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Potential Benefits and Costs of Speed Changes on Rural Roads

Max Cameron

Monash University Accident Research Centre

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Abstract

The objective of the project was to explore the potential 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 rural freeways, other divided roads and undivided roads. Within the limits of the assumptions made and the data available for this study, the following general conclusions were reached:

1. Increasing the speed limit to 130 km/h for all vehicles on rural freeways would have substantial social costs. The total social cost could be constrained, and even reduced, if trucks were limited to 100 km/h on such roads. A variable speed limit system allowing speeds of 120 km/h for cars and light commercial vehicles during good conditions, but reduced to 100 km/h under adverse conditions, while limiting trucks to 100 km/h at all times, would keep total social costs below current levels. However, all scenarios whereby speed limits are increased for some vehicle types and circumstances are necessarily accompanied by increased road trauma to provide travel time saving benefits.
2. Increasing the speed limit to 130 km/h on rural divided roads would have even greater social costs than the increased limit on freeways. If trucks were limited to 100 km/h, the impact on total social costs would be smaller but they would still increase. Even a variable speed limit like that for freeways described above would be associated with an increase in road trauma costs. The higher crash rate on the divided roads compared with rural freeways will result in any speed limit increase producing even greater road trauma increases than on the freeways, despite lower traffic volumes on non-freeway roads.
3. If the ‘willingness to pay’ valuations of crash costs reflecting consumer preferences are used, the optimum speeds on rural freeways would be 120 km/h for cars and light commercial vehicles and 95 km/h for trucks. On divided rural roads, the optimum speeds would be 110 km/h and 90 km/h, respectively. If the speed limits on each of these rural roads were to be set at these optimum speeds for each vehicle type, there would be a reduction in total social costs in each environment. However, there would be increases in road trauma on the rural freeways due to the increase in car speeds.
4. There is no economic justification for increasing the speed limit on two-lane undivided rural roads, even on those safer roads with sealed shoulders. On undivided roads through terrain requiring slowing for sharp bends and occasional stops in towns, the increased fuel consumption and air pollution emissions associated with deceleration from and acceleration to high cruise speeds would add very substantially to the total social costs. Using ‘human capital’ costs to value road trauma, the optimum speed for cars is about the current speed limit (100 km/h) on straight sections of these roads, but 10-15 km/h less on the curvy roads with intersections and towns. The optimum speed for trucks is substantially below the current speed limit, and even lower on the curvy roads. The optimum speeds would be even lower if ‘willingness to pay’ valuations of crash costs were used.

Keywords

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

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EXECUTIVE SUMMARY

OBJECTIVES

The objective of the project was to explore the potential 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 (dual carriageway roads with grade-separated intersections and a design speed of 130 km/h, usually designed as such when originally constructed)
- other divided rural roads (not of freeway standard)
- two-lane undivided rural roads (two illustrative 'road stereotypes' with different crash rates).

Specific objectives were to explore a number of scenarios, such as:

- increasing limits on high standard roads with a low crash rate (per vehicle-kilometre) from 110 to 130 km/h (or intermediate speeds)
- increasing limits on high standard roads with a low crash rate from 110 to 130 km/h subject to a variable speed limit system that would reduce speeds under adverse conditions such as poor light, bad weather or dense traffic ('VSL option')
- decreasing limits on lower standard rural roads with higher crash rates.

PREVIOUS RESEARCH

Research in Europe has examined the collective impacts of vehicle speeds on road trauma, travel times, operating costs, and air and noise pollution. The optimum speed for a class of road has been defined as one which minimises the total social costs of the impacts of speed. The optimum speed has been estimated for urban roads, where speed limits are generally 50 km/h in Europe, and for rural freeways and divided and undivided roads. The European research has generally found that optimum speeds on rural roads are 15-25 km/h lower than current European speed limits and travel speeds. Australia's use of relatively low values for the economic cost of road trauma, and full valuation of travel time savings, tends to produce higher estimates of optimum speeds.

METHOD OF THIS STUDY

The effects of speed on road trauma levels were calculated using well-established 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. Vehicle operating costs for cars, light commercial vehicles and rigid and articulated trucks were based on Austroads published models linking these costs with speed. Emission rates of air pollutants of each type were derived from research conducted as part of the Managing Speeds of Traffic on European Roads (MASTER) project for the European Commission. 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. The analysis also provided estimates of average speeds over 100 km sections of curvy undivided roads.

Travel time was assumed to be inversely related to average speeds and was valued by Austroads estimates of time costs reflecting the vehicle type and trip purposes. Scenarios whereby leisure travel time was not valued were also considered. Road trauma was valued by BTRE's standard 'human capital' unit costs related to the injury severity of crash outcomes, and also by 'willingness to pay' values to test the sensitivity of the key results to this assumption.

ASSUMPTIONS

1. The current speed limits on freeway standard and other divided rural roads are 110 km/h for cars and light commercial vehicles (LCVs) and 100 km/h for all rigid and articulated trucks, and the speed limit on undivided rural roads is 100 km/h for all types of vehicle.

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

3. Apart from where indicated, the rural roads are relatively straight without intersections and towns, allowing vehicles to travel at cruise speed throughout the whole road section.

4. The mix of traffic by vehicle type is the same on each class of rural road, namely 67% passenger cars, 20% light commercial vehicles, 5% rigid trucks and 8% articulated trucks, and that this mix does not vary by time of day on rural freeways and other divided roads.

5. Crashes involving material damage only, and no personal injury, were not included in the analysis of crash changes with speed, and the likely increase in these crashes with increased speeds (albeit to a lesser extent than fatal and injury crashes) was not valued. Material damage crashes represented about 16.3% of total crash costs in Australia during 1996 (BTE 2000).

6. Scenarios in which truck speed limits are lower than light vehicle limits have been analysed on the assumption that the (increased) speed differential between these vehicle types does not in itself increase crash risk or the severity of the crash outcome.

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

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

9. The current economic valuations of travel time, road trauma, and air pollution emissions provide an appropriate basis for analysis which summates their values, together with vehicle operating costs, in a way which represents the total social costs of each speed. In other words, the current valuations are an appropriate basis for 'trading off' these tangible and intangible values of each impact. (Results for some alternative valuations are also presented).

10. Assessment scenarios involving variable speed limit systems do not include any estimates of capital and maintenance costs for the systems.

11. Illustrative traffic volumes used in the analysis were 20,000 vehicles per day for freeways, 15,000 for divided highways and 1,000 for undivided roads.

RESULTS

Summaries of the estimated effects of the different speed limit changes on 100 km sections of the three classes of rural roads are given in Tables 1 and 2. Table 2 also includes an estimate (to the nearest 5 km/h) of the optimum speed, based on the total economic cost of each speed for all vehicles combined, and also for the light vehicles and trucks separately.

Table 1: Travel time savings and road trauma increases per 100 km of rural road.

	Travel time saving per vehicle over 100 km (minutes)		**Road trauma increases per 100 km of road per year**		
Scenario	Cars & LCVs	Trucks	Fatal crashes	Serious injury crashes	Other injury crashes
RURAL FREEWAYS (20,000 vehicles per day)					
Speed limit raised to 130 km/h (base scenario)[1]	8.4	13.8	2.8	11.1	14.1
Trucks limited to 100 km/h	8.4	0.0	1.6	8.4	11.6
Variable speed limit (VSL)[2]	5.6*	0.0	0.7	3.7	4.9
VSL (day limit 120 km/h)[2]	2.5*	0.0	0.2	1.0	1.3
RURAL DIVIDED ROADS (15,000 vehicles per day)					
Speed limit raised to 130 km/h (base scenario)[3]	8.4	13.8	3.4	13.6	17.2
Trucks limited to 100 km/h	8.4	0.0	1.9	10.3	14.2
Variable speed limit (VSL)[4]	5.6*	0.0	0.9	4.6	6.0
VSL (day limit 120 km/h)[4]	2.5*	0.0	0.3	1.3	1.6
RURAL TWO-WAY UNDIVIDED ROADS (1,000 vehicles per day)[5]					
Speed limit raised to 130 km/h on standard 7.0 m sealed roads	13.8	13.8	0.8	3.3	4.1
Standard 7.0 m sealed roads, curvy with crossroads/towns	9.8	9.8	0.9	3.7	4.6
Speed limit raised to 130 km/h on shoulder-sealed 8.5 m roads	13.8	13.8	0.5	2.1	2.6
Shoulder-sealed 8.5 m roads, curvy with crossroads/towns	9.8	9.8	0.6	2.3	2.9

[1,3] Speed limit raised from 110 km/h (cars and light commercial vehicles) and 100 km/h (trucks) to 130 km/h (all vehicles).

[2,4] Day speed limit for cars and light commercial vehicles raised to 130 km/h (or 120 km/h where indicated); night speed limit reduced to 100 km/h; truck speed limit fixed at 100 km/h during all times of day.

[5] Speed limit raised from 100 km/h to 130 km/h for all types of vehicle.

* Travel time savings averaged across all times of day (assuming 20% of total traffic at night).

Table 2: Summary of economic impacts of scenarios, & estimated optimum speeds.

Scenario	**Effect on total economic cost** Change ($ million) p.a./100 km	Percentage change	**Optimum Speed (km/h)** (speed which minimises total economic cost) All vehicles combined	Cars & LCVs	Trucks
RURAL FREEWAYS (20,000 vehicles per day)					
Base scenario[1]	2.350	0.6%	120	125	100
- Leisure travel time not valued	7.618	2.2%	110	115	100
- 'Willingness to pay' (WTP) values of road trauma	10.497	2.7%	110	120	95
Trucks limited to 100 km/h	-3.641	-1.0%	n.a.	125	100
Variable speed limit (VSL)[2]	-3.483	-0.9%			
- WTP values of road trauma	-1.308	-0.3%			
VSL (day limit 120 km/h)[2]	-2.334	-0.6%			
- WTP values of road trauma	-1.735	-0.4%			
RURAL DIVIDED ROADS (15,000 vehicles per day)					
Base scenario[3]	6.454	2.2%	110	120	95
- Leisure travel time not valued	10.405	4.0%	105	110	95
- 'Willingness to pay' (WTP) values of road trauma	16.453	5.5%	105	110	90
Trucks limited to 100 km/h	0.372	0.1%	n.a.	120	95
Variable speed limit (VSL)[4]	-1.201	-0.4%			
- WTP values of road trauma	1.468	0.5%			
VSL (day limit 120 km/h)[4]	-1.363	-0.5%			
- WTP values of road trauma	-0.627	-0.2%			
RURAL TWO-WAY UNDIVIDED ROADS (1,000 vehicles per day)[5]					
Standard 7.0 m sealed roads	2.040	9.8%	95	100	85
Standard 7.0 m sealed roads, curvy with crossroads/towns	14.781	66.3%	85	85	At most 80
Shoulder-sealed 8.5 m roads	1.021	5.1%	105	105	90
Shoulder-sealed 8.5 m roads, curvy with crossroads/towns	13.645	63.5%	85	90	85

[1,3] Speed limit raised from 110 km/h (cars and light commercial vehicles) and 100 km/h (trucks) to 130 km/h (all vehicles). Leisure travel time valued and road trauma valued by 'Human Capital' approach.

[2,4] Day speed limit for cars and light commercial vehicles raised to 130 km/h (or 120 km/h where indicated); night speed limit reduced to 100 km/h; truck speed limit fixed at 100 km/h during all times of day.

[5] Speed limit raised from 100 km/h to 130 km/h for all types of vehicle. Leisure travel time valued and road trauma valued by 'Human Capital' approach.

Rural freeways

An increase in the speed limit to 130 km/h on rural freeways would save each car 8.4 minutes and each truck 13.8 minutes per 100 km, but would increase the number of fatal crashes by 2.8 per year per 100 km of freeway. Casualty crash costs would increase by 89%, vehicle operating costs would increase by 7% and time costs would decrease by 17%. There would be a net cost increase of $2.35 million per year per 100 km of road, provided it is appropriate to value leisure travel time savings and to value the road trauma increases by the 'human capital' approach. If the leisure time savings are not valued, then the net impact would be an economic cost of $7.6 million per year per 100 km of freeway. If road trauma is valued by society's 'willingness to pay' to prevent it, the net cost would be $10.5 million per year per 100 km. Since these alternative valuations of leisure travel time and road trauma are central to the estimated economic output of the increased speed limit on rural freeways, the implications of their choice in making policy decisions needs to be considered carefully.

However, the analysis does indicate that the negative economic impacts of the increased speed limit on rural freeways could be overcome, and even made positive, if trucks were limited on such roads to 100 km/h. A further alternative would be a variable speed limit system, whereby the speed limit is reduced to 100 km/h for cars and light commercial vehicles under adverse road conditions (such as at night or other adverse condition approximately doubling the crash risk for about 20% of the traffic), and is fixed at 100 km/h for trucks at all times. If the increased speed limit under good conditions was no more than 120 km/h, the increase in road trauma would be minimal. This variable speed limit system would still result, however, in an increase in fatal crashes of 0.2 per year per 100 km of freeway, due to the increase in speed limit for 80% of the traffic, albeit during safer daytime conditions. This system would increase casualty crash costs by 7%, increase vehicle operating costs by 1% and reduce time costs by 4%.

Divided roads

The travel time savings if the speed limit were increased to 130 km/h on rural divided roads were estimated to be the same as on freeways, and the percentage change in crash costs would be similar. However the number of additional casualties would be higher because of the higher initial crash rate. Fatal crashes would increase by 3.4 per year per 100 km of divided road. Similar remarks regarding the economic analysis of rural divided roads apply as were made for freeways, except that a simple increase in the speed limit to 130 km/h would have a substantial economic cost ($6.45 million increase per year per 100 km of road). Even higher figures would be estimated with alternative valuations of leisure travel time and road trauma.

The economic loss on divided roads could be overcome to a large extent if trucks were limited to 100 km/h. However a variable speed limit system allowing speeds of 120 km/h under good conditions would not be as beneficial as on rural freeways. There would be an additional 0.3 fatal crashes per year per 100 km of road, but a saving of 2.5 minutes per car travelling over the 100 km section averaged over the whole day. A system allowing 130 km/h on divided rural roads during good conditions would result in greater road trauma levels.

Undivided roads

There is apparently no economic justification for increasing the speed limit to 130 km/h on the two-way undivided roads, especially the lower standard 7.0 m sealed roads without shoulder sealing.

On the straight undivided sections without intersections or towns, total costs on the 7.0 m roads would be increased by $2.04 million per annum per 100 km of road, or almost 10% of current costs. There would be travel time savings of 13.8 minutes per vehicle over 100 km, but an increase of 0.8 fatal crashes per year on the same road section. (The increase in casualty crash costs would be 142%, but the number of additional fatalities and casualties per 100 km road section would be lower than on divided roads because of the lower traffic volumes on typical undivided roads.)

On the lower standard undivided roads through curvy terrain requiring slowing and occasional towns requiring stopping, the average speed would be lower and the travel time savings would be only 9.8 minutes per vehicle over 100 km. The total cost associated with raising the speed limit, and hence the cruise speeds, to 130 km/h is estimated to be $14.78 million per annum per 100 km, due to increased fuel consumption predominantly and to increased air pollution emissions, each associated with the deceleration-acceleration required by slowing and stopping from 130 km/h cruise speed and returning to that speed.

The optimum cruise speed for cars travelling on these roads is estimated to be 100 km/h if the road is straight without crossroads and towns, but only 85 km/h if the road has many sharp bends and includes intersections and towns requiring stopping. The optimum cruise speed for trucks is estimated to be 85 km/h, and no more than 80 km/h on curvy undivided roads of the same standard. Optimum cruise speeds would be somewhat lower if ‘willingness to pay’ values were used for crash costs, or lower values were used for leisure time savings.

On the higher standard, 8.5 m shoulder-sealed undivided roads, an increase in the speed limit to 130 km/h would not result in as many additional crashes as on the lower standard roads, but the total cost would still increase by $1.02 million per annum per 100 km of straight road: about 5% of current total costs. The travel time savings would be the same as on the lower standard undivided roads, but on the straight sections without intersections or towns there would still be 0.5 additional fatal crashes per year per 100 km of road. These calculations assume equal traffic volumes on higher standard and lower standard undivided roads. In practice, traffic volumes are likely to be higher on the better roads, so the number of additional casualties and the net cost increase per section could be higher on these roads.

Again, as with the lower standard undivided roads, the higher standard roads through curvy terrain and passing through towns would experience substantial increases in total social costs associated with the increased speed limit, due to increased fuel consumption and emissions because of frequent deceleration and acceleration. The total cost associated with cruise speeds of 130 km/h on such roads would be $13.65 million per annum per 100 km of road. Travel time savings would be reduced compared with straight 8.5 m shoulder-sealed sections, and fatal crashes would be increased by 0.6 per year per 100 km of curvy road.

The optimum cruise speed for cars travelling on the higher standard undivided roads is estimated to be 105 km/h if the road is straight without crossroads and towns, but only 90 km/h if the road has many sharp bends and includes intersections and towns requiring stopping. The optimum cruise speed for trucks is estimated to be 90 km/h, but only 85 km/h on curvy undivided roads of the same standard.

DISCUSSION

Appropriateness of valuing leisure travel time savings

The analysis of speed limit changes on rural freeways and divided roads included scenarios where leisure trip travel time was valued at zero, for comparison with the results where it was valued in the same way as trips in cars for other private purposes.

There is a view that on some trips, the travel time saving per trip travelled at a higher speed is so small that the benefit cannot be perceived by vehicle occupants and hence has zero value. In rural areas, trip distances are typically longer than in urban areas and travel time savings per trip are potentially substantial if travelling at a higher speed. A DOTARS analysis showed that 41 minutes per trip could be saved on a 700 km rural section of the Hume Highway if travelling at 130 km/h on the better one-third of road and 120 km/h on the remainder, compared with travelling at 110 km/h over its whole length. It is likely that vehicle occupants would perceive travel time savings of this magnitude over long rural trips and would place value on the time savings.

Another issue arising in the valuation of travel time savings on rural roads is the desirability of consistency in the valuation of leisure time in the travel time costs and in the road trauma costs. The 'human capital' crash cost estimates do not include any value for leisure time forgone by crash victims. For consistency reasons, it could be argued that when the human capital cost estimates are used, the leisure trip travel time savings should be valued at zero. This variation on the base scenario analyses for rural freeways and rural divided roads was presented for this reason (Table 2).

'Willingness to pay' valuations of road trauma

There has been considerable attention given in the USA to valuing road trauma costs as comprehensively as possible, especially including values for lost quality of life in the case of killed and incapacitated crash victims. A leading US transport safety economist, Ted Miller, has argued that comprehensive crash costs, otherwise known as 'willingness to pay' values, should be used in benefit-cost analysis. This is because 'willingness to pay' values reflect society's consumer preferences when it comes to decisions about road safety initiatives.

Miller (1996) has also suggested that 'it seems essential to use compatible values of life and travel time in transport investment analyses'. Since the travel time values normally used for transport decisions reflect consumer preferences, this implies that 'willingness to pay' values of road trauma should be used when travel time savings are valued.

Reflecting this argument, the analysis in this study includes variations on the base scenarios for rural freeways and rural divided roads in which 'willingness to pay' values are used (Table 2). Travel time for all purposes of trip (including leisure trips) is valued in these analyses. It is suggested that this is technically the correct combination of valuations of these two important impacts of the speed limit changes analysed in this study.

On the basis of these valuations, the optimum speed on the rural freeways is 120 km/h for cars and light commercial vehicles and 95 km/h for trucks. If these speeds were to become the speed limits for each type of vehicle, respectively, there would be a net saving of $1.36 million per annum per 100 km of rural freeway. There would be a travel time saving of 4.5 minutes per car, but an increase of 3.2 minutes per truck, and there would be an additional 0.6 fatal crashes per year per 100 km of freeway.

On rural divided roads, the optimum speed is 110 km/h for cars and light commercial vehicles and 90 km/h for trucks, if ‘willingness to pay’ valuations of road trauma are used. If the truck optimum was to become their speed limit (but no change in limit for cars), the total impact would be a saving of $864,000 per annum per 100 km of divided road. There would be no travel time saving for cars, but an increase of 6.7 minutes per truck, and there would be a reduction of 0.3 fatal crashes per year per 100 km of divided road.

If speed limits on each class of rural road (including rural undivided roads) were to be moved closer to the optimum speeds, there could be a substantial net gain in total economic costs across the road network (and perhaps even a net reduction in crash costs). This is because a large proportion of rural road travel (and an even larger proportion of rural crashes) is on undivided roads. A reduction in crash costs may result because, although speed limits for cars would increase on freeways, their limits would decrease or remain the same on other roads, and truck speed limits would decrease on all roads, especially the undivided roads with higher crash rates. However, reliable data on rural traffic levels using each of the four classes of road analysed in this study was not available to calculate the total economic impacts across the rural road network.

CONCLUSIONS

Within the limits of the assumptions made and the data available for this study, the following general conclusions were reached:

1. Increasing the speed limit to 130 km/h for all vehicles on rural freeways would have substantial social costs. The total social cost could be constrained, and even reduced, if trucks were limited to 100 km/h on such roads. A variable speed limit system allowing speeds of 120 km/h for cars and light commercial vehicles during good conditions, but reduced to 100 km/h under adverse conditions, while limiting trucks to 100 km/h at all times, would keep total social costs below current levels. However, all scenarios whereby speed limits are increased for some vehicle types and circumstances are necessarily accompanied by increased road trauma to provide travel time saving benefits.

2. Increasing the speed limit to 130 km/h on rural divided roads would have even greater social costs than the increased limit on freeways. If trucks were limited to 100 km/h, the impact on total social costs would be smaller but they would still increase. Even a variable speed limit like that for freeways described above would be associated with an increase in road trauma costs. The higher crash rate on the divided roads compared with rural freeways will result in any speed limit increase producing even greater road trauma increases than on the freeways, despite lower traffic volumes on non-freeway roads.

3. If the ‘willingness to pay’ valuations of crash costs reflecting consumer preferences are used, the optimum speeds on rural freeways would be 120 km/h for cars and light commercial vehicles and 95 km/h for trucks. On divided rural roads, the optimum speeds would be 110 km/h and 90 km/h, respectively. If the speed limits on each of these rural roads were to be set at these optimum speeds for each vehicle type, there would be a reduction in total social costs in each environment. However, there would be increases in road trauma on the rural freeways due to the increase in car speeds.

4. There is no economic justification for increasing the speed limit on two-lane undivided rural roads, even on those safer roads with sealed shoulders. On undivided roads through terrain requiring slowing for sharp bends and occasional stops in towns, the increased fuel consumption and air pollution emissions associated with deceleration from and

acceleration to high cruise speeds would add very substantially to the total social costs. Using ‘human capital’ costs to value road trauma, the optimum speed for cars is about the current speed limit (100 km/h) on straight sections of these roads, but 10-15 km/h less on the curvy roads with intersections and towns. The optimum speed for trucks is substantially below the current speed limit, and even lower on the curvy roads. The optimum speeds would be even lower if ‘willingness to pay’ valuations of crash costs were used.

POTENTIAL BENEFITS AND COSTS OF SPEED CHANGES ON RURAL ROADS

1. INTRODUCTION

The objective of this project was to explore the potential 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 roads
- two-lane undivided rural roads (two illustrative ‘road stereotypes’ with different crash rates).

Specific objectives were to explore a number of scenarios, such as:

- increasing limits on high standard roads with a low crash rate (per vehicle-kilometre) from 110 to 130 km/h (or intermediate speeds)
- increasing limits on high standard roads with a low crash rate from 110 to 130 km/h subject to a variable speed limit system that would reduce speeds under adverse conditions such as poor light, bad weather or dense traffic (‘VSL option’)
- decreasing limits on lower standard rural roads with higher crash rates.

Previous research in Europe suggested that there is sufficient knowledge relating road trauma, vehicle operating costs, 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).

2. PREVIOUS RESEARCH ON IMPACTS OF SPEEDS

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 feed-back 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) 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).

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 zones 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 because of findings that, for a given increase in the speed of traffic, 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).

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:

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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.

- **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 Kallberg and Toivanen's relationship between speed and casualty crash costs

The MASTER spreadsheet uses Nilsson's relationship, with **p** = 2, as the impact function linking casualty (fatal and injury) crashes with mean speeds (section D3a in Appendix A), based on Andersson and Nilsson (1997). It was recognised that this function does not capture the effects of changing injury severity distribution resulting from changes in speed (Kallberg and Toivanen 1998). Thus the MASTER spreadsheet uses a development of this function to calculate speed-related changes in crash costs (section D3b):

$$C_A = [k*((v_A/v_B)^2-1)+1]*C_B$$

where C_A = crash costs after

C_B = crash costs before

k = a constant depending on the actual unit costs of fatal, serious and minor injuries and the average number of each in casualty crashes of various severities (Kallberg and Toivanen found that k = 2, approximately, applied in most European countries, and adopted this value in the spreadsheet).

3.1.4 Road trauma relationship used in this study

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's (1984) relationships were able to represent this better than Kallberg and Toivanen's (1998) crash costs relationship, which was in part derived from Nilsson's relationships anyway. Nilsson's relationships were also more appropriate than Kloeden et al's (2001) estimates of relative 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's (1984) 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.

An Austroads project has estimated casualty crash rates on different classes of rural roads and examined other factors which influence these rates (Mclean 2001). 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 0.25 casualty crashes per million VKT.

No information could be readily found on the rate per million VKT of material damage (property damage only) crashes on Australian rural roads. (Even if it could, the relationships linking crash risks with speed, described above, apply only to casualty crashes, not less serious crashes.) For this reason, the analysis covered only the impacts of speed on casualty crashes and any impacts on material damage crashes were not estimated nor costed in the total social impacts.

Mclean (2001) provides adjustment factors (multipliers) to estimate the casualty crash rate on other classes of rural road, in particular the classes defined for consideration here:

- Rural freeway 0.275
- Divided rural road 0.45
- Two-lane undivided 8.5 m shoulder-sealed road 0.64
- Two-lane undivided 7.0 m sealed road 1.00 (reference class).

Mclean 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 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 below.) 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 provided by Mclean were taken to be the same rate (after adjustment for road class) for each type of vehicle on rural roads in this study.

3.1.6 Crash severity by vehicle type involved

The Austroads project 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 (Mclean 2001). 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 all rural roads in Australia.

3.2 VEHICLE OPERATING COSTS

Austroads have published models for calculating vehicle operating costs as a function of travel speeds, nominally in urban areas (Thoresen, Roper and Michel 2003).

The ‘Freeway Model’ is proposed be used for freeways and high quality arterial roads where average speeds are typically in excess of 60 km/h. This model was considered to be applicable to operating costs on rural roads. The estimated vehicle operating cost, c (cents/km resource cost at September 2000 prices), for a given journey speed, V (km/h), is:

$$c = C_0 + C_1V + C_2V^2$$

Thoresen et al (2003) provide the parameters of this model for private and business cars, light commercial vehicles, and rigid and articulated trucks separately. For example, the values $C_0 = 21.49$, $C_1 = -0.021$, and $C_2 = 0.00030$, applicable to private (used) 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 with scenarios relating to roads with those characteristics later.

3.3 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 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.

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, it is believed that the assumption is reasonable.

3.4 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 Australia.

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 up to 130 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 with scenarios relating to roads with those characteristics later.

3.5 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 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.

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 costs of road trauma in Australia during 1996. A 4% discount rate was used to value future earnings of killed and disabled road trauma victims. These estimates were updated to year 2000 values using the Consumer Price Index. The updated estimates of the human capital cost of road crashes, by the injury level of the most severe injury, in year 2000 A$ are:

- fatal crashes $1,740,359
- serious injury crashes $429,553
- other injury crashes $14,504.

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 2000 A$ using the Consumer Price Index to provide the following estimates of the ‘willingness to pay’ values of road crashes:

- fatal crashes $4,550,944
- serious injury crashes $368,964
- other injury crashes $82,030.

It was noted that the ‘willingness to pay’ estimate of the value of a serious injury crash was below the human capital cost based on BTE (2000). This was considered likely to be due to methodological differences compared with BTCE (1997), 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 September 2000 prices) for travel times in rural areas (Thoresen, Roper and Michel 2003). 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
- leisure trips.

There is a view that the value of time on leisure trips (or, more precisely, the increase or decrease in time travelled, due to changes in travel speed in normal ranges) should be set to zero when time savings are compared to crash cost estimates based on human capital methodology (see Discussion). To test the sensitivity of the analysis to this question, analysis was also conducted in which the value of time for leisure trips was set at zero.

4.3 AIR POLLUTION EMISSIONS

Air pollution cost estimates were provided by Cosgrove (1994). The Consumer Price Index was used to provide estimates in year 2000 A$, namely:

- Carbon monoxide $0.002 per kilogram
- Hydrocarbons $0.44 per kilogram
- Oxides of nitrogen $1.74 per kilogram
- Particulates (PM10) $13.77 per kilogram
- Carbon dioxide $0.022 per kilogram.

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

5. RURAL ROAD USE

Information on travel on Australia's rural roads, categorised by class of road and type of vehicle, is scarce. NRTC (1996), in its Mass Limits Review, estimated the total travel on national highways, rural arterial roads (separately for roads above and below 5,000 vehicles per day), and rural local roads (Table 5.1). The national highways consist of freeways, divided highways and even two-lane undivided roads in some parts of Australia. The average pavement width is 8.07 m, suggesting a mix of divided and undivided roads. VicRoads presented evidence to the Road Safety Committee (2002) of the Parliament of Victoria showing that the AADT on Victoria's rural freeways outside provincial cities was about 16,700 vehicles per day in 1998. This contrasts with about 2,900 vehicles per day across the whole national highway system (Table 5.1).

The rural arterials with more than 5,000 vehicles per day have an average pavement width of 10.4 m, suggesting that these roads are divided to a large extent. The average traffic volumes of 11,400 per day in 1991 are consistent with this high standard.

In contrast, the rural arterials with less than 5,000 vehicles per day had an average pavement width of 6.5 m and an AADT of about 800 vehicles per day. These parameters are consistent with a standard two-lane undivided road in Australia. NRTC (1996) indicates that 78% of these roads were sealed in 1991. In contrast, the rural local roads covered in Table 5.1 were sealed for only 23% of their length and carried only about 30 vehicles per day. This latter class of rural road was not considered a candidate for the speed limit increases analysed in this study.

Table 5.1: Total travel and Annual Average Daily Traffic (AADT) volumes on Australian rural roads, 1991. Source: NRTC (1996) Mass Limits Review.

	Passenger vehicles	Light commercial vehicles	Rigid trucks	Artic-ulated trucks	Total all vehicles*	Pavement area ('000 sq. m.)	Average pavement width (m)
National highways							
Length (km)	18,370	18,370	18,370	18,370	18,370	148,300	8.07
Travel (mill veh-km)	12,593	3,708	976	1,556	19,346		
AADT	1,878.1	553.0	145.6	232.1	2,885.3		
	65.1%	19.2%	5.0%	8.0%	100.0%		
Rural arterials >5, 000 vehicles per day							
Length (km)	2,760	2,760	2,760	260	2,760	28,800	10.43
Travel (mill veh-km)	7,413	2,183	575	916	11,388		
AADT	7,358.5	2,167.0	570.8	909.3	11,304.3		
	65.1%	19.2%	5.0%	8.0%	100.0%		
Rural arterials <5,000 vehicles per day							
Length (km)	94,080	94,080	94,080	94,080	94,080	612,100	6.51
Travel (mill veh-km)	17,914	5,274	1,389	2,214	27,522		
AADT	521.7	153.6	40.4	64.5	801.5		
	65.1%	19.2%	5.0%	8.0%	100.0%		
Rural local roads							
Length (km)	587,700	587,700	587,700	587,700	587,700	3,703,000	6.30
Travel (mill veh-km)	4,748	1,406	256	87	6,652		
AADT	22.1	6.6	1.2	0.4	31.0		
	71.4%	21.1%	3.8%	1.3%	100.0%		
RURAL TOTAL							
Length (km)	702,910	702,910	702,910	702,910	702,910	4,492,200	6.39
Travel (mill veh-km)	42,668	12,570	3,195	4,773	64,908		
AADT	166.3	49.0	12.5	18.6	253.0		
	65.7%	19.4%	4.9%	7.4%	100.0%		

* Including other vehicle types also, such as motorcycles and buses

The growth in travel on rural roads between 1991 and 2001 was estimated to be 17.4% over all types of vehicle, with substantially greater increase in that performed by articulated trucks (36%) but an 8% decrease in travel by rigid trucks (Table 5.2). The information available from the ABS Surveys of Motor Vehicle Usage covers travel in ‘other areas’, outside the capital city and outside urban areas with more than 40,000 population, in the state of registration, and travel by interstate vehicles. Comparison of Tables 5.1 and 5.2 shows that the ABS survey did not cover all rural travel during 1991.

From these two sources, it was decided to consider the following mix of traffic by vehicle type to be typical on Australia's rural roads during the early years of this century:

- Cars 67%
- Light commercial vehicles 20%
- Rigid trucks 5%
- Articulated trucks 8%.

The NRTC (1996) estimates had not indicated any difference in the traffic mix by rural road class above local roads and the same assumption was made in this study.

Table 5.2: Growth in traffic on Australian rural roads. Source: ABS Surveys of Motor Vehicle Usage, 1991 and 2001.

'Other Areas' plus 'Interstate' travel (million veh-km)					
	Passenger vehicles	Light commercial vehicles	Rigid trucks	Artic-ulated trucks	Total all vehicles
1991	33,941	10,010	2,350	2,889	50,532
2001	39,757	12,362	2,156	3,940	59,307
Traffic growth (%)	17.1%	23.5%	-8.3%	36.4%	17.4%
2001 distribution	67.0%	20.8%	3.6%	6.6%	100.0%

Based on the growth in travel during 1991-2001, the following AADTs were estimated as typical traffic volumes, for illustrative purposes, on the three classes of road considered:

- Rural freeways 20,000 vehicles per day
- Rural divided highways 15,000 vehicles per day
- Rural two-way undivided roads 1,000 vehicles per day.

Information on the purpose of travel for each vehicle type was available from the 2001 Survey of Motor Vehicle Usage, but not for rural roads separately (Table 5.3). 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.

Table 5.3 indicates that 25% of travel by passenger cars was for business purposes and that, of the remainder, 35% was for work commuting purposes and 65% was for personal purposes (leisure time trips). For light commercial vehicles, the data indicate that 63% of travel was for business purposes, 16% for commuting, and 21% for personal purposes. Essentially 100% of trips by each type of truck are for business purposes. These percentages were used to further sub-divide the mix of traffic for each vehicle type (see above) by trip purpose as part of assigning travel time values (section A of Appendices B onwards). Since passenger car travel is a substantial part of rural travel (67%) and leisure travel is a substantial part of private car travel, the assumptions made about trip purposes on rural roads were critical to the analysis.

Table 5.3: Purpose of trip on travel on Australian roads. (Information for rural roads not available.) Source: ABS Survey of Motor Vehicle Usage, 2001.

Purpose	Passenger vehicles	Light commercial vehicles	Rigid trucks	Artic-ulated trucks	Total all vehicles
TRAVEL (million veh-km)					
Business use	36,357	1,901	6,463	5,317	69,713
To and from work	37,261	4,962	101	3	42,807
Personal and other	70,307	6,466	63	2	77,632
TOTAL	143,925	30,728	6,627	5,321	190,152
DISTRIBUTION					
Business use	25.3%	62.8%	97.5%	99.9%	36.7%
To and from work	25.9%	16.1%	1.5%	0.1%	22.5%
Personal and other	48.8%	21.0%	1.0%	0.0%	40.8%
TOTAL	100.0%	100.0%	100.0%	100.0%	100.0%

6. RURAL FREEWAYS

Analysis of the total economic cost from road trauma, air pollutants, travel time, and vehicle operating costs was conducted for a hypothetical 100 km section of rural freeway. The average annual daily traffic (AADT) on this section was assumed to be 20,000 vehicles per day, with the following proportions of traffic by vehicle type:

- private car 50%
- business car 17%
- light commercial vehicles 20%
- rigid trucks 5%
- articulated trucks 8%.

The assumption of 20,000 vehicles per day is not critical to the analysis and is merely illustrative of the scale of impacts and costs which could be experienced per 100 km of freeway operating at such volumes. The estimates are directly related to the assumed volume and could be rescaled accordingly if an alternative AADT is considered.

The casualty crash rate was assumed to be 0.06875 crashes per million VKT, derived from Austroads research (Mclean 2001), under existing speed conditions. Current average speeds were taken to be the same as the speed limit (110 km/h) in the case of light vehicles (cars and light commercial vehicles), but 100 km/h in the case of trucks (rigid and articulated). Since 1991, Australian Design Rule 65/00 has required that all new vehicles over 12 tonnes gross vehicle mass be speed limited to 100 km/h. In some States, this requirement was made retrospective to some pre-1991 heavy vehicles.

6.1 SPEED LIMIT RAISED FROM 110 TO 130 KM/H

6.1.1 Base scenario

The economic impact of raising the speed limit from 110 to 130 km/h was estimated by assuming that the average speeds for all types of vehicles would increase to 130 km/h. The base scenario considered placed value on leisure time travel (see section 4.2) and valued road trauma using the Human Capital method (see section 4.1). Details of the analysis are given in Appendix B.

Under this scenario, the travel time savings per vehicle over 100 km would be 8.4 minutes for cars and light commercial vehicles, and 13.8 minutes for each truck. Over the same 100 km of freeway, it is estimated that there would be an additional 2.8 fatal crashes, 11.1 serious injury crashes and 14.1 less-serious injury crashes per year (Appendix B).

It was estimated that annual vehicle operating costs would increase by $15.8 million (7.2%), crash costs by $9.8 million (89%) and air pollution costs by $450,000 (7.2%), per 100 kilometres of rural freeway (Table 6.1.1). Travel time costs would reduce by $23.7 million per year (16.9%). The total economic impact was estimated to increase by $2.35 million per annum, or 0.6% of the total impact with the 110 km/h speed limit.

Table 6.1.1: Economic impact of raising speed limit on rural freeways from 110 km/h (before) to 130 km/h (after).

$'000/year	**Before**	**After**	**Change**	
Vehicle operating costs	220,368	236,151	15,783	7.2 %
Time costs	140,418	116,705	-23,713	-16.9 %
Crash costs	10,996	20,826	9,829	89.4%
Air pollution costs	6,282	6,733	450	7.2 %
Total	**378,065**	**380,414**		
Change			**2,350**	**0.6 %**

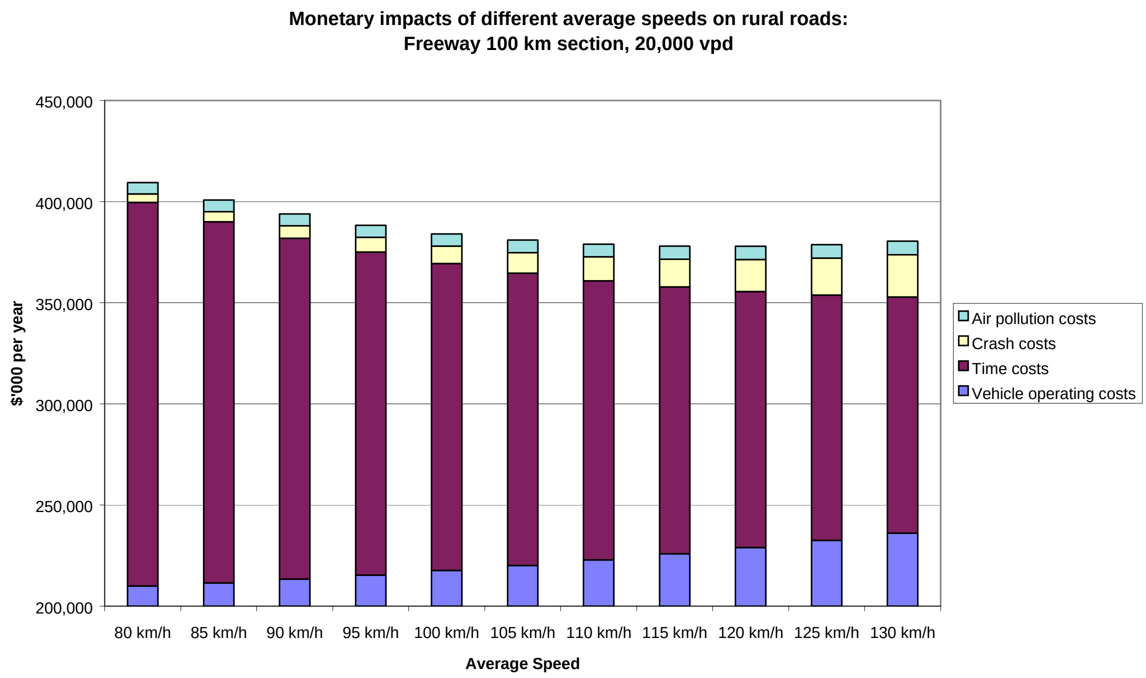
The analysis considered the impacts of different average speeds below 130 km/h by modifying the 'after' average speed in the spreadsheet, in 5 km/h increments between 80 and 130 km/h, and recording each result (section H3 of Appendix B). In this way, the effect of raising or lowering the speed limit to different values other than 130 km/h 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 trucks (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 average speeds on rural freeways.

$'000/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
Vehicle op. costs	209,942	211,512	213,315	215,353	217,623	220,127	222,865	225,836	229,041	232,480	236,151
Time costs	189,645	178,489	168,573	159,701	151,716	144,491	137,924	131,927	126,430	121,373	116,705
Crash costs	4,154	5,060	6,101	7,289	8,636	10,156	11,861	13,766	15,886	18,234	20,826
Air pollution costs	5,675	5,781	5,887	5,993	6,098	6,204	6,310	6,415	6,521	6,627	6,733
Total	**409,416**	**400,842**	**393,877**	**388,335**	**384,074**	**380,979**	**378,960**	**377,945**	**377,879**	**378,713**	**380,415**
of which:											
Cars & LCVs	310,136	302,617	296,326	291,111	286,852	283,456	280,843	278,956	277,745	**277,171**	277,203
Trucks	99,280	98,226	97,551	97,224	**97,222**	97,523	98,117	98,989	100,133	101,542	103,212

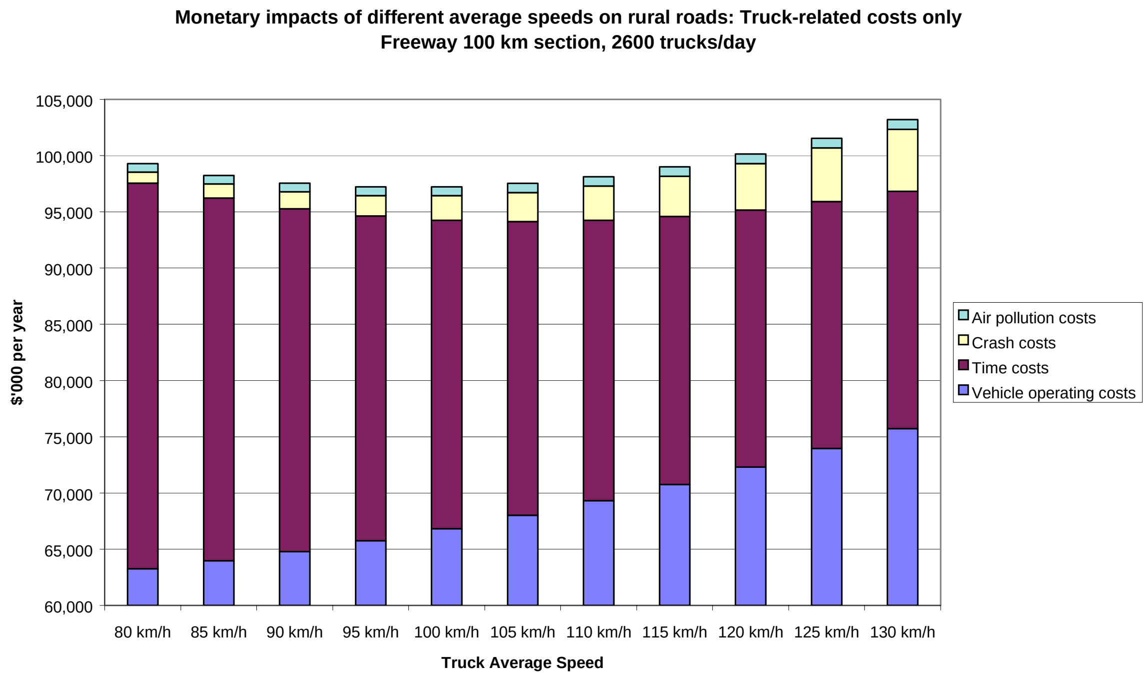
Table 6.1.2 shows that the speed which minimises the total economic impact, as valued in this base scenario for rural freeways, is 120 km/h. This is also apparent in Figure 6.1.1. (Only impacts above $200 million are shown in the Figure because of the substantial level of fixed operating costs.) However, the optimum speed differs substantially by vehicle type (shown in bold at the foot of Table 6.1.2). It was estimated as 125 km/h for cars and LCVs and 100 km/h for trucks.

Figure 6.1.1: Rural freeways – Base scenario.



The contributions of trucks to each component of the total economic impact is shown in Figure 6.1.2. Note that the contribution of trucks to air pollution costs may be under-estimated because of the inability of the analysis to include emission rates related to each type of vehicle and to trucks in particular. However the overall estimate of air pollution costs aggregated across all vehicle types (Table 6.1.2 and Figure 6.1.1) is likely to be correct.

Figure 6.1.2: Rural freeways – Base scenario. Truck-related costs.



6.1.2 Leisure travel time not valued

The base scenario was modified by placing zero value on leisure travel time to test the sensitivity of the total economic impact to this assumption (Appendix C).

Under this scenario, the annual saving in travel time costs would reduce from $23.7 million to $18.4 million per 100 kilometres of rural freeway (Table 6.1.3). The total economic impact associated with the increase in speed limit would then be an increase of about $7.6 million per year, or 2.2% of the total impact with the 110 km/h speed limit.

When a range of average speeds was considered, the speed which minimised the total economic impact was 110 km/h (Table 6.1.4 and Figure 6.1.3). The optimum speed for cars and LCVs was estimated to be 115 km/h. The economic impacts related to trucks, and the optimum speed of 100 km/h, were unchanged because the analysis did not include any use of trucks for leisure travel.

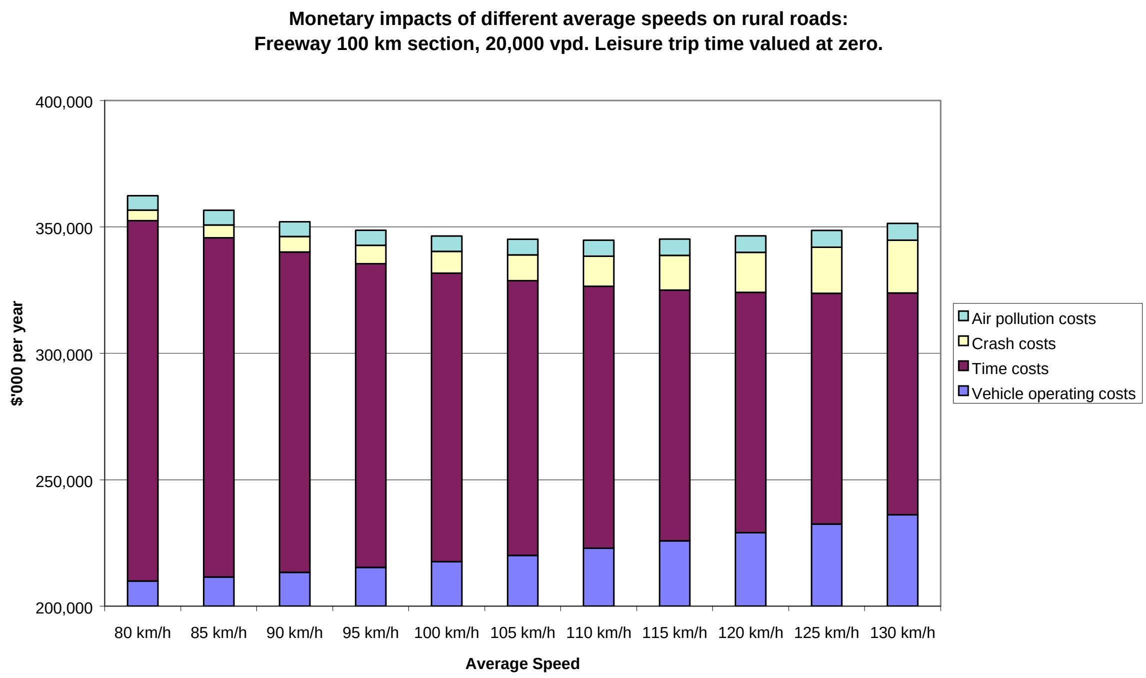
Table 6.1.3: Economic impact of raising speed limit on rural freeways from 110 km/h (before) to 130 km/h (after). Leisure travel time not valued.

$'000/year	Before	After	Change	
Vehicle operating costs	220,368	236,151	15,783	7.2 %
Time costs	106,172	87,727	-18,444	-17.4 %
Crash costs	10,996	20,826	9,829	89.4%
Air pollution costs	6,282	6,733	450	7.2 %
Total	**343,819**	**351,437**		
Change			**7,618**	**2.2 %**

Table 6.1.4: Economic impact of different average speeds on rural freeways. Leisure travel time not valued.

$'000/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
Vehicle op. costs	209,942	211,512	213,315	215,353	217,623	220,127	222,865	225,836	229,041	232,480	236,151
Time costs	142,557	134,171	126,717	120,048	114,046	108,615	103,678	99,170	95,038	91,236	87,727
Crash costs	4,154	5,060	6,101	7,289	8,636	10,156	11,861	13,766	15,886	18,234	20,826
Air pollution costs	5,675	5,781	5,887	5,993	6,098	6,204	6,310	6,415	6,521	6,627	6,733
Total	**362,328**	**356,524**	**352,020**	**348,682**	**346,403**	**345,102**	**344,714**	**345,188**	**346,486**	**348,576**	**351,437**
of which:											
Cars & LCVs	263,047	258,298	254,470	251,458	249,182	247,578	246,597	**246,199**	246,353	247,034	248,225
Trucks	99,280	98,226	97,551	97,224	**97,221**	97,524	98,117	98,989	100,133	101,542	103,212

Figure 6.1.3: Rural freeways – Leisure travel time not valued.



6.1.3 Willingness to pay valuation of road trauma

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

Under this scenario, the annual crash costs would increase by $18.0 million per 100 kilometres of rural freeway (Table 6.1.5), compared with an estimated increase of $9.8 million per annum using human capital costs. The total economic impact associated with the increase in speed limit would then be about $10.5 million per year, or 2.7% of the total impact with the 110 km/h speed limit.

Table 6.1.5: Economic impact of raising speed limit on rural freeways from 110 km/h (before) to 130 km/h (after). 'Willingness to pay' valuations of crash costs.

$'000/year	**Before**	**After**	**Change**	
Vehicle operating costs	220,368	236,151	15,783	7.2 %
Time costs	140,418	116,705	-23,713	-16.9 %
Crash costs	18,808	36,784	17,977	95.6%
Air pollution costs	6,282	6,733	450	7.2 %
Total	**385,876**	**396,373**		
Change			**10,497**	**2.7 %**

When a range of average speeds was considered, the speed which minimised the total economic impact was 110 km/h (Table 6.1.6 and Figure 6.1.4). The optimum speed for cars and LCVs was estimated to be 120 km/h and that for trucks was estimated to be 95 km/h using the 'willingness to pay' valuations of road trauma. The economic impact related to trucks reflected the higher valuation of the crash costs associated with their use (Figure 6.1.5).

Table 6.1.6: Economic impact of different average speeds on rural freeways. 'Willingness to pay' valuations of crash costs.

$'000/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
Vehicle op. Costs	209,942	211,512	213,315	215,353	217,623	220,127	222,865	225,836	229,041	232,480	236,151
Time costs	189,645	178,489	168,573	159,701	151,716	144,491	137,924	131,927	126,430	121,373	116,705
Crash costs	7,044	8,597	10,394	12,460	14,821	17,504	20,537	23,951	27,775	32,042	36,784
Air pollution costs	5,675	5,781	5,887	5,993	6,098	6,204	6,310	6,415	6,521	6,627	6,733
Total	**412,306**	**404,379**	**398,170**	**393,507**	**390,259**	**388,327**	**387,636**	**388,130**	**389,767**	**392,521**	**396,373**
of which:											
Cars & LCVs	312,183	305,097	299,308	294,674	291,081	288,445	286,698	285,791	**285,684**	286,349	287,767
Trucks	100,124	99,283	98,862	**98,833**	99,178	99,882	100,938	102,339	104,083	106,172	108,607

Figure 6.1.4: Rural freeways – 'Willingness to pay' valuations of road trauma.

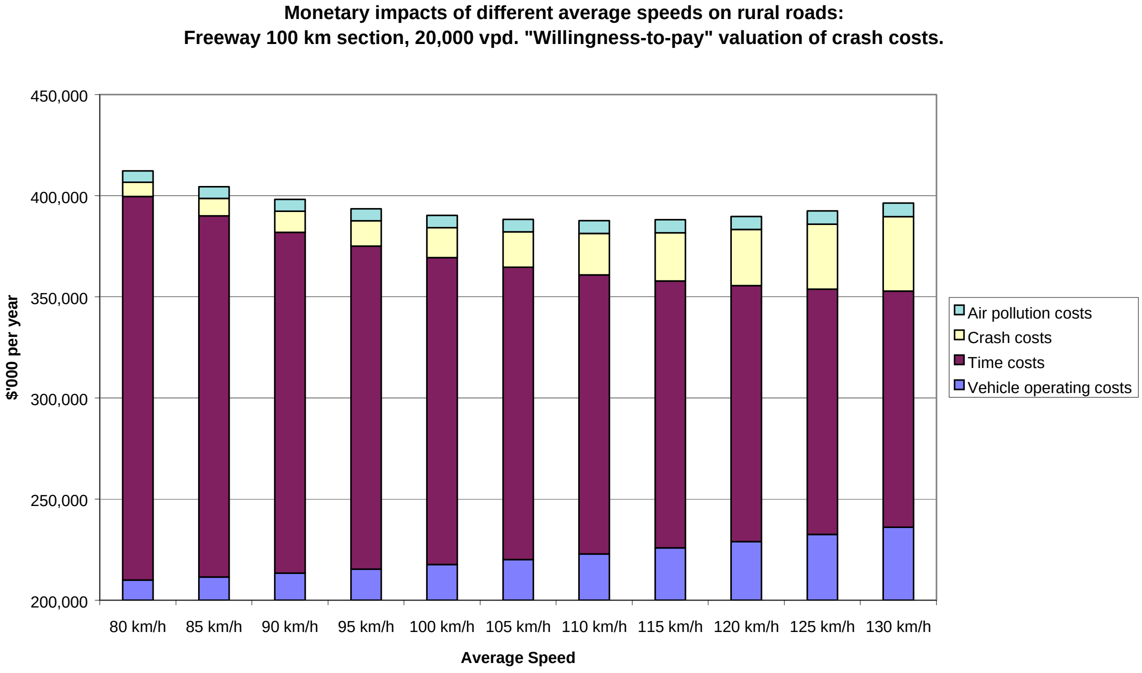
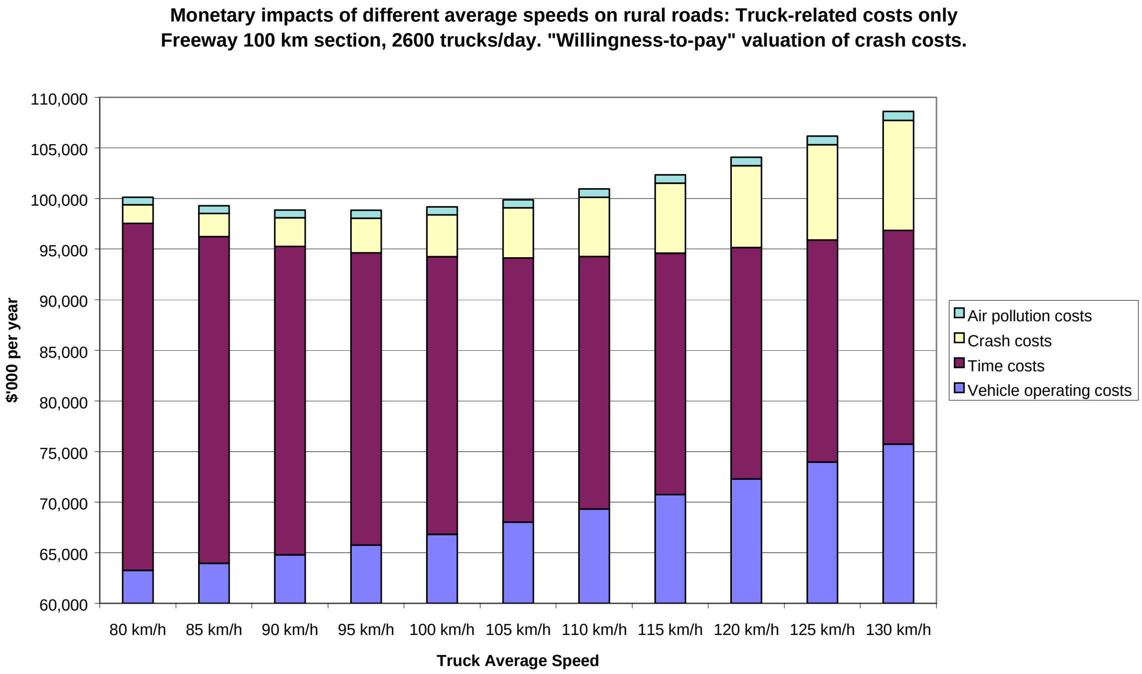


Figure 6.1.5: Rural freeways – 'Willingness to pay' valuations of road trauma. Truck-related costs.



6.2 TRUCKS LIMITED TO 100 KM/H

A modification to the base scenario for rural freeways to limit truck speeds to 100 km/h was also considered (Appendix E). In this, and in a number of subsequent scenarios for freeways and divided rural roads, the current differential between the speed limits for light vehicles and trucks (currently 10 km/h), was increased. There may be concern that a substantial speed differential between classes of vehicles may increase crash risk, or the severity of crash outcome, over and above any effect of increases in speed.

The US Transportation Research Board (1998), in a comprehensive review of current speed management practice, found that 'No conclusive evidence could be found to support or reject the use of differential speed limits for passenger cars and heavy trucks. More research and evaluation of the effects of differential speed limits on driving speeds and safety outcomes are needed in states that have adopted them.' Similarly, a US Department of Transportation study tour of practices in Europe found that 'Differential limits for cars and trucks are used in most countries. For example, general speed limits of 110 and 120 km/h for light vehicles were used in the countries visited. General speed limits for heavy vehicles are typically 80 km/h. Differential speed limits can lead to large differences in speed, which may have adverse safety effects. No studies have been conducted in the countries visited to determine if the effects are real or imagined' (Coleman et al 1995).

On this basis, it was assumed that in scenarios where truck speed limits are lower than light vehicle limits, any increased speed differential between these vehicle types will not in itself increase crash risk or the severity of the crash outcome.

Under the scenario where truck speeds were fixed at 100 km/h while light vehicle speeds increased to 130 km/h on rural freeways, it was estimated that the increase in fatal crashes would be limited to 1.6 per year, serious injury crashes 8.4 per year, and less-serious injury crashes 11.6 per year, on each 100 km section of freeway. The travel time savings for cars and light commercial vehicles would be 8.4 minutes per vehicle per 100 km section, as in the base scenario, but there would be no time savings for trucks because their speeds were assumed to be unchanged.

The total economic impact of raising the speed limit for cars and LCVs under this scenario was estimated to be an annual saving of $3.64 million per 100 kilometres of rural freeway (Table 6.2.1). Travel time savings were reduced from $23.7 million per annum to $17.4 million, compared with the base scenario, but there were substantial reductions in the increases in crash costs and vehicle operating costs, compared to the base scenario of an increase to 130 km/h for all vehicles.

Table 6.2.1: Economic impact of raising speed limit on rural freeways from 110 km/h (before) to 130 km/h (after) for cars and LCVs. Trucks limited to 100 km/h.

$'000/year	Before	After	Change	
Vehicle operating costs	220,368	227,241	6,873	3.1 %
Time costs	140,418	123,035	-17,382	-12.4 %
Crash costs	10,996	17,497	6,501	59.1%
Air pollution costs	6,282	6,650	368	5.9 %
Total	**378,065**	**374,424**		
Change			**-3,641**	**-1.0 %**

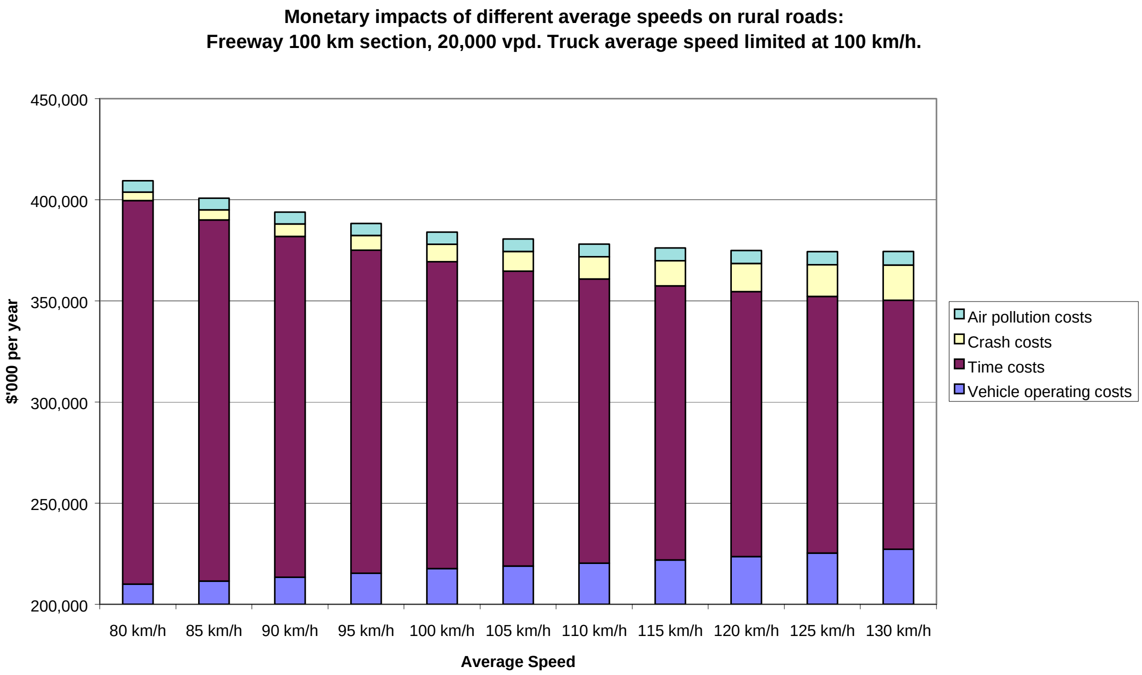
If 'willingness to pay' values of road trauma were used, the annual crash costs would increase by $11.21 million from $18.81 million per 100 kilometres of rural freeway, compared with an estimated increase of $6.5 million per annum using human capital costs. The total economic impact associated with the increase in speed limit would then be an additional annual cost of $1.07 million per year, or 0.3% of the total impact with the 110 km/h speed limit.

Under this scenario, using human capital costs of road trauma, the optimum speed which minimises the total economic impact overall and for cars and LCVs in particular was 125 km/h (Table 6.2.2 and Figure 6.2.1).

Table 6.2.2: Economic impact of different average speeds on rural freeways. Truck speeds same as cars and LCVs up to 100 km/h, then limited to 100 km/h.

						Car average speed (Truck average speed fixed at 100 km/h)					
$'000/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
Vehicle op. costs	209,942	211,512	213,315	215,353	217,623	218,938	220,368	221,914	223,574	225,350	227,241
Time costs	189,645	178,489	168,573	159,701	151,716	145,798	140,418	135,505	131,002	126,859	123,035
Crash costs	4,154	5,060	6,101	7,289	8,636	9,750	10,996	12,384	13,924	15,624	17,497
Air pollution costs	5,675	5,781	5,887	5,993	6,098	6,190	6,282	6,374	6,466	6,558	6,650
Total	**409,416**	**400,842**	**393,877**	**388,335**	**384,074**	**380,676**	**378,065**	**376,177**	**374,966**	**374,392**	**374,424**
of which:											
Cars & LCVs	310,135	302,617	296,326	291,111	286,853	283,455	280,843	278,956	277,745	**277,171**	277,202
Trucks	99,280	98,226	97,551	97,224	**97,221**	97,221	97,221	97,221	97,221	97,221	97,221

Figure 6.2.1: Rural freeways – Trucks limited to 100 km/h.



6.3 VARIABLE SPEED LIMIT

Another scenario considered for rural freeways was an increase in the basic speed limit for cars and light commercial vehicles to 130 km/h (or 120 km/h) under good conditions, accompanied by a reduced limit under adverse conditions such as poor light, bad weather or dense traffic, i.e. a variable speed limit (VSL) system.

The potential for such a system depends on the proportion of traffic and crashes appearing on rural freeways under such adverse conditions. The ATSB Fatal Accident file was interrogated to determine the proportion of fatal crashes on sealed rural roads which occurred during fog, rain and night conditions. During 1996-1999, only 2.1% of fatal crashes on rural roads were recorded as occurring during fog, and 9.8% during rain (1.9% during heavy rain). If these adverse conditions are associated with increased risk of a fatal crash, then even smaller proportions of the traffic on rural roads must have experienced each of these conditions. The application of a VSL system to reduce the speeds and hence the road trauma on rural roads during fog and/or (heavy) rain conditions would appear to have very limited potential.

However the proportion of fatal crashes occurring at night on rural roads during 1996-1999 was 37%. There were suggestions that this proportion was somewhat higher on rural freeways and divided roads, but there were relatively few crashes on these roads compared with two-lane undivided roads and the apparent difference may not be reliable.

There is evidence that the fatal crash rate per million VKT is higher at night than during the day, with a study of Australian fatal crash risks estimating the relative risk to be 10:1 (Anderson, Montesin and Adena 1989). If this relative risk is still the case, it implies that the proportion of traffic at night is only 5-6%. This was considered an unreasonably low estimate. The risk of a fatal crash at night may be inflated by the higher speeds under less congested traffic conditions and by other risk factors associated with night driving (drink-driving and discretionary travel by young, inexperienced drivers).

Against this background, the scenario for a VSL on rural freeways was based on an assumed doubling of the casualty crash rate per million VKT during night conditions and the assumption that 20% of traffic occurs at night. While there may be questions about the realism of these assumptions, the scenario serves to illustrate the outcome of a VSL based on any adverse road condition which approximately doubles the crash rate and affects about 20% of rural traffic (Appendix F). To maintain the balance implicit in the Austroads overall crash rate (all times of day) of 0.06875 casualty crashes per million VKT (Mclean 2001), it was calculated that the daytime crash rate would be 25% less than the all-times average, under the above assumptions. Thus the daytime crash rate was reduced by 25% while the night-time rate was doubled when considering the VSL scenarios. In total, across all times of day, this produces the same crash numbers and costs under existing conditions as that estimated for the base scenario (Table 6.1.1).

6.3.1 Basic speed limit raised to 130 km/h

Under this scenario the basic speed limit was raised to 130 km/h for cars and light commercial vehicles, but not trucks, during day-time. At night, the speed limit for cars and light commercial vehicles was reduced to 100 km/h (from the existing 110 km/h). Average speeds were assumed to change accordingly. The speed limit for trucks was fixed at 100 km/h during all times of day.

The travel time savings per vehicle during daytime would be the same as in the base scenario, but at night there would be an increase of 5.5 minutes for cars and light commercial vehicles travelling over each 100 km of freeway. Averaged over all times of day, there would be a saving of 5.6 minutes for these vehicles. There would be no change in travel times for trucks

Casualty crashes at night would be reduced, so that the overall impact of the VSL across all times of day would be an additional 0.7 fatal crashes, 3.7 serious injury crashes and 4.9 less-serious injury crashes per 100 km of freeway per year (Appendix F), i.e. less than half the crash increases associated with the scenario whereby the speed limit for cars and LCVs was increased to 130 km/h during all times of day.

When the impacts under day and night conditions are aggregated, the net impact is an annual saving of $3.48 million per 100 kilometres of rural freeway (Table 6.3.1). This is slightly less than the estimated saving of $3.64 million per annum if the speed limit for cars and LCVs was increased to 130 km/h at all times of day. However, the VSL produces a substantially smaller increase in crash costs ($2.96 million per annum, or 27%) compared with the increase if the speed limit were increased at all times of day ($6.50 million per annum; Table 6.2.1).

Table 6.3.1: Economic impact of variable speed limits on rural freeways. Day speed limit for cars and LCVs raised to 130 km/h, night speed limit reduced to 100 km/h. Truck speed limit fixed at 100 km/h.

	Day Average Speed (km/h)				Night Average Speed (km/h)				Total Impact of VSL			
Cars & LCVs	**110**	**130**			**110**	**100**						
Trucks	**100**	**100**			**100**	**100**			Total of night and day changes			
$'000/year	**Before**	**After**	**Change**		**Before**	**After**	**Change**		**Before**	**After**	**Change**	
Vehicle op. costs	176,295	181,793	5,498	3.1 %	44,074	43,525	-549	-1.2 %	220,368	225,318	4,949	2.2 %
Time costs	112,334	98,428	-13,906	-12.4 %	28,084	30,343	2,260	8.0 %	140,418	128,771	-11,646	-8.3 %
Crash costs	6,598	10,498	3,901	59.1%	4,399	3,455	-944	-21.5%	10,996	13,953	2,957	26.9%
Air pollution costs	5,026	5,320	294	5.9 %	1,256	1,220	-37	-2.9 %	6,282	6,540	258	4.1 %
Total	**300,252**	**296,040**			**77,812**	**78,542**			**378,065**	**374,582**		
Change			**-4,213**	**-1.4 %**			**730**	**0.9 %**			**-3,483**	**-0.9 %**

If 'willingness to pay' values of road trauma were used, the annual crash costs would increase by $5.13 million from $18.81 million per 100 kilometres of rural freeway, compared with the estimated increase of $2.96 million per annum using human capital costs. The total economic impact associated with the increase in speed limit would reduce to an annual saving of $1.31 million per year, or 0.3% of the total impact with the 110 km/h speed limit.

6.3.2 Basic speed limit increased to 120 km/h

The findings in Table 6.3.1 were based on increasing the daytime speeds above the average speed of 125 km/h which had been previously identified as the optimum speed for cars and LCVs on rural freeways during analysis of the base scenario (section 6.1.1). For this reason, a VSL in which their daytime speed limit was increased to 120 km/h was also examined (Table 6.3.2).

Table 6.3.2: Economic impact of variable speed limits on rural freeways. Day speed limit for cars and LCVs raised to 120 km/h, night speed limit reduced to 100 km/h. Truck speed limit fixed at 100 km/h.

	Day Average Speed (km/h)				Night Average Speed (km/h)				Total Impact of VSL			
Cars & LCVs	**110**	**120**			**110**	**100**						
Trucks	**100**	**100**			**100**	**100**			Total of night and day changes			
$'000/year	**Before**	**After**	**Change**		**Before**	**After**	**Change**		**Before**	**After**	**Change**	
Vehicle op. costs	176,295	178,860	2,565	1.5 %	44,074	43,525	-549	-1.2 %	220,368	222,384	2,016	0.9 %
Time costs	112,334	104,802	-7,532	-6.7 %	28,084	30,343	2,260	8.0 %	140,418	135,145	-5,273	-3.8 %
Crash costs	6,598	8,354	1,756	26.6%	4,399	3,455	-944	-21.5%	10,996	11,809	812	7.4%
Air pollution costs	5,026	5,173	147	2.9 %	1,256	1,220	-37	-2.9 %	6,282	6,393	110	1.8 %
Total	**300,252**	**297,188**			**77,812**	**78,542**			**378,065**	**375,730**		
Change			**-3,064**	**-1.0 %**			**730**	**0.9 %**			**-2,334**	**-0.6 %**

Under this scenario, compared with the increase in the daytime speed limit to 130 km/h, the increase in casualty crashes during the day would be less, resulting in an overall increase of 0.2 fatal crashes, 1.0 serious injury crashes and 1.3 less-serious injury crashes per 100 km of freeway, compared with existing speed conditions. Although travel time would be increased at night, there would still be overall savings of 2.5 minutes for cars and light commercial vehicles per 100 km of freeway, averaged across all times of day.

Thus a VSL with a basic speed limit of 120 km/h, reducing to 100 km/h at night for cars and light commercial vehicles, (but fixed at 100 km/h for trucks), is estimated to produce an annual saving in total costs of $2.33 million per 100 kilometres of rural freeway (Table 6.3.2). This would be achieved by constraining the increase in crash costs to 7.4% and the increase in operating costs to only 0.9%, while providing almost 4% saving in travel time costs on rural freeways. A base scenario where speeds of cars and LCVs were increased to 120 km/h at all times of day is estimated to increase crash costs by 27% to provide a 6.7% saving in travel time costs.

If 'willingness to pay' values of road trauma were used, the annual crash costs would increase by $1.41 million from $18.81 million per 100 kilometres of rural freeway, compared with the estimated increase of $812,000 per annum using human capital costs. The total economic impact associated with the increase in speed limit would reduce to an annual saving of $1.74 million per year, or 0.4% of the total impact with the 110 km/h speed limit.

7. RURAL DIVIDED ROADS

Analysis of the total economic cost from road trauma, air pollutants, travel time, and vehicle operating costs was conducted for a hypothetical 100 km section of rural divided road. The average annual daily traffic (AADT) on this section was assumed to be 15,000 vehicles per day, and the traffic mix was assumed to be the same as on rural freeways.

The casualty crash rate was assumed to be 0.1125 crashes per million VKT, derived from Austroads research (Mclean 2001), under existing speed conditions. Current average speeds were taken to be the same as the speed limit (assumed 110 km/h) in the case of light vehicles (cars and light commercial vehicles) and 100 km/h in the case of trucks (rigid and articulated).

7.1 SPEED LIMIT RAISED FROM 110 TO 130 KM/H

7.1.1 Base scenario

The economic impact of raising the speed limit from 110 to 130 km/h was estimated by assuming that the average speeds for all types of vehicles would increase to 130 km/h. The base scenario considered placed value on leisure time travel (see section 4.2) and valued road trauma using the Human Capital method (see section 4.1). Details of the analysis are given in Appendix G.

Under this scenario, the travel time savings per vehicle over 100 km would be 8.4 minutes for cars and light commercial vehicles, and 13.8 minutes for each truck. Over the same 100 km of divided road, it is estimated that there would be an additional 3.4 fatal crashes, 13.6 serious injury crashes and 17.2 less-serious injury crashes per year (Appendix G).

It was estimated that annual vehicle operating costs would increase by $11.84 million, crash costs by $12.06 million and air pollution costs by $338,000, per 100 kilometres of rural divided road (Table 7.1.1). Travel time costs would reduce by $17.79 million per year. The total economic impact was estimated to increase by $6.45 million per annum, or 2.2% of the total impact with the 110 km/h speed limit.

Table 7.1.1: Economic impact of raising speed limit on rural divided roads from 110 km/h (before) to 130 km/h (after).

$'000/year	Before	After	Change	
Vehicle operating costs	165,276	177,114	11,837	7.2 %
Time costs	105,313	87,528	-17,785	-16.9 %
Crash costs	13,496	25,559	12,063	89.4%
Air pollution costs	4,712	5,049	338	7.2 %
Total	**288,797**	**295,250**		
Change			**6,454**	**2.2 %**

The speed which minimises the total economic impact, as valued in this base scenario for rural divided roads, is 110 km/h (Table 7.1.2 and Figure 7.1.1). However, the optimum speed differs substantially by vehicle type (shown in bold at the foot of Table 7.1.2). It was estimated as 120 km/h for cars and LCVs and 95 km/h for trucks (Figure 7.1.2).

Table 7.1.2: Economic impact of different average speeds on rural divided roads.

$'000/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
Vehicle op. costs	157,456	158,634	159,987	161,514	163,217	165,096	167,149	169,377	171,781	174,360	177,114
Time costs	142,234	133,867	126,430	119,776	113,787	108,369	103,443	98,945	94,823	91,030	87,528
Crash costs	5,098	6,210	7,488	8,946	10,599	12,464	14,557	16,895	19,496	22,377	25,559
Air pollution costs	4,256	4,336	4,415	4,494	4,574	4,653	4,732	4,812	4,891	4,970	5,049
Total	**309,044**	**303,047**	**298,319**	**294,730**	**292,177**	**290,581**	**289,881**	**290,029**	**290,990**	**292,737**	**295,250**
of which:											
Cars & LCVs	234,106	228,789	224,439	220,946	218,225	216,208	214,844	214,091	**213,917**	214,299	215,216
Trucks	74,938	74,258	73,881	**73,784**	73,953	74,373	75,037	75,938	77,073	78,438	80,034

Figure 7.1.1: Rural divided roads – Base scenario.

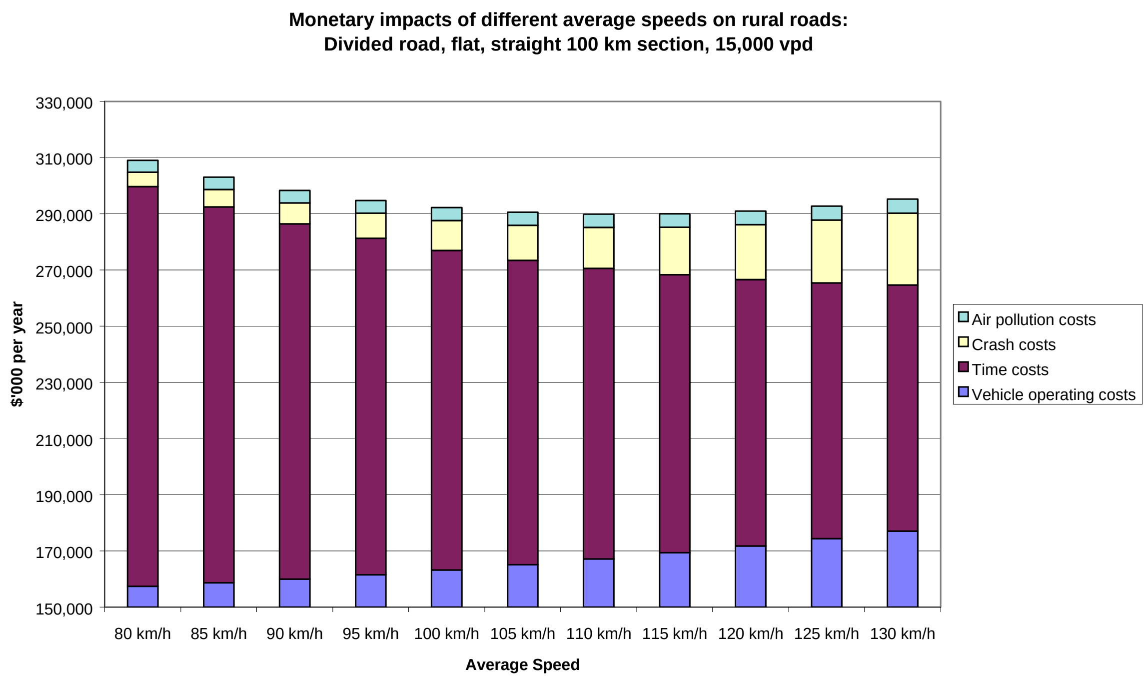
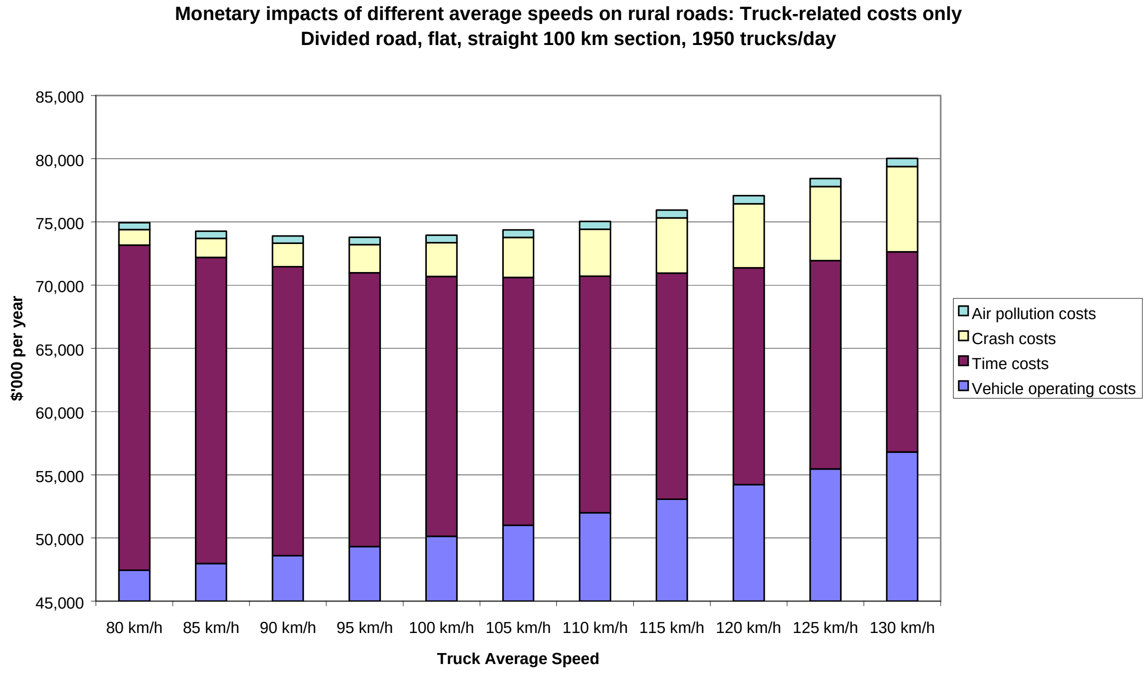


Figure 7.1.2: Rural divided roads – Base scenario. Truck-related costs.



7.1.2 Leisure travel time not valued

The base scenario was modified by placing zero value on leisure travel time to test the sensitivity of the total economic impact to this assumption (Appendix H).

Under this scenario, the annual saving in travel time costs would reduce from $17.79 million to $13.83 million per 100 kilometres of rural divided road (Table 7.1.3). The total economic impact associated with the increase in speed limit would then be about $10.41 million per year, or 4.0% of the total impact with the 110 km/h speed limit.

Table 7.1.3: Economic impact of raising speed limit on rural divided roads from 110 km/h (before) to 130 km/h (after). Leisure travel time not valued.

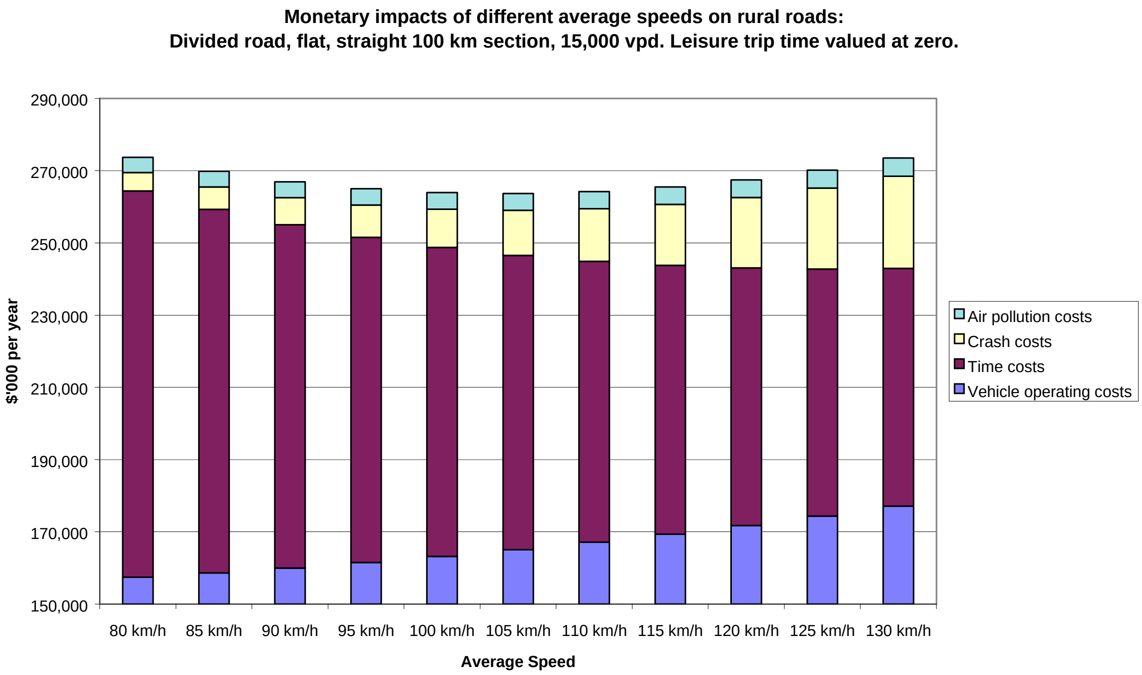
$'000/year	Before	After	Change	
Vehicle operating costs	165,276	177,114	11,837	7.2 %
Time costs	79,629	65,795	-13,833	-17.4 %
Crash costs	13,496	25,559	12,063	89.4%
Air pollution costs	4,712	5,049	338	7.2 %
Total	**263,112**	**273,517**		
Change			**10,405**	**4.0 %**

When a range of average speeds was considered, the speed which minimised the total economic impact was 105 km/h (Table 7.1.4 and Figure 7.1.3). The optimum speed for cars and LCVs was estimated to be 110 km/h. The economic impact related to trucks, and the optimum speed of 95 km/h, were unchanged because the analysis did not include any use of trucks for leisure travel.

Table 7.1.4: Economic impact of different average speeds on rural divided roads. Leisure travel time not valued.

$'000/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
Vehicle op. costs	157,456	158,634	159,987	161,514	163,217	165,096	167,149	169,377	171,781	174,360	177,114
Time costs	106,918	100,628	95,038	90,036	85,534	81,461	77,758	74,378	71,278	68,427	65,795
Crash costs	5,098	6,210	7,488	8,946	10,599	12,464	14,557	16,895	19,496	22,377	25,559
Air pollution costs	4,256	4,336	4,415	4,494	4,574	4,653	4,732	4,812	4,891	4,970	5,049
Total	**273,728**	**269,808**	**266,927**	**264,990**	**263,924**	**263,674**	**264,197**	**265,462**	**267,446**	**270,135**	**273,517**
of which:											
Cars & LCVs	198,790	195,550	193,047	191,206	189,972	189,301	**189,160**	189,523	190,373	191,696	193,483
Trucks	74,938	74,258	73,881	**73,784**	73,953	74,373	75,037	75,938	77,073	78,438	80,034

Figure 7.1.3: Rural divided roads – Leisure travel time not valued.



7.1.3 Willingness to pay valuation of road trauma

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

Under this scenario, the annual crash costs would increase by $22.06 million per 100 kilometres of rural divided road (Table 7.1.5), compared with an estimated increase of $12.06 million per annum using human capital costs. The total economic impact associated with the increase in speed limit would then be about $16.45 million per year, or 5.5% of the total impact with the 110 km/h speed limit.

Table 7.1.5: Economic impact of raising speed limit on rural divided roads from 110 km/h (before) to 130 km/h (after). 'Willingness to pay' valuations of crash costs.

$'000/year	Before	After	Change	
Vehicle operating costs	165,276	177,114	11,837	7.2 %
Time costs	105,313	87,528	-17,785	-16.9 %
Crash costs	23,082	45,145	22,062	95.6%
Air pollution costs	4,712	5,049	338	7.2 %
Total	**298,384**	**314,836**		
Change			**16,453**	**5.5 %**

When a range of average speeds was considered, the speed which minimised the total economic impact was 105 km/h (Table 7.1.6 and Figure 7.1.4). The optimum speed for cars and LCVs was estimated to be 110 km/h and that for trucks was estimated to be 90 km/h using the 'willingness to pay' valuations of road trauma. The economic impact related to trucks reflected the higher valuation of their crash costs associated (Figure 7.1.5).

Table 7.1.6: Economic impact of different average speeds on rural divided roads. 'Willingness to pay' valuations of crash costs.

$'000/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
Vehicle op. costs	157,456	158,634	159,987	161,514	163,217	165,096	167,149	169,377	171,781	174,360	177,114
Time costs	142,234	133,867	126,430	119,776	113,787	108,369	103,443	98,945	94,823	91,030	87,528
Crash costs	8,645	10,551	12,757	15,292	18,190	21,482	25,205	29,394	34,087	39,324	45,145
Air pollution costs	4,256	4,336	4,415	4,494	4,574	4,653	4,732	4,812	4,891	4,970	5,049
Total	**312,592**	**307,388**	**303,588**	**301,077**	**299,768**	**299,600**	**300,529**	**302,528**	**305,581**	**309,683**	**314,836**
of which:											
Cars & LCVs	236,619	231,832	228,099	225,318	223,414	222,332	**222,030**	222,479	223,661	225,563	228,181
Trucks	75,973	75,556	**75,490**	75,759	76,354	77,268	78,499	80,049	81,921	84,120	86,655

Figure 7.1.4: Rural divided roads – 'Willingness to pay' valuations of road trauma.

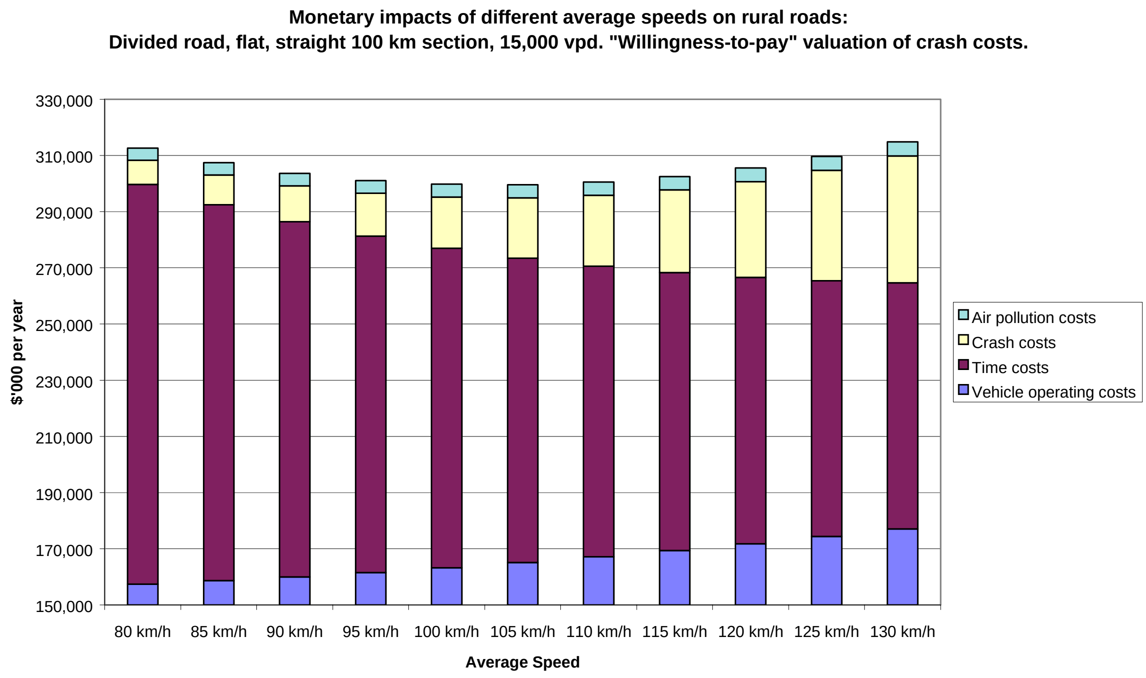
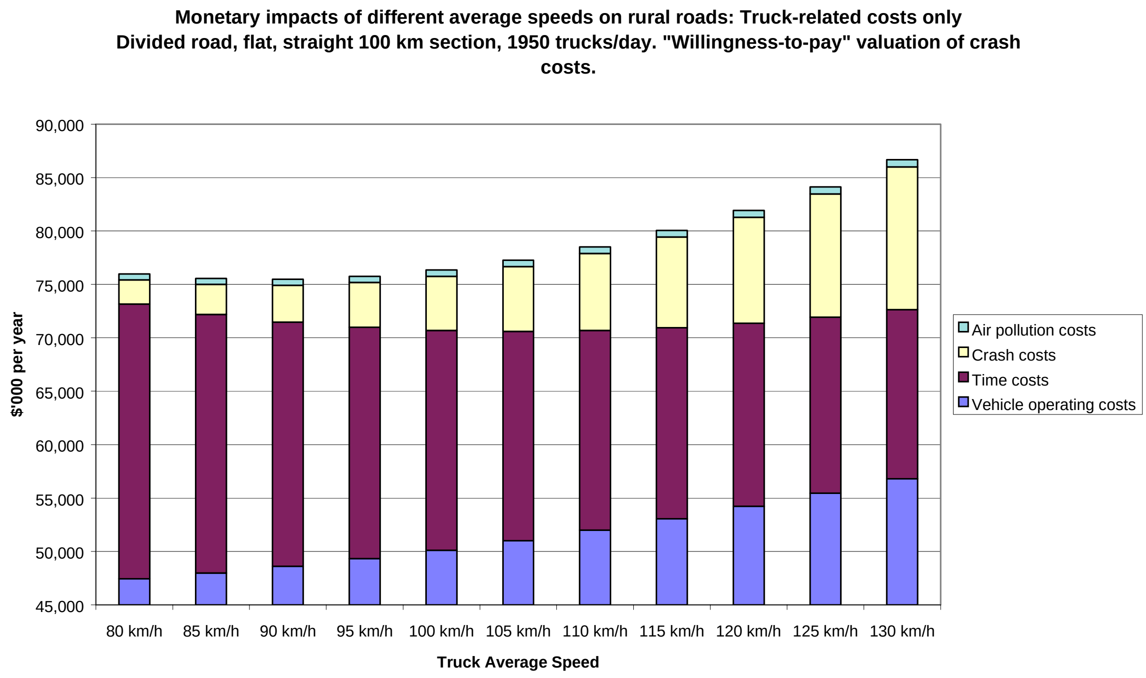


Figure 7.1.5: Rural divided roads – 'Willingness to pay' valuations of road trauma. Truck-related costs.



7.2 TRUCKS LIMITED TO 100 KM/H

A modification to the base scenario for rural divided roads to limit truck speeds to 100 km/h was also considered (Appendix J). Under this scenario, the increase in fatal crashes would be limited to 1.9 per year, serious injury crashes 10.3 per year, and less-serious injury crashes 14.2 per year, on each 100 km section of divided road. The travel time savings for cars and light commercial vehicles would be 8.4 minutes per vehicle per 100 km section, as in the base scenario, but there would be no time savings for trucks because their speeds were assumed to be unchanged.

The total economic impact of raising the speed limit for cars and LCVs under this scenario was estimated to be an annual cost of $372,000 per 100 kilometres of rural divided road (Table 7.2.1). Travel time savings were reduced from $17.79 million per annum to $13.04 million, compared with the base scenario, but there were substantial savings in the increases in crash costs and vehicle operating costs.

Table 7.2.1: Economic impact of raising speed limit on rural divided roads from 110 km/h (before) to 130 km/h (after) for cars and LCVs. Trucks limited to 100 km/h.

$'000/year	Before	After	Change	
Vehicle operating costs	165,276	170,431	5,155	3.1 %
Time costs	105,313	92,276	-13,037	-12.4 %
Crash costs	13,496	21,474	7,978	59.1%
Air pollution costs	4,712	4,988	276	5.9 %
Total	**288,797**	**289,169**		
Change			**372**	**0.1 %**

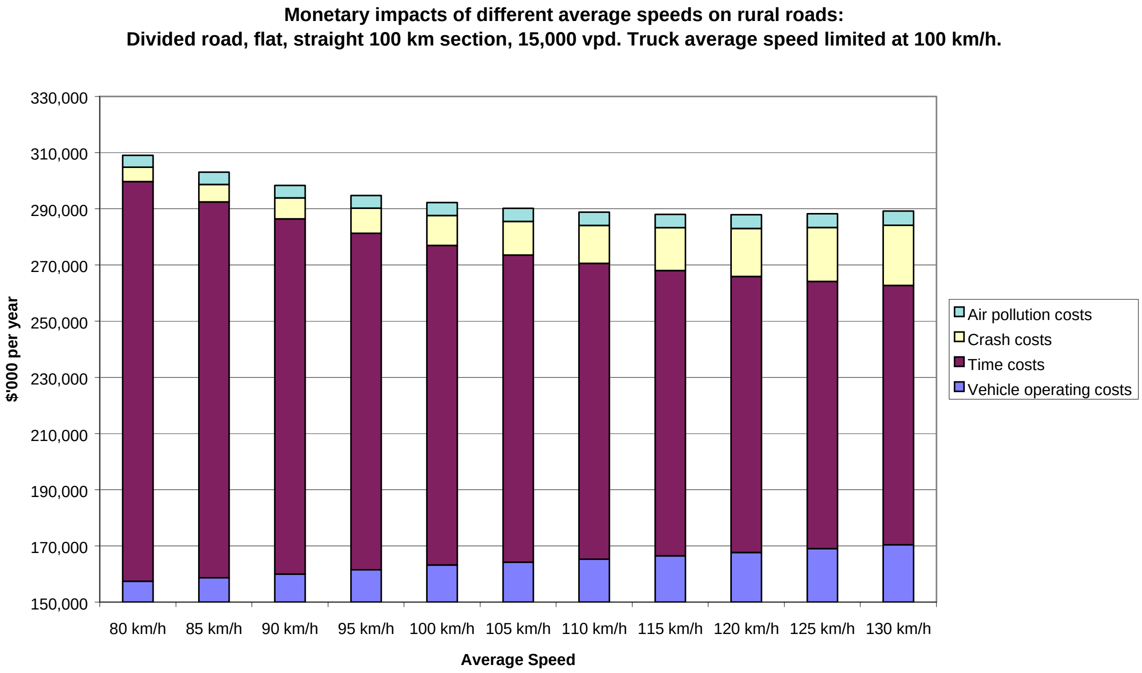
If 'willingness to pay' values of road trauma were used, the annual crash costs would increase by $13.76 million from $23.08 million per 100 kilometres of rural divided road, compared with an estimated increase of $7.98 million per annum using human capital costs. The total economic impact associated with the increase in speed limit would then be an additional annual cost of $6.15 million per year, or 2.1% of the total impact with the 110 km/h speed limit.

Under this scenario, using human capital costs of road trauma, the optimum speed which minimises the total economic impact overall and for cars and LCVs in particular was 120 km/h (Table 7.2.2 and Figure 7.2.1).

Table 7.2.2: Economic impact of different average speeds on rural divided roads. Truck speeds same as cars and LCVs up to 100 km/h, then limited to 100 km/h.

						Car average speed (Truck average speed fixed at 100 km/h)					
$'000/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
Vehicle op. costs	157,456	158,634	159,987	161,514	163,217	164,204	165,276	166,435	167,681	169,013	170,431
Time costs	142,234	133,867	126,430	119,776	113,787	109,348	105,313	101,629	98,252	95,144	92,276
Crash costs	5,098	6,210	7,488	8,946	10,599	11,966	13,496	15,199	17,088	19,175	21,474
Air pollution costs	4,256	4,336	4,415	4,494	4,574	4,643	4,712	4,781	4,850	4,919	4,988
Total	**309,044**	**303,047**	**298,319**	**294,730**	**292,177**	**290,161**	**288,797**	**288,044**	**287,870**	**288,251**	**289,169**
of which:											
Cars & LCVs	234,106	228,789	224,439	220,946	218,225	216,208	214,844	214,091	**213,917**	214,299	215,216
Trucks	74,938	74,258	73,881	**73,784**	73,953	73,953	73,953	73,953	73,953	73,953	73,953

Figure 7.2.1: Rural divided roads – Trucks limited to 100 km/h.



7.3 VARIABLE SPEED LIMIT

Another scenario considered for rural divided roads was an increase in the basic speed limit for cars and light commercial vehicles to 130 km/h (or 120 km/h) under good conditions, accompanied by a reduced limit under adverse conditions such as poor light, bad weather or dense traffic, i.e. a variable speed limit (VSL) system.

The same scenario for a VSL on rural divided roads was considered as that considered for rural freeways, an increase in the speed limit during daytime and a reduction at night to 100 km/h, for cars and light commercial vehicles only. The speed limit for trucks was fixed at 100 km/h during all times of day. This scenario was also based on an assumed doubling of the casualty crash rate per million VKT during night conditions and the assumption that 20% of traffic occurs at night (Appendix K).

7.3.1 Basic speed limit raised to 130 km/h

The travel time savings per vehicle during daytime would be the same as in the base scenario, but at night there would be an increase of 5.5 minutes for cars and LCVs travelling over each 100 km of rural divided road. Averaged over all times of day, there would be a saving of 5.6 minutes for these vehicles, but no change for trucks.

Casualty crashes at night would be reduced, so that the overall impact of the VSL across all times of day would be an additional 0.9 fatal crashes, 4.6 serious injury crashes and 6.0 less-serious injury crashes per 100 km of divided road per year (Appendix K), i.e. less than half the crash increases associated with the base scenario whereby the speed limit for cars and LCVs was increased to 130 km/h during all times of day.

When the impacts under day and night conditions are aggregated, the net impact is an annual saving of $1.20 million per 100 kilometres of rural divided road (Table 7.3.1). This compares with the estimated increase of $0.37 million per annum if the basic speed limit for cars and LCVs was increased to 130 km/h at all times of day. The VSL produces a substantially smaller increase in crash costs ($3.63 million per annum) compared with the increase if the speed limit were increased at all times of day ($7.98 million per annum; Table 7.2.1).

Table 7.3.1: Economic impact of variable speed limits on rural divided roads. Day speed limit for cars and LCVs raised to 130 km/h, night speed limit reduced to 100 km/h. Truck speed limit fixed at 100 km/h.

	Day Average Speed (km/h)				Night Average Speed (km/h)				Total Impact of VSL			
Cars & LCVs	**110**	**130**			**110**	**100**						
Trucks	**100**	**100**			**100**	**100**			Total of night and day changes			
$'000/year	**Before**	**After**	**Change**		**Before**	**After**	**Change**		**Before**	**After**	**Change**	
Vehicle op. costs	132,221	136,345	4,124	3.1 %	33,055	32,643	-412	-1.2 %	165,276	168,988	3,712	2.2 %
Time costs	84,251	73,821	-10,429	-12.4 %	21,063	22,757	1,695	8.0 %	105,313	96,578	-8,735	-8.3 %
Crash costs	8,097	12,884	4,787	59.1%	5,398	4,240	-1,159	-21.5%	13,496	17,124	3,628	26.9%
Air pollution costs	3,769	3,990	221	5.9 %	942	915	-28	-2.9 %	4,712	4,905	193	4.1 %
Total	**228,338**	**227,040**			**60,458**	**60,555**			**288,797**	**287,596**		
Change			**-1,298**	**-0.6 %**			**97**	**0.2 %**			**-1,201**	**-0.4 %**

If 'willingness to pay' values of road trauma were used, the annual crash costs would increase by $6.30 million from $23.08 million per 100 kilometres of rural divided road, compared with the estimated increase of $3.63 million per annum using human capital costs. The economic impact due to the increase in speed limit would increase to an annual cost of $1.47 million per year, or 0.5% of the total impact with the 110 km/h speed limit.

7.3.2 Basic speed limit increased to 120 km/h

The findings in Table 7.3.1 were based on increasing the daytime speeds well above the average speed of 120 km/h which had been previously identified as the optimum speed for cars and LCVs on rural divided roads during analysis of the base scenario (section 7.1.1). For this reason, a VSL in which their speed limit was increased to only 120 km/h was also examined (Table 7.3.2).

Table 7.3.2: Economic impact of variable speed limits on rural divided roads. Day speed limit for cars and LCVs raised to 120 km/h, night speed limit reduced to 100 km/h. Truck speed limit fixed at 100 km/h.

	Day Average Speed (km/h)		Night Average Speed (km/h)		Total Impact of VSL
Cars & LCVs	**110**	**120**	**110**	**100**	
Trucks	**100**	**100**	**100**	**100**	Total of night and day changes

$'000/year	**Before**	**After**	**Change**		**Before**	**After**	**Change**		**Before**	**After**	**Change**	
Vehicle op. costs	132,221	134,145	1,924	1.5 %	33,055	32,643	-412	-1.2 %	165,276	166,788	1,512	0.9 %
Time costs	84,251	78,601	-5,649	-6.7 %	21,063	22,757	1,695	8.0 %	105,313	101,359	-3,954	-3.8 %
Crash costs	8,097	10,253	2,155	26.6%	5,398	4,240	-1,159	-21.5%	13,496	14,492	997	7.4%
Air pollution costs	3,769	3,880	110	2.9 %	942	915	-28	-2.9 %	4,712	4,794	83	1.8 %
Total	**228,338**	**226,878**			**60,458**	**60,555**			**288,797**	**287,434**		
Change			**-1,460**	**-0.6 %**			**97**	**0.2 %**			**-1,363**	**-0.5 %**

Under this scenario, compared with the increase in the daytime speed limit to 130 km/h, the increase in casualty crashes during the day would be less, resulting in an overall increase of 0.3 fatal crashes, 1.3 serious injury crashes and 1.6 less-serious injury crashes per 100 km of divided road, compared with existing speed conditions. Although travel time would be increased at night, there would still be overall savings of 2.5 minutes for cars and light commercial vehicles per 100 km of divided road, averaged across all times of day.

Thus a VSL with a basic speed limit of 120 km/h, reducing to 100 km/h at night for cars and light commercial, (but fixed at 100 km/h for trucks), is estimated to produce an annual saving in total costs of $1.36 million per 100 kilometres of rural divided road (Table 7.3.2). The saving per annum is greater than the saving if the daytime speed limit was increased to 130 km/h (Table 7.3.1). This would be achieved by constraining the increase in crash costs to 7.4% and the increase in operating costs to only 0.9%, while providing almost 4% saving in travel time costs on rural divided roads. A base scenario where speeds of cars and LCVs were increased to 120 km/h at all times of day is estimated to increase crash costs by 27% to provide a 6.7% saving in travel time costs.

If 'willingness to pay' values of road trauma were used, the annual crash costs would increase by $1.73 million from $23.08 million per 100 kilometres of rural divided road, compared with the estimated increase of $997,000 per annum using human capital costs. The total economic impact associated with the increase in speed limit would reduce to an annual saving of $627,000 per year, or 0.2% of the total impact with the 110 km/h speed limit.

8. RURAL UNDIVIDED ROADS

Analysis of the total economic cost from road trauma, air pollutants, travel time, and vehicle operating costs was conducted for each of two hypothetical 100 km sections of two-lane undivided rural road. The first was a hypothetical section of undivided road with 7.0 metre sealed profile, which Austroads research had estimated to have a casualty crash rate of 0.25 crashes per million VKT (Mclean 2001), under existing speed conditions. The second was an undivided road with shoulder sealing and 8.5 metre sealed profile, which Mclean estimated to have a relative crash rate of 0.64, i.e. 0.16 casualty crashes per million VKT.

It was assumed that each 100 km section had an AADT of 1,000 vehicles per day, and that the traffic mix by vehicle type was the same as for other rural road scenarios considered earlier. Current average unimpeded speeds (cruise speeds) were taken to be the same as the speed limit (assumed 100 km/h) in the case of each type of vehicle. Analysis was conducted for straight roads of each type and then for the same types of roads with curvy alignment (requiring slowing on some bends) and crossroads (with the threat of interacting traffic) and passing through towns (requiring stopping at traffic lights or for other reasons). These latter roads were considered to be more typical of undivided rural roads in Australia, with the attendant increases in crash risk, emission outputs and fuel consumption.

8.1 STANDARD 7.0 M SEALED ROADS

8.1.1 Straight roads without stops (Base scenario)

Under the scenario of raising the speed limit to 130 km/h for all vehicles, and assuming that average speeds would follow, the travel time savings per vehicle over 100 km would be 13.8 minutes for each type of vehicle. Over the same 100 km of lower standard (7.0 m sealed) undivided road, it is estimated that there would be an additional 0.8 fatal crashes, 3.3 serious injury crashes and 4.1 less-serious injury crashes per year (Appendix L).

The economic impact of raising the speed limit from 100 to 130 km/h on the undivided rural roads was estimated to be an increase of $2.04 million per 100 kilometres of road per annum (Table 8.1.1). This was mainly due to the increase in crash costs.

Table 8.1.1: Economic impact of raising speed limit on undivided 7.0 m sealed rural roads from 100 km/h (before) to 130 km/h (after).

$'000/year	**Before**	**After**	**Change**	
Vehicle operating costs	10,881	11,808	926	8.5 %
Time costs	7,586	5,835	-1,751	-23.1 %
Crash costs	1,999	4,832	2,833	141.7%
Air pollution costs	305	337	32	10.4 %
Total	**20,771**	**22,812**		
Change			**2,040**	**9.8 %**

The speed at which the total economic impact is minimised on such roads is 95 km/h (Table 8.1.2 and Figure 8.1.1). The optimum speed for cars and LCVs was estimated as 100 km/h and estimated as 85 km/h for trucks (Figure 8.1.2).

Table 8.1.2: Economic impact of different average speeds on undivided 7.0 m sealed rural roads.

$'000/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
Vehicle op. costs	10,497	10,576	10,666	10,768	10,881	11,006	11,143	11,292	11,452	11,624	11,808
Time costs	9,482	8,924	8,429	7,985	7,586	7,225	6,896	6,596	6,322	6,069	5,835
Crash costs	960	1,170	1,411	1,687	1,999	2,352	2,748	3,191	3,683	4,229	4,832
Air pollution costs	284	289	294	300	305	310	315	321	326	331	337
Total	**21,223**	**20,959**	**20,800**	**20,739**	**20,771**	**20,893**	**21,103**	**21,400**	**21,783**	**22,253**	**22,812**
of which:											
Cars & LCVs	16,127	15,885	15,724	15,638	**15,624**	15,677	15,797	15,982	16,231	16,546	16,926
Trucks	5,096	**5,074**	5,076	5,100	5,147	5,216	5,306	5,418	5,552	5,707	5,886

Figure 8.1.1: Rural undivided 7.0 m sealed roads – Base scenario.

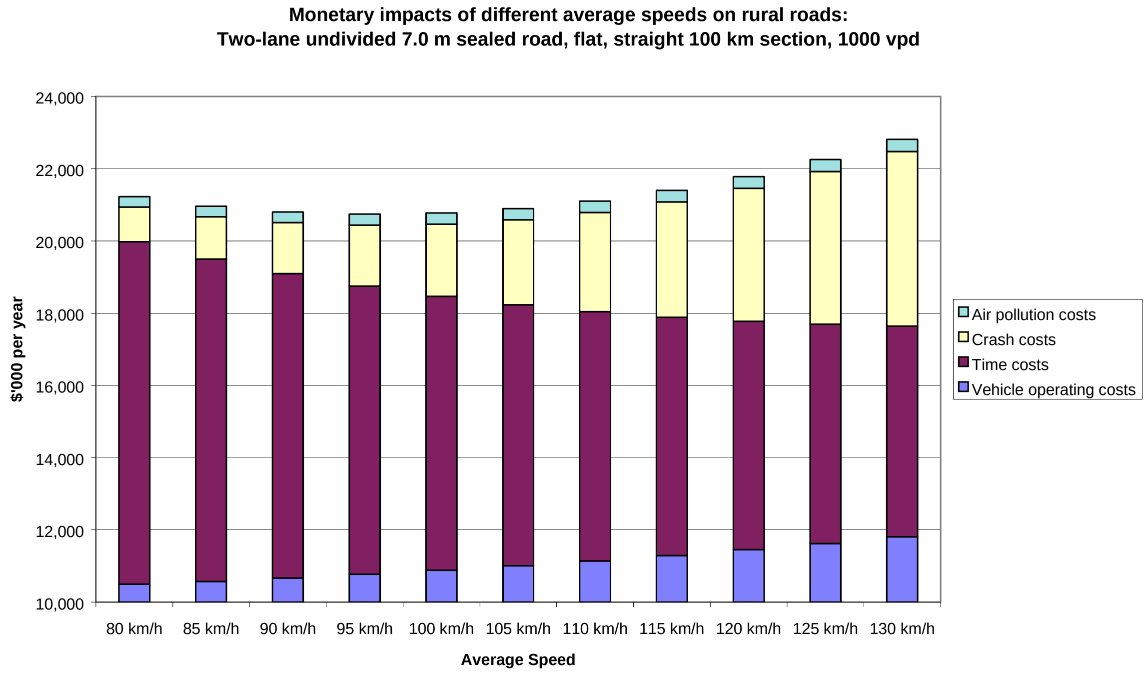
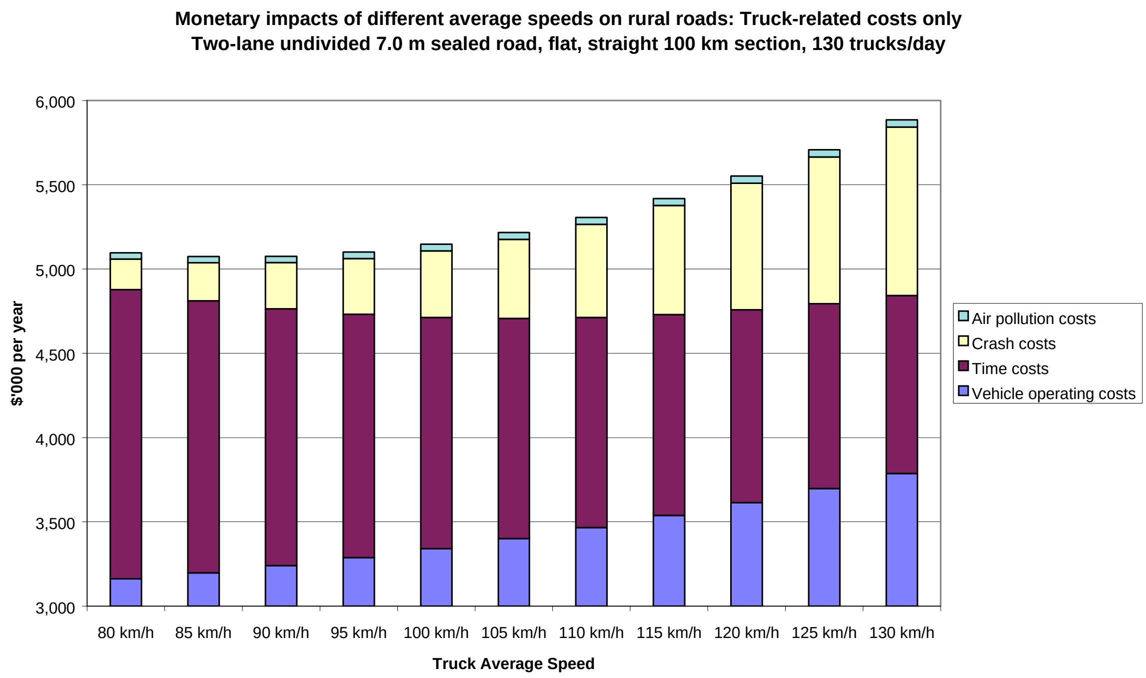


Figure 8.1.2: Rural undivided 7.0 m sealed roads – Base scenario. Truck-related costs.



8.1.2 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. Adjustments to the base scenario to take into the increased economic impact of increased road trauma, operating costs and emissions, and decreased travel times, associated with each cruise speed are outlined below.

8.1.2.1 Crash rates on curvy 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 2.5th 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 an Australian rural road section, these densities were taken as the same in Australia (recognising that this may overstate the frequency of such features in roads in some parts of Australia). 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 the existing casualty crash rate on curvy 7.0 m sealed undivided roads with crossroads was taken as 0.25 x 111.42% = 0.279 casualty crashes per 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 Nilsson's (1984) relationships (see Section 3.1.2) using the change in cruise speeds, not the change in average speeds over the 100 km 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 average speeds under cruise conditions, not the average speed over a whole section (especially where significant slowing and stopping is involved).

8.1.2.2 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, 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 the emission rates rise substantially associated 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 130 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 8.1.3).

Table 8.1.3: 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	49.22	0.097	75.23	94.055	80
85	0.424	52.77	0.156	77.99	90.946	85
90	0.485	56.15	0.216	80.62	87.736	90
95	0.555	59.75	0.286	83.44	84.021	95
100	0.635	63.53	0.366	86.41	79.789	100
105	0.720	67.25	0.452	89.34	75.250	105
110	0.820	71.24	0.551	92.48	69.968	110
115	0.934	75.40	0.661	95.64	64.147	115
120	1.062	79.67	0.793	99.12	57.151	120
125	1.213	84.21	0.944	102.70	49.163	125
130	1.390	89.02	1.122	106.46	39.745	130

Together this information was used to estimate the average speed and speed variance associated with three stops and 50 sharp curves over the 100 km section. 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 8.1.4). 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 8.1.4: 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
85	84.04	34.79	1.073	1.115	1.136	1.144
90	88.49	52.44	1.133	1.211	1.254	1.270
95	92.76	73.62	1.209	1.332	1.406	1.435
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
115	107.49	260.97	2.145	3.068	3.899	4.290
120	110.43	333.69	2.673	4.184	5.740	6.517
125	112.99	417.04	3.433	5.914	8.880	10.465
130	115.09	511.42	4.546	8.642	14.425	17.755

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, multiplied by the resource cost of fuel (taken as 50 cents per litre), and added to the fixed cost parameter (C_0) of the Austroads vehicle operating cost model (Thoresen et al 2003) for each vehicle type (see section 3.2).

As noted in section 3.4, in the absence of better information, the emission coefficients were applied to each type of vehicle (cars, LCVs and trucks). This may under- or over-estimate the pollution from some types of vehicle when examined separately, but in aggregate the total pollution from the full mix of vehicle types in rural traffic should be close to correct.

8.1.2.3 Travel times on curvy roads

The travel times 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 above, 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 other scenarios on straight roads without stopping, the cruise speed and the average speed were considered to be equal (and usually the same as the speed limit under consideration).

8.1.2.4 Economic impacts of speed changes on curvy roads

The estimated effect of raising the speed limit from 100 to 130 km/h on lower standard undivided rural roads transiting through curvy terrain with crossroads and towns was to increase the average speed from 96.8 km/h to 115.1 km/h. This would result in travel time savings of 9.8 minutes per vehicle over 100 km. Over the same 100 km of lower standard undivided road, it is estimated that there would be an additional 0.9 fatal crashes, 3.7 serious injury crashes and 4.6 less-serious injury crashes per year (Appendix M).

The economic impact was estimated to be an increase of $14.78 million per 100 kilometres of road per annum (Table 8.1.5). This was mainly due to the increase in vehicle operating costs, to a much greater extent than the increase associated with an increased speed limit on the same quality roads with straight alignment and without crossroads and towns. There were also relatively large increases in air pollution costs.

Table 8.1.5: Economic impact of raising speed limit on undivided 7.0 m sealed rural roads from 100 km/h (before) to 130 km/h (after). Curvy roads with crossroads and towns.

$'000/year	**Before**	**After**	**Change**	
Vehicle operating costs	11,793	22,183	10,389	88.1 %
Time costs	7,835	6,591	-1,244	-15.9 %
Crash costs	2,228	5,384	3,156	141.7%
Air pollution costs	436	2,915	2,479	568.8 %
Total	**22,292**	**37,073**		
Change			**14,781**	**66.3 %**

The speed at which the total economic impact is minimised on such roads is 85 km/h (Table 8.1.6 and Figure 8.1.3). The optimum speed for cars and LCVs was estimated as 85 km/h and estimated as less than or equal to 80 km/h for trucks (Figure 8.1.4).

Table 8.1.6: Economic impact of different average speeds on undivided 7.0 m sealed rural roads. Curvy roads with crossroads and towns.

$'000/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
Vehicle op. Costs	10,651	10,789	11,056	11,380	11,793	12,519	13,359	14,642	16,346	18,742	22,183
Time costs	9,550	9,026	8,572	8,178	7,835	7,537	7,279	7,057	6,869	6,714	6,591
Crash costs	1,069	1,303	1,572	1,879	2,228	2,621	3,062	3,555	4,104	4,712	5,384
Air pollution costs	304	317	379	385	436	541	673	908	1,268	1,869	2,915
Total	**21,574**	**21,436**	**21,580**	**21,821**	**22,292**	**23,217**	**24,373**	**26,162**	**28,588**	**32,037**	**37,073**
of which:											
Cars & LCVs	16,390	**16,241**	16,302	16,428	16,725	17,344	18,130	19,364	21,055	23,479	27,052
Trucks	5,184	5,195	5,278	5,394	5,567	5,873	6,243	6,798	7,534	8,559	10,022

Figure 8.1.3: Rural undivided 7.0 m sealed roads – Curvy roads with crossroads and towns.

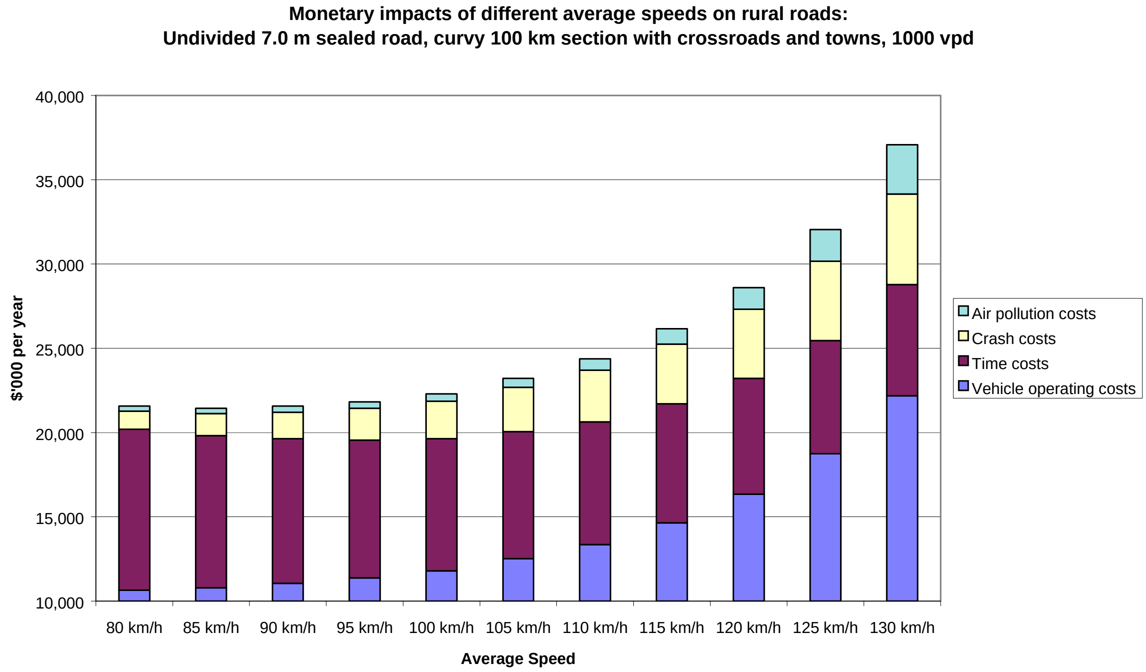
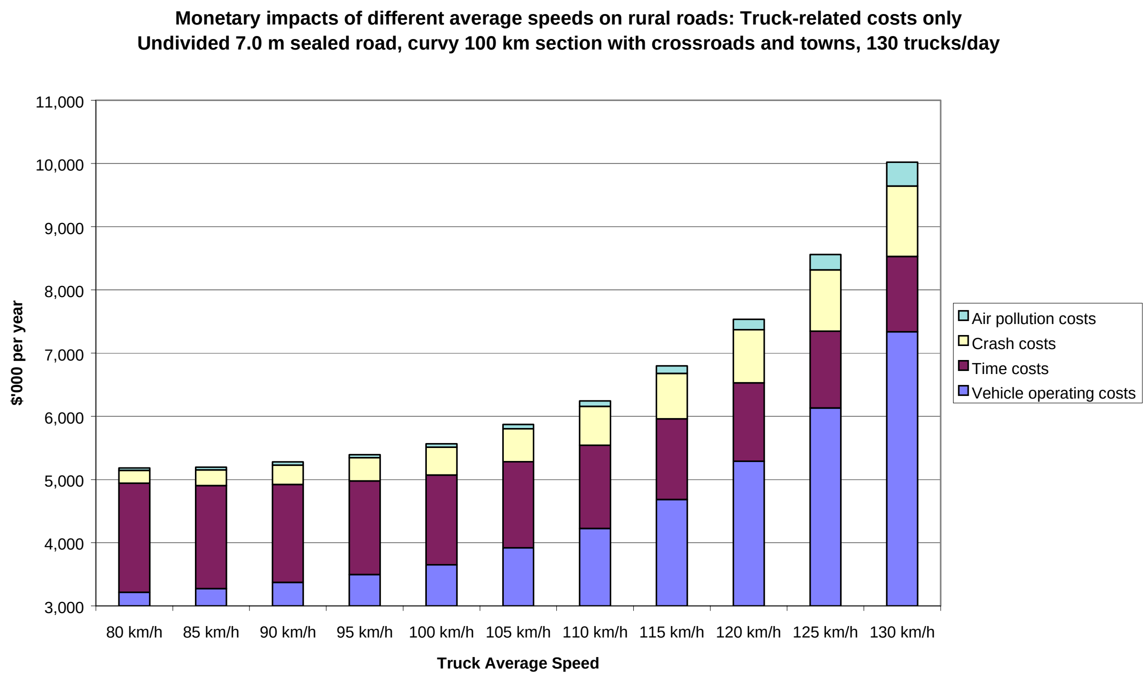


Figure 8.1.4: Rural undivided 7.0 m sealed roads – Curvy roads with crossroads and towns. Truck-related costs.



8.2 SHOULDER-SEALED 8.5 M UNDIVIDED ROADS

8.2.1 Straight roads without stops (Base scenario)

Under the scenario of raising the speed limit to 130 km/h on the higher standard (8.5 m shoulder-sealed) for all vehicles, and assuming that average speeds would follow, the travel time savings per vehicle over 100 km would be 13.8 minutes for each type of vehicle. Over the same 100 km of higher standard undivided road, it is estimated that there would be an additional 0.5 fatal crashes, 2.1 serious injury crashes and 2.6 less-serious injury crashes per year (Appendix N).

The economic impact of raising the speed limit from 110 to 130 km/h on these undivided rural roads was estimated to be an increase of $1.02 million per 100 kilometres of road per annum (Table 8.2.1). This increase in crash costs was substantially less than that estimated for the lower standard undivided rural roads if its speed limit was increased to the same extent. (These calculations assume equal traffic volumes on higher standard and lower standard undivided roads. In practice, traffic volumes are likely to be higher on the better roads, so the number of additional casualties and the cost increase per 100 km section could be higher on these roads. However, traffic volumes do not affect the conclusion that the percentage increase in total costs would be lower on the better roads: this is a function of the lower base crash rates on these roads.)

Table 8.2.1: Economic impact of raising speed limit on undivided 8.5 m shoulder-sealed rural roads from 100 km/h (before) to 130 km/h (after).

$'000/year	**Before**	**After**	**Change**	
Vehicle operating costs	10,881	11,808	926	8.5 %
Time costs	7,586	5,835	-1,751	-23.1 %
Crash costs	1,280	3,093	1,813	141.7%
Air pollution costs	305	337	32	10.4 %
Total	**20,051**	**21,072**		
Change			**1,021**	**5.1 %**

The speed at which the total economic impact is minimised on the higher standard undivided roads is 105 km/h (Table 8.2.2 and Figure 8.2.1). The optimum speed for cars and LCVs was estimated as 105 km/h and estimated as 90 km/h for trucks (Figure 8.2.2).

Table 8.2.2: Economic impact of different average speeds on undivided 8.5 m shoulder-sealed rural roads.

$'000/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
Vehicle op. costs	10,497	10,576	10,666	10,768	10,881	11,006	11,143	11,292	11,452	11,624	11,808
Time costs	9,482	8,924	8,429	7,985	7,586	7,225	6,896	6,596	6,322	6,069	5,835
Crash costs	614	749	903	1,079	1,280	1,505	1,759	2,042	2,357	2,707	3,093
Air pollution costs	284	289	294	300	305	310	315	321	326	331	337
Total	**20,877**	**20,538**	**20,292**	**20,132**	**20,051**	**20,047**	**20,114**	**20,251**	**20,457**	**20,731**	**21,072**
of which:											
Cars & LCVs	15,847	15,545	15,315	15,150	15,046	**14,999**	15,006	15,066	15,176	15,336	15,546
Trucks	5,030	4,993	**4,977**	4,982	5,005	5,047	5,107	5,185	5,281	5,394	5,526

Figure 8.2.1: Rural undivided 8.5 m shoulder-sealed roads – Base scenario.

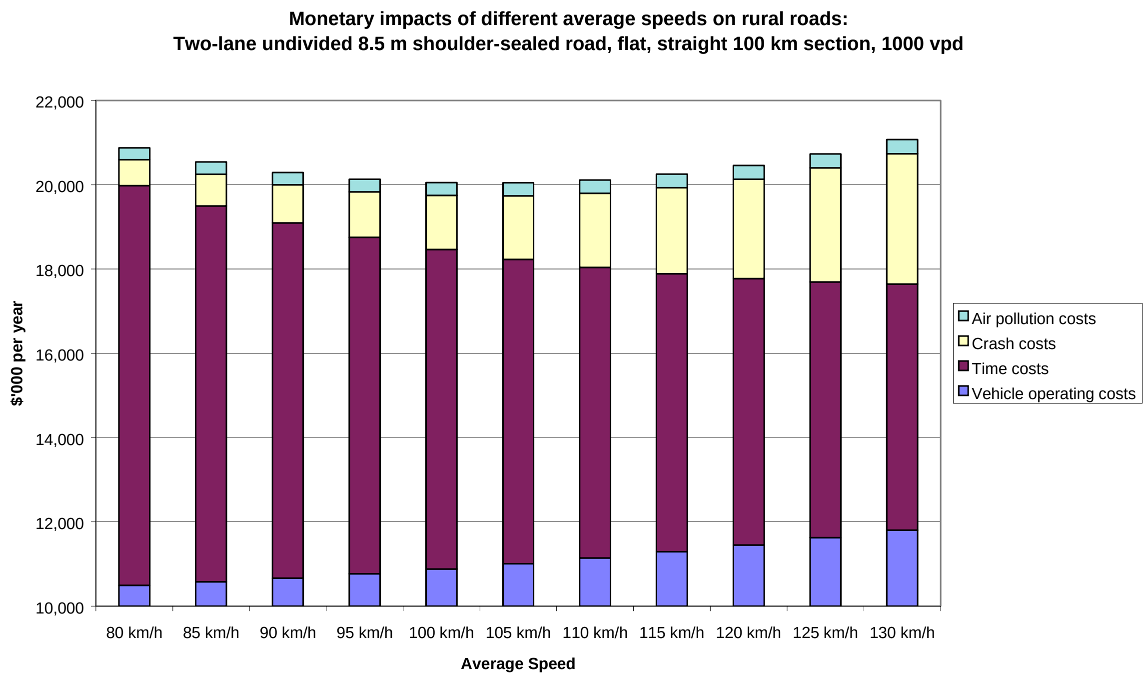
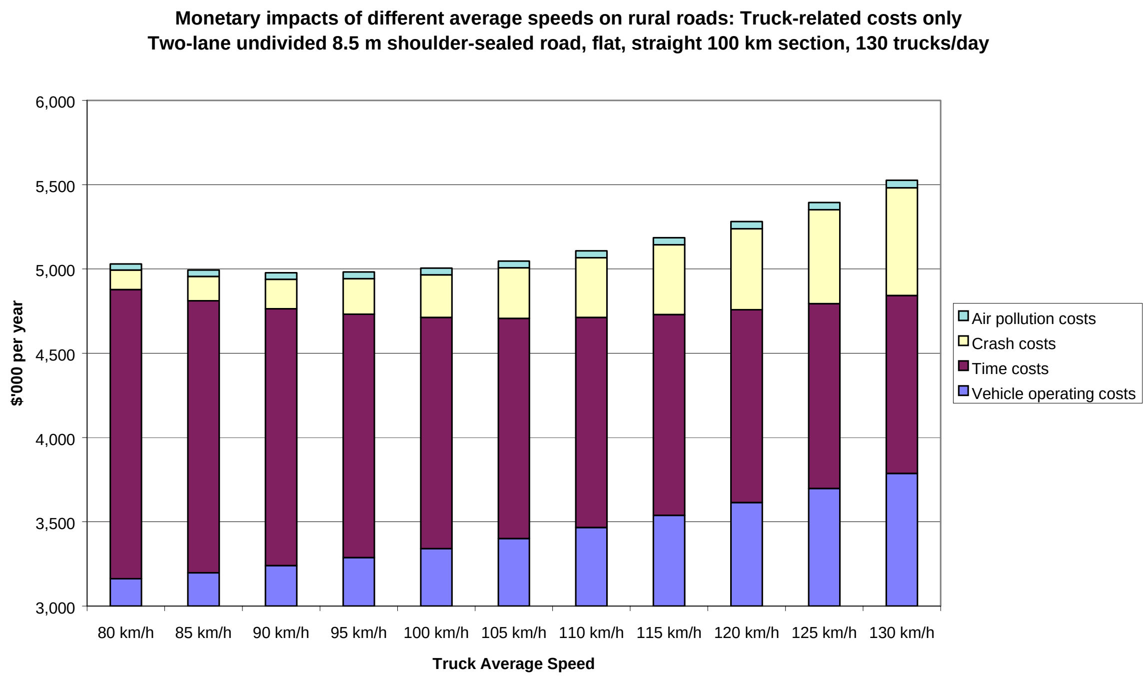


Figure 8.2.2: Rural undivided 8.5 m shoulder-sealed roads – Base scenario. Truck-related costs.



8.2.2 Curvy roads with crossroads and towns

As with the lower standard undivided rural roads transiting through curvy terrain with crossroads and towns, the estimated effect of raising the speed limit from 100 to 130 km/h was to increase the average speed from 96.8 km/h to 115.1 km/h. This would result in travel time savings of 9.8 minutes per vehicle over 100 km. Over the same 100 km of higher standard undivided road, there would be an additional 0.6 fatal crashes, 2.3 serious injury crashes and 2.9 less-serious injury crashes per year (Appendix O).

The economic impact was estimated to be an increase of $13.65 million per 100 kilometres of road per annum (Table 8.2.3). As with the lower standard undivided roads, this was mainly due to the increase in vehicle operating costs. The increase in crash costs was a relatively minor contributor to the total economic impact.

Table 8.2.3: Economic impact of raising speed limit on undivided 8.5 m shoulder-sealed rural roads from 100 km/h (before) to 130 km/h (after). Curvy roads with crossroads and towns.

$'000/year	**Before**	**After**	**Change**	
Vehicle operating costs	11,793	22,183	10,389	88.1 %
Time costs	7,835	6,591	-1,244	-15.9 %
Crash costs	1,426	3,446	2,020	141.7%
Air pollution costs	436	2,915	2,479	568.8 %
Total	**21,490**	**35,135**		
Change			**13,645**	**63.5 %**

The speed at which the total economic impact is minimised on such roads is 85 km/h (Table 8.2.4 and Figure 8.2.3). The optimum speed for cars and LCVs was estimated as 90 km/h and estimated as 85 km/h for trucks (Figure 8.2.4).

Table 8.2.4: Economic impact of different average speeds on undivided 8.5 m shoulder-sealed rural roads. Curvy roads with crossroads and towns.

$'000/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
Vehicle op. costs	10,651	10,789	11,056	11,380	11,793	12,519	13,359	14,642	16,346	18,742	22,183
Time costs	9,550	9,026	8,572	8,178	7,835	7,537	7,279	7,057	6,869	6,714	6,591
Crash costs	684	834	1,006	1,203	1,426	1,677	1,960	2,275	2,627	3,016	3,446
Air pollution costs	304	317	379	385	436	541	673	908	1,268	1,869	2,915
Total	**21,189**	**20,967**	**21,014**	**21,145**	**21,490**	**22,273**	**23,271**	**24,882**	**27,111**	**30,341**	**35,135**
of which:											
Cars & LCVs	16,078	15,862	**15,846**	15,884	16,082	16,588	17,249	18,344	19,879	22,131	25,515
Trucks	5,111	**5,105**	5,168	5,261	5,408	5,685	6,022	6,538	7,232	8,210	9,620

Figure 8.2.3: Rural undivided 8.5 m shoulder-sealed roads – Curvy roads with crossroads and towns.

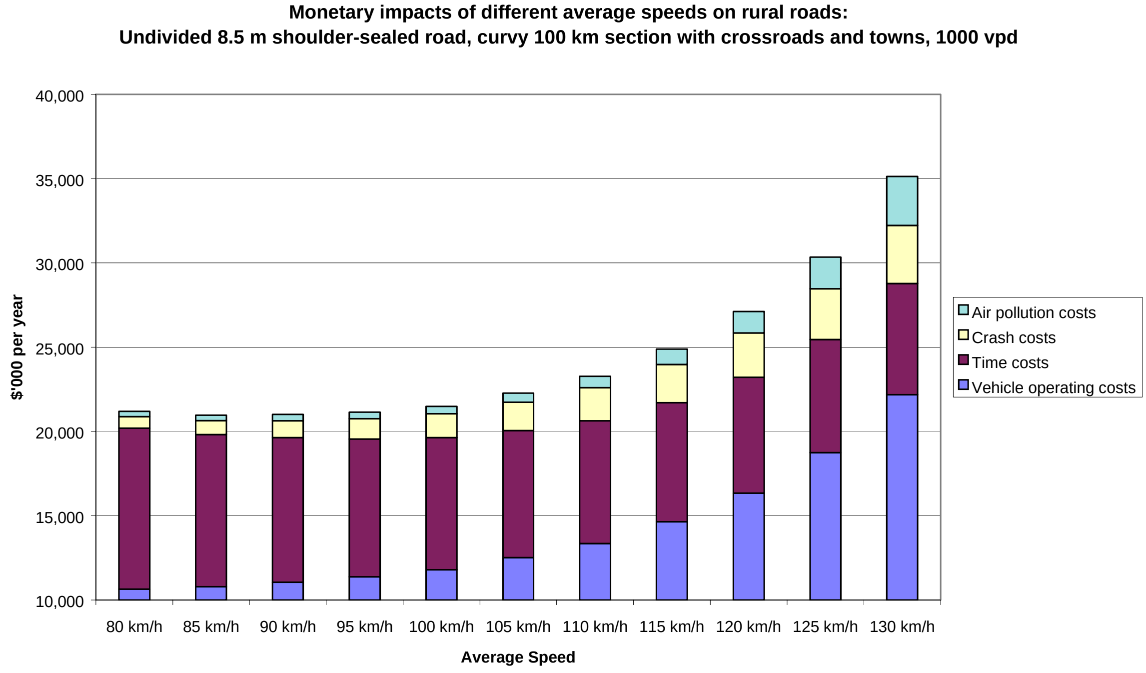
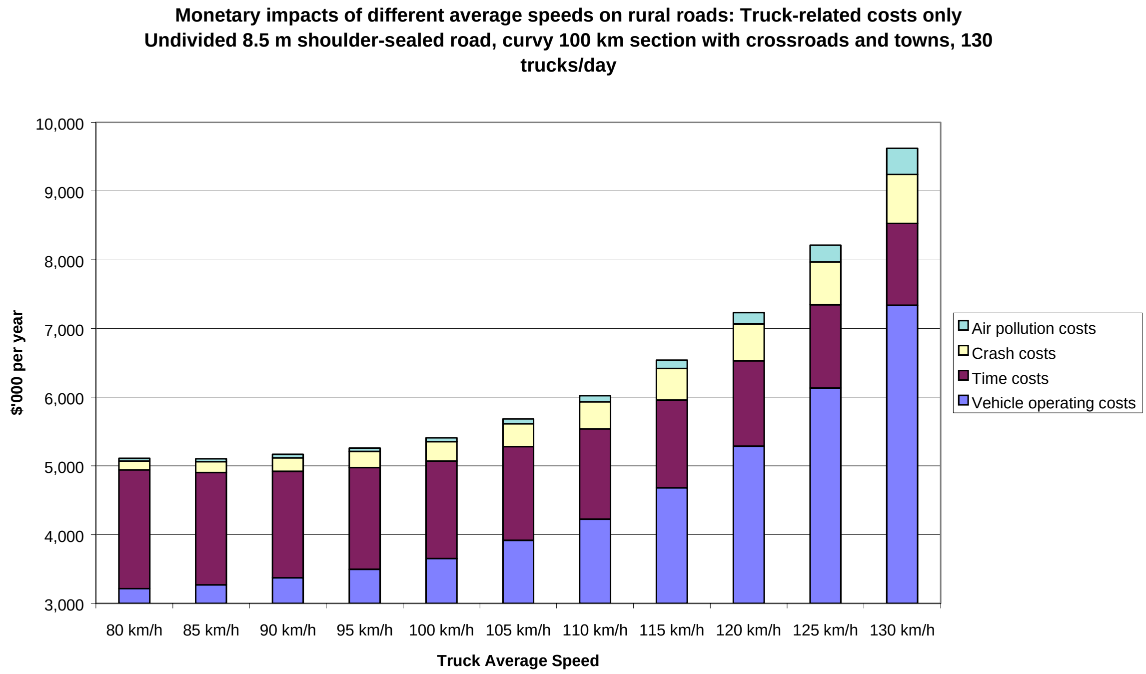


Figure 8.2.4: Rural undivided 8.5 m shoulder-sealed roads – Curvy roads with crossroads and towns. Truck-related costs.



9. SUMMARY AND DISCUSSION

Summaries of the estimated effects of the different speed limit changes on 100 km sections of the three classes of rural roads are given in Tables 9.1 and 9.2.

Table 9.1: Travel time savings and road trauma increases per 100 km of rural road.

	Travel time saving per vehicle over 100 km (minutes)		**Road trauma increases per 100 km of road per year**		
Scenario	Cars & LCVs	Trucks	Fatal crashes	Serious injury crashes	Other injury crashes
RURAL FREEWAYS (20,000 vehicles per day)					
Speed limit raised to 130 km/h (base scenario)[1]	8.4	13.8	2.8	11.1	14.1
Trucks limited to 100 km/h	8.4	0.0	1.6	8.4	11.6
Variable speed limit (VSL)[2]	5.6*	0.0	0.7	3.7	4.9
VSL (day limit 120 km/h)[2]	2.5*	0.0	0.2	1.0	1.3
RURAL DIVIDED ROADS (15,000 vehicles per day)					
Speed limit raised to 130 km/h (base scenario)[3]	8.4	13.8	3.4	13.6	17.2
Trucks limited to 100 km/h	8.4	0.0	1.9	10.3	14.2
Variable speed limit (VSL)[4]	5.6*	0.0	0.9	4.6	6.0
VSL (day limit 120 km/h)[4]	2.5*	0.0	0.3	1.3	1.6
RURAL TWO-WAY UNDIVIDED ROADS (1,000 vehicles per day)[5]					
Speed limit raised to 130 km/h on standard 7.0 m sealed roads	13.8	13.8	0.8	3.3	4.1
Standard 7.0 m sealed roads, curvy with crossroads/towns	9.8	9.8	0.9	3.7	4.6
Speed limit raised to 130 km/h on shoulder-sealed 8.5 m roads	13.8	13.8	0.5	2.1	2.6
Shoulder-sealed 8.5 m roads, curvy with crossroads/towns	9.8	9.8	0.6	2.3	2.9

[1,3] Speed limit raised from 110 km/h (cars and light commercial vehicles) and 100 km/h (trucks) to 130 km/h (all vehicles).

[2,4] Day speed limit for cars and light commercial vehicles raised to 130 km/h (or 120 km/h where indicated); night speed limit reduced to 100 km/h; truck speed limit fixed at 100 km/h during all times of day.

[5] Speed limit raised from 100 km/h to 130 km/h for all types of vehicle.

* Travel time savings averaged across all times of day (assuming 20% of total traffic at night).

Table 9.2: Summary of economic impacts of scenarios, & estimated optimum speeds.

	Effect on total economic cost		Optimum Speed (km/h) (speed which minimises total economic cost)		
Scenario	Change ($ million) p.a./100 km	Percentage change	All vehicles combined	Cars & LCVs	Trucks
RURAL FREEWAYS (20,000 vehicles per day)					
Base scenario[1]	2.350	0.6%	120	125	100
- Leisure travel time not valued	7.618	2.2%	110	115	100
- 'Willingness to pay' (WTP) values of road trauma	10.497	2.7%	110	120	95
Trucks limited to 100 km/h	-3.641	-1.0%	n.a.	125	100
Variable speed limit (VSL)[2]	-3.483	-0.9%			
- WTP values of road trauma	-1.308	-0.3%			
VSL (day limit 120 km/h)[2]	-2.334	-0.6%			
- WTP values of road trauma	-1.735	-0.4%			
RURAL DIVIDED ROADS (15,000 vehicles per day)					
Base scenario[3]	6.454	2.2%	110	120	95
- Leisure travel time not valued	10.405	4.0%	105	110	95
- 'Willingness to pay' (WTP) values of road trauma	16.453	5.5%	105	110	90
Trucks limited to 100 km/h	0.372	0.1%	n.a.	120	95
Variable speed limit (VSL)[4]	-1.201	-0.4%			
- WTP values of road trauma	1.468	0.5%			
VSL (day limit 120 km/h)[4]	-1.363	-0.5%			
- WTP values of road trauma	-0.627	-0.2%			
RURAL TWO-WAY UNDIVIDED ROADS (1,000 vehicles per day)[5]					
Standard 7.0 m sealed roads	2.040	9.8%	95	100	85
Standard 7.0 m sealed roads, curvy with crossroads/towns	14.781	66.3%	85	85	At most 80
Shoulder-sealed 8.5 m roads	1.021	5.1%	105	105	90
Shoulder-sealed 8.5 m roads, curvy with crossroads/towns	13.645	63.5%	85	90	85

[1,3] Speed limit raised from 110 km/h (cars and light commercial vehicles) and 100 km/h (trucks) to 130 km/h (all vehicles). Leisure travel time valued and road trauma valued by 'Human Capital' approach.

[2,4] Day speed limit for cars and light commercial vehicles raised to 130 km/h (or 120 km/h where indicated); night speed limit reduced to 100 km/h; truck speed limit fixed at 100 km/h during all times of day.

[5] Speed limit raised from 100 km/h to 130 km/h for all types of vehicle. Leisure travel time valued and road trauma valued by 'Human Capital' approach.

9.1 RURAL FREEWAYS

An increase in the speed limit to 130 km/h on rural freeways would save each car 8.4 minutes and each truck 13.8 minutes per 100 km, but would increase the number of fatal crashes by 2.8 per year per 100 km of freeway. Casualty crash costs would increase by 89%, vehicle operating costs would increase by 7% and time costs would decrease by 17%. There would be a net cost increase of $2.35 million per year per 100 km of road, provided it is appropriate to value leisure travel time savings and to value the road trauma increases by the human capital approach. If the leisure time savings are not valued, then the net impact would be an economic cost of $7.6 million per year per 100 km of freeway. If road trauma is valued by society's 'willingness to pay' to prevent it, the net cost would be $10.5 million per year per 100 km. Since these alternative valuations of leisure travel time and road trauma are central to the estimated economic output of the increased speed limit on rural freeways, the implications of their choice in making policy decisions needs to be considered carefully.

However, the analysis does indicate that the negative economic impacts of the increased speed limit on rural freeways could be overcome, and even made positive, if trucks were limited on such roads to 100 km/h. A further alternative would be a variable speed limit system, whereby the speed limit is reduced to 100 km/h for cars and light commercial vehicles under adverse road conditions (such as at night or other adverse condition approximately doubling the crash risk for about 20% of the traffic), and is fixed at 100 km/h for trucks at all times. If the increased speed limit under good conditions was no more than 120 km/h, the increase in road trauma would be minimal. This variable speed limit system would still result, however, in an increase in fatal crashes of 0.2 per year per 100 km of freeway, due to the increase in speed limit for 80% of the traffic, albeit during safer daytime conditions. This system would increase casualty crash costs by 7%, increase vehicle operating costs by 1% and reduce time costs by 4%.

9.2 DIVIDED ROADS

The travel time savings if the speed limit were increased to 130 km/h on rural divided roads were estimated to be the same as on freeways, and the percentage change in crash costs would be similar. However the number of additional casualties would be higher (taking into account lower traffic volumes than on freeways, but a higher initial crash rate). Fatal crashes would increase by 3.4 per year per 100 km of divided road. Similar remarks regarding the economic analysis of rural divided roads apply as were made for freeways, except that a simple increase in the speed limit to 130 km/h would have a substantial economic cost ($6.45 million increase per year per 100 km of road). Even higher figures would be estimated with alternative valuations of leisure travel time and road trauma.

The economic loss on divided roads could be overcome to a large extent if trucks were limited to 100 km/h. However a variable speed limit system allowing speeds of 120 km/h under good conditions would not be as beneficial as on rural freeways. There would be an additional 0.3 fatal crashes per year per 100 km of road, but a saving of 2.5 minutes per car travelling over the 100 km section averaged over the whole day. A system allowing 130 km/h on divided rural roads during good conditions would result in greater road trauma levels.

9.3 UNDIVIDED ROADS

There is apparently no economic justification for increasing the speed limit to 130 km/h on the two-way undivided roads, especially the lower standard 7.0 m sealed roads without shoulder sealing. On the straight undivided sections without intersections or towns, total economic impact would be increased by $2.04 million per annum per 100 km of road, or almost 10% of current monetary costs. There would be travel time savings of 13.8 minutes per vehicle over 100 km, but an increase of 0.8 fatal crashes per year on the same road section. (The increase in casualty crash costs would be 142%, but the number of additional fatalities and casualties per 100 km road section would be lower than on divided roads because of the lower traffic volumes on typical undivided roads.)

On the lower standard undivided roads through curvy terrain requiring slowing and occasional towns requiring stopping, the average speed would be lower and the travel time savings would be only 9.8 minutes per vehicle over 100 km. The total cost associated with raising the speed limit, and hence the cruise speeds, to 130 km/h is estimated to be $14.78 million per annum per 100 km, due to increased fuel consumption predominantly and to increased air pollution emissions, each associated with the deceleration-acceleration required by slowing and stopping from 130 km/h cruise speed and returning to that speed.

The optimum cruise speed for cars travelling on these roads is estimated to be 100 km/h if the road is straight without crossroads and towns, but only 85 km/h if the road has many sharp bends and includes intersections and towns requiring stopping. The optimum cruise speed for trucks is estimated to be 85 km/h, and no more than 80 km/h on curvy undivided roads of the same standard. Optimum cruise speeds would be somewhat lower if ‘willingness to pay’ values were used for crash costs, or lower values were used for leisure time savings.

On the higher standard, 8.5 m shoulder-sealed undivided roads, an increase in the speed limit to 130 km/h would not result in as many additional crashes as on the lower standard roads, but the total economic impact would still increase by $1.02 million per annum per 100 km of straight road: about 5% of current total costs. The travel time savings would be the same as on the lower standard undivided roads, but on the straight sections without intersections or towns there would still be 0.5 additional fatal crashes per year per 100 km of road. These calculations assume equal traffic volumes on higher standard and lower standard undivided roads. In practice, traffic volumes are likely to be higher on the better roads, so the number of additional casualties and the net cost per section could be higher on these roads. Estimates of changes in costs and crash counts are directly proportional to the assumed volume of 1,000 vehicles per day, and could be rescaled to provide estimates for different traffic volumes.

Again, as with the lower standard undivided roads, the higher standard roads through curvy terrain and passing through towns would experience substantial increases in total social costs associated with the increased speed limit, due to increased fuel consumption and emissions because of frequent deceleration and acceleration. The total economic impact associated with cruise speeds of 130 km/h on such roads would be $13.65 million per annum per 100 km of road. Travel time savings would be reduced compared with straight 8.5 m shoulder-sealed sections, and fatal crashes would be increased by 0.6 per year per 100 km of curvy road. The optimum cruise speed for cars travelling on the higher standard undivided roads is estimated to be 105 km/h if the road is straight without crossroads and towns, but only 90 km/h if the road has many sharp bends and includes intersections and towns requiring stopping. The optimum cruise speed for trucks is estimated to be 90 km/h, but only 85 km/h on curvy undivided roads of the same standard.

9.4 APPROPRIATENESS OF VALUING LEISURE TRAVEL TIME SAVINGS

The analysis of speed limit changes on rural freeways and divided roads included scenarios where leisure trip travel time was valued at zero, for comparison with the results where it was valued in the same way as trips in cars for other (non-business) private purposes, such as commuting trips. Business travel time and commuting and personal business trip time were valued in all scenarios, using Austroads estimates (Thoresen et al 2003).

There is a view that on some trips, the travel time saving per trip travelled at a higher speed is so small that the benefit cannot be perceived by vehicle occupants and hence has zero value. In an analysis for NRTC of the likely effects of reducing the default urban speed limit in Australia from 60 km/h to 50 km/h, Haworth et al (2001) found that the time increase per urban trip would be less than 10 seconds. They cited other authors questioning the meaningfulness of valuing very small amounts of travel time across large numbers of vehicles. Furthermore, their analysis indicated that if all travel time increases were valued, the reduction in speed limit would result in increased total social costs unless the crash savings were valued at higher levels than ‘human capital’ costs (BTE 2000).

In rural areas, trip distances are typically longer than in urban areas and travel time savings per trip are potentially substantial if travelling at a higher speed. A DOTARS analysis showed that 41 minutes per trip could be saved on a 700 km rural section of the Hume Highway if travelling at 130 km/h on the better one-third of road and 120 km/h on the remainder, compared with travelling at 110 km/h over its whole length (Crawford 2002). This is consistent with the travel time savings per vehicle estimated in Table 9.1 if speed limits for cars were increased from 110 km/h to 130 km/h on rural freeways and divided roads. It is likely that vehicle occupants would perceive travel time savings of this magnitude over long rural trips and would place value on the time savings. There may be a threshold of travel time saving per trip before it is perceived and valued. It is likely that this threshold is exceeded in many rural trips, but seldom exceeded in urban trips.

Another issue arising in the valuation of travel time savings on rural roads is the desirability of consistency in the valuation of leisure time in the travel time costs and in the road trauma costs. The ‘human capital’ cost estimates produced by BTE (2000) include the value of paid work time, and also the value of unpaid work time outside the workplace, which is forgone in the future by killed or partially incapacitated road crash victims. However the human capital estimates do not include any value for leisure time forgone by crash victims. Thus, for consistency reasons, it could be argued that when the human capital cost estimates are used for valuing road trauma, the leisure trip travel time savings should be valued at zero. This variation on the base scenario analyses for rural freeways and rural divided roads was undertaken in Sections 6.1.2 and 7.1.2, respectively.

A related approach was adopted in some analyses for NRTC of the likely effects of reducing the default urban speed limit in Australia (Haworth et al 2001). In most situations where the travel time increases were valued, the values of personal business, commuting and leisure trips by car or light commercial vehicle were set at zero, i.e. only the business trips by these vehicles (and all truck trips) were valued using Austroads estimates. Only when a high estimate of crash costs (approximating ‘willingness to pay’ values) was used was it considered appropriate in the NRTC analysis to value the travel time increases for all purposes of trip.

9.5 ‘WILLINGNESS TO PAY’ VALUATIONS OF ROAD TRAUMA

There has been considerable attention given in the USA to valuing road trauma costs as comprehensively as possible, especially including values for lost quality of life in the case of killed and incapacitated crash victims. Miller (1993) drew a distinction between these ‘comprehensive costs’ and the ‘monetary costs’ (those excluding quality of life values), showing that the former are about four times the latter in the case of killed and critically injured victims. While Australian ‘human capital’ costs include a component for quality of life forgone (BTE 2000), they do not appear to value this dimension as comprehensively as US estimates.

Miller (1993) argued that comprehensive costs, otherwise known as ‘willingness to pay’ values, should be used in benefit-cost analysis in preference to monetary costs and cited a number of economists who support that position. This is because ‘willingness to pay’ values reflect society’s consumer preferences when it comes to decisions about road safety initiatives, whereas monetary costs do not to the full extent. Elsewhere, Miller (1996) has suggested that ‘it seems essential to use compatible values of life and travel time in transport investment analyses’. Since the travel time values normally used for transport decisions reflect consumer preferences, this implies that ‘willingness to pay’ values of road trauma should be used when travel time savings are compared directly with crash costs.

Reflecting this argument, the analysis in this study includes variations on the base scenarios for rural freeways and rural divided roads, in Sections 6.1.3 and 7.1.3 respectively, in which ‘willingness to pay’ values are used and, as in the base scenario, the travel time for all purposes of trip (including leisure trips) is valued. It is suggested that this is technically the correct combination of valuations of these two important impacts of the speed limit changes analysed in this study.

When ‘willingness to pay’ valuations of road trauma were used, the optimum speed on the rural freeways was 120 km/h for cars and light commercial vehicles and 95 km/h for trucks (Table 6.1.6). If these speeds were to become the speed limits for each type of vehicle, respectively, the total economic impact would be a saving of $1.36 million per annum per 100 km of rural freeway (Table 9.3). There would be a travel time saving of 4.5 minutes per car, but an increase of 3.2 minutes per truck, and there would be an additional 0.6 fatal crashes, 3.5 serious injury crashes and 5.2 less-serious injury crashes per year per 100 km of freeway.

On rural divided roads, the optimum speed was 110 km/h for cars and light commercial vehicles and 90 km/h for trucks, when ‘willingness to pay’ valuations of road trauma were used (Table 7.1.6). The optimum speed for cars is the assumed current speed limit on these roads. If the truck optimum was to become their speed limit, the total economic impact would be a saving of $864,000 per annum per 100 km of divided road (Table 9.4). There would be no travel time saving for cars, but an increase of 6.7 minutes per truck, and there would be reductions of 0.3 fatal crashes, 0.8 serious injury crashes and 0.8 less-serious injury crashes per year per 100 km of divided road.

Table 9.3: Economic impact of changing speed limits on rural freeways to optimum speeds: 120 km/h for cars, 95 km/h for trucks. 'Willingness to pay' valuations of crash costs, and leisure travel time valued.

	Average Speed (km/h)			
Cars and LCVs	**110**	**120**		
Trucks	**100**	**95**		
$'000/year	**Before**	**After**	**Change**	
Vehicle operating costs	220,368	222,504	2,135	1.0 %
Time costs	140,418	132,446	-7,972	-5.7 %
Crash costs	18,808	23,115	4,307	22.9%
Air pollution costs	6,282	6,452	170	2.7 %
Total	**385,876**	**384,517**		
Change			**-1,359**	**-0.4 %**

Table 9.4: Economic impact of setting speed limits on rural divided roads at optimum speeds: 110 km/h for cars, 90 km/h for trucks. 'Willingness to pay' valuations of crash costs, and leisure travel time valued.

	Average Speed (km/h)			
Cars and LCVs	**110**	**110**		
Trucks	**100**	**90**		
$'000/year	**Before**	**After**	**Change**	
Vehicle operating costs	165,276	163,759	-1,518	-0.9 %
Time costs	105,313	107,599	2,286	2.2 %
Crash costs	23,082	21,471	-1,612	-7.0%
Air pollution costs	4,712	4,691	-21	-0.4 %
Total	**298,384**	**297,520**		
Change			**-864**	**-0.3 %**

If speed limits on each class of rural road were to be moved closer to the optimum speeds defined above (and in Table 9.2 for rural undivided roads), there could be a substantial net gain in total economic costs across the road network (and perhaps even a net reduction in crash costs). This is because a large proportion of rural road travel (and an even larger proportion of rural crashes) is on undivided roads (see Table 5.1). A reduction in crash costs may result because, although speed limits for cars would increase on freeways, their limits would decrease or remain the same on other roads, and truck speed limits would decrease on all roads, especially the undivided roads with higher crash rates. However, reliable data on rural traffic levels using each of the four classes of road analysed in this study was not available to calculate the total economic impacts across the rural road network.

10. CONCLUSIONS

Within the limits of the assumptions made and the data available for this study, the following general conclusions were reached:

1. Increasing the speed limit to 130 km/h for all vehicles on rural freeways would have substantial social costs. The total social cost could be constrained, and even reduced, if trucks were limited to 100 km/h on such roads. A variable speed limit system allowing speeds of 120 km/h for cars and light commercial vehicles during good conditions, but reduced to 100 km/h under adverse conditions, while limiting trucks to 100 km/h at all times, would keep total social costs below current levels. However, all scenarios whereby speed limits are increased for some vehicle types and circumstances are necessarily accompanied by increased road trauma to provide travel time saving benefits.

2. Increasing the speed limit to 130 km/h on rural divided roads would have even greater social costs than the increased limit on freeways. If trucks were limited to 100 km/h, the impact on total social costs would be smaller but they would still increase. Even a variable speed limit like that for freeways described above would be associated with an increase in road trauma costs. The higher crash rate on the divided roads compared with rural freeways will result in any speed limit increase producing even greater road trauma increases than on the freeways, despite lower traffic volumes on non-freeway roads.

3. If the ‘willingness to pay’ valuations of crash costs reflecting consumer preferences are used, the optimum speeds on rural freeways would be 120 km/h for cars and light commercial vehicles and 95 km/h for trucks. On divided rural roads, the optimum speeds would be 110 km/h and 90 km/h, respectively. If the speed limits on each of these rural roads were to be set at these optimum speeds for each vehicle type, there would be a reduction in total social costs in each environment. However, there would be increases in road trauma on the rural freeways due to the increase in car speeds.

4. There is no economic justification for increasing the speed limit on two-lane undivided rural roads, even on those safer roads with sealed shoulders. On undivided roads through terrain requiring slowing for sharp bends and occasional stops in towns, the increased fuel consumption and air pollution emissions associated with deceleration from and acceleration to high cruise speeds would add very substantially to the total social costs. Using ‘human capital’ costs to value road trauma, the optimum speed for cars is about the current speed limit (100 km/h) on straight sections of these roads, but 10-15 km/h less on the curvy roads with intersections and towns. The optimum speed for trucks is substantially below the current speed limit, and even lower on the curvy roads. The optimum speeds would be even lower if ‘willingness to pay’ valuations of crash costs were used.

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

blanco.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: ____________________
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 $L_{Aeq,07-22hrs}$ > 55 dB		0	0	0	#DIV/0!

H2. Monetary impacts

kECU/year	**Before**	**After**	**Change**	
Consumer 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:
RURAL FREEWAYS – BASE SCENARIO

FreewayFSHC.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 Increase of 110 km/h speed limit to 130 km/h on rural freeways (essentially flat and straight)

A1. Length of link 100 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**
Mean speed, km/h	110	110	100	100	110	**108.7**	130	130	130	130	130	**130.0**
AADT*	10,000	3,400	1,000	1,600	4000	**20,000**	10,000	3,400	1,000	1,600	4000	**20,000**
Share of traffic	50%	17%	5%	8%	20%	100%	50%	17%	5%	8%	20%	100%
Business trips, %		100	100	100	63	**43**		100	100	100	63	**43**
Pers. bus. and commuting. trips, %	35				16	**21**	35				16	**21**
Leisure trips, %	65				21	**37**	65				21	**37**

*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

Increase of 110 km/h speed limit to 130 km/h on rural freeways (essentially flat and straight)

2. Measurement of impacts

D. Impact functions

D1. Vehicle operating costs

Freeway Model for operations on freeways and high quality arterial roads (Thoresen et al 2003); September 2000 prices

D2. Travel time

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

D3a. Accidents

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

Fatal accidents	$n_{IA} = (v_A/v_B)^4 * n_{IB}$	(Andersson & Nilsson, 1997)
Serious injury accidents	$n_{IA} = (v_A/v_B)^3 * n_{IB}$	
Other injury accidents	$n_{IA} = (v_A/v_B)^2 * n_{IB}$	

D4. Air pollutant emission coefficients

*Emission factors**	At initial speed, g/km						At final speed, g/km					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Carbon monoxide CO	2.43	2.43	2.27	2.27	2.43	2.41	2.75	2.75	2.75	2.75	2.75	2.75
Hydrocarbons HC	0.43	0.43	0.40	0.40	0.43	0.43	0.49	0.49	0.49	0.49	0.49	0.49
Oxides of nitrogen NO_x	1.54	1.54	1.51	1.51	1.54	1.54	1.61	1.61	1.61	1.61	1.61	1.61
Particles PM	0.035	0.035	0.032	0.032	0.035	0.034	0.040	0.040	0.040	0.040	0.040	0.040
Carbon dioxide CO_2	240.2	240.2	231.7	231.7	240.2	239.1	257.1	257.1	257.1	257.1	257.1	257.1

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	0.51	0.57

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Vehicle oper. costs*	0.228	0.238	0.523	0.818	0.279	**0.302**	0.238	0.247	0.591	0.927	0.293	**0.323**
*With Co	21.49	22.69	52.45	83.47	28.83		21.49	22.69	52.45	83.47	28.83	
C1	-0.021	-0.021	-0.18	-0.311	-0.073		-0.021	-0.021	-0.18	-0.311	-0.073	
C2	0.0003	0.00028	0.00178	0.00294	0.00059		0.0003	0.00028	0.00178	0.0029	0.0006	

E2a. Time costs per hour

Value of travel time	$ per hour				
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm
Business trips, %		35.3	22.9	32.7	23.6
Pers. bus. and commuting. trips,	14.5				11.1
Leisure trips, %	14.5				11.1
Average	**14.5**	**35.3**	**22.9**	**32.7**	**19.0**

E2b. Time costs per kilometre

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Time costs	0.131	0.321	0.229	0.327	0.172	**0.1924**	0.111	0.272	0.176	0.251	0.146	**0.1599**

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

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Total user costs	0.359	0.559	0.752	1.144	0.452	**0.494**	0.349	0.519	0.767	1.178	0.439	**0.483**

E4. Accident costs

Accident type	**kA$/ accid.**
Fatal accident	1740.36
Serious injury accident	429.55
Other injury accident	14.50
Personal injury accident (av.)	N.A.

"Human capital" valuation (BTE 2000) indexed to year 2000 prices

E5a. Air pollution costs

Air pollutants' unit costs	**$/t**
Carbon monoxide CO	2
Hydrocarbons HC	440
Oxides of nitrogen NOx	1740
Particles PM	13770
Carbon dioxide CO2	22

Cosgrove (1994) indexed to year 2000 prices

E5b. Noise pollution costs

Unit costs of noise pollution	**$/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, k$/year						After policy, k$/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total
Vehicle operating costs	83,257	29,496	19,071	47,754	40,791	**220,368**	86,980	30,643	21,583	54,152	42,794	**236,151**

F2a. Travel time

	Before policy, vehicle-hours/day						After policy, vehicle-hours/day					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total
Total travel time on link	9,091	3,091	1,000	1,600	3,636	**18,418**	7,692	2,615	769	1,231	3,077	**15,385**

F2b. Travel time costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total
Total travel time costs	47,948	39,863	8,359	19,073	25,175	**140,418**	40,571	33,730	6,430	14,672	21,302	**116,705**

F3. Consumer surplus

	Input data, before policy						Input data, after policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Total user costs, $/veh.km	0.359	0.559	0.752	1.144	0.452	**0.494**	0.349	0.519	0.767	1.178	0.439	0.483
Mio veh.kms/year	365	124	37	58	146	**730**	365	124	37	58	146	**730**

	Change in consumer surplus					Total
k$/year	-3654	-4986	583	1997	-1870	**-7930**

F4a. Casualty accident rates

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm		Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	
Crash rate per million VKT	0.07	0.07	0.07	0.07	0.07		0.10	0.10	0.13	0.14	0.10	

F4b. Casualty accident severity

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm		Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	
Fatal (%)	3.8	3.8	8.0	11.4	3.8		5.0	5.0	11.7	16.3	5.0	
Serious injury (%)	29.4	29.4	34.0	35.2	29.4		32.5	32.5	38.2	38.6	32.5	
Minor injury (%)	66.8	66.8	58.0	53.4	66.8		62.5	62.5	50.1	45.1	62.5	

F4c. Accidents

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total
Fatal accident	1.0	0.3	0.2	0.5	0.4	**2.3**	1.9	0.6	0.6	1.3	0.7	**5.1**
Serious injury accident	7.4	2.5	0.9	1.4	3.0	**15.1**	12.2	4.1	1.9	3.1	4.9	**26.2**
Minor injury accident	16.8	5.7	1.5	2.1	6.7	**32.8**	23.4	8.0	2.5	3.6	9.4	**46.8**
Total casualty accidents	25.1	8.5	2.5	4.0	10.0	**50.2**	37.5	12.7	4.9	8.0	15.0	**78.1**

F4d. Accident costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total
Fatal accident	1,660	564	349	797	664	**4,034**	3,237	1,101	998	2,275	1,295	**8,906**
Serious injury accident	3,169	1,077	366	607	1,268	**6,488**	5,231	1,779	805	1,334	2,092	**11,241**
Minor injury accident	243	83	21	31	97	**475**	339	115	36	53	136	**679**
Total casualty accidents	5,072	1,724	737	1,435	2,029	**10,996**	8,808	2,995	1,839	3,661	3,523	**20,826**

F5a. Air pollution

Emissions	At initial speed, t/year						At final speed, t/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Carbon monoxide CO	886	301	83	132	355	**1,758**	1,003	341	100	161	401	**2,006**
Hydrocarbons HC	157	53	15	23	63	**311**	179	61	18	29	72	**359**
Oxides of nitrogen NOx	564	192	55	88	225	**1,124**	588	200	59	94	235	**1,175**
Particles PM	13	4	1	2	5	**25**	14	5	1	2	6	**29**
Carbon dioxide CO2	87,656	29,803	8,457	13,531	35,062	**174,509**	93,833	31,903	9,383	15,013	37,533	**187,666**

F5b. Air pollution costs

Emissions	At initial speed, k$/year						At final speed, k$/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Carbon monoxide CO	2	1	0	0	1	**4**	2	1	0	0	1	**4**
Hydrocarbons HC	69	24	6	10	28	**137**	79	27	8	13	32	**158**
Oxides of nitrogen NOx	981	333	96	154	392	**1,956**	1,023	348	102	164	409	**2,045**
Particles PM	175	59	16	26	70	**347**	199	67	20	32	79	**397**
Carbon dioxide CO2	1,928	656	186	298	771	**3,839**	2,064	702	206	330	826	**4,129**
Total	**3,155**	**1,073**	**305**	**488**	**1,262**	**6,282**	**3,366**	**1,145**	**337**	**539**	**1,347**	**6,733**

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	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Total monetary impact	139,431	72,156	28,472	68,750	69,256	**378,065**	139,725	68,512	30,188	73,024	68,965	**380,414**

End of sheet

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework

Ver. 01/99

Increase of 110 km/h speed limit to 130 km/h on rural freeways (essentially flat and straight)

H. Net impacts

Average Speed (km/h)

	Before	After
Cars and LCVs	**110**	**130**
Trucks	**100**	**130**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		18,418	15,385	-3,034	-16.5 %
Number of Crashes per year		50.2	78.1	27.9	55.6%
Emissions, t/year	Carbon monoxide CO	1758	2006	249	14.2 %
	Hydrocarbons HC	311	359	47.4	15.2 %
	Oxides of nitrogen NOx	1124	1175	51	4.6 %
	Particles PM	25.2	28.8	3.65	14.5 %
	Carbon dioxide CO2	174509	187666	13157	7.5 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Saving/vehicle/100km (mins.) Cars&LCVs: **8.4** Trucks: **13.8**

Increase/100km Fatal: **2.8** Serious Inj: **11.1** Other Inj: **14.1**

H2. Monetary impacts

k$/year	Before	After	Change	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	220,368	236,151	15783	7.2 %
Time costs	140,418	116,705	-23713	-16.9 %
Crash costs	10,996	20,826	9,829	89.4%
Air pollution costs	6,282	6,733	450	7.2 %
Noise costs	0	0	0	
Total	**378,065**	**380,414**		
Change			**2,350**	**0.6 %**

~~H3. Summary of monetary impacts for intermediate and lower average speeds~~

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	209,942	211,512	213,315	215,353	217,623	220,127	222,865	225,836	229,041	232,480	236,151
Time costs	189,645	178,489	168,573	159,701	151,716	144,491	137,924	131,927	126,430	121,373	116,705
Crash costs	4,154	5,060	6,101	7,289	8,636	10,156	11,861	13,766	15,886	18,234	20,826
Air pollution costs	5,675	5,781	5,887	5,993	6,098	6,204	6,310	6,415	6,521	6,627	6,733
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**409,416**	**400,842**	**393,877**	**388,335**	**384,074**	**380,979**	**378,960**	**377,945**	**377,878**	**378,713**	**380,414**
of which:											
Cars & light comm. vehs.	310,135	302,617	296,326	291,111	286,853	283,455	280,843	278,956	277,745	**277,171**	277,202
Trucks (rigid and artic.)	99,280	98,226	97,551	97,224	**97,221**	97,524	98,117	98,989	100,133	101,542	103,212

~~H4. Monetary impacts for trucks at intermediate and lower average speeds~~

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	63,251	63,967	64,802	65,754	66,825	68,014	69,322	70,748	72,292	73,954	75,735
Time costs	34,290	32,273	30,480	28,876	27,432	26,126	24,938	23,854	22,860	21,946	21,101
Crash costs	1,001	1,234	1,504	1,815	2,172	2,577	3,037	3,554	4,134	4,781	5,500
Air pollution costs	738	752	765	779	793	807	820	834	848	861	875
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**99,280**	**98,226**	**97,551**	**97,224**	**97,221**	**97,524**	**98,117**	**98,989**	**100,133**	**101,542**	**103,212**

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

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	146,690	147,544	148,514	149,598	150,798	152,113	153,544	155,089	156,750	158,525	160,416
Time costs	155,355	146,217	138,093	130,825	124,284	118,366	112,986	108,073	103,570	99,427	95,603
Crash costs	3,153	3,826	4,597	5,474	6,465	7,579	8,825	10,212	11,752	13,453	15,326
Air pollution costs	4,938	5,030	5,121	5,213	5,305	5,397	5,489	5,581	5,673	5,765	5,857
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**310,135**	**302,617**	**296,326**	**291,111**	**286,853**	**283,455**	**280,843**	**278,956**	**277,745**	**277,171**	**277,202**

APPENDIX C: RURAL FREEWAYS – LEISURE TRAVEL TIME NOT VALUED

FreewayFSHCLo.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 ~~Increase of 110 kmh speed limit to 130 kmh on rural freeways. Leisure trip time valued at zero.~~

~~A1. Length of link~~ 100 km

~~A2. Flow characteristics~~

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**
Mean speed, km/h	110	110	100	100	110	**108.7**	130	130	130	130	130	**130.0**
AADT*	10,000	3,400	1,000	1,600	4000	**20,000**	10,000	3,400	1,000	1,600	4000	**20,000**
Share of traffic	50%	17%	5%	8%	20%	100%	50%	17%	5%	8%	20%	100%
Business trips, %		100	100	100	63	**43**		100	100	100	63	**43**
Pers. bus. and commuting. trips, %	35				16	**21**	35				16	**21**
Leisure trips, %	65				21	**37**	65				21	**37**

*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

Increase of 110 kmh speed limit to 130 kmh on rural freeways. Leisure trip time valued at zero.

H. Net impacts

	Average Speed (km/h)	
Cars and LCVs	**110**	**130**
Trucks	**100**	**130**

~~H1. Physical impacts~~

		Before	After	Change	
Total travel time on link, hours/day		18,418	15,385	-3,034	-16.5 %
Number of Crashes per year		50.2	78.1	27.9	55.6%
Emissions, t/year	Carbon monoxide CO	1758	2006	249	14.2 %
	Hydrocarbons HC	311	359	47.4	15.2 %
	Oxides of nitrogen NOx	1124	1175	51	4.6 %
	Particles PM	25.2	28.8	3.65	14.5 %
	Carbon dioxide CO2	174509	187666	13157	7.5 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Saving/vehicle/100km (mins.)			Cars&LCVs:	**8.4**	Trucks:	**13.8**		
Increase/100km	Fatal:	**2.8**	Serious Inj:	**11.1**	Other Inj:	**14.1**		

~~H2. Monetary impacts~~

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	220,368	236,151	15783	7.2 %
Time costs	106,172	87,727	-18444	-17.4 %
Crash costs	10,996	20,826	9,829	89.4%
Air pollution costs	6,282	6,733	450	7.2 %
Noise costs	0	0	0	
Total	**343,819**	**351,437**		
Change			**7,618**	**2.2 %**

~~H3. Summary of monetary impacts for intermediate and lower average speeds~~

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	209,942	211,512	213,315	215,353	217,623	220,127	222,865	225,836	229,041	232,480	236,151
Time costs	142,557	134,171	126,717	120,048	114,046	108,615	103,678	99,170	95,038	91,236	87,727
Crash costs	4,154	5,060	6,101	7,289	8,636	10,156	11,861	13,766	15,886	18,234	20,826
Air pollution costs	5,675	5,781	5,887	5,993	6,098	6,204	6,310	6,415	6,521	6,627	6,733
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**362,328**	**356,524**	**352,020**	**348,682**	**346,403**	**345,102**	**344,714**	**345,188**	**346,486**	**348,576**	**351,437**
of which:											
Cars & light comm. vehs.	263,047	258,298	254,470	251,458	249,182	247,578	246,597	**246,199**	246,353	247,034	248,225
Trucks (rigid and artic.)	99,280	98,226	97,551	97,224	**97,221**	97,524	98,117	98,989	100,133	101,542	103,212

~~H4. Monetary impacts for trucks at intermediate and lower average speeds~~

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	63,251	63,967	64,802	65,754	66,825	68,014	69,322	70,748	72,292	73,954	75,735
Time costs	34,290	32,273	30,480	28,876	27,432	26,126	24,938	23,854	22,860	21,946	21,101
Crash costs	1,001	1,234	1,504	1,815	2,172	2,577	3,037	3,554	4,134	4,781	5,500
Air pollution costs	738	752	765	779	793	807	820	834	848	861	875
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**99,280**	**98,226**	**97,551**	**97,224**	**97,221**	**97,524**	**98,117**	**98,989**	**100,133**	**101,542**	**103,212**

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

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	146,690	147,544	148,514	149,598	150,798	152,113	153,544	155,089	156,750	158,525	160,416
Time costs	108,267	101,898	96,237	91,172	86,614	82,489	78,740	75,316	72,178	69,291	66,626
Crash costs	3,153	3,826	4,597	5,474	6,465	7,579	8,825	10,212	11,752	13,453	15,326
Air pollution costs	4,938	5,030	5,121	5,213	5,305	5,397	5,489	5,581	5,673	5,765	5,857
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**263,047**	**258,298**	**254,470**	**251,458**	**249,182**	**247,578**	**246,597**	**246,199**	**246,353**	**247,034**	**248,225**

APPENDIX D:
RURAL FREEWAYS – 'WILLINGNESS TO PAY' VALUATIONS OF ROAD TRAUMA

FreewayFSWTP.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 ~~Increase of 110 kmh speed limit to 130 kmh on rural freeways. WTP valuation of crash costs.~~

~~A1. Length of link~~ 100 km

~~A2. Flow characteristics~~

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**
Mean speed, km/h	110	110	100	100	110	**108.7**	130	130	130	130	130	**130.0**
AADT*	10,000	3,400	1,000	1,600	4000	**20,000**	10,000	3,400	1,000	1,600	4000	**20,000**
Share of traffic	50%	17%	5%	8%	20%	100%	50%	17%	5%	8%	20%	100%
Business trips, %		100	100	100	63	**43**		100	100	100	63	**43**
Pers. bus. and commuting. trips, %	35				16	**21**	35				16	**21**
Leisure trips, %	65				21	**37**	65				21	**37**

*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

Increase of 110 kmh speed limit to 130 kmh on rural freeways. WTP valuation of crash costs.

H. Net impacts

Average Speed (km/h)

Cars and LCVs	**110**	**130**
Trucks	**100**	**130**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		18,418	15,385	-3,034	-16.5 %
Number of Crashes per year		50.2	78.1	27.9	55.6%
Emissions, t/year	Carbon monoxide CO	1758	2006	249	14.2 %
	Hydrocarbons HC	311	359	47.4	15.2 %
	Oxides of nitrogen NOx	1124	1175	51	4.6 %
	Particles PM	25.2	28.8	3.65	14.5 %
	Carbon dioxide CO2	174509	187666	13157	7.5 %
Residents in area where $L_{Aeq,07-22hrs}$ > 55 dB		0	0	0	

Saving/vehicle/100km (mins.) Cars&LCVs: **8.4** Trucks: **13.8**

Increase/100km Fatal: **2.8** Serious Inj: **11.1** Other Inj: **14.1**

H2. Monetary impacts

k$/year	Before	After	Change	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	220,368	236,151	15783	7.2 %
Time costs	140,418	116,705	-23713	-16.9 %
Crash costs	18,808	36,784	17,977	95.6%
Air pollution costs	6,282	6,733	450	7.2 %
Noise costs	0	0	0	
Total	**385,876**	**396,373**		
Change			**10,497**	**2.7 %**

~~H3. Summary of monetary impacts for intermediate and lower average speeds~~

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	209,942	211,512	213,315	215,353	217,623	220,127	222,865	225,836	229,041	232,480	236,151
Time costs	189,645	178,489	168,573	159,701	151,716	144,491	137,924	131,927	126,430	121,373	116,705
Crash costs	7,044	8,597	10,394	12,460	14,821	17,504	20,537	23,951	27,775	32,042	36,784
Air pollution costs	5,675	5,781	5,887	5,993	6,098	6,204	6,310	6,415	6,521	6,627	6,733
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**412,306**	**404,379**	**398,170**	**393,507**	**390,259**	**388,327**	**387,636**	**388,130**	**389,767**	**392,521**	**396,373**
of which:											
Cars & light comm. vehs.	312,183	305,097	299,308	294,674	291,081	288,445	286,698	285,791	**285,684**	286,349	287,767
Trucks (rigid and artic.)	100,124	99,283	98,862	**98,833**	99,178	99,882	100,938	102,339	104,083	106,172	108,607

~~H4. Monetary impacts for trucks at intermediate and lower average speeds~~

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	63,251	63,967	64,802	65,754	66,825	68,014	69,322	70,748	72,292	73,954	75,735
Time costs	34,290	32,273	30,480	28,876	27,432	26,126	24,938	23,854	22,860	21,946	21,101
Crash costs	1,845	2,291	2,815	3,424	4,128	4,936	5,858	6,903	8,084	9,411	10,895
Air pollution costs	738	752	765	779	793	807	820	834	848	861	875
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**100,124**	**99,283**	**98,862**	**98,833**	**99,178**	**99,882**	**100,938**	**102,339**	**104,083**	**106,172**	**108,607**

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

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	146,690	147,544	148,514	149,598	150,798	152,113	153,544	155,089	156,750	158,525	160,416
Time costs	155,355	146,217	138,093	130,825	124,284	118,366	112,986	108,073	103,570	99,427	95,603
Crash costs	5,200	6,306	7,580	9,036	10,693	12,568	14,680	17,047	19,691	22,631	25,890
Air pollution costs	4,938	5,030	5,121	5,213	5,305	5,397	5,489	5,581	5,673	5,765	5,857
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**312,183**	**305,097**	**299,308**	**294,674**	**291,081**	**288,445**	**286,698**	**285,791**	**285,684**	**286,349**	**287,767**

APPENDIX E: RURAL FREEWAYS – TRUCKS LIMITED TO 100 KM/H

FreewayFSHCT100.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 Increase of 110 kmh speed limit to 130 kmh for cars and LCVs on rural freeways (trucks limited to 100 kmh)

A1. Length of link 100 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**
Mean speed, km/h	110	110	100	100	110	**108.7**	130	130	100	100	130	**126.1**
AADT*	10,000	3,400	1,000	1,600	4000	**20,000**	10,000	3,400	1,000	1,600	4000	**20,000**
Share of traffic	50%	17%	5%	8%	20%	100%	50%	17%	5%	8%	20%	100%
Business trips, %		100	100	100	63	**43**		100	100	100	63	**43**
Pers. bus. and commuting. trips, %	35				16	**21**	35				16	**21**
Leisure trips, %	65				21	**37**	65				21	**37**

*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

Increase of 110 kmh speed limit to 130 kmh for cars and LCVs on rural freeways (trucks limited to 100 kmh)

H. Net impacts

	Average Speed (km/h)	
Cars and LCVs	**110**	**130**
Trucks	**100**	**100**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		18,418	15,985	-2,434	-13.2 %
Number of Crashes per year		50.2	71.7	21.5	42.8%
Emissions, t/year	Carbon monoxide CO	1758	1961	203	11.6 %
	Hydrocarbons HC	311	350	38.7	12.4 %
	Oxides of nitrogen NOx	1124	1166	42	3.7 %
	Particles PM	25.2	28.2	2.98	11.9 %
	Carbon dioxide CO2	174509	185257	10748	6.2 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Saving/vehicle/100km (mins.)			Cars&LCVs:	**8.4**	Trucks:	**0.0**
Increase/100km	Fatal:	**1.6**	Serious Inj:	**8.4**	Other Inj:	**11.6**

H2. Monetary impacts

k\$/year	Before	After	Change	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	220,368	227,241	6873	3.1 %
Time costs	140,418	123,035	-17382	-12.4 %
Crash costs	10,996	17,497	6,501	59.1%
Air pollution costs	6,282	6,650	368	5.9 %
Noise costs	0	0	0	
Total	**378,065**	**374,424**		
Change			**-3,641**	**-1.0 %**

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

						Car average speed (Truck average speed fixed at 100 kmh)					
kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	209,942	211,512	213,315	215,353	217,623	218,938	220,368	221,914	223,574	225,350	227,241
Time costs	189,645	178,489	168,573	159,701	151,716	145,798	140,418	135,505	131,002	126,859	123,035
Crash costs	4,154	5,060	6,101	7,289	8,636	9,750	10,996	12,384	13,924	15,624	17,497
Air pollution costs	5,675	5,781	5,887	5,993	6,098	6,190	6,282	6,374	6,466	6,558	6,650
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**409,416**	**400,842**	**393,877**	**388,335**	**384,074**	**380,676**	**378,065**	**376,177**	**374,966**	**374,392**	**374,424**
of which:											
Cars & light comm. vehs.	310,135	302,617	296,326	291,111	286,853	283,455	280,843	278,956	277,745	**277,171**	277,202
Trucks (rigid and artic.)	99,280	98,226	97,551	97,224	**97,221**	97,221	97,221	97,221	97,221	97,221	97,221

H4. Monetary impacts for trucks at intermediate and lower average speeds

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	63,251	63,967	64,802	65,754	66,825	66,825	66,825	66,825	66,825	66,825	66,825
Time costs	34,290	32,273	30,480	28,876	27,432	27,432	27,432	27,432	27,432	27,432	27,432
Crash costs	1,001	1,234	1,504	1,815	2,172	2,172	2,172	2,172	2,172	2,172	2,172
Air pollution costs	738	752	765	779	793	793	793	793	793	793	793
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**99,280**	**98,226**	**97,551**	**97,224**	**97,221**	**97,221**	**97,221**	**97,221**	**97,221**	**97,221**	**97,221**

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

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	146,690	147,544	148,514	149,598	150,798	152,113	153,544	155,089	156,750	158,525	160,416
Time costs	155,355	146,217	138,093	130,825	124,284	118,366	112,986	108,073	103,570	99,427	95,603
Crash costs	3,153	3,826	4,597	5,474	6,465	7,579	8,825	10,212	11,752	13,453	15,326
Air pollution costs	4,938	5,030	5,121	5,213	5,305	5,397	5,489	5,581	5,673	5,765	5,857
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**310,135**	**302,617**	**296,326**	**291,111**	**286,853**	**283,455**	**280,843**	**278,956**	**277,745**	**277,171**	**277,202**

APPENDIX F:
RURAL FREEWAYS – VARIABLE SPEED LIMIT

FreewayFSHCVSL130.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 ~~Increased speed limit for cars and LCVs to 130 kmh on rural freeways during daytime, reduction to 100 kmh at night~~

~~A1. Length of link~~ 100 km

~~A2. Flow characteristics~~

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**
Mean speed, km/h	110	110	100	100	110	**108.7**	130	130	100	100	130	**126.1**
AADT*	10,000	3,400	1,000	1,600	4000	**20,000**	10,000	3,400	1,000	1,600	4000	**20,000**
Share of traffic	50%	17%	5%	8%	20%	100%	50%	17%	5%	8%	20%	100%
Business trips, %		100	100	100	63	**43**		100	100	100	63	**43**
Pers. bus. and commuting. trips, %	35				16	**21**	35				16	**21**
Leisure trips, %	65				21	**37**	65				21	**37**

*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

Increased speed limit for cars and LCVs to 130 kmh on rural freeways during daytime, reduction to 100 kmh at night

H. Net impacts

	Day Average Speed (km/h)		Night Average Speed (km/h)		Total Impact of VSL
Cars and LCVs	**110**	**130**	**110**	**100**	Total of night and day changes
Trucks	**100**	**100**	**100**	**100**	

~~H1. Physical impacts~~

		Day Before	Day After	Day Change	Day Change %	Night Before	Night After	Night Change	Night Change %	Total Before	Total After	Total Change	Total Change %
Total travel time on link, hours/day		14,735	12,788	-1,947	-13.2 %	3,684	4,000	316	8.6 %	18,418	16,788	-1,630	-8.9 %
Number of Crashes per year		30.1	43.0	12.9	42.8%	20.1	16.6	-3.5	-17.5%	50.2	59.6	9.4	18.7%
Emissions, t/year	Carbon monoxide CO	1,406	1,569	163	11.6 %	352	331	-20	-5.8 %	1,758	1,900	142	8.1 %
	Hydrocarbons HC	249	280	31.0	12.4 %	62	58	-3.9	-6.2 %	311	338	27.1	8.7 %
	Oxides of nitrogen NOx	899	933	34	3.7 %	225	221	-4	-1.9 %	1,124	1,153	29	2.6 %
	Particles PM	20.1	22.5	2.39	11.9 %	5.0	4.7	-0.30	-5.9 %	25.2	27.3	2.09	8.3 %
	Carbon dioxide CO2	139,607	148,206	8598	6.2 %	34,902	33,827	-1075	-3.1 %	174,509	182,033	7523	4.3 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0		0	0	0		0	0	0	

		Day		Night			Total
Travel time saving/vehicle/100km (mins.)	Cars&LCVs:	**8.4**	Cars&LCVs:	**-5.5**	**Average**	Cars&LCVs:	**5.6**
	Trucks:	**0.0**	Trucks:	**0.0**		Trucks:	**0.0**
Casualty crash increase/100km	Fatal:	**0.9**	Fatal:	**-0.2**	**Total**	Fatal:	**0.7**
	Serious Inj:	**5.0**	Serious Inj:	**-1.3**		Serious Inj:	**3.7**
	Other Inj:	**6.9**	Other Inj:	**-2.0**		Other Inj:	**4.9**

~~H2. Monetary impacts~~

k$/year	Day Before	Day After	Day Change	Day Change %	Night Before	Night After	Night Change	Night Change %	Total Before	Total After	Total Change	Total Change %
Consumer surplus	(N. A.)	(N. A.)	0	(N. A.)	(N. A.)	(N. A.)	0	(N. A.)	(N. A.)	(N. A.)	0	(N. A.)
Vehicle operating costs	176,295	181,793	5,498	3.1 %	44,074	43,525	-549	-1.2 %	220,368	225,318	4,949	2.2 %
Time costs	112,334	98,428	-13,906	-12.4 %	28,084	30,343	2,260	8.0 %	140,418	128,771	-11,646	-8.3 %
Crash costs	6,598	10,498	3,901	59.1%	4,399	3,455	-944	-21.5%	10,996	13,953	2,957	26.9%
Air pollution costs	5,026	5,320	294	5.9 %	1,256	1,220	-37	-2.9 %	6,282	6,540	258	4.1 %
Noise costs	0	0	0		0	0	0		0	0	0	
Total	**300,252**	**296,040**			**77,812**	**78,542**			**378,065**	**374,582**		
Change			**-4,213**	**-1.4 %**			**730**	**0.9 %**			**-3,483**	**-0.9 %**

APPENDIX G: RURAL DIVIDED ROADS – BASE SCENARIO

DividedFSHC.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 Increase of 110 km/h speed limit to 130 km/h on divided, flat, straight rural roads

A1. Length of link 100 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**
Mean speed, km/h	110	110	100	100	110	**108.7**	130	130	130	130	130	**130.0**
AADT*	7,500	2,550	750	1,200	3000	**15,000**	7,500	2,550	750	1,200	3000	**15,000**
Share of traffic	50%	17%	5%	8%	20%	100%	50%	17%	5%	8%	20%	100%
Business trips, %		100	100	100	63	**43**		100	100	100	63	**43**
Pers. bus. and commuting. trips, %	35				16	**21**	35				16	**21**
Leisure trips, %	65				21	**37**	65				21	**37**

*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

Increase of 110 km/h speed limit to 130 km/h on divided, flat, straight rural roads

2. Measurement of impacts

D. Impact functions

D1. Vehicle operating costs

Freeway Model for operations on freeways and high quality arterial roads (Thoresen et al 2003); September 2000 prices

D2. Travel time

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

D3a. Accidents

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

Fatal accidents	$n_{IA} = (v_A/v_B)^4 * n_{IB}$	(Andersson & Nilsson, 1997)
Serious injury accidents	$n_{IA} = (v_A/v_B)^3 * n_{IB}$	
Other injury accidents	$n_{IA} = (v_A/v_B)^2 * n_{IB}$	

D4. Air pollutant emission coefficients

*Emission factors**	At initial speed, g/km						At final speed, g/km					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Carbon monoxide CO	2.43	2.43	2.27	2.27	2.43	2.41	2.75	2.75	2.75	2.75	2.75	2.75
Hydrocarbons HC	0.43	0.43	0.40	0.40	0.43	0.43	0.49	0.49	0.49	0.49	0.49	0.49
Oxides of nitrogen NO_x	1.54	1.54	1.51	1.51	1.54	1.54	1.61	1.61	1.61	1.61	1.61	1.61
Particles PM	0.035	0.035	0.032	0.032	0.035	0.034	0.040	0.040	0.040	0.040	0.040	0.040
Carbon dioxide CO_2	240.2	240.2	231.7	231.7	240.2	239.1	257.1	257.1	257.1	257.1	257.1	257.1

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	0.51	0.57

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Vehicle oper. costs*	0.228	0.238	0.523	0.818	0.279	**0.302**	0.238	0.247	0.591	0.927	0.293	**0.323**
*With Co	21.49	22.69	52.45	83.47	28.83		21.49	22.69	52.45	83.47	28.83	
C1	-0.021	-0.021	-0.18	-0.311	-0.073		-0.021	-0.021	-0.18	-0.311	-0.073	
C2	0.0003	0.00028	0.00178	0.00294	0.00059		0.0003	0.00028	0.00178	0.0029	0.0006	

E2a. Time costs per hour

Value of travel time	$ per hour				
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm
Business trips, %		35.3	22.9	32.7	23.6
Pers. bus. and commuting. trips, %	14.5				11.1
Leisure trips, %	14.5				11.1
Average	**14.5**	**35.3**	**22.9**	**32.7**	**19.0**

E2b. Time costs per kilometre

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Time costs	0.131	0.321	0.229	0.327	0.172	**0.1924**	0.111	0.272	0.176	0.251	0.146	**0.1599**

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

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Total user costs	0.359	0.559	0.752	1.144	0.452	**0.494**	0.349	0.519	0.767	1.178	0.439	**0.483**

E4. Accident costs

Accident type	kA$/ accid.
Fatal accident	1740.36
Serious injury accident	429.55
Other injury accident	14.50
Personal injury accident (av.)	N.A.

"Human capital" valuation (BTE 2000) indexed to year 2000 prices

E5a. Air pollution costs

Air pollutants' unit costs	$/t
Carbon monoxide CO	2
Hydrocarbons HC	440
Oxides of nitrogen NOx	1740
Particles PM	13770
Carbon dioxide CO2	22

Cosgrove (1994) indexed to year 2000 prices

E5b. Noise pollution costs

Unit costs of noise pollution	$/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, k$/year						After policy, k$/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total
Vehicle operating costs	62,442	22,122	14,303	35,815	30,593	**165,276**	65,235	22,982	16,187	40,614	32,096	**177,114**

F2a. Travel time

	Before policy, vehicle-hours/day						After policy, vehicle-hours/day					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total
Total travel time on link	6,818	2,318	750	1,200	2,727	**13,814**	5,769	1,962	577	923	2,308	**11,538**

F2b. Travel time costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total
Total travel time costs	35,961	29,897	6,269	14,305	18,881	**105,313**	30,428	25,298	4,822	11,004	15,976	**87,528**

F3. Consumer surplus

	Input data, before policy						Input data, after policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Total user costs, $/veh.km	0.359	0.559	0.752	1.144	0.452	**0.494**	0.349	0.519	0.767	1.178	0.439	0.483
Mio veh.kms/year	274	93	27	44	110	**548**	274	93	27	44	110	**548**

	Change in consumer surplus					Total
k$/year	-2740	-3740	437	1498	-1402	**-5947**

F4a. Casualty accident rates

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm		Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	
Crash rate per million VKT	0.11	0.11	0.11	0.11	0.11		0.17	0.17	0.22	0.23	0.17	

F4b. Casualty accident severity

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm		Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	
Fatal (%)	3.8	3.8	8.0	11.4	3.8		5.0	5.0	11.7	16.3	5.0	
Serious injury (%)	29.4	29.4	34.0	35.2	29.4		32.5	32.5	38.2	38.6	32.5	
Minor injury (%)	66.8	66.8	58.0	53.4	66.8		62.5	62.5	50.1	45.1	62.5	

F4c. Accidents

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total
Fatal accident	1.2	0.4	0.2	0.6	0.5	**2.8**	2.3	0.8	0.7	1.6	0.9	**6.3**
Serious injury accident	9.1	3.1	1.0	1.7	3.6	**18.5**	14.9	5.1	2.3	3.8	6.0	**32.1**
Minor injury accident	20.6	7.0	1.8	2.6	8.2	**40.2**	28.7	9.8	3.0	4.4	11.5	**57.5**
Total casualty accidents	30.8	10.5	3.1	4.9	12.3	**61.6**	46.0	15.6	6.0	9.9	18.4	**95.9**

F4d. Accident costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total
Fatal accident	2,037	692	429	978	815	**4,950**	3,973	1,351	1,225	2,792	1,589	**10,930**
Serious injury accident	3,889	1,322	450	745	1,556	**7,962**	6,420	2,183	988	1,637	2,568	**13,795**
Minor injury accident	298	101	26	38	119	**583**	417	142	44	64	167	**833**
Total casualty accidents	6,224	2,116	904	1,761	2,490	**13,496**	10,810	3,675	2,257	4,494	4,324	**25,559**

F5a. Air pollution

Emissions	At initial speed, t/year						At final speed, t/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Carbon monoxide CO	665	226	62	99	266	**1,318**	752	256	75	120	301	**1,505**
Hydrocarbons HC	118	40	11	18	47	**234**	135	46	13	22	54	**269**
Oxides of nitrogen NOx	423	144	41	66	169	**843**	441	150	44	71	176	**881**
Particles PM	10	3	1	1	4	**19**	11	4	1	2	4	**22**
Carbon dioxide CO2	65,742	22,352	6,343	10,148	26,297	**130,882**	70,375	23,927	7,037	11,260	28,150	**140,750**

F5b. Air pollution costs

Emissions	At initial speed, k$/year						At final speed, k$/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Carbon monoxide CO	1	0	0	0	1	**3**	2	1	0	0	1	**3**
Hydrocarbons HC	52	18	5	8	21	**103**	59	20	6	9	24	**118**
Oxides of nitrogen NOx	735	250	72	115	294	**1,467**	767	261	77	123	307	**1,534**
Particles PM	131	45	12	20	52	**260**	149	51	15	24	60	**298**
Carbon dioxide CO2	1,446	492	140	223	579	**2,879**	1,548	526	155	248	619	**3,096**
Total	**2,366**	**804**	**229**	**366**	**946**	**4,712**	**2,525**	**858**	**252**	**404**	**1,010**	**5,049**

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	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Total monetary impact	106,994	54,940	21,705	52,247	52,910	**288,797**	108,997	52,814	23,519	56,515	53,405	**295,250**

MANAGING SPEEDS OF TRAFFIC ON EUROPEAN ROADS

Application of the MASTER framework

Ver. 01/99

Increase of 110 km/h speed limit to 130 km/h on divided, flat, straight rural roads

H. Net impacts

Average Speed (km/h)

	Before	After
Cars and LCVs	**110**	**130**
Trucks	**100**	**130**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		13,814	11,538	-2,275	-16.5 %
Number of Crashes per year		61.6	95.9	34.3	55.6%
Emissions, t/year	Carbon monoxide CO	1318	1505	187	14.2 %
	Hydrocarbons HC	234	269	35.6	15.2 %
	Oxides of nitrogen NOx	843	881	38	4.6 %
	Particles PM	18.9	21.6	2.74	14.5 %
	Carbon dioxide CO2	130882	140750	9868	7.5 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Saving/vehicle/100km (mins.)		Cars&LCVs:	**8.4**	Trucks:	**13.8**	
Increase/100km	Fatal:	**3.4**	Serious Inj:	**13.6**	Other Inj:	**17.2**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	165,276	177,114	11837	7.2 %
Time costs	105,313	87,528	-17785	-16.9 %
Crash costs	13,496	25,559	12,063	89.4%
Air pollution costs	4,712	5,049	338	7.2 %
Noise costs	0	0	0	
Total	**288,797**	**295,250**		
Change			**6,454**	**2.2 %**

~~H3. Summary of monetary impacts for intermediate and lower average speeds~~

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	157,456	158,634	159,987	161,514	163,217	165,096	167,149	169,377	171,781	174,360	177,114
Time costs	142,234	133,867	126,430	119,776	113,787	108,369	103,443	98,945	94,823	91,030	87,528
Crash costs	5,098	6,210	7,488	8,946	10,599	12,464	14,557	16,895	19,496	22,377	25,559
Air pollution costs	4,256	4,336	4,415	4,494	4,574	4,653	4,732	4,812	4,891	4,970	5,049
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**309,044**	**303,047**	**298,319**	**294,730**	**292,177**	**290,581**	**289,881**	**290,029**	**290,990**	**292,737**	**295,250**
of which:											
Cars & light comm. vehs.	234,106	228,789	224,439	220,946	218,225	216,208	214,844	214,091	**213,917**	214,299	215,216
Trucks (rigid and artic.)	74,938	74,258	73,881	**73,784**	73,953	74,373	75,037	75,938	77,073	78,438	80,034

~~H4. Monetary impacts for trucks at intermediate and lower average speeds~~

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	47,439	47,975	48,601	49,316	50,119	51,011	51,991	53,061	54,219	55,466	56,801
Time costs	25,717	24,205	22,860	21,657	20,574	19,594	18,704	17,890	17,145	16,459	15,826
Crash costs	1,229	1,514	1,846	2,228	2,665	3,163	3,727	4,362	5,073	5,867	6,750
Air pollution costs	553	564	574	584	595	605	615	626	636	646	656
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**74,938**	**74,258**	**73,881**	**73,784**	**73,953**	**74,373**	**75,037**	**75,938**	**77,073**	**78,438**	**80,034**

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

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	110,018	110,658	111,385	112,199	113,099	114,085	115,158	116,317	117,562	118,894	120,312
Time costs	116,516	109,662	103,570	98,119	93,213	88,774	84,739	81,055	77,678	74,570	71,702
Crash costs	3,869	4,696	5,642	6,718	7,934	9,301	10,830	12,534	14,423	16,510	18,809
Air pollution costs	3,703	3,772	3,841	3,910	3,979	4,048	4,117	4,186	4,255	4,324	4,393
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**234,106**	**228,789**	**224,439**	**220,946**	**218,225**	**216,208**	**214,844**	**214,091**	**213,917**	**214,299**	**215,216**

APPENDIX H: RURAL DIVIDED ROADS – LEISURE TRAVEL TIME NOT VALUED

DividedFSHCLo.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 Increase of 110 km/h speed limit to 130 km/h on divided, flat, straight rural roads. Leisure travel time not valued.

A1. Length of link 100 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**
Mean speed, km/h	110	110	100	100	110	**108.7**	130	130	130	130	130	**130.0**
AADT*	7,500	2,550	750	1,200	3000	**15,000**	7,500	2,550	750	1,200	3000	**15,000**
Share of traffic	50%	17%	5%	8%	20%	100%	50%	17%	5%	8%	20%	100%
Business trips, %		100	100	100	63	**43**		100	100	100	63	**43**
Pers. bus. and commuting. trips, %	35				16	**21**	35				16	**21**
Leisure trips, %	65				21	**37**	65				21	**37**

*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

Increase of 110 km/h speed limit to 130 km/h on divided, flat, straight rural roads. Leisure travel time not valued.

H. Net impacts

	Average Speed (km/h)	
Cars and LCVs	**110**	**130**
Trucks	**100**	**130**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		13,814	11,538	-2,275	-16.5 %
Number of Crashes per year		61.6	95.9	34.3	55.6%
Emissions, t/year	Carbon monoxide CO	1318	1505	187	14.2 %
	Hydrocarbons HC	234	269	35.6	15.2 %
	Oxides of nitrogen NOx	843	881	38	4.6 %
	Particles PM	18.9	21.6	2.74	14.5 %
	Carbon dioxide CO2	130882	140750	9868	7.5 %
Residents in area where $L_{Aeq,07-22hrs}$ > 55 dB		0	0	0	

Saving/vehicle/100km (mins.)			Cars&LCVs:	**8.4**	Trucks:	**13.8**
Increase/100km	Fatal:	**3.4**	Serious Inj:	**13.6**	Other Inj:	**17.2**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	165,276	177,114	11837	7.2 %
Time costs	79,629	65,795	-13833	-17.4 %
Crash costs	13,496	25,559	12,063	89.4%
Air pollution costs	4,712	5,049	338	7.2 %
Noise costs	0	0	0	
Total	**263,112**	**273,517**		
Change			**10,405**	**4.0 %**

~~H3. Summary of monetary impacts for intermediate and lower average speeds~~

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	157,456	158,634	159,987	161,514	163,217	165,096	167,149	169,377	171,781	174,360	177,114
Time costs	106,918	100,628	95,038	90,036	85,534	81,461	77,758	74,378	71,278	68,427	65,795
Crash costs	5,098	6,210	7,488	8,946	10,599	12,464	14,557	16,895	19,496	22,377	25,559
Air pollution costs	4,256	4,336	4,415	4,494	4,574	4,653	4,732	4,812	4,891	4,970	5,049
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**273,728**	**269,808**	**266,927**	**264,990**	**263,924**	**263,674**	**264,197**	**265,462**	**267,446**	**270,135**	**273,517**
of which:											
Cars & light comm. vehs.	198,790	195,550	193,047	191,206	189,972	189,301	**189,160**	189,523	190,373	191,696	193,483
Trucks (rigid and artic.)	74,938	74,258	73,881	**73,784**	73,953	74,373	75,037	75,938	77,073	78,438	80,034

~~H4. Monetary impacts for trucks at intermediate and lower average speeds~~

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	47,439	47,975	48,601	49,316	50,119	51,011	51,991	53,061	54,219	55,466	56,801
Time costs	25,717	24,205	22,860	21,657	20,574	19,594	18,704	17,890	17,145	16,459	15,826
Crash costs	1,229	1,514	1,846	2,228	2,665	3,163	3,727	4,362	5,073	5,867	6,750
Air pollution costs	553	564	574	584	595	605	615	626	636	646	656
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**74,938**	**74,258**	**73,881**	**73,784**	**73,953**	**74,373**	**75,037**	**75,938**	**77,073**	**78,438**	**80,034**

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

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	110,018	110,658	111,385	112,199	113,099	114,085	115,158	116,317	117,562	118,894	120,312
Time costs	81,200	76,424	72,178	68,379	64,960	61,867	59,055	56,487	54,133	51,968	49,969
Crash costs	3,869	4,696	5,642	6,718	7,934	9,301	10,830	12,534	14,423	16,510	18,809
Air pollution costs	3,703	3,772	3,841	3,910	3,979	4,048	4,117	4,186	4,255	4,324	4,393
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**198,790**	**195,550**	**193,047**	**191,206**	**189,972**	**189,301**	**189,160**	**189,523**	**190,373**	**191,696**	**193,483**

APPENDIX I:
RURAL DIVIDED ROADS – 'WILLINGNESS TO PAY' VALUATIONS OF ROAD TRAUMA

DividedFSWTP.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 Increase of 110 km/h speed limit to 130 km/h on divided, flat, straight rural roads. WTP valuation of crash costs.

A1. Length of link 100 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**
Mean speed, km/h	110	110	100	100	110	**108.7**	130	130	130	130	130	**130.0**
AADT*	7,500	2,550	750	1,200	3000	**15,000**	7,500	2,550	750	1,200	3000	**15,000**
Share of traffic	50%	17%	5%	8%	20%	100%	50%	17%	5%	8%	20%	100%
Business trips, %		100	100	100	63	**43**		100	100	100	63	**43**
Pers. bus. and commuting. trips, %	35				16	**21**	35				16	**21**
Leisure trips, %	65				21	**37**	65				21	**37**

*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

Increase of 110 km/h speed limit to 130 km/h on divided, flat, straight rural roads. WTP valuation of crash costs.

H. Net impacts

Average Speed (km/h)		
Cars and LCVs	**110**	**130**
Trucks	**100**	**130**

~~H1. Physical impacts~~

		Before	After	Change	
Total travel time on link, hours/day		13,814	11,538	-2,275	-16.5 %
Number of Crashes per year		61.6	95.9	34.3	55.6%
Emissions, t/year	Carbon monoxide CO	1318	1505	187	14.2 %
	Hydrocarbons HC	234	269	35.6	15.2 %
	Oxides of nitrogen NOx	843	881	38	4.6 %
	Particles PM	18.9	21.6	2.74	14.5 %
	Carbon dioxide CO2	130882	140750	9868	7.5 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Saving/vehicle/100km (mins.) Cars&LCVs: **8.4** Trucks: **13.8**

Increase/100km Fatal: **3.4** Serious Inj: **13.6** Other Inj: **17.2**

~~H2. Monetary impacts~~

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	165,276	177,114	11837	7.2 %
Time costs	105,313	87,528	-17785	-16.9 %
Crash costs	23,082	45,145	22,062	95.6%
Air pollution costs	4,712	5,049	338	7.2 %
Noise costs	0	0	0	
Total	**298,384**	**314,836**		
Change			**16,453**	**5.5 %**

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

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	157,456	158,634	159,987	161,514	163,217	165,096	167,149	169,377	171,781	174,360	177,114
Time costs	142,234	133,867	126,430	119,776	113,787	108,369	103,443	98,945	94,823	91,030	87,528
Crash costs	8,645	10,551	12,757	15,292	18,190	21,482	25,205	29,394	34,087	39,324	45,145
Air pollution costs	4,256	4,336	4,415	4,494	4,574	4,653	4,732	4,812	4,891	4,970	5,049
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**312,592**	**307,388**	**303,588**	**301,077**	**299,768**	**299,600**	**300,529**	**302,528**	**305,581**	**309,683**	**314,836**
of which:											
Cars & light comm. vehs.	236,619	231,832	228,099	225,318	223,414	222,332	**222,030**	222,479	223,661	225,563	228,181
Trucks (rigid and artic.)	75,973	75,556	**75,490**	75,759	76,354	77,268	78,499	80,049	81,921	84,120	86,655

H4. Monetary impacts for trucks at intermediate and lower average speeds

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	47,439	47,975	48,601	49,316	50,119	51,011	51,991	53,061	54,219	55,466	56,801
Time costs	25,717	24,205	22,860	21,657	20,574	19,594	18,704	17,890	17,145	16,459	15,826
Crash costs	2,264	2,812	3,455	4,202	5,066	6,058	7,189	8,472	9,921	11,549	13,371
Air pollution costs	553	564	574	584	595	605	615	626	636	646	656
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**75,973**	**75,556**	**75,490**	**75,759**	**76,354**	**77,268**	**78,499**	**80,049**	**81,921**	**84,120**	**86,655**

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

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	110,018	110,658	111,385	112,199	113,099	114,085	115,158	116,317	117,562	118,894	120,312
Time costs	116,516	109,662	103,570	98,119	93,213	88,774	84,739	81,055	77,678	74,570	71,702
Crash costs	6,382	7,739	9,302	11,090	13,123	15,425	18,016	20,922	24,166	27,774	31,774
Air pollution costs	3,703	3,772	3,841	3,910	3,979	4,048	4,117	4,186	4,255	4,324	4,393
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**236,619**	**231,832**	**228,099**	**225,318**	**223,414**	**222,332**	**222,030**	**222,479**	**223,661**	**225,563**	**228,181**

APPENDIX J: RURAL DIVIDED ROADS – TRUCKS LIMITED TO 100 KM/H

DividedFSHCT100.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 Increase of 110 km/h speed limit to 130 km/h for cars and LCVs on divided, flat, straight rural roads (trucks limited to 100 km/h)

A1. Length of link 100 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**
Mean speed, km/h	110	110	100	100	110	**108.7**	130	130	100	100	130	**126.1**
AADT*	7,500	2,550	750	1,200	3000	**15,000**	7,500	2,550	750	1,200	3000	**15,000**
Share of traffic	50%	17%	5%	8%	20%	100%	50%	17%	5%	8%	20%	100%
Business trips, %		100	100	100	63	**43**		100	100	100	63	**43**
Pers. bus. and commuting. trips, %	35				16	**21**	35				16	**21**
Leisure trips, %	65				21	**37**	65				21	**37**

*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

Increase of 110 km/h speed limit to 130 km/h for cars and LCVs on divided, flat, straight rural roads (trucks limited to 100 km/h)

H. Net impacts

	Average Speed (km/h)	
Cars and LCVs	**110**	**130**
Trucks	**100**	**100**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		13,814	11,988	-1,825	-13.2 %
Number of Crashes per year		61.6	88.0	26.4	42.8%
Emissions, t/year	Carbon monoxide CO	1318	1471	152	11.6 %
	Hydrocarbons HC	234	263	29.1	12.4 %
	Oxides of nitrogen NOx	843	874	31	3.7 %
	Particles PM	18.9	21.1	2.24	11.9 %
	Carbon dioxide CO2	130882	138943	8061	6.2 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Saving/vehicle/100km (mins.) Cars&LCVs: **8.4** Trucks: **0.0**

Increase/100km Fatal: **1.9** Serious Inj: **10.3** Other Inj: **14.2**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	165,276	170,431	5155	3.1 %
Time costs	105,313	92,276	-13037	-12.4 %
Crash costs	13,496	21,474	7,978	59.1%
Air pollution costs	4,712	4,988	276	5.9 %
Noise costs	0	0	0	
Total	**288,797**	**289,169**		
Change			**372**	**0.1 %**

~~H3. Summary of monetary impacts for intermediate and lower average speeds~~

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
						Car average speed (Truck average speed fixed at 100 kmh)					
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	157,456	158,634	159,987	161,514	163,217	164,204	165,276	166,435	167,681	169,013	170,431
Time costs	142,234	133,867	126,430	119,776	113,787	109,348	105,313	101,629	98,252	95,144	92,276
Crash costs	5,098	6,210	7,488	8,946	10,599	11,966	13,496	15,199	17,088	19,175	21,474
Air pollution costs	4,256	4,336	4,415	4,494	4,574	4,643	4,712	4,781	4,850	4,919	4,988
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**309,044**	**303,047**	**298,319**	**294,730**	**292,177**	**290,161**	**288,797**	**288,044**	**287,870**	**288,251**	**289,169**
of which:											
Cars & light comm. vehs.	234,106	228,789	224,439	220,946	218,225	216,208	214,844	214,091	**213,917**	214,299	215,216
Trucks (rigid and artic.)	74,938	74,258	73,881	**73,784**	73,953	73,953	73,953	73,953	73,953	73,953	73,953

~~H4. Monetary impacts for trucks at intermediate and lower average speeds~~

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	47,439	47,975	48,601	49,316	50,119	50,119	50,119	50,119	50,119	50,119	50,119
Time costs	25,717	24,205	22,860	21,657	20,574	20,574	20,574	20,574	20,574	20,574	20,574
Crash costs	1,229	1,514	1,846	2,228	2,665	2,665	2,665	2,665	2,665	2,665	2,665
Air pollution costs	553	564	574	584	595	595	595	595	595	595	595
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**74,938**	**74,258**	**73,881**	**73,784**	**73,953**	**73,953**	**73,953**	**73,953**	**73,953**	**73,953**	**73,953**

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

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	110,018	110,658	111,385	112,199	113,099	114,085	115,158	116,317	117,562	118,894	120,312
Time costs	116,516	109,662	103,570	98,119	93,213	88,774	84,739	81,055	77,678	74,570	71,702
Crash costs	3,869	4,696	5,642	6,718	7,934	9,301	10,830	12,534	14,423	16,510	18,809
Air pollution costs	3,703	3,772	3,841	3,910	3,979	4,048	4,117	4,186	4,255	4,324	4,393
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**234,106**	**228,789**	**224,439**	**220,946**	**218,225**	**216,208**	**214,844**	**214,091**	**213,917**	**214,299**	**215,216**

APPENDIX K:
RURAL DIVIDED ROADS – VARIABLE SPEED LIMIT

DividedFSHCVSL130.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 ~~Increased speed limit for cars and LCVs to 130 kmh on divided rural roads during daytime, reduction to 100 kmh at night~~

~~A1. Length of link~~ 100 km

~~A2. Flow characteristics~~

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**
Mean speed, km/h	110	110	100	100	110	**108.7**	130	130	100	100	130	**126.1**
AADT*	7,500	2,550	750	1,200	3000	**15,000**	7,500	2,550	750	1,200	3000	**15,000**
Share of traffic	50%	17%	5%	8%	20%	100%	50%	17%	5%	8%	20%	100%
Business trips, %		100	100	100	63	**43**		100	100	100	63	**43**
Pers. bus. and commuting. trips, %	35				16	**21**	35				16	**21**
Leisure trips, %	65				21	**37**	65				21	**37**

*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

Increased speed limit for cars and LCVs to 130 kmh on divided rural roads during daytime, reduction to 100 kmh at night

H. Net impacts

	Day Average Speed (km/h)		Night Average Speed (km/h)		Total Impact of VSL
Cars and LCVs	**110**	**130**	**110**	**100**	Total of night and day changes
Trucks	**100**	**100**	**100**	**100**	

~~H1. Physical impacts~~

		Day Before	Day After	Day Change		Night Before	Night After	Night Change		Total Before	Total After	Total Change	
Total travel time on link, hours/day		11,051	9,591	-1,460	-13.2 %	2,763	3,000	237	8.6 %	13,814	12,591	-1,223	-8.9 %
Number of Crashes per year		37.0	52.8	15.8	42.8%	24.6	20.3	-4.3	-17.5%	61.6	73.1	11.5	18.7%
Emissions, t/year	Carbon monoxide CO	1,055	1,177	122	11.6 %	264	248	-15	-5.8 %	1,318	1,425	107	8.1 %
	Hydrocarbons HC	187	210	23.2	12.4 %	47	44	-2.9	-6.2 %	234	254	20.3	8.7 %
	Oxides of nitrogen NOx	674	700	25	3.7 %	169	165	-3	-1.9 %	843	865	22	2.6 %
	Particles PM	15.1	16.9	1.79	11.9 %	3.8	3.6	-0.22	-5.9 %	18.9	20.5	1.57	8.3 %
	Carbon dioxide CO2	104,706	111,154	6449	6.2 %	26,176	25,370	-806	-3.1 %	130,882	136,525	5643	4.3 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0		0	0	0		0	0	0	

		Day		Night			Total
Travel time saving/vehicle/100km (mins.)	Cars&LCVs:	**8.4**	Cars&LCVs:	**-5.5**	**Average**	Cars&LCVs:	**5.6**
	Trucks:	**0.0**	Trucks:	**0.0**		Trucks:	**0.0**
Casualty crash increase/100km	Fatal:	**1.2**	Fatal:	**-0.3**	**Total**	Fatal:	**0.9**
	Serious Inj:	**6.2**	Serious Inj:	**-1.6**		Serious Inj:	**4.6**
	Other Inj:	**8.5**	Other Inj:	**-2.5**		Other Inj:	**6.0**

~~H2. Monetary impacts~~

k$/year	Day Before	Day After	Day Change		Night Before	Night After	Night Change		Total Before	Total After	Total Change	
Consumer surplus	(N. A.)	(N. A.)	0	(N. A.)	(N. A.)	(N. A.)	0	(N. A.)	(N. A.)	(N. A.)	0	(N. A.)
Vehicle operating costs	132,221	136,345	4,124	3.1 %	33,055	32,643	-412	-1.2 %	165,276	168,988	3,712	2.2 %
Time costs	84,251	73,821	-10,429	-12.4 %	21,063	22,757	1,695	8.0 %	105,313	96,578	-8,735	-8.3 %
Crash costs	8,097	12,884	4,787	59.1%	5,398	4,240	-1,159	-21.5%	13,496	17,124	3,628	26.9%
Air pollution costs	3,769	3,990	221	5.9 %	942	915	-28	-2.9 %	4,712	4,905	193	4.1 %
Noise costs	0	0	0		0	0	0		0	0	0	
Total	**228,338**	**227,040**			**60,458**	**60,555**			**288,797**	**287,596**		
Change			**-1,298**	**-0.6 %**			**97**	**0.2 %**			**-1,201**	**-0.4 %**

APPENDIX L: RURAL UNDIVIDED 7.0 M SEALED ROADS - BASE SCENARIO

Undivided1FSHC.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 ~~Increase of 100 km/h speed limit to 130 km/h on two-lane undivided 7.0 m sealed flat straight rural roads~~

~~A1. Length of link~~ 100 km

~~A2. Flow characteristics~~

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**
Mean speed, km/h	100	100	100	100	100	**100.0**	130	130	130	130	130	**130.0**
AADT*	500	170	50	80	200	**1,000**	500	170	50	80	200	**1,000**
Share of traffic	50%	17%	5%	8%	20%	100%	50%	17%	5%	8%	20%	100%
Business trips, %		100	100	100	63	**43**		100	100	100	63	**43**
Pers. bus. and commuting. trips, %	35				16	**21**	35				16	**21**
Leisure trips, %	65				21	**37**	65				21	**37**

*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

Increase of 100 km/h speed limit to 130 km/h on two-lane undivided 7.0 m sealed flat straight rural roads

2. Measurement of impacts

D. Impact functions

D1. Vehicle operating costs

Freeway Model for operations on freeways and high quality arterial roads (Thoresen et al 2003); September 2000 prices

D2. Travel time

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

D3a. Accidents

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

Fatal accidents	$n_{IA} = (v_A/v_B)^4 * n_{IB}$	(Andersson & Nilsson, 1997)
Serious injury accidents	$n_{IA} = (v_A/v_B)^3 * n_{IB}$	
Other injury accidents	$n_{IA} = (v_A/v_B)^2 * n_{IB}$	

D4. Air pollutant emission coefficients

*Emission factors**	At initial speed, g/km						At final speed, g/km					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Carbon monoxide CO	2.27	2.27	2.27	2.27	2.27	2.27	2.75	2.75	2.75	2.75	2.75	2.75
Hydrocarbons HC	0.40	0.40	0.40	0.40	0.40	0.40	0.49	0.49	0.49	0.49	0.49	0.49
Oxides of nitrogen NO_x	1.51	1.51	1.51	1.51	1.51	1.51	1.61	1.61	1.61	1.61	1.61	1.61
Particles PM	0.032	0.032	0.032	0.032	0.032	0.032	0.040	0.040	0.040	0.040	0.040	0.040
Carbon dioxide CO_2	231.7	231.7	231.7	231.7	231.7	231.7	257.1	257.1	257.1	257.1	257.1	257.1

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	0.51	0.57

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Vehicle oper. costs*	0.224	0.234	0.523	0.818	0.274	**0.298**	0.238	0.247	0.591	0.927	0.293	**0.323**
*With Co	21.49	22.69	52.45	83.47	28.83		21.49	22.69	52.45	83.47	28.83	
C1	-0.021	-0.021	-0.18	-0.311	-0.073		-0.021	-0.021	-0.18	-0.311	-0.073	
C2	0.0003	0.00028	0.00178	0.00294	0.00059		0.0003	0.00028	0.00178	0.0029	0.0006	

E2a. Time costs per hour

Value of travel time	$ per hour				
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm
Business trips, %		35.3	22.9	32.7	23.6
Pers. bus. and commuting. trips, %	14.5				11.1
Leisure trips, %	14.5				11.1
Average	**14.5**	**35.3**	**22.9**	**32.7**	**19.0**

E2b. Time costs per kilometre

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Time costs	0.145	0.353	0.229	0.327	0.190	**0.2078**	0.111	0.272	0.176	0.251	0.146	**0.1599**

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

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Total user costs	0.368	0.587	0.752	1.144	0.464	**0.506**	0.349	0.519	0.767	1.178	0.439	**0.483**

E4. Accident costs

Accident type	**kA$/ accid.**
Fatal accident	1740.36
Serious injury accident	429.55
Other injury accident	14.50
Personal injury accident (av.)	N.A.

"Human capital" valuation (BTE 2000) indexed to year 2000 prices

E5a. Air pollution costs

Air pollutants' unit costs	**$/t**
Carbon monoxide CO	2
Hydrocarbons HC	440
Oxides of nitrogen NOx	1740
Particles PM	13770
Carbon dioxide CO2	22

Cosgrove (1994) indexed to year 2000 prices

E5b. Noise pollution costs

Unit costs of noise pollution	**$/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, k$/year						After policy, k$/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total
Vehicle operating costs	4,086	1,451	954	2,388	2,002	**10,881**	4,349	1,532	1,079	2,708	2,140	**11,808**

F2a. Travel time

	Before policy, vehicle-hours/day						After policy, vehicle-hours/day					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total
Total travel time on link	500	170	50	80	200	**1,000**	385	131	38	62	154	**769**

F2b. Travel time costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total
Total travel time costs	2,637	2,192	418	954	1,385	**7,586**	2,029	1,687	321	734	1,065	**5,835**

F3. Consumer surplus

	Input data, before policy						Input data, after policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Total user costs, $/veh.km	0.368	0.587	0.752	1.144	0.464	**0.506**	0.349	0.519	0.767	1.178	0.439	0.483
Mio veh.kms/year	18	6	2	3	7	**37**	18	6	2	3	7	**37**

	Change in consumer surplus					Total
k$/year	-346	-425	29	100	-182	**-824**

F4a. Casualty accident rates

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm		Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	
Crash rate per million VKT	0.25	0.25	0.25	0.25	0.25		0.47	0.47	0.49	0.50	0.47	

F4b. Casualty accident severity

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm		Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	
Fatal (%)	3.8	3.8	8.0	11.4	3.8		5.8	5.8	11.7	16.3	5.8	
Serious injury (%)	29.4	29.4	34.0	35.2	29.4		34.3	34.3	38.2	38.6	34.3	
Minor injury (%)	66.8	66.8	58.0	53.4	66.8		59.9	59.9	50.1	45.1	59.9	

F4c. Accidents

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total
Fatal accident	0.2	0.1	0.0	0.1	0.1	**0.4**	0.5	0.2	0.1	0.2	0.2	**1.2**
Serious injury accident	1.3	0.5	0.2	0.3	0.5	**2.7**	2.9	1.0	0.3	0.6	1.2	**6.0**
Minor injury accident	3.0	1.0	0.3	0.4	1.2	**6.0**	5.2	1.8	0.4	0.7	2.1	**10.1**
Total casualty accidents	4.6	1.6	0.5	0.7	1.8	**9.1**	8.6	2.9	0.9	1.5	3.4	**17.3**

F4d. Accident costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Total
Fatal accident	302	103	64	145	121	**733**	862	293	181	414	345	**2,095**
Serious injury accident	576	196	67	110	230	**1,180**	1,266	430	146	242	506	**2,592**
Minor injury accident	44	15	4	6	18	**86**	75	25	6	10	30	**146**
Total casualty accidents	922	314	134	261	369	**1,999**	2,202	749	334	666	881	**4,832**

F5a. Air pollution

Emissions	At initial speed, t/year						At final speed, t/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Carbon monoxide CO	41	14	4	7	17	**83**	50	17	5	8	20	**100**
Hydrocarbons HC	7	2	1	1	3	**15**	9	3	1	1	4	**18**
Oxides of nitrogen NOx	28	9	3	4	11	**55**	29	10	3	5	12	**59**
Particles PM	1	0	0	0	0	**1**	1	0	0	0	0	**1**
Carbon dioxide CO2	4,228	1,438	423	677	1,691	**8,457**	4,692	1,595	469	751	1,877	**9,383**

F5b. Air pollution costs

Emissions	At initial speed, k$/year						At final speed, k$/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Carbon monoxide CO	0	0	0	0	0	**0**	0	0	0	0	0	**0**
Hydrocarbons HC	3	1	0	1	1	**6**	4	1	0	1	2	**8**
Oxides of nitrogen NOx	48	16	5	8	19	**96**	51	17	5	8	20	**102**
Particles PM	8	3	1	1	3	**16**	10	3	1	2	4	**20**
Carbon dioxide CO2	93	32	9	15	37	**186**	103	35	10	17	41	**206**
Total	**152**	**52**	**15**	**24**	**61**	**305**	**168**	**57**	**17**	**27**	**67**	**337**

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	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Total monetary impact	7,798	4,009	1,521	3,627	3,817	**20,771**	8,748	4,025	1,752	4,134	4,153	**22,812**

End of sheet

Application of the MASTER framework

Ver. 01/99

Increase of 100 km/h speed limit to 130 km/h on two-lane undivided 7.0 m sealed flat straight rural roads

H. Net impacts

Average Speed (km/h)

Cars and LCVs	**100**	**130**
Trucks	**100**	**130**

~~H1. Physical impacts~~

		Before	After	Change	
Total travel time on link, hours/day		1,000	769	-231	-23.1 %
Number of Crashes per year		9.1	17.3	8.2	89.6%
Emissions, t/year	Carbon monoxide CO	83	100	18	21.2 %
	Hydrocarbons HC	15	18	3.3	22.9 %
	Oxides of nitrogen NOx	55	59	4	6.6 %
	Particles PM	1.2	1.4	0.26	21.7 %
	Carbon dioxide CO2	8457	9383	927	11.0 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Saving/vehicle/100km (mins.) Cars&LCVs: **13.8** Trucks: **13.8**

Increase/100km Fatal: **0.8** Serious Inj: **3.3** Other Inj: **4.1**

~~H2. Monetary impacts~~

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	10,881	11,808	926	8.5 %
Time costs	7,586	5,835	-1751	-23.1 %
Crash costs	1,999	4,832	2,833	141.7%
Air pollution costs	305	337	32	10.4 %
Noise costs	0	0	0	
Total	**20,771**	**22,812**		
Change			**2,040**	**9.8 %**

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

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	10,497	10,576	10,666	10,768	10,881	11,006	11,143	11,292	11,452	11,624	11,808
Time costs	9,482	8,924	8,429	7,985	7,586	7,225	6,896	6,596	6,322	6,069	5,835
Crash costs	960	1,170	1,411	1,687	1,999	2,352	2,748	3,191	3,683	4,229	4,832
Air pollution costs	284	289	294	300	305	310	315	321	326	331	337
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**21,223**	**20,959**	**20,800**	**20,739**	**20,771**	**20,893**	**21,103**	**21,400**	**21,783**	**22,253**	**22,812**
of which:											
Cars & light comm. vehs.	16,127	15,885	15,724	15,638	**15,624**	15,677	15,797	15,982	16,231	16,546	16,926
Trucks (rigid and artic.)	5,096	**5,074**	5,076	5,100	5,147	5,216	5,306	5,418	5,552	5,707	5,886

H4. Monetary impacts for trucks at intermediate and lower average speeds

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	3,163	3,198	3,240	3,288	3,341	3,401	3,466	3,537	3,615	3,698	3,787
Time costs	1,714	1,614	1,524	1,444	1,372	1,306	1,247	1,193	1,143	1,097	1,055
Crash costs	182	224	273	330	395	469	552	646	752	869	1,000
Air pollution costs	37	38	38	39	40	40	41	42	42	43	44
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**5,096**	**5,074**	**5,076**	**5,100**	**5,147**	**5,216**	**5,306**	**5,418**	**5,552**	**5,707**	**5,886**

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

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	7,335	7,377	7,426	7,480	7,540	7,606	7,677	7,754	7,837	7,926	8,021
Time costs	7,768	7,311	6,905	6,541	6,214	5,918	5,649	5,404	5,179	4,971	4,780
Crash costs	778	945	1,138	1,357	1,604	1,884	2,196	2,545	2,932	3,360	3,832
Air pollution costs	247	251	256	261	265	270	274	279	284	288	293
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**16,127**	**15,885**	**15,724**	**15,638**	**15,624**	**15,677**	**15,797**	**15,982**	**16,231**	**16,546**	**16,926**

APPENDIX M:
RURAL UNDIVIDED 7.0 M SEALED ROADS – CURVY ROADS WITH CROSSROADS AND TOWNS

Undivided1CCTHC.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 Increase of 100 kmh speed limit to 130 kmh on two-lane undivided 7.0 m sealed curvy rural roads with crossroads & towns [50 sharp bends, 14 cross roads, and 3 intersections requiring stopping (usually in towns) per 100 kilometres]

A1. Length of link 100 km

A2. Flow characteristics

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	100	100	100	100	100	**100.0**	130	130	130	130	130	**130.0**
Average of all speeds on link	96.8	96.8	96.8	96.8	96.8		115.1	115.1	115.1	115.1	115.1	
AADT*	500	170	50	80	200	**1,000**	500	170	50	80	200	**1,000**
Share of traffic	50%	17%	5%	8%	20%	100%	50%	17%	5%	8%	20%	100%
Business trips, %		100	100	100	63	**43**		100	100	100	63	**43**
Pers. bus. and commuting. trips, %	35				16	**21**	35				16	**21**
Leisure trips, %	65				21	**37**	65				21	**37**

*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

Increase of 100 kmh speed limit to 130 kmh on two-lane undivided 7.0 m sealed curvy rural roads with crossroads & towns

2. Measurement of impacts

D. Impact functions

D1. Vehicle operating costs

Freeway Model for operations on freeways and high quality arterial roads (Thoresen et al 2003); September 2000 prices

D2. Travel time

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

D3a. Accidents

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

Fatal accidents	$n_{IA} = (v_A/v_B)^4 * n_{IB}$	(Andersson & Nilsson, 1997)
Serious injury accidents	$n_{IA} = (v_A/v_B)^3 * n_{IB}$	
Other injury accidents	$n_{IA} = (v_A/v_B)^2 * n_{IB}$	

D4. Air pollutant emission coefficients

*Emission factors**	At initial speed, g/km						At final speed, g/km					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Carbon monoxide CO	3.68	3.68	3.68	3.68	3.68	3.68	39.65	39.65	39.65	39.65	39.65	39.65
Hydrocarbons HC	0.60	0.60	0.60	0.60	0.60	0.60	4.25	4.25	4.25	4.25	4.25	4.25
Oxides of nitrogen NO_x	2.53	2.53	2.53	2.53	2.53	2.53	28.59	28.59	28.59	28.59	28.59	28.59
Particles PM	0.04	0.04	0.04	0.04	0.04	0.043	0.18	0.18	0.18	0.18	0.18	0.180
Carbon dioxide CO_2	303.9	303.9	303.9	303.9	303.9	303.9	1168.7	1168.7	1168.7	1168.7	1168.7	1168.7

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	0.51	0.57

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Vehicle oper. costs*	0.242	0.252	0.566	0.897	0.295	**0.323**	0.448	0.456	1.090	1.832	0.527	**0.608**
*With Co	23.33	24.53	56.83	91.42	30.89		42.41	43.61	102.28	173.90	52.24	
C1	-0.021	-0.021	-0.18	-0.311	-0.073		-0.021	-0.021	-0.18	-0.311	-0.073	
C2	0.0003	0.00028	0.00178	0.00294	0.00059		0.0003	0.00028	0.00178	0.0029	0.0006	
Co	21.49	22.69	52.45	83.47	28.83		21.49	22.69	52.45	83.47	28.83	
C1	-0.021	-0.021	-0.18	-0.311	-0.073		-0.021	-0.021	-0.18	-0.311	-0.073	
C2	0.0003	0.00028	0.00178	0.00294	0.00059		0.0003	0.00028	0.00178	0.0029	0.0006	
Fuel consumption rate (lt/100km)	11.8	11.8	28.1	51.0	13.2		11.8	11.8	28.1	51.0	13.2	
Increase associated with speed	1.31183	1.31183	1.31183	1.31183	1.31183		4.54629	4.54629	4.54629	4.5463	4.5463	

E2a. Time costs per hour

Value of travel time	$ per hour				
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm
Business trips, %		35.3	22.9	32.7	23.6
Pers. bus. and commuting. trips, %	14.5				11.1
Leisure trips, %	14.5				11.1
Average	**14.5**	**35.3**	**22.9**	**32.7**	**19.0**

E2b. Time costs per kilometre

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Time costs	0.149	0.365	0.237	0.337	0.196	**0.2147**	0.126	0.307	0.199	0.284	0.165	**0.1806**

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

	$ per vehicle-km											
	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	Average
Total user costs	0.392	0.617	0.803	1.235	0.491	**0.538**	0.573	0.763	1.289	2.115	0.692	**0.788**

E4. Accident costs

Accident type	**kA$/ accid.**
Fatal accident	1740.36
Serious injury accident	429.55
Other injury accident	14.50
Personal injury accident (av.)	N.A.

"Human capital" valuation (BTE 2000) indexed to year 2000 prices

E5a. Air pollution costs

Air pollutants' unit costs	**$/t**
Carbon monoxide CO	2
Hydrocarbons HC	440
Oxides of nitrogen NOx	1740
Particles PM	13770
Carbon dioxide CO2	22

Cosgrove (1994) indexed to year 2000 prices

E5b. Noise pollution costs

Unit costs of noise pollution	**$/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, k$/year						After policy, k$/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Vehicle operating costs	4,422	1,566	1,034	2,620	2,153	**11,793**	8,167	2,830	1,988	5,348	3,848	**22,183**

F2a. Travel time

	Before policy, vehicle-hours/day						After policy, vehicle-hours/day					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Total travel time on link	516	176	52	83	207	**1,033**	434	148	43	70	174	**869**

F2b. Travel time costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Total travel time costs	2,724	2,264	432	985	1,430	**7,835**	2,291	1,905	363	829	1,203	**6,591**

F3. Consumer surplus

	Input data, before policy						Input data, after policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Average**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Average**
Total user costs, $/veh.km	0.392	0.617	0.803	1.235	0.491	**0.538**	0.573	0.763	1.289	2.115	0.692	0.788
Mio veh.kms/year	18	6	2	3	7	**37**	18	6	2	3	7	**37**

	Change in consumer surplus					Total
k$/year	3313	905	886	2572	1469	**9146**

F4a. Casualty accident rates

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm		Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	
Crash rate per million VKT	0.28	0.28	0.28	0.28	0.28		0.52	0.52	0.54	0.56	0.52	

F4b. Casualty accident severity

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm		Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	
Fatal (%)	3.8	3.8	8.0	11.4	3.8		5.8	5.8	11.7	16.3	5.8	
Serious injury (%)	29.4	29.4	34.0	35.2	29.4		34.3	34.3	38.2	38.6	34.3	
Minor injury (%)	66.8	66.8	58.0	53.4	66.8		59.9	59.9	50.1	45.1	59.9	

F4c. Accidents

	Before policy, crashes/year						After policy, crashes/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Fatal accident	0.2	0.1	0.0	0.1	0.1	**0.5**	0.6	0.2	0.1	0.3	0.2	**1.3**
Serious injury accident	1.5	0.5	0.2	0.3	0.6	**3.1**	3.3	1.1	0.4	0.6	1.3	**6.7**
Minor injury accident	3.4	1.2	0.3	0.4	1.4	**6.6**	5.7	2.0	0.5	0.7	2.3	**11.2**
Total casualty accidents	5.1	1.7	0.5	0.8	2.0	**10.2**	9.6	3.3	1.0	1.6	3.8	**19.3**

F4d. Accident costs

	Before policy, k$/year						After policy, k$/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Fatal accident	336	114	71	161	134	**817**	960	326	202	461	384	**2,334**
Serious injury accident	642	218	74	123	257	**1,314**	1,410	480	163	270	564	**2,887**
Minor injury accident	49	17	4	6	20	**96**	83	28	7	11	33	**163**
Total casualty accidents	1,027	349	149	291	411	**2,228**	2,454	834	372	742	982	**5,384**

F5a. Air pollution

Emissions	At initial speed, t/year						At final speed, t/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Carbon monoxide CO	67	23	7	11	27	**134**	724	246	72	116	289	**1,447**
Hydrocarbons HC	11	4	1	2	4	**22**	78	26	8	12	31	**155**
Oxides of nitrogen NOx	46	16	5	7	18	**92**	522	177	52	83	209	**1,043**
Particles PM	1	0	0	0	0	**2**	3	1	0	1	1	**7**
Carbon dioxide CO2	5,547	1,886	555	888	2,219	**11,094**	21,330	7,252	2,133	3,413	8,532	**42,659**

F5b. Air pollution costs

Emissions	At initial speed, k$/year						At final speed, k$/year					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Carbon monoxide CO	0	0	0	0	0	**0**	1	0	0	0	1	**3**
Hydrocarbons HC	5	2	0	1	2	**10**	34	12	3	5	14	**68**
Oxides of nitrogen NOx	80	27	8	13	32	**161**	908	309	91	145	363	**1,815**
Particles PM	11	4	1	2	4	**21**	45	15	5	7	18	**90**
Carbon dioxide CO2	122	41	12	20	49	**244**	469	160	47	75	188	**939**
Total	**218**	**74**	**22**	**35**	**87**	**436**	**1,458**	**496**	**146**	**233**	**583**	**2,915**

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	Truck - Rigid	Truck - Artic.	Light Comm	**Total**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total**
Total monetary impact	8,391	4,253	1,636	3,930	4,081	**22,292**	14,370	6,065	2,870	7,152	6,616	**37,073**

Application of the MASTER framework

Ver. 01/99

Increase of 100 kmh speed limit to 130 kmh on two-lane undivided 7.0 m sealed curvy rural roads with crossroads & towns

H. Net impacts

Cruise Speed (km/h)		
Cars and LCVs	**100**	**130**
Trucks	**100**	**130**

Average speed on link (km/h)	Before	After
Cars and LCVs	**96.8**	**115.1**
Trucks	**96.8**	**115.1**

~~H1. Physical impacts~~

		Before	After	Change	
Total travel time on link, hours/day		1,033	869	-164	-15.9 %
Number of Crashes per year		10.2	19.3	9.1	89.6%
Emissions, t/year	Carbon monoxide CO	134	1447	1313	976.6 %
	Hydrocarbons HC	22	155	133.2	609.3 %
	Oxides of nitrogen NOx	92	1043	951	1030.5 %
	Particles PM	1.6	6.6	5.00	321.9 %
	Carbon dioxide CO2	11094	42659	31565	284.5 %
Residents in area where $L_{Aeq,07-22hrs}$ > 55 dB		0	0	0	

Saving/vehicle/100km (mins.) Cars&LCVs: **9.8** Trucks: **9.8**

Increase/100km Fatal: **0.9** Serious Inj: **3.7** Other Inj: **4.6**

~~H2. Monetary impacts~~

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	11,793	22,183	10389	88.1 %
Time costs	7,835	6,591	-1244	-15.9 %
Crash costs	2,228	5,384	3,156	141.7%
Air pollution costs	436	2,915	2,479	568.8 %
Noise costs	0	0	0	
Total	**22,292**	**37,073**		
Change			**14,781**	**66.3 %**

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

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	10,651	10,789	11,056	11,380	11,793	12,519	13,359	14,642	16,346	18,742	22,183
Time costs	9,550	9,026	8,572	8,178	7,835	7,537	7,279	7,057	6,869	6,714	6,591
Crash costs	1,069	1,303	1,572	1,879	2,228	2,621	3,062	3,555	4,104	4,712	5,384
Air pollution costs	304	317	379	385	436	541	673	908	1,268	1,869	2,915
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**21,574**	**21,436**	**21,580**	**21,821**	**22,292**	**23,217**	**24,373**	**26,162**	**28,588**	**32,037**	**37,073**
of which:											
Cars & light comm. vehs.	16,390	**16,241**	16,302	16,428	16,725	17,344	18,130	19,364	21,055	23,479	27,052
Trucks (rigid and artic.)	5,184	5,195	5,278	5,394	5,567	5,873	6,243	6,798	7,534	8,559	10,022

H4. Monetary impacts for trucks at intermediate and lower cruise speeds

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	3,215	3,271	3,374	3,497	3,653	3,918	4,224	4,684	5,289	6,133	7,337
Time costs	1,727	1,632	1,550	1,479	1,417	1,363	1,316	1,276	1,242	1,214	1,192
Crash costs	203	250	305	368	440	522	615	720	837	968	1,114
Air pollution costs	39	41	49	50	57	70	88	118	165	243	379
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**5,184**	**5,195**	**5,278**	**5,394**	**5,567**	**5,873**	**6,243**	**6,798**	**7,534**	**8,559**	**10,022**

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

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	7,436	7,518	7,683	7,883	8,140	8,601	9,135	9,958	11,057	12,609	14,846
Time costs	7,823	7,394	7,022	6,699	6,418	6,174	5,963	5,781	5,627	5,500	5,399
Crash costs	866	1,053	1,268	1,512	1,788	2,099	2,447	2,835	3,267	3,744	4,270
Air pollution costs	264	276	330	335	379	470	586	790	1,103	1,626	2,536
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**16,390**	**16,241**	**16,302**	**16,428**	**16,725**	**17,344**	**18,130**	**19,364**	**21,055**	**23,479**	**27,052**

APPENDIX N: RURAL UNDIVIDED 8.5 M SHOULDER-SEALED ROADS - BASE SCENARIO

Undivided2FSHC.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 ~~Increase of 100 km/h speed limit to 130 km/h on two-lane undivided 8.5 m shoulder-sealed flat straight rural roads~~

~~A1. Length of link~~ 100 km

~~A2. Flow characteristics~~

Traffic attributes	**Before policy**						**After policy**					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**
Mean speed, km/h	100	100	100	100	100	**100.0**	130	130	130	130	130	**130.0**
AADT*	500	170	50	80	200	**1,000**	500	170	50	80	200	**1,000**
Share of traffic	50%	17%	5%	8%	20%	100%	50%	17%	5%	8%	20%	100%
Business trips, %		100	100	100	63	**43**		100	100	100	63	**43**
Pers. bus. and commuting. trips, %	35				16	**21**	35				16	**21**
Leisure trips, %	65				21	**37**	65				21	**37**

*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

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Increase of 100 km/h speed limit to 130 km/h on two-lane undivided 8.5 m shoulder-sealed flat straight rural roads

H. Net impacts

	Average Speed (km/h)	
Cars and LCVs	100	130
Trucks	100	130

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		1,000	769	-231	-23.1 %
Number of Crashes per year		5.8	11.1	5.2	89.6%
Emissions, t/year	Carbon monoxide CO	83	100	18	21.2 %
	Hydrocarbons HC	15	18	3.3	22.9 %
	Oxides of nitrogen NOx	55	59	4	6.6 %
	Particles PM	1.2	1.4	0.26	21.7 %
	Carbon dioxide CO2	8457	9383	927	11.0 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Saving/vehicle/100km (mins.) Cars&LCVs: **13.8** Trucks: **13.8**

Increase/100km Fatal: **0.5** Serious Inj: **2.1** Other Inj: **2.6**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	10,881	11,808	926	8.5 %
Time costs	7,586	5,835	-1751	-23.1 %
Crash costs	1,280	3,093	1,813	141.7%
Air pollution costs	305	337	32	10.4 %
Noise costs	0	0	0	
Total	**20,051**	**21,072**		
Change			**1,021**	**5.1 %**

~~H3. Summary of monetary impacts for intermediate and lower average speeds~~

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	10,497	10,576	10,666	10,768	10,881	11,006	11,143	11,292	11,452	11,624	11,808
Time costs	9,482	8,924	8,429	7,985	7,586	7,225	6,896	6,596	6,322	6,069	5,835
Crash costs	614	749	903	1,079	1,280	1,505	1,759	2,042	2,357	2,707	3,093
Air pollution costs	284	289	294	300	305	310	315	321	326	331	337
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**20,877**	**20,538**	**20,292**	**20,132**	**20,051**	**20,047**	**20,114**	**20,251**	**20,457**	**20,731**	**21,072**
of which:											
Cars & light comm. vehs.	15,847	15,545	15,315	15,150	15,046	**14,999**	15,006	15,066	15,176	15,336	15,546
Trucks (rigid and artic.)	5,030	4,993	**4,977**	4,982	5,005	5,047	5,107	5,185	5,281	5,394	5,526

~~H4. Monetary impacts for trucks at intermediate and lower average speeds~~

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	3,163	3,198	3,240	3,288	3,341	3,401	3,466	3,537	3,615	3,698	3,787
Time costs	1,714	1,614	1,524	1,444	1,372	1,306	1,247	1,193	1,143	1,097	1,055
Crash costs	117	144	175	211	253	300	353	414	481	556	640
Air pollution costs	37	38	38	39	40	40	41	42	42	43	44
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**5,030**	**4,993**	**4,977**	**4,982**	**5,005**	**5,047**	**5,107**	**5,185**	**5,281**	**5,394**	**5,526**

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

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	7,335	7,377	7,426	7,480	7,540	7,606	7,677	7,754	7,837	7,926	8,021
Time costs	7,768	7,311	6,905	6,541	6,214	5,918	5,649	5,404	5,179	4,971	4,780
Crash costs	498	605	728	868	1,027	1,205	1,406	1,629	1,876	2,150	2,453
Air pollution costs	247	251	256	261	265	270	274	279	284	288	293
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**15,847**	**15,545**	**15,315**	**15,150**	**15,046**	**14,999**	**15,006**	**15,066**	**15,176**	**15,336**	**15,546**

APPENDIX O:
RURAL UNDIVIDED 8.5 M SHOULDER-SEALED ROADS – CURVY ROADS WITH CROSSROADS AND TOWNS

Undivided2CCTHC.xls

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

1. Outlining

A. Policy test ~~Increased speed limit to 130 kmh on two-lane undivided 8.5 m shoulder-sealed curvy rural roads with crossroads & towns~~
[50 sharp bends, 14 cross roads, and 3 intersections requiring stopping (usually in towns) per 100 kilometres]

~~A1. Length of link~~ 100 km

~~A2. Flow characteristics~~

Traffic attributes	Before policy						After policy					
	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**	Car - Private	Car - Business	Truck - Rigid	Truck - Artic.	Light Comm	**Total/ Average**
Cruise speed, km/h	100	100	100	100	100	**100.0**	130	130	130	130	130	**130.0**
Average of all speeds on link	96.8	96.8	96.8	96.8	96.8		115.1	115.1	115.1	115.1	115.1	
AADT*	500	170	50	80	200	**1,000**	500	170	50	80	200	**1,000**
Share of traffic	50%	17%	5%	8%	20%	100%	50%	17%	5%	8%	20%	100%
Business trips, %		100	100	100	63	**43**		100	100	100	63	**43**
Pers. bus. and commuting. trips, %	35				16	**21**	35				16	**21**
Leisure trips, %	65				21	**37**	65				21	**37**

*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

Application of the MASTER framework

Ver. 01/99

Increase of 100 kmh speed limit to 130 kmh on two-lane undivided 8.5 m shoulder-sealed curvy rural roads with crossroads and towns

H. Net impacts

Cruise Speed (km/h)		
Cars and LCVs	**100**	**130**
Trucks	**100**	**130**

Average speed on link (km/h)	Before	After
Cars and LCVs	**96.8**	**115.1**
Trucks	**96.8**	**115.1**

H1. Physical impacts

		Before	After	Change	
Total travel time on link, hours/day		1,033	869	-164	-15.9 %
Number of Crashes per year		6.5	12.3	5.8	89.6%
Emissions, t/year	Carbon monoxide CO	134	1447	1313	976.6 %
	Hydrocarbons HC	22	155	133.2	609.3 %
	Oxides of nitrogen NOx	92	1043	951	1030.5 %
	Particles PM	1.6	6.6	5.00	321.9 %
	Carbon dioxide CO2	11094	42659	31565	284.5 %
Residents in area where $L_{Aeq,07\text{-}22hrs}$ > 55 dB		0	0	0	

Saving/vehicle/100km (mins.) Cars&LCVs: **9.8** Trucks: **9.8**

Increase/100km Fatal: **0.6** Serious Inj: **2.3** Other Inj: **2.9**

H2. Monetary impacts

k$/year	**Before**	**After**	**Change**	
Consumer surplus	(N. A.)	(N. A.)		(N. A.)
Vehicle operating costs	11,793	22,183	10389	88.1 %
Time costs	7,835	6,591	-1244	-15.9 %
Crash costs	1,426	3,446	2,020	141.7%
Air pollution costs	436	2,915	2,479	568.8 %
Noise costs	0	0	0	
Total	**21,490**	**35,135**		
Change			**13,645**	**63.5 %**

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

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	10,651	10,789	11,056	11,380	11,793	12,519	13,359	14,642	16,346	18,742	22,183
Time costs	9,550	9,026	8,572	8,178	7,835	7,537	7,279	7,057	6,869	6,714	6,591
Crash costs	684	834	1,006	1,203	1,426	1,677	1,960	2,275	2,627	3,016	3,446
Air pollution costs	304	317	379	385	436	541	673	908	1,268	1,869	2,915
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**21,189**	**20,967**	**21,014**	**21,145**	**21,490**	**22,273**	**23,271**	**24,882**	**27,111**	**30,341**	**35,135**
of which:											
Cars & light comm. vehs.	16,078	15,862	**15,846**	15,884	16,082	16,588	17,249	18,344	19,879	22,131	25,515
Trucks (rigid and artic.)	5,111	**5,105**	5,168	5,261	5,408	5,685	6,022	6,538	7,232	8,210	9,620

~~H4. Monetary impacts for trucks at intermediate and lower cruise speeds~~

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	3,215	3,271	3,374	3,497	3,653	3,918	4,224	4,684	5,289	6,133	7,337
Time costs	1,727	1,632	1,550	1,479	1,417	1,363	1,316	1,276	1,242	1,214	1,192
Crash costs	130	160	195	235	282	334	394	461	536	620	713
Air pollution costs	39	41	49	50	57	70	88	118	165	243	379
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**5,111**	**5,105**	**5,168**	**5,261**	**5,408**	**5,685**	**6,022**	**6,538**	**7,232**	**8,210**	**9,620**

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

kA$/year	80 km/h	85 km/h	90 km/h	95 km/h	100 km/h	105 km/h	110 km/h	115 km/h	120 km/h	125 km/h	130 km/h
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	7,436	7,518	7,683	7,883	8,140	8,601	9,135	9,958	11,057	12,609	14,846
Time costs	7,823	7,394	7,022	6,699	6,418	6,174	5,963	5,781	5,627	5,500	5,399
Crash costs	554	674	811	967	1,144	1,343	1,566	1,815	2,091	2,396	2,733
Air pollution costs	264	276	330	335	379	470	586	790	1,103	1,626	2,536
Noise costs	0	0	0	0	0	0	0	0	0	0	0
Total	**16,078**	**15,862**	**15,846**	**15,884**	**16,082**	**16,588**	**17,249**	**18,344**	**19,879**	**22,131**	**25,515**