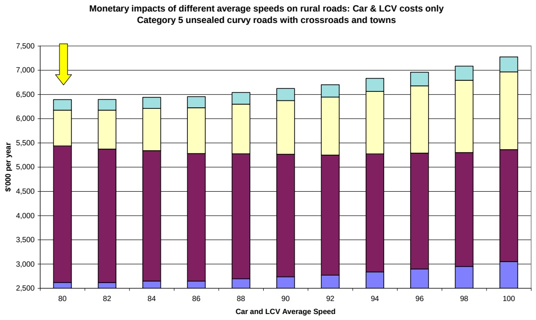
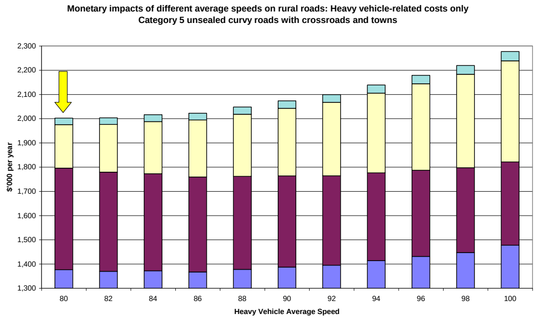


Figure 9.3.3: Undivided Category 5 roads in curvy road environments

Figure 9.3.4: Unsealed Category 5 roads in curvy road environments





10 SUMMARY AND DISCUSSION

The economic analysis considered 3,002 km of rural roads on Tasmania's State Road Network for which a reduction in the speed limit was envisaged (Table 10.1). A reduction in the speed limit on divided Category 1 (National Highway) roads with 110 km/h limits was included in the analysis, though this was not initially proposed. The analysed roads represent about 85% of the State Road Network, which in turn represents about 18% of Tasmania's rural road system. The majority of vehicle travel occurs on State Roads. On local roads the traffic volume is much smaller – around 25% of the level on State Roads.

Table 10.1: State Road Network roads designated for speed limit reductions. Traffic parameters and mean speeds for each road category.

	Traffic parameters		**Mean free speed 2009** (km/h)		
Road category and current speed limit	Length (km)	AADT 2007	Cars & LCVs	Rigid heavy vehicles	Artic. heavy vehicles
Rural roads with 110 km/h speed limits					
Divided Category 1 Trunk Roads	67.3	9,058	110	109	100
Undivided Cat. 1 Trunk Roads	238	7,030	105	100	99
Undivided rural roads with 100 km/h speed limits					
Category 2 Regional Freight Roads	263	2,714	85	81	78
Category 3 Regional Access Roads	572	2,012	87	82	82
Category 4 Feeder Roads	825	1,349	91	85	75
Category 5 "Other" Roads[1]	1,037	712	84	76	82
Unsealed rural roads (100 km/h speed limit)					
Category 5 "Other" Roads	206	140	85	80	80

[1] Includes unsealed gravel roads on SRN. Estimated 18% of length and 3% of travel on Category 5 roads

Of the estimated 10,300 km of unsealed gravel roads, only 206 km are part of the State Road Network. Thus the analysis of the reduction of the speed limit on unsealed roads would underestimate the total impact on such roads in Tasmania, but the relative economic impact should be indicative of the overall impact on this class of road.

10.1 INITIAL RESULTS OF THE ECONOMIC ANALYSIS

It was not expected that mean free speeds would drop to the same extent as the reduction in speed limit on each category of rural road. This is especially the case on the Category 2-5 roads where the mean free speeds in 2009 were already lower than the envisaged lower limits. The economic analyses considered the impacts of a hypothetical 5 km/h reduction in the mean free speed of each vehicle type as being the likely maximum reduction which would result. Lower speeds in 2 km/h steps were also analysed to determine the speed which minimises the total economic impact ("optimum speed") for each general class of vehicle. This is the speed which balances the social costs and benefits of increased travel time with decreased road trauma, vehicle operating costs, emissions and other costs.

Using the "human capital" approach to value road trauma costs, there would be overall economic benefits from reducing speed limits on divided and undivided Category 1 roads from 110 km/h to 100km/h (Table 10.2). The optimum speed for all vehicle types combined on these roads is no more than 100 km/h, so this would support a reduction in the limit to 100 km/h in each case.

If it is assumed that the majority of the Tasmanian State Road Network consists of straight, unimpeded road sections, then for the undivided roads in each of Categories 2-5, the hypothesised 5 km/h reduction in mean free speeds due to a reduction in their current 100 km/h limits would appear to result in an overall economic loss. The optimum speeds on these roads are generally about the same as the envisaged lower limit proposed for each class of road (90 km/h for sealed Category 2-5 roads and 80 km/h for the unsealed Category 5 roads), but the hypothesised reduced mean speeds are substantially less. However these economic analysis results assume that road trauma (crashes and serious injuries) should be valued by conservative "human capital" costs; and that vehicles travel on Category 2-5 roads at their mean free speeds throughout their length without slowing for sharp curves and stopping occasionally.

Table 10.2: Economic impacts of speed reductions, and estimated optimum speeds. Straight, unimpeded road environment. "Human capital" costs of road trauma.

	Effect of 5 km/h mean speed reductions on total economic cost		**Optimum Speed (km/h)** (speed which minimises total economic cost)		
Road category and current speed limit	Change p.a. ($ million)	Percentage change	All vehicles combined	Cars & LCVs	Heavy vehicles
Rural roads with 110 km/h speed limits					
Divided Category 1 Trunk Roads	-1.083	-0.8%	100	102	94
Undivided Cat. 1 Trunk Roads	-1.870	-0.4%	98	100	92
Undivided rural roads with 100 km/h speed limits					
Category 2 Regional Freight Roads	+3.291	+1.7%	90	92	88
Category 3 Regional Access Roads	+2.593	+0.9%	88	90	86
Category 4 Feeder Roads	+2.261	+0.8%	90	92	86
Category 5 "Other" Roads[1]	+2.722	+1.4%	88	88	84
Unsealed rural roads (100 km/h speed limit)					
Category 5 "Other" Roads[2]	+0.027	+0.3%	82	82	82

[1] Includes unsealed gravel roads on State Road Network. Crash data 2004-2008 not provided separately.
[2] Casualty crash rate per 100 million vehicle-kilometres from AGPE04/08 Table 4.1, not real crash data.

10.2 WILLINGNESS TO PAY VALUATION OF ROAD TRAUMA

"Willingness to pay" valuations of road trauma are more consistent with the Safe System approach embodied in the federal government's *National Road Safety Strategy 2001-2010*, and the *Tasmanian Road Safety Strategy 2007-2016.* Fatal crashes are valued more than 2.5 times their "human capital" costs and injury crashes are also valued higher. On this basis, the economic benefits of reducing speed limits on Category 1 roads from 110 km/h to 100km/h would be even greater, especially on the undivided Category 1 roads (Table 10.3).

Using "willingness to pay" valuations of road trauma, the reduction in mean free speeds on Category 3-5 roads would result in overall economic benefits and the apparent economic loss on the Category 2 roads would be substantially reduced. The optimum speeds would be substantially lower than the envisaged lower limits for each of the Category 2-5 roads, including the unsealed Category 5 roads. The optimum speed on the undivided Category 1 roads is no more than 90 km/h for each class of vehicle, suggesting that the 90 km/h limit envisaged for the sealed Category 2-5 roads could be considered for these roads as well.

Table 10.3: Economic impacts of speed reductions, and estimated optimum speeds. Straight, unimpeded road environment. "Willingness to pay" values of road trauma.

	Effect of 5 km/h mean speed reductions on total economic cost		**Optimum Speed (km/h)** (speed which minimises total economic cost)		
Road category and current speed limit	Change p.a. ($ million)	Percentage change	All vehicles combined	Cars & LCVs	Heavy vehicles
Rural roads with 110 km/h speed limits					
Divided Category 1 Trunk Roads	-3.098	-2.0%	92	92	90
Undivided Cat. 1 Trunk Roads	-8.537	-1.8%	90	90	86
Undivided rural roads with 100 km/h speed limits					
Category 2 Regional Freight Roads	+0.565	+0.3%	82	82	80
Category 3 Regional Access Roads	-2.907	-0.9%	80	80	78
Category 4 Feeder Roads	-1.831	-0.6%	82	84	80
Category 5 "Other" Roads	-0.486	-0.2%	78	80	78
Unsealed rural roads (100 km/h speed limit)					
Category 5 "Other" Roads	-0.172	-1.9%	74	74	74

10.3 CURVY ROAD ENVIRONMENTS REQUIRING SLOWING AND STOPS

Much of Tasmania's rural road system has frequent curved alignments and passes through intersections and towns often requiring vehicles to slow substantially and occasionally stop. On these types of road the average journey speed over a whole trip is lower than the cruise speeds that vehicles would do on straight unimpeded road sections. This increases the travel time and the slowing and stopping increases the fuel consumption and air pollution emissions of vehicles using the road section. The crash rate also increases because of the curved alignment and because of the increased crash risk associated with cross roads. Adjustments to the economic analyses were made to take into account the impact of increased road trauma, operating costs, emissions and travel times, except for divided Category 1 roads where slowing for sharp curves and stopping is less common.

Assuming that the curvy road environment with frequent slowing and occasional stops applies along the full length of each of the undivided Category 1-5 roads, the economic analysis using "human capital" costs of road trauma showed that there were overall economic benefits from a 5 km/h reduction in cruise speeds (average free speeds) on most classes of road (Table 10.4). The exceptions were the undivided Category 2 Regional Freight Roads and the Category 5 "Other" Roads (but not including the separately analysed unsealed Category 5 roads). However, the optimum speeds on these two classes of road were below the envisaged 90 km/h limit suggesting that the reduced limit would still be justified even if the hypothesised 5 km/h reduction in cruise speeds did not result.

The greatest economic benefit was from a reduction in cruise speeds on undivided Category 1 roads with current 110 km/h speed limit. In curvy road environments, the optimum speed on these roads was estimated to be 86 km/h for all classes of vehicle. This supports a lower speed limit than the 100 km/h limit envisaged, at least on the undivided Category 1 roads through curvy road environments where a 90 km/h limit could be considered.

Table 10.4: Economic impacts of speed reductions, and estimated optimum speeds. Curvy road environment with frequent slowing and occasional stops along full length of the road category (except divided Category 1 roads). "Human capital" costs of road trauma.

	Effect of 5 km/h mean speed reductions on total economic cost		**Optimum Speed (km/h)** (speed which minimises total economic cost)		
Road category and current speed limit	Change p.a. ($ million)	Percentage change	All vehicles combined	Cars & LCVs	Heavy vehicles
Rural roads with 110 km/h speed limits					
Divided Category 1 Trunk Roads[1]	-1.083	-0.8%	100	102	94
Undivided Cat. 1 Trunk Roads	-32.853	-5.9%	86	86	86
Undivided rural roads with 100 km/h speed limits					
Category 2 Regional Freight Roads	+1.566	+0.8%	86	86	86
Category 3 Regional Access Roads	-0.929	-0.3%	82	82	82
Category 4 Feeder Roads	-3.021	-1.0%	86	86	82
Category 5 "Other" Roads	+1.000	+0.5%	82	82	82
Unsealed rural roads (100 km/h speed limit)					
Category 5 "Other" Roads	-0.049	-0.6%	80	80	80

[1] Assumed to be primarily freeway standard roads with high design speeds and controlled access, not requiring frequent slowing due to sharp curves and stops for towns and intersections, and hence not analysed for a curvy road environment. Results assumed to be same as in Table 10.2 for straight unimpeded road environment.

10.4 OVERALL BENEFITS AND COSTS OF REDUCED SPEED LIMITS

The seven road environments summarised in Table 10.4 were considered in aggregate to be representative of rural State Roads in Tasmania. Ignoring the double-counting of the economic benefit on unsealed Category 5 roads, the combined results suggest that there would be a total economic benefit to Tasmania of $35.37 million per annum if the envisaged reduced speed limits were introduced and a 5 km/h reduction in current free speeds on the targeted roads were to result. Even if the full 5 km/h reduction in current speeds was not achieved, the optimum speeds for each road class and vehicle type suggest that limiting vehicle free speeds to the envisaged speed limits would result in a net economic benefit.

Table 10.5 shows the estimated crash savings if the 5 km/h reductions in mean free speeds were to result from the speed limit reductions in each road environment. Again ignoring the double-counting on unsealed Category 5 roads, it is estimated that there would be 25% reduction in fatal crashes, 15% reduction is serious injury crashes, and nearly 12% reduction in minor injury crashes associated with the speed limit reductions. Nearly one-third of the fatal crashes savings would come from the reduction in the limit on existing 110 km/h undivided Category 1 roads.

Table 10.5: Estimated crash reductions per year. Curvy road environment with frequent slowing and occasional stops (except divided Category 1 roads).

	Estimated crash savings due to 5 km/h mean speed reductions				
Road category and current speed limit	Fatal crashes p.a.	Serious injury crashes p.a.	Other injury crashes p.a.	Annual casualty crashes (estimate)	Casualty crash saving (% p.a.)
Rural roads with 110 km/h speed limits					
Divided Category 1 Trunk Roads	0.44	0.83	5.54	65.7	10.4%
Undivided Cat. 1 Trunk Roads	2.20	2.08	5.53	81.2	12.1%
Undivided rural roads with 100 km/h speed limits					
Category 2 Regional Freight Roads	0.72	2.07	6.08	64.2	13.8%
Category 3 Regional Access Roads	1.45	3.77	12.51	132.3	13.4%
Category 4 Feeder Roads	1.01	4.25	12.38	137.6	12.8%
Category 5 "Other" Roads[1]	0.80	3.12	9.32	95.7	13.8%
Unsealed rural roads on SRN (100 km/h speed limit)					
Category 5 "Other" Roads	0.05	0.18	0.35	4.1	14.1%
TOTAL CRASH SAVINGS p.a.	**6.67**	**16.30**	**51.71**	580.8	**12.9%**
Annual crashes by severity (est.)	26.7	108.1	446.0		
PERCENT CRASH SAVINGS	**25.0%**	**15.1%**	**11.6%**		

[1] Includes unsealed gravel roads on State Road Network, representing 4.3% of casualty crashes on Cat. 5 roads.

10.5 ALTERNATIVE METHOD FOR ESTIMATING EFFECTS OF SPEED CHANGES ON CASUALTY CRASHES

The economic analysis results rely on the integrity of the analysis tools, a key part of which is the use of Nilsson-type relationships to link changes in mean free speeds on rural roads with the changes in numbers of casualty crashes, at each level of injury outcome of the crashes (see section 3.1.4). It has been found in the Kingborough Safer Speeds Demonstration project that the 10 km/h reduction in the 100 km/h limit on sealed roads resulted in little or no reduction in mean free speeds, but substantial reductions in the proportion of vehicles travelling above 91 km/h (and commensurate increases in the proportion travelling 71-90 km/h). Compared with a "control" municipality where there were no speed limit changes, there was a 51% reduction in casualty crashes on sealed roads (not statistically significant) and 60% reduction in all reported crashes (statistically significant). Mean free speeds at six sites on the Kingborough sealed roads before the speed limit reduction ranged from 52 to 84 km/h, plus 96 km/h measured at one site (Langford 2009).

It is possible that Nilsson-type relationships may not adequately represent the expected changes in casualty crashes if speed limits are reduced in rural road environments where free speeds are already substantially below the current (and reduced) limits on many targeted roads. A change in the distribution of speeds, instead of or in addition to a reduction in mean speed, may be expected to produce the reduction in casualty crashes. To estimate the likely reduction in casualty crashes, it may be possible to weight each of the observed speeds by the relative risk of a casualty crash, as estimated by Kloeden et al (2001) for rural roads. A hypothesised change in the speed distribution, based on the Kingborough experience, could then be estimated and the risk-weighting re-applied to estimate the changes in casualty crashes. The change in the severity of the casualty crashes (thus estimating the numbers of fatal and serious injury crashes) may be possible to estimate based on a modification of the Nilsson-type relationships.

It is recommended that an alternative method of estimating the changes in the numbers of casualty crashes on the Category 2-5 roads associated with a potential change in the speed distribution due to a reduction in their 100 km/h limit, based on Kloeden et al's (2001) relative risk relationships, be investigated and if feasible be incorporated in a re-analysis of the economic benefits of the envisaged speed limit reduction on undivided Category 2-5 roads.

11 CONCLUSIONS

1. The envisaged reduction in the 110 km/h speed limit to 100 km/h on Category 1 (National Highways) roads in Tasmania would be economically justified on both the divided and undivided sections under consideration.

2. The economic justification is even greater on the undivided Category 1 roads when: (a) the saving in road trauma is valued by "willingness to pay" estimates; or (b) the high proportion of road environments with frequent sharp curves, at-grade intersections, and occasional stops in towns traversed by these roads is recognised. A 90 km/h limit on undivided Category 1 roads could be considered, particularly through curvy road environments.

3. The envisaged reduction in the default 100 km/h speed limit to 90 km/h on sealed rural roads would be economically justified when it is recognised that a high proportion of Category 2-5 roads are through road environments with frequent sharp curves, at-grade intersections, and occasional stops in towns. The optimum speed on these roads through curvy environments is below 90 km/h for all classes of vehicle.

4. The envisaged reduction in the default 100 km/h speed limit to 80 km/h on unsealed (gravel) roads would be economically justified. The optimum speed on these roads on the State Road Network is close to the proposed new speed limit for all classes of vehicle.

5. If mean free speeds were reduced by 5 km/h on each category of road in response to the envisaged reduced speed limit applicable in each case, there would be an estimated total economic benefit exceeding $35 million per annum to Tasmania. It is estimated that there would be 25% reduction in fatal crashes, 15% reduction is serious injury crashes, and nearly 12% reduction in minor injury crashes on the roads with the speed limit reductions.

6. It is possible that the relationships developed by Nilsson (1984), linking crashes and their injury severity with changes in mean free speeds, may not adequately represent the expected changes in casualty crashes if speed limits are reduced in rural road environments where free speeds are already substantially below the current (and reduced) limits on many targeted roads. A change in the distribution of speeds, instead of, or in addition to a reduction in mean speed, may be expected to produce a reduction in casualty crashes. It is recommended that an alternative method of estimating the changes in the numbers of casualty crashes on the Category 2-5 roads be investigated and if feasible, incorporated in further analysis of the economic benefits of the envisaged speed limit reductions.

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APPENDIX A:
MASTER FRAMEWORK FOR ANALYSIS OF IMPACTS OF A SPEED MANAGEMENT POLICY

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MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: ______________________
Institution: ______________________

1. Outlining

A. Policy test

~~A1. Length of link~~ ______ km

~~A2. Flow characteristics~~

Traffic attributes	Before policy						After policy					
						Total/ Average	0	0	0	0	0	**Total/ Average**
Mean speed, km/h						**#DIV/0!**						**#DIV/0!**
AADT*						**0**						**0**
Share of traffic	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Business trips, %						**#DIV/0!**						**#DIV/0!**
Pers. bus. and commuting. trips, %						**#DIV/0!**						**#DIV/0!**
Leisure trips, %						**#DIV/0!**						**#DIV/0!**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [ ] Vehicle operating costs
- [ ] Travel time
- [ ] Accidents
- [ ] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

2. Measurement of impacts

D. Impact functions

~~D1. Vehicle operating costs~~

(describe here)

~~D2. Travel time~~

Function: travel time = link length/speed of traffic flow

~~D3a. Accidents~~

For example:

Injury accidents before = n_{IB} Average speed before = v_B

Injury accidents after = n_{IA} Average speed after = v_A

$$n_{IA} = (v_A/v_B)^2 * n_{IB}$$ (Andersson & Nilsson, 1997)

~~D3b. Accident costs~~

For example:

Total accident costs before = C_B, total accident costs after = C_A

k = country specific constant 1.75…2.30

$$C_A = [k*((v_A/v_B)^2-1)+1]*C_B$$ (Andersson & Nilsson, 1997)

~~D4. Air pollutant emission coefficients~~

*Emission factors**	At initial speed, g/km						At final speed, g/km					
	0	0	0	0	0	Average	0	0	0	0	0	Average
Carbon monoxide CO						**#DIV/0!**						**#DIV/0!**
Hydrocarbons HC						**#DIV/0!**						**#DIV/0!**
Oxides of nitrogen NO_x						**#DIV/0!**						**#DIV/0!**
Particles PM						**#DIV/0!**						**#DIV/0!**
Carbon dioxide CO_2						**#DIV/0!**						**#DIV/0!**

~~D5. Noise pollution~~

(specify model used here)

E. Unit prices

E1. Vehicle operating costs

	Petrol	Diesel
Fuel price, ECU per litre		

(inserting prices here is preferred to writing them in formulas with absolute numbers)

	ECU per vehicle-km											
	Before policy						After policy					
	0	0	0	0	0	Average	0	0	0	0	0	Average
Vehicle oper. costs*						**#DIV/0!**						**#DIV/0!**

**Without tax*

E2a. Time costs per hour

	ECU per hour				
Value of travel time	0	0	0	0	0
Business trips, %					
Pers. bus. and commuting. trips, %					
Leisure trips, %					
Average	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

E2b. Time costs per kilometre

	ECU per vehicle-km											
	Before policy						After policy					
	0	0	0	0	0	Average	0	0	0	0	0	Average
Time costs	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	**#DIV/0!**	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	**#DIV/0!**

E3. Total user costs
(vehicle operating+ time costs)

	ECU per vehicle-km											
	Before policy						After policy					
	0	0	0	0	0	Average	0	0	0	0	0	Average
Total user costs	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	**#DIV/0!**	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	**#DIV/0!**

E4. Accident costs

	Before	After
Accident type	**kECU/ accid.**	**kECU/ accid.**
Personal injury accident	316	#DIV/0!

E5a. Air pollution costs

Air pollutants' unit costs	**ECU/t**
Carbon monoxide CO	
Hydrocarbons HC	
Oxides of nitrogen NOx	
Particles PM	
Carbon dioxide CO2	

E5b. Noise pollution costs

Unit costs of noise pollution	**ECU/year**
Noise zone 55 to 65 dB	
Noise zone 65 to 70 dB	
Noise zone >70 dB	

F. Calculation of impacts

F1. Vehicle operating costs

	Before policy, kECU/year						After policy, kECU/year					
	0	0	0	0	0	**Total**	0	0	0	0	0	**Total**
Vehicle operating costs	0	0	0	0	0	**0**	0	0	0	0	0	**0**

F2a. Travel time

	Before policy, vehicle-hours/day						After policy, vehicle-hours/day					
	0	0	0	0	0	**Total**	0	0	0	0	0	**Total**
Total travel time on link	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	**#DIV/0!**	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	**#DIV/0!**

F2b. Travel time costs

	Before policy, kECU/year						After policy, kECU/year					
	0	0	0	0	0	**Total**	0	0	0	0	0	**Total**
Total travel time costs	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	**#DIV/0!**	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	**#DIV/0!**

F3. Consumer surplus

	Input data, before policy						Input data, after policy					
	0	0	0	0	0	**Average**	0	0	0	0	0	**Average**
Total user costs, ECU/veh.km	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	**#DIV/0!**	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Mio veh.kms/year	0	0	0	0	0	**0**	0	0	0	0	0	**0**

	Change in consumer surplus					Total
kECU/year	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	**#DIV/0!**

F4a. Accidents

Number of accidents per year	**Before policy**	**After policy**	**Change**	
Personal injury accident		#DIV/0!	#DIV/0!	#DIV/0!

F4b. Accident costs

	kECU/year			
Cost of accidents	**Before policy**	**After policy**	**Change**	
Personal injury accident		#DIV/0!	#DIV/0!	#DIV/0!

F5a. Air pollution

	At initial speed, t/year						At final speed, t/year					
Emissions	0	0	0	0	0	**Total**	0	0	0	0	0	**Total**
Carbon monoxide CO	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Hydrocarbons HC	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Oxides of nitrogen NOx	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Particles PM	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Carbon dioxide CO2	0	0	0	0	0	**0**	0	0	0	0	0	**0**

F5b. Air pollution costs

	At initial speed, kECU/year						At final speed, kECU/year					
Emissions	0	0	0	0	0	**Total**	0	0	0	0	0	**Total**
Carbon monoxide CO	-	-	-	-	-	-	-	-	-	-	-	-
Hydrocarbons HC	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Oxides of nitrogen NOx	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Particles PM	-	-	-	-	-	-	-	-	-	-	-	-
Carbon dioxide CO2	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Total	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

F5c. Noise pollution

No. of residents	**Before policy**	**After policy**	**Change**	
Noise zone 55 to 65 dB			0	#DIV/0!
Noise zone 65 to 70 dB			0	#DIV/0!
Noise zone >70 dB			0	#DIV/0!

F5d. Noise pollution costs

	kECU/ year			
	Before policy	**After policy**	**Change**	
Noise zone 55 to 65 dB	0	0	0	#DIV/0!
Noise zone 65 to 70 dB	0	0	0	#DIV/0!
Noise zone >70 dB	0	0	0	#DIV/0!
Total	**0**	**0**	**0**	**#DIV/0!**

G. Non-quantified impacts

(describe here)

H. Net impacts

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Number of accidents per year		0.0	#DIV/0!	#DIV/0!	#DIV/0!
Emissions, t/year	Carbon monoxide CO	0	0	0	#DIV/0!
	Hydrocarbons HC	0	0	0.0	#DIV/0!
	Oxides of nitrogen NOx	0	0	0	#DIV/0!
	Particles PM	0	0	0.00	#DIV/0!
	Carbon dioxide CO2	0	0	0	#DIV/0!
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	#DIV/0!

H2. Monetary impacts

kECU/year	Before	After	Change	
Consumber surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	0	0	0	#DIV/0!
Time costs	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!
Accident costs	0	#DIV/0!	#DIV/0!	#DIV/0!
Air pollution costs	0	0	0	#DIV/0!
Noise costs	0	0	0	#DIV/0!
Total	**#DIV/0!**	**#DIV/0!**		
Change			**#DIV/0!**	**#DIV/0!**

NB: Table H2 has two alternative appearances depending on whether the traffic volume changes:
If the **traffic volume does not change**, the difference of the sums of vehicle operating and time costs is used normally. Without an estimate of the demand curve of traffic as a function of user costs, the before and after figures for consumer surplus (CS) cannot, however, be presented. In this case, the change in consumer surplus equals the change in vehicle operating + time costs.
If the **traffic volume changes** as a result of the policy, change of the user costs cannot be used as a component of socio-economic costs of the policy. Instead, the change in consumer surplus is used. But, as stated above, the CS figures for the initial and final situation are not known, and thus the *Total* row will only include accident and environmental costs in the before and after columns. The absolute figure for total change will in all cases include changes in the total costs, as this can always be calculated. No percent change is presented in this latter case.

I. Distribution of impacts

Affected Groups	Vehicle costs	Travel time	Accid-ents	Pollut-ion
Private motorists				
Coach passengers				
Goods traffic				
Nearby residents				
Animals crossing road				
Oth 1				
Oth 2				
Oth 3				
Oth 4				

J. Sensitivity tests

(list here)

End of sheet

APPENDIX B:
CATEGORY 1 DIVIDED RURAL ROADS 110 KM/H

Cat1DividedFSHC.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 1 divided rural roads with current 110 km/h speed limit

A1. Length of link 67.3 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total/ Average	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total/ Average
Cruise speed, km/h	110	110	109	100	110	**109.9**	105	105	104	95	105	**104.9**
Average of all speeds on link	110	110	109	100	110	**109.9**	105	105	104	95	105	**104.9**
AADT*	5,233	1,087	440	51	2247	**9,058**	5,233	1,087	440	51	2247	**9,058**
Share of traffic	58%	12%	5%	1%	25%	100%	58%	12%	5%	1%	25%	100%
Business trips, %		100	93.5	100	48.5	**29**		100	93.5	100	48.5	**29**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**27**	35.7		6.5		25.7	**27**
Leisure trips, %	64.3				25.8	**44**	64.3				25.8	**44**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

Category 1 divided rural roads with current 110 km/h speed limit

2. Measurement of impacts

D. Impact functions

D1. Vehicle operating costs

Freeway Model for operations of free-running traffic in Table 3.10 of AGPE04/08; June 2007 prices

D2. Travel time

Function: travel time = link length/speed of traffic flow (flat straight roads only; see adjustment factors for curvy roads with cross roads and towns)

D3a. Accidents

Injury accidents before = n_{IB} Average speed before = v_B
Injury accidents after = n_{IA} Average speed after = v_A

		Exponent	Value	
Fatal accidents	$n_{IA} = (v_A/v_B)F * n_{IB}$	**F**	**4.36**	Rural highway exponent estimates
Serious injury accidents	$n_{IA} = (v_A/v_B)S * n_{IB}$	**S**	**2.78**	from Cameron and Elvik (2008), Table 6
Other injury accidents	$n_{IA} = (v_A/v_B)O * n_{IB}$	**O**	**2.22**	

D4. Air pollutant emission coefficients

*Emission factors**	At initial speed, g/km						At final speed, g/km					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average
Carbon monoxide CO	2.43	2.43	2.41	2.27	2.43	2.43	2.35	2.35	2.33	2.19	2.35	2.35
Hydrocarbons HC	0.43	0.43	0.43	0.40	0.43	0.43	0.42	0.42	0.41	0.38	0.42	0.41
Oxides of nitrogen NO_x	1.54	1.54	1.54	1.51	1.54	1.54	1.53	1.53	1.52	1.49	1.53	1.53
Particles PM	0.03	0.03	0.03	0.03	0.03	0.035	0.03	0.03	0.03	0.03	0.03	0.034
Carbon dioxide CO_2	240.2	240.2	239.3	231.7	240.2	240.1	235.9	235.9	235.1	227.5	235.9	235.8

Emission coefficients not available by vehicle type, only for mix of traffic close to mix outlined here
Same coefficient assumed for all vehicles at given speed for each pollutant

D5. Noise pollution

No impact function available; noise pollution assumed small because of negligible human population living in vicinity of rural roads considered

E. Unit prices

E1. Vehicle operating costs

	Petrol	Diesel	
Fuel price, $ per litre	0.8804	0.8639	Resource prices in Table 2.4 of AGPE04/08 for Hobart, June 2007

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average
Vehicle oper. costs*	0.244	0.244	1.220	1.176	0.443	**0.346**	0.238	0.238	1.193	1.161	0.432	**0.338**
*With A	-16.26	-16.26	-30.00	-30.00	-30.00		-16.26	-16.26	-30.00	-30.00	-30.00	
B	1553.78	1553.78	8544.38	8544.38	3396.74		1553.78	1553.78	8544.38	8544.4	3396.7	
C	0.23531	0.23531	0.0185	0.0185	0.25629		0.23531	0.23531	0.0185	0.0185	0.2563	
D	5E-05	5E-05	0.00603	0.00603	0.00126		5E-05	5E-05	0.00603	0.006	0.0013	
Base A	-16.262	-16.262	-30	-30	-30		-16.262	-16.262	-30	-30	-30	
Fuel A	-18.433	-18.433	-65.056	-80	-27.456		-18.433	-18.433	-65.056	-80	-27.46	
Fuel B	1306.02	1306.02	4156.75	6342.8	2060.5		1306.02	1306.02	4156.75	6342.8	2060.5	
Fuel C	0.15477	0.15477	0.49681	0.48496	0.1911		0.15477	0.15477	0.49681	0.485	0.1911	
Fuel D	0.00032	0.00032	0.00068	0.00209	0.00085		0.00032	0.00032	0.00068	0.0021	0.0009	
Fuel consumption rate (lt/100km)	14.34	14.34	35.31	52.82	22.59		13.79	13.79	33.93	51.70	21.62	
Increase associated with speed	1	1	1	1	1		1	1	1	1	1	

E2a. Time costs per hour

Value of travel time	$ per hour					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	
Business trips, %		47.8	29.0	40.8	29.9	Travel time values at June 2007 from Table 3.2 of AGPE04/08
Pers. bus. and commuting. trips, %	19.5		23.3		14.9	
Leisure trips, %	19.5				14.9	
Average	**19.5**	**47.8**	**28.6**	**40.8**	**22.2**	

E2b. Time costs per kilometre	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average
Time costs	0.178	0.434	0.263	0.408	0.202	**0.2198**	0.186	0.455	0.275	0.430	0.211	**0.2303**

E3. Total user costs
(vehicle operating+ time costs)

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average
Total user costs	0.421	0.678	1.483	1.584	0.645	**0.566**	0.424	0.693	1.468	1.591	0.643	**0.568**

E4. Accident costs

Accident type	**kA$/ accid.**	
Fatal accident	2155	
Serious injury accident	455	
Other injury accident	21.7	
Personal injury accident (av.)	167.0	"Human capital" valuation (BTE 2000) for non-urban crashes in Tasmania indexed to June 2007 resource

E5a. Air pollution costs

Air pollutants' unit costs	**$/t**
Carbon monoxide CO	3
Hydrocarbons HC	958
Oxides of nitrogen NOx	1912
Particles PM	304298
Carbon dioxide CO2	48

Unit costs in 2007 prices from Table 5.3 in AGPE04/08

E5b. Noise pollution costs

Unit costs of noise pollution	**$/year**	
Noise zone 55 to 65 dB		Treated as zero in rural areas in Tabl
Noise zone 65 to 70 dB		
Noise zone >70 dB		

F. Calculation of impacts

F1. Vehicle operating costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Vehicle operating costs	31,307	6,504	13,187	1,475	24,476	**76,949**	30,590	6,355	12,890	1,457	23,831	**75,123**

F2a. Travel time

	Before policy, vehicle-hours/day						After policy, vehicle-hours/day					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Total travel time on link	3,202	665	272	34	1,375	**5,548**	3,354	697	285	36	1,440	**5,812**

F2b. Travel time costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Total travel time costs	22,827	11,603	2,837	512	11,136	**48,915**	23,914	12,155	2,973	539	11,666	**51,248**

F3. Consumer surplus

	Input data, before policy						Input data, after policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average
Total user costs, $/veh.km	0.421	0.678	1.483	1.584	0.645	**0.566**	0.424	0.693	1.468	1.591	0.643	0.568
Mio veh.kms/year	129	27	11	1	55	**223**	129	27	11	1	55	**223**

	Change in consumer surplus					Total
k$/year	370	404	-160	8	-114	**508**

F4a. Casualty accident rates

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Crash rate per million VKT	0.295	0.295	0.295	0.295	0.295	0.295	0.265	0.265	0.263	0.260	0.265	0.265
Fatal crash rate per 100M VKT						1.08						0.89

F4b. Casualty accident severity

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average
Fatal (%)	3.5	3.5	7.3	10.4	3.5	3.7	3.1	3.1	6.6	9.4	3.1	3.3
Serious injury (%)	10.3	10.3	12.0	12.4	10.3	10.4	10.1	10.1	11.8	12.2	10.1	10.2
Minor injury (%)	86.2	86.2	80.8	77.3	86.2	85.9	86.7	86.7	81.6	78.4	86.7	86.4

F4c. Accidents

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Fatal accident	1.3	0.3	0.2	0.0	0.6	**2.4**	1.1	0.2	0.2	0.0	0.5	**2.0**
Serious injury accident	3.9	0.8	0.4	0.0	1.7	**6.9**	3.4	0.7	0.3	0.0	1.5	**6.0**
Minor injury accident	32.7	6.8	2.6	0.3	14.0	**56.4**	29.5	6.1	2.3	0.3	12.7	**50.9**
Total casualty accidents	37.9	7.9	3.2	0.4	16.3	**65.7**	34.0	7.1	2.8	0.3	14.6	**58.9**

F4d. Accident costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Fatal accident	2,821	586	499	83	1,211	**5,201**	2,303	479	407	66	989	**4,244**
Serious injury accident	1,785	371	174	21	767	**3,117**	1,569	326	152	18	674	**2,739**
Minor injury accident	710	147	56	6	305	**1,224**	640	133	50	6	275	**1,104**
Total casualty accidents	5,317	1,105	729	110	2,283	**9,542**	4,512	937	610	90	1,938	**8,087**

F5a. Air pollution

Emissions	At initial speed, t/year						At final speed, t/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Carbon monoxide CO	312	65	26	3	134	**540**	302	63	25	3	130	**522**
Hydrocarbons HC	55	11	5	1	24	**96**	53	11	4	0	23	**92**
Oxides of nitrogen NOx	198	41	17	2	85	**343**	196	41	16	2	84	**340**
Particles PM	4	1	0	0	2	**8**	4	1	0	0	2	**7**
Carbon dioxide CO2	30,872	6,414	2,586	291	13,256	**53,418**	30,328	6,301	2,540	285	13,022	**52,477**

F5b. Air pollution costs

Emissions	At initial speed, k$/year						At final speed, k$/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Carbon monoxide CO	0.9	0.2	0.1	0.0	0.4	**1.6**	0.9	0.2	0.1	0.0	0.4	**1.6**
Hydrocarbons HC	53	11	4	0	23	**92**	51	11	4	0	22	**88**
Oxides of nitrogen NOx	379	79	32	4	163	**657**	375	78	31	4	161	**650**
Particles PM	1,361	283	114	12	585	**2,355**	1,315	273	110	12	565	**2,275**
Carbon dioxide CO2	1,482	308	124	14	636	**2,564**	1,456	302	122	14	625	**2,519**
Total	**3,277**	**681**	**274**	**30**	**1,407**	**5,669**	**3,199**	**665**	**268**	**30**	**1,373**	**5,534**

F5c. Noise pollution

No. of residents	**Before policy**	**After policy**	**Change**	
Noise zone 55 to 65 dB			0	#DIV/0!
Noise zone 65 to 70 dB			0	#DIV/0!
Noise zone >70 dB			0	#DIV/0!

F5d. Noise pollution costs

	k$/ year			
	Before policy	**After policy**	**Change**	
Noise zone 55 to 65 dB	0	0	0	#DIV/0!
Noise zone 65 to 70 dB	0	0	0	#DIV/0!
Noise zone >70 dB	0	0	0	#DIV/0!
Total	**0**	**0**	**0**	**#DIV/0!**

G. Non-quantified impacts

Noise pollution

Summary of quantified impacts

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Total monetary impact	62,727	19,892	17,027	2,127	39,301	**141,075**	62,215	20,112	16,741	2,115	38,808	**139,992**

End of sheet

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework

Ver. 01/99

Category 1 divided rural roads with current 110 km/h speed limit

H. Net impacts

	Cruise Speed (km/h)	
Cars and LCVs	**110**	**105**
Rigid heavy vehicles	**109**	**104**
Artic. heavy vehicles	**100**	**95**

Average speed on link (km/h)	Before	After
Cars and LCVs	**110.0**	**105.0**
Rigid heavy vehicles	**109.0**	**104.0**
Articulated heavy vehicles	**100.0**	**95.0**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		5,548	5,812	264	4.8 %
Number of Crashes per year		65.7	58.9	-6.8	-10.4%
Emissions, t/year	Carbon monoxide CO	540	522	-18	-3.3 %
	Hydrocarbons HC	96	92	-3.4	-3.5 %
	Oxides of nitrogen NOx	343	340	-4	-1.1 %
	Particles PM	7.7	7.5	-0.26	-3.4 %
	Carbon dioxide CO2	53418	52477	-941	-1.8 %
Residents in area where $L_{Aeq,07-22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **2.6** Trucks: **2.6**

Saving p.a Fatal: **0.4** Serious Inj: **0.8** Other Inj: **5.5**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	76,949	75,123	-1826	-2.4 %
Time costs	48,915	51,248	2333	4.8 %
Crash costs	9,542	8,087	-1,456	-15.3%
Air pollution costs	5,669	5,534	-135	-2.4 %
Noise costs	0	0	0	
Total	**141,075**	**139,992**		
Change			**-1,083**	**-0.8 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	71,379	71,263	71,235	71,291	71,427	71,636	71,916	72,263	72,673	73,143	73,671	74,253	74,887	75,571	76,303	77,080
Time costs	67,158	65,520	63,960	62,473	61,053	59,696	58,399	57,156	55,965	54,823	53,727	52,673	51,660	50,686	49,747	48,843
Crash costs	3,209	3,484	3,777	4,088	4,419	4,771	5,144	5,539	5,957	6,399	6,867	7,361	7,882	8,431	9,009	9,619
Air pollution costs	4,861	4,915	4,969	5,023	5,077	5,131	5,185	5,239	5,293	5,348	5,402	5,456	5,510	5,564	5,618	5,672
Noise costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**146,608**	**145,182**	**143,941**	**142,876**	**141,976**	**141,235**	**140,644**	**140,198**	**139,889**	**139,714**	**139,666**	**139,742**	**139,938**	**140,251**	**140,677**	**141,213**
of which:																
Cars & light comm. vehs.	127,466	126,195	125,082	124,117	123,293	122,602	122,039	121,597	121,272	121,058	120,952	**120,951**	121,049	121,246	121,537	121,921
Heavy vehicles (rigid and artic.)	19,142	18,987	18,859	18,759	18,684	18,633	18,606	**18,601**	18,618	18,655	18,714	18,792	18,889	19,005	19,140	19,292

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	14,095	14,021	13,968	13,934	13,919	13,922	13,942	13,979	14,031	14,099	14,181	14,277	14,387	14,510	14,646	14,794
Time costs	4,506	4,396	4,291	4,191	4,096	4,005	3,918	3,835	3,755	3,678	3,604	3,534	3,466	3,400	3,337	3,277
Crash costs	277	304	331	361	393	428	464	503	545	589	635	685	738	793	852	915
Air pollution costs	263	266	269	272	275	278	281	284	287	290	293	296	299	302	304	307
Noise costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**19,142**	**18,987**	**18,859**	**18,759**	**18,684**	**18,633**	**18,606**	**18,601**	**18,618**	**18,655**	**18,714**	**18,792**	**18,889**	**19,005**	**19,140**	**19,292**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	57,284	57,242	57,267	57,357	57,507	57,714	57,974	58,284	58,642	59,045	59,490	59,976	60,500	61,061	61,657	62,287
Time costs	62,653	61,125	59,669	58,282	56,957	55,691	54,481	53,322	52,211	51,145	50,122	49,139	48,194	47,285	46,410	45,566
Crash costs	2,931	3,180	3,445	3,727	4,026	4,343	4,679	5,036	5,412	5,811	6,232	6,676	7,144	7,637	8,157	8,704
Air pollution costs	4,598	4,649	4,700	4,751	4,802	4,853	4,904	4,955	5,007	5,058	5,109	5,160	5,211	5,262	5,313	5,364
Noise costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**127,466**	**126,195**	**125,082**	**124,117**	**123,293**	**122,602**	**122,039**	**121,597**	**121,272**	**121,058**	**120,952**	**120,951**	**121,049**	**121,246**	**121,537**	**121,921**

APPENDIX C: CATEGORY 1 DIVIDED RURAL ROADS 110 KM/H – ‘WILLINGNESS TO PAY’ VALUATIONS OF ROAD TRAUMA

Cat1DividedFSwtp.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 1 divided rural roads with current 110 km/h speed limit. WTP valuation of crash costs.

A1. Length of link 67.3 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	110	110	109	100	110	**109.9**	105	105	104	95	105	**104.9**
Average of all speeds on link	110	110	109	100	110	**109.9**	105	105	104	95	105	**104.9**
AADT*	5,233	1,087	440	51	2247	**9,058**	5,233	1,087	440	51	2247	**9,058**
Share of traffic	58%	12%	5%	1%	25%	100%	58%	12%	5%	1%	25%	100%
Business trips, %		100	93.5	100	48.5	**29**		100	93.5	100	48.5	**29**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**27**	35.7		6.5		25.7	**27**
Leisure trips, %	64.3				25.8	**44**	64.3				25.8	**44**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework

Ver. 01/99

Category 1 divided rural roads with current 110 km/h speed limit. WTP valuation of crash costs.

H. Net impacts

	Cruise Speed (km/h)	
Cars and LCVs	**110**	**105**
Rigid heavy vehicles	**109**	**104**
Artic. heavy vehicles	**100**	**95**

Average speed on link (km/h)	Before	After
Cars and LCVs	**110.0**	**105.0**
Rigid heavy vehicles	**109.0**	**104.0**
Articulated heavy vehicles	**100.0**	**95.0**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		5,548	5,812	264	4.8 %
Number of Crashes per year		65.7	58.9	-6.8	-10.4%
Emissions, t/year	Carbon monoxide CO	540	522	-18	-3.3 %
	Hydrocarbons HC	96	92	-3.4	-3.5 %
	Oxides of nitrogen NOx	343	340	-4	-1.1 %
	Particles PM	7.7	7.5	-0.26	-3.4 %
	Carbon dioxide CO2	53418	52477	-941	-1.8 %
Residents in area where $L_{Aeq,07-22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **2.6** Trucks: **2.6**

Saving p.a Fatal: **0.4** Serious Inj: **0.8** Other Inj: **5.5**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	76,949	75,123	-1826	-2.4 %
Time costs	48,915	51,248	2333	4.8 %
Crash costs	22,615	19,144	-3,470	-15.3%
Air pollution costs	5,669	5,534	-135	-2.4 %
Noise costs	0	0	0	
Total	**154,147**	**151,049**		
Change			**-3,098**	**-2.0 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	71,379	71,263	71,235	71,291	71,427	71,636	71,916	72,263	72,673	73,143	73,671
Time costs	67,158	65,520	63,960	62,473	61,053	59,696	58,399	57,156	55,965	54,823	53,727
Crash costs	7,610	8,256	8,945	9,679	10,459	11,288	12,169	13,103	14,093	15,141	16,250
Air pollution costs	4,861	4,915	4,969	5,023	5,077	5,131	5,185	5,239	5,293	5,348	5,402
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**151,009**	**149,954**	**149,110**	**148,466**	**148,016**	**147,752**	**147,669**	**147,761**	**148,025**	**148,455**	**149,049**
of which:											
Cars & light comm. vehs.	131,485	130,549	129,792	129,207	128,786	128,525	**128,417**	128,459	128,646	128,975	129,444
Heavy vehicles (rigid and artic.)	19,524	19,405	19,318	19,259	19,230	**19,227**	19,252	19,303	19,379	19,480	19,605

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	14,095	14,021	13,968	13,934	13,919	13,922	13,942	13,979	14,031	14,099	14,181
Time costs	4,506	4,396	4,291	4,191	4,096	4,005	3,918	3,835	3,755	3,678	3,604
Crash costs	660	722	790	862	939	1,022	1,111	1,205	1,306	1,413	1,527
Air pollution costs	263	266	269	272	275	278	281	284	287	290	293
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**19,524**	**19,405**	**19,318**	**19,259**	**19,230**	**19,227**	**19,252**	**19,303**	**19,379**	**19,480**	**19,605**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	57,284	57,242	57,267	57,357	57,507	57,714	57,974	58,284	58,642	59,045	59,490
Time costs	62,653	61,125	59,669	58,282	56,957	55,691	54,481	53,322	52,211	51,145	50,122
Crash costs	6,950	7,534	8,155	8,817	9,520	10,266	11,058	11,898	12,787	13,728	14,723
Air pollution costs	4,598	4,649	4,700	4,751	4,802	4,853	4,904	4,955	5,007	5,058	5,109
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**131,485**	**130,549**	**129,792**	**129,207**	**128,786**	**128,525**	**128,417**	**128,459**	**128,646**	**128,975**	**129,444**

APPENDIX D:
CATEGORY 1 UNDIVIDED RURAL ROADS 110 KM/H

Cat1UndividedFSHC.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 1 undivided rural roads with current 110 km/h speed limit

A1. Length of link 238 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total/ Average	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total/ Average
Cruise speed, km/h	105	105	100	99	105	**104.3**	100	100	95	94	100	**99.3**
Average of all speeds on link	105	105	100	99	105	**104.3**	100	100	95	94	100	**99.3**
AADT*	3,792	788	313	509	1628	**7,030**	3,792	788	313	509	1628	**7,030**
Share of traffic	54%	11%	4%	7%	23%	100%	54%	11%	4%	7%	23%	100%
Business trips, %		100	93.5	100	48.5	**34**		100	93.5	100	48.5	**34**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**25**	35.7		6.5		25.7	**25**
Leisure trips, %	64.3				25.8	**41**	64.3				25.8	**41**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework

Ver. 01/99

Category 1 undivided rural roads with current 110 km/h speed limit

H. Net impacts

	Cruise Speed (km/h)	
Cars and LCVs	**105**	**100**
Rigid heavy vehicles	**100**	**95**
Artic. heavy vehicles	**99**	**94**

Average speed on link (km/h)	Before	After
Cars and LCVs	**105.0**	**100.0**
Rigid heavy vehicles	**100.0**	**95.0**
Articulated heavy vehicles	**99.0**	**94.0**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		16,039	16,847	808	5.0 %
Number of Crashes per year		66.0	58.0	-8.0	-12.1%
Emissions, t/year	Carbon monoxide CO	1428	1379	-49	-3.4 %
	Hydrocarbons HC	252	243	-9.3	-3.7 %
	Oxides of nitrogen NOx	931	921	-10	-1.1 %
	Particles PM	20.4	19.7	-0.72	-3.5 %
	Carbon dioxide CO2	143732	141149	-2584	-1.8 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **2.9** Trucks: **3.2**

Saving p.a Fatal: **1.8** Serious Inj: **1.7** Other Inj: **4.5**

H2. Monetary impacts

k$/year	Before	After	Change	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	239,519	235,240	-4280	-1.8 %
Time costs	148,325	155,820	7495	5.1 %
Crash costs	26,769	22,055	-4,714	-17.6%
Air pollution costs	15,146	14,775	-371	-2.4 %
Noise costs	0	0	0	
Total	**429,759**	**427,889**		
Change			**-1,870**	**-0.4 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	230,220	229,672	229,422	229,454	229,750	230,298	231,084	232,096	233,322	234,754	236,381	238,195	240,188	242,353	244,683	247,172
Time costs	192,823	188,120	183,641	179,370	175,294	171,398	167,672	164,105	160,686	157,407	154,259	151,234	148,326	145,527	142,832	140,235
Crash costs	9,895	10,867	11,912	13,034	14,237	15,525	16,901	18,372	19,940	21,611	23,389	25,280	27,287	29,417	31,674	34,065
Air pollution costs	13,341	13,489	13,638	13,786	13,934	14,083	14,231	14,379	14,527	14,676	14,824	14,972	15,120	15,269	15,417	15,565
Noise costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**446,279**	**442,149**	**438,613**	**435,644**	**433,215**	**431,304**	**429,889**	**428,951**	**428,476**	**428,447**	**428,852**	**429,680**	**430,921**	**432,566**	**434,607**	**437,037**
of which:																
Cars & light comm. vehs.	326,508	323,323	320,552	318,173	316,168	314,518	313,210	312,228	311,562	311,199	**311,131**	311,349	311,845	312,612	313,646	314,941
Heavy vehicles (rigid and artic.)	119,772	118,826	118,062	117,471	117,048	116,785	**116,679**	116,723	116,914	117,248	117,721	118,332	119,077	119,953	120,961	122,097

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	83,431	82,992	82,677	82,478	82,390	82,408	82,528	82,745	83,055	83,454	83,940	84,510	85,159	85,887	86,690	87,566
Time costs	32,278	31,491	30,741	30,026	29,343	28,691	28,068	27,470	26,898	26,349	25,822	25,316	24,829	24,361	23,909	23,475
Crash costs	2,503	2,766	3,050	3,356	3,686	4,040	4,420	4,827	5,263	5,729	6,226	6,756	7,321	7,921	8,559	9,237
Air pollution costs	1,560	1,577	1,594	1,612	1,629	1,646	1,664	1,681	1,698	1,716	1,733	1,750	1,768	1,785	1,802	1,820
Noise costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**119,772**	**118,826**	**118,062**	**117,471**	**117,048**	**116,785**	**116,679**	**116,723**	**116,914**	**117,248**	**117,721**	**118,332**	**119,077**	**119,953**	**120,961**	**122,097**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100	102	104	106	108	110
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	146,788	146,679	146,746	146,976	147,361	147,890	148,556	149,351	150,267	151,299	152,440	153,685	155,029	156,466	157,994	159,607
Time costs	160,545	156,630	152,900	149,345	145,950	142,707	139,605	136,634	133,788	131,057	128,436	125,918	123,496	121,166	118,923	116,760
Crash costs	7,392	8,101	8,862	9,678	10,551	11,485	12,482	13,545	14,677	15,882	17,163	18,523	19,966	21,496	23,115	24,828
Air pollution costs	11,782	11,913	12,043	12,174	12,305	12,436	12,567	12,698	12,829	12,960	13,091	13,222	13,353	13,484	13,615	13,746
Noise costs	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**326,508**	**323,323**	**320,552**	**318,173**	**316,168**	**314,518**	**313,210**	**312,228**	**311,562**	**311,199**	**311,131**	**311,349**	**311,845**	**312,612**	**313,646**	**314,941**

APPENDIX E: CATEGORY 1 UNDIVIDED RURAL ROADS 110 KM/H – 'WILLINGNESS TO PAY' VALUATIONS OF ROAD TRAUMA

Cat1UndividedFSwtp.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 1 undivided rural roads with current 110 km/h speed limit. WTP valuation of crash costs

A1. Length of link 238 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	105	105	100	99	105	**104.3**	100	100	95	94	100	**99.3**
Average of all speeds on link	105	105	100	99	105	**104.3**	100	100	95	94	100	**99.3**
AADT*	3,792	788	313	509	1628	**7,030**	3,792	788	313	509	1628	**7,030**
Share of traffic	54%	11%	4%	7%	23%	100%	54%	11%	4%	7%	23%	100%
Business trips, %		100	93.5	100	48.5	**34**		100	93.5	100	48.5	**34**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**25**	35.7		6.5		25.7	**25**
Leisure trips, %	64.3				25.8	**41**	64.3				25.8	**41**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework

Ver. 01/99

Category 1 undivided rural roads with current 110 km/h speed limit. WTP valuation of crash costs

H. Net impacts

	Cruise Speed (km/h)	
Cars and LCVs	**105**	**100**
Rigid heavy vehicles	**100**	**95**
Artic. heavy vehicles	**99**	**94**

Average speed on link (km/h)	Before	After
Cars and LCVs	**105.0**	**100.0**
Rigid heavy vehicles	**100.0**	**95.0**
Articulated heavy vehicles	**99.0**	**94.0**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		16,039	16,847	808	5.0 %
Number of Crashes per year		66.0	58.0	-8.0	-12.1%
Emissions, t/year	Carbon monoxide CO	1428	1379	-49	-3.4 %
	Hydrocarbons HC	252	243	-9.3	-3.7 %
	Oxides of nitrogen NOx	931	921	-10	-1.1 %
	Particles PM	20.4	19.7	-0.72	-3.5 %
	Carbon dioxide CO2	143732	141149	-2584	-1.8 %
Residents in area where $L_{Aeq,07-22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **2.9** Trucks: **3.2**

Saving p.a Fatal: **1.8** Serious Inj: **1.7** Other Inj: **4.5**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	239,519	235,240	-4280	-1.8 %
Time costs	148,325	155,820	7495	5.1 %
Crash costs	62,754	51,373	-11,381	-18.1%
Air pollution costs	15,146	14,775	-371	-2.4 %
Noise costs	0	0	0	
Total	**465,744**	**457,207**		
Change			**-8,537**	**-1.8 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	230,220	229,672	229,422	229,454	229,750	230,298	231,084	232,096	233,322	234,754	236,381
Time costs	192,823	188,120	183,641	179,370	175,294	171,398	167,672	164,105	160,686	157,407	154,259
Crash costs	22,477	24,767	27,237	29,895	32,754	35,822	39,112	42,634	46,399	50,420	54,709
Air pollution costs	13,341	13,489	13,638	13,786	13,934	14,083	14,231	14,379	14,527	14,676	14,824
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**458,861**	**456,048**	**453,938**	**452,505**	**451,732**	**451,602**	**452,099**	**453,213**	**454,935**	**457,256**	**460,173**
of which:											
Cars & light comm. vehs.	335,619	333,368	331,605	330,313	329,476	**329,083**	329,123	329,586	330,465	331,754	333,450
Heavy vehicles (rigid and artic.)	123,242	122,680	122,333	**122,193**	122,256	122,518	122,976	123,628	124,470	125,502	126,723

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	83,431	82,992	82,677	82,478	82,390	82,408	82,528	82,745	83,055	83,454	83,940
Time costs	32,278	31,491	30,741	30,026	29,343	28,691	28,068	27,470	26,898	26,349	25,822
Crash costs	5,974	6,621	7,321	8,078	8,894	9,773	10,717	11,732	12,819	13,983	15,227
Air pollution costs	1,560	1,577	1,594	1,612	1,629	1,646	1,664	1,681	1,698	1,716	1,733
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**123,242**	**122,680**	**122,333**	**122,193**	**122,256**	**122,518**	**122,976**	**123,628**	**124,470**	**125,502**	**126,723**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	146,788	146,679	146,746	146,976	147,361	147,890	148,556	149,351	150,267	151,299	152,440
Time costs	160,545	156,630	152,900	149,345	145,950	142,707	139,605	136,634	133,788	131,057	128,436
Crash costs	16,504	18,146	19,916	21,818	23,860	26,050	28,395	30,902	33,580	36,438	39,482
Air pollution costs	11,782	11,913	12,043	12,174	12,305	12,436	12,567	12,698	12,829	12,960	13,091
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**335,619**	**333,368**	**331,605**	**330,313**	**329,476**	**329,083**	**329,123**	**329,586**	**330,465**	**331,754**	**333,450**

APPENDIX F:
CATEGORY 2 UNDIVIDED RURAL ROADS

Cat2UndividedFSHC.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 2 undivided rural roads with current 100 km/h speed limit

A1. Length of link 263 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	85	85	81	78	85	**84.3**	80	80	76	73	80	**79.3**
Average of all speeds on link	85	85	81	78	85	**84.3**	80	80	76	73	80	**79.3**
AADT*	1,433	298	206	163	615	**2,714**	1,433	298	206	163	615	**2,714**
Share of traffic	53%	11%	8%	6%	23%	100%	53%	11%	8%	6%	23%	100%
Business trips, %		100	93.5	100	48.5	**35**		100	93.5	100	48.5	**35**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**25**	35.7		6.5		25.7	**25**
Leisure trips, %	64.3				25.8	**40**	64.3				25.8	**40**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

Application of the MASTER framework

Ver. 01/99

Category 2 undivided rural roads with current 100 km/h speed limit

H. Net impacts

Cruise Speed (km/h)		
Cars and LCVs	**85**	**80**
Rigid heavy vehicles	**81**	**76**
Artic. heavy vehicles	**78**	**73**

Average speed on link (km/h)	Before	After
Cars and LCVs	**85.0**	**80.0**
Rigid heavy vehicles	**81.0**	**76.0**
Articulated heavy vehicles	**78.0**	**73.0**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		8,474	9,009	535	6.3 %
Number of Crashes per year		57.6	49.7	-8.0	-13.8%
Emissions, t/year	Carbon monoxide CO	525	505	-21	-4.0 %
	Hydrocarbons HC	92	88	-4.0	-4.3 %
	Oxides of nitrogen NOx	380	376	-4	-1.1 %
	Particles PM	7.5	7.2	-0.31	-4.1 %
	Carbon dioxide CO2	56897	55795	-1102	-1.9 %
Residents in area where $L_{Aeq,07-22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **4.4** Trucks: **4.9**

Saving p.a Fatal: **0.6** Serious Inj: **1.9** Other Inj: **5.5**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	102,715	103,557	842	0.8 %
Time costs	78,239	83,201	4962	6.3 %
Crash costs	12,214	9,859	-2,355	-19.3%
Air pollution costs	5,827	5,669	-158	-2.7 %
Noise costs	0	0	0	
Total	**198,995**	**202,286**		
Change			**3,291**	**1.7 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	102,634	102,371	102,242	102,239	102,356	102,587	102,924	103,363	103,900	104,528	105,246
Time costs	82,065	80,063	78,157	76,339	74,604	72,947	71,361	69,842	68,387	66,992	65,652
Crash costs	10,497	11,442	12,452	13,530	14,678	15,900	17,200	18,581	20,046	21,599	23,244
Air pollution costs	5,692	5,755	5,818	5,882	5,945	6,008	6,071	6,135	6,198	6,261	6,324
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**200,887**	**199,631**	**198,669**	**197,990**	**197,584**	**197,441**	**197,556**	**197,921**	**198,531**	**199,380**	**200,466**
of which:											
Cars & light comm. vehs.	141,040	140,097	139,350	138,791	138,412	138,209	**138,174**	138,305	138,596	139,045	139,648
Heavy vehicles (rigid and artic.)	59,847	59,535	59,320	59,200	**59,171**	59,233	59,382	59,616	59,934	60,335	60,818

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	41,349	41,132	40,975	40,877	40,833	40,842	40,902	41,009	41,163	41,361	41,602
Time costs	15,037	14,670	14,321	13,988	13,670	13,366	13,076	12,797	12,531	12,275	12,030
Crash costs	2,688	2,951	3,233	3,536	3,861	4,209	4,580	4,976	5,399	5,849	6,328
Air pollution costs	773	782	790	799	807	816	824	833	842	850	859
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**59,847**	**59,535**	**59,320**	**59,200**	**59,171**	**59,233**	**59,382**	**59,616**	**59,934**	**60,335**	**60,818**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	61,284	61,239	61,267	61,363	61,523	61,744	62,022	62,354	62,737	63,168	63,644
Time costs	67,028	65,393	63,836	62,352	60,935	59,580	58,285	57,045	55,857	54,717	53,622
Crash costs	7,809	8,491	9,219	9,993	10,817	11,692	12,620	13,604	14,647	15,750	16,916
Air pollution costs	4,919	4,973	5,028	5,083	5,138	5,192	5,247	5,302	5,356	5,411	5,466
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**141,040**	**140,097**	**139,350**	**138,791**	**138,412**	**138,209**	**138,174**	**138,305**	**138,596**	**139,045**	**139,648**

APPENDIX G: CATEGORY 2 UNDIVIDED RURAL ROADS – 'WILLINGNESS TO PAY' VALUATIONS OF ROAD TRAUMA

Cat2UndividedFSwtp.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 2 undivided rural roads with current 100 km/h speed limit. WTP valuation of crash costs

A1. Length of link 263 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	85	85	81	78	85	**84.3**	80	80	76	73	80	**79.3**
Average of all speeds on link	85	85	81	78	85	**84.3**	80	80	76	73	80	**79.3**
AADT*	1,433	298	206	163	615	**2,714**	1,433	298	206	163	615	**2,714**
Share of traffic	53%	11%	8%	6%	23%	100%	53%	11%	8%	6%	23%	100%
Business trips, %		100	93.5	100	48.5	**35**		100	93.5	100	48.5	**35**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**25**	35.7		6.5		25.7	**25**
Leisure trips, %	64.3				25.8	**40**	64.3				25.8	**40**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

Application of the MASTER framework

Ver. 01/99

Category 2 undivided rural roads with current 100 km/h speed limit. WTP valuation of crash costs

H. Net impacts

	Cruise Speed (km/h)	
Cars and LCVs	85	80
Rigid heavy vehicles	81	76
Artic. heavy vehicles	78	73

Average speed on link (km/h)	Before	After
Cars and LCVs	85.0	80.0
Rigid heavy vehicles	81.0	76.0
Artiulated. heavy vehicles	78.0	73.0

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		8,474	9,009	535	6.3 %
Number of Crashes per year		57.6	49.7	-8.0	-13.8%
Emissions, t/year	Carbon monoxide CO	525	505	-21	-4.0 %
	Hydrocarbons HC	92	88	-4.0	-4.3 %
	Oxides of nitrogen NOx	380	376	-4	-1.1 %
	Particles PM	7.5	7.2	-0.31	-4.1 %
	Carbon dioxide CO2	56897	55795	-1102	-1.9 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **4.4** Trucks: **4.9**

Saving p.a Fatal: **0.6** Serious Inj: **1.9** Other Inj: **5.5**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	102,715	103,557	842	0.8 %
Time costs	78,239	83,201	4962	6.3 %
Crash costs	25,365	20,284	-5,081	-20.0%
Air pollution costs	5,827	5,669	-158	-2.7 %
Noise costs	0	0	0	
Total	**212,145**	**212,710**		
Change			**565**	**0.3 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	102,634	102,371	102,242	102,239	102,356	102,587	102,924	103,363	103,900	104,528	105,246
Time costs	82,065	80,063	78,157	76,339	74,604	72,947	71,361	69,842	68,387	66,992	65,652
Crash costs	21,755	23,801	25,996	28,348	30,864	33,553	36,424	39,484	42,743	46,210	49,896
Air pollution costs	5,692	5,755	5,818	5,882	5,945	6,008	6,071	6,135	6,198	6,261	6,324
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**212,145**	**211,990**	**212,214**	**212,809**	**213,770**	**215,095**	**216,780**	**218,824**	**221,228**	**223,992**	**227,118**
of which:											
Cars & light comm. vehs.	149,049	**148,862**	148,927	149,240	149,795	150,592	151,626	152,898	154,406	156,151	158,134
Heavy vehicles (rigid and artic.)	**63,097**	63,128	63,286	63,569	63,975	64,503	65,154	65,926	66,822	67,840	68,983

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	41,349	41,132	40,975	40,877	40,833	40,842	40,902	41,009	41,163	41,361	41,602
Time costs	15,037	14,670	14,321	13,988	13,670	13,366	13,076	12,797	12,531	12,275	12,030
Crash costs	5,938	6,545	7,200	7,906	8,664	9,479	10,352	11,287	12,287	13,354	14,493
Air pollution costs	773	782	790	799	807	816	824	833	842	850	859
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**63,097**	**63,128**	**63,286**	**63,569**	**63,975**	**64,503**	**65,154**	**65,926**	**66,822**	**67,840**	**68,983**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	61,284	61,239	61,267	61,363	61,523	61,744	62,022	62,354	62,737	63,168	63,644
Time costs	67,028	65,393	63,836	62,352	60,935	59,580	58,285	57,045	55,857	54,717	53,622
Crash costs	15,817	17,256	18,796	20,442	22,200	24,075	26,072	28,197	30,456	32,856	35,402
Air pollution costs	4,919	4,973	5,028	5,083	5,138	5,192	5,247	5,302	5,356	5,411	5,466
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**149,049**	**148,862**	**148,927**	**149,240**	**149,795**	**150,592**	**151,626**	**152,898**	**154,406**	**156,151**	**158,134**

APPENDIX H:
CATEGORY 3 UNDIVIDED RURAL ROADS

Cat3UndividedFSHC.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 3 undivided rural roads with current 100 km/h speed limit

A1. Length of link 572 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	87	87	82	82	87	**86.7**	82	82	77	77	82	**81.7**
Average of all speeds on link	87	87	82	82	87	**86.7**	82	82	77	77	82	**81.7**
AADT*	1,145	238	108	28	492	**2,012**	1,145	238	108	28	492	**2,012**
Share of traffic	57%	12%	5%	1%	24%	100%	57%	12%	5%	1%	24%	100%
Business trips, %		100	93.5	100	48.5	**30**		100	93.5	100	48.5	**30**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**27**	35.7		6.5		25.7	**27**
Leisure trips, %	64.3				25.8	**43**	64.3				25.8	**43**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework

Ver. 01/99

Category 3 undivided rural roads with current 100 km/h speed limit

H. Net impacts

Cruise Speed (km/h)		
Cars and LCVs	**87**	**82**
Rigid heavy vehicles	**82**	**77**
Artic. heavy vehicles	**82**	**77**

Average speed on link (km/h)	Before	After
Cars and LCVs	**87.0**	**82.0**
Rigid heavy vehicles	**82.0**	**77.0**
Articulated heavy vehicles	**82.0**	**77.0**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		13,281	14,095	814	6.1 %
Number of Crashes per year		118.7	102.8	-15.9	-13.4%
Emissions, t/year	Carbon monoxide CO	863	830	-34	-3.9 %
	Hydrocarbons HC	151	145	-6.4	-4.2 %
	Oxides of nitrogen NOx	616	609	-7	-1.1 %
	Particles PM	12.3	11.8	-0.49	-4.0 %
	Carbon dioxide CO2	92572	90795	-1777	-1.9 %
Residents in area where $L_{Aeq,07-22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **4.2** Trucks: **4.8**

Saving p.a Fatal: **1.3** Serious Inj: **3.4** Other Inj: **11.2**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	139,977	140,172	195	0.1 %
Time costs	118,001	125,239	7238	6.1 %
Crash costs	24,301	19,715	-4,585	-18.9%
Air pollution costs	9,515	9,260	-255	-2.7 %
Noise costs	0	0	0	
Total	**291,794**	**294,386**		
Change			**2,593**	**0.9 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	139,890	139,635	139,557	139,645	139,889	140,281	140,812	141,476	142,265	143,174	144,196
Time costs	127,649	124,535	121,570	118,743	116,044	113,466	110,999	108,637	106,374	104,203	102,119
Crash costs	18,603	20,277	22,065	23,973	26,006	28,170	30,471	32,916	35,511	38,262	41,175
Air pollution costs	9,176	9,278	9,380	9,482	9,584	9,686	9,788	9,890	9,992	10,094	10,196
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**295,318**	**293,726**	**292,572**	**291,843**	**291,523**	**291,602**	**292,070**	**292,919**	**294,142**	**295,732**	**297,686**
of which:											
Cars & light comm. vehs.	247,842	246,452	245,421	244,737	244,387	**244,362**	244,654	245,257	246,163	247,369	248,870
Heavy vehicles (rigid and artic.)	47,475	47,273	47,151	**47,106**	47,137	47,240	47,416	47,663	47,979	48,363	48,816

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	33,330	33,155	33,028	32,949	32,914	32,921	32,969	33,056	33,180	33,339	33,533
Time costs	11,102	10,831	10,573	10,327	10,093	9,868	9,654	9,448	9,252	9,063	8,881
Crash costs	2,420	2,658	2,912	3,186	3,479	3,793	4,129	4,487	4,869	5,276	5,709
Air pollution costs	623	630	637	644	651	658	665	672	678	685	692
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**47,475**	**47,273**	**47,151**	**47,106**	**47,137**	**47,240**	**47,416**	**47,663**	**47,979**	**48,363**	**48,816**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	106,560	106,481	106,529	106,696	106,976	107,360	107,843	108,420	109,086	109,835	110,663
Time costs	116,547	113,704	110,997	108,416	105,952	103,597	101,345	99,189	97,122	95,140	93,238
Crash costs	16,183	17,619	19,152	20,787	22,526	24,377	26,343	28,429	30,642	32,985	35,466
Air pollution costs	8,553	8,648	8,743	8,838	8,933	9,028	9,123	9,218	9,313	9,408	9,503
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**247,842**	**246,452**	**245,421**	**244,737**	**244,387**	**244,362**	**244,654**	**245,257**	**246,163**	**247,369**	**248,870**

APPENDIX I: CATEGORY 3 UNDIVIDED RURAL ROADS – 'WILLINGNESS TO PAY' VALUATIONS OF ROAD TRAUMA

Cat3UndividedFSwtp.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 3 undivided rural roads with current 100 km/h speed limit. WTP valuation of crash costs

A1. Length of link 572 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	87	87	82	82	87	**86.7**	82	82	77	77	82	**81.7**
Average of all speeds on link	87	87	82	82	87	**86.7**	82	82	77	77	82	**81.7**
AADT*	1,145	238	108	28	492	**2,012**	1,145	238	108	28	492	**2,012**
Share of traffic	57%	12%	5%	1%	24%	100%	57%	12%	5%	1%	24%	100%
Business trips, %		100	93.5	100	48.5	**30**		100	93.5	100	48.5	**30**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**27**	35.7		6.5		25.7	**27**
Leisure trips, %	64.3				25.8	**43**	64.3				25.8	**43**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework

Ver. 01/99

Category 3 undivided rural roads with current 100 km/h speed limit. WTP valuation of crash costs

H. Net impacts

	Cruise Speed (km/h)	
Cars and LCVs	**87**	**82**
Rigid heavy vehicles	**82**	**77**
Artic. heavy vehicles	**82**	**77**

Average speed on link (km/h)	Before	After
Cars and LCVs	**87.0**	**82.0**
Rigid heavy vehicles	**82.0**	**77.0**
Articulated heavy vehicles	**82.0**	**77.0**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		13,281	14,095	814	6.1 %
Number of Crashes per year		118.7	102.8	-15.9	-13.4%
Emissions, t/year	Carbon monoxide CO	863	830	-34	-3.9 %
	Hydrocarbons HC	151	145	-6.4	-4.2 %
	Oxides of nitrogen NOx	616	609	-7	-1.1 %
	Particles PM	12.3	11.8	-0.49	-4.0 %
	Carbon dioxide CO2	92572	90795	-1777	-1.9 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **4.2** Trucks: **4.8**

Saving p.a Fatal: **1.3** Serious Inj: **3.4** Other Inj: **11.2**

H2. Monetary impacts

k$/year	Before	After	Change	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	139,977	140,172	195	0.1 %
Time costs	118,001	125,239	7238	6.1 %
Crash costs	51,691	41,606	-10,085	-19.5%
Air pollution costs	9,515	9,260	-255	-2.7 %
Noise costs	0	0	0	
Total	**319,184**	**316,277**		
Change			**-2,907**	**-0.9 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	139,890	139,635	139,557	139,645	139,889	140,281	140,812	141,476	142,265	143,174	144,196
Time costs	127,649	124,535	121,570	118,743	116,044	113,466	110,999	108,637	106,374	104,203	102,119
Crash costs	39,246	42,912	46,844	51,054	55,557	60,369	65,502	70,975	76,801	82,998	89,583
Air pollution costs	9,176	9,278	9,380	9,482	9,584	9,686	9,788	9,890	9,992	10,094	10,196
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**315,960**	**316,361**	**317,351**	**318,924**	**321,075**	**323,801**	**327,101**	**330,978**	**335,432**	**340,469**	**346,094**
of which:											
Cars & light comm. vehs.	**265,492**	265,779	266,550	267,799	269,522	271,717	274,382	277,520	281,130	285,218	289,787
Heavy vehicles (rigid and artic.)	50,468	50,582	50,801	51,125	51,553	52,084	52,719	53,458	54,302	55,251	56,308

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	33,330	33,155	33,028	32,949	32,914	32,921	32,969	33,056	33,180	33,339	33,533
Time costs	11,102	10,831	10,573	10,327	10,093	9,868	9,654	9,448	9,252	9,063	8,881
Crash costs	5,413	5,967	6,563	7,205	7,896	8,637	9,432	10,283	11,192	12,164	13,200
Air pollution costs	623	630	637	644	651	658	665	672	678	685	692
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**50,468**	**50,582**	**50,801**	**51,125**	**51,553**	**52,084**	**52,719**	**53,458**	**54,302**	**55,251**	**56,308**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	106,560	106,481	106,529	106,696	106,976	107,360	107,843	108,420	109,086	109,835	110,663
Time costs	116,547	113,704	110,997	108,416	105,952	103,597	101,345	99,189	97,122	95,140	93,238
Crash costs	33,832	36,946	40,281	43,849	47,662	51,732	56,071	60,692	65,609	70,834	76,383
Air pollution costs	8,553	8,648	8,743	8,838	8,933	9,028	9,123	9,218	9,313	9,408	9,503
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**265,492**	**265,779**	**266,550**	**267,799**	**269,522**	**271,717**	**274,382**	**277,520**	**281,130**	**285,218**	**289,787**

APPENDIX J:
CATEGORY 4 UNDIVIDED RURAL ROADS

Cat4UndividedFSHC.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 4 undivided rural roads with current 100 km/h speed limit.

A1. Length of link 825 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	91	91	85	75	91	**90.2**	86	86	80	70	86	**85.2**
Average of all speeds on link	91	91	85	75	91	**90.2**	86	86	80	70	86	**85.2**
AADT*	759	158	66	41	326	**1,349**	759	158	66	41	326	**1,349**
Share of traffic	56%	12%	5%	3%	24%	100%	56%	12%	5%	3%	24%	100%
Business trips, %		100	93.5	100	48.5	**31**		100	93.5	100	48.5	**31**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**27**	35.7		6.5		25.7	**27**
Leisure trips, %	64.3				25.8	**42**	64.3				25.8	**42**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework Ver. 01/99

Category 4 undivided rural roads with current 100 km/h speed limit.

H. Net impacts

	Cruise Speed (km/h)	
Cars and LCVs	**91**	**86**
Rigid heavy vehicles	**85**	**80**
Artic. heavy vehicles	**75**	**70**

Average speed on link (km/h)	Before	After
Cars and LCVs	**91.0**	**86.0**
Rigid heavy vehicles	**85.0**	**80.0**
Articulated heavy vehicles	**75.0**	**70.0**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		12,352	13,079	727	5.9 %
Number of Crashes per year		123.5	107.6	-15.8	-12.8%
Emissions, t/year	Carbon monoxide CO	858	826	-32	-3.8 %
	Hydrocarbons HC	150	144	-6.2	-4.1 %
	Oxides of nitrogen NOx	601	594	-7	-1.1 %
	Particles PM	12.2	11.8	-0.48	-3.9 %
	Carbon dioxide CO2	90762	89043	-1719	-1.9 %
Residents in area where $L_{Aeq,07-22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **3.8** Trucks: **4.4**

Saving p.a Fatal: **0.9** Serious Inj: **3.8** Other Inj: **11.1**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	140,523	140,363	-159	-0.1 %
Time costs	111,285	117,873	6588	5.9 %
Crash costs	22,552	18,631	-3,921	-17.4%
Air pollution costs	9,379	9,133	-247	-2.6 %
Noise costs	0	0	0	
Total	**283,739**	**286,000**		
Change			**2,261**	**0.8 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	139,493	139,219	139,123	139,192	139,419	139,795	140,311	140,960	141,736	142,632	143,643
Time costs	124,746	121,704	118,806	116,043	113,406	110,886	108,475	106,167	103,955	101,834	99,797
Crash costs	15,781	17,120	18,545	20,058	21,663	23,364	25,166	27,072	29,087	31,214	33,460
Air pollution costs	8,875	8,974	9,072	9,171	9,270	9,368	9,467	9,566	9,664	9,763	9,861
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**288,895**	**287,017**	**285,546**	**284,464**	**283,758**	**283,413**	**283,419**	**283,765**	**284,442**	**285,443**	**286,761**
of which:											
Cars & light comm. vehs.	234,316	232,694	231,389	230,388	229,676	229,244	**229,083**	229,182	229,536	230,137	230,980
Heavy vehicles (rigid and artic.)	54,580	54,323	54,157	**54,077**	54,082	54,169	54,336	54,582	54,906	55,305	55,780

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	37,697	37,499	37,356	37,267	37,227	37,235	37,289	37,387	37,527	37,708	37,927
Time costs	13,410	13,083	12,772	12,475	12,191	11,920	11,661	11,413	11,175	10,947	10,728
Crash costs	2,767	3,028	3,308	3,608	3,928	4,270	4,634	5,023	5,436	5,875	6,342
Air pollution costs	705	713	720	728	736	744	752	760	767	775	783
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**54,580**	**54,323**	**54,157**	**54,077**	**54,082**	**54,169**	**54,336**	**54,582**	**54,906**	**55,305**	**55,780**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	101,796	101,720	101,766	101,926	102,193	102,560	103,022	103,573	104,208	104,924	105,715
Time costs	111,336	108,621	106,034	103,568	101,215	98,965	96,814	94,754	92,780	90,887	89,069
Crash costs	13,013	14,092	15,237	16,450	17,735	19,095	20,532	22,049	23,651	25,339	27,118
Air pollution costs	8,170	8,261	8,352	8,443	8,534	8,624	8,715	8,806	8,897	8,988	9,078
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**234,316**	**232,694**	**231,389**	**230,388**	**229,676**	**229,244**	**229,083**	**229,182**	**229,536**	**230,137**	**230,980**

APPENDIX K:
CATEGORY 4 UNDIVIDED RURAL ROADS – ‘WILLINGNESS TO PAY’ VALUATIONS OF ROAD TRAUMA

Cat4UndividedFSwtp.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 4 undivided rural roads with current 100 km/h speed limit. WTP valuation of crash costs

A1. Length of link 825 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	91	91	85	75	91	**90.2**	86	86	80	70	86	**85.2**
Average of all speeds on link	91	91	85	75	91	**90.2**	86	86	80	70	86	**85.2**
AADT*	759	158	66	41	326	**1,349**	759	158	66	41	326	**1,349**
Share of traffic	56%	12%	5%	3%	24%	100%	56%	12%	5%	3%	24%	100%
Business trips, %		100	93.5	100	48.5	**31**		100	93.5	100	48.5	**31**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**27**	35.7		6.5		25.7	**27**
Leisure trips, %	64.3				25.8	**42**	64.3				25.8	**42**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework

Ver. 01/99

Category 4 undivided rural roads with current 100 km/h speed limit. WTP valuation of crash costs

H. Net impacts

Cruise Speed (km/h)		
Cars and LCVs	**91**	**86**
Rigid heavy vehicles	**85**	**80**
Artic. heavy vehicles	**75**	**70**

Average speed on link (km/h)	Before	After
Cars and LCVs	**91.0**	**86.0**
Rigid heavy vehicles	**85.0**	**80.0**
Articulated heavy vehicles	**75.0**	**70.0**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		12,352	13,079	727	5.9 %
Number of Crashes per year		123.5	107.6	-15.8	-12.8%
Emissions, t/year	Carbon monoxide CO	858	826	-32	-3.8 %
	Hydrocarbons HC	150	144	-6.2	-4.1 %
	Oxides of nitrogen NOx	601	594	-7	-1.1 %
	Particles PM	12.2	11.8	-0.48	-3.9 %
	Carbon dioxide CO2	90762	89043	-1719	-1.9 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **3.8** Trucks: **4.4**

Saving p.a Fatal: **0.9** Serious Inj: **3.8** Other Inj: **11.1**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	140,523	140,363	-159	-0.1 %
Time costs	111,285	117,873	6588	5.9 %
Crash costs	44,450	36,436	-8,014	-18.0%
Air pollution costs	9,379	9,133	-247	-2.6 %
Noise costs	0	0	0	
Total	**305,637**	**303,806**		
Change			**-1,831**	**-0.6 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	139,493	139,219	139,123	139,192	139,419	139,795	140,311	140,960	141,736	142,632	143,643
Time costs	124,746	121,704	118,806	116,043	113,406	110,886	108,475	106,167	103,955	101,834	99,797
Crash costs	30,905	33,630	36,540	39,643	42,950	46,469	50,211	54,186	58,404	62,876	67,613
Air pollution costs	8,875	8,974	9,072	9,171	9,270	9,368	9,467	9,566	9,664	9,763	9,861
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**304,020**	**303,527**	**303,541**	**304,050**	**305,045**	**306,518**	**308,464**	**310,878**	**313,759**	**317,104**	**320,915**
of which:											
Cars & light comm. vehs.	246,348	245,791	**245,624**	245,839	246,427	247,381	248,695	250,365	252,390	254,765	257,492
Heavy vehicles (rigid and artic.)	**57,672**	57,736	57,916	58,210	58,617	59,137	59,769	60,513	61,369	62,339	63,423

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	37,697	37,499	37,356	37,267	37,227	37,235	37,289	37,387	37,527	37,708	37,927
Time costs	13,410	13,083	12,772	12,475	12,191	11,920	11,661	11,413	11,175	10,947	10,728
Crash costs	5,859	6,441	7,068	7,741	8,463	9,238	10,067	10,953	11,900	12,909	13,984
Air pollution costs	705	713	720	728	736	744	752	760	767	775	783
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**57,672**	**57,736**	**57,916**	**58,210**	**58,617**	**59,137**	**59,769**	**60,513**	**61,369**	**62,339**	**63,423**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	101,796	101,720	101,766	101,926	102,193	102,560	103,022	103,573	104,208	104,924	105,715
Time costs	111,336	108,621	106,034	103,568	101,215	98,965	96,814	94,754	92,780	90,887	89,069
Crash costs	25,046	27,189	29,472	31,902	34,486	37,231	40,144	43,232	46,504	49,967	53,629
Air pollution costs	8,170	8,261	8,352	8,443	8,534	8,624	8,715	8,806	8,897	8,988	9,078
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**246,348**	**245,791**	**245,624**	**245,839**	**246,427**	**247,381**	**248,695**	**250,365**	**252,390**	**254,765**	**257,492**

APPENDIX L:
CATEGORY 5 UNDIVIDED RURAL ROADS

Cat5UndividedFSHC.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 5 undivided rural roads with current 100 km/h speed limit (includes gravel roads)

A1. Length of link 1037 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	84	84	76	82	84	**83.4**	79	79	71	77	79	**78.4**
Average of all speeds on link	84	84	76	82	84	**83.4**	79	79	71	77	79	**78.4**
AADT*	398	83	55	7	171	**712**	398	83	55	7	171	**712**
Share of traffic	56%	12%	8%	1%	24%	100%	56%	12%	8%	1%	24%	100%
Business trips, %		100	93.5	100	48.5	**31**		100	93.5	100	48.5	**31**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**27**	35.7		6.5		25.7	**27**
Leisure trips, %	64.3				25.8	**42**	64.3				25.8	**42**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework

Ver. 01/99

Category 5 undivided rural roads with current 100 km/h speed limit (includes gravel roads)

H. Net impacts

Cruise Speed (km/h)		
Cars and LCVs	**84**	**79**
Rigid heavy vehicles	**76**	**71**
Artic. heavy vehicles	**82**	**77**

Average speed on link (km/h)	Before	After
Cars and LCVs	**84.0**	**79.0**
Rigid heavy vehicles	**76.0**	**71.0**
Articulated heavy vehicles	**82.0**	**77.0**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		8,869	9,436	567	6.4 %
Number of Crashes per year		85.9	74.0	-11.9	-13.8%
Emissions, t/year	Carbon monoxide CO	540	518	-22	-4.0 %
	Hydrocarbons HC	94	90	-4.1	-4.4 %
	Oxides of nitrogen NOx	393	388	-4	-1.1 %
	Particles PM	7.7	7.4	-0.32	-4.1 %
	Carbon dioxide CO2	58687	57546	-1141	-1.9 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **4.5** Trucks: **5.6**

Saving p.a Fatal: **0.7** Serious Inj: **2.8** Other Inj: **8.4**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	94,676	95,506	829	0.9 %
Time costs	78,951	84,006	5055	6.4 %
Crash costs	15,942	12,944	-2,998	-18.8%
Air pollution costs	6,002	5,838	-164	-2.7 %
Noise costs	0	0	0	
Total	**195,571**	**198,294**		
Change			**2,722**	**1.4 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	94,342	94,149	94,076	94,116	94,263	94,511	94,854	95,288	95,808	96,410	97,090
Time costs	82,086	80,083	78,177	76,359	74,623	72,965	71,379	69,860	68,405	67,009	65,668
Crash costs	14,196	15,427	16,739	18,134	19,617	21,191	22,860	24,629	26,501	28,482	30,574
Air pollution costs	5,892	5,957	6,023	6,088	6,154	6,219	6,284	6,350	6,415	6,481	6,546
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**196,515**	**195,616**	**195,014**	**194,696**	**194,656**	**194,885**	**195,377**	**196,127**	**197,129**	**198,381**	**199,879**
of which:											
Cars & light comm. vehs.	157,592	156,821	156,280	155,960	**155,853**	155,955	156,259	156,762	157,459	158,347	159,424
Heavy vehicles (rigid and artic.)	38,923	38,795	**38,734**	38,737	38,803	38,930	39,118	39,365	39,671	40,034	40,455

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	27,294	27,151	27,047	26,982	26,954	26,960	26,999	27,070	27,171	27,302	27,461
Time costs	8,754	8,541	8,337	8,143	7,958	7,782	7,612	7,450	7,295	7,146	7,003
Crash costs	2,365	2,588	2,827	3,084	3,358	3,650	3,962	4,295	4,649	5,025	5,424
Air pollution costs	510	516	522	527	533	539	544	550	556	561	567
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**38,923**	**38,795**	**38,734**	**38,737**	**38,803**	**38,930**	**39,118**	**39,365**	**39,671**	**40,034**	**40,455**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	67,048	66,998	67,028	67,133	67,309	67,551	67,855	68,218	68,637	69,108	69,629
Time costs	73,331	71,543	69,839	68,215	66,665	65,183	63,766	62,410	61,109	59,862	58,665
Crash costs	11,831	12,839	13,911	15,050	16,259	17,540	18,898	20,334	21,853	23,457	25,150
Air pollution costs	5,381	5,441	5,501	5,561	5,621	5,680	5,740	5,800	5,860	5,920	5,980
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**157,592**	**156,821**	**156,280**	**155,960**	**155,853**	**155,955**	**156,259**	**156,762**	**157,459**	**158,347**	**159,424**

APPENDIX M: CATEGORY 5 UNDIVIDED RURAL ROADS – 'WILLINGNESS TO PAY' VALUATIONS OF ROAD TRAUMA

Cat5UndividedFSwtp.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 5 undivided rural roads with current 100 km/h speed limit (includes gravel roads). WTP valuation of crash costs

A1. Length of link 1037 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	84	84	76	82	84	**83.4**	79	79	71	77	79	**78.4**
Average of all speeds on link	84	84	76	82	84	**83.4**	79	79	71	77	79	**78.4**
AADT*	398	83	55	7	171	**712**	398	83	55	7	171	**712**
Share of traffic	56%	12%	8%	1%	24%	100%	56%	12%	8%	1%	24%	100%
Business trips, %		100	93.5	100	48.5	**31**		100	93.5	100	48.5	**31**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**27**	35.7		6.5		25.7	**27**
Leisure trips, %	64.3				25.8	**42**	64.3				25.8	**42**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

Category 5 undivided rural roads with current 100 km/h speed limit (includes gravel roads). WTP valuation of crash costs

H. Net impacts

	Cruise Speed (km/h)	
Cars and LCVs	**84**	**79**
Rigid heavy vehicles	**76**	**71**
Artic. heavy vehicles	**82**	**77**

Average speed on link (km/h)	Before	After
Cars and LCVs	**84.0**	**79.0**
Rigid heavy vehicles	**76.0**	**71.0**
Articulated heavy vehicles	**82.0**	**77.0**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		8,869	9,436	567	6.4 %
Number of Crashes per year		85.9	74.0	-11.9	-13.8%
Emissions, t/year	Carbon monoxide CO	540	518	-22	-4.0 %
	Hydrocarbons HC	94	90	-4.1	-4.4 %
	Oxides of nitrogen NOx	393	388	-4	-1.1 %
	Particles PM	7.7	7.4	-0.32	-4.1 %
	Carbon dioxide CO2	58687	57546	-1141	-1.9 %
Residents in area where $L_{Aeq,07-22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **4.5** Trucks: **5.6**

Saving p.a Fatal: **0.7** Serious Inj: **2.8** Other Inj: **8.4**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	94,676	95,506	829	0.9 %
Time costs	78,951	84,006	5055	6.4 %
Crash costs	31,860	25,654	-6,207	-19.5%
Air pollution costs	6,002	5,838	-164	-2.7 %
Noise costs	0	0	0	
Total	**211,490**	**211,003**		
Change			**-486**	**-0.2 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	94,342	94,149	94,076	94,116	94,263	94,511	94,854	95,288	95,808	96,410	97,090
Time costs	82,086	80,083	78,177	76,359	74,623	72,965	71,379	69,860	68,405	67,009	65,668
Crash costs	28,334	30,895	33,635	36,562	39,685	43,016	46,562	50,334	54,343	58,599	63,114
Air pollution costs	5,892	5,957	6,023	6,088	6,154	6,219	6,284	6,350	6,415	6,481	6,546
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**210,653**	**211,084**	**211,909**	**213,124**	**214,725**	**216,710**	**219,079**	**221,832**	**224,971**	**228,499**	**232,419**
of which:											
Cars & light comm. vehs.	**169,070**	169,353	169,942	170,833	172,022	173,507	175,289	177,367	179,743	182,417	185,393
Heavy vehicles (rigid and artic.)	41,583	41,731	41,967	42,292	42,703	43,203	43,790	44,465	45,228	46,082	47,026

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	27,294	27,151	27,047	26,982	26,954	26,960	26,999	27,070	27,171	27,302	27,461
Time costs	8,754	8,541	8,337	8,143	7,958	7,782	7,612	7,450	7,295	7,146	7,003
Crash costs	5,025	5,524	6,061	6,639	7,258	7,923	8,634	9,395	10,207	11,073	11,995
Air pollution costs	510	516	522	527	533	539	544	550	556	561	567
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**41,583**	**41,731**	**41,967**	**42,292**	**42,703**	**43,203**	**43,790**	**44,465**	**45,228**	**46,082**	**47,026**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	67,048	66,998	67,028	67,133	67,309	67,551	67,855	68,218	68,637	69,108	69,629
Time costs	73,331	71,543	69,839	68,215	66,665	65,183	63,766	62,410	61,109	59,862	58,665
Crash costs	23,309	25,371	27,574	29,923	32,427	35,093	37,928	40,940	44,137	47,527	51,119
Air pollution costs	5,381	5,441	5,501	5,561	5,621	5,680	5,740	5,800	5,860	5,920	5,980
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**169,070**	**169,353**	**169,942**	**170,833**	**172,022**	**173,507**	**175,289**	**177,367**	**179,743**	**182,417**	**185,393**

APPENDIX N:
CATEGORY 5 UNSEALED RURAL ROADS

Cat5UnsealedFSHC.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 5 unsealed rural roads with current 100 km/h speed limit

A1. Length of link 206 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	85	85	80	80	85	**84.4**	80	80	75	75	80	**79.4**
Average of all speeds on link	85	85	80	80	85	**84.4**	80	80	75	75	80	**79.4**
AADT*	76	16	14	2	33	**140**	76	16	14	2	33	**140**
Share of traffic	54%	11%	10%	1%	23%	100%	54%	11%	10%	1%	23%	100%
Business trips, %		100	93.5	100	48.5	**33**		100	93.5	100	48.5	**33**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**26**	35.7		6.5		25.7	**26**
Leisure trips, %	64.3				25.8	**41**	64.3				25.8	**41**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework

Ver. 01/99

Category 5 unsealed rural roads with current 100 km/h speed limit

H. Net impacts

	Cruise Speed (km/h)	
	Before	After
Cars and LCVs	**85**	**80**
Rigid heavy vehicles	**80**	**75**
Artic. heavy vehicles	**80**	**75**

Average speed on link (km/h)	Before	After
Cars and LCVs	**85.0**	**80.0**
Rigid heavy vehicles	**80.0**	**75.0**
Articulated heavy vehicles	**80.0**	**75.0**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		343	364	22	6.3 %
Number of Crashes per year		3.7	3.2	-0.5	-14.1%
Emissions, t/year	Carbon monoxide CO	21	20	-1	-4.0 %
	Hydrocarbons HC	4	4	-0.2	-4.3 %
	Oxides of nitrogen NOx	15	15	0	-1.1 %
	Particles PM	0.3	0.3	-0.01	-4.1 %
	Carbon dioxide CO2	2308	2263	-45	-1.9 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **4.4** Trucks: **5.0**

Saving p.a Fatal: **0.05** Serious Inj: **0.16** Other Inj: **0.31**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	3,918	3,944	26	0.7 %
Time costs	3,069	3,263	194	6.3 %
Crash costs	977	790	-187	-19.1%
Air pollution costs	236	230	-6	-2.7 %
Noise costs	0	0	0	
Total	**8,200**	**8,227**		
Change			**27**	**0.3 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	3,917	3,908	3,904	3,905	3,910	3,920	3,933	3,951	3,972	3,996	4,024
Time costs	3,234	3,155	3,080	3,008	2,940	2,874	2,812	2,752	2,695	2,640	2,587
Crash costs	824	898	976	1,060	1,149	1,244	1,345	1,452	1,565	1,685	1,812
Air pollution costs	231	233	236	238	241	244	246	249	251	254	256
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**8,206**	**8,194**	**8,196**	**8,211**	**8,240**	**8,282**	**8,336**	**8,403**	**8,483**	**8,575**	**8,680**
of which:											
Cars & light comm. vehs.	6,225	**6,215**	6,215	6,225	6,245	6,275	6,313	6,362	6,419	6,485	6,561
Heavy vehicles (rigid and artic.)	1,981	**1,979**	1,981	1,986	1,995	2,007	2,023	2,042	2,064	2,090	2,119

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	1,359	1,352	1,347	1,343	1,342	1,342	1,344	1,348	1,353	1,359	1,367
Time costs	436	425	415	405	396	387	379	371	363	356	349
Crash costs	161	177	193	211	230	250	272	295	320	347	374
Air pollution costs	25	26	26	26	27	27	27	27	28	28	28
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**1,981**	**1,979**	**1,981**	**1,986**	**1,995**	**2,007**	**2,023**	**2,042**	**2,064**	**2,090**	**2,119**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	2,558	2,556	2,557	2,561	2,568	2,577	2,589	2,603	2,619	2,637	2,657
Time costs	2,798	2,730	2,665	2,603	2,544	2,487	2,433	2,381	2,332	2,284	2,238
Crash costs	663	721	783	849	919	994	1,073	1,156	1,245	1,339	1,438
Air pollution costs	205	208	210	212	214	217	219	221	224	226	228
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**6,225**	**6,215**	**6,215**	**6,225**	**6,245**	**6,275**	**6,313**	**6,362**	**6,419**	**6,485**	**6,561**

APPENDIX O: CATEGORY 5 UNSEALED RURAL ROADS – 'WILLINGNESS TO PAY' VALUATIONS OF ROAD TRAUMA

Cat5UnsealedFSwtp.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 5 unsealed rural roads with current 100 km/h speed limit. WTP valuation of crash costs

A1. Length of link 206 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	85	85	80	80	85	**84.4**	80	80	75	75	80	**79.4**
Average of all speeds on link	85	85	80	80	85	**84.4**	80	80	75	75	80	**79.4**
AADT*	76	16	14	2	33	**140**	76	16	14	2	33	**140**
Share of traffic	54%	11%	10%	1%	23%	100%	54%	11%	10%	1%	23%	100%
Business trips, %		100	93.5	100	48.5	**33**		100	93.5	100	48.5	**33**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**26**	35.7		6.5		25.7	**26**
Leisure trips, %	64.3				25.8	**41**	64.3				25.8	**41**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

Application of the MASTER framework

Ver. 01/99

Category 5 unsealed rural roads with current 100 km/h speed limit. WTP valuation of crash costs

H. Net impacts

	Cruise Speed (km/h)	
Cars and LCVs	**85**	**80**
Rigid heavy vehicles	**80**	**75**
Artic. heavy vehicles	**80**	**75**

Average speed on link (km/h)	Before	After
Cars and LCVs	**85.0**	**80.0**
Rigid heavy vehicles	**80.0**	**75.0**
Articulated heavy vehicles	**80.0**	**75.0**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		343	364	22	6.3 %
Number of Crashes per year		3.7	3.2	-0.5	-14.1%
Emissions, t/year	Carbon monoxide CO	21	20	-1	-4.0 %
	Hydrocarbons HC	4	4	-0.2	-4.3 %
	Oxides of nitrogen NOx	15	15	0	-1.1 %
	Particles PM	0.3	0.3	-0.01	-4.1 %
	Carbon dioxide CO2	2308	2263	-45	-1.9 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **4.4** Trucks: **5.0**

Saving p.a Fatal: **0.05** Serious Inj: **0.16** Other Inj: **0.31**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	3,918	3,944	26	0.7 %
Time costs	3,069	3,263	194	6.3 %
Crash costs	1,917	1,531	-386	-20.1%
Air pollution costs	236	230	-6	-2.7 %
Noise costs	0	0	0	
Total	**9,140**	**8,968**		
Change			**-172**	**-1.9 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	3,917	3,908	3,904	3,905	3,910	3,920	3,933	3,951	3,972	3,996	4,024
Time costs	3,234	3,155	3,080	3,008	2,940	2,874	2,812	2,752	2,695	2,640	2,587
Crash costs	1,606	1,759	1,922	2,097	2,285	2,485	2,699	2,927	3,170	3,428	3,703
Air pollution costs	231	233	236	238	241	244	246	249	251	254	256
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**8,988**	**9,055**	**9,142**	**9,248**	**9,375**	**9,522**	**9,690**	**9,878**	**10,087**	**10,318**	**10,570**
of which:											
Cars & light comm. vehs.	6,829	6,879	6,944	7,023	7,117	7,226	7,350	7,489	7,644	7,815	8,001
Heavy vehicles (rigid and artic.)	2,159	2,176	2,198	2,226	2,258	2,296	2,340	2,389	2,443	2,503	2,569

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	1,359	1,352	1,347	1,343	1,342	1,342	1,344	1,348	1,353	1,359	1,367
Time costs	436	425	415	405	396	387	379	371	363	356	349
Crash costs	339	373	410	451	494	540	590	643	700	760	825
Air pollution costs	25	26	26	26	27	27	27	27	28	28	28
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**2,159**	**2,176**	**2,198**	**2,226**	**2,258**	**2,296**	**2,340**	**2,389**	**2,443**	**2,503**	**2,569**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	2,558	2,556	2,557	2,561	2,568	2,577	2,589	2,603	2,619	2,637	2,657
Time costs	2,798	2,730	2,665	2,603	2,544	2,487	2,433	2,381	2,332	2,284	2,238
Crash costs	1,268	1,385	1,512	1,647	1,791	1,945	2,109	2,284	2,470	2,668	2,878
Air pollution costs	205	208	210	212	214	217	219	221	224	226	228
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**6,829**	**6,879**	**6,944**	**7,023**	**7,117**	**7,226**	**7,350**	**7,489**	**7,644**	**7,815**	**8,001**

APPENDIX P:
CATEGORY 1 UNDIVIDED RURAL ROADS 110 KM/H – CURVY ROADS WITH CROSSROADS & TOWNS

Cat1UndividedCCTHC.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 1 undivided rural roads with current 110 km/h speed limit - curvy road with crossroads and towns
[50 sharp bends, 14 cross roads, and 3 intersections requiring stopping (usually in towns) per 100 kilometres]

A1. Length of link 263 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	105	105	100	99	105	**104.3**	100	100	95	94	100	**99.3**
Average of all speeds on link	**100.65**	**100.65**	**96.82**	**96.02**	**100.65**		**96.82**	**96.82**	**92.76**	**91.92**	**96.82**	
AADT*	3,792	788	313	509	1628	**7,030**	3,792	788	313	509	1628	**7,030**
Share of traffic	54%	11%	4%	7%	23%	100%	54%	11%	4%	7%	23%	100%
Business trips, %		100	93.5	100	48.5	**34**		100	93.5	100	48.5	**34**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**25**	35.7		6.5		25.7	**25**
Leisure trips, %	64.3				25.8	**41**	64.3				25.8	**41**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

Category 1 undivided rural roads with current 110 km/h speed limit - curvy road with crossroads and towns

2. Measurement of impacts

I

D. Impact functions

D1. Vehicle operating costs

Freeway Model for operations of free-running traffic in Table 3.10 of AGPE04/08; June 2007 prices

D2. Travel time

Function: travel time = link length/speed of traffic flow (flat straight roads only; see adjustment factors for curvy roads with cross roads and towns)

D3a. Accidents

Injury accidents before = n_{IB} Average speed before = v_B

Injury accidents after = n_{IA} Average speed after = v_A

		Exponent	Value	
Fatal accidents	$n_{IA} = (v_A/v_B)F * n_{IB}$	**F**	**4.36**	Rural highway exponent estimates
Serious injury accidents	$n_{IA} = (v_A/v_B)S * n_{IB}$	**S**	**2.78**	from Cameron and Elvik (2008), Table 6
Other injury accidents	$n_{IA} = (v_A/v_B)O * n_{IB}$	**O**	**2.22**	

D4. Air pollutant emission coefficients

*Emission factors**	**At initial speed, g/km**						**At final speed, g/km**					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average
Carbon monoxide CO	4.95	4.95	4.78	4.75	4.95	4.93	3.68	3.68	3.55	3.53	3.68	3.67
Hydrocarbons HC	0.77	0.77	0.74	0.74	0.77	0.77	0.60	0.60	0.58	0.57	0.60	0.60
Oxides of nitrogen NO_x	3.38	3.38	3.35	3.34	3.38	3.38	2.53	2.53	2.50	2.50	2.53	2.52
Particles PM	0.05	0.05	0.05	0.05	0.05	0.051	0.04	0.04	0.04	0.04	0.04	0.042
Carbon dioxide CO_2	357.9	357.9	351.5	350.2	357.9	357.0	303.9	303.9	298.4	297.3	303.9	303.2

Emission coefficients not available by vehicle type, only for mix of traffic close to mix outlined here
Same coefficient assumed for all vehicles at given speed for each pollutant

D5. Noise pollution

No impact function available; noise pollution assumed small because of negligible human population living in vicinity of rural roads considered

E. Unit prices

E1. Vehicle operating costs

	Petrol	Diesel	
Fuel price, $ per litre	0.8804	0.8639	Resource prices in Table 2.4 of AGPE04/08 for Hobart, June 2007

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Average**
Vehicle oper. costs*	0.301	0.301	1.323	1.407	0.530	**0.479**	0.270	0.270	1.247	1.298	0.479	**0.436**
*With A	-9.99	-9.99	-15.27	-6.53	-20.16		-12.61	-12.61	-21.37	-16.12	-24.30	
B	1553.78	1553.78	8544.38	8544.38	3396.74		1553.78	1553.78	8544.38	8544.4	3396.7	
C	0.23531	0.23531	0.0185	0.0185	0.25629		0.23531	0.23531	0.0185	0.0185	0.2563	
D	5E-05	5E-05	0.00603	0.00603	0.00126		5E-05	5E-05	0.00603	0.006	0.0013	
Base A	-16.262	-16.262	-30	-30	-30		-16.262	-16.262	-30	-30	-30	
Fuel A	-18.433	-18.433	-65.056	-80	-27.456		-18.433	-18.433	-65.056	-80	-27.46	
Fuel B	1306.02	1306.02	4156.75	6342.8	2060.5		1306.02	1306.02	4156.75	6342.8	2060.5	
Fuel C	0.15477	0.15477	0.49681	0.48496	0.1911		0.15477	0.15477	0.49681	0.485	0.1911	
Fuel D	0.00032	0.00032	0.00068	0.00209	0.00085		0.00032	0.00032	0.00068	0.0021	0.0009	
Fuel consumption rate (lt/100km)	13.79	13.79	32.99	52.56	21.62		13.31	13.31	32.03	51.53	20.77	
Increase associated with speed	1.51694	1.51694	1.51694	1.51694	1.51694		1.31183	1.31183	1.31183	1.3118	1.3118	

E2a. Time costs per hour

Value of travel time	$ per hour					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	
Business trips, %		47.8	29.0	40.8	29.9	Travel time values at June 2007 from Table 3.2 of AGPE04/08
Pers. bus. and commuting. trips, %	19.5				14.9	
Leisure trips, %	19.5				14.9	
Average	**19.5**	**47.8**	**27.1**	**40.8**	**22.2**	

E2b. Time costs per kilometre

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Average**
Time costs	0.194	0.475	0.280	0.425	0.220	**0.2522**	0.202	0.494	0.292	0.444	0.229	**0.2624**

E3. Total user costs
(vehicle operating+ time costs)

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Average**
Total user costs	0.495	0.776	1.603	1.832	0.751	**0.732**	0.471	0.763	1.540	1.742	0.708	**0.698**

E4. Accident costs

Accident type	**kA$/ accid.**	
Fatal accident	2155	
Serious injury accident	455	
Other injury accident	21.7	
Personal injury accident (av.)	167.0	"Human capital" valuation (BTE 2000) for non-urban crashes in Tasmania indexed to June 2007 resource

E5a. Air pollution costs

Air pollutants' unit costs	**$/t**
Carbon monoxide CO	3
Hydrocarbons HC	958
Oxides of nitrogen NOx	1912
Particles PM	304298
Carbon dioxide CO2	48

Unit costs in 2007 prices from Table 5.3 in AGPE04/08

E5b. Noise pollution costs

Unit costs of noise pollution	**$/year**	
Noise zone 55 to 65 dB		Treated as zero in rural areas in Tabl
Noise zone 65 to 70 dB		
Noise zone >70 dB		

F. Calculation of impacts

F1. Vehicle operating costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**
Vehicle operating costs	109,460	22,741	39,761	68,714	82,857	**323,532**	98,141	20,389	37,484	63,385	74,896	**294,295**

F2a. Travel time

	Before policy, vehicle-hours/day						After policy, vehicle-hours/day					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**
Total travel time on link	9,908	2,059	850	1,393	4,255	**18,465**	10,300	2,140	888	1,456	4,423	**19,206**

F2b. Travel time costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**
Total travel time costs	70,643	35,906	8,413	20,761	34,462	**170,185**	73,437	37,327	8,781	21,688	35,825	**177,057**

F3. Consumer surplus

	Input data, before policy						Input data, after policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Average**
Total user costs, $/veh.km	0.495	0.776	1.603	1.832	0.751	**0.732**	0.471	0.763	1.540	1.742	0.708	0.698
Mio veh.kms/year	364	76	30	49	156	**675**	364	76	30	49	156	**675**

	Change in consumer surplus					Total
k$/year	-8524	-931	-1909	-4403	-6597	**-22364**

F4a. Casualty accident rates

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**
Crash rate per million VKT	**0.120**	0.120	0.120	0.120	0.120	0.120	0.106	0.106	0.104	0.103	0.106	0.106
Fatal crash rate per 100M VKT						1.68						1.35

F4b. Casualty accident severity

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Average**
Fatal (%)	**11.7**	11.7	24.6	35.0	11.7	13.9	10.7	10.7	22.8	32.8	10.7	12.8
Serious injury (%)	**19.6**	19.6	22.7	23.5	19.6	20.0	19.4	19.4	22.7	23.8	19.4	19.8
Minor injury (%)	68.7	68.7	52.8	41.5	68.7	66.0	69.9	69.9	54.5	43.4	69.9	67.4

F4c. Accidents

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**
Fatal accident	5.1	1.1	0.9	2.1	2.2	**11.3**	4.1	0.9	0.7	1.6	1.8	**9.1**
Serious injury accident	8.6	1.8	0.8	1.4	3.7	**16.2**	7.5	1.6	0.7	1.2	3.2	**14.2**
Minor injury accident	30.1	6.3	1.9	2.4	12.9	**53.6**	27.0	5.6	1.7	2.2	11.6	**48.1**
Total casualty accidents	43.8	9.1	3.6	5.9	18.8	**81.2**	38.6	8.0	3.1	5.0	16.6	**71.4**

F4d. Accident costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**
Fatal accident	11,025	2,291	1,916	4,438	4,734	**24,404**	8,913	1,852	1,532	3,540	3,827	**19,663**
Serious injury accident	3,904	811	373	627	1,676	**7,392**	3,409	708	323	543	1,464	**6,447**
Minor injury accident	653	136	41	53	281	**1,164**	586	122	37	47	252	**1,044**
Total casualty accidents	15,583	3,237	2,330	5,118	6,691	**32,959**	12,908	2,682	1,892	4,130	5,542	**27,155**

F5a. Air pollution

Emissions	At initial speed, t/year						At final speed, t/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**
Carbon monoxide CO	1,803	375	144	232	774	**3,328**	1,341	279	107	172	576	**2,474**
Hydrocarbons HC	281	58	22	36	121	**519**	218	45	17	28	94	**402**
Oxides of nitrogen NOx	1,231	256	101	163	529	**2,279**	920	191	75	122	395	**1,704**
Particles PM	19	4	1	2	8	**34**	15	3	1	2	7	**29**
Carbon dioxide CO2	130,272	27,065	10,561	17,102	55,937	**240,936**	110,637	22,986	8,967	14,518	47,506	**204,614**

F5b. Air pollution costs

Emissions	At initial speed, k$/year						At final speed, k$/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**
Carbon monoxide CO	5.4	1.1	0.4	0.7	2.3	**10.0**	4.0	0.8	0.3	0.5	1.7	**7.4**
Hydrocarbons HC	269	56	21	35	116	**497**	209	43	17	27	90	**385**
Oxides of nitrogen NOx	2,354	489	192	312	1,011	**4,357**	1,760	366	144	233	756	**3,258**
Particles PM	5,650	1,174	450	726	2,426	**10,426**	4,715	980	375	605	2,025	**8,700**
Carbon dioxide CO2	6,253	1,299	507	821	2,685	**11,565**	5,311	1,103	430	697	2,280	**9,821**
Total	**14,532**	**3,019**	**1,171**	**1,894**	**6,240**	**26,855**	**11,998**	**2,493**	**966**	**1,562**	**5,152**	**22,172**

F5c. Noise pollution

No. of residents	**Before policy**	**After policy**	**Change**	
Noise zone 55 to 65 dB			0	#DIV/0!
Noise zone 65 to 70 dB			0	#DIV/0!
Noise zone >70 dB			0	#DIV/0!

F5d. Noise pollution costs

	k$/ year			
	Before policy	**After policy**	**Change**	
Noise zone 55 to 65 dB	0	0	0	#DIV/0!
Noise zone 65 to 70 dB	0	0	0	#DIV/0!
Noise zone >70 dB	0	0	0	#DIV/0!
Total	**0**	**0**	**0**	**#DIV/0!**

G. Non-quantified impacts

Noise pollution

Summary of quantified impacts

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total**
Total monetary impact	210,217	64,903	51,675	96,487	130,250	**553,531**	196,484	62,890	49,123	90,765	######	**520,679**

End of sheet

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework

Ver. 01/99

Category 1 undivided rural roads with current 110 km/h speed limit - curvy road with crossroads and towns

H. Net impacts

	Cruise Speed (km/h)	
Cars and LCVs	**105**	**100**
Rigid heavy vehicles	**100**	**95**
Artic. heavy vehicles	**99**	**94**

Average speed on link (km/h)	Before	After
Cars and LCVs	**100.7**	**96.8**
Rigid heavy vehicles	**96.8**	**92.8**
Articulated heavy vehicles	**96.0**	**91.9**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		18,465	19,206	741	4.0 %
Number of Crashes per year		81.2	71.4	-9.8	-12.1%
Emissions, t/year	Carbon monoxide CO	3328	2474	-854	-25.7 %
	Hydrocarbons HC	519	402	-116.8	-22.5 %
	Oxides of nitrogen NOx	2279	1704	-575	-25.2 %
	Particles PM	34.3	28.6	-5.67	-16.6 %
	Carbon dioxide CO2	240936	204614	-36322	-15.1 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **2.4** Trucks: **2.7**

Saving p.a. Fatal: **2.2** Serious Inj: **2.1** Other Inj: **5.5**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	323,532	294,295	-29237	-9.0 %
Time costs	170,185	177,057	6872	4.0 %
Crash costs	32,959	27,155	-5,805	-17.6%
Air pollution costs	26,855	22,172	-4,684	-17.4 %
Noise costs	0	0	0	
Total	**553,531**	**520,679**		
Change			**-32,853**	**-5.9 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	259,850	259,362	261,452	260,980	265,113	268,547	271,229	277,199	282,424	287,054	295,804
Time costs	214,035	209,112	204,508	200,127	196,020	192,121	188,437	184,952	181,652	178,542	175,592
Crash costs	12,184	13,380	14,667	16,048	17,529	19,115	20,810	22,620	24,551	26,608	28,798
Air pollution costs	15,623	15,812	19,489	16,457	17,269	17,918	18,391	19,389	20,214	20,887	22,243
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**501,691**	**497,665**	**500,116**	**493,612**	**495,931**	**497,701**	**498,866**	**504,160**	**508,841**	**513,092**	**522,436**
of which:											
Cars & light comm. vehs.	367,672	364,571	366,684	**361,253**	362,779	363,875	364,496	368,161	371,345	374,183	380,791
Heavy vehicles (rigid and artic.)	134,020	133,094	133,432	**132,358**	133,152	133,827	134,371	135,999	137,496	138,909	141,646

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	93,759	93,301	93,619	93,247	94,218	95,025	95,655	97,241	98,649	99,924	102,377
Time costs	35,352	34,539	33,779	33,055	32,377	31,733	31,124	30,549	30,004	29,490	29,003
Crash costs	3,082	3,406	3,755	4,132	4,538	4,974	5,442	5,943	6,480	7,053	7,666
Air pollution costs	1,826	1,848	2,278	1,924	2,019	2,095	2,150	2,267	2,363	2,442	2,600
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**134,020**	**133,094**	**133,432**	**132,358**	**133,152**	**133,827**	**134,371**	**135,999**	**137,496**	**138,909**	**141,646**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	166,091	166,061	167,833	167,732	170,895	173,522	175,574	179,958	183,775	187,130	193,426
Time costs	178,683	174,573	170,730	167,072	163,643	160,388	157,313	154,403	151,648	149,052	146,589
Crash costs	9,101	9,974	10,912	11,916	12,991	14,141	15,368	16,677	18,071	19,555	21,132
Air pollution costs	13,796	13,963	17,210	14,533	15,250	15,824	16,241	17,122	17,851	18,446	19,643
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**367,672**	**364,571**	**366,684**	**361,253**	**362,779**	**363,875**	**364,496**	**368,161**	**371,345**	**374,183**	**380,791**

APPENDIX Q: CATEGORY 2 UNDIVIDED RURAL ROADS – CURVY ROADS WITH CROSSROADS AND TOWNS

Cat2UndividedCCTHC.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 2 undivided rural roads with current 100 km/h speed limit - curvy road with crossroads and towns
[50 sharp bends, 14 cross roads, and 3 intersections requiring stopping (usually in towns) per 100 kilometres]

A1. Length of link 263 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	85	85	80	80	85	**84.3**	80	80	75	75	80	**79.3**
Average of all speeds on link	84.04	84.04	79.43	79.43	84.04		79.43	79.43	74.60	74.60	79.43	
AADT*	1,433	298	206	163	615	**2,714**	1,433	298	206	163	615	**2,714**
Share of traffic	53%	11%	8%	6%	23%	100%	53%	11%	8%	6%	23%	100%
Business trips, %		100	93.5	100	48.5	**35**		100	93.5	100	48.5	**35**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**25**	35.7		6.5		25.7	**25**
Leisure trips, %	64.3				25.8	**40**	64.3				25.8	**40**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

Category 2 undivided rural roads with current 100 km/h speed limit - curvy road with crossroads and towns

2. Measurement of impacts

I

D. Impact functions

D1. Vehicle operating costs

Freeway Model for operations of free-running traffic in Table 3.10 of AGPE04/08; June 2007 prices

D2. Travel time

Function: travel time = link length/speed of traffic flow (flat straight roads only; see adjustment factors for curvy roads with cross roads and towns)

D3a. Accidents

Injury accidents before = n_{IB} Average speed before = v_B

Injury accidents after = n_{IA} Average speed after = v_A

		Exponent	Value	
Fatal accidents	$n_{IA} = (v_A/v_B)F * n_{IB}$	**F**	**4.36**	Rural highway exponent estimates
Serious injury accidents	$n_{IA} = (v_A/v_B)S * n_{IB}$	**S**	**2.78**	from Cameron and Elvik (2008), Table 6
Other injury accidents	$n_{IA} = (v_A/v_B)O * n_{IB}$	**O**	**2.22**	

D4. Air pollutant emission coefficients

*Emission factors**	**At initial speed, g/km**						**At final speed, g/km**					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average
Carbon monoxide CO	2.32	2.32	2.23	2.23	2.32	2.31	2.14	2.14	2.05	2.05	2.14	2.13
Hydrocarbons HC	0.40	0.40	0.38	0.38	0.40	0.40	0.37	0.37	0.35	0.35	0.37	0.37
Oxides of nitrogen NO_x	1.68	1.68	1.67	1.67	1.68	1.68	1.60	1.60	1.58	1.58	1.60	1.59
Particles PM	0.03	0.03	0.03	0.03	0.03	0.031	0.03	0.03	0.03	0.03	0.03	0.029
Carbon dioxide CO_2	235.7	235.7	231.2	231.2	235.7	235.1	226.1	226.1	221.6	221.6	226.1	225.5

Emission coefficients not available by vehicle type, only for mix of traffic close to mix outlined here
Same coefficient assumed for all vehicles at given speed for each pollutant

D5. Noise pollution

No impact function available; noise pollution assumed small because of negligible human population living in vicinity of rural roads considered

E. Unit prices

E1. Vehicle operating costs

	Petrol	Diesel	
Fuel price, $ per litre	0.8804	0.8639	Resource prices in Table 2.4 of AGPE04/08 for Hobart, June 2007

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average
Vehicle oper. costs*	0.232	0.232	1.189	1.203	0.422	**0.406**	0.229	0.229	1.207	1.216	0.419	**0.405**
*With A	-15.43	-15.43	-27.95	-26.60	-28.71		-15.69	-15.69	-28.57	-27.61	-29.12	
B	1553.78	1553.78	8544.38	8544.38	3396.74		1553.78	1553.78	8544.38	8544.4	3396.7	
C	0.23531	0.23531	0.0185	0.0185	0.25629		0.23531	0.23531	0.0185	0.0185	0.2563	
D	5E-05	5E-05	0.00603	0.00603	0.00126		5E-05	5E-05	0.00603	0.006	0.0013	
Base A	-16.262	-16.262	-30	-30	-30		-16.262	-16.262	-30	-30	-30	
Fuel A	-18.433	-18.433	-65.056	-80	-27.456		-18.433	-18.433	-65.056	-80	-27.46	
Fuel B	1306.02	1306.02	4156.75	6342.8	2060.5		1306.02	1306.02	4156.75	6342.8	2060.5	
Fuel C	0.15477	0.15477	0.49681	0.48496	0.1911		0.15477	0.15477	0.49681	0.485	0.1911	
Fuel D	0.00032	0.00032	0.00068	0.00209	0.00085		0.00032	0.00032	0.00068	0.0021	0.0009	
Fuel consumption rate (lt/100km)	12.40	12.40	31.00	51.45	19.18		12.32	12.32	31.45	52.70	19.03	
Increase associated with speed	1.07643	1.07643	1.07643	1.07643	1.07643		1.05256	1.05256	1.05256	1.0526	1.0526	

E2a. Time costs per hour

Value of travel time	$ per hour					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	
Business trips, %		47.8	29.0	40.8	29.9	Travel time values at June 2007 from Table 3.2 of AGPE04/08
Pers. bus. and commuting. trips, %	19.5				14.9	
Leisure trips, %	19.5				14.9	
Average	**19.5**	**47.8**	**27.1**	**40.8**	**22.2**	

E2b. Time costs per kilometre

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average
Time costs	0.232	0.569	0.341	0.514	0.264	**0.3016**	0.246	0.602	0.363	0.547	0.279	**0.3195**

E3. Total user costs
(vehicle operating+ time costs)

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average
Total user costs	0.465	0.801	1.530	1.717	0.686	**0.707**	0.475	0.830	1.570	1.763	0.699	**0.725**

E4. Accident costs

Accident type	**kA$/ accid.**	
Fatal accident	2155	
Serious injury accident	455	
Other injury accident	21.7	
Personal injury accident (av.)	167.0	"Human capital" valuation (BTE 2000) for non-urban crashes in Tasmania indexed to June 2007 resource

E5a. Air pollution costs

Air pollutants' unit costs	**$/t**
Carbon monoxide CO	3
Hydrocarbons HC	958
Oxides of nitrogen NOx	1912
Particles PM	304298
Carbon dioxide CO2	48

Unit costs in 2007 prices from Table 5.3 in AGPE04/08

E5b. Noise pollution costs

Unit costs of noise pollution	**$/year**	
Noise zone 55 to 65 dB		Treated as zero in rural areas in Tabl
Noise zone 65 to 70 dB		
Noise zone >70 dB		

F. Calculation of impacts

F1. Vehicle operating costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Vehicle operating costs	31,928	6,633	23,513	18,771	24,893	**105,738**	31,461	6,536	23,856	18,982	24,755	**105,590**

F2a. Travel time

	Before policy, vehicle-hours/day						After policy, vehicle-hours/day					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Total travel time on link	4,483	931	682	538	1,925	**8,560**	4,744	986	726	573	2,037	**9,065**

F2b. Travel time costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Total travel time costs	31,965	16,247	6,747	8,021	15,594	**78,574**	33,820	17,190	7,184	8,541	16,499	**83,234**

F3. Consumer surplus

	Input data, before policy						Input data, after policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average
Total user costs, $/veh.km	0.465	0.801	1.530	1.717	0.686	**0.707**	0.475	0.830	1.570	1.763	0.699	0.725
Mio veh.kms/year	138	29	20	16	59	**261**	138	29	20	16	59	**261**

	Change in consumer surplus					Total
k$/year	1388	846	780	730	767	**4511**

F4a. Casualty accident rates

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Crash rate per million VKT	0.246	0.246	0.246	0.246	0.246	0.246	0.213	0.213	0.210	0.208	0.213	0.212
Fatal crash rate per 100M VKT						1.17						0.89

F4b. Casualty accident severity

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Average
Fatal (%)	3.9	3.9	8.3	11.8	3.9	4.7	3.5	3.5	7.4	10.5	3.5	4.2
Serious injury (%)	20.1	20.1	23.2	24.0	20.1	20.6	19.6	19.6	22.8	23.8	19.6	20.1
Minor injury (%)	76.0	76.0	68.5	64.1	76.0	74.7	76.9	76.9	69.8	65.7	76.9	75.7

F4c. Accidents

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Fatal accident	1.3	0.3	0.4	0.5	0.6	**3.0**	1.0	0.2	0.3	0.3	0.4	**2.3**
Serious injury accident	6.8	1.4	1.1	0.9	2.9	**13.2**	5.8	1.2	0.9	0.8	2.5	**11.1**
Minor injury accident	25.8	5.4	3.3	2.5	11.1	**48.0**	22.5	4.7	2.9	2.1	9.7	**41.9**
Total casualty accidents	33.9	7.0	4.9	3.8	14.6	**64.2**	29.3	6.1	4.1	3.3	12.6	**55.3**

F4d. Accident costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Fatal accident	2,878	598	871	980	1,236	**6,563**	2,209	459	657	740	949	**5,014**
Serious injury accident	3,097	643	515	421	1,330	**6,006**	2,616	544	430	352	1,123	**5,066**
Minor injury accident	559	116	72	54	240	**1,041**	488	101	63	46	210	**909**
Total casualty accidents	6,534	1,357	1,458	1,454	2,805	**13,609**	5,314	1,104	1,151	1,138	2,282	**10,989**

F5a. Air pollution

Emissions	At initial speed, t/year						At final speed, t/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Carbon monoxide CO	319	66	44	35	137	**601**	295	61	41	32	126	**555**
Hydrocarbons HC	55	11	8	6	23	**103**	51	11	7	5	22	**95**
Oxides of nitrogen NOx	232	48	33	26	99	**438**	220	46	31	25	94	**415**
Particles PM	4	1	1	0	2	**8**	4	1	1	0	2	**8**
Carbon dioxide CO2	32,420	6,736	4,571	3,608	13,921	**61,256**	31,089	6,459	4,382	3,459	13,349	**58,738**

F5b. Air pollution costs

Emissions	At initial speed, k$/year						At final speed, k$/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Carbon monoxide CO	1.0	0.2	0.1	0.1	0.4	**1.8**	0.9	0.2	0.1	0.1	0.4	**1.7**
Hydrocarbons HC	52	11	7	6	22	**99**	48	10	7	5	21	**91**
Oxides of nitrogen NOx	443	92	63	50	190	**838**	420	87	60	47	180	**794**
Particles PM	1,303	271	180	142	559	**2,455**	1,222	254	168	133	525	**2,302**
Carbon dioxide CO2	1,556	323	219	173	668	**2,940**	1,492	310	210	166	641	**2,819**
Total	**3,355**	**697**	**469**	**371**	**1,441**	**6,333**	**3,184**	**661**	**445**	**351**	**1,367**	**6,009**

F5c. Noise pollution

No. of residents	**Before policy**	**After policy**	**Change**	
Noise zone 55 to 65 dB			0	#DIV/0!
Noise zone 65 to 70 dB			0	#DIV/0!
Noise zone >70 dB			0	#DIV/0!

F5d. Noise pollution costs

	k$/ year			
	Before policy	**After policy**	**Change**	
Noise zone 55 to 65 dB	0	0	0	#DIV/0!
Noise zone 65 to 70 dB	0	0	0	#DIV/0!
Noise zone >70 dB	0	0	0	#DIV/0!
Total	**0**	**0**	**0**	**#DIV/0!**

G. Non-quantified impacts

Noise pollution

Summary of quantified impacts

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	Total
Total monetary impact	73,782	24,935	32,188	28,617	44,733	**204,255**	73,779	25,492	32,636	29,012	44,903	**205,821**

End of sheet

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework

Ver. 01/99

Category 2 undivided rural roads with current 100 km/h speed limit - curvy road with crossroads and towns

H. Net impacts

	Cruise Speed (km/h)	
Cars and LCVs	**85**	**80**
Rigid heavy vehicles	**80**	**75**
Artic. heavy vehicles	**80**	**75**

Average speed on link (km/h)	Before	After
Cars and LCVs	**84.0**	**79.4**
Rigid heavy vehicles	**79.4**	**74.6**
Articulated heavy vehicles	**79.4**	**74.6**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		8,560	9,065	505	5.9 %
Number of Crashes per year		64.2	55.3	-8.9	-13.8%
Emissions, t/year	Carbon monoxide CO	601	555	-46	-7.7 %
	Hydrocarbons HC	103	95	-7.7	-7.5 %
	Oxides of nitrogen NOx	438	415	-23	-5.2 %
	Particles PM	8.1	7.6	-0.50	-6.2 %
	Carbon dioxide CO2	61256	58738	-2518	-4.1 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **4.1** Trucks: **4.9**

Saving p.a. Fatal: **0.7** Serious Inj: **2.1** Other Inj: **6.1**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	105,738	105,590	-148	-0.1 %
Time costs	78,574	83,234	4659	5.9 %
Crash costs	13,609	10,989	-2,620	-19.3%
Air pollution costs	6,333	6,009	-324	-5.1 %
Noise costs	0	0	0	
Total	**204,255**	**205,821**		
Change			**1,566**	**0.8 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	104,744	104,526	105,315	105,116	106,708	108,035	109,076	111,396	113,434	115,245	118,659
Time costs	82,277	80,385	78,615	76,931	75,352	73,854	72,437	71,098	69,829	68,634	67,499
Crash costs	11,613	12,658	13,773	14,964	16,232	17,582	19,017	20,542	22,160	23,875	25,691
Air pollution costs	6,032	6,105	6,322	6,354	6,667	6,918	7,100	7,486	7,804	8,064	8,588
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**204,666**	**203,674**	**204,026**	**203,364**	**204,959**	**206,388**	**207,631**	**210,522**	**213,227**	**215,818**	**220,438**
of which:											
Cars & light comm. vehs.	144,174	143,433	143,649	**143,120**	144,207	145,162	145,967	147,954	149,792	151,532	154,732
Heavy vehicles (rigid and artic.)	60,492	60,241	60,376	**60,245**	60,752	61,227	61,664	62,568	63,435	64,286	65,705

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	41,992	41,786	41,905	41,744	42,141	42,476	42,741	43,406	44,001	44,545	45,580
Time costs	14,769	14,429	14,111	13,809	13,525	13,256	13,002	12,762	12,534	12,319	12,116
Crash costs	2,913	3,197	3,502	3,829	4,180	4,555	4,956	5,384	5,841	6,327	6,844
Air pollution costs	819	829	859	863	905	939	964	1,017	1,060	1,095	1,166
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**60,492**	**60,241**	**60,376**	**60,245**	**60,752**	**61,227**	**61,664**	**62,568**	**63,435**	**64,286**	**65,705**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	62,752	62,740	63,410	63,372	64,567	65,559	66,335	67,991	69,433	70,701	73,079
Time costs	67,509	65,956	64,504	63,122	61,827	60,597	59,435	58,336	57,295	56,314	55,384
Crash costs	8,700	9,461	10,272	11,135	12,052	13,027	14,061	15,158	16,319	17,548	18,848
Air pollution costs	5,213	5,276	5,464	5,491	5,762	5,978	6,136	6,469	6,744	6,969	7,422
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**144,174**	**143,433**	**143,649**	**143,120**	**144,207**	**145,162**	**145,967**	**147,954**	**149,792**	**151,532**	**154,732**

APPENDIX R: CATEGORY 3 UNDIVIDED RURAL ROADS – CURVY ROADS WITH CROSSROADS AND TOWNS

Cat3UndividedCCTHC.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 3 undivided rural roads with current 100 km/h speed limit - curvy road with crossroads and towns
[50 sharp bends, 14 cross roads, and 3 intersections requiring stopping (usually in towns) per 100 kilometres]

A1. Length of link 572 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	87	87	82	82	87	**86.7**	82	82	77	77	82	**81.7**
Average of all speeds on link	**85.84**	**85.84**	**81.30**	**81.30**	**85.84**		**81.30**	**81.30**	**76.54**	**76.54**	**81.30**	
AADT*	1,145	238	108	28	492	**2,012**	1,145	238	108	28	492	**2,012**
Share of traffic	57%	12%	5%	1%	24%	100%	57%	12%	5%	1%	24%	100%
Business trips, %		100	93.5	100	48.5	**30**		100	93.5	100	48.5	**30**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**27**	35.7		6.5		25.7	**27**
Leisure trips, %	64.3				25.8	**43**	64.3				25.8	**43**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

Application of the MASTER framework

Ver. 01/99

Category 3 undivided rural roads with current 100 km/h speed limit - curvy road with crossroads and towns

H. Net impacts

	Cruise Speed (km/h)	
Cars and LCVs	**87**	**82**
Rigid heavy vehicles	**82**	**77**
Artic. heavy vehicles	**82**	**77**

Average speed on link (km/h)	Before	After
Cars and LCVs	**85.8**	**81.3**
Rigid heavy vehicles	**81.3**	**76.5**
Articulated heavy vehicles	**81.3**	**76.5**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		13,456	14,214	758	5.6 %
Number of Crashes per year		132.3	114.6	-17.7	-13.4%
Emissions, t/year	Carbon monoxide CO	1007	913	-95	-9.4 %
	Hydrocarbons HC	172	157	-15.2	-8.8 %
	Oxides of nitrogen NOx	725	674	-51	-7.1 %
	Particles PM	13.4	12.5	-0.96	-7.1 %
	Carbon dioxide CO2	100839	95672	-5168	-5.1 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **3.9** Trucks: **4.6**

Saving p.a. Fatal: **1.4** Serious Inj: **3.8** Other Inj: **12.5**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	145,139	143,253	-1886	-1.3 %
Time costs	119,122	125,840	6719	5.6 %
Crash costs	27,076	21,967	-5,109	-18.9%
Air pollution costs	10,476	9,823	-653	-6.2 %
Noise costs	0	0	0	
Total	**301,812**	**300,883**		
Change			**-929**	**-0.3 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	142,898	142,711	143,945	143,756	146,113	148,079	149,624	152,989	155,938	158,551	163,452
Time costs	128,134	125,187	122,431	119,808	117,349	115,015	112,810	110,724	108,748	106,886	105,120
Crash costs	20,727	22,593	24,585	26,710	28,976	31,387	33,951	36,675	39,566	42,631	45,877
Air pollution costs	9,724	9,841	12,130	10,243	10,748	11,152	11,446	12,068	12,581	13,000	13,844
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**301,483**	**300,332**	**303,091**	**300,517**	**303,187**	**305,634**	**307,831**	**312,456**	**316,833**	**321,069**	**328,294**
of which:											
Cars & light comm. vehs.	253,589	**252,579**	255,060	252,653	254,888	256,914	258,706	262,579	266,220	269,721	275,789
Heavy vehicles (rigid and artic.)	47,894	**47,752**	48,031	47,864	48,299	48,720	49,125	49,877	50,613	51,348	52,504

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	33,786	33,619	33,689	33,566	33,846	34,086	34,282	34,768	35,209	35,618	36,383
Time costs	10,751	10,504	10,273	10,052	9,846	9,650	9,465	9,290	9,124	8,968	8,820
Crash costs	2,697	2,961	3,245	3,550	3,877	4,226	4,600	4,999	5,425	5,879	6,361
Air pollution costs	660	668	824	695	730	757	777	819	854	883	940
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**47,894**	**47,752**	**48,031**	**47,864**	**48,299**	**48,720**	**49,125**	**49,877**	**50,613**	**51,348**	**52,504**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	109,112	109,092	110,256	110,190	112,267	113,993	115,341	118,221	120,729	122,933	127,069
Time costs	117,383	114,683	112,159	109,756	107,503	105,365	103,345	101,433	99,623	97,918	96,300
Crash costs	18,031	19,631	21,340	23,160	25,099	27,161	29,351	31,676	34,141	36,752	39,516
Air pollution costs	9,063	9,173	11,306	9,547	10,019	10,395	10,669	11,248	11,727	12,118	12,904
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**253,589**	**252,579**	**255,060**	**252,653**	**254,888**	**256,914**	**258,706**	**262,579**	**266,220**	**269,721**	**275,789**

APPENDIX S: CATEGORY 4 UNDIVIDED RURAL ROADS – CURVY ROADS WITH CROSSROADS AND TOWNS

Cat4UndividedCCTHC.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 4 undivided rural roads with current 100 km/h speed limit - curvy road with crossroads and towns
[50 sharp bends, 14 cross roads, and 3 intersections requiring stopping (usually in towns) per 100 kilometres]

A1. Length of link 825 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	91	91	85	75	91	**90.2**	86	86	80	70	86	**85.2**
Average of all speeds on link	**89.36**	**89.36**	**84.04**	**74.60**	**89.36**		**84.95**	**84.95**	**79.43**	**69.78**	**84.95**	
AADT*	759	158	66	41	326	**1,349**	759	158	66	41	326	**1,349**
Share of traffic	56%	12%	5%	3%	24%	100%	56%	12%	5%	3%	24%	100%
Business trips, %		100	93.5	100	48.5	**31**		100	93.5	100	48.5	**31**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**27**	35.7		6.5		25.7	**27**
Leisure trips, %	64.3				25.8	**42**	64.3				25.8	**42**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

Application of the MASTER framework

Ver. 01/99

Category 4 undivided rural roads with current 100 km/h speed limit - curvy road with crossroads and towns

H. Net impacts

	Cruise Speed (km/h)	
Cars and LCVs	91	86
Rigid heavy vehicles	85	80
Artic. heavy vehicles	75	70

Average speed on link (km/h)	Before	After
Cars and LCVs	89.4	85.0
Rigid heavy vehicles	84.0	79.4
Articulated heavy vehicles	74.6	69.8

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		12,568	13,233	664	5.3 %
Number of Crashes per year		137.6	119.9	-17.6	-12.8%
Emissions, t/year	Carbon monoxide CO	1076	938	-138	-12.8 %
	Hydrocarbons HC	182	161	-21.4	-11.8 %
	Oxides of nitrogen NOx	763	679	-83	-10.9 %
	Particles PM	13.9	12.6	-1.25	-9.0 %
	Carbon dioxide CO2	102876	95545	-7331	-7.1 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **3.5** Trucks: **4.1**

Saving p.a. Fatal: **1.0** Serious Inj: **4.2** Other Inj: **12.4**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	148,347	144,596	-3751	-2.5 %
Time costs	112,835	118,847	6012	5.3 %
Crash costs	25,127	20,759	-4,369	-17.4%
Air pollution costs	10,799	9,886	-914	-8.5 %
Noise costs	0	0	0	
Total	**297,108**	**294,087**		
Change			**-3,021**	**-1.0 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	142,499	142,291	143,504	143,296	145,631	147,576	149,101	152,443	155,370	157,963	162,837
Time costs	125,261	122,380	119,686	117,122	114,718	112,436	110,280	108,241	106,309	104,490	102,763
Crash costs	17,583	19,076	20,663	22,349	24,137	26,033	28,040	30,164	32,408	34,779	37,281
Air pollution costs	9,405	9,519	11,732	9,907	10,396	10,787	11,071	11,672	12,169	12,574	13,391
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**294,747**	**293,266**	**295,585**	**292,674**	**294,883**	**296,832**	**298,493**	**302,520**	**306,257**	**309,806**	**316,272**
of which:											
Cars & light comm. vehs.	239,526	238,234	240,248	**237,561**	239,276	240,757	241,977	245,147	248,054	250,785	255,924
Heavy vehicles (rigid and artic.)	55,221	**55,031**	55,337	55,113	55,607	56,076	56,515	57,373	58,202	59,021	60,347

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	38,265	38,077	38,178	38,033	38,384	38,680	38,917	39,508	40,039	40,526	41,450
Time costs	13,126	12,824	12,542	12,273	12,021	11,782	11,556	11,343	11,140	10,950	10,769
Crash costs	3,083	3,374	3,686	4,020	4,376	4,757	5,163	5,596	6,057	6,546	7,066
Air pollution costs	747	756	932	787	825	856	879	927	966	998	1,063
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**55,221**	**55,031**	**55,337**	**55,113**	**55,607**	**56,076**	**56,515**	**57,373**	**58,202**	**59,021**	**60,347**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	104,233	104,214	105,326	105,263	107,248	108,897	110,184	112,936	115,331	117,436	121,388
Time costs	112,135	109,556	107,144	104,849	102,697	100,654	98,724	96,898	95,169	93,540	91,994
Crash costs	14,499	15,702	16,977	18,329	19,761	21,275	22,877	24,567	26,352	28,233	30,215
Air pollution costs	8,658	8,763	10,801	9,120	9,571	9,930	10,192	10,745	11,203	11,576	12,327
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**239,526**	**238,234**	**240,248**	**237,561**	**239,276**	**240,757**	**241,977**	**245,147**	**248,054**	**250,785**	**255,924**

APPENDIX T: CATEGORY 5 UNDIVIDED RURAL ROADS – CURVY ROADS WITH CROSSROADS AND TOWNS

Cat5UndividedCCTHC.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 5 undivided rural roads with current 100 km/h speed limit - curvy road with crossroads and towns
[50 sharp bends, 14 cross roads, and 3 intersections requiring stopping (usually in towns) per 100 kilometres]

A1. Length of link 1037 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	84	84	76	82	84	**83.4**	79	79	71	77	79	**78.4**
Average of all speeds on link	**83.13**	**83.13**	**75.57**	**76.54**	**83.13**		**78.47**	**78.47**	**70.74**	**76.54**	**78.47**	
AADT*	398	83	55	7	171	**712**	398	83	55	7	171	**712**
Share of traffic	56%	12%	8%	1%	24%	100%	56%	12%	8%	1%	24%	100%
Business trips, %		100	93.5	100	48.5	**31**		100	93.5	100	48.5	**31**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**27**	35.7		6.5		25.7	**27**
Leisure trips, %	64.3				25.8	**42**	64.3				25.8	**42**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

Application of the MASTER framework

Ver. 01/99

Category 5 undivided rural roads with current 100 km/h speed limit - curvy road with crossroads and towns

H. Net impacts

Cruise Speed (km/h)		
Cars and LCVs	**84**	**79**
Rigid heavy vehicles	**76**	**71**
Artic. heavy vehicles	**82**	**77**

Average speed on link (km/h)	Before	After
Cars and LCVs	**83.1**	**78.5**
Rigid heavy vehicles	**75.6**	**70.7**
Articulated heavy vehicles	**76.5**	**76.5**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		8,964	9,497	533	6.0 %
Number of Crashes per year		95.7	82.4	-13.2	-13.8%
Emissions, t/year	Carbon monoxide CO	606	560	-46	-7.6 %
	Hydrocarbons HC	104	96	-7.7	-7.4 %
	Oxides of nitrogen NOx	443	421	-23	-5.1 %
	Particles PM	8.2	7.7	-0.51	-6.2 %
	Carbon dioxide CO2	62506	59966	-2540	-4.1 %
Residents in area where $L_{Aeq,07-22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **4.3** Trucks: **5.4**

Saving p.a. Fatal: **0.8** Serious Inj: **3.1** Other Inj: **9.3**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	97,113	97,082	-31	0.0 %
Time costs	79,405	84,104	4699	5.9 %
Crash costs	17,763	14,422	-3,340	-18.8%
Air pollution costs	6,444	6,117	-327	-5.1 %
Noise costs	0	0	0	
Total	**200,725**	**201,725**		
Change			**1,000**	**0.5 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	96,300	96,151	96,932	96,792	98,315	99,588	100,591	102,784	104,711	106,422	109,628
Time costs	82,280	80,387	78,618	76,933	75,355	73,856	72,440	71,100	69,831	68,636	67,502
Crash costs	15,817	17,189	18,650	20,205	21,857	23,611	25,471	27,441	29,528	31,734	34,066
Air pollution costs	6,243	6,319	7,788	6,577	6,901	7,161	7,349	7,749	8,078	8,347	8,889
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**200,641**	**200,047**	**201,989**	**200,507**	**202,428**	**204,215**	**205,851**	**209,074**	**212,148**	**215,140**	**220,085**
of which:											
Cars & light comm. vehs.	161,396	**160,876**	162,557	161,166	162,699	164,104	165,366	167,940	170,372	172,719	176,686
Heavy vehicles (rigid and artic.)	39,245	**39,170**	39,432	39,341	39,729	40,111	40,485	41,134	41,775	42,420	43,400

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	27,647	27,511	27,559	27,461	27,676	27,863	28,018	28,399	28,748	29,073	29,677
Time costs	8,422	8,229	8,048	7,875	7,713	7,560	7,415	7,278	7,148	7,026	6,910
Crash costs	2,635	2,884	3,150	3,436	3,741	4,067	4,415	4,785	5,180	5,599	6,044
Air pollution costs	541	547	674	570	598	620	636	671	700	723	770
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**39,245**	**39,170**	**39,432**	**39,341**	**39,729**	**40,111**	**40,485**	**41,134**	**41,775**	**42,420**	**43,400**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	68,653	68,640	69,373	69,331	70,639	71,725	72,573	74,385	75,963	77,349	79,952
Time costs	73,858	72,159	70,570	69,058	67,641	66,296	65,024	63,822	62,683	61,610	60,592
Crash costs	13,182	14,306	15,500	16,769	18,116	19,543	21,056	22,656	24,348	26,136	28,022
Air pollution costs	5,703	5,772	7,114	6,007	6,304	6,541	6,713	7,077	7,379	7,624	8,119
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**161,396**	**160,876**	**162,557**	**161,166**	**162,699**	**164,104**	**165,366**	**167,940**	**170,372**	**172,719**	**176,686**

APPENDIX U: CATEGORY 5 UNSEALED RURAL ROADS – CURVY ROADS WITH CROSSROADS AND TOWNS

Cat5UnsealedCCTHC.xls

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework (see separate instructions) Ver. 01/99

LINK-LEVEL ANALYSIS OF THE IMPACTS OF A SPEED MANAGEMENT POLICY

Name of applier: Max Cameron
Institution: Monash University Accident Research Centre

1. Outlining

A. Policy test Category 5 unsealed undivided rural roads with current 100 km/h speed limit - curvy road with crossroads and towns
[50 sharp bends, 14 cross roads, and 3 intersections requiring stopping (usually in towns) per 100 kilometres]

A1. Length of link 206 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	HV - Rigid	HV - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	85	85	80	80	85	**84.4**	80	80	75	75	80	**79.4**
Average of all speeds on link	84.04	84.04	79.43	79.43	84.04		79.43	79.43	74.60	74.60	79.43	
AADT*	76	16	14	2	33	**140**	76	16	14	2	33	**140**
Share of traffic	54%	11%	10%	1%	23%	100%	54%	11%	10%	1%	23%	100%
Business trips, %		100	93.5	100	48.5	**33**		100	93.5	100	48.5	**33**
Pers. bus. and commuting. trips, %	35.7		6.5		25.7	**26**	35.7		6.5		25.7	**26**
Leisure trips, %	64.3				25.8	**41**	64.3				25.8	**41**

*average annual daily traffic volume, vehicles per day

B. Link/network level analysis

This workbook is best suited for link analysis. However, elastic travel demand can be assumed, for the workbook contains formulas for consumer surplus calculation.

C. Deciding on relevant impacts

- [x] Vehicle operating costs
- [x] Travel time
- [x] Accidents
- [x] Air pollution
- [ ] Noise
- [ ] Other

End of sheet

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework

Ver. 01/99

Category 5 unsealed undivided rural roads with current 100 km/h speed limit - curvy road with crossroads and towns

H. Net impacts

	Cruise Speed (km/h)	
Cars and LCVs	**85**	**80**
Rigid heavy vehicles	**80**	**75**
Artic. heavy vehicles	**80**	**75**

Average speed on link (km/h)	Before	After
Cars and LCVs	**84.0**	**79.4**
Rigid heavy vehicles	**79.4**	**74.6**
Articulated heavy vehicles	**79.4**	**74.6**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		346	367	20	5.9 %
Number of Crashes per year		4.1	3.5	-0.6	-14.1%
Emissions, t/year	Carbon monoxide CO	24	23	-2	-7.7 %
	Hydrocarbons HC	4	4	-0.3	-7.5 %
	Oxides of nitrogen NOx	18	17	-1	-5.2 %
	Particles PM	0.3	0.3	-0.02	-6.2 %
	Carbon dioxide CO2	2484	2382	-102	-4.1 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Increase/vehicle/100km (mins.) Cars&LCVs: **4.1** Trucks: **4.9**

Saving p.a. Fatal: **0.1** Serious Inj: **0.2** Other Inj: **0.3**

H2. Monetary impacts

k$/year	Before	After	Change	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	4,033	4,024	-10	-0.2 %
Time costs	3,083	3,264	182	5.9 %
Crash costs	1,088	880	-208	-19.1%
Air pollution costs	257	244	-13	-5.1 %
Noise costs	0	0	0	
Total	**8,461**	**8,412**		
Change			**-49**	**-0.6 %**

H3. Summary of monetary impacts for intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	3,996	3,989	4,019	4,013	4,073	4,124	4,164	4,252	4,330	4,399	4,528
Time costs	3,237	3,163	3,093	3,027	2,965	2,906	2,850	2,797	2,748	2,700	2,656
Crash costs	918	1,000	1,088	1,181	1,281	1,386	1,498	1,618	1,744	1,878	2,019
Air pollution costs	245	247	256	258	270	280	288	303	316	327	348
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**8,396**	**8,399**	**8,456**	**8,478**	**8,589**	**8,696**	**8,800**	**8,970**	**9,137**	**9,304**	**9,551**
of which:											
Cars & light comm. vehs.	**6,394**	6,396	6,440	6,455	6,541	6,623	6,701	6,831	6,959	7,084	7,274
Heavy vehicles (rigid and artic.)	**2,002**	2,003	2,016	2,023	2,048	2,074	2,099	2,139	2,179	2,219	2,277

H4. Monetary impacts for heavy vehicles at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	1,377	1,370	1,372	1,367	1,378	1,387	1,395	1,414	1,431	1,448	1,478
Time costs	419	410	401	392	384	376	369	362	356	350	344
Crash costs	179	197	215	235	256	279	303	329	357	386	417
Air pollution costs	27	27	28	28	30	31	32	33	35	36	38
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**2,002**	**2,003**	**2,016**	**2,023**	**2,048**	**2,074**	**2,099**	**2,139**	**2,179**	**2,219**	**2,277**

H5. Monetary impacts for cars and LCVs at intermediate and lower cruise speeds

kA$/year km/h	80	82	84	86	88	90	92	94	96	98	100
Consumer surplus	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)	(N. A.)
Vehicle operating costs	2,619	2,619	2,647	2,645	2,695	2,737	2,769	2,838	2,898	2,951	3,050
Time costs	2,818	2,753	2,693	2,635	2,581	2,529	2,481	2,435	2,392	2,351	2,312
Crash costs	739	804	873	946	1,024	1,107	1,195	1,288	1,387	1,492	1,602
Air pollution costs	218	220	228	229	241	250	256	270	282	291	310
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**6,394**	**6,396**	**6,440**	**6,455**	**6,541**	**6,623**	**6,701**	**6,831**	**6,959**	**7,084**	**7,274**