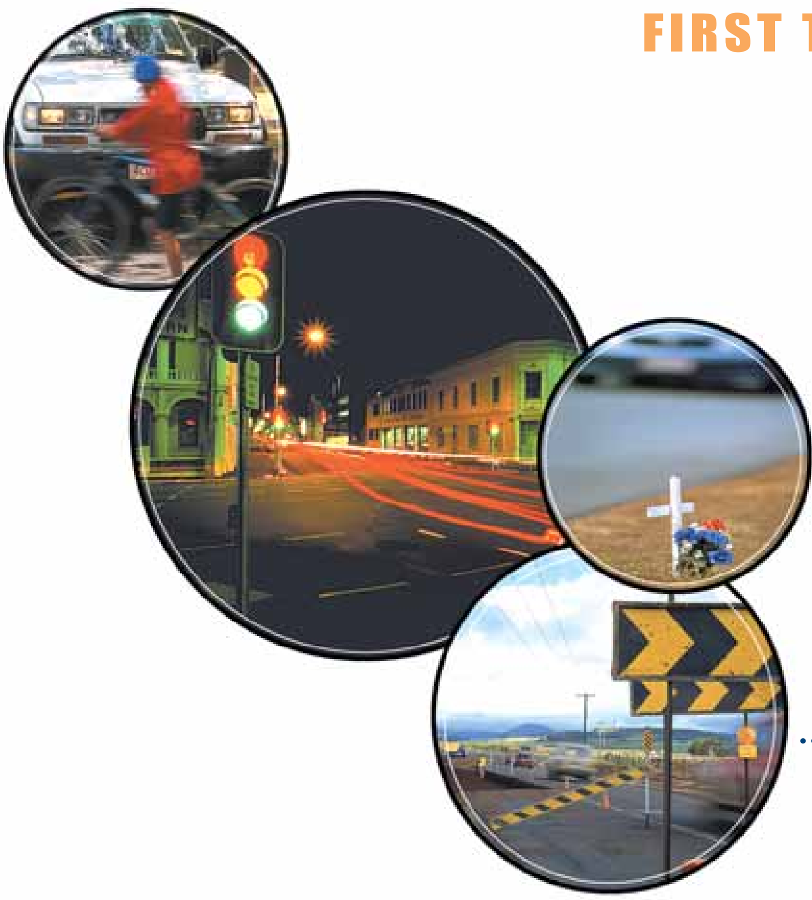
FEDERALLY FUNDED
BLACK SPOT PROJECT

AUSTRALIA

THE BLACK SPOT PROGRAM 1996–2002

AN EVALUATION of the FIRST THREE YEARS



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FOREWORD

The Federal Government has, since 1990–91, allocated substantial resources through its Black Spot Program to reduce the number and severity of crashes at black spot locations as part of its overall road safety strategy.

Bureau of Transport and Communications Economics (BTCE) Report 90 *Evaluation of the Black Spot Program* published in 1995 evaluated the program that operated from 1990–91 to 1992–93 inclusive. The study found that the Program delivered benefits of four dollars for each dollar of expenditure. As remaining black spots are treated, periodic evaluation is necessary to assist governments to determine if treatment benefits continue to justify the costs.

This evaluation relates to the *Capital Funding for Black Spots Roads Programme*—more generally known as the Federal Road Safety Black Spot Program—that provided $36 million per year in 1996–97 dollars from 1996–97 until 1999–2000. The Program was extended in the 1999–2000 Budget, which provided $40.8 million in 2000–01 and $41.7 million in 2001–02.

The Australian Transport Safety Bureau administered the Program, and the Bureau of Transport Economics conducted the evaluation for the period 1996–97 to 1998–99.

The Bureau of Transport Economics acknowledges with appreciation the assistance of State and Territory road and traffic agency staff who provided data for the study and Australian Transport Safety Bureau staff who provided advice throughout the study period.

The Bureau of Transport Economics also thanks Professor T. O'Neill, Dr M. Martin and Dr S. Stern of the Australian National University and DSI Consulting Pty Ltd for providing advice on statistical issues.

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Tony Slatyer
Executive Director

Bureau of Transport Economics
Canberra
July 2001

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EXECUTIVE SUMMARY

BACKGROUND

For over a decade, the Federal Government has operated programs to improve the physical condition or management of hazardous locations with a history of crashes involving death or serious injury.

Two studies by the former Bureau of Transport and Communications Economics found that the Black Spot Program that operated from 1990–91 to 1992–93 inclusive succeeded in reducing road trauma.

As traffic patterns and road use change over time, new black spots emerge. As road and traffic authorities will tend to treat the worst sites first, the benefits from treating remaining sites reduce progressively. This means that ongoing evaluation is necessary to help governments determine if the benefits from further treatment of black spot sites justify the treatment costs.

This evaluation relates to the *Capital Funding for Black Spots Roads Programme*, more generally known as the Federal Road Safety Black Spot Program, which commenced in 1996–97 and is scheduled to conclude in 2001–02. In total, 983 black spot projects had been implemented under the Program as at 30 June 1999. The Australian Transport Safety Bureau administered the Program.

A sample of 608 black spot projects around Australia undertaken between 1 July 1996 and 30 June 1999 was analysed. The total cost of these projects was approximately $59.5 million.

The evaluation would have been more comprehensive if it had been conducted after the Program had been completed, enabling the assessment of projects carried out towards the latter part of the Program. However, the evaluation's purpose was to provide information to help the Federal Government assess the merits of continuing to fund black spot treatment. Delaying the evaluation would have reduced its usefulness for Federal Government planning purposes.

PROGRAM EXPENDITURE

Between 1996–97 and 1999–2000, $146.3 million was allocated to the Program and $145.5 million was spent. However, when the analysis for this report was done, project details were available for only $116.6 million of expenditure.

Urban projects involving five types of treatments—roundabouts, new traffic lights with no turn arrows, modified signals, new traffic lights with turn arrows and sealing road shoulders—involved total expenditure of around $30.8 million. They accounted for approximately 57 per cent of the $54.5 million spent by the Federal Government on urban projects and for approximately 26 per cent of total expenditure in the first three years of the Program.

Regional projects involving two types of treatments—roundabouts and sealing road shoulders—involved total expenditure of around $29.1 million. They accounted for approximately 47 per cent of the $62.2 million spent by the Federal Government on regional projects and for approximately 25 per cent of total expenditure in the first three years of the Program.

There were 111 safety-audit projects, which accounted for approximately $8.9 million or 7.6 per cent of total expenditure in the first three years of the Program.

DATA AVAILABILITY AND QUALITY ISSUES

It is important to ensure that the collection and handling of data for evaluation are not excessively onerous for State and Territory road traffic authorities. However, data availability, timeliness and quality issues have limited the usefulness of both this Black Spot Program evaluation and its predecessor. These factors reduce the quality of the advice that can be provided to increase the effectiveness of future programs.

States and Territories should submit crash data on treated sites with their financial statements each year, and submit time series data, traffic flow data, and descriptions of the physical layout of nominated sites as part of the black spot nomination process. In addition, police in all jurisdictions should continue—or in South Australia's case, resume—the preparation of crash diagrams as part of their road crash reports. Crash diagrams enable road engineers to identify why sites are dangerous and to select appropriate treatments. If this kind of information is not available, there is a real risk of black spot program funding being wasted on ineffective treatments.

EVALUATION METHODOLOGY

This study adopted a before and after treatment approach. This methodology was chosen because of its compatibility with the nature of the data available for analysis. The evaluation compared the number and severity of crashes after the black spots were treated with the number and severity of crashes that would have been expected with no treatment. The expected crash history was estimated using the actual crash history of the black spots before treatment and data on other variables expected to affect crashes at black spots after treatment. A Poisson regression model was used to determine whether black spot treatments had a statistically significant effect.

The benefits of black spot treatments were estimated in terms of crash costs avoided. Crash costs were estimated on the basis of crash severity. This analysis disregards other benefits and costs that might arise from treatment. For example, the installation of traffic lights may make traffic flow more or less efficient and create driver time savings or costs depending on the particular situation. As these effects are location-specific, it was not feasible to include them in this analysis. A decision on whether to apply a treatment at a site should be based on a more comprehensive benefit-cost analysis that considers all these factors.

The benefit-cost analysis was done using treatment effects obtained from the sample of projects. The analysis was completed using a five per cent discount rate. This rate is an approximation of the geometric mean of the real Federal Government 10-year bond rate at the time the funds allocated to the Black Spot Program were spent—that is, the opportunity cost to the Federal Government of borrowing the funds. A sensitivity analysis was conducted at rates of three, seven, and eight per cent. Varying the discount rate did not significantly alter the findings of this evaluation.

KEY FINDINGS

In this analysis, *very strong* evidence means that the probability of an event occurring by chance is less than one in one thousand; *strong* evidence means that the probability is less than one in one hundred; *moderate* evidence means that the probability is less than one in fifty; and *weak* evidence means that the probability is less than one in ten.

Overall, the evaluation provides very strong evidence that the Program achieved its aim of improving safety at locations with a history of crashes involving death or serious injury. Using the treatment results obtained from the sample and applying them to the population of projects, it is estimated that from 1996–97 to 1998–99—and excluding expenditure on safety-audited projects—the Black Spot Program generated a net present value of $1.3 billion and a benefit-cost ratio of 14.

Nevertheless, the Program was not uniformly effective in reducing the number of casualty crashes. Not all road engineering treatments had a statistically significant effect. In the capital cities, sealing road shoulders, edge lines, pedestrian facilities, and signs had no statistically significant effect on road safety. The lack of a statistically significant result on road safety from sealing road shoulders in capital cities is particularly interesting, as this was the fifth most popular treatment in expenditure terms, and accounted for nearly seven per cent of expenditure on urban black spot treatment. Attempts to improve lighting in the capital cities appear to have had a counterproductive effect. In regional areas, traffic islands on approach, indented right and left turn lanes, non-skid surfaces, and pedestrian facilities had no statistically significant effect on road safety.

On the other hand, there were many areas in which the Program had a dramatic effect in reducing the number of casualty crashes, and some engineering treatments were consistently very successful. There is very strong evidence that road safety improved in Melbourne, Brisbane and Adelaide, and in regional areas in New South Wales, Victoria, Queensland and Tasmania. There is moderate to strong evidence that the Program resulted in improved road safety in Perth, Hobart, Darwin and Canberra, as well as in regional South Australia and Western Australia. There is weak evidence that the Program resulted in improved road safety in regional areas in the Northern Territory.

There are some statistically significant differences in the number of fatal crashes and the number of fatalities by various measures across States and Territories. The Northern Territory's very poor road safety performance relative to the rest of the country suggests this issue needs further investigation. A better understanding of the reasons for the Northern Territory's poor record may enable more effective policy responses to be formulated.

Roundabouts and new traffic lights with no turn arrows appeared to be very successful in improving safety in both capital cities and regional areas, with the probability of such large improvements being due to chance being less than one in ten thousand. There was very strong evidence that installing roundabouts successfully improved safety regardless of how expensive, and presumably how large, the roundabouts were. New traffic lights with turn arrows, medians and non-skid surfaces were similarly successful when used in capital cities. In regional areas, there is very strong evidence that signs and new traffic lights with turn arrows improved safety, and moderate evidence that medians, shoulder sealing, edge lines, and improved lighting increased safety. In capital cities, there is very strong evidence that traffic islands on approaches and indented right and left hand turns improved safety.

This does not mean that particular engineering treatments improved or failed to improve road safety in all cases. However, it does indicate that road engineers should consider using one of the more generally successful treatments if there is more than one feasible way of treating a particular traffic hazard. When considering what kind of treatment to use, the probability that the treatment is effective, its benefit-cost ratio, and its net present value need to be considered in combination.

Overall, the Black Spot Program appears to have been highly effective in reducing the number of casualty crashes. It is estimated that the Program prevented around 32 fatal crashes and 1 539 serious crashes between 1996–97 and 1998–99. The Program is therefore estimated to have saved at least 32 lives and prevented a large number of injuries over these three years. Further benefits will continue to accrue over the life of the black spot treatments that were applied.

The fatality and serious injury rates for regional areas are much higher than in urban areas. The relative risks for regional areas compared to urban areas are decreasing in some, but not all, jurisdictions. It is important to note that it is the number of crashes that occur, not the crash rates in particular areas, which affects the cost of crashes to the community.

Urban areas derived significantly greater benefits from the Program than regional areas. This is attributed to greater traffic flow through urban black spots. The urban benefit-cost ratio was over 18, whereas the regional benefit-cost ratio was under 11. Given this, if the only criterion for program expenditure was to maximise the economic return to Australia, then the proportion of expenditure in urban areas would be increased.

This analysis supports continuing the Program, but suggests modifications to increase its effectiveness. The fall in benefit-cost ratios over the three years examined was not statistically significant. As a matter of good public policy, it would be advisable to evaluate the entire current six-year Program after its completion.

1

THE BLACK SPOT PROGRAM EVALUATION—BACKGROUND AND PURPOSE

PURPOSE AND ADMINISTRATION OF THE BLACK SPOT PROGRAM

The Federal Government's first black spot program commenced on 1 July 1990 and continued until 30 June 1993. The current *Capital Funding for Black Spots Roads Programme*, more generally known as the Federal Road Safety Black Spot Program, commenced on 1 July 1996 and is presently scheduled to continue until 30 June 2002.

The Program's objective is to reduce the social and economic costs of road trauma by improving the physical condition and management of black spots. It aims to achieve this by implementing traffic management techniques and other road safety measures that have proven road safety value.

The *Notes on Administration* of the Program are at appendix I. The Program is administered in accordance with the provisions of the *Australian Land Transport Development Act 1988*.

Reasons for evaluation

Two previous evaluation studies by the former Bureau of Transport and Communications Economics (BTCE) provided evidence to indicate that the Black Spot Program that operated from 1 July 1990 to 30 June 1993 succeeded in reducing road trauma. BTCE Working Paper 9, *Cost-Effectiveness of 'Black Spot' Treatments: A Pilot Study*, examined a sample of 26 projects in Victoria and 25 in New South Wales. BTCE Report 90, *Evaluation of the Black Spot Program*, analysed the treatments applied at a sample of 254 black spot sites around Australia. Both studies found that the Program was a good investment for the Australian community.

Treating black spots is one of several means of improving road safety. Road and traffic authorities have generally treated the worst black spots first, and treated less hazardous sites and road lengths as resources became available. New black spots emerge as road use changes over time, new roads are built, and previously unrecognised hazards are reported. Nonetheless, at any given time, there is a finite number of black spot locations in Australia, and the success of the previous Program suggests this number should be decreasing. It is therefore expected that the Federal Government will experience diminishing returns on future investments in black spot treatment. This means that, despite the success of the previous Program, ongoing evaluation is necessary to determine if further expenditure on black spot treatment is warranted. It is likely to be appropriate for Federal Governments to reduce future funding for black spot treatment. With the possible exception of funding to treat a small number of new black spots as they emerge, the return from other means of improving road safety or other investments will eventually exceed the diminished return from further black spot treatment.

One of the purposes of this evaluation is to determine whether this is an issue that needs to be considered in the formulation of the 2002 Budget, or whether the Federal Government should continue to fund black spot treatment on an undiminished scale beyond 30 June 2002.

What is a black spot?

There is no universally accepted definition of a black spot. Sites are classified as black spots after an assessment of the level of risk and the likelihood of a crash occurring at each site. The risk of a crash is not uniform throughout the road network. At certain locations, the level of risk will be higher than the general level of risk in surrounding areas. Crashes will tend to be concentrated at these relatively high-risk locations. Locations that have an abnormally high number of crashes are described as crash concentrated, high hazard, hazardous or black spot sites.

Although the term *black spot* suggests a precise location, it is also often used to refer to sections of road. Black spots are usually linked to particular characteristics of the road environment, such as busy intersections and sharp bends.

Black spots are difficult to define precisely, because there are many factors associated with them. These factors include degree and type of risk, road characteristics, traffic exposure and crash severity. Sites with potentially hazardous features are sometimes described as grey spots. A hazardous site should be regarded as indicating a problem in a traffic network, and not be considered in isolation. The prescribed treatment may therefore involve other sites or even wider areas as well as the site in question.

The Federal Government's Black Spot Program defines black spots using the criteria specified in the *Notes on Administration* in appendix I. This definition facilitated participation by all States and Territories, and local government, and accommodated diverse administrative practices. The Program also provides funding approval for road safety enhancement measures based on non site-specific criteria.

Rationale for black spot treatment

The number of crashes is affected by three factors:

- the road environment;
- the condition of vehicles using the road system; and
- the skills, concentration and physical state of road users.

Research indicates that the overwhelming majority of crashes are caused by human factors (BTCE 1995). There is, therefore, considerable controversy about which measures would be most cost-effective in reducing crashes. Crash reduction measures broadly involve education, enforcement and engineering. This broad approach to improving road safety is embodied in the National Road Safety Strategy.

Changing drivers' attitudes and motivations could, in theory, have a substantial effect in reducing crashes. Engineering programs are a popular strategy for reducing crash rates worldwide because more is known about how to achieve sustained improvements in road conditions and vehicle characteristics than in human behaviour. However, as crashes are usually the result of several causes, multi-factor solutions are likely to be the most effective in the longer term. For example, attitudinal change to drinking and driving has had a major effect on road safety in Australia. The potential gains from changing social attitudes towards driving while fatigued are enormous; so although changing human behaviour is difficult, it should still be attempted.

Technological improvements that can be used to influence behavioural changes without increased policing effort or changing vehicle or road conditions are providing new options for crash reduction.

There are four basic approaches to reducing crashes by applying engineering treatments or countermeasures:

- single sites or black spots—treating specific sites or short sections of road;
- route action—applying known remedies on a route with an abnormally high crash rate;
- area-wide action—applying several treatments over a wide area; and
- mass action—applying a known remedy to locations with common crash problems or causal factors.

The Federal Government's Black Spot Program was established to provide for the use of the first two of these four approaches.

Prioritisation of black spot projects

Jurisdictions do not rely solely on crash history to identify black spots and prioritise them for treatment. Local knowledge and judgment are used as well as statistical information. In major metropolitan centres, the black spots associated with the most crashes are often central business district intersections. However, most of these crashes occur at low speeds and involve very low degrees of injury or only vehicle damage. Many of these central business district sites were not selected for treatment under the Black Spot Program. In addition, a number of sites with substantial crash histories were not selected for treatment because rectification was too costly. The Federal Road Safety Black Spot Program criteria require that sites have a history of crashes and are cost-effective to treat to qualify for funding.

Comparison of this Program with the previous Black Spot Program

The funds allocated to each jurisdiction under the current Black Spot Program must be allocated evenly between the treatment of regional and urban black spot sites. This is a new requirement.

Up to 10 per cent of the funds allocated under the previous Program were made available for other tangible and visible road safety enhancement projects. These included speed and alcohol limit control equipment and bicycle and pedestrian safety projects. There is no similar provision under the current Program.

Black spots are defined in the current *Notes on Administration*. The current Program allocates up to 20 per cent of available funds to treat sites, lengths and areas that do not qualify for funding under this definition. An official road safety-audit report recommending treatment for a site is required to qualify for treatment under this funding provision.

In the previous Black Spot Program, the Federal Government defined the black spot treatments that it would support without further justification by issuing a *Schedule of Acceptable Treatments*. Treatments not on the Schedule were considered only if they were submitted with a business case showing evidence that they would generate a benefit-cost ratio (BCR) of at least two—or if they were innovative. Under the current program treatments are considered only if they will generate a BCR of at least two. Submissions need not include a full business case, but a justification for the claimed BCR must be provided on request.

While the Schedule has been updated and distributed, it no longer has any status under the *Notes on Administration*. At the time the *Notes on Administration* of the current Program were finalised, the Schedule had outlived its usefulness as a prescriptive tool. The prioritisation processes in place at the start of the current Black Spot Program, and the level of knowledge in the States and

Territories about traffic engineering treatments and their appropriateness in different circumstances, meant the Schedule was best used as a guide. The requirement to demonstrate a BCR of at least two remains. The Australian Transport Safety Bureau (ATSB) checks that proposals submitted for funding under the new Program relate to sites and road lengths that meet the black spot eligibility criteria. The ATSB makes recommendations to the Parliamentary Secretary to the Minister for Transport and Regional Services on all proposals that meet these criteria.

In the current Black Spot Program, preference is given to projects where the Federal Government's contribution is estimated to cost less than $500 000. Under the previous program, preference was given to projects where the Federal Government's contribution was estimated to cost less than $200 000.

CAUSES OF ROAD CRASHES

Several models of crash causation are proposed in the road safety literature. These models generally explain crashes as being a consequence of driver behaviour that is not correctly matched with the demands of the road environment or to vehicle characteristics, or to both. These models are only briefly discussed here and only research findings published after the completion of the previous Black Spot evaluation report (BTCE 1995) are discussed in detail. A fuller discussion of these models is available in BTCE (1995).

One crash causation model suggests that drivers' performance level varies with time because of factors such as lack of concentration, fatigue, drowsiness and illness. The demands of the road environment vary due to factors such as traffic flow rates, geometric features of the road and type of road. Drivers normally adapt their performance level to the demands of the road system. A crash occurs when the driver's performance level is insufficient to meet the performance demands of the road environment. Most of the time, driver capabilities exceed performance demands. Black spots are points of peak performance demand. Engineering improvements in the road network lower performance demands on the driver. This increases the safety margin between the driver's performance level and the performance demands of the road environment, and reduces the probability of a crash.

However, there is substantial theoretical and empirical evidence that suggests that engineering improvements to the road system alone may not reduce the number of expected crashes if driver behaviour tends to compensate for the safety improvement. Driving is a self-paced task—the driver largely determines the degree of difficulty of the task and the performance level. Drivers may respond to safer roads by driving more dangerously. In extreme cases, introducing a measure intended to enhance safety could unintentionally reduce safety. This is more likely to occur if an engineering treatment masks warning signs that the performance demands of the road system are about to increase.

Even programs intended to increase driver skills may suffer from the same effect if driver behaviour changes as well.

It has been suggested that the most effective treatments make the traffic system objectively safer while simultaneously increasing the subjective risk—thus motivating drivers to maintain high performance levels.

Changes in driver behaviour

Changes in driver behaviour may result in decreased or increased risk-taking.

For example, Hakamies-Blomqvist (1994) found that age-related deterioration of various driver functions did not affect the number of fatal crashes in Finland from 1984 to 1990 in the manner that would be expected without compensatory behavioural changes. Drivers learn to deal with poorer night vision, less acute hearing and other physical changes as they age. Drivers aged over 65 had more crashes in daytime—in good weather conditions, with good visibility and road conditions—than drivers aged 26 to 40. However, it seems that older drivers limit their exposure to difficult external conditions and are less likely to drive after consuming alcohol or to be in a hurry.

The Federal Office of Road Safety (FORS) assessed driver risk at different ages in 1996 (FORS 1998). Measured by the risk of driver fatalities per million kilometres travelled, driver risk in Australia appears to rise and fall at different ages. Driver risk is lowest for those aged 35–50 and highest for those of legal minimum driving age. The risk decreases between legal minimum driving age and 35, increasing again for those aged over 50. Drivers under 75 are at no more risk than very young drivers. Driver risk begins to climb quite rapidly beyond age 75, although part of this is due to the increased vulnerability of older drivers to injuries sustained in crashes.

A community attitudes survey in Australia (ATSB 1999a) found that only four per cent of drivers aged over 60 say they often exceed the speed limit, compared with seven per cent of drivers aged 40–59. The survey findings suggest that—if age-related driver function deterioration is similar in Australia to that experienced in other countries—older Australian drivers are also adopting compensatory driving behaviours.

Risk compensation by older drivers appears to be widespread. Hakamies-Blomqvist et al (1996) compared the fatality rates of older drivers in Finland—where drivers have to pass regular medical reviews after age 45 to keep their licenses—and Sweden, which conducts no screening. The study found that medical screening of older drivers is ineffective as a traffic safety measure.

Theory suggests that road engineering should aim to create a road environment which imposes low performance demands on drivers and ensures that drivers do not underestimate the dangers.

Some studies have suggested that visual cues may be useful in improving safety by increasing driver attention just before an increase in the performance demand of the road system.

The ATSB (1999b) used a simulator to test driver responses to visual cues including:

- transverse road markings;
- lane edge and herringbone treatments;
- the Drenthe province treatment—a gravel centreline plus an intermittent gravel edgeline;
- centreline and other edgeline treatments; and
- several enhanced curvature treatments.

Some of these treatments, particularly transverse lines, caused drivers to reduce their speed.

However, it is possible that these measures would be less effective if they were more common; particularly if they were used in situations where there was not an obvious increase in the performance demanded by the road system. If drivers became used to these measures, they might downgrade their level of subjective risk.

2

PROGRAM EXPENDITURE AND ANALYSIS

EXPENDITURE ON BLACK SPOT TREATMENT

The Federal Government has operated black spot programs since 1 July 1990. The current program commenced on 1 July 1996, and will continue until 30 June 2002. The Federal Government spent $145 million during the first four years of the program, and intends to spend $227 million in total. Measured in 1996–97 dollars, using a discount rate of five per cent, these figures equate to $135 million and $201 million respectively.

The Federal Government has always intended to reduce road trauma rather than to replace State and Territory expenditure on black spot treatment. To clarify its intention, the Government added a new condition—in section 3.4—to the *Notes on Administration* of the 1996–2000 Black Spot Program:

> The Commonwealth expects States to retain their existing expenditure patterns on black spot programs. In the final determination of allocations to States, the Minister will take into account whether a State has maintained its own spending on black spot projects.

The Bureau of Transport Economics (BTE) suggests there could be merit in ensuring that the *Notes on Administration* for any future black spot program include more specific criteria about jurisdictions maintaining funding. The meaning of *maintenance* in this context is not clear. The *Notes on Administration* could specify, for example, whether States and Territories must maintain:

- expenditure in real terms—and if so, over what period and compared to which base period;
- a constant proportion of State or Territory budget outlays; or
- a minimum ratio of expenditure on black spot treatments relative to Federal Government expenditure on black spot treatments.

Such specificity would remove the uncertainty over whether a State or Territory has 'maintained its own spending on black spot projects'.

Despite the concerns discussed above, the available evidence suggests the Federal Government's expenditure on black spot treatment has added to, rather than replaced, State and Territory expenditure.

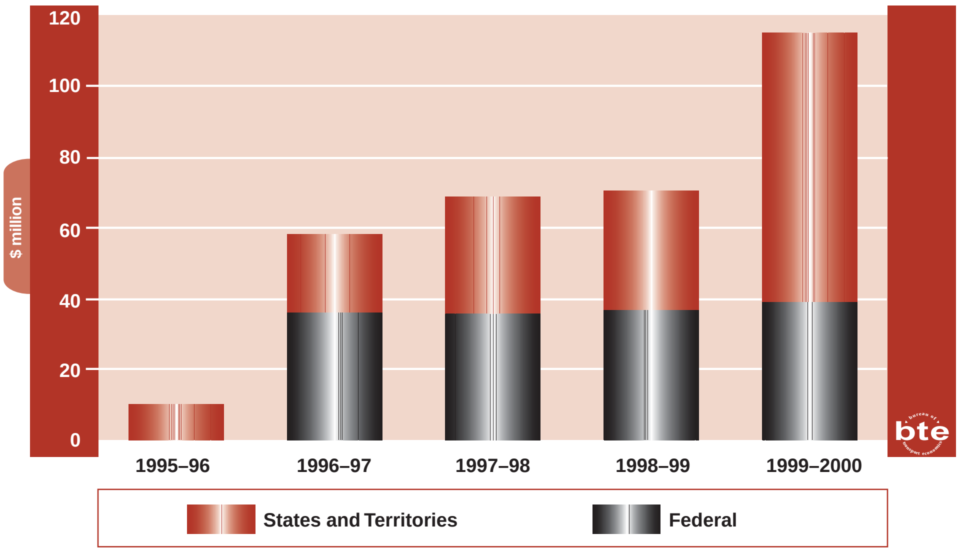
Federal and State contributions to black spot amelioration are shown in figure 2.1. As the Northern Territory has not yet determined how much it will spend in 2000–01, the Australian total for 2000–01 shown in table 2.1 represents a minimum value. Therefore, 2000–01 figures are not included in figure 2.1.

Figure 2.2 displays the same information for 1995–96 to 1998–99 in 1998–99 dollars, calculated using the BTE's Road Construction and Maintenance Price Index. The index for 1999–2000 was not available when this report was prepared.

Federal funding of black spot treatments has remained stable in real terms since the current Program was introduced on 1 July 1996. State and Territory funding of black spot treatments increased substantially in 1996–97 and 1997–98. It is expected to increase again in 2000–01 due to new initiatives by the Victorian and Western Australian Governments.

The information presented in figures 2.1 and 2.2 and table 2.1 should be interpreted with caution, as it is affected by three data quality issues.

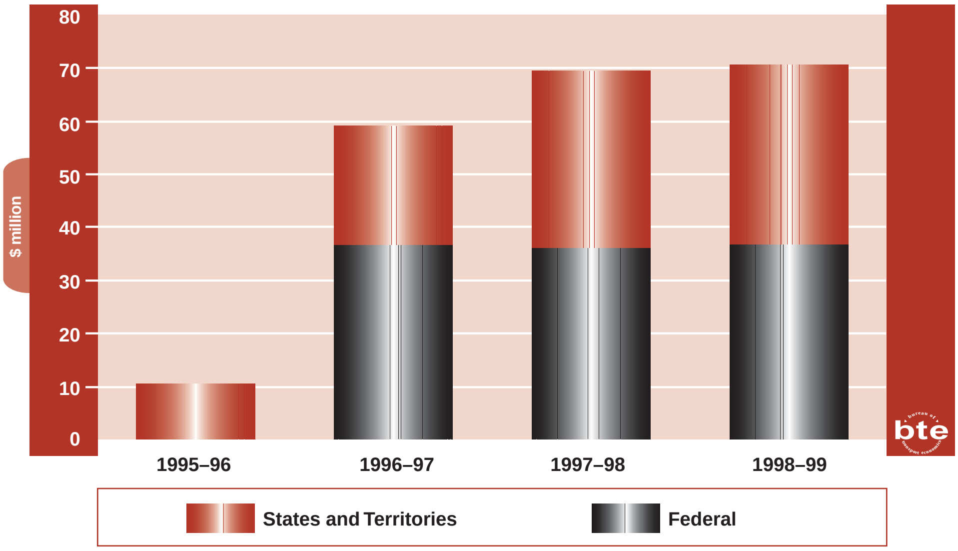
FIGURE 2.1 EXPENDITURE ON BLACK SPOT TREATMENT—NOMINAL DOLLARS—1995–96 TO 1999–2000



Note Nominal expenditure means expenditure expressed in terms of the dollar value of the year in which it was incurred.

Sources ATSB and State and Territory governments

FIGURE 2.2 EXPENDITURE ON BLACK SPOT TREATMENT—1998–99 DOLLARS—1995–96 TO 1998–99



Sources ATSB, BTE and State and Territory governments

Firstly, it is likely that expenditure on black spot treatments by State and Territory governments has been understated. Some States and Territories have kept detailed records of their expenditure on black spot treatments throughout the period shown, whereas others have only more general records of expenditure on road safety, or have introduced more detailed record keeping systems during the period. For example, a Western Australian Government policy decision radically increased expenditure on black spot treatments in 2000–01 compared with 1999–2000. However, it is likely that part of the increase shown in table 2.1 resulted from a change in record keeping practices between these two years.

Secondly, not all States and Territories use the Federal Government's definition of a black spot for programs they fund. And not all State and Territory governments were able to fully correct their figures to allow for definitional inconsistencies.

Finally, table 2.1 does not include expenditure on black spot treatments at local government level, and hence can only be regarded as an approximation of the minimum expenditure on black spot treatments in Australia. State and Territory governments do not record local government expenditure on black spot treatments in their jurisdictions, unless the expenditure was funded by grants administered by State and Territory governments.

TABLE 2.1 EXPENDITURE ON BLACK SPOT TREATMENT
($ million)

Year	NSW	VIC	QLD	WA	SA	TAS	ACT	NT	Total
Actual expenditure—prior to current Black Spot Program									
1995/1996									
Federal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
State	1.6	0.0	0.0	0.5	7.4	0.0	0.0	0.7	10.2
Total	*1.6*	*0.0*	*0.0*	*0.5*	*7.4*	*0.0*	*0.0*	*0.7*	*10.2*
Actual expenditure—during current Black Spot Program									
1996/1997									
Federal	11.8	8.2	7.0	4.0	3.0	1.0	0.5	0.6	36.0
State	6.5	4.0	0.0	0.6	9.0	0.1	1.3	0.8	22.2
Total	*18.3*	*12.2*	*7.0*	*4.6*	*12.0*	*1.1*	*1.8*	*1.4*	*58.2*
1997/1998									
Federal	12.1	7.8	7.1	4.1	3.0	0.6	0.5	0.6	35.8
State	7.5	3.8	10.0	0.6	8.3	0.6	1.2	1.4	33.4
Total	*19.6*	*11.6*	*17.1*	*4.7*	*11.3*	*1.2*	*1.7*	*1.9*	*69.2*
1998/1999									
Federal	12.0	8.9	6.5	4.1	3.0	1.2	0.4	0.6	36.6
State	8.0	4.1	10.0	0.7	9.4	0.4	0.4	0.9	33.9
Total	*20.0*	*13.0*	*16.5*	*4.8*	*12.4*	*1.6*	*0.8*	*1.5*	*70.5*
1999/2000									
Federal	12.3	8.5	7.1	4.2	3.0	1.0	0.5	0.6	37.2
State	11.7	4.1	10.0	0.9	10.9	0.5	0.1	0.7	38.9
Total	*24.0*	*12.6*	*17.1*	*5.1*	*13.9*	*1.5*	*0.6*	*1.3*	*76.1*
1996/97 to 1999/2000									
Federal	48.2	33.5	27.7	16.3	12.0	3.7	1.8	2.2	145.5
State	33.6	16.0	30.0	2.7	37.5	1.4	3.0	3.9	128.0
Total	*81.8*	*49.5*	*57.7*	*19.0*	*49.5*	*5.1*	*4.8*	*6.1*	*273.5*
Budgeted expenditure									
2000/2001									
Federal	13.1	9.1	7.7	4.4	3.2	1.0	0.5	0.6	39.7
State	12.2	41.9	10.0	16.3	11.1	0.1	0.8	nya	92.4
Total	*25.3*	*51.0*	*17.7*	*20.7*	*14.3*	*1.1*	*1.3*	*0.6*	*132.0*
2001/2002									
Federal	13.8	9.6	8.1	4.7	3.4	1.1	0.5	0.6	41.9
State	nya	nya	nya	16.2	nya	nya	nya	nya	nya
Total	*nya*	*nya*	*nya*	*20.9*	*nya*	*nya*	*nya*	*nya*	*nya*

Note 'nya' represents 'not yet available'.
Figures do not add to totals in all cases due to rounding. Figures are in cash, not accrual, terms.

Sources ATSB and State and Territory governments

Local governments do not generally report their expenditure on black spot treatments in a manner that separates their own expenditure from the expenditure of Federal, State or Territory grant funds. Aggregating local government records would therefore have led to substantial double-counting of funds spent on black spot treatments. The difference between the totals shown and actual expenditure—at all levels of government—on black spot treatments is expected to be small.

Policy issues

The Black Spot Program was intended to reduce road trauma nationally, by treating black spots in regional and urban areas in all States and Territories.

Funds are divided between the States and Territories on the basis of a weighting system. The weights were calculated on the basis of average population and the number of casualty crashes in each jurisdiction in the three years before the program started. Population and the number of casualty crashes were weighted equally in determining the funding for each jurisdiction. This reflects the Federal Government's policy that State and Territory motorists are entitled to lifesaving expenditure on black spots that is not allocated solely on efficiency criteria.

The funds provided to each jurisdiction are allocated evenly between regional and urban locations. Although there are fewer crashes in regional areas relative to urban areas, regional crashes tend to be more severe. Motorists in regional areas generally face a higher risk of fatal and serious injury crashes than their urban counterparts.

The Black Spot Program is targeted at reducing death and injury, rather than minimising total estimated crash costs. Only locations that have had casualties are eligible under the crash criteria. Locations that may offer relatively higher economic benefits because of a high incidence of property damage only (PDO) crashes are not eligible.

Program management issues

Allocation of funds to States and Territories

As the formula for allocating funding is well-known and based on publicly available data, State and Territory governments are able to predict the amount of funding they will be allocated with a high degree of accuracy. They generally submit a list of eligible projects in priority order that will exhaust all of the funds expected to be allocated. For the most part, projects are prioritised according to their BCRs.

The larger States also include additional eligible projects in their submissions. Experience has shown that, for various reasons, some approved projects may not be completed, or may not even start, during a particular financial year. Additional projects are usually approved for most States and Territories to prevent underspending on black spot treatments. Nevertheless, States and Territories cannot receive more than their total allocation. Table 2.1 shows expenditure in cash, rather than accrual terms, because most State and Territory Governments rely on cash accounting and Federal Government data are available on both a cash and an accrual basis. The apparent overspends in some jurisdictions in some years where expenditures have exceeded official allocations compensate for underspends in previous years. Only projects included in Federal Government submissions are eligible for approval.

Evaluations of black spot treatments funded by States and Territories

To date, only the Victorian Government has conducted large-scale evaluations of State-funded black spot treatments, although several jurisdictions are now planning such evaluations. The Western Australian Government conducted an evaluation of some of the black spot treatments funded by the Federal Government during the first Federal Black Spot Program. To help them assess the effectiveness of different engineering treatments, most jurisdictions have calculated the percentage reductions in crash rates achieved at treated sites. However, they have not published the results of these assessments or prepared benefit-cost analyses.

In Victoria, the black spot program is administered by the Transport Accident Commission (TAC), implemented by VicRoads, and evaluated by the Monash University Accident Research Centre (MUARC). MUARC's study of Victoria's first black spot program, introduced in 1979, found that for black spot intersection treatments, casualty crash frequencies fell by an average of 33 per cent, and the average BCR was approximately 9.0 (Corben et al 1990). There is a forthcoming MUARC study evaluating the Victorian Black Spot Program from 1992–93 to 1995–96.

The MUARC study evaluated treatments that were applied from 1977 to 1987. While there was no program aimed specifically at black spots before 1979, some black spots were treated before 1979 under other road safety programs. A subsequent MUARC study of mid-block black spot treatments conducted from 1977 to 1991 showed similar results for decreases in casualty crash rates and BCRs to the previous MUARC study (Tziotis 1993). MUARC's report on the Victorian black spot program conducted from 1989–90 to 1992–93 showed that casualty crash numbers decreased by 17 per cent, and the average BCR was 4.4. It also found weak or better evidence that new roundabouts, signal remodels involving fully controlled right-turn phases, intersection channelisation, tactile edge marking and shoulder sealing reduced casualty crash frequencies and costs (Corben et al 1996).

Expenditure on all projects

The top five black spot treatments funded by the Federal Government in dollar and percentage of total expenditure order were:

- roundabouts—$28.7 million or 25 per cent;
- sealing road shoulders—$14.3 million or 12 per cent;
- installing new traffic lights with no turn arrows—$9.6 million or eight per cent;
- installing new traffic lights with turn arrows—$6.2 million or 5.3 per cent; and
- modifying existing signals—$5.5 million or 4.7 per cent.

These treatments accounted for $64.3 million or 55 per cent of $116.6 million spent by the Federal Government on black spot treatments.

Expenditure on urban projects

Urban projects involving the following five treatments accounted for $30.8 million—or 26 per cent—of total black spot expenditure:

- roundabouts;
- new traffic lights with no turn arrows;
- modified signals where traffic lights with one or more turn arrows are installed in place of traffic lights with no turn arrows;
- new traffic lights with turn arrows; and
- sealing road shoulders.

Total and mean expenditure on projects involving these treatments is shown in table 2.3. These treatments accounted for 57 per cent of the $54.5 million spent on urban projects.

Expenditure on regional projects

Regional projects involving two treatments accounted for $29.1 million—or 25 per cent—of total black spot expenditure:

- roundabouts; and
- sealing road shoulders.

Total and mean expenditure on projects involving these treatments is shown in table 2.4. The two treatments accounted for 47 per cent of the $62.2 million spent on regional projects.

TABLE 2.2 NUMBER OF PROJECTS AND TOTAL AND MEAN EXPENDITURE—ALL TREATMENTS

Treatment	*Treatment code*[a]	*No. of proj.*	*Total Federal funding*	*Average Federal funding per project*	*Percentage of Federal total*	*Total other funding*
Roundabout	K1	195	28 713 407	147 248	24.62	3 057 000
Seal shoulders	S14	82	14 311 750	174 534	12.27	208 000
New traffic signal—no turn arrow	K2	78	9 602 918	123 114	8.23	710 000
New signal—with turn arrow	K3	55	6 163 340	112 061	5.28	205 000
Modify signals	K4	83	5 469 765	65 901	4.69	25 300
Roadside hazards—guard rail	S12	37	3 717 600	100 476	3.19	nya
Traffic islands on approaches	K14	65	3 506 250	53 942	3.01	35 000
Edgelines	S17	19	2 808 140	147 797	2.41	nya
Extend median through intersection	K19	28	2 231 080	79 681	1.91	148 000
Signs	S20	54	2 061 290	38 172	1.77	47 500
Non-skid surface	S13	24	1 774 000	73 917	1.52	nya
Non-skid treatment	K18	11	980 850	89 168	0.84	400 000
Pedestrian refuge	S2	19	751 600	39 558	0.64	2 000
Pedestrian signals	S5	7	616 000	88 000	0.53	213 000
Improved route lighting	S7	14	587 380	41 956	0.50	1 000
Indented right [a] turn island	K15	4	400 000	100 000	0.34	nya
Medians on existing carriageway	S1	3	290 000	96 667	0.25	60 000
Indented right[a] turn island	S9	1	250 000	250 000	0.21	nya
Other treatment	OT	343	32 390 943	135 885	27.77	3 719 600
Total		1122	116 626 313	103 945	100.00	8 831 400

a. See appendix VI for definitions of treatment codes, including the distinction between K and S codes.

Note 'nya' represents 'not yet available'. The figures contained in the last column should be considered as minimum known expenditure, rather than actual expenditure on particular treatment types.

Sources ATSB and State and Territory governments

TABLE 2.3 NUMBER OF PROJECTS AND TOTAL AND MEAN EXPENDITURE—URBAN TREATMENTS

Treatment	*Treatment code*[a]	*No. of proj.*	*Total Federal funding*	*Average Federal funding per project*	*Percentage of Federal total*	*Total other funding*
Roundabout	K1	79	10 276 050	130 077	18.87	993 000
New traffic signal—no turn arrow	K2	60	7 474 918	124 582	13.72	220 000
Modify signals	K4	67	4 861 965	72 567	8.93	nya
New signal—with turn arrows	K3	43	4 518 340	105 078	8.30	175 000
Seal shoulders	S14	20	3 666 240	183 312	6.73	nya
Traffic islands on approaches	K14	40	2 102 600	52 565	3.86	15 000
Roadside hazards—guard rail	S12	13	1 825 400	140 415	3.35	3 000
Extend median through intersection	K19	18	1 312 080	72 893	2.41	145 500
Signs	S20	30	992 790	33 093	1.82	7 500
Pedestrian refuge	S2	15	725 600	48 373	1.33	nya
Non-skid surface	S13	18	720 000	40 000	1.32	nya
Pedestrian signals	S5	6	536 000	89 333	0.98	213 000
Indented right[a] turn island	K15	4	400 000	100 000	0.73	nya
Edgelines	S17	6	376 140	62 690	0.69	nya
Improved route lighting	S7	9	359 380	39 931	0.66	nya
Non-skid treatment	K18	8	254 000	31 750	0.47	nya
Indented right[a] turn island	S9	1	250 000	250 000	0.46	nya
Protected left turn lane in crossing street	K21	3	200 000	66 667	0.37	nya
Medians on existing carriageway	S1	2	150 000	75 000	0.28	nya
Reduce radius on left turn sliplane	K20	5	90 000	18 000	0.17	7 500
Ban right turns	K11	3	80 000	26 667	0.15	nya
Street closure—cross intersection	K7	1	66 000	66 000	0.12	nya
Improve sight lines	K6	1	50 000	50 000	0.09	nya
Delineation	S16	1	29 000	29 000	0.05	nya
Improve/reinforce priority signs	K10	2	20 250	10 125	0.04	nya
Other treatment	OT	154	13 127 250	85 242	24.10	1 282 100
Total		609	54 464 003	89 432	100.00	3 061 600

a. See appendix VI for definitions of treatment codes, including the distinction between K and S codes.

Note ‘nya’ represents ‘not yet available’. The figures contained in the last column should be considered as minimum known expenditure, rather than actual expenditure on particular treatment types.

Sources ATSB and State and Territory governments

TABLE 2.4 NUMBER OF PROJECTS AND TOTAL AND MEAN EXPENDITURE—REGIONAL TREATMENTS

Treatment	*Treatment code*[a]	*No. of proj.*	*Total Federal funding*	*Average Federal funding per project*	*Percentage of Federal total*	*Total other funding*
Roundabout	K1	116	18 437 357	158 943	29.66	2 064 000
Seal shoulders	S14	62	10 645 510	171 702	17.13	208 000
Edgelines	S17	13	2 432 000	187 077	3.91	nya
New traffic signal—no turn arrow	K2	18	2 128 000	118 222	3.42	490 000
Roadside hazards—guard rail	S12	24	1 892 200	78 842	3.04	nya
New signal—with turn arrows	K3	12	1 645 000	137 083	2.65	30 000
Traffic islands on approaches	K14	25	1 403 650	56 146	2.26	20 000
Signs	S20	24	1 068 500	44 521	1.72	40 000
Non-skid surface	S13	6	1 054 000	175 667	1.70	
Extend median through intersection	K19	10	919 000	91 900	1.48	2 500
Non-skid treatment	K18	3	726 850	242 283	1.17	400 000
Modify signals	K4	16	607 800	37 988	0.98	25 300
Improved route lighting	S7	5	228 000	45 600	0.37	1000
Pedestrian underpass	S4	1	150 000	150 000	0.24	nya
Medians on existing carriageway	S1	1	140 000	140 000	0.23	60 000
Improve lighting	K13	1	130 000	130 000	0.21	nya
Street closure—cross intersection	K7	2	101 100	50 550	0.16	nya
Pedestrian signals	S5	1	80 000	80 000	0.13	nya
Improve/reinforce priority signs	K10	5	70 000	14 000	0.11	nya
Stagger cross intersection	K9	2	47 360	23 680	0.08	nya
Painted turn lane	K16	2	34 600	17 300	0.06	nya
Advisory speeds on curves	S15	1	30 000	30 000	0.05	nya
Pedestrian refuge	S2	4	26 000	6 500	0.04	2 000
Improve sight lines	K6	1	25 000	25 000	0.04	nya
Delineation	S16	1	23 000	23 000	0.04	nya
Street closure—T-intersection	K8	1	13 270	13 270	0.02	nya
Other treatment	OT	156	18 104 113	116 052	29.12	2 430 000
Total		513	62 162 310	121 174	100	5 772 800

a. See appendix VI for definitions of treatment codes, including the distinction between K and S codes.

Note 'nya' represents 'not yet available'. The figures contained in the last column should be considered as minimum known expenditure, rather than actual expenditure on particular treatment types.

Sources ATSB and State and Territory governments

EXPENDITURE BY JURISDICTION

Expenditure on black spot treatment in 2000–01 is expected to differ substantially from expenditure in 1999–2000, so expenditure by jurisdiction for both years is shown in figures 2.3 and 2.4. These figures show most of the planned expenditure increase will be spent on treating black spots in Victoria and Western Australia. The Victorian Government's decision to increase its expenditure on black spot treatments is of particular interest, given Victoria's relatively good crash record. This is discussed in more detail in chapter 3.

Figure 2.5 shows Victoria's relatively good crash record in recent years was achieved at quite a low cost per person. Figures 2.5 and 2.6 also indicate that there have been substantial population movements within Australia since the Federal Government's black spot treatment funding allocation formula was developed. This formula may need to be updated before the commencement of any future black spot program. If State and Territory crash rates were identical, Federal Government funding per person for black spot treatments should be the same for all jurisdictions. Chapter 3 shows that crash rates are not identical across Australia. However, they do not reflect the expenditure pattern of black spot treatments shown in figures 2.3 to 2.6. For example, if only fatalities were considered, the Northern Territory should have the highest Federal expenditure per person on black spot treatments because it has the highest fatal crash rate—not Western Australia. And the Australian Capital Territory should have the lowest Federal expenditure per person because it has the lowest fatal crash rate—not South Australia.

Figures 2.7 to 2.14 show the treatments having the highest proportion of expenditure were:

- New South Wales—roundabouts and new traffic lights with no turn arrows—figure 2.7;
- Victoria—sealing road shoulders, roundabouts and edge lines—figure 2.8;
- Queensland—roundabouts and re-modelling signals—figure 2.9;
- Western Australia—roundabouts—although spending was relatively even across different types of black spot treatments compared to other jurisdictions—figure 2.10;
- South Australia—sealing road shoulders and roundabouts—figure 2.11;
- Tasmania—roundabouts, sealing road shoulders, and new traffic signals with no turn arrows—figure 2.12;
- Northern Territory—sealing road shoulders, roundabouts, and pedestrian refuges—figure 2.13; and
- the Australian Capital Territory—roundabouts—figure 2.14.

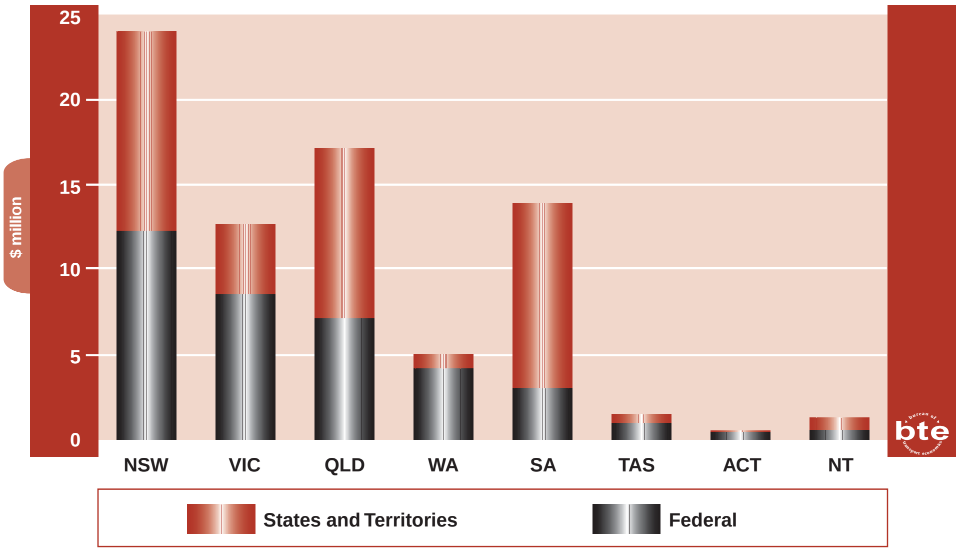
Tables 2.5, 2.6 and 2.7 show the allocation of funding by jurisdiction nationally, in urban areas, and in regional areas. The totals in these tables differ from that in table 2.1 because of changes in the scope of projects after they were approved.

CONCLUSION

The analysis of expenditure by jurisdiction shows that:

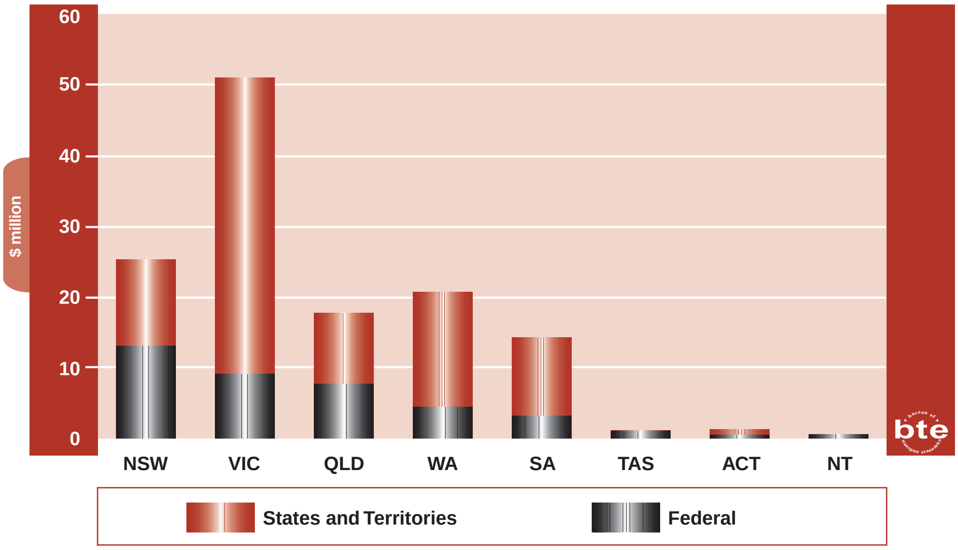
- the *Notes on Administration* may need to be updated, to remove ambiguities about maintaining expenditure by State and Territory governments;
- total funding by State and Territory governments for black spot treatment increased over the life of the Federal Black Spot Program; and
- nationally, considerably more money was spent on roundabouts than on any other treatment type.

FIGURE 2.3 EXPENDITURE ON BLACK SPOT TREATMENT IN 1999–2000



Sources ATSB and State and Territory governments

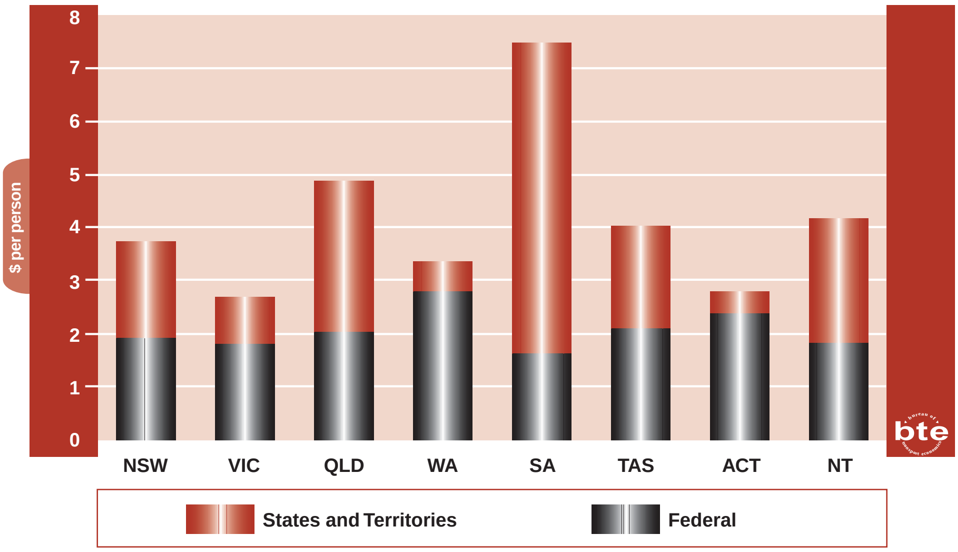
FIGURE 2.4 BUDGETED EXPENDITURE ON BLACK SPOT TREATMENT IN 2000–01



Note The Northern Territory Government's expenditure is unlikely to be zero, as shown above. However, it did not report its planned expenditure on black spot treatments in time for inclusion in this report.

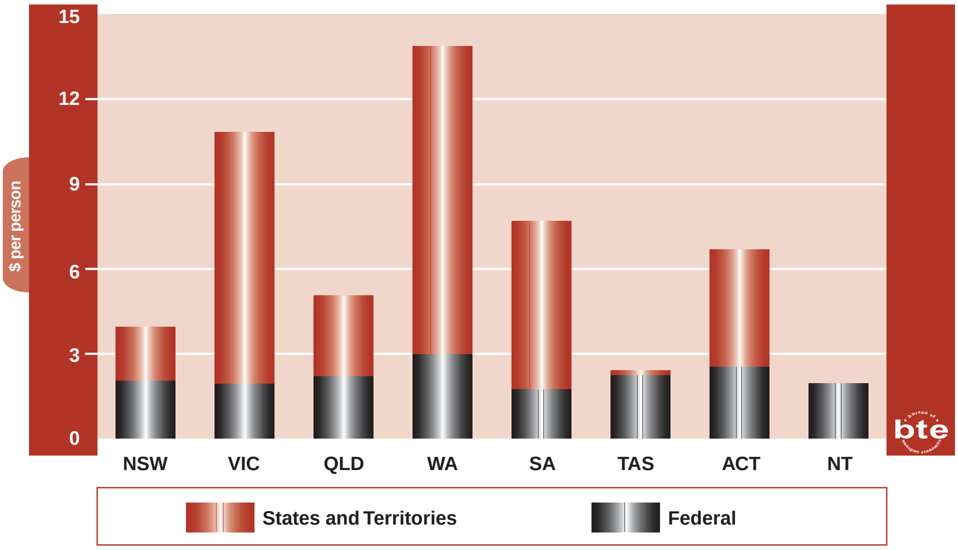
Sources ATSB and State and Territory governments

FIGURE 2.5 EXPENDITURE PER PERSON ON BLACK SPOT TREATMENT IN 1999–2000



Sources ATSB, State and Territory governments, ABS (1999)

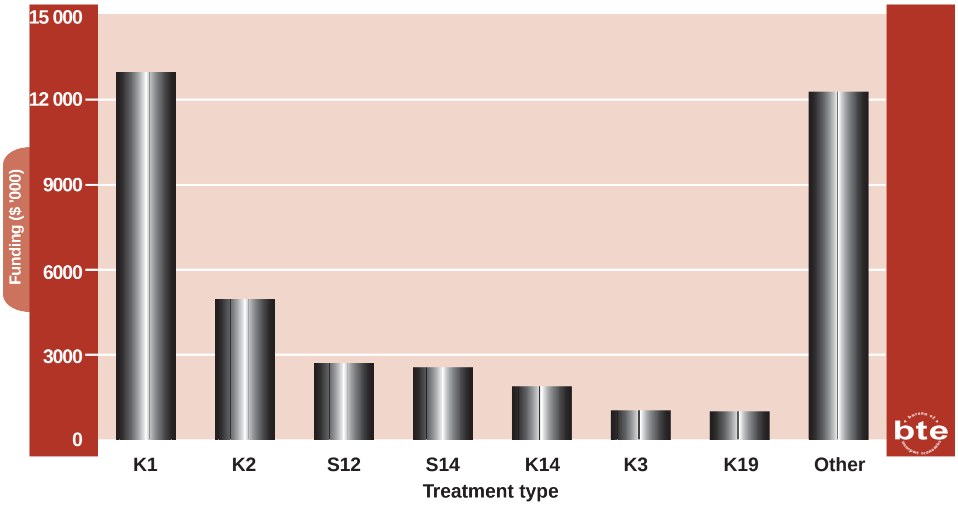
FIGURE 2.6 BUDGETED EXPENDITURE PER PERSON ON BLACK SPOT TREATMENT IN 2000–01



Note Figures 2.5 and 2.6 are based on population figures for June 1999, as these were the latest available at the time this report was prepared.
The Northern Territory Government's expenditure is unlikely to be zero, as shown above. However, it did not report its planned expenditure on black spot treatments in time for inclusion in this report.

Sources ATSB and State and Territory governments

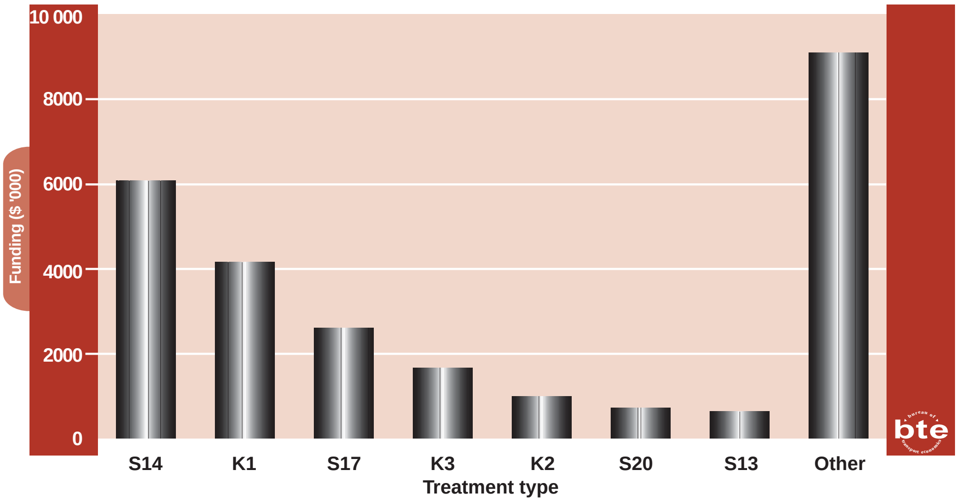
FIGURE 2.7 FEDERAL FUNDING OF BLACK SPOT TREATMENTS IN NEW SOUTH WALES 1996–97—1998–99



Key K1 roundabout K2 new traffic light no turn arrow S12 roadside hazards guard rail
S14 shoulder seal K14 traffic island on approach K3 new traffic light with turn arrow/s
K19 median

Sources ATSB, New South Wales Government

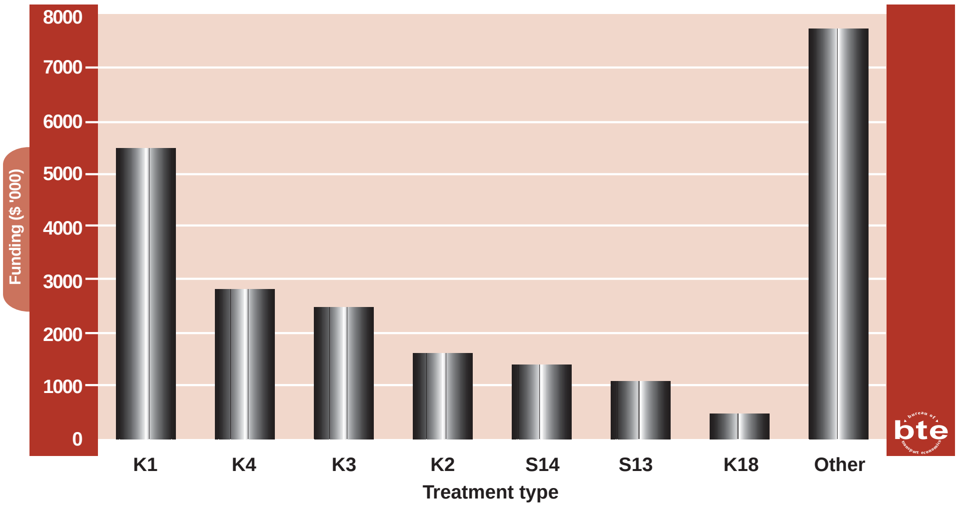
FIGURE 2.8 FEDERAL FUNDING OF BLACK SPOT TREATMENTS IN VICTORIA 1996–97—1998–99



Key S14 shoulder seal K1 roundabout S17 edge lines K3 new traffic light with turn arrow/s K2 new traffic light no turn arrow S20 signs S13 non-skid surface

Sources ATSB, Victorian Government

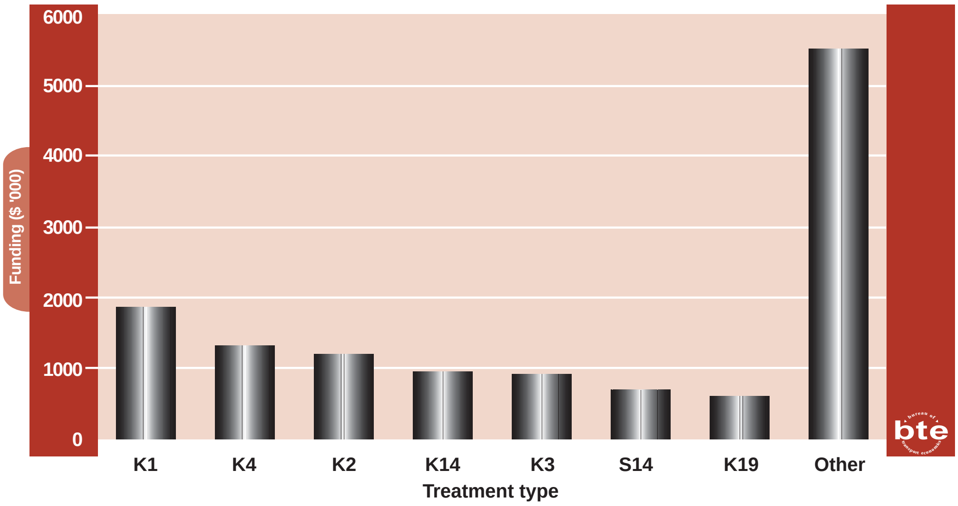
FIGURE 2.9 FEDERAL FUNDING OF BLACK SPOT TREATMENTS IN QUEENSLAND 1996–97—1998–99



Key K1 roundabout K4 re-model signal K3 new traffic light with turn arrow/s K2 new traffic light no turn arrow S14 shoulder seal S13 non-skid surface K18 non-skid treatment

Sources ATSB, Queensland Government

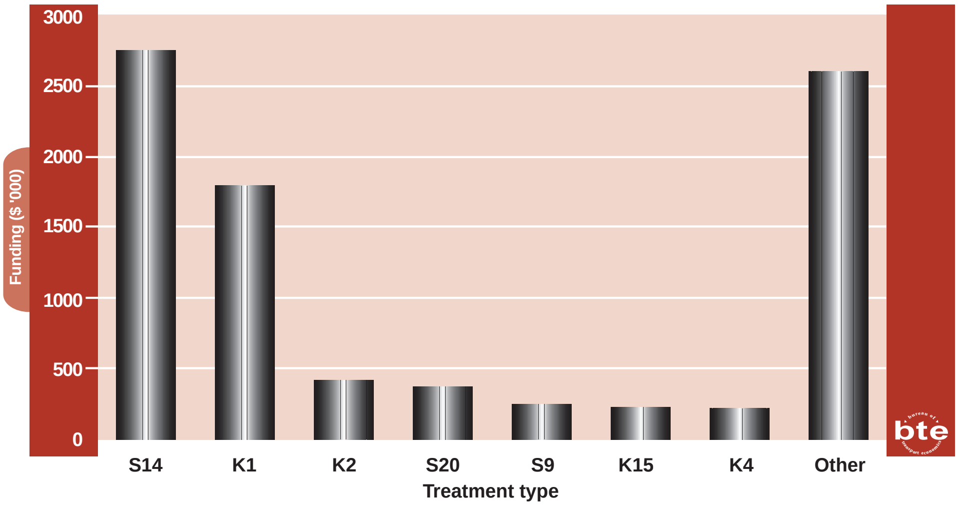
FIGURE 2.10 FEDERAL FUNDING OF BLACK SPOT TREATMENTS IN WESTERN AUSTRALIA 1996–97—1998–99



Key K1 roundabout K4 re-model signal K2 new traffic light no turn arrow K14 traffic islands on approaches K3 new traffic light with turn arrow/s S14 shoulder seal K19 extend median through intersection

Sources ATSB, Western Australian Government

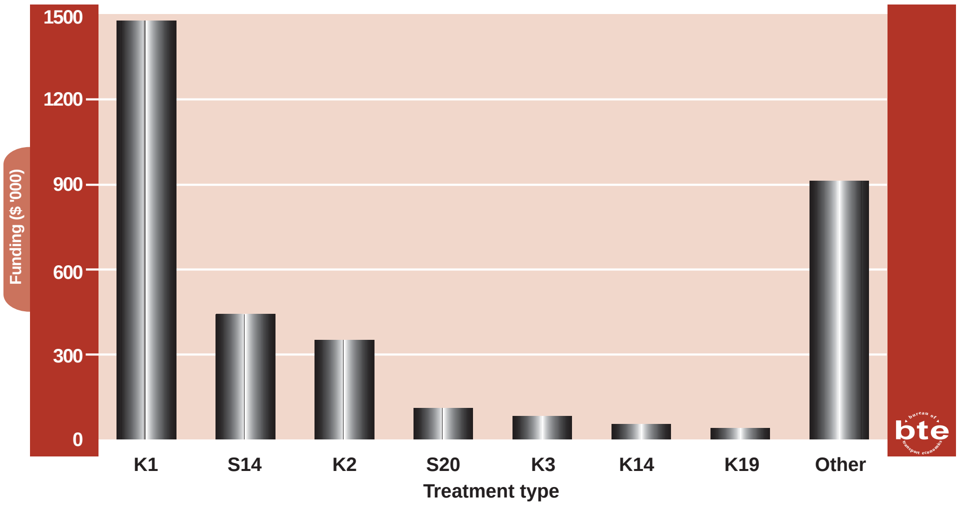
FIGURE 2.11 FEDERAL FUNDING OF BLACK SPOT TREATMENTS IN SOUTH AUSTRALIA 1996–97—1998–99



Key S14 shoulder seal K1= roundabout K2 new traffic light no turn arrow S20 signs S9 indented right hand island K15 indented right turn island K4 re-model signal

Sources ATSB, South Australian Government

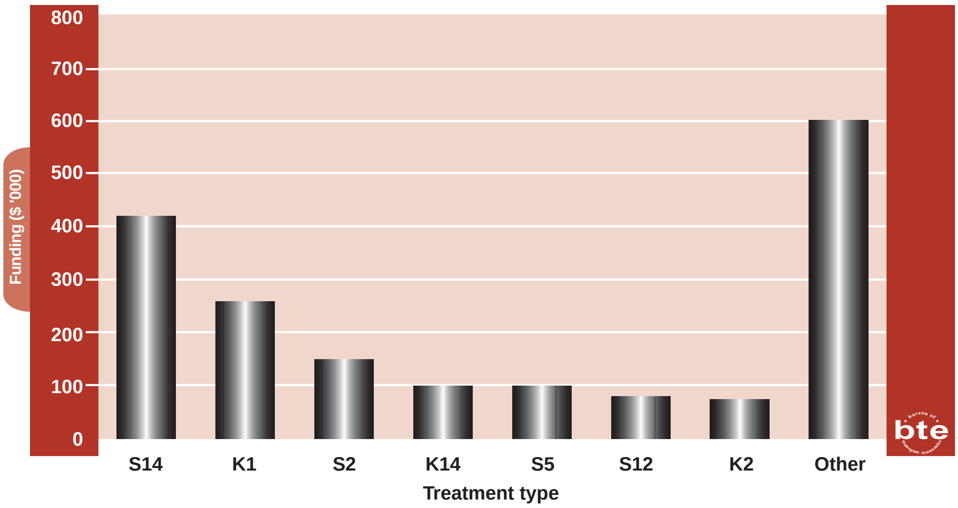
FIGURE 2.12 FEDERAL FUNDING OF BLACK SPOT TREATMENTS IN TASMANIA 1996–97—1998–99



Key K1 roundabout S14 shoulder seal K2 new traffic light no turn arrow S20 signs
K3 new signal with turn arrows K14 traffic islands on approaches
K19 extend median through intersection

Sources ATSB, Tasmanian Government

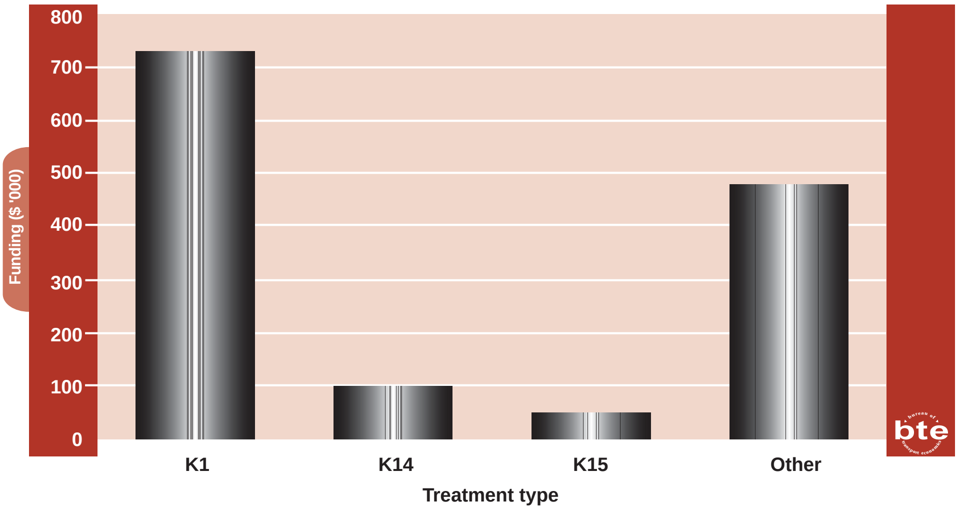
FIGURE 2.13 FEDERAL FUNDING OF BLACK SPOT TREATMENTS IN THE NORTHERN TERRITORY 1996–97—1998–99



Key S14 shoulder seal K1 roundabout S2 pedestrian refuge
K14 traffic islands on approaches S5 pedestrian signals
S12 roadside hazards—guard rail K2 new traffic light no turn arrow

Sources ATSB, Northern Territory Government

FIGURE 2.14 FEDERAL FUNDING OF BLACK SPOT TREATMENTS IN THE AUSTRALIAN CAPITAL TERRITORY 1996–97—1998–99



Key K1 roundabout K14 traffic islands on approaches K15 indented right turn island

Sources ATSB, Australian Capital Territory Government

TABLE 2.5 FEDERAL BLACK SPOT TREATMENT FUNDING BY JURISDICTION 1996–97—1998–99

Jurisdiction	*Number of projects*	*Total Federal funding*	*Average Federal funding per project*	*Percentage of Federal total*
NSW	326	39 256 100	120 417	33.7
VIC	277	25 941 500	93 652	22.2
QLD	184	23 095 238	125 518	19.8
WA	180	13 090 774	72 727	11.2
SA	69	8 633 201	125 119	7.4
TAS	57	3 463 500	60 763	3.0
NT	21	1 786 000	85 048	1.5
ACT	8	1 360 000	170 000	1.2
Total	1122	116 626 313	103 945	100.0

Source ATSB

TABLE 2.6 FEDERAL URBAN BLACK SPOT TREATMENT FUNDING BY JURISDICTION 1996–97—1998–99

Jurisdiction	*Number of projects*	*Total Federal funding*	*Average Federal funding per project*	*Percentage of Federal total*
NSW	176	18 802 500	106 832	34.5
VIC	165	12 024 530	72 876	22.1
QLD	82	9 421 400	114 895	17.3
WA	112	6 601 523	58 942	12.1
SA	28	2 825 150	100 898	5.2
NT	21	1 786 000	85 048	3.3
TAS	17	1 642 900	96 641	3.0
ACT	8	1 360 000	170 000	2.5
Total	609	54 464 003	89 432	100.0

Source ATSB

TABLE 2.7 FEDERAL REGIONAL BLACK SPOT TREATMENT FUNDING BY JURISDICTION 1996–97—1998–99

Jurisdiction	*Number of projects*	*Total Federal funding*	*Average Federal funding per project*	*Percentage of Federal total*
NSW	150	20 453 600	136 357	32.9
VIC	112	13 916 970	124 259	22.4
QLD	102	13 673 838	134 057	22.0
WA	68	6 489 251	95 430	10.4
SA	41	5 808 051	141 660	9.3
TAS	40	1 820 600	45 515	2.9
ACT	0	0	0	0.0
Total	513	62 162 310	121 174	100.0

Source ATSB

3

CRASH TRENDS AND ANALYSIS

When assessing black spot treatment effects, it is important to consider any underlying crash trends that may affect crash rates at a site before and after treatment, independently of any treatment effect.

This chapter analyses crash trends in Australia in recent years. The analysis examines crash trends in Australian States and Territories and compares Australia's performance with that of other Organisation for Economic Cooperation and Development (OECD) nations. The analysis also includes a comparison of crash trends in urban and regional areas.

THEORETICAL ASSUMPTIONS ABOUT CRASH DISTRIBUTIONS

Much of the literature dealing with crash reductions following site treatment assumes there is a constant underlying mean annual crash rate at individual sites. This assumption is valid only where crash numbers vary from year to year, but are not subject to marked upward or downward trends.

There are various statistical models for analysing crash data at individual sites and groups of sites. These include the Poisson distribution, negative binomial distribution and various compound or generalised Poisson models (Kemp 1973) and the logarithmic series distribution (Andreassen and Hoque 1986). The analysis in this report assumes that, in a 12-month period, crashes at an intersection have a Poisson distribution, and that site means have a gamma distribution. The theoretical basis for this assumption is that the number of crashes at an intersection can be modelled as a collection of rare events arising from a very small but constant probability of impact as two vehicles approach the intersection.

CHANGES IN CRASH TRENDS IN AUSTRALIA

Figures 3.1 and 3.2 show that crash trends in Australia have changed dramatically since 1925. The number of registered vehicles has increased steadily and the number of fatalities per 10 000 vehicles and per 100 000 people has decreased. Road fatalities have decreased more noticeably since the 1970s, when the compulsory wearing of seatbelts and restrictions on drink-driving were introduced.

Figures 3.3 to 3.6 show the number of fatal crashes in Australia since 1990:

- in absolute terms;
- per 100 000 people;
- per 10 000 registered vehicles; and
- per 100 million vehicle-kilometres travelled.

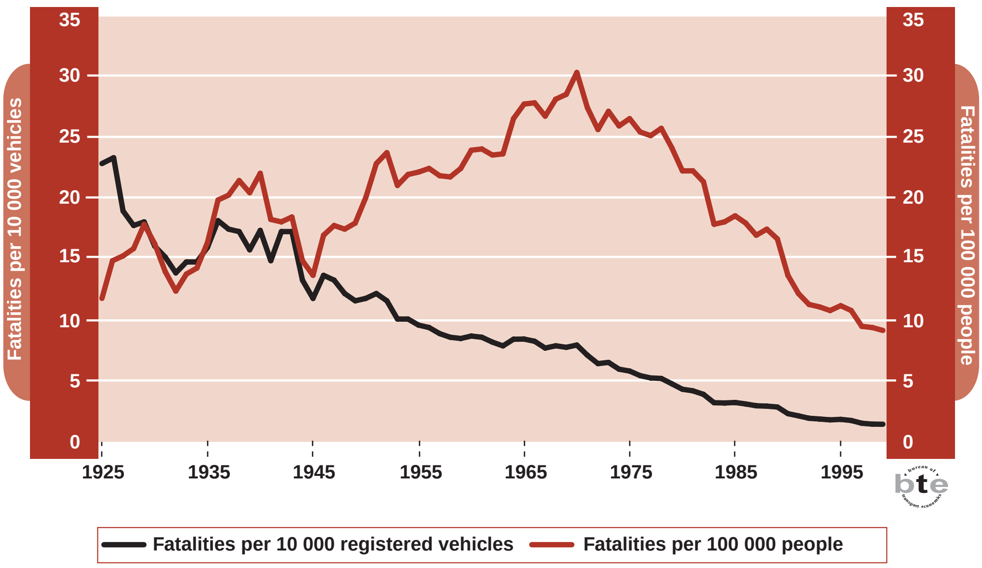
The number of fatal crashes differs from the number of fatalities because more than one person may die in a fatal crash.

Road crash fatalities in Australia have been almost constant since 1997 in absolute terms, but declined per 100 000 people, per 10 000 registered vehicles, and per 100 million vehicle-kilometres travelled. These trends are illustrated in figures 3.7 to 3.10. The declines shown in figures 3.8 to 3.10 are statistically significant.

AUSTRALIA'S CRASH TRENDS RELATIVE TO OTHER OECD NATIONS

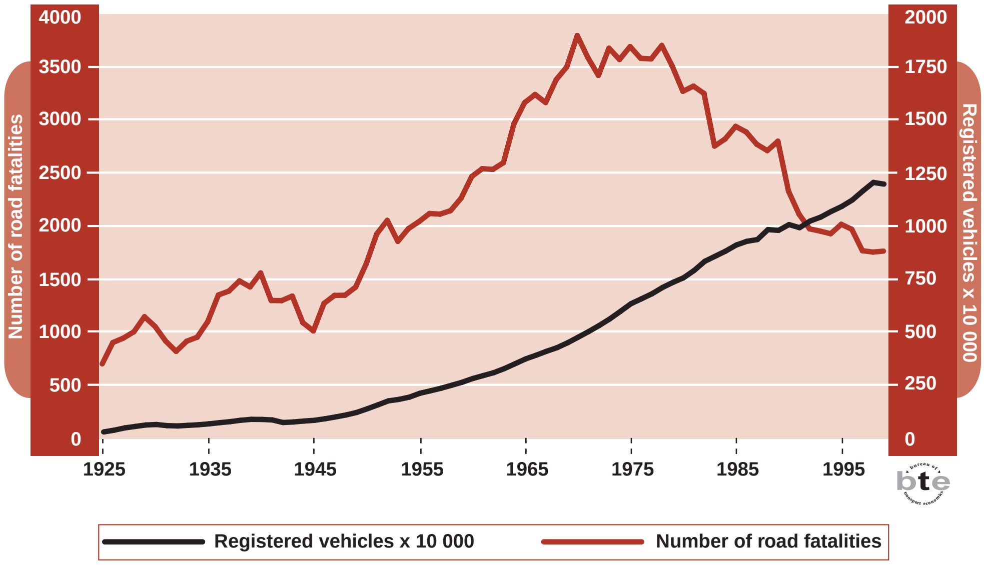
Australia's number of fatalities per 100 000 people, per 10 000 registered vehicles, and per 100 million vehicle-kilometres travelled were slightly better than the OECD median values in 1998—the most recent OECD figures available when this report was being prepared. Australian and OECD trends are shown in figures 3.11 to 3.13. For most of the last decade, Australian fatality trends are similar to those of the OECD.

FIGURE 3.1 ROAD FATALITIES PER 10 000 REGISTERED VEHICLES AND PER 100 000 PEOPLE IN AUSTRALIA 1925–1999



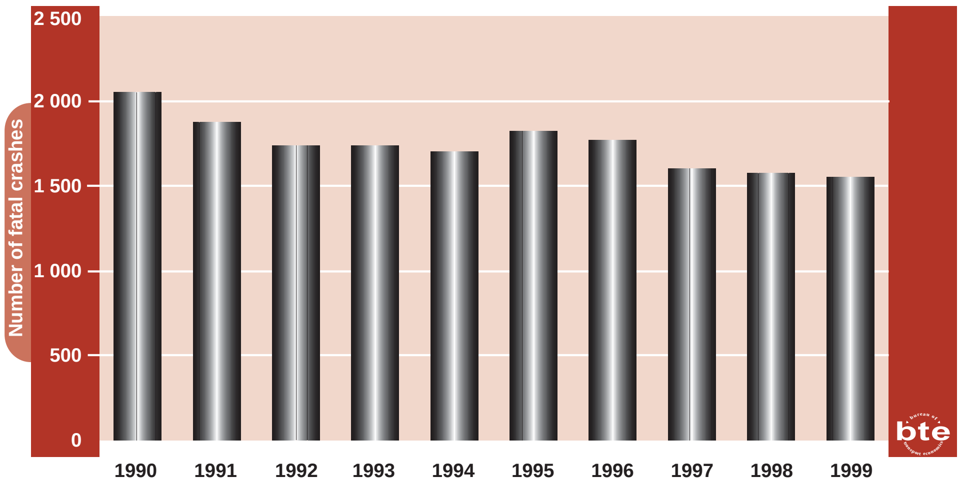
Source ATSB

FIGURE 3.2 NUMBER OF ROAD FATALITIES AND REGISTERED VEHICLES IN AUSTRALIA 1925–1999



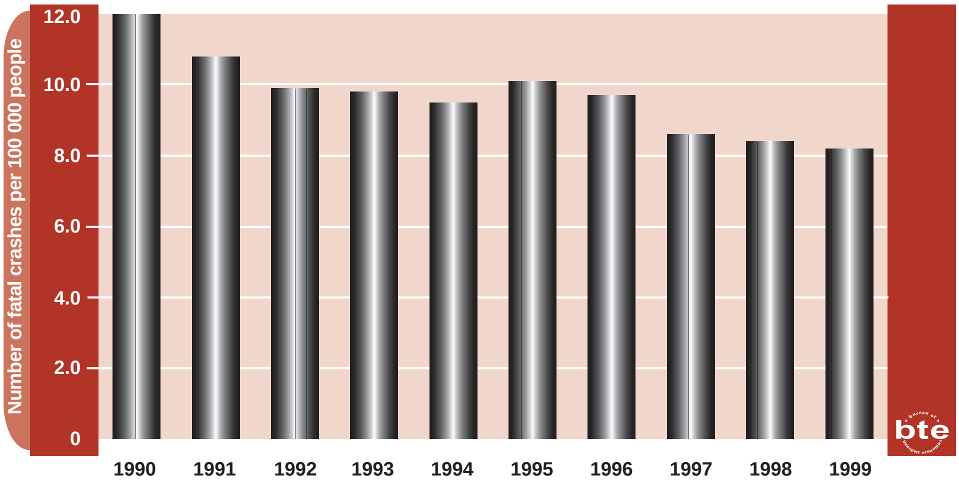
Source ATSB

FIGURE 3.3 FATAL CRASHES IN AUSTRALIA 1990–1999



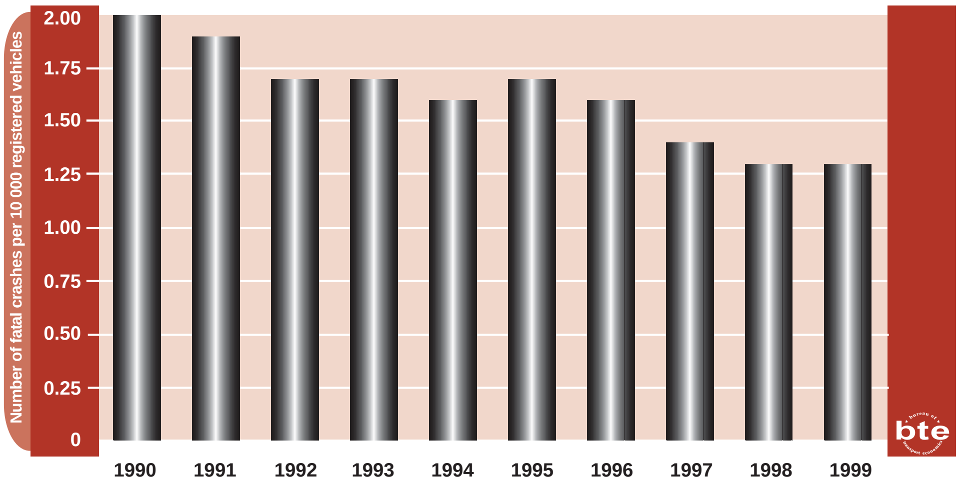
Source ATSB

FIGURE 3.4 FATAL CRASHES PER 100 000 PEOPLE IN AUSTRALIA 1990–1999



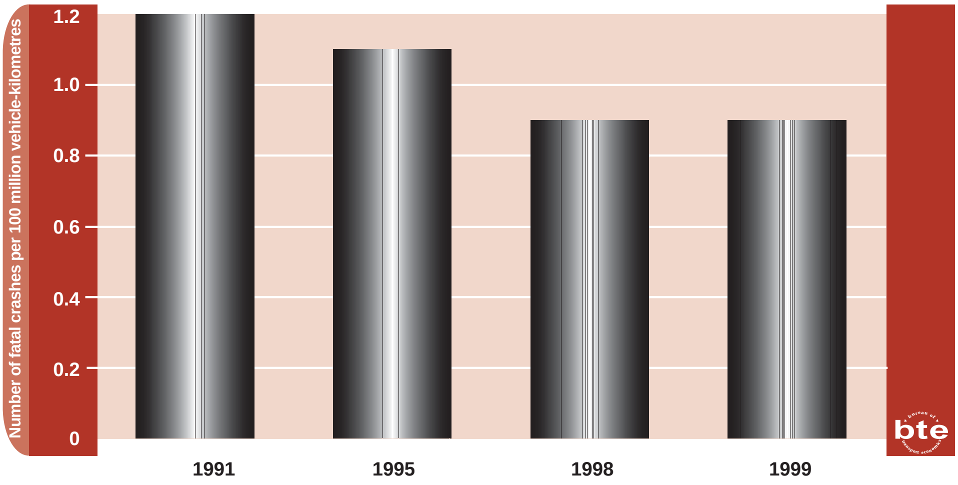
Source ATSB

FIGURE 3.5 FATAL CRASHES PER 10 000 REGISTERED VEHICLES IN AUSTRALIA 1990–1999



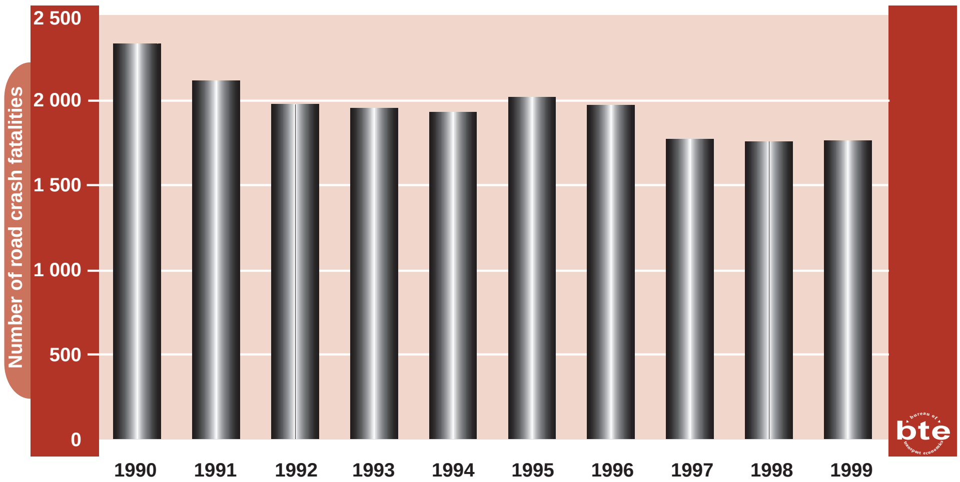
Source ATSB

FIGURE 3.6 FATAL CRASHES PER 100 MILLION VEHICLE-KILOMETRES TRAVELLED IN AUSTRALIA 1991–1999



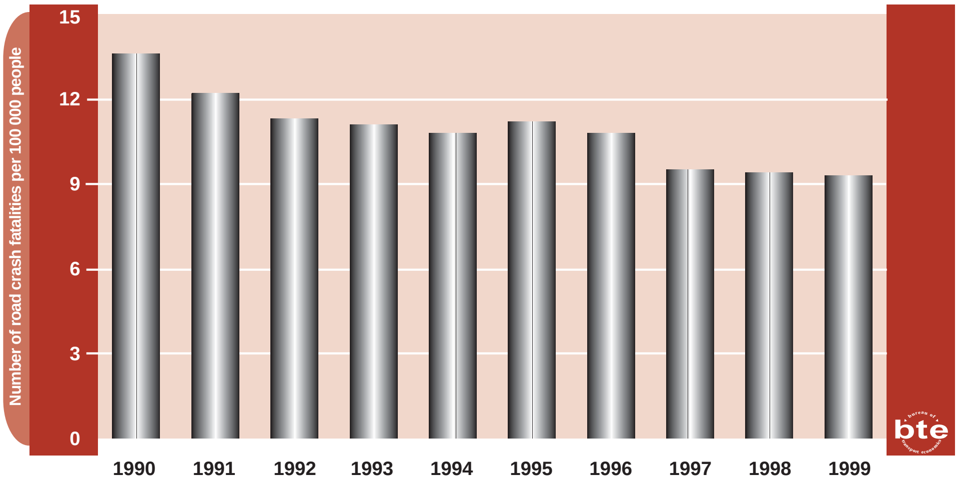
Source ATSB

FIGURE 3.7 ROAD CRASH FATALITIES IN AUSTRALIA 1990–1999



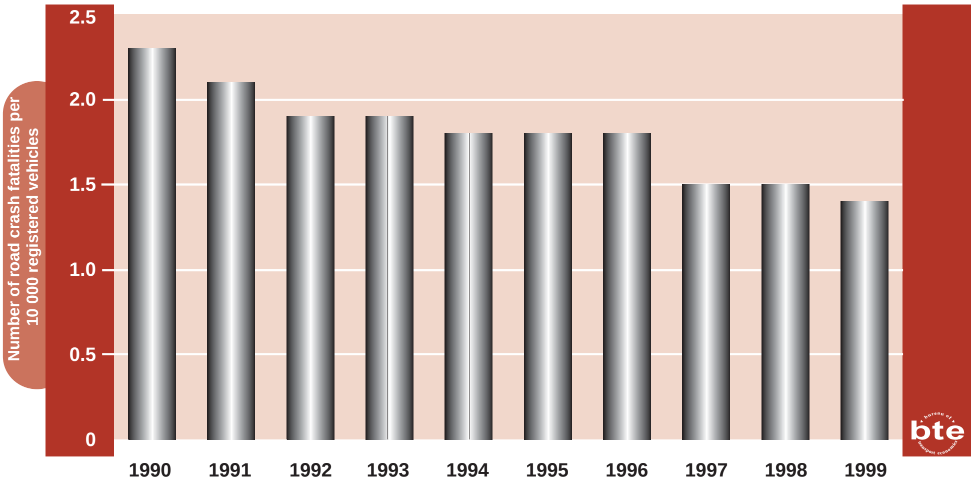
Source ATSB

FIGURE 3.8 ROAD CRASH FATALITIES PER 100 000 PEOPLE IN AUSTRALIA 1990–1999



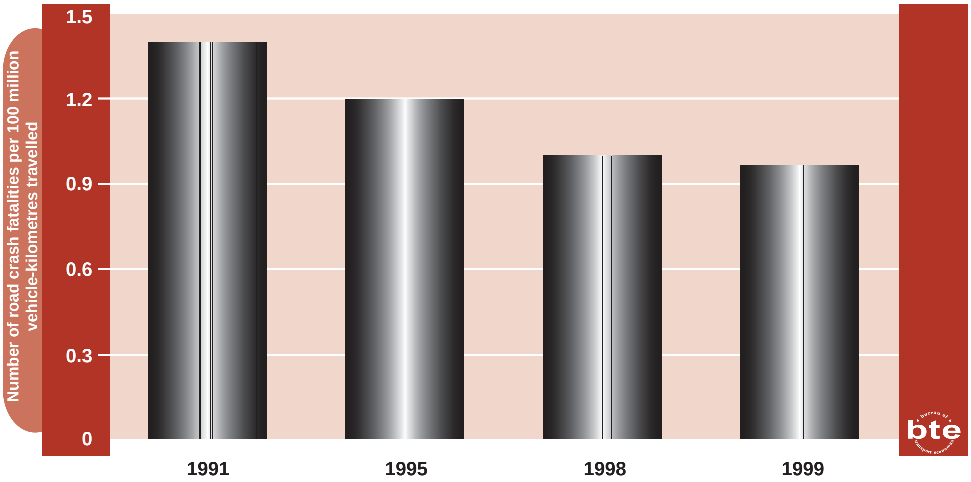
Source ATSB

FIGURE 3.9 ROAD CRASH FATALITIES PER 10 000 REGISTERED VEHICLES IN AUSTRALIA 1990–1999



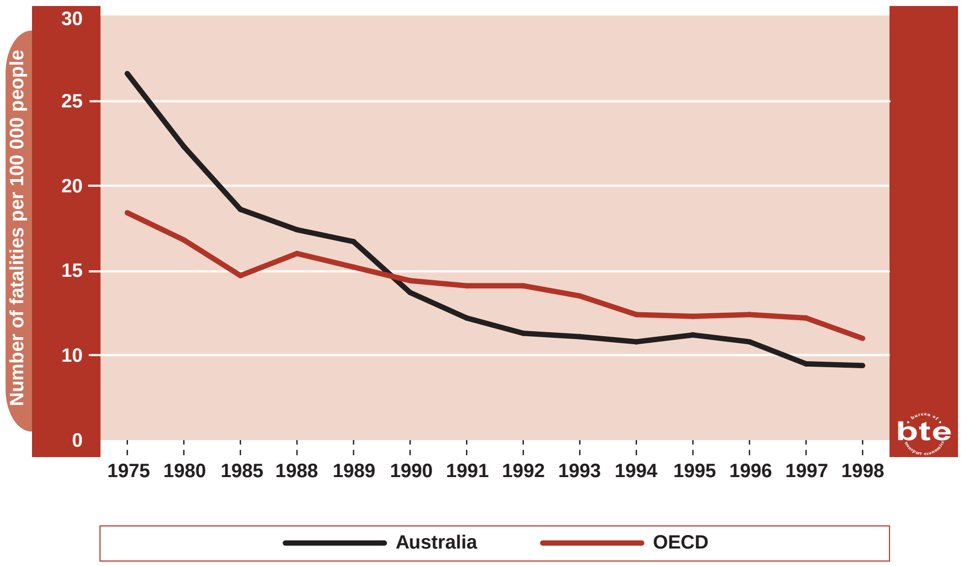
Source ATSB

FIGURE 3.10 ROAD CRASH FATALITIES PER 100 MILLION VEHICLE-KILOMETRES TRAVELLED IN AUSTRALIA 1991–1999



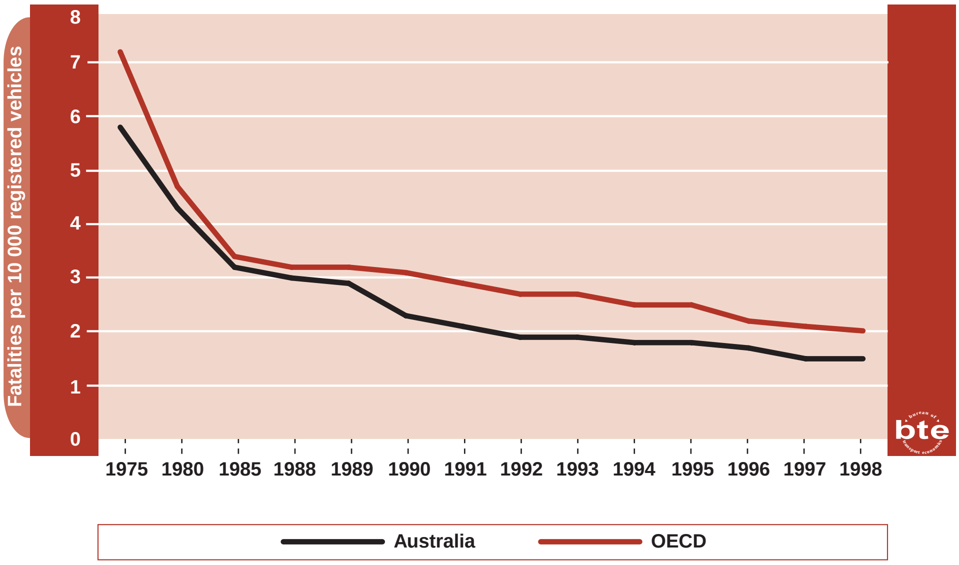
Source ATSB

FIGURE 3.11 AUSTRALIAN AND OECD MEDIAN FATALITIES PER 100 000 PEOPLE 1975–1998



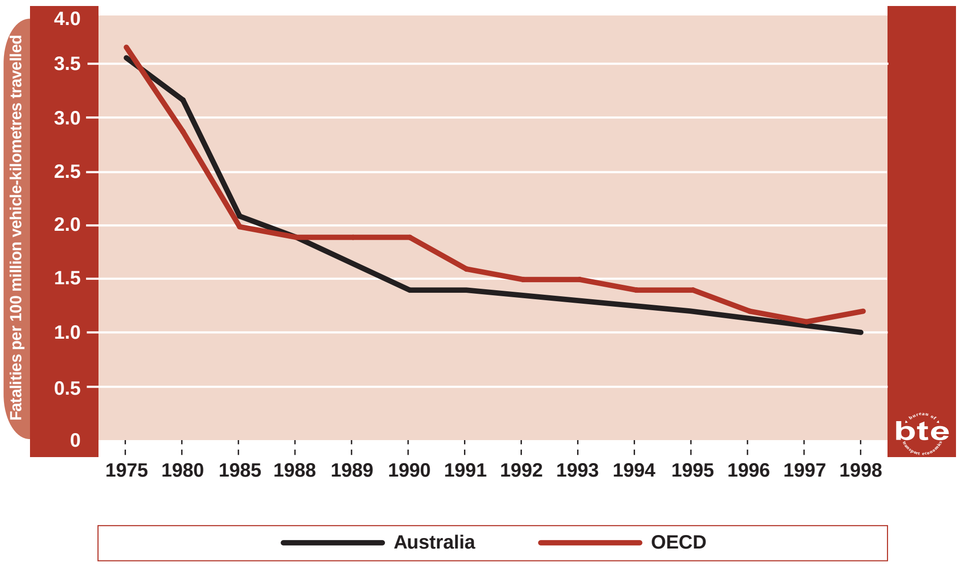
Source OECD International Road Traffic Accident Database

FIGURE 3.12 AUSTRALIAN AND OECD MEDIAN FATALITIES PER 10 000 REGISTERED VEHICLES 1975–1998



Source OECD International Road Traffic Accident Database

FIGURE 3.13 AUSTRALIAN AND OECD MEDIAN FATALITIES PER 100 MILLION VEHICLE-KILOMETRES TRAVELLED 1975–1998



Source OECD International Road Traffic Accident Database

However, Australia's road safety performance varies significantly across the country. There are considerable State and Territory differences between fatalities per 100 000 people, per 10 000 registered vehicles and per 100 million vehicle-kilometres travelled.

Figures 3.14, 3.15 and 3.16 compare fatalities in Australian States and Territories with the Australian average and with the performance of other OECD nations in 1998:

- per 100 000 people;
- per 10 000 registered vehicles; and
- per 100 million vehicle-kilometres travelled.

Among Australian jurisdictions, the Australian Capital Territory had the safest roads and ranked behind only Sweden, the United Kingdom and the Netherlands for number of fatalities per 100 000 people. For number of fatalities per 10 000 registered vehicles and per 100 million vehicle-kilometres travelled, the Australian Capital Territory was safer than any OECD nation.

Victoria and Queensland performed well compared with most OECD nations, while New South Wales' performance was similar to the Australian average. In 1998, South Australia's and Tasmania's performance was below the Australian average. Western Australia's performance was the second worst in Australia and below the OECD medians for measures other than number of fatalities per 10 000 registered vehicles.

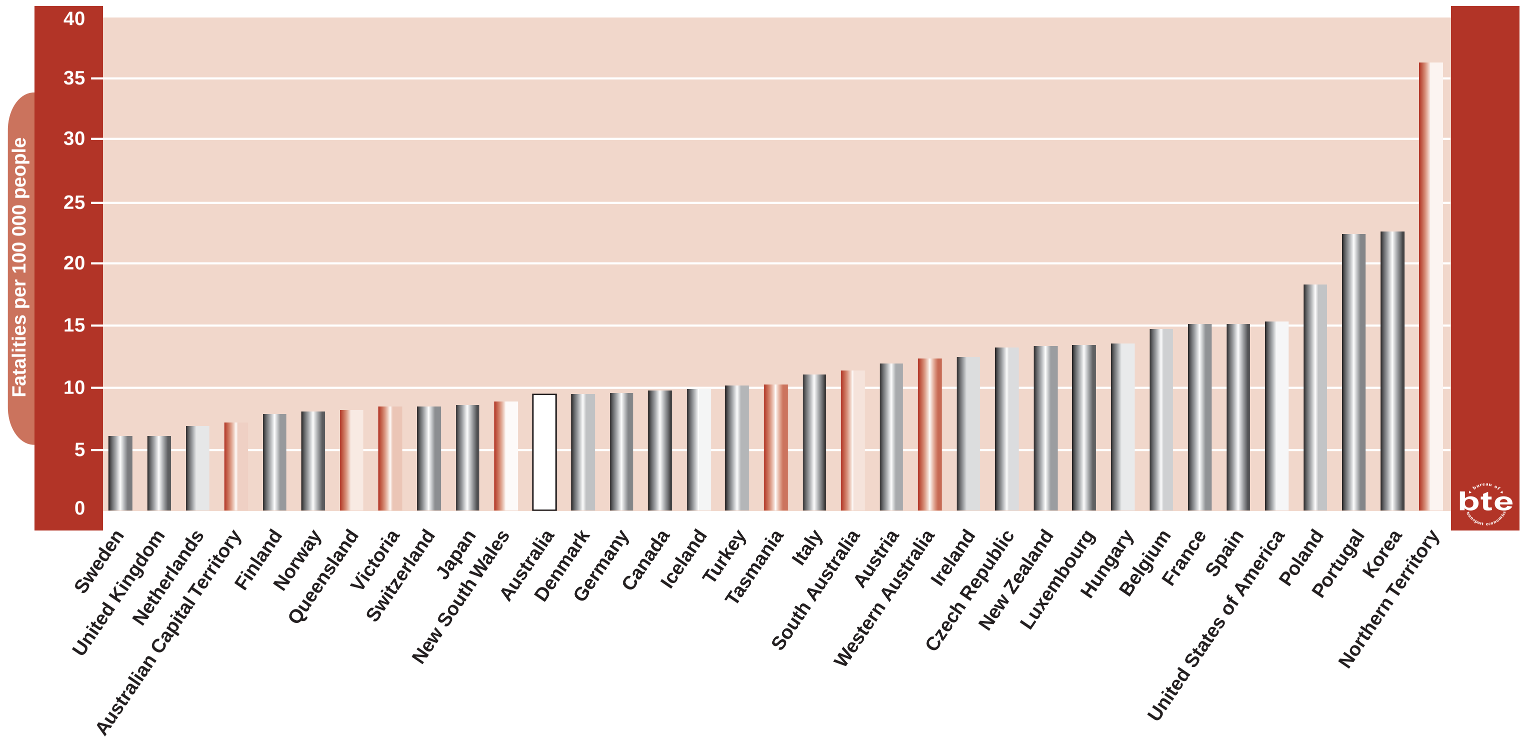
The Northern Territory's road safety record was the worst in Australia for number of fatalities by any criteria and ranked below all OECD nations for number of fatalities per 100 000 people. For number of fatalities per 10 000 registered vehicles, the Northern Territory ranked higher than only Turkey and Korea, and higher only than Turkey for number of fatalities per 100 million kilometres-travelled.

COMPARING URBAN AND REGIONAL CRASH TRENDS

This evaluation analysed urban and regional crash rates for New South Wales, Victoria, Queensland, South Australia and Western Australia. However, the available data distinguished only the capital cities in those five states as urban. In this report, therefore, *urban* refers to capital cities. *Regional* refers to all other locations.

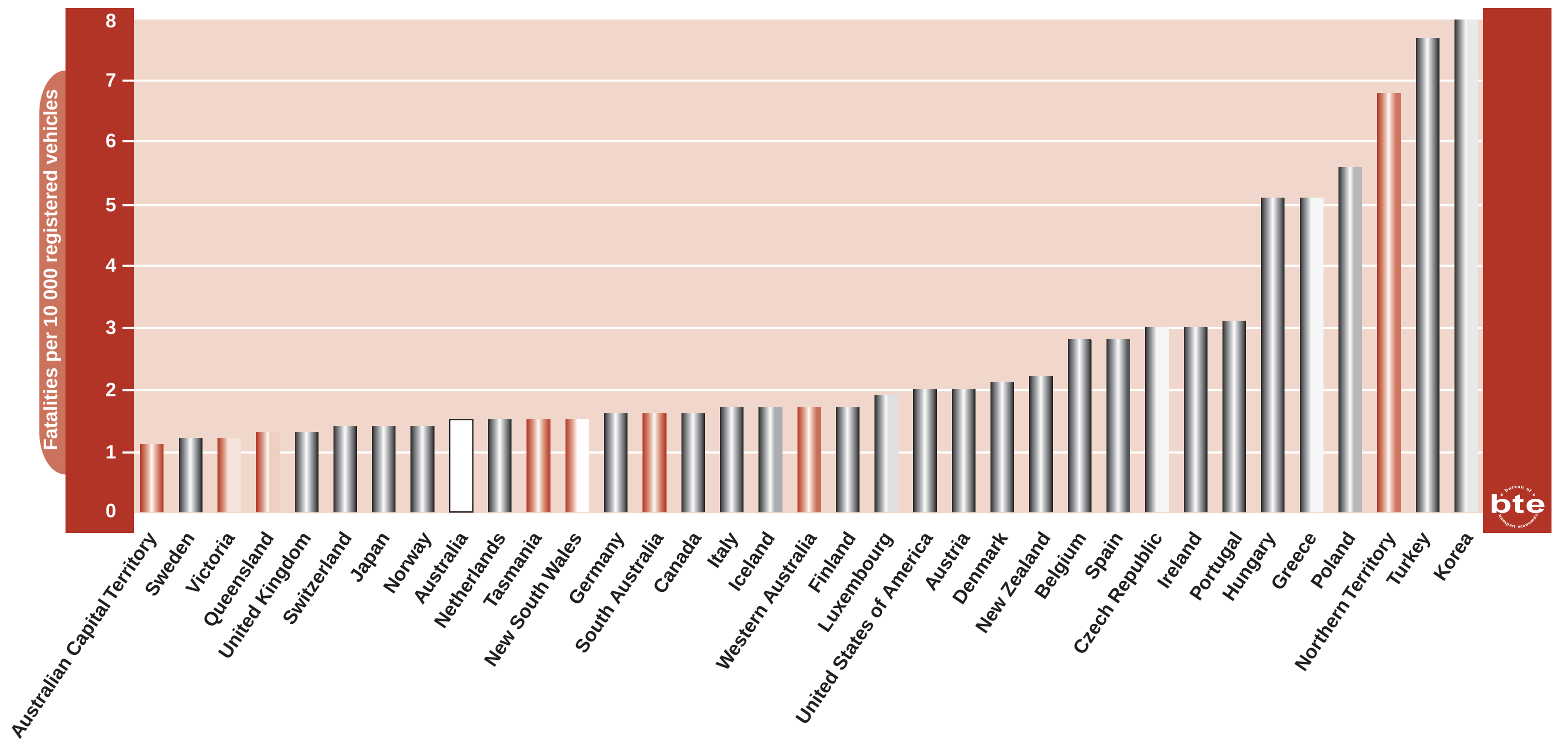
The distinction between crash rates and crash numbers is very important because crash numbers affect the cost of crashes to the community. The criteria for a site to be defined as a black spot are weighted towards crash numbers rather than crash rates.

FIGURE 3.14 FATALITIES PER 100 000 PEOPLE: OECD NATIONS AND AUSTRALIAN STATES AND TERRITORIES 1998



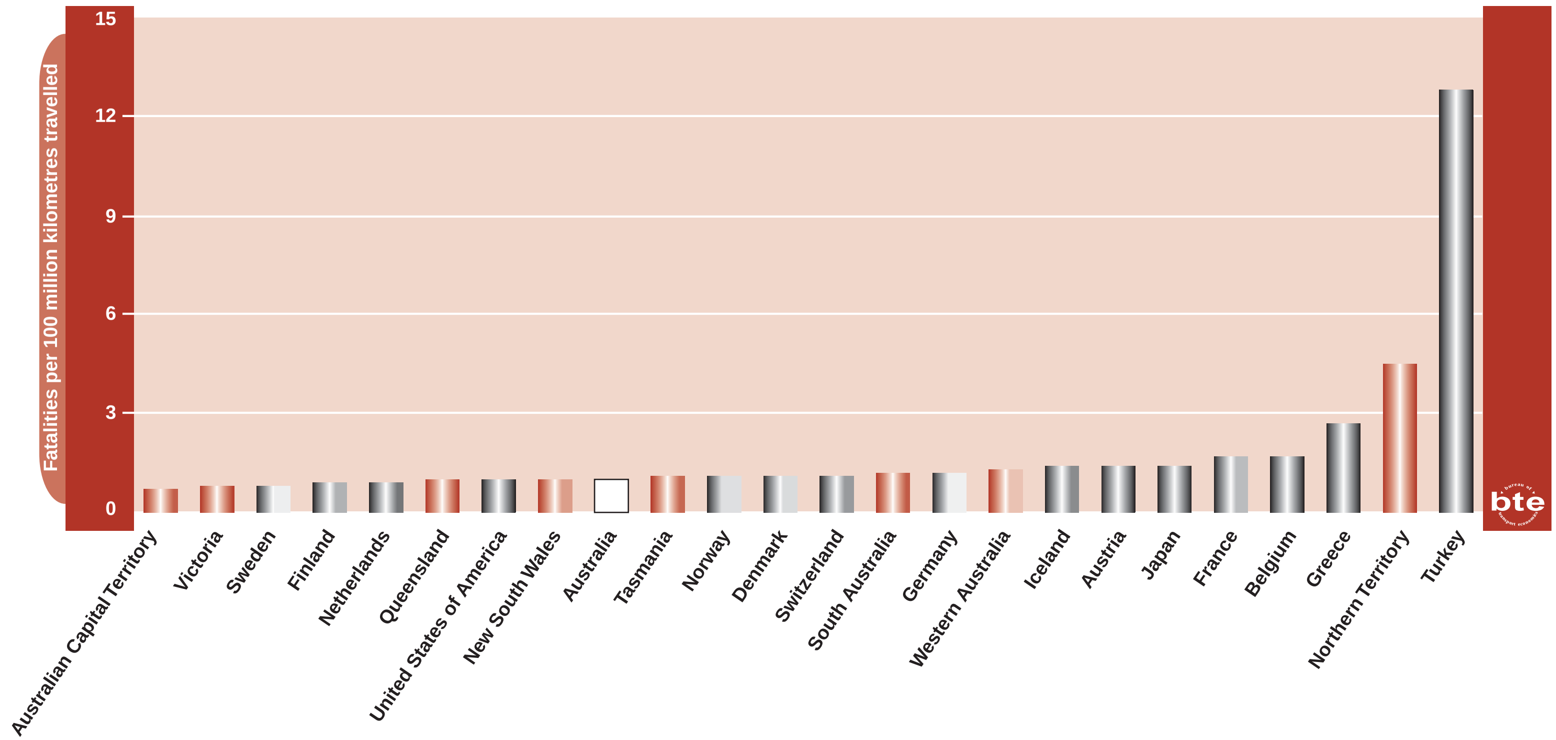
Source OECD, ATSB

FIGURE 3.15 FATALITIES PER 10 000 REGISTERED VEHICLES: OECD NATIONS AND AUSTRALIAN STATES AND TERRITORIES 1998



Source OECD, ATSB

FIGURE 3.16 FATALITIES PER 100 MILLION VEHICLE-KILOMETRES TRAVELLED: OECD NATIONS AND AUSTRALIAN STATES AND TERRITORIES 1998



Source OECD, ATSB

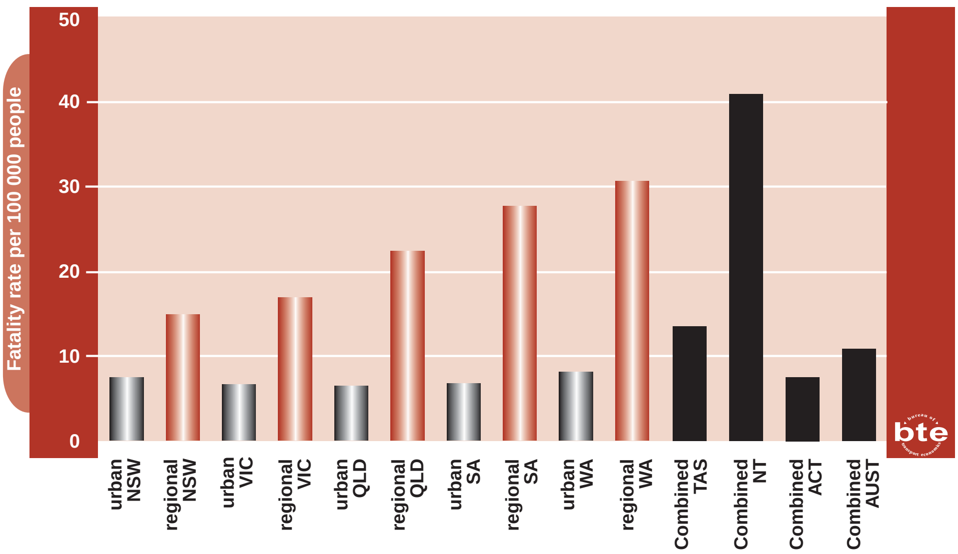
An area's crash rate per 100 000 people for a specific time period is calculated by dividing the crash number for the area by the area's population, measured in units of 100 000.

There was very strong evidence that in all states the fatality rate was higher in regional than in urban areas from 1991 to 1996. Figure 3.17 shows the substantial differences between urban and regional crash fatality rates in all states in 1996. The evidence was also very strong—for all states except Victoria—that over the same period, serious injury and serious crash rates were higher in regional than in urban areas. The urban and regional serious injury rates for all states in 1996 are shown in figure 3.18.

In Victoria, there was very strong evidence that the serious injury rate was higher in regional than in urban areas between 1991 and 1995 and that the serious crash rate was higher in regional than in urban areas between 1991 and 1994. There was also strong evidence that the serious crash rate was higher in regional than in urban areas for 1995, and weak evidence that it was higher in regional than in urban areas for 1996.

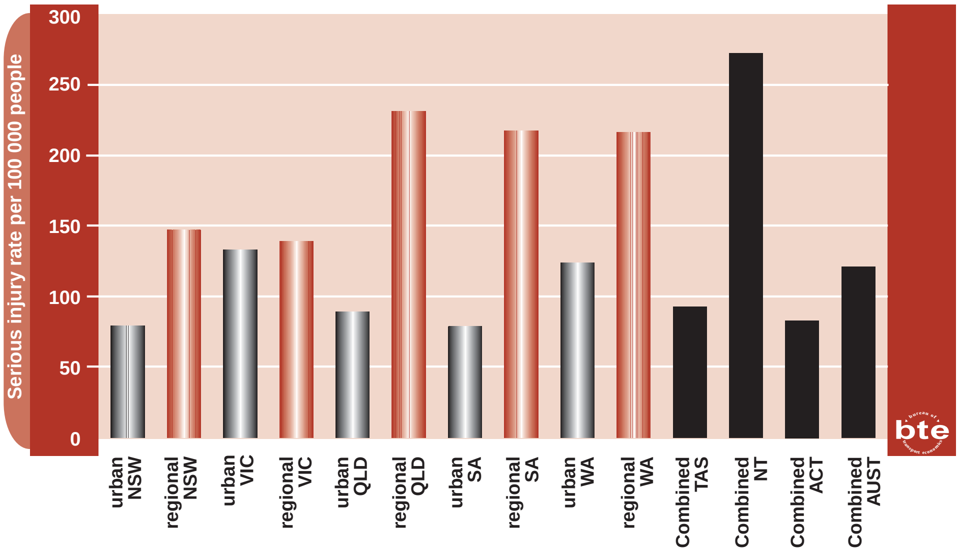
There is very strong evidence that the ratio of regional to urban fatal crashes per 100 000 people decreased between 1991 and 1996 in New South Wales and Queensland. There is no evidence that the ratio declined in Western Australia, Victoria or South Australia.

FIGURE 3.17 URBAN AND REGIONAL FATALITY RATES 1996



Source ATSB

FIGURE 3.18 URBAN AND REGIONAL SERIOUS INJURY RATES 1996



Source ATSB

There is very strong evidence that the ratio of regional to urban serious crashes per 100 000 people decreased between 1991 and 1996 in Queensland and Western Australia. The ratio declined over most of the period in Victoria, but there was a large number of serious regional crashes there in 1996. South Australia's ratio was unstable over time and there was no evidence that the ratio for New South Wales changed significantly over the period.

CRASH TRENDS IN AUSTRALIAN STATES AND TERRITORIES

Figures 3.19 to 3.24 compare the number of fatal crashes and the number of fatalities in each State and Territory per 100 000 people, per 10 000 registered vehicles, and per 100 million vehicle-kilometres travelled. Figures 3.19, 3.20 and 3.21 are included because they show more recent data than the OECD comparisons in figures 3.14, 3.15 and 3.16. OECD data for 1999 were not available at the time this report was being prepared.

To perform the analysis—described in chapter 6—of black spot treatments' effectiveness in reducing crashes, BTE needed information on national, State and Territory crash trends for 1996–97, 1997–98, and 1998–99. However, the serious injury road crash figures for 1998 were not available when this report was prepared. The serious injury road crash figures from 1988 to 1997 were used to generate forecast values for 1998. This was done after experimenting with various types of polynominal functions to determine which functions best fitted each set of data. The statistical application SAS was used to generate the constants for the best fitting linear, quadratic, third power and higher order functions for each dataset. The quality of the fits obtained was traded off against the loss of degrees of freedom as the complexity of the models rose. The projections used, and the fits obtained, are shown in figures 3.25 to 3.33. The data used and the forecast values obtained are given in appendix IX.

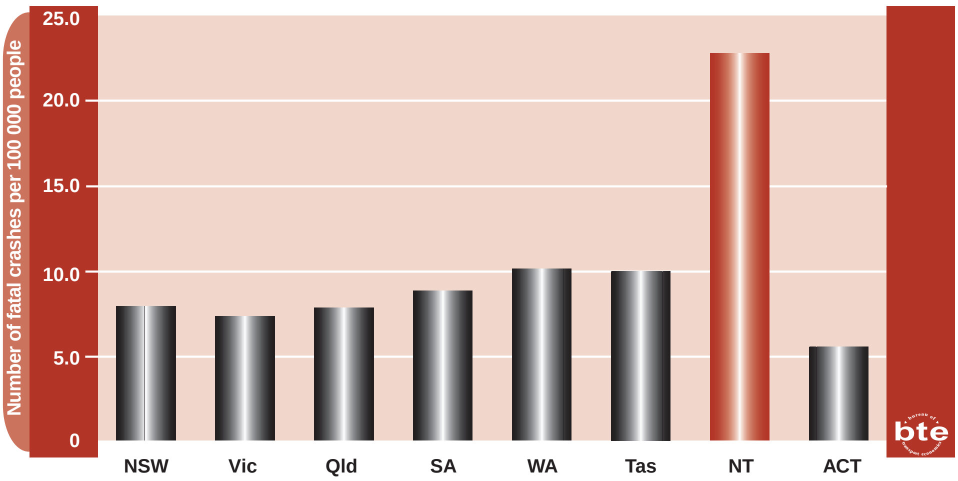
The Northern Territory

A detailed analysis of road safety issues in the Northern Territory is outside the scope of this report. However, further study might be worthwhile given the relative scale of the Northern Territory's road safety problem. The analysis presented below attempts to clarify the issues identified.

Indigenous road deaths

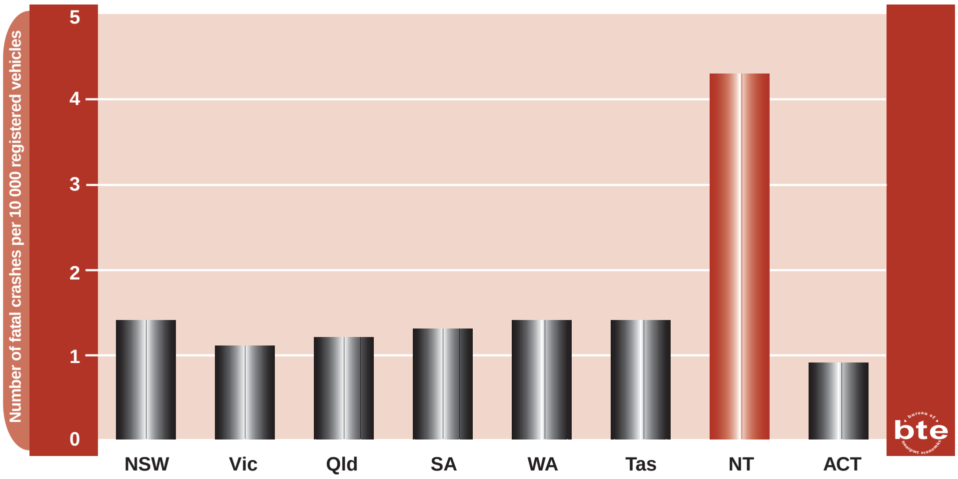
The road crash databases maintained by Western Australia, South Australia and the Northern Territory identify whether persons who die in road crashes are indigenous or non-indigenous. The number of road deaths per 100 000 people was higher in the indigenous populations of these jurisdictions from 1994 to 1997 (McFadden et al 2000). The much higher proportion of indigenous people in the Northern Territory—around 28 per cent of the population—compared with the proportion in the rest of the country—around two per cent (ABS 1999)—is likely to be a contributory factor to the Northern Territory's relatively high road toll.

FIGURE 3.19 FATAL CRASHES PER 100 000 PEOPLE IN AUSTRALIA 1999



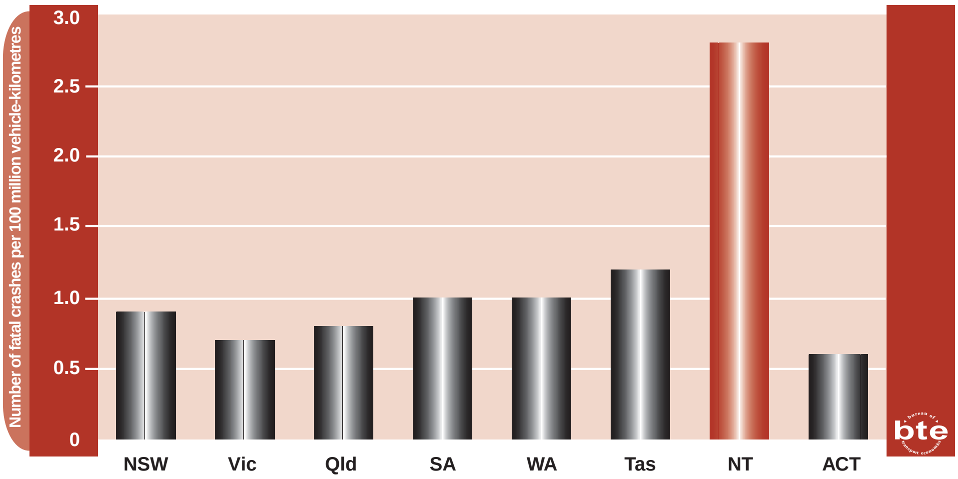
Source ATSB

FIGURE 3.20 FATAL CRASHES PER 10 000 REGISTERED VEHICLES IN AUSTRALIA 1999



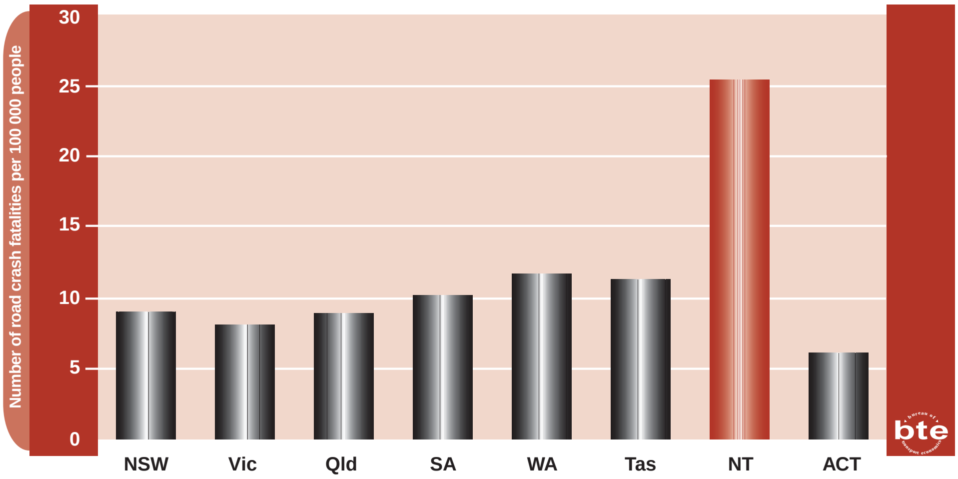
Source ATSB

FIGURE 3.21 FATAL CRASHES PER 100 MILLION VEHICLE-KILOMETRES TRAVELLED IN AUSTRALIA 1999



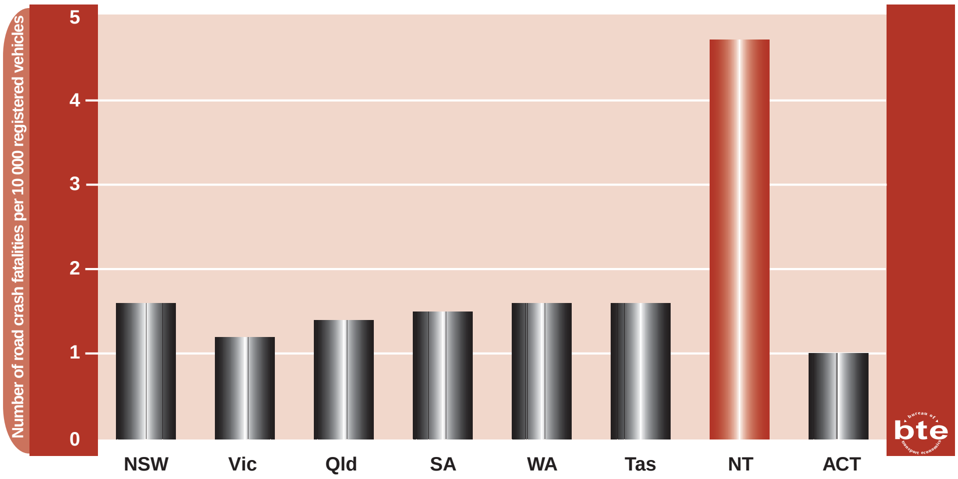
Source ATSB

FIGURE 3.22 ROAD CRASH FATALITIES PER 100 000 PEOPLE IN AUSTRALIA 1999



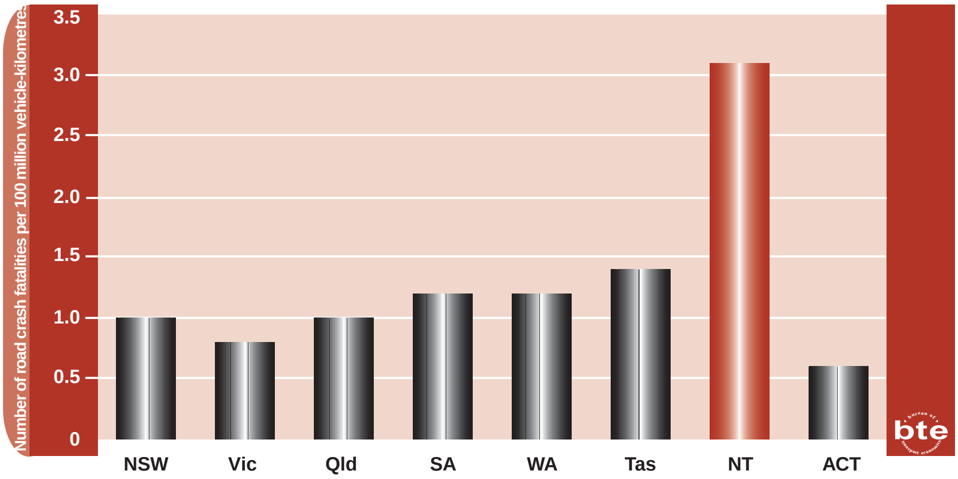
Source ATSB

FIGURE 3.23 ROAD CRASH FATALITIES PER 10 000 REGISTERED VEHICLES IN AUSTRALIA 1999



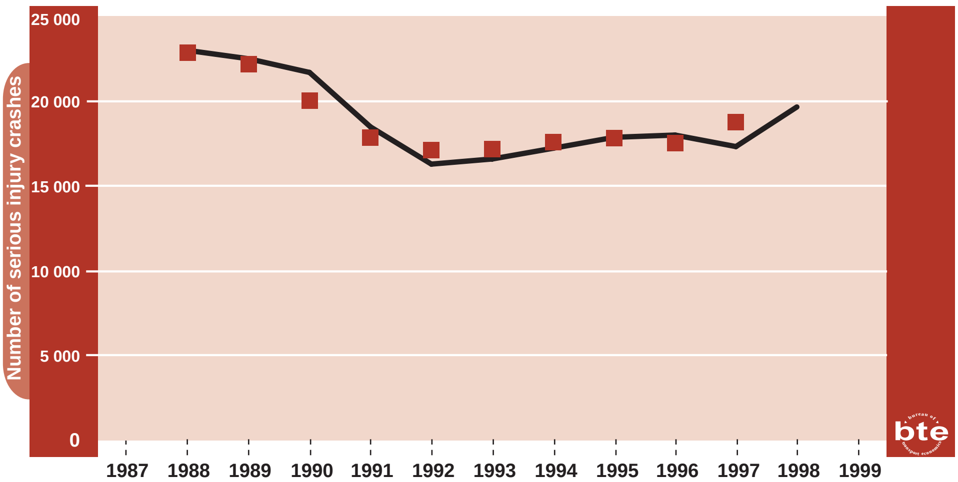
Source ATSB

FIGURE 3.24 ROAD CRASH FATALITIES PER 100 MILLION VEHICLE-KILOMETRES TRAVELLED IN AUSTRALIA 1999



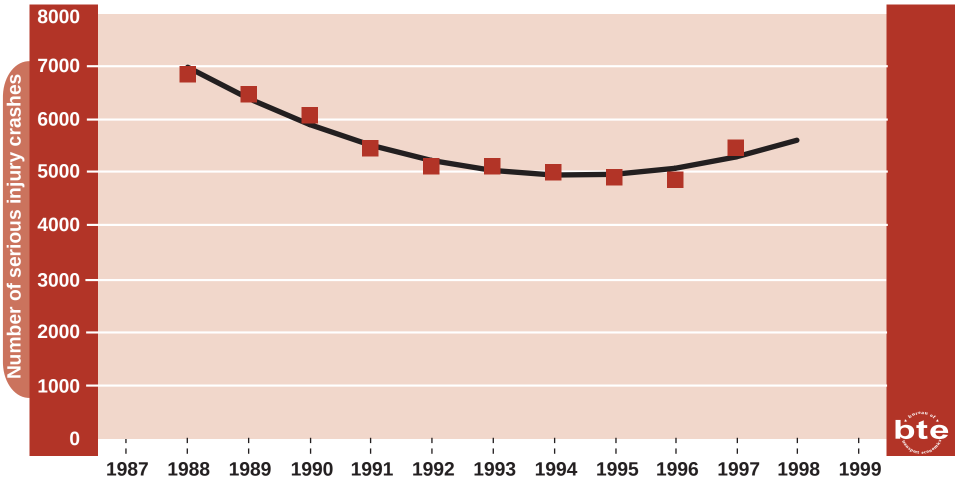
Source ATSB

FIGURE 3.25 SERIOUS INJURY ROAD CRASHES IN AUSTRALIA 1988–1997



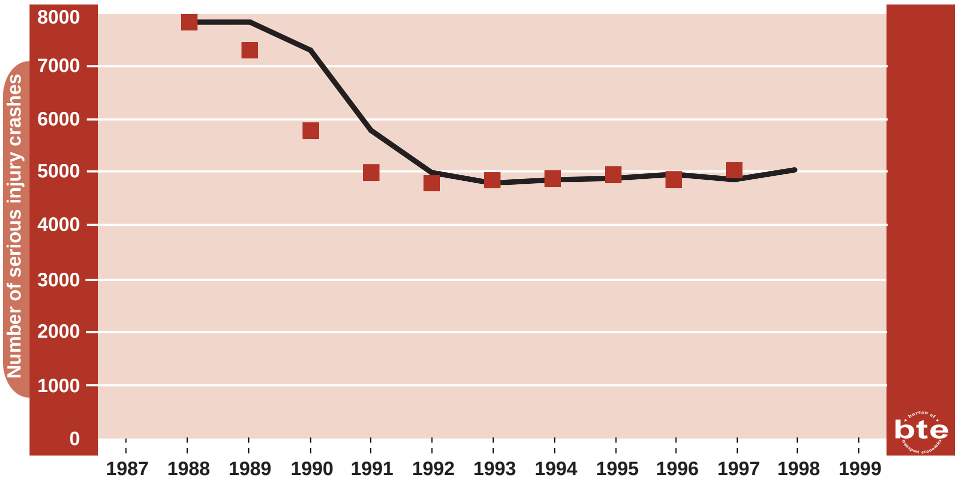
Source BTE analysis of ATSB data

FIGURE 3.26 SERIOUS INJURY ROAD CRASHES IN NEW SOUTH WALES 1988–1997



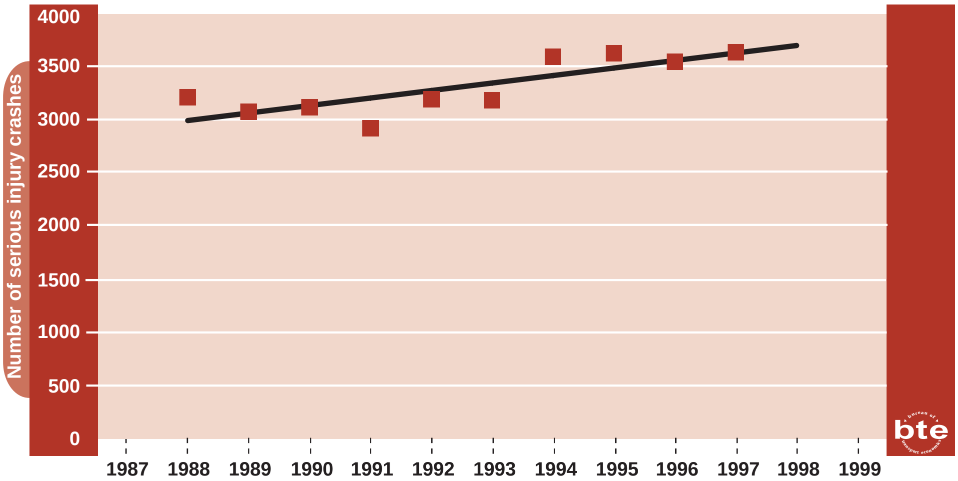
Source BTE analysis of ATSB data

FIGURE 3.27 SERIOUS INJURY ROAD CRASHES IN VICTORIA 1988–1997



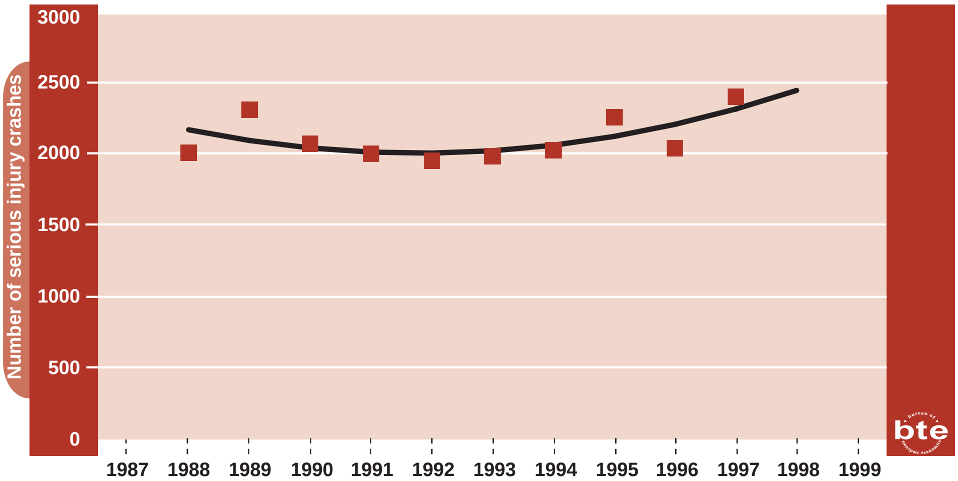
Source BTE analysis of ATSB data

FIGURE 3.28 SERIOUS INJURY ROAD CRASHES IN QUEENSLAND 1988–1997



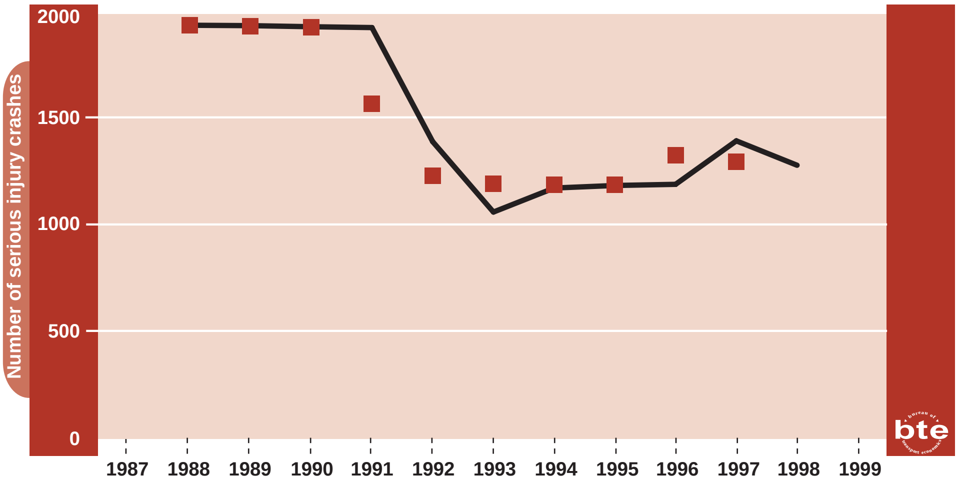
Source BTE analysis of ATSB data

FIGURE 3.29 SERIOUS INJURY ROAD CRASHES IN WESTERN AUSTRALIA 1988–1997



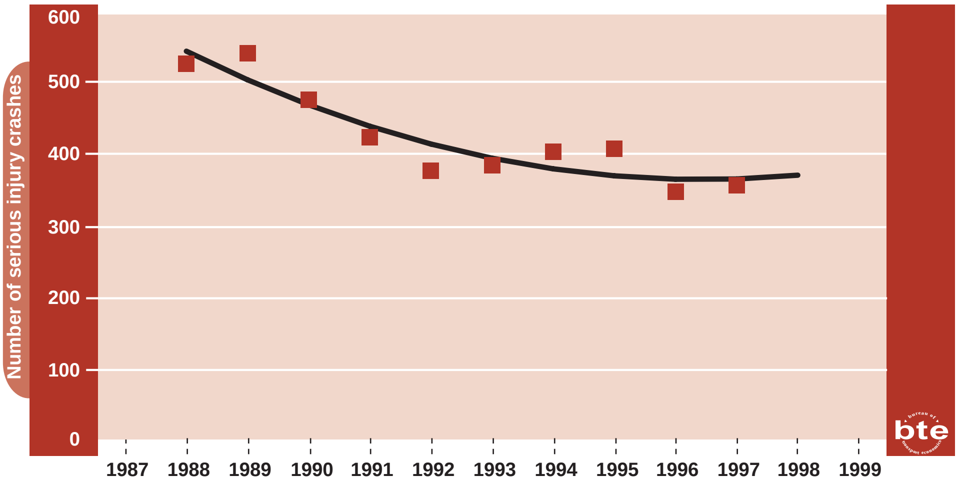
Source BTE analysis of ATSB data

FIGURE 3.30 SERIOUS INJURY ROAD CRASHES IN SOUTH AUSTRALIA 1988–1997



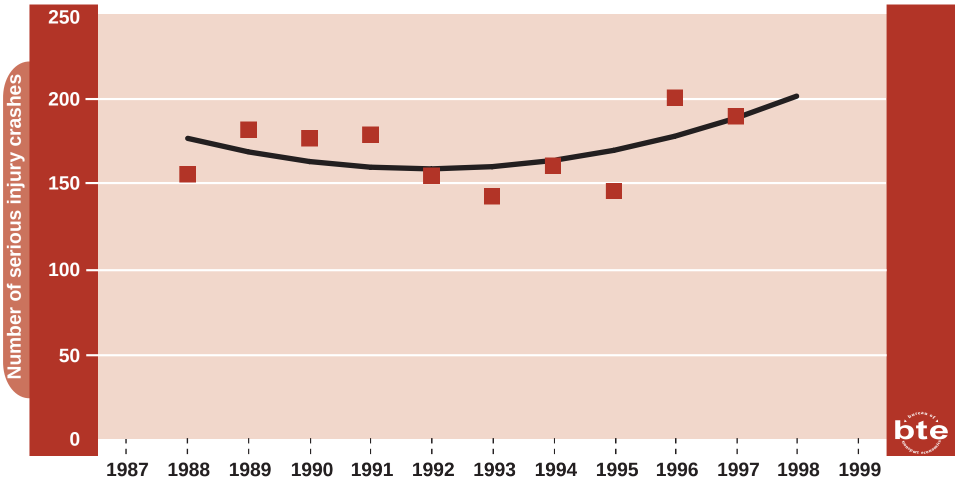
Source BTE analysis of ATSB data

FIGURE 3.31 SERIOUS INJURY ROAD CRASHES IN TASMANIA 1988–1997



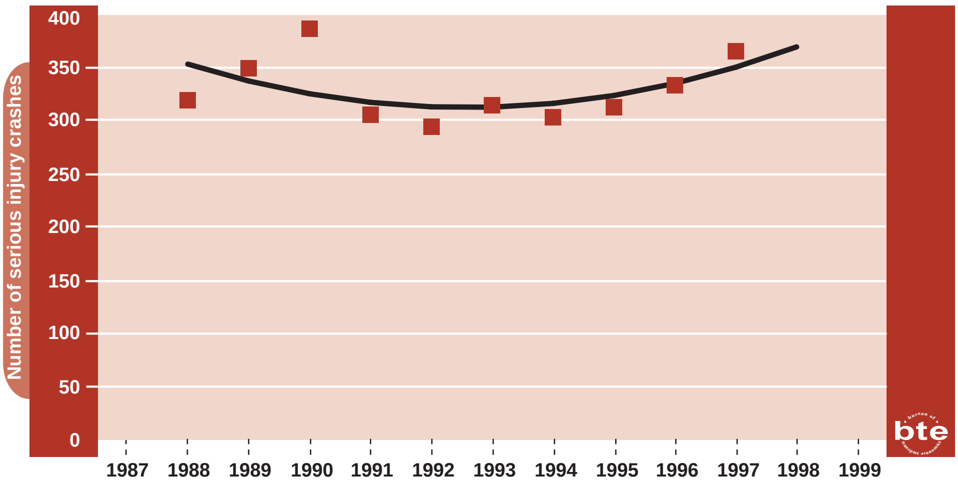
Source BTE analysis of ATSB data

FIGURE 3.32 SERIOUS INJURY ROAD CRASHES IN THE AUSTRALIAN CAPITAL TERRITORY 1988–1997



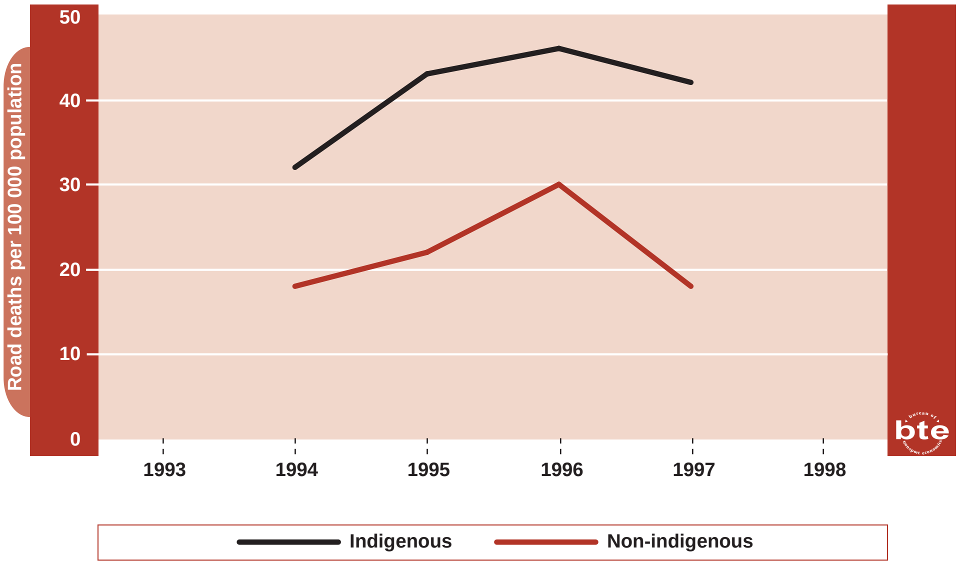
Source BTE analysis of ATSB data

FIGURE 3.33 SERIOUS INJURY ROAD CRASHES IN THE NORTHERN TERRITORY 1988–1997



Source BTE analysis of ATSB data

FIGURE 3.34 ROAD DEATHS PER 100 000 PEOPLE IN THE INDIGENOUS AND NON-INDIGENOUS POPULATIONS OF THE NORTHERN TERRITORY 1994–1997



Source McFadden et al (2000)

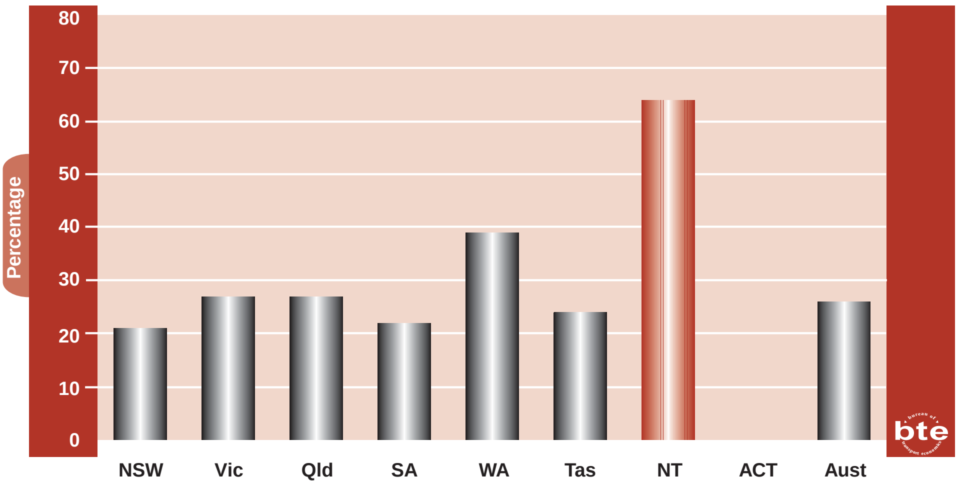
Some studies have found correlations between the probability of being involved in a fatal crash and both educational and occupational status. Research shows that people with low educational levels and those who are employed in unskilled or blue collar occupations are more likely to be involved in fatal crashes. The apparent correlation between the probability of being involved in a fatal crash and being of Aboriginal or Torres Strait Islander background may therefore reflect the lower average educational and occupational status of indigenous people. The condition of link roads to indigenous communities may also be a factor. Further research in this area may be required.

Intoxicated drivers

Figure 3.35 shows intoxicated drivers are a much more serious problem in the Northern Territory than in any other part of Australia. They are also a serious problem in Western Australia.

An analysis of drink-driving statistics between 1990 and 1998 showed weak evidence that drink-driving has become less of a safety issue for Australia. However, this result is largely due to the decrease in the number of New South Wales drivers who died with a blood alcohol concentration of over 0.05 in both absolute terms and as a proportion of New South Wales driver deaths. In most jurisdictions, there was no statistically significant evidence against the hypothesis that drink-driver fatalities were simply a constant proportion of driver fatalities. There was moderate evidence against this hypothesis in only two jurisdictions, New South Wales and the Australian Capital Territory, where drink-driver fatalities fell faster than all driver fatalities. For Western Australia and the Northern Territory, plots of the number of drivers who died with a blood alcohol concentration of over 0.05 versus the number of driver deaths between 1990 and 1998 show a particularly strong relationship. This does not mean that the numbers of drivers who died with blood alcohol concentrations of over 0.05 have not fallen in jurisdictions other than New South Wales and the Australian Capital Territory. However, the falls were not significantly different from those that would have been expected as a result of road safety improvements in those jurisdictions.

FIGURE 3.35 PERCENTAGE OF FATALLY INJURED DRIVERS AND MOTORCYCLE RIDERS WITH A BLOOD ALCOHOL CONCENTRATION OF 0.05 GRAMS PER 100 MILLILITRES OR GREATER IN AUSTRALIA 1998



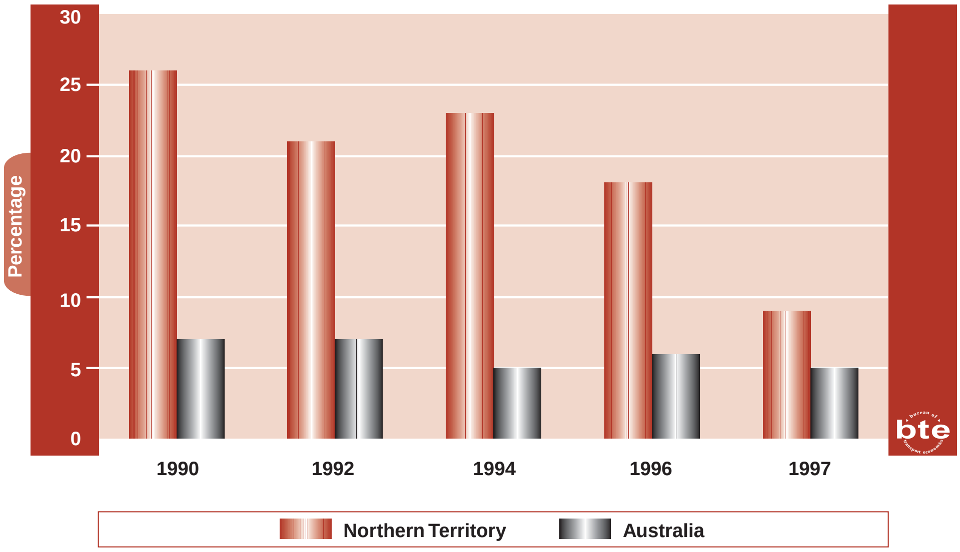
Source **ATSB (2001)**

Unlicensed drivers

It is generally believed that unlicensed drivers are more likely to be involved in fatal crashes than licensed drivers. Figure 3.36 shows that the Northern Territory appears to have a much higher proportion of unlicensed drivers than the rest of Australia.

While it is difficult to estimate the number of unlicensed drivers, the proportion of such drivers involved in fatal crashes in the Northern Territory in 1992 and 1994 was 21 and 23 per cent respectively. For the whole of Australia, the corresponding figures were around five to six per cent. Most of these drivers had never held a license for the vehicle type they were driving when they crashed.

FIGURE 3.36 PERCENTAGE OF UNLICENSED DRIVERS AND MOTOR CYCLE RIDERS INVOLVED IN FATAL CRASHES IN AUSTRALIA 1990–1997



Source ATSB fatality crash database

CONCLUSION

Most of the road safety measures based on existing technology that are effective, relatively cheap and easy to implement are already in use in Australia, as they are in most of the developed world. Therefore, without help from new technology, it will be difficult to substantially improve Australia's road safety statistics. This does not mean that treating individual sites and stretches of road identified as hazardous would not be worthwhile. It means that all available quick fixes are already in widespread use.

The fatality and serious injury rates for regional areas are much higher than in urban areas. The relative risks for regional areas compared to urban ones are declining in some, but not all, jurisdictions. However, it is important to remember that crash costs are determined by crash numbers, not crash rates.

There are some statistically significant differences in the number of fatal crashes and the number of fatalities by various measures across States and Territories. The Australian Capital Territory and Victoria are doing quite well compared with other jurisdictions. The Australian Capital Territory's performance would be of concern if this was not the case, because it is a predominantly urban environment. Victoria's performance is particularly impressive, given its relatively low level of expenditure per person in recent years on black spot treatments until 2000–01. Victoria was the first jurisdiction to begin treating black spots, having introduced its first program in 1979. It may be that Victoria's statistics reflect the accumulated safety benefits of many years of relatively low-cost programs.

Western Australia has a much poorer road safety record than the national average. The Western Australian Government substantially increased its expenditure per person on black spot treatments in 2000-01, but the effects of this are too recent to be analysed. The Northern Territory's very poor road safety performance compared with the rest of the country suggests that it warrants further investigation. A better understanding of the reasons for the Northern Territory's poor record may enable more effective policy responses to be formulated.

New South Wales and the Australian Capital Territory are making some progress in reducing drink-driving. However, drink-driving is still a major issue for the Northern Territory and Western Australia.

4

DATA AVAILABILITY AND QUALITY ISSUES

The Black Spot Program evaluation was affected by the availability and quality of data. Analytical models superior to those used in this report are available, but the BTE did not have adequate data to use them. These models are discussed in chapter 5.

State and Territory road crash databases were not designed for this type of evaluation and the quality and type of data available varies between jurisdictions. There is considerable pressure on the relevant agencies in the States and Territories to reduce costs by reducing the amount of data collected, stored and analysed. In most States and Territories, the road crash databases are maintained by a few staff for whom this is a part-time responsibility. These factors affected the availability and quality of data, as well as the timeliness with which the BTE received data. Only one jurisdiction delivered the information requested by the BTE on or before the stipulated date. Of the others, three had to replace portions of their data when errors were discovered following a preliminary analysis by the BTE.

Data provision issues should be addressed before the commencement of any future black spot program. Changes to administrative arrangements—including modifications to State and Territory road crash databases—should be in place when a new program begins. If this is not done, data availability issues will continue to compromise the quality of any future evaluations. This is important because data limitations reduce the capability of evaluations to assess different treatments' effectiveness and to provide advice on future funding allocations.

COLLECTION OF ROAD CRASH DATA

All States and Territories maintain crash databases based on information contained in police crash reports. These reports are compiled after police attendance at crash sites or as a result of individuals involved in crashes reporting them at police stations.

Despite several changes in the type of information collected and stored about crashes, most jurisdictions keep crash site records for at least 20 years. Some jurisdictions have records going back much further. For example, South Australia's road crash database records go back to 1968.

However, in several jurisdictions there are significant gaps in the data series, because fields have been added or altered, or reporting or recording criteria have changed. For instance, in New South Wales the legal reporting requirements for crashes have remained constant since 1995. But the information recorded in the New South Wales road crash database has changed considerably over the same period. While there have been some additions—for example, details of airbag use—there have been more deletions. The age, gender and blood alcohol concentration of drivers are no longer recorded for many crashes. Serious injuries are no longer reported in New South Wales because the reliability of police reports on hospital admissions was reduced in July 1997 following the introduction of a new information system and changed administrative practices.

In recent years there has been a trend in many jurisdictions for police to collect less information about crashes, particularly those involving less severe injuries. Significant reductions in data collection have already occurred in the Australian Capital Territory and New South Wales. The New South Wales Police are considering further reductions, including discontinuing the preparation of site diagrams which illustrate how crashes occurred and substituting text-based descriptions.

The loss of site diagrams would significantly degrade the effectiveness of any future black spot treatment program unless another equally precise substitute—such as definitions for classifying accidents (DCA) code—was used instead. Text-based descriptions have two disadvantages. Firstly, it is extremely difficult to describe crashes accurately in words without being ambiguous or making the explanation very lengthy. Allowing officers to describe crashes themselves is likely to make crash analysis very difficult, so standard text options would have to be developed. Secondly, lengthy text options are unlikely to be used effectively. In such circumstances, the first text option that is of the correct general type is likely be selected, even though not all the characteristics may be an exact match.

The probability of a crash at a given site may be affected by many factors, but each treatment will generally only reduce the risk from one factor. If it is not possible to identify from the relevant road crash database exactly what types of crashes are occurring at a particular site—and hence to establish why that site is particularly dangerous—selecting an appropriate treatment will become much more difficult.

There is a real risk that any saving to the police from reduced data collection costs would be negated by the cost of ineffective road engineering work due to inappropriate treatment selection.

The storage format for crash records varies across jurisdictions. Some jurisdictions create a single record for each crash. The record lists particulars of injuries for a given maximum number of people involved in each crash, together with vehicle information, vehicle movements prior to the crash, and other details. In other jurisdictions, the primary record is for the vehicles involved and information about the crashes is extracted through vehicle data.

The most common format for data storage is a three-tier system. This system deals separately with crash details, vehicle details and casualty details through a linked crash number and, where appropriate, one or more linked vehicle numbers. This relational database approach enables all crash particulars to be stored in a system that requires minimal memory capacity. Some programming is usually needed to extract more detailed information about different aspects of crashes.

Two factors influence jurisdictions' development of electronic data storage systems:

- the method used to store paper records before computerisation; and
- detailed planning for major hardware and software upgrades.

No jurisdiction appears to have changed the basic format of its crash database since the previous Black Spot Program evaluation.

Data coding process

Each jurisdiction employs or contracts specialised coders to enter the data recorded by police on crash reporting forms. These coders require some specialist knowledge to interpret the data recorded and resolve any inconsistencies.

In several jurisdictions there appears to be very little contact between road and traffic authorities and police. However, this is not the case everywhere. For example, the Queensland Department of Main Roads indicated that police were contacted after approximately 40 per cent of all crashes to clarify or obtain missing information. The New South Wales Roads and Traffic Authority indicated that police were contacted after most fatal crashes, but not contacted about crashes of lesser severity.

The correct identification and entry of site particulars presents difficulties in all jurisdictions, especially in regional areas. For example, if a road name is misspelled, it would be impossible to extract all the relevant crash details for a site on that road without exploring all the possibilities for errors in entry. Using specialist coders rather than data entry staff to enter crash particulars into databases appears to increase the reliability of analyses conducted using those databases.

In most jurisdictions, many reported crashes are not recorded in road crash databases. In Victoria, PDO crashes are not recorded, even when they have been reported. In New South Wales, PDO crashes are recorded, but it appears that New South Wales police do not record self-reported crashes. If police do not attend the scene, they regard any report as less reliable. One reason for this is that there have been organised insurance frauds based on self-reporting of faked crashes.

The time that elapses between a crash and its record becoming available on the database varies considerably between jurisdictions. In New South Wales, the introduction of the Computerised Operational Policing System in 1997, together with other improvements, mean the basic details of most crashes are available almost immediately. It usually takes about a month to complete checks, such as confirming the geocoding location of the crash. In other jurisdictions the elapsed time varies from four to six weeks to two to three months. The time lag depends on the severity of the crash. Basic information about fatal crashes is usually entered within two days. The lag also varies according to the type of information recorded. Blood alcohol concentration levels may not be available for months, while some particulars of fatal crashes may occasionally take a year or more to be settled by the coroner.

Changes in road crash databases

The road crash databases in each jurisdiction have evolved over time. Most changes since the previous Black Spot Program evaluation in 1995 have been relatively minor. But some have affected the consistency and comparability of road crash data series over time. For example, all states, except South Australia and Tasmania, now use a version of the DCA code. Tasmania expects to adopt DCA coding when it introduces its new database in the second half of 2001.

New South Wales introduced several changes to its road crash database in 1996. Most of these involved splitting fields to capture additional information about crashes. In 1998, the system started distinguishing road trains and B-doubles from other trucks. In 1999, it began recording airbag deployments. Over the same period, some inconsistencies were introduced by changes in police data collection. Recent crash records do not consistently include age, gender and blood alcohol concentration of drivers.

The content of Victorian and South Australian databases has not changed significantly since 1995. However, Victoria now uses a Geographical Information System (GIS)—that generates maps—to present crash location data. Apart from the inclusion of additional fields, the Queensland database has remained substantially unchanged since 1995.

The Western Australian road crash database now contains a link to the State's road information database. The road information database contains the engineering records of the configuration and condition of each stretch of road, showing what road works have been done and when. This link is very useful because it makes it easy to check if a black spot location has been significantly altered and, if so, when. Any analysis of a site's crash history to determine how dangerous it is, or a treatment's effectiveness, must disregard records preceding any previous treatment.

Since 1 December 1997, the Tasmanian Motor Accidents Insurance Board has not accepted injury compensation claims for any crash that has not been reported to the police. This has resulted in a 10 per cent increase in reported crashes. Some insurance companies also require that the crash be reported. Tasmanian Police have indicated that the number of crashes reported for insurance purposes appears to be increasing. Tasmanian crash statistics for 2000 show an apparent increase in the number of crashes compared with previous years because crashes in road-related areas such as car parks are now included.

Tasmania is currently in the process of developing a completely new road crash database that will incorporate a GIS and a link to the State's road information database.

In 1996, the Australian Federal Police reduced the information they recorded about minor crashes in the Australian Capital Territory. Consequently, relatively little is known about minor crashes, which account for about 96 per cent of all crashes.

CRASH LOCATION

Being able to determine where crashes occurred is vital for the success of the Black Spot Program. There are two issues associated with this:

- correctly identifying the location of the crash; and
- consistently recording the location in the road crash database so that details of all crashes at that location are readily accessible.

Intersections are the simplest locations to identify. But problems can arise from misspelling street names. To ensure that all crash records for a particular site are recovered, it is necessary to search on all likely misspellings of a street name as well as its actual spelling. This is a cumbersome and time-consuming process and is not always effective.

Locations away from intersections are harder to identify. Three methods are commonly used. A section of road may be defined by identifying two other roads that intersect the first road at either end of the section. This method is usually only applied to short sections of road in urban areas. Outside cities and towns, the section may be defined by the distance and direction away from an intersection or other definite landmark, or by a geographical description of the location's surroundings. These definitions are prone to errors and ambiguities. In regional areas, stated distances may be very approximate and landmark references may be obscure, or even misleading, to those unfamiliar with the area. In regional cities, a single stretch of road may have several different names. If a crash does not occur at an intersection, a mistake about the name of a section of road may go unnoticed.

Using Global Positioning System (GPS) receivers to identify crash sites would greatly improve the accuracy of crash site location. These receivers are relatively cheap and simple to use. A GPS receiver provides an unambiguous, reliable reference for a crash location instantly, whether the location is at an intersection or elsewhere.

Trials with GPS equipment in western New South Wales have had limited success so far. They revealed that a small number of sites were incorrectly identified. For example, two different landmarks had the same name, leading to confusion over the location of some crashes. The introduction of GPS receivers enabled the landmarks to be correctly identified.

Police have many duties at a crash site. The limited success of the GPS trials to date could be attributed to police officers not being fully aware of the information's road safety value.

For recording crash locations, several jurisdictions have assigned unique identification numbers to all roads in urban areas and larger towns. In some jurisdictions, pairs of road numbers are used to identify intersections. In others, intersections have their own unique numbers. Because roads can intersect at more than one place, unique numbering is preferred because it is more accurate.

Some jurisdictions use geocoding, where geographic coordinates are assigned to each location. Geocoding solves most location recording problems, and makes it easier to identify clusters of crashes in an area. Because GPS receivers identify locations with a form of geocode (latitude and longitude), they combine ideally with geocoded location recording.

In New South Wales, only roads for which the New South Wales Roads and Traffic Authority is responsible have a unique identification number. The more important roads are divided into sections. City road lengths vary from 0.5 to three kilometres while regional road lengths vary from 10 to 30 kilometres. Sections that show high numbers of crashes are then investigated further.

New South Wales maintains its black spots database separately from its road crash database. Intersections in the black spots database have unique numbers and a list of all likely misspellings of each street name. But only intersections that pass a threshold number of crashes in a two-year period are included. The street name information is necessary so that data held in the road crash database instead of in the black spots database can be retrieved.

The use of geocoding appears to be increasing. Victoria has made this information available in a GIS that allows crash locations to be displayed on maps. A subset of the Victorian crash database is available on the VicRoads website—www.vicroads.vic.gov.au/roadsafe/. Other states are soon expected to adopt GIS.

During the data gathering process, an official in a jurisdiction commented that the current ATSB black spot nomination form is unsatisfactory because it does not allow black spot positions to be described precisely.

THE RANGE OF INJURIES IN CRASHES AND CRASH SEVERITY

Fatalities

Fatalities are the most accurately reported of all casualties due to road crashes. For statistical purposes, all Australian jurisdictions attribute the cause of death to road crashes when death occurs within 30 days of a crash.

The ATSB is responsible for maintaining the Australian fatal crash database and presenting the data in a monthly publication titled *Road Fatalities Australia*. The Bureau also commissions studies to examine various trends in fatal and hospitalisation crash statistics and to compare the crash involvement of different types of road users.

Some jurisdictions release periodic information updates about fatal crashes, partly to maintain public awareness of road safety issues through the media attention generated. For example, each month the Office of Road Safety in South Australia releases a four-page bulletin with information on crash involvement and statistics for the current and previous year.

Hospitalisation injuries

After fatal injury, the next most serious injury category is hospital admission or treatment. In theory, a person must remain in hospital for at least 24 hours to be classified as a hospitalisation injury.

However, there is no uniform approach among the jurisdictions for police recording and checking of hospital admission information. The complicating factor is that not all those dispatched in ambulances are admitted to hospitals. This factor—together with the lack of any system for tracking casualties through ambulance transport and treatment—means that the reliability of these data depends on whether police follow up with hospitals and how carefully this is done.

In Victoria for example, the coding category which best fits the Federal definition of *hospital admission or treatment* is the *sent to hospital* category. This refers to people dispatched to hospital in an ambulance from the crash scene. New South Wales abandoned the distinction between hospital admission injuries and other injuries in 1997 because New South Wales police ceased to verify that the victim actually was admitted, making the distinction of questionable value. Queensland retains the distinction between *hospital admitted* and *treated but not admitted* injuries, although Queensland police do not verify the admission of victims to hospital. The distinction is based on the judgement of police and ambulance officers at the scene, and reviewed by coders based on injury descriptions. Other States and Territories make the distinction, although it is not always clear how carefully the police verify hospital admission.

In addition, it has long been recognised that not all people who enter hospital as a result of road trauma appear on police reports or database records. The relationship between reported crash statistics and hospital records is thus considerably less than perfect. Several studies were conducted on the relationship between reported crash statistics and hospital admission records before 1995. The results of these studies and their findings are described in BTCE (1995).

There is no unique identification system for individuals admitted to hospitals as a result of road trauma in Australia. It is thus very difficult to match records to obtain information on multiple admissions of the same individual and to calculate the average hospital stay, average cost incurred, and other details per individual per crash.

Other injuries

Injuries less severe than hospitalisation are sometimes reported as a single category—for example, in the Australian Capital Territory and Victoria. They may also be reported as one of two generic possibilities: *medical treatment*—whether at a hospital with discharge immediately thereafter or through a medical practitioner elsewhere—and *first aid* or *injured but did not require medical treatment*, where the assistance provided by ambulance officers and others in attendance is adequate and the injured person does not require further medical attention.

Uninjured persons

Information on uninjured people involved in crashes—and the number of people involved in a crash—is also useful, since evaluations like this one need to examine the link between crashes avoided and lives saved and injuries avoided. Knowing how many of these people were uninjured can improve the accuracy of crash costing.

Many jurisdictions do not record the details of individuals involved in a crash who were not injured and were not driving one of the vehicles involved. Some do not record the total number of people involved, or the number of those uninjured.

Details of those involved in a crash are recorded differently in different jurisdictions. In some jurisdictions, this information appears in the crash file, or can be extracted from the casualty file with the individual injury particulars. However, in New South Wales, the total number of people involved in a crash is entered in the *traffic unit* file, and can be extracted only through programming that scans entries in that file and the casualty file. The number of people involved in the crash is often unknown, particularly if police have not attended the crash site.

Victoria and Tasmania record either injury particulars or the number of uninjured people involved in crashes. Most other jurisdictions record the injury particulars of drivers and casualties. The details of those involved but not injured are not always available. Estimates of average vehicle occupancy in urban or regional areas are also not readily available.

Crash severity

The severity of a crash is defined by the most severe injury occurring in that crash. The costs applied to crashes in estimating the BCR of the Black Spots Program are those given in BTE (2000). The analysis uses the costs of fatal, injury and PDO crashes.

CRASH TYPES AND THEIR CLASSIFICATION

Certain site treatments can increase the numbers of one or more types of crash at particular sites, while still decreasing the number of crashes at that site overall, or reducing their severity, or both. For example, if new traffic signals are installed without a protected right-turn phase at a previously unprotected intersection, the numbers of rear-end and right-turn against the traffic flow crashes may rise. Nevertheless, they may still provide a net benefit to society. The benefits from preventing right-angle crashes of high severity may exceed the additional costs due to the new types of crashes and the costs of the engineering treatments.

Crash types need to be recorded in a standardised way or analysis of different treatments' effectiveness in reducing the number of certain crash types will not yield meaningful results.

Definitions for classifying accidents (DCA)

The ATSB uses the DCA code as a standard system for recording crash types. Most States and Territories use the DCA code or a close variant, such as the road user movements (RUM) code, the DCA code's predecessor. South Australia and Tasmania are the only jurisdictions that do not use the DCA code or something very similar. Tasmania expects to adopt the Victorian variant of the DCA code within a year. South Australia's ability to use the DCA code is hampered because police in that State have not provided sketches of each crash in their reports since April 1992. Without a proper collision diagram and description of each crash, it is very difficult to assign DCA codes with any confidence.

Under the DCA classification, basic crash types—for example, pedestrian crashes and right-angle crashes—form the columns of a grid describing what type of movements those involved in the crash were making just before collision. The rows distinguish between these basic crash types according to the finer details of the movements, such as the exact combination of turning movements being made by the vehicles in a right-angle crash.

While most crash types can be identified under any variant of DCA code, translating codes adds to the complexity of analysing crash types, and there is not always a one-to-one correspondence between code types. The italicised crash types in this paragraph are the names of the code categories. For example, the codes for *struck animal*, *off end of road*, *T-intersection*, and *movements not known* are different under the Victorian DCA code and the RUM code, but their definitions are functionally similar. However, *overtake turning* is a crash type under the RUM code but not under the Victorian DCA code; *struck rail crossing furniture* is a crash type under the Victorian DCA code but not under the RUM code; and the definitions of *overtaking-head on* are inconsistent. The Victorian DCA code for *overtaking-head on* does not include side-swipes, whereas the RUM code does. These inconsistencies mean that important national crash trends may be missed through totalling data from different jurisdictions. The Victorian DCA code is the most publicised DCA code variant. Appendix VIII shows how crash types are coded using this code.

Annual reports issued by the former Road Safety Bureau of New South Wales indicated that most crashes are concentrated in the *pedestrian*, *right-angle*, *right-turn*, *rear-end*, *side-swipe*, *head-on* and various *run-off-road* categories.

The Australian Road Research Board (ARRB 1992) has noted that jurisdictions do not always apply codes consistently. An analysis of batches of New South Wales and Victorian crash data showed systematic differences in how codes were applied in these States to crashes involving vehicles running off a straight road or a curve, and vehicles either hitting or not hitting objects. Approaches varied in deciding how to describe events after a vehicle ran off the road.

It appears that consistency in applying codes across jurisdictions is still an issue. An officer who helped code the Tasmanian crashes analysed in this report attended a DCA code training course run by the Victorian Government late in 1999. The officer commented afterwards that the coding of some crashes supplied by Tasmania was inconsistent with how Victoria would have classified the same crashes.

The ATSB may wish to examine the DCA code and its variants and produce a definitive version. If States and Territories adopted this version, some of the data problems discussed above could be resolved.

Establishing the dates of changes to black spot sites

Accurately dating events in each black spot's history and treatment was as difficult during this evaluation as it was previously (BTCE 1995). Determining the dates for the start and end of each treatment of each black spot was crucial to the evaluation. Unfortunately, most jurisdictions have difficulty providing exact dates. Section 6 of the *Notes on Administration* for the Black Spot Program requires that dates be provided that are accurate to within one week. Despite this requirement, most regional authorities do not keep precise records of when work started or finished. The date on which work was authorised may not have been the date on which work started. And the date on which work was signed off as completed may not have been the date on which it was completed.

For this evaluation, it is crucial that neither the before treatment period nor the after treatment period overlaps the construction period. If this occurs, the analysis is invalid. However, uncertainties about when these before and after treatment dates occurred meant the BTE had to be cautious when selecting data for analysis. The need for caution means that some potentially useful data were not used. This loss is not considered serious in the context of the overall Black Spot Evaluation Program evaluation.

The main problem with dates during this evaluation related to determining when black spots were identified. Ideally, the evaluation would use the date on which the jurisdiction that nominated a particular site believed it had conclusive evidence that the site was a black spot. For example, suppose a road traffic authority collected data on a site until the end of June in one year, nominated that site as a black spot in September that year, and the site was approved as a black spot in November the same year. For evaluation purposes, the decision was based on information collected as at the end of June. However, the jurisdictions were unable to supply the data collection cut-off dates.

The BTE expected to use the time lag method—discussed in detail in chapter 5—to correct for the regression-to-mean effect. Applying this method requires each black spot site's crash history after it has been approved for treatment and before the commencement of treatment. South Australia was unable to supply these dates, and most jurisdictions had difficulty identifying them accurately. The period between when approval is given for a black spot treatment and when treatment work starts is normally relatively short. For the time lag method, a substantial proportion of the total available lag data could not be used. This was because of the need to ensure that three distinct periods used in the analysis—before site identification, after identification but before treatment, and after treatment—did not overlap. Data problems prevented the use of the time lag method in this evaluation.

Traffic flow data

Information on traffic volumes over time at individual black spot sites is necessary to determine whether any changes in crash history are mainly due to black spot treatments or whether changes in traffic flows have had an effect. States and Territories were therefore requested to provide annual average daily traffic (AADT) flows at black spot sites before and after treatments were applied.

Unfortunately, the roads and traffic authorities in all jurisdictions do not maintain comprehensive records of traffic volumes. Some jurisdictions operate systematic programs to obtain traffic counts on major roads over a cycle of several years. Others concentrate most of their available resources on responding to field requests for data associated with specific planned work. The provision of traffic volume measurements has not improved since the previous Black Spot Program evaluation (BTCE 1995).

Of just over 550 sites in the main black spot sample grouping—that is, excluding those chosen for detailed time series study—only 25 per cent had before and after traffic flow figures that differed, indicating that separate traffic flow measurements were obtained. In all other cases, the traffic flow figures were:

- definitely unknown;
- known only for either the before or after treatment period but not both; or
- the before and after treatment traffic flow figures were shown as being identical.

While in some cases the traffic flow figures may genuinely have remained constant, it is likely that, in most cases, only one traffic flow measurement was obtained. The best data came from Western Australia, which supplied before and after traffic flow figures for the separate legs of many intersections.

For sites where before and after traffic flow data were not available, the jurisdictions were asked to comment about changes in traffic flows for the relevant periods for particular sites. Their response in each case was that there were no significant changes.

The value of traffic flow data needs to be considered. Good traffic flow data are necessary to ascertain, rather than guess, what kind of engineering work is required and where. There is a trade-off to be made between the administrative cost of collecting traffic flow data and the benefits of a better-targeted program.

It may be necessary to change the way traffic flow data are generated to improve the quality of the data without unnecessarily inflating collection costs. Most cities and towns have automated traffic control systems. These systems use the detectors installed at traffic lights to count vehicles so that they can adjust traffic signal timing to minimise congestion across a controlled area—normally an entire city or town. In principle, these systems could be a relatively cheap source of traffic flow data for controlled intersections and their surrounding areas.

Traffic signal detectors have some disadvantages as sources of traffic flow data. Firstly, the left-turn slip-lanes at controlled intersections do not usually have detectors installed. Secondly, the induction-loop detectors are subject to error. They sometimes count two vehicles as one. This is particularly common when two vehicles have stopped partially over the same detector. Heavy vehicles sometimes trigger detectors in adjacent lanes.

However, no counting method is perfect. If the detectors were highly inaccurate, the traffic control system could not control congestion. Comparing traffic flow results from traffic signal detectors against those generated from conventional counting techniques at a sample of sites would enable analysts to compensate for the types of systematic errors described above. For the purposes of evaluating black spot treatments, imperfect traffic flow data are much better than no traffic flow data.

Data on other factors that may affect the crash history of a site

A site's crash history is affected by factors other than its traffic configuration. This is discussed in detail in chapter 5. It seems unlikely that local variations in drink-driving or the extent of seatbelt use would be substantial enough to affect the crash rate at a given black spot. However, differences in other factors, such as weather patterns, could be both large and systematic enough to have an effect. To some extent, these factors are accounted for by the use of State and Territory crash trend data. Nevertheless, it would be useful—when investigating a change in a black spot site's crash history—to be able to check if some factor other than a black spot treatment—such as a particularly wet winter—had a significant influence on the number of crashes.

Crash databases in all jurisdictions contain some data on weather, alcohol, and seatbelt use. It was not possible to use these data in this evaluation given the time constraints. However, future evaluations may consider the effects of changes in weather, alcohol and seatbelt use.

CRASH DATA REQUESTED

Each jurisdiction was asked to provide data to support each of three methods for analysing black spot treatments' effects on crash rates.

Time series method

The time series analysis required data showing the number of crashes in each year at a given treatment site for a period of at least five years before treatment. Jurisdictions were able to supply these data for the previous eight to ten years. To be meaningful, the data needed to be for the road in its current—pre-treatment—configuration. Where a major change or changes, were made to the road in the past, crash data from before the most recent change were excluded. Time series data were only requested for a sample of sites.

Each jurisdiction was also asked to provide matching year-by-year AADT data. Most jurisdictions provided this information, although it was clear from the information supplied that a large proportion of entries were the result of interpolation or extrapolation.

Lag period method

The bulk of the data required for analysis consisted of crash counts before and after treatment at each site.

States and Territories had already provided the ATSB with some crash data from the period before the treatment period for each site during the black spot nomination process. The information supplied included the period during which the counts were made and comprised the number of fatal crashes, injury crashes and, in some jurisdictions, PDO crashes. Injury in this case meant any crash in which an injury was recorded, regardless of severity. This information was required by the ATSB as part of the process to determine which locations should be treated under the Federal Black Spot Program.

The most important information required for this evaluation was the equivalent data on crashes after treatment. This again included the period during which the counts were made—in months—and comprised the total numbers of fatal, injury, and where available, PDO crashes over the period since treatment work was completed.

In addition to post-treatment crash data, jurisdictions were asked to supply the numbers of crashes for each location for the period between its declaration as a black spot and the commencement of treatment work. However, although jurisdictions knew when crashes occurred, most could only give the approximate declaration date and when treatment work started and finished.

The more populous jurisdictions were asked for these data only for a sample of their sites. The selection of this sample was not entirely random. Sites were selected so that all the main treatment types would be well represented, and preference was given to sites where data had been gathered over longer periods. The less populous jurisdictions provided data for all of their black spot sites. Because of the small number of sites treated, this was necessary for the statistical analysis for the smaller jurisdictions to be meaningful.

However, as stated earlier, the BTE did not use this analysis when preparing its evaluation. The data quality problems experienced were too severe for this form of analysis to yield meaningful results.

Control sites

States and Territories were asked to supply information about control sites, similar to the time series data they were asked to supply about black spot sites. They were asked to select control sites that were as similar as possible to black spot sites in road configuration, traffic flow, crash history and geographical location. The controls could be drawn from sites to be treated in subsequent years, as part of future treatment programs. The road traffic authorities in each jurisdiction selected the control sites because they were presumed to have greater practical knowledge of their own networks.

Poisson regression method

After analysing the data availability and quality issues discussed earlier, the BTE decided to use the weighted Poisson regression method, which is discussed in detail in chapter 5. As far as the BTE is aware, this method has not previously been used for this type of analysis. The data requirements of this method are not very onerous. The before and after treatment crash counts, the before and after periods during which treatment data were collected, and traffic counts for each period are sufficient to enable use of this method. The periods over which the crash counts were taken were used to weight the data. Ideally, the BTE would have liked to use the traffic volumes before and after treatment as weightings. But, as discussed above, these were not always available for both the before and after treatment periods.

Benefit-cost analysis information

In addition to the data on numbers of crashes, jurisdictions were asked to provide data for the benefit-cost analysis (BCA). For each site, jurisdictions were asked for data on:

- the total cost of the treatment;
- the annual marginal maintenance cost—that is, the change in cost compared with the previous configuration; and
- the expected treatment life—the period for which it is expected to be effective.

The ATSB provided information about the expected treatment costs supplied by States and Territories as part of the black spot nomination process. However, these costs were not provided in a consistent format. Some jurisdictions provided the cost to the Federal Government, rather than the total treatment cost to each level of government involved. Using partial costs in an evaluation of this kind would produce misleading results. In March 1999, the ATSB began asking jurisdictions to supply total treatment cost figures as part of the black spot nomination process. Thereafter, States and Territories began supplying the project costs they met themselves and those that were met by the Federal Government.

However, the total project cost data supplied after March 1999 are still not an exact reflection of how much was spent on black spot treatment. In some jurisdictions, local governments are also involved in treating black spots. For example, some local governments receive grants from their State or Territory Governments to apply black spot treatments. These grants may be comprised entirely of State or Territory funds, Federal funds, or a mixture of both. Local governments do not generally provide their respective State or Territory Governments with enough information to enable them to determine by how much, if any, local governments have supplemented the grant funds they received on a project basis. The BTE questioned a small number of local governments on this issue to try to determine the scale of this systematic error. None of the local governments questioned reported providing any supplementary funding. On this basis, the BTE treated the cost of a black spot treatment project as equivalent to the sum of Federal and State or Territory spending on that project.

Maintenance costs and treatment lifetimes may vary significantly between jurisdictions, even for similar types of projects. The useful life of a project is seldom clear-cut. For example, many sets of traffic lights are still operating after 30 years. However, in the inner city, intersections may be rebuilt for reasons unrelated to safety, and the traffic lights at such intersections may be replaced within 10 years. Determining the life of a project is thus a matter of judgement.

Different jurisdictions define maintenance costs in different ways. For example, the Northern Territory defines maintenance as anything required to keep a treatment at its original standard, including total rebuilding. Using this definition results in higher maintenance costs and longer treatment lifetimes. Some other jurisdictions would regard rebuilding as a new project, and would cite lower maintenance costs and project lifetimes.

The information requested from the States and Territories is given in appendix X.

CONCLUSION

It is important to ensure that providing data for evaluation is not excessively onerous for State and Territory road traffic authorities. However, data availability, timeliness and quality issues have limited the usefulness of this Black Spot Program evaluation and the previous evaluation. This reduces the quality of the advice that can be provided to improve the effectiveness of future programs.

It would be advantageous to obtain the data that will be needed for future reviews as early as possible. One of the reasons for the low quality of the data submitted is that most jurisdictions prepare large portions of the data requested just before—or more commonly, just after—the due date.

One option would be for the ATSB to ask each jurisdiction to submit crash data on treated sites with their financial statements each year. The black spot nomination process could include a request for time series data and traffic flow data for all nominated sites.

The ATSB could also consider incorporating a requirement for data on the physical layout of sites being nominated as black spots in future notes on administration. The data submitted by States and Territories are often unclear about issues, including how many arms an intersection has and whether there are traffic signals, give way signs, stop signs, or a roundabout. Knowing more about black spots before treatment would enable future evaluations to provide better advice about different treatments' effectiveness when applied to different road configurations.

Educating police about how the information they collect is used will be vital to future evaluations. In particular, the crash diagrams prepared by police provide very valuable information and should not be abandoned.

If the quantity and quality of data collected are to be reduced, this should only occur after examining and comparing the information's value with its cost. Currently, there is little evidence to suggest that decision-makers are considering the effect of administrative savings on road trauma.

5

EVALUATION METHODOLOGY

This evaluation is based on a before and after assessment of black spot treatment effectiveness. A before and after study compares a site's crash history after treatment with the expected crash history if no treatment was applied. It is called a before and after study because crash history before treatment is one of the principal factors used to calculate expected crash history. However, extraneous factors may mask a treatment's true effect and it is desirable to control for as many of these as possible.

FACTORS POTENTIALLY AFFECTING THE EVALUATION

In theory, all known factors with the potential to affect a treatment's evaluation should be accounted for when estimating that treatment's effect. However, as found by Elvik (1997), the more external factors that are accounted for, the less effective the treatment appears to be.

The factors that may affect the evaluation of black spot treatments' effectiveness are described below.

Site-specific factors

Specific events other than treatment could account for at least a part of any observed change in the number and severity of crashes at a site. For example, there may have been increased publicity about the site or about safety in the local media. Such publicity may lead to a—perhaps temporary—increase in driver caution and a consequent reduction in crashes that has little to do with the road engineering features of any treatment applied.

The weather conditions at the site may have altered since the treatment was applied. A fall in the number and severity of crashes may be associated with an extended dry period. This is more likely if the site is observed for only a short period following treatment. The number of vehicles using the site may have changed due to local changes in traffic flow. For example, the Olympics had a substantial short-term effect on traffic flow patterns in Sydney in 2000. There may have been a change in traffic law enforcement at or near the site by the police, that may have affected driver behaviour.

The lack of site-specific before and after data on these variables meant it was not possible to assess their effects. It appears unlikely that site-specific factors would have a significant effect on the evaluation of the Black Spot Program as a whole, although they may affect the analysis of treatments at particular sites.

Other publicity effects

Not all publicity that may change behaviour is site-specific. Most material encouraging road safety is addressed to the broader community. However, there were insufficient data available to assess the effects of recent publicity. As discussed under the heading *Maturation*, long term publicity effects may affect the long-term crash trend.

Maturation—trends over time

Maturation refers to the process by which crash numbers or rates change over time. Any analysis of black spot treatments' effectiveness must consider crash trends.

In chapter 3, serious injury crashes—referred to as hospitalisation crashes in some jurisdictions—from 1988 to 1997 were analysed, and national, State and Territory crash trends derived. The calculations in chapter 6 assume that serious injury crashes increased nationally by about 4.8 per cent in 1998. State and Territory crash trends are upwards in most cases. However, in South Australia the trend is downwards, and in Victoria, the trend is flat. There may also be local and district level trends.

Ideally, an appropriate trend indicator relates crashes to a measure of motorisation—vehicle-kilometres travelled or number of vehicles registered. The basic data for this analysis are the numbers or rates, of crashes per year, which do not incorporate motorisation.

Regression-to-mean

If black spot sites are chosen for treatment solely on the basis of their high recent crash record, the chosen sites may genuinely be very hazardous. However, it is also possible that the high crash rates observed at some sites may be due to chance, or a combination of both chance and a moderately hazardous nature. These sites are likely to have fewer crashes in a subsequent period even if no treatment is carried out, because the number of crashes will tend to gravitate towards the long-term mean value. Under these conditions, the effect of any treatment is likely to be over-estimated. This effect is most commonly called the regression-to-mean effect and is sometimes known as the bias-by-selection effect.

Hauer (1980) described the regression-to-mean effect as follows:

> ...consider a group of 100 persons each throwing a fair die once. Select from the group those who have thrown a six. There might be some 16 such persons. In an effort to cure the 'proneness to throw sixes', each of the selected persons is administered a glass of water and asked to throw the die again. One can expect that all but two or three persons have been cured. This 'success' of the water cure is attributable entirely to the process of selection for treatment.

Hauer's example is roughly analogous to arranging sites according to the number of crashes that have occurred at each site and then defining the 16 per cent with the most crashes as black spots and treating them. Failing to allow for the regression-to-mean effect in an analysis could generate statistically significant results for treatments that are actually ineffective. This would, in turn, cause the net present value and BCR of the Black Spot Program to be overstated.

Compensating for the regression-to-mean effect is important in evaluating the Black Spot Program, to prevent resources being wasted by replicating ineffective treatments throughout the road network.

Under-reporting of crashes

Inferences about road safety should be drawn from the number of crashes that *occur*. In practice, inferences are drawn from the number of crashes that are *reported*. Many people do not report the minor crashes in which they are involved. The crashes reported are, in effect, a sample of all crashes.

> The registration of injured accident victims constitutes a large problem. The under-reporting of traffic accidents depends very much on the type of accident. In general, serious injuries are more often reported to the police than slight injuries (Berns 1998).

Changing the way crashes are recorded in a jurisdiction could cause an apparent change in the number, type and severity of crashes. Some jurisdictions have threshold monetary levels for the damage that must be caused by a crash before it must be reported by road users, or before it is included in the jurisdictions' records. A crash may be reported to the police but not included in a jurisdiction's records if the damage caused was below the threshold set by that jurisdiction.

Changes in the propensity to report crashes can also make it difficult to discern changes in safety over time. There is little incentive to report PDO crashes where the damage caused is valued at less than the excess for vehicle insurance policies, or where there is no insurance. A change in vehicle insurance excess could thus affect the propensity of road users to report PDO crashes. Furthermore, if damage thresholds and insurance excesses are not revised as the cost of vehicle repairs increases, the proportion of crashes reported will increase over time.

Incomplete crash reporting is a universal problem. Hauer and Hakkert (1988) reviewed 18 studies on crash reporting in several countries—not including

Australia. The study revealed considerable variability in the degree of non-reporting. Their estimates were that fatalities may be known to within plus or minus about five per cent, and that approximately 50 per cent of all injuries, and 20 per cent of those requiring hospitalisation, are not included in official statistics. They estimate that reporting of PDO crashes is likely to be even lower than 50 per cent.

Later research has found under-reporting problems of similar magnitude.

> It is commonly known that not all traffic accidents with personal injury are reported to the police, even if they are supposed to be so by law. Research done in several countries by matching data from hospitals with police records, both of in-patients and out-patients, reveals that the police are receiving information on about 30-60% of all the personal injury accidents they are supposed to know about (Hvoslef 1994).

If serious injury crashes decrease after a treatment, but PDO crashes increase, the under-reporting of PDO crashes would mean the treatment's effectiveness would be overstated. In crash studies, a common approach is to assume a certain ratio of PDO crashes to injury crashes. For example, in costing road crashes that occurred in 1988, BTCE (1992) assumed a ratio of 6.8 nil injury crashes to each reported casualty crash—a ratio estimated by Atkins (1981). The use of these ratios may be justified for estimating total crashes, but general average ratios between reported and unreported crashes have no known validity at specific sites.

If the probability of a crash being reported at a particular site remains constant over the period of an evaluation, the reliability of the analysis will not be significantly affected (Hauer and Hakkert 1988). The effect of incomplete reporting in these circumstances prolongs the time required to collect a fixed amount of crash data. However, Hauer and Hakkert argue that many of the factors that affect the probability of a reportable crash being reported are likely to change with time and location. These factors include crash severity, structure of insurance premiums, age and sobriety of the driver, age of victims, inclination to seek compensation, number of vehicles involved, proximity to police station, and workload of the police force. Certain treatments are likely to affect these variables—particularly crash severity—thereby affecting the probability of crashes being reported.

Hauer and Hakkert found that the variance of the estimate of the safety effect[1] of a treatment is inversely proportional to the square of the average proportion of crashes reported. This means that the accuracy of statements about the treatment's safety effect would deteriorate rapidly as the proportion of crashes reported falls, and as the uncertainty about the prevailing level of crash

1. The safety effect of a treatment is the difference between the number of crashes that would have occurred without treatment, and the number of crashes that occurred with treatment.

reporting increases. Hauer and Hakkert concluded that credible statements about road safety can only be made if the proportion of crashes reported to the police is high, accurate and stable over time and location.

The general approach adopted in this study was to use all available reported crash data in the analysis. No adjustments were made for unreported crashes at sample sites as such adjustments would have been arbitrary. In the absence of site-specific information, it is thus possible that projects that showed positive net benefits on the basis of reported crash data, could have shown greater or lesser benefits if complete crash data had been available.

Statistical instability

Crash data are susceptible to chance or random fluctuations when recorded over a period of time. In general, the smaller the sample size, the greater this statistical instability. A major part of the instability in crash data may be due to numerous site-specific events which individually cause small variations and which collectively represent the site's crash history. After all confounding effects are removed from the data, appropriate statistical tests can determine, with a specified level of confidence, whether the observed change in crashes following the treatment can be attributed to the treatment or is due to chance.

Crash migration

The term crash migration—sometimes referred to as accident migration—describes an increase in crashes at sites in the vicinity of a black spot following the treatment of that black spot, giving the appearance of a movement of crashes away from the treated site to the surrounding area. There is still controversy about whether or not the effect is real.

Some argue that if a whole area is dangerous, rather than just a single site, the identified black spot may be the first point where drivers encounter the change from a low- to a high-challenge driving environment. Treating this first point may increase its apparent safety, reducing the stimulus to drivers to change their level of driving effort, and moving the problem deeper into the hazardous area. This explanation essentially involves the concept of risk compensation. Effective treatment in this situation would require treating the whole high-risk area.

Drivers can choose to drive in the same way after the treatment of black spots as they did before, and face a lower risk as a result of the treatment. However, drivers may change their behaviour and drive more dangerously to obtain other benefits such as reduced travel time. If this occurs, the improvement in the safety of the driving environment benefits drivers but may not lead to a substantial reduction in the number and severity of crashes. A subset of this group believes in risk homeostasis—that is, that drivers maintain a certain target level of risk independent of external conditions (Wilde 1982). If this group is correct, applying treatments produces no net safety benefit. However, this is not a popularly held view.

Some, including Mountain et al (1994), argue that crash migration is a product of the regression-to-mean effect discussed earlier, but operating in the reverse direction. Sites in the surrounding area were not identified as black spots because of the initially low number of crashes there. However, the low number of crashes was due to chance rather than the inherent safety of these sites. The number of crashes, therefore, tends to move towards the mean in later periods.

Boyle and Wright (1984); Levine et al (1988); Mountain and Fawaz (1989); and Persaud (1985 and 1987) reported positive evidence of crash migration. Mountain et al (1994) and Short and Robertson (1998) found no evidence to support crash migration.

If crash migration is a real effect, it could potentially affect the returns attributable to road safety investment. However, the current research is inconclusive. Evans (1991) pointed out that even the worst black spots have only a few crashes per year. Given the many other factors involved in crashes, he concluded that it would be almost impossible to find convincing evidence of migration.

This analysis has not attempted to deal with crash migration.

TECHNIQUES AVAILABLE TO ANALYSE BLACK SPOT TREATMENTS' EFFECTIVENESS

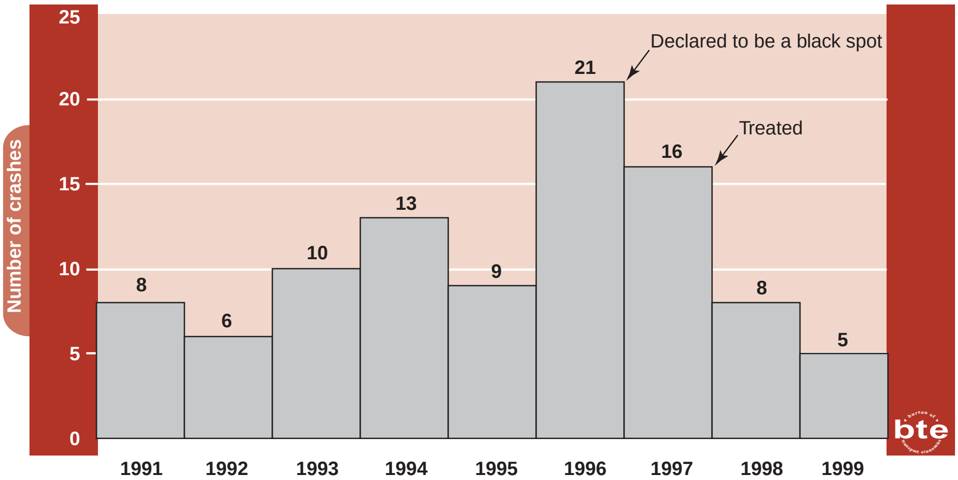
Several different experimental designs could be used to evaluate various treatments' effectiveness at black spots. These designs range from simple before and after comparisons to more sophisticated techniques using time series, matched comparison groups, and random assignment of sites to treatment. The approach chosen for this study was driven by two factors: the availability of appropriate data—as discussed in chapter 4—and the need to reduce road trauma.

There are several techniques available that could have been used to analyse the black spot treatments' effectiveness. These techniques, and the reasons why they were not used in this evaluation, are discussed below. The techniques that were used, and the reasons for their use, are described in *Analytical issues and preferred methodology* later in this chapter.

The crash numbers in figure 5.1 have been used to illustrate each of these techniques. Each scenario assumes that:

- a section of the Tullamarine Freeway in Victoria became slippery when wet;
- the section was declared to be a black spot at the end of 1996;
- a skid-resistant surface was applied at the end of 1997; and

FIGURE 5.1 CRASHES ON A SECTION OF THE TULLAMARINE FREEWAY IN VICTORIA



Source Victorian Government

- traffic patterns in the region remained unchanged unless otherwise specified.

Simple method

This method assumes that if there had been no treatment at the end of 1997, the number of crashes in 1998 would have been the same as in 1997. Hence the effect would be estimated as 16-8 = 8—that is, a 50 per cent reduction in the number of crashes per year.

It is possible to use more sophisticated versions of this method that allow for other effects. For example, for the section of Tullamarine Freeway considered above, the expected reduction in crashes should be adjusted downwards by 4.5 per cent.[2]

The effect, after adjusting for trend, would be estimated as:

[16*(1-0.045)]-8 = 15.28-8 = 7.28—a 48 per cent reduction in the number of crashes per year.

2. This figure—Victoria's average reduction in casualty crashes—is used here for illustrative purposes only. See appendix IX for details.

This would be appropriate if the number of crashes per year followed a random walk,[3] instead of being affected by road conditions. Kendall (1953) first raised the issue of predicting random events in connection with share and commodity prices. Kendall had been looking for evidence of regular price cycles, but was unable to find any. Changes in share and commodity prices did not appear to follow any pattern. Kendall found that for events that occur at random, the best predictor is the most recent event. The formula for this is:

$$P_t = P_{t-1} + \varepsilon_t$$

Where P_t is the value of a random variable P at time t, P_{t-1} is the value of the variable P during the previous time period, and ε_t is the random change in the variable P.

However, for variables that are not completely random, there are better predictors available than their previous value. There is evidence to suggest that the probability of a crash is a function of deficiencies in the road network, the interaction of various other variables, and chance. Indeed, there would be no point in conducting a Black Spot Program if crashes occurred completely at random. Given that the data are available to support a more complex analysis, it makes sense to use a better predictor.

Mean method

This method takes the arithmetic mean of the number of crashes in each of the last three years and assumes that the number of crashes in the next period would equal the mean if no treatment is applied. From figure 5.1 this would be: (9+21+16)/3=15.3 . With this method, the reduction would be estimated as: 15.3-8 = 7.3—that is, about 48 per cent.

This approach is, in effect, a moving average, since the prediction is based on the last three years each time it is made. A longer period could also be used to estimate the mean. In this example, seven years of historical data are available. However, there are problems in using figures from too far in the past. The more time that has passed, the greater the probability that road conditions have altered or traffic patterns have changed. In this example, the seven-year average would be: (8+6+10+13+9+21+16)/7 = 11.9 . Thus, the reduction would be: 11.9-8 = 3.9—that is, about 33 per cent.

The results from the simple and mean methods show that the period used to calculate the average can potentially make a large difference to the treatment's apparent effectiveness.

It is possible to use more sophisticated versions of the mean method that take other effects into account. For the section of Tullamarine Freeway considered above, the expected reduction in crashes should be adjusted downwards by 4.5 per cent—see footnote 2.

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3. The term *random walk* means that successive events are independent of each other.

Using a three-year average, the estimated effect—after adjusting for trend—would be:

[15.3*(1-0.045)]-8 = 14.6-8 = 6.6—a 43 per cent reduction in the number of crashes per year.

It is necessary to adjust the number of crashes expected to ensure that the benefits of applying treatments are not overestimated.

Figure 5.2 illustrates the expected effects if the number of crashes over the period continues to decrease. Even if there is no treatment, or treatment is ineffective, for any given period there is a better than even chance that the number of crashes in any future period will be lower than in the past.

Apart from the use of several years' crash data instead of one, the mean method is similar to the simple method. Better predictors of crash probability are available.

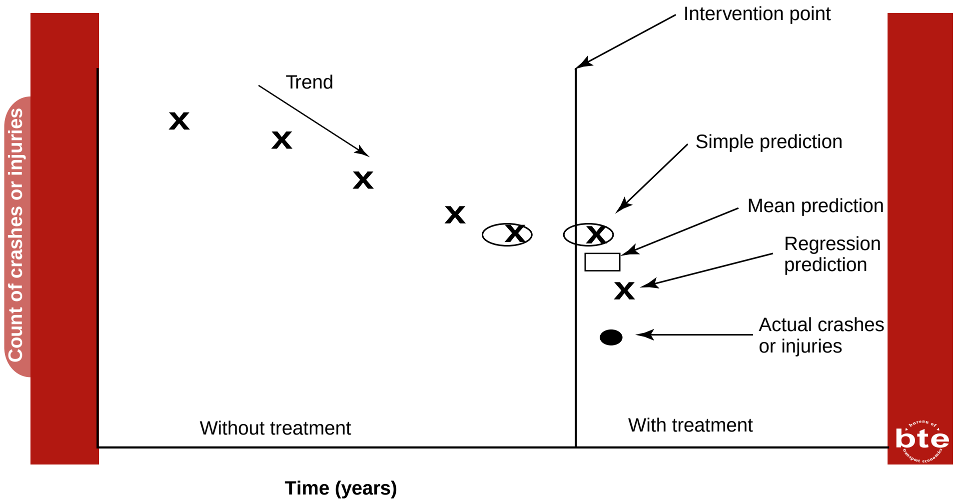
Empirical Bayes method

Hauer (1997) argues that before and after treatment studies are statistically inappropriate because the data used are not obtained from random samples. Hauer proposed instead that the Empirical Bayes approach be used to analyse treatment effects.

Two sets of data are required to use the Empirical Bayes method:

- the crash history of the black spots; and
- data about the safety of sites with similar traits.

FIGURE 5.2 AN ILLUSTRATION OF THE EFFECT OF UNADJUSTED SIMPLE AND MEAN PREDICTIONS



Note **Adapted from Hauer (1997)**

The data available are not sufficiently detailed to permit the use of this method. There is an example in appendix XI of how this method could be used if appropriate data were available.

Linear regression

Linear regression is an appropriate method for predicting crash numbers, provided certain conditions are met. The variables that are expected to affect the number of crashes need to be specified. These variables may not always be directly causally related to the number of crashes. Hence, they are referred to here as predictor variables rather than causal variables. For example, these variables may include whether the site in question is urban or regional, whether a site is a stretch of straight road or an intersection, the type of traffic controls in operation at the site and traffic volume.

The linear model also assumes that the:

- dependent variable is plausibly linearly related to the predictor variables;
- errors are independent and identically distributed with a mean of zero;
- errors have a common variance; and
- that errors follow a Normal distribution.

The appropriateness of these assumptions may be assessed by fitting a model and analysing the distribution of the model's residuals. If the residuals are inconsistent with the model's assumptions, the model can be modified by transforming the dependent variable values, or using a generalised linear model. An iterative process of model fitting and checking the distribution of the model's residuals could be used to develop a more satisfactory model. The linear regression method could be used in conjunction with the paired difference procedure—which pairs the before and after treatment data for each site, and examines the changes—to measure black spot treatments' effectiveness while trying to account for the effects of variables.

The basic form of the predictive regression model can be expressed as

$$Y = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \ldots + \beta_n x_n + \varepsilon$$

where Y is the expected crash frequency, α is a constant, β_1 to β_n are estimated coefficients, x_1 to x_n are predictor variables and ε is an error term. Short and Robertson (1998) and Golias (1997) discuss this method in more detail. This method requires substantial historical data to provide good predictive power if several predictive variables are used.

It was not possible to obtain enough data to apply this method to the assessment of the whole Black Spot Program.

Comparison or control sites

Comparison sites—sometimes called control sites—are sites with very similar characteristics to the treatment sites with which they are matched. For example, they might have similar geometric design, environment, annual average daily traffic and speed limits. The basic assumption is that if the characteristics of matched sites are identical, then their crash frequencies should be too. The comparison sites are used to indicate what would have happened at the treated sites if no treatments had been applied.

The expected number of crashes at a site following treatment is equal to the number of crashes at that site prior to treatment multiplied by the comparison ratio. The comparison ratio is the ratio of the number of crashes at the comparison site in a specific period after treatment to the number of crashes in an equivalent period before treatment. The reduction in crashes is the expected number of crashes after treatment minus the observed number of crashes.

There is a moral problem associated with testing the efficacy of treatments by electing not to treat some black spots in order to use them as comparison sites. Treatment evaluation would be more reliable if this approach was adopted. However, the Federal Government established the Black Spot Program because it believed that this Program would reduce road trauma. A trade-off thus should be made between the expected level of road trauma from any sites left untreated and the reliability of the evaluation. In practice, the control sites selected by States and Territories were those earmarked for treatment in future years of the Black Spot Program.

The use of a control site is described below using the simple method.

Table 5.1 shows hypothetical numbers of crashes in the years before and after treatment of the section of the Tullamarine Freeway discussed earlier and at a control site.

Expected number of crashes after treatment = 15/18*16 = 13.3.

Reduction in crashes = 13.3-8 = 5.3.

The reduction in crashes using this method is about 40 per cent, rather than the 50 per cent calculated using the simple method based on a reduction in crashes of 16-8 = 8.

TABLE 5.1 TREATED SITE VERSUS CONTROL SITE

	Treatment site	*Control site (not treated)*
Before	16	18
After	8	15
Total	24	32

This method deals with crash trends and the regression-to-mean effect. However, its effectiveness is heavily dependent on the quality of the match of sites. For example, if two sites are similar, but widely separated, they may experience different weather conditions. Such differences may be sufficient to invalidate the assumption that the comparison site indicates what would have happened at the treated site if there had been no treatment. Furthermore, obtaining consistent data is not always easy. Notwithstanding these limitations, this method addresses some of the critical limitations inherent in the simple and mean methods.

Lag period method

The traditional assessment of safety treatment effects as described above uses two time periods: before the treatment was applied and afterwards. However, Mountain et al (1998) have suggested an approach that assesses the magnitude of the regression-to-mean effect more directly. The approach uses data from three time periods. It uses the crash history of a site:

- before it was identified as a black spot;
- during the lag period between its identification and the commencement of the treatment; and
- after the treatment.

Mountain et al claim that if it can be assumed that the changes due to crash trends and any local effects are small, then any change in crashes between the period prior to identification and the lag period can be assumed to be due to the regression-to-mean effect. Using this model, the change in crashes between the lag period and the after treatment period reflects the treatment effect.

Again, using figure 5.1:

Number of crashes prior to identification as a black spot = 21

Number of crashes between identification as a black spot and treatment = 16

Number of crashes after treatment = 8

Regression-to-mean effect = [(21-16)/21]*100 = 24 per cent

Treatment effect = [(21-8)/21]*100 - regression-to-mean effect

= 62 per cent -24 per cent = 38 per cent

Statistically, this approach is less than ideal. It treats the observed crash history during the lag period as if it was the expected crash history. Extreme observations of a variable generally tend towards the mean in a subsequent period. The observed value in a later period may still be unusual, although it is more likely to be closer to the mean than it was in the earlier period.

From a statistical perspective, this method works better when the lag period between identification and treatment is longer. The observed crash frequency during the lag is then more likely to approximate the mean. However, for practical road safety reasons, the Black Spot Program should treat black spots as quickly as possible. Between 1996 and 1999, for those sites for which data could be obtained, there was usually a lag of six or more months between identification and treatment.

Statistical significance

When using any method, it is important to test the hypothesis that any change in the number of crashes at a black spot following treatment is due to chance. Vehicle crashes may occur by chance or because of some causal variable. It is thus necessary to determine how unlikely it is for an event to occur by chance.

Griffin (1989) describes how to use the Z—Normal distribution—test to examine this issue. The data for the section of Tullamarine Freeway corrected for maturation used to illustrate the simple method have also been used below to illustrate the Z test for statistical significance.

Single site test—simple method

Logit $= ln(8/15.28) = -0.6471$

Std error $= (1/8+1/15.28)^{0.5} = 0.4364$

$Z = -0.6471/0.4364$

$Z = -1.48$

The Normal distribution table shows that the probability of obtaining a 48 per cent reduction in crashes in the absence of any treatment effect is about 14 per cent. There is weak evidence for an alternative hypothesis—in this case, that the black spot treatment has affected the number of crashes—if the probability of obtaining such a result by chance is less than 10 per cent. In this case, the Z test found no statistically significant evidence of a black spot treatment effect.

Multiple site test

The paired t-test is used to analyse large samples or groupings of sites where it is assumed that the sampling distribution of the mean will follow the Normal distribution. The paired t-test is used to determine whether the means of two samples differ. It assumes that the population of differences is normally distributed and is relatively insensitive to mild departures of the population from normality.

Table 5.2 shows the results of a paired t-test on the sample of Victoria's data contained in appendix XII. The hypothesis $\mu_1 - \mu_2 = 0$ is tested against the alternative $\mu_1 - \mu_2 \neq 0$, where μ_1 is the mean of the before treatment crash data and μ_2 is the mean of the after treatment crash data.

There is strong evidence for an alternative hypothesis—in this case, that the black spot treatment has affected the number of crashes—if the probability of obtaining such a result by chance is less than one per cent.

The p value shown in table 5.2 indicates that there is strong evidence that the means of the before and after treatment distributions are different. Under the null hypothesis that the treatment is ineffective, the number of crashes per time period would not be expected to change from before to after treatment—$\mu_1 - \mu_2 = 0$. However, the test results indicate that the before treatment mean is significantly different from the after treatment mean. The odds of achieving the 60 per cent reduction observed by chance are seven in one million.

The paired t-test was not used because it is less sensitive than the weighted Poisson regression test method, described later.

ANALYTICAL ISSUES AND PREFERRED METHODOLOGY

The analysis in chapter 6 is based on the weighted Poisson regression method. Issues relevant to the selection of this approach are described below. Although not new, to the best of the BTE's knowledge, this method has not been used before in this type of evaluation; so the method and issues relevant to its selection are described below.

Analytical issues

Weighting

One fundamental principle of the simple t-test approach described above is that each observed data point contributes equally to the analysis. However, in

TABLE 5.2 PAIRED T-TEST RESULTS

Paired t-test (results)	*Before*	*After*
Mean	1.5576	0.6309
Variance	0.9988	0.8308
Observations	36	36
Pearson Correlation	0.3907	
Hypothesised Mean Difference	0	
Degrees of freedom	35	
t Stat	5.2590	
p one-tail	0.000004	
p two-tail	0.000007	
t critical one-tail	2.0301	
t critical two-tail	1.68957	

Note See appendix XII for data.

the current situation, the amount of data contained in the observed crash rates at individual black spot sites before and after treatment differs, depending on the duration over which data were collected. As such, any analysis of the data ought to incorporate an appropriate weighting scheme to account for this fact. If the duration of crash data is similar for each observed black spot site, weighting is less critical, as the weights will be similar and hence have little effect.

Multiplicative versus additive effect on estimation

The paired t-test approach described above estimates the raw drop in crash rates. This approach is reasonable if each of the black spot sites have comparable before treatment rates. However, this will not generally be the case, and in such circumstances raw differences are problematic. For example, if a particular site has a before treatment crash rate of 0.2 crashes per month, then the difference between the before and after treatment crash rates can be no larger than 0.2. However, larger before treatment rates mean that larger differences are possible—though they may not be observed. Thus, it is more reasonable to estimate relative differences and any statistical model of the crash data ought to be multiplicative—or, equivalently, differences ought to be dealt with using a logarithmic scale. This idea is inherent in the methods described earlier, where percentage decreases have been reported.

Relevance

Using historical data to calculate before treatment crash rates is important in adjusting for the regression-to-mean effect. However, because crash rates demonstrate significant trends over time, it is important to include only the historical data deemed relevant. For example, suppose that seven years of historical crash data are available for a particular black spot site. Suppose also that investigation of the yearly crash rates for these seven years reveals a significant change in rate three years ago—perhaps due to some dramatic change in site-specific conditions. In this case, only the most recent three years of historical data should be used to calculate the before treatment crash rate. It is recognised, however, that such detailed information may not be available for all black spot sites.

Different baselines

As noted above in the discussion of multiplicative versus additive modelling, it is likely that individual black spot sites will have different before treatment crash rates. These differences can be taken into account in a more complicated statistical methodology. Whether such methodologies are implemented depends to some extent on the perceived variation in the before treatment crash rates of individual black spot sites.

Categorisation

Certain treatment types are likely to be relatively more effective than others. As such, it is desirable to use an analytical method that allows for the separate estimation of crash rate decreases at various types of black spots and for various treatment types. Such an approach could be based on analysis of variance procedures, which expand on the standard t-test approach.

Preferred methodology

The simplest extension to the paired t-test approach which incorporates the principles discussed above is the weighted log-linear ANOVA (analysis of variance) model:

$$E\{\ln(r_{ij})\} = \mu_i + \beta z_j$$

where r_{ij} is an observed crash rate at black spot site i, and the j subscript indicates whether it is a before treatment crash rate (j = 1) or an after treatment crash rate (j = 2). Furthermore, μ_i is the site-specific before treatment mean crash rate, β is the relative treatment effect, and z_j is an indicator of whether the rate is a before treatment crash rate ($z_j = 0$) or an after treatment crash rate ($z_j = 1$). This model should then be fitted using a weighted generalised linear model technique employing a Poisson error structure, where the associated weight for each r_{ij} is the length of the observation period on which the rate r_{ij} is based. Ideally, the weight should be the AADT, but this information is not always available.

This approach, though more complicated than the paired t-test, has two advantages:

- it is based on the standard model for traffic count data; and
- it is able to handle directly the issue of observed crash rates of zero—which pose problems for classical Normal approaches under multiplicative models.

Moreover, this model has the advantage of allowing various levels of flexibility. These include incorporating indicator variables to allow the separate effects for various treatment types and black spots to be estimated; and the modelling of lag-period crash rates—given sufficient data. This enables adjustments to be made for regression-to-mean and trend effects.

Furthermore, standard techniques exist to assess the statistical significance of the estimated treatment effect, β. Further details about Poisson generalised linear models can be found in Dobson (1990). An example of the results produced by applying this methodology is shown in appendix XIII, using SAS and also S-Plus statistical analysis application. Some of the options that can be applied are shown below. These options have been included for illustrative purposes only.

Model 1: Overall treatment effect

For this model, only the site-specific baseline mean crash rates and an overall remediation effect were included.

$E\{\ln(r_{ij})\} = \mu_i + \beta z_j$

Terms are defined as above.

Results

The estimated relative treatment effect is $e^{\hat{\beta}} = 0.74$—that is, the after treatment crash rate is 74 per cent of the before treatment crash rate, or there was an overall 26 per cent reduction in the crash frequency. This reduction was statistically significant at the 0.0354 level. The site-specific baseline mean crash rates, μ_i, can also be estimated from this model.

Model 2: Treatment-specific effects

For this model, the site-specific baseline mean crash rates and three treatment-specific effects were incorporated. These treatment effects were for black spots where:

- roundabouts were installed;
- road sealing was performed; and
- where other modifications were made.

$E\{\ln(r_{ij})\} = \mu_i + \beta_1 z_{\text{Roundabout},j} + \beta_2 z_{\text{Seal},j} + \beta_3 z_{\text{Other},j}$

The z terms are indicators of the specific treatment types. This breakdown of the specific treatment types is arbitrary and is presented for illustrative purposes only.

Results

The estimated relative treatment effects were:

$e^{\hat{\beta}_1} = 0.23$—or a 77 per cent reduction in crash rates for sites treated with roundabouts—significant at the 0.01 level;

$eb^{\hat{\beta}_2} = 0.90$—or a 10 per cent reduction in crash rates for sites treated by resealing—not statistically significant; and

$eb^{\hat{\beta}_3} = 0.50$—or a 50 per cent reduction in crash rates for sites with other types of treatment—significant at the 0.001 level.

Again, the site-specific mean crash rates can be estimated.

ESTIMATING CRASH REDUCTION BENEFITS

The primary aim of black spot treatment work is to reduce the number and severity of crashes, thereby releasing resources for alternative community uses. For example, raising national productivity, and reducing pressure on medical and health services.

Road trauma is a major public health issue. During the 1990s, around 2000 people per year died and over 20 000 per year sustained serious injuries on Australian roads. The BTE (2000) estimated that the social cost of road crashes in 1996 was $15 billion in 1996 dollars. A study by FORS (1991) found that although road crashes were responsible for just over two per cent of total deaths each year, they accounted for almost seven per cent of years of statistical life lost through all causes of death—more than years lost through cerebrovascular disease or lung cancer. The study also found that when only years of life lost before the age of 65 or during the working age span were considered, road crashes accounted for more years lost than years lost through all forms of heart disease, and about three-quarters of years lost through all types of cancer.

The issue is thus how to value any reduction in road trauma caused by treating black spots to facilitate the allocation of resources between this and other measures which may improve the health and safety of the community.

Approaches to measuring crash reduction benefits

In evaluating black spot treatments' effectiveness crash reduction benefits are generally estimated in terms of crash costs avoided. Two methods are used in Australia to estimate road crash costs: crash-severity and crash-type.

Crash-severity method

The crash-severity method adopts the crash as the costing unit, classified by the highest degree of severity of the victims involved.

This method was used to calculate the benefits of the Black Spot Program. The main advantage of the crash-severity method is that it requires very little data, and that is why it has been used here. However, it is generally inferior to the crash-type method, discussed below. If the data problems raised in chapter 4 could be dealt with, it would be desirable to use the crash-type method in future.

Crash-type method

The crash-type method of costing crashes is based on the movements of vehicles or individuals just prior to the crash and uses data derived from collision diagrams. The method involves calculating mean personal injury costs for each type of crash, and adding this amount to vehicle repair costs and various other costs related to the crash.

Different types of crashes have characteristic outcomes in terms of the number and injury severity of the casualties involved as well as the number of vehicles involved and the extent of damage to them. Some crash types such as head-on crashes would be expected to produce more severe injuries and vehicle damage than others such as rear-end crashes. Andreassen (1986) noted that the number and severity of casualties associated with particular crash types was fairly consistent over the period of time he examined. On the basis of historical data, it was therefore possible to predict the expected casualty outcomes of a particular type of crash. This enables standardised injury profiles and costs to be calculated for each crash type. In the crash-type method, standardised costs per person and per incident are aggregated to produce a standardised cost for each type of crash. Black spot treatments can affect the overall distribution of crashes in terms of both incidence and severity. For example, following the installation of right-turn phases at an intersection, right-turn crashes may decline but side-swipe and rear-end crashes may increase. In these cases it is necessary to determine the net change in crash costs.

Approach used in this report

This evaluation used crash-severity data.

The crash costs used are those reported in BTE (2000). It is important to note that the crash and injury costs in BTE (2000) are higher than those that were widely used previously. This is a key reason why the net present values and BCRs generated in chapter 7 are high relative to those generated by the evaluation of the previous Black Spot Program.

Approaches to estimating human costs of crashes

The conceptual basis for estimating human costs in the crash-severity and crash-type methods is the human capital approach—also known as the accounting or ex-post approach. The human capital approach measures the lost output or productivity of individual crash victims due to premature death or disability. This is generally done by calculating the present value of the crash victim's potential future output, as measured by the victim's discounted anticipated stream of earnings. Other costs are added to the estimates of lost productivity to obtain estimates of the overall social cost of crashes. The other costs include monetary estimates of lost quality of life, the value of non-market output such as the services of those involved in household and community duties, and resource costs including vehicle damage, insurance administration, and medical, hospital, police and ambulance costs.

The human capital approach produces lower bound estimates of the overall cost of road crashes. This is because it is difficult to capture within the human capital framework the full range of costs that society incurs because of crashes. It is especially difficult to assign monetary values to intangibles such as grief, pain, suffering and stress. Within the human capital framework, if these are valued at all, the valuation has to be performed on an arbitrary basis. Furthermore, the approach tends to undervalue the costs of crashes involving the very young or old.

The other significant method for estimating road crash costs is based on society's willingness to pay for reductions in risk to life and limb. The willingness to pay approach is widely regarded as having greater theoretical validity than the human capital approach in economic appraisals involving human life. However, willingness to pay is not as straightforward to apply as the human capital approach and involves more complicated methodological issues. Essentially, the approach seeks to measure individual incremental rates of substitution of wealth for changes in risk of death or injury. The approach is better suited to valuing intangible effects of crashes. This is because individuals are expected to take account of the full range of effects of crashes on their welfare in determining what they are willing to pay to reduce the risks involved.

The willingness to pay approach has some shortcomings. People may not accurately perceive their risks or how their risks may be controlled, and may have difficulty valuing small risks. The approach values the reduction in risk to the population affected by the black spot—statistical lives—rather than the lives of identified individuals. In general, willingness to pay to save identified lives is much higher. Willingness to pay does not necessarily imply ability to pay. Budgetary constraints may restrict willingness to pay. There may be substantial differences between willingness to pay to avoid risk and willingness to accept compensation for risk. People may ignore externalities, so that aggregating the willingness to pay of individuals may not give society's willingness to pay. Survey results may be distorted by strategic behaviour, as the response given by an individual is generally not binding on that individual. Furthermore, the value of a decrease in risk to an individual will change with income and with variations in road safety.

The willingness to pay approach—particularly studies using contingent valuation methods—generally produces estimates of the human costs of crashes that are considerably higher than those calculated using the human capital approach.

Both the human capital and willingness to pay approaches share certain deficiencies. For example, both ignore the effects of intergenerational cost-shifting and social equity issues.

The human costs of road crashes are those directly associated with death or injury—loss of output, workplace disruption and staff replacement costs, loss of quality of life, medical costs, and coronial, funeral, legal and prison costs. There are other human costs, but these have not been incorporated into this study due to the unavailability of reliable data.

Other costs of crashes

The vehicle costs of crashes include the cost of repairs or replacement, towing, and the value of time lost due to vehicle unavailability. Other crash costs include non-vehicle property damage—for example, damage to road furniture, fences and housing—the costs of police, fire services, insurance administration, and travel delay. This list is not exhaustive, but other costs have not been considered in this study due to data limitations.

There is uncertainty associated with the crash cost estimates used to value the benefits of crash reduction following treatment. The BTE believes this uncertainty is likely to be far greater than most other sources of uncertainty in evaluating treatment effectiveness.

Discount rate issues

Benefit-cost analyses use discount rates in project assessments to compare the value of benefits and costs in the future with those in the present.

The discount rate for a project should reflect the opportunity cost of using resources in that project and alternative means of obtaining equivalent benefits. That is, it should look at what could have been achieved by investing the resources according to the best option available other than the project, and at the minimum alternative investment necessary to achieve equivalent benefits.

The geometric mean of the real cost of borrowing funds to the Federal Government—and thus to society—over the time period during which black spot treatment expenditure occurred was around five per cent. The domestic final demand chain price index, a series produced by the Australian Bureau of Statistics, was used to adjust the Government 10-year bond rate. The sensitivity analysis conducted in chapter 7 shows that the results of the evaluation are not particularly sensitive to small changes in the discount rate used.

The BTE decided to conduct this evaluation using calculations at four discount rates. The rate of five per cent was considered to generate the most meaningful result, for the reasons described above.

However, the analysis was also completed using a three per cent discount rate, because the Government indexed bond rate was closer to three per cent than four per cent at the time this report was prepared. The indexed bond rate is the real market cost of long-term funds to the Government. Therefore it is a reasonable choice of discount rate for valuing the benefits and costs of any future Black Spot Program. The main point of this evaluation is to determine if the Federal Government should invest in black spot treatment in the future.

The analysis was also completed using a seven per cent discount rate, to facilitate comparability with AUSTROADS analyses, because AUSTROADS has been publishing its analyses at seven per cent since 1996. Following a suggestion from the Department of Finance and Administration, the analysis was also completed using an eight per cent discount rate.

Chapter 7 shows that the results obtained by using the four discount rates do not affect the policy implications of this evaluation.

CONCLUSION

The BTE decided to evaluate the Black Spot Program using a weighted Poisson regression model.

This decision was made after considering which of the evaluation methods discussed in this chapter would be most appropriate to assess the effectiveness of black spot treatments, given:

- the confounding variables that need to be controlled; and
- the data availability and quality issues discussed in chapter 4.

The BTE chose to conduct its BCA at discount rates of three, five, seven, and eight per cent. The five per cent rate generated the most meaningful result, given all the circumstances relating to the benefits and costs of the Black Spot Program.

6

BLACK SPOT TREATMENTS' EFFECTIVENESS IN REDUCING CRASHES

SELECTING BLACK SPOT SITES FOR ANALYSIS

The Minister for Transport and Regional Services or his Parliamentary Secretary approved the treatment of 1 122 black spots between 1996–97 and 1998–99. As at end June 1999, treatments had been implemented at 983 sites. This evaluation considers the black spot treatments' effectiveness during the three-year period.

Selection process

Each year the appropriate agency in each jurisdiction analyses its database to identify particularly dangerous sites. Some of these sites are nominated for treatment as black spot sites. Most of the sites treated in the Federal Black Spot Program have been nominated by State and Territory Governments. However, because databases only identify actual crashes—and do not include near misses—clubs and associations, and road user, community and industry groups are also entitled to nominate sites in their areas. If the Federal Government assesses a site as a black spot, the local agency responsible for the Program's implementation performs a preliminary BCA to determine what treatment will be applied.

The Black Spot Program *Notes on Administration* require each State and Territory to establish a consultative panel. All States and Territories have complied with this requirement. The results of the BCA are submitted to the relevant consultative panel. The panels consider and comment on all projects nominated and then prepare a submission to the Parliamentary Secretary to the Minister for Transport and Regional Services for consideration and approval.

Care is needed when considering the results in this chapter and chapter 7 in the context of the crash trends examined in chapter 3. The databases used to derive the results given in this chapter and chapter 7 assume that *urban* means *in a capital city* and *regional* means *not in a capital city*.

Unfortunately, it was not possible to collect all of the data required for a rigorous assessment of projects from all States and Territories. The assessment of the entire Black Spot Program requires several assumptions about the data that were not supplied. Some jurisdictions—particularly those with smaller populations—were able to submit information on all of their projects. However, others were only able to submit data on a sample of their projects. This evaluation considered a sample of 608 projects. Only sites for which at least six months of crash data were available after treatment was completed were included in the sample. Table 6.1 shows details about the sample.

Six of these sample projects were later eliminated from the assessment of treatment effectiveness because of data quality problems. However, all 608 projects were used in the BCA in chapter 7.

The sample selection process was not entirely random. Smaller jurisdictions were over-sampled to ensure that the sample sizes for these jurisdictions

TABLE 6.1 NUMBER OF PROJECTS AND FUNDING LEVELS EVALUATED

			Project funding $		
State	*Local govt. area*	*No. of projects*	*Aggregate*	*Maximum per project*	*Mean per project*
NSW	Regional	53	8 052 500	400 000	151 934
	Urban	60	6 321 250	480 000	105 354
VIC	Regional	61	5 558 000	500 000	91 115
	Urban	119	7 927 030	486 000	66 614
QLD	Regional	47	8 377 459	960 000	178 244
	Urban	60	6 604 987	350 000	110 083
SA	Regional	27	3 202 787	362 062	118 622
	Urban	16	1 507 146	251 577	94 197
WA	Regional	33	3 556 360	300 000	107 769
	Urban	61	3 759 373	400 000	61 629
TAS	Regional	28	800 900	80 000	28 604
	Urban	15	748 500	200 000	49 900
NT	Regional	9	1 002 135	320 000	111 348
	Urban	11	744 500	150 000	67 682
ACT	Urban	8	1 360 000	380 000	170 000
Total		608	59 522 927	na	na

Note The total in this table—which is expressed in nominal dollars—does not match the total obtained by adding project costs in tables in chapter 7, which are expressed in real terms.

Source ATSB

would be large enough to generate meaningful results. Some projects were included to ensure that all treatment types were adequately represented in the sample. The sample of projects initially proposed by the BTE was discussed with the Program Manager in each State and Territory to ensure that the required data were either available or could be collected within the required time frame. Some projects were eliminated after this consultation process. Others were eliminated later, because circumstances in particular jurisdictions changed and nominations were withdrawn after approval or treatments were not completed.

DATA REQUESTED FROM STATES AND TERRITORIES

Most treatments are effective in preventing only one kind of crash. Many black spots are dangerous because of a high frequency of one type of crash. Crashes were therefore divided into target crashes—crashes whose frequency a particular treatment should reduce—and non-target crashes—crashes on whose frequency a particular treatment should have no effect. Each treatment's effectiveness was assessed by examining what happened to the number of crashes targeted by that treatment. Situations where statistical analysis suggested particular treatments also had a positive or negative effect on the number of non-target crashes were also examined. Definitions for classifying accidents (DCA) codes were used to determine what types of crashes occurred at each black spot.

Target and non-target crashes

This section gives a more detailed explanation of how target and non-target crashes were separated. Hauer (1997) defines a treatment's target crash as the crash type/s that can be affected by the treatment.

Conversely, non-target crashes at a treatment site are crashes that are not affected by the treatment. To illustrate, suppose a black spot on a section of highway is treated by applying skid-resistant material in the expectation of reducing crashes when the road is wet. The treatment targets crashes occurring during wet periods. The BTE would begin assessing the treatment's effectiveness by comparing the crashes that occurred during wet periods after the treatment was applied with the number that would have been expected in wet periods if no treatment was applied. It would then assess whether the treatment affected dry weather crashes in any way. For example, the surface material may have unanticipated effects on speed or braking distance. If there was evidence of unanticipated effects, then dry weather crashes would also be considered as target crashes.

Similarly, suppose streetlights were installed at a black spot to reduce the number of crashes at night. The treatment targets crashes at night and its effectiveness would be assessed by comparing the crashes that occurred at night after the lights were installed with the number that would have been expected at night without the lights. Daytime crashes would be considered non-target, unless there was evidence of other effects. If installing streetlights affected the incidence of crashes during the day—for example by impeding visibility or providing obstacles—then daytime crashes would also be considered as target crashes.

The issue of what was, and was not, a target crash, became more complicated at sites with a complex physical layout. For example, treating one arm of a complex intersection may increase crashes on some arms while decreasing crashes on other arms. However, the principle was applied consistently. If a treatment affected a crash type, then that crash type was defined as a target crash.

To apply this approach, the crash count data needed to be analysed using DCA codes to separate the target and non-target crashes.

The crash count data also needed to be analysed to determine what a relatively typical profile of crash types looked like before and after treatment for a site treated in a particular way. It was not possible to prepare a comprehensive analysis, as States and Territories did not have access to comprehensive information on crashes at each site—including collision diagrams and practical knowledge of each site. The analysis performed was based on a sample of projects for which sufficient information was available.

The percentage reduction factor derived was based on the number of target crashes recorded after treatment—compared with the number of target crashes expected without treatment. This was done for all treated sites except intersections treated with roundabouts or traffic lights. For intersections treated with roundabouts or traffic lights, the analysis of crash-type profiles became very complex, and the BTE decided to base its analysis of these treatments on all crashes rather than just target crashes. For other sites, the number of crashes recorded after treatment at each site was adjusted using the dominant DCA code information provided.

The results of this analysis are presented by jurisdiction in the next section.

ASSESSING DIFFERENT TREATMENTS' EFFECTIVENESS

This section assesses the Black Spot Program's effectiveness in terms of lives saved or crashes prevented, rather than economic benefits obtained. It examines the statistical evidence on whether or not treatments affected road safety. The results of this analysis were used in chapter 7, which assesses the Program's performance from a economic perspective.

The analysis in this chapter was performed using the log-linear ANOVA weighted Poisson regression model described in detail in chapter 5. This model is theoretically capable of estimating the effect of each treatment at each site.

However, a dramatic difference would be required between the after treatment crash rate and the expected crash rate without treatment to generate a statistically significant result for a single site. Therefore, the model was used to estimate treatment effects nationally, by State and Territory, and by urban and regional groupings in each jurisdiction. Similar treatment types were grouped together to achieve more statistical power. For example, all treatments involving the provision of a roundabout were grouped together, regardless of the size of the roundabout installed or the number of road arms connected to it. The model was applied using the SAS statistical analysis software package.

Table 6.2 shows the Black Spot Program's effect on road safety in urban areas. In this table, β, the parameter estimate, is in log format, so the reduction is actually $1-e^{\beta}$. A negative value for β indicates that the number of casualty crashes[4] decreased following treatment, whereas a positive value indicates that the number of casualty crashes increased. The probability of treatment causing a result of this magnitude by chance is given by p. For example, $p<.0001$ means that the probability of obtaining such a result by chance is less than one in ten thousand. The percentage reduction in the number of casualty crashes attributable to each treatment type is shown in the last column under the heading *Casualty crash reduction*.

Under the Black Spot Program, the number of casualty crashes at treated sites in capital cites decreased by approximately 31 per cent nationally. This figure is an average, taking into account both effective and ineffective treatments.

TABLE 6.2 CAPITAL CITY PROGRAM RESULTS

Area	*Estimate(β)*	*Std Error*	*Probability 0≤p≤1*	*Casualty crash reduction (%)*
Sydney	–0.2125	0.0984	0.0307	19.1
Melbourne	–0.2703	0.0465	<.0001	23.7
Brisbane	–1.1934	0.1229	<.0001	69.7
Adelaide	–0.638	0.1539	<.0001	47.2
Perth	–0.2199	0.0683	0.0013	19.7
Hobart	–0.501	0.2173	0.0211	39.4
Darwin	–0.4963	0.2488	0.0461	39.1
Canberra	–0.7102	0.3113	0.0225	50.8
All capital cities	–0.3743	0.0326	<.0001	31.2

Source BTE estimates

4. In this report, the term *casualty crashes* means all crashes in which at least one person was killed or injured.

TABLE 6.3 REGIONAL PROGRAM RESULTS

Area	*Estimate(β)*	*Std Error*	*Probability $0 \le p \le 1$*	*Casualty crash reduction (%)*
NSW	-1.0128	0.1400	<.0001	63.7
VIC	-0.5713	0.1044	<.0001	43.5
NT	-0.3660	0.1933	0.0583	30.6
SA	-0.3075	0.1470	0.0364	26.5
WA	-0.4187	0.1303	0.0013	34.2
QLD	-0.9864	0.1684	<.0001	62.7
TAS	-1.3724	0.3311	<.0001	74.7
All regional	-0.6587	0.0558	<.0001	48.2

Source BTE estimates

The Program had a statistically significant effect in all capital cities. The reduction in casualty crashes ranged from approximately 70 per cent at treated sites in Brisbane to approximately 20 per cent in Sydney.

Under the Black Spot Program the number of casualty crashes at treated sites in regional areas decreased by approximately 48 per cent nationally. The Program had a statistically significant effect in all regional areas. The reduction in casualty crashes ranged from approximately 75 per cent at treated sites in regional Tasmania to approximately 27 per cent in regional South Australia.

Not all treatments had statistically significant effects on crash reduction, and not all statistically significant results showed a reduction in the number of casualty crashes.

To overcome small sample size problems—except for roundabouts, traffic lights with no turn arrows, traffic lights with turn arrows, non-skid surfaces, sealing road shoulders, and improved lighting—treatment types were grouped into broad headings.

Table 6.4 shows the Poisson analysis by treatment type. As the Poisson model is not linear, the averages for smaller areas within Australia cannot be used to derive the national average. The national average was estimated independently.

In this analysis, *very strong* evidence means that the probability of an event occurring by chance is less than one in one thousand; *strong* evidence means that the probability is less than one in one hundred; *moderate* evidence means that the probability is less than one in fifty; and *weak* evidence means that the probability is less than one in ten.

In the capital cities, sealing road shoulders, marking edge lines, improving pedestrian facilities, and erecting signs did not have a statistically significant effect on road crashes. Curiously, sealing road shoulders did not produce a

TABLE 6.4 CAPITAL CITY AND REGIONAL RESULTS BY TREATMENT TYPE

T Code		Estimate(β)	Std Error	Probability 0≤p≤1	Casualty crash reduction (%)
	Urban				
K1	Roundabout	–1.2013	0.1840	<.0001	69.9
K14	Traffic island on approach	–0.4507	0.1363	0.0009	36.3
K15	Indented right & left turn islands	–0.3857	0.1135	0.0007	32.0
K19	Median	–0.6239	0.1417	<.0001	46.4
K2	New traffic light—no turn arrow	–0.6367	0.1386	<.0001	47.1
K3	New traffic light—with turn arrow	–0.5598	0.0686	<.0001	42.9
OT	All other	–0.3330	0.1340	0.0130	28.3
S13	Non-skid surface	–0.4703	0.1181	<.0001	37.5
S14	Shoulder seal	–0.1365	0.1550	0.3786	12.8*
S17	Edge lines	0.0672	0.1585	0.6717	–7.0*
S2	Pedestrian facilities	–0.0599	0.1273	0.6379	5.8*
S20	Signs	–0.1724	0.1086	0.1125	15.8*
S7	Improved lighting	0.2386	0.0955	0.0125	–26.9
	Regional				
K1	Roundabout	–1.3892	0.1511	<.0001	75.1
K14	Traffic island on approach	–0.2174	0.1982	0.2728	19.5*
K15	Indented right & left turn islands	–0.3310	0.2111	0.1168	28.2*
K19	Median	–0.8358	0.3386	0.0136	56.6
K2	New traffic light—no turn arrow	–1.4254	0.3494	<.0001	76.0
K3	New traffic light—with turn arrow	–0.4672	0.1681	0.0054	37.3
OT	All other	–0.7574	0.1626	<.0001	53.1
S13	Non-skid surface	0.2368	0.2273	0.2975	–26.7*
S14	Seal shoulders	–0.3403	0.1347	0.0116	28.8
S17	Edge lines	–0.4071	0.1764	0.021	33.4
S2	Pedestrian facilities	0.2635	0.5877	0.6539	–30.1*
S20	Signs	–0.7722	0.2263	0.0006	53.8
S7	Improved lighting	–0.9985	0.4363	0.0221	63.2

Note T Code =Treatment code—for details see appendix VI.
Some T-codes are a combination of several T-codes.
Reductions that are not statistically significant are indicated with an asterisk (*).

Source BTE estimates

statistically significant effect—expenditure on this treatment was the fifth most popular and accounted for almost seven per cent of urban black spot treatment expenditure. Attempts to improve lighting in the capital cities appear to have had a counter-productive effect. There is moderate evidence that improved lighting in capital cities increased crash numbers. In regional areas, traffic islands on approach, indented right and left turn lanes, non-skid surfaces, and improving pedestrian facilities did not have a statistically significant effect on road crashes.

Conversely, there is very strong evidence that, in many areas, the Program appeared to have a dramatic effect in reducing the number of casualty crashes and some engineering treatments were consistently very successful. The probability of achieving such large improvements in road safety by chance in Melbourne, Brisbane and Adelaide—or in regional areas in New South Wales, Victoria, Queensland and Tasmania—is less than one in ten thousand. There is moderate to strong evidence that road safety improved in Perth, Hobart, Darwin and Canberra and in regional South Australia and regional Western Australia. There is weak evidence that road safety improved in regional areas in the Northern Territory.

Roundabouts and new traffic lights with no turn arrows appeared to be very successful in improving safety in both capital city and regional areas. The probability of such large improvements occurring by chance is less than one in ten thousand. An assessment was made of whether more expensive, and presumably larger, roundabouts were more successful in improving safety than cheaper, presumably smaller, roundabouts. Nationally, there was very strong evidence that installing roundabouts successfully improved safety irrespective of the roundabout's cost. The assessment of roundabouts is presented in appendix XIV. New traffic lights with turn arrows, medians and non-skid surfaces were similarly successful in capital cities. There is very strong evidence that traffic islands on approaches and indented right and left hand turns improved safety in capital cities. In regional areas, evidence for safety improvement was very strong for signs and new traffic lights with turn arrows and moderate for medians, shoulder sealing, edge lines, and improved lighting.

This does not mean that particular engineering treatments improved or failed to improve road safety in all cases. However, it does indicate that road engineers should consider using one of the more generally successful treatments if there is more than one feasible way of trying to fix or improve a particular traffic hazard.

There are four possible reasons why treatments may appear to have had no effect on treated sites. The first is that the treatments may genuinely have had no effect on road safety.

Secondly, traffic flow may have changed at some of the treated sites. Because of poor traffic count data provided by most jurisdictions, these changes in traffic flow can affect the reliability of the analysis. Consider an instance where the road was widened after the treatment to cater for an increased traffic flow—because, for example, of the construction of a new shopping complex. Unless accurate traffic flow figures in the periods before and after treatment were provided—to calculate crash rates—the analysis would not be reliable.

Thirdly, the period over which casualty crash data were collected after treatment was relatively short—in some cases only for six months. The probability of observing a significantly atypical crash rate over a given period is higher when the data collection period is short.

Fourthly, as described above, some treatments may have been used too seldomly to generate statistically significant effects in the time available. For these treatments, traffic engineers may need to take a 'wait and see' approach. Small samples may generate statistically insignificant results even if the treatments are working well. This issue is particularly relevant when interpreting the results of treatment effect by jurisdiction reported below.

However, as statistically insignificant results were obtained for some treatment types, nationally and in each of the jurisdictions—despite reasonably large sample sizes—some reassessment of apparently ineffective treatment types needs to be done.

Tables 6.5 to 6.12 show the treatment effectiveness assessment results by jurisdiction, by urban and regional areas, and by treatment type. Not all treatments are shown for all jurisdictions. Because some treatments were seldom used in particular jurisdictions, they are included under the treatment heading *all other*.

New South Wales

There was strong evidence in Sydney that roundabouts and new traffic lights with no turn arrows effectively reduced the number of casualty crashes. There was no statistical evidence that traffic islands on approach, new traffic lights with turn arrows, edge lines, medians or signs effectively reduced the number of casualty crashes in Sydney. However, the results for medians and signs were just outside the cut-off point for weak evidence of an effect. There was moderate evidence that installing pedestrian facilities was counter-productive and weak evidence that sealing road shoulders contributed to an increase in casualty crashes.

In regional New South Wales, there was very strong evidence that roundabouts effectively reduced the number of casualty crashes. There was strong evidence that new traffic lights with no turn arrows and signs—and weak evidence that indented right and left turn islands and medians—effectively reduced the number of casualty crashes. There was no statistical evidence that traffic islands on approach, new traffic lights with turn arrows, sealing road shoulders, and pedestrian facilities affected the number of casualty crashes.

TABLE 6.5 TREATMENT EFFECT IN NEW SOUTH WALES BY TREATMENT TYPE

T Code	*NSW*	*Estimate(β)*	*Std Error*	*Probability 0≤p≤1*	*Casualty crash reduction (%)*
	Sydney				
K1	Roundabout	–1.6416	0.5155	0.0015	80.6
K14	Traffic island on approach	–0.3134	0.3965	0.4293	26.9*
K19	Median	–0.1139	0.3303	0.7301	10.8*
K2	New traffic light—no turn arrow	–0.6604	0.2460	0.0073	48.3
K3	New traffic light—with turn arrow	–0.1539	0.3417	0.6523	14.3*
OT	All other	–1.5584	1.0411	0.1344	79.0*
S13	Non-skid surface	–1.1589	0.7338	0.1143	68.6*
S14	Shoulder seal	0.7273	0.4045	0.0722	–106.9
S17	Edge lines	0.1400	0.4366	0.7485	–15.0*
S2	Pedestrian facilities	0.3176	0.1600	0.0471	–37.4
S20	Signs	–1.6809	1.0392	0.1058	81.4
	Regional NSW				
K1	Roundabout	–1.1878	0.2426	<.0001	69.5
K14	Traffic Island on approach	–0.2929	0.5492	0.5938	25.4*
K15	Indented right & left turn islands	–0.8902	0.5282	0.0919	58.9
K19	Median	–0.8296	0.4797	0.0838	56.4
K2	New traffic light—no turn arrow	–1.2070	0.3763	0.0013	70.1
K3	New traffic light—with turn arrow	–0.5298	0.4874	0.2771	41.1*
OT	All other	–0.7655	0.4913	0.1192	53.5*
S14	Shoulder seal	–0.6716	0.614	0.274	48.9*
S2	Pedestrian facilities	–0.0465	0.8362	0.9557	4.5*
S20	Signs	–1.7557	0.5968	0.0033	82.7

Note T Code =Treatment code—for details see appendix VI.
Some T-codes are a combination of several T-codes.
Reductions that are not statistically significant are indicated with an asterisk (*).

Source BTE estimates

Victoria

There was very strong evidence in Melbourne that new traffic lights with turn arrows and non-skid surfaces effectively reduced the number of casualty crashes. There was strong statistical evidence that roundabouts and medians —and moderate statistical evidence that sealing road shoulders—effectively reduced the number of casualty crashes. There was no statistical evidence that traffic islands on approach, indented left and right hand turn islands, new traffic lights with no turn arrows, edge lines, pedestrian facilities and signs effectively reduced the number of casualty crashes. There was moderate evidence that improved lighting was ineffective in reducing the number of casualty crashes.

In regional Victoria, there was very strong evidence that roundabouts effectively reduced the number of casualty crashes. There was moderate evidence that sealing road shoulders—and weak evidence that medians and edge lines—effectively reduced the number of casualty crashes. There was no statistical evidence that traffic islands on approach, indented right and left turn islands, new traffic lights with no turn arrows, new traffic lights with turn arrows, non-skid surfaces, pedestrian facilities, signs and improved lighting affected the number of casualty crashes.

Evaluation of black spot treatments funded by the Victorian Government

It is interesting to compare the results from the MUARC evaluation of the TAC Accident Black Spot Program with those in table 6.7. MUARC evaluated the TAC Program for 1994–95 and 1995–96 and used a different methodology to that used in this evaluation. Table 6.6 shows the results of MUARC's evaluation.

The BTE and MUARC evaluations found moderate evidence that sealing road shoulders effectively reduced the number of casualty crashes in Melbourne. However, there was no evidence that this treatment effectively reduced the number of crashes in other capital cities. Therefore, a more detailed examination of shoulder sealing in Melbourne might be worthwhile to:

- establish if this result was influenced by local factors; and
- to find out if there is a lesson for other jurisdictions in Victoria's shoulder sealing practices.

A site-specific evaluation would be advisable before applying shoulder sealing to capital city black spots other than in Melbourne. Although this evaluation and the MUARC evaluation found moderate evidence of a beneficial safety effect, that is not sufficient to conclude that shoulder sealing would improve road safety in all urban areas.

TABLE 6.6 PERCENTAGE REDUCTIONS IN CASUALTY CRASH NUMBERS AND VICTORIAN TRAFFIC ACCIDENT COMMISSION COSTS BY TREATMENT TYPE 1994–95 AND 1995–96

Treatment type	*Casualty crash reductions (percentage)*	*TAC costs*
New roundabouts	86	97
Signal remodels—fully controlled right-turn phases	50	55
New intersection signals	45	52
Intersection channelisation	37	68
Shoulder sealing	23	22

There was no statistical evidence in this evaluation, or in MUARC's analysis, that pedestrian facilities affected the number of casualty crashes.

Queensland

There was very strong evidence in Brisbane that roundabouts and new traffic lights with turn arrows effectively reduced the number of casualty crashes. There was weak statistical evidence that new traffic lights with no turn arrows effectively reduced the number of casualty crashes. There was no statistical evidence that traffic islands on approach, indented left and right hand turn islands, medians, non-skid surfaces, sealing road shoulders and signs effectively reduced the number of casualty crashes.

In regional Queensland, there was very strong evidence that roundabouts and new traffic lights with turn arrows effectively reduced the number of casualty crashes. There was no statistical evidence that traffic islands on approach, indented right and left turn islands, new traffic lights with no turn arrows, sealing road shoulders, edge lines and improved lighting affected the number of casualty crashes.

South Australia

There was very strong evidence in Adelaide that indented left and right hand turn islands effectively reduced the number of casualty crashes. There was weak statistical evidence that new traffic lights with no turn arrows effectively reduced the number of casualty crashes. There was no statistical evidence that roundabouts, traffic islands on approach, new traffic lights with turn arrows, sealing road shoulders and signs affected the number of casualty crashes.

TABLE 6.7 TREATMENT EFFECT IN VICTORIA BY TREATMENT TYPE

T Code	*VIC*	*Estimate(β)*	*Std Error*	*Probability 0≤p≤1*	*Casualty crash reduction (%)*
	Melbourne				
K1	Roundabout	–2.0743	0.7149	0.0037	87.4
K14	Traffic island on approach	–0.5491	0.3914	0.1607	42.3*
K15	Indented right & left turn islands	–0.2056	0.2088	0.3248	18.6*
K19	Median	–0.5936	0.1949	0.0023	44.8
K2	New traffic light—no turn arrow	–0.4617	0.3162	0.1443	37.0*
K3	New traffic light—with turn arrow	–0.5568	0.1381	<.0001	42.7
OT	All other	–0.2951	0.1462	0.0435	25.6
S13	Non-skid surface	–0.4218	0.1224	0.0006	34.4
S14	Shoulder seal	–0.424	0.2136	0.0471	34.6
S17	Edge lines	0.0563	0.1702	0.7406	–5.8*
S2	Pedestrian facilities	–0.2539	0.2253	0.2598	22.4*
S20	Signs	–0.3021	0.1404	0.0314	26.1
S7	Improved lighting	0.2314	0.0985	0.0188	–26.0
	Regional Victoria				
K1	Roundabout	–1.2782	0.3481	0.0002	72.1
K14	Traffic island on approach	–0.7814	0.5229	0.1351	54.2*
K15	Indented right & left turn islands	0.0164	0.2646	0.9507	–1.7*
K19	Median	–1.7112	1.0395	0.0997	81.9
K2	New traffic light—no turn arrow	–18	4 353.724	0.9967	100.0*
K3	New traffic light—with turn arrow	–0.0667	0.2949	0.8211	6.5*
OT	All other	–0.8862	0.3421	0.0096	58.8
S13	Non-skid surface	0.0074	0.4565	0.9871	–0.7*
S14	Shoulder seal	–0.5792	0.2339	0.0133	44.0
S17	Edge lines	–0.4539	0.2461	0.0652	36.5
S2	Pedestrian facilities	0.4925	1.0954	0.653	–63.6*
S20	Signs	–1.5623	1.0199	0.1256	79.0*
S7	Improved lighting	–18	8 925.707	0.9984	100.0*

Note T Code =Treatment code—for details see appendix VI.
Some T-codes are a combination of several T-codes.
Reductions that are not statistically significant are indicated with an asterisk (*).

Source BTE estimates

TABLE 6.8 TREATMENT EFFECT IN QUEENSLAND BY TREATMENT TYPE

T Code	QLD	Estimate(β)	Std Error	Probability 0≤p≤1	Casualty crash reduction (%)
	Brisbane				
K1	Roundabout	–2.1018	0.5957	0.0004	87.8
K14	Traffic island on approach	–18	3 233.657	0.9956	100.0*
K15	Indented right & left turn islands	–0.4028	0.5349	0.4514	33.2*
K19	Median	–18	1 598.040	0.991	100.0*
K2	New traffic light—no turn arrow	–1.1505	0.6172	0.0623	68.4
K3	New traffic light—with turn arrow	–1.0893	0.148	<.0001	66.4
OT	All other	–0.1346	0.6081	0.8248	12.6*
S13	Non-skid surface	–18	4 891.700	0.9971	100.0*
S14	Shoulder seal	–0.2882	0.3927	0.463	25.0*
S20	Signs	–0.6685	1.0437	0.5219	48.8*
	Regional Queensland				
K1	Roundabout	–1.6122	0.3656	<.0001	80.1
K14	Traffic island on approach	–0.1956	0.3967	0.622	17.8*
K15	Indented right & left turn islands	–18	5 055.290	0.9972	100.0*
K2	New traffic light—no turn arrow	–18	5 025.045	0.9971	100.0*
K3	New traffic light—with turn arrow	–1.7106	0.4634	0.0002	81.9
OT	All other	–18	2 782.682	0.9948	100.0*
S13	Non-skid surface	0.8308	0.4424	0.0604	–129.5
S14	Shoulder seal	–0.3125	0.3898	0.4227	26.8*
S17	Edge lines	–18	4 196.180	0.9966	100.0*
S7	Improved lighting	0.6763	0.8347	0.4178	–96.7*

Note T Code =Treatment code—for details see appendix VI.
Some T-codes are a combination of several T-codes.
Reductions that are not statistically significant are indicated with an asterisk (*).

Source BTE estimates

TABLE 6.9 TREATMENT EFFECT IN SOUTH AUSTRALIA BY TREATMENT TYPE

T Code	*SA*	*Estimate(β)*	*Std Error*	*Probability 0≤p≤1*	*Casualty crash reduction (%)*
	Adelaide				
K1	Roundabout	–18	4 706.643	0.9969	100.0*
K14	Traffic island on approach	–18	4 068.448	0.9965	100.0*
K15	Indented right & left turn islands	–0.7288	0.2159	0.0007	51.8
K2	New traffic light—no turn arrow	–0.6277	0.3670	0.0872	46.6
K3	New traffic light—with turn arrow	–0.3287	0.3361	0.3281	28.0*
S14	Shoulder seal	0.3252	0.6136	0.5962	–38.4*
S20	Signs	0.3316	1.1565	0.7743	–39.3*
	Regional South Australia				
K1	Roundabout	–1.2574	0.5234	0.0163	71.6
K14	Traffic island on approach	0.2264	0.602	0.7069	–25.4*
K15	Indented right & left turn islands	–0.7146	1.0699	0.5042	51.1*
K2	New traffic light—no turn arrow	–18	6 656.198	0.9978	100.0*
OT	All other	–18	5 028.092	0.9971	100.0*
S14	Shoulder seal	–0.0310	0.2086	0.8817	3.1*
S20	Signs	–0.2291	0.263	0.3837	20.5*

Note T Code =Treatment code—for details see appendix VI.
Some T-codes are a combination of several T-codes.
Reductions that are not statistically significant are indicated with an asterisk (*).

Source BTE estimates

TABLE 6.10 TREATMENT EFFECT IN WESTERN AUSTRALIA BY TREATMENT TYPE

T Code	*WA*	*Estimate(β)*	*Std Error*	*Probability 0≤p≤1*	*Casualty crash reduction (%)*
	Perth				
K1	Roundabout	–0.6596	0.2930	0.0244	48.3
K14	Traffic island on approach	–0.3348	0.1787	0.0610	28.5
K15	Indented right & left turn islands	–0.0926	0.2000	0.6434	8.8*
K19	Median	–0.9757	0.6080	0.1085	62.3
K2	New traffic light—no turn arrow	–0.4831	0.2542	0.0574	38.3
K3	New traffic light—with turn arrow	–0.2194	0.1034	0.0339	19.7
OT	All other	0.5149	0.5152	0.3176	–67.3*
S13	Non-skid surface	0.1083	0.6332	0.8641	–11.4*
S20	Signs	0.1547	0.2095	0.4602	–16.7*
S7	Improved lighting	0.4287	0.4297	0.3184	–53.5*
	Regional Western Australia				
K1	Roundabout	–2.7311	1.0130	0.0070	93.5
K14	Traffic island on approach	0.2822	0.3873	0.4663	–32.6*
K15	Indented right & left turn islands	–1.2631	1.0709	0.2382	71.7*
K19	Median	–0.4111	1.0967	0.7078	33.7*
K2	New traffic light—no turn arrow	–1.0680	1.0615	0.3144	65.6*
K3	New traffic light—with turn arrows	0.0430	0.2710	0.8739	–4.4*
OT	All other	–1.1624	0.4755	0.0145	68.7
S13	Non-skid surface	0.0948	0.3223	0.7688	–9.9*
S14	Shoulder seal	–1.4603	1.0548	0.1662	76.8*
S17	Edge lines	-0.1504	0.2563	0.5575	14.0*
S20	Signs	-18	8 209.749	0.9983	100.0*
S7	Improved lighting	–1.1265	0.6173	0.0680	67.6

Note T Code =Treatment code—for details see appendix VI.
Some T-codes are a combination of several T-codes.
Reductions that are not statistically significant are indicated with an asterisk (*).

Source BTE estimates

In regional South Australia, there was moderate evidence that roundabouts effectively reduced the number of casualty crashes. There was no statistical evidence that traffic islands on approach, indented right and left turn islands, new traffic lights with no turn arrows, sealing road shoulders and signs affected the number of casualty crashes.

Western Australia

There was moderate evidence in Perth that roundabouts and new traffic lights with turn arrows effectively reduced the number of casualty crashes. There was weak statistical evidence that traffic islands on approach and new traffic lights with no turn arrows effectively reduced the number of casualty crashes. There was no statistical evidence that indented left and right hand turn islands, medians, non-skid surfaces, signs and improved lighting affected the number of casualty crashes. However, the results for medians were just outside the cut-off point for weak evidence of an effect.

In regional Western Australia, there was strong evidence that roundabouts effectively reduced the number of casualty crashes. There was weak evidence that improved lighting effectively reduced the number of casualty crashes. There was no statistical evidence that traffic islands on approach, indented right and left turn islands, medians, new traffic lights with no turn arrows, new traffic lights with turn arrows, non-skid surfaces, sealing road shoulders, edge lines and signs affected the number of casualty crashes.

Tasmania

There was strong evidence in Hobart that new traffic lights with turn arrows effectively reduced the number of casualty crashes. There was no statistical evidence that roundabouts, indented left and right hand turn islands, non-skid surfaces, sealing road shoulders, pedestrian facilities and signs affected the number of casualty crashes.

In regional Tasmania, there was very strong evidence that roundabouts effectively reduced the number of casualty crashes. There was no statistical evidence that traffic islands on approach, indented right and left turn islands, medians, sealing road shoulders, edge lines, pedestrian facilities and signs affected the number of casualty crashes.

Northern Territory

There was weak evidence in Darwin that medians effectively reduced the number of casualty crashes. There was no statistical evidence that roundabouts, traffic islands on approach, new traffic lights with no turn arrows, pedestrian facilities and improved lighting affected the number of casualty crashes.

TABLE 6.11 TREATMENT EFFECT IN TASMANIA BY TREATMENT TYPE

T Code	TAS	Estimate(β)	Std Error	Probability 0≤p≤1	Casualty crash reduction (%)
	Hobart				
K1	Roundabout	–0.6765	0.5246	0.1972	49.2*
K15	Indented right & left turn islands	–0.5872	0.7039	0.4041	44.4*
K3	New traffic light—with turn arrow	–1.5443	0.5382	0.0041	78.7
S13	Non-skid surface	–18	4 674.484	0.9969	100.0*
S14	Shoulder seal	1.4865	0.9738	0.1269	–342.2*
S2	Pedestrian facilities	–1.1908	1.1150	0.2855	69.6*
S20	Signs	0.2879	0.3907	0.4611	–33.4*
	Regional Tasmania				
K1	Roundabout	–1.9878	0.5963	0.0009	86.3
K14	Traffic island on approach	–0.8982	0.7750	0.2465	59.3*
K15	Indented right & left turn islands	0.1168	0.7631	0.8783	–12.4*
K19	Median	–0.9276	1.0301	0.3678	60.4*
OT	All other	–18	5 198.556	0.9972	100.0*
S14	Shoulder seal	–18	7 295.636	0.9980	100.0*
S17	Edge lines	–18	8 773.450	0.9984	100.0*
S2	Pedestrian facilities	0.7033	1.1508	0.5411	–102.0*
S20	Signs	–1.3579	1.0285	0.1867	74.3*

Note T Code =Treatment code—for details see appendix VI.
Some T-codes are a combination of several T-codes.
Reductions that are not statistically significant are indicated with an asterisk (*).

Source BTE estimates

TABLE 6.12 TREATMENT EFFECT IN THE NORTHERN TERRITORY BY TREATMENT TYPE

T Code	*NT*	*Estimate(β)*	*Std Error*	*Probability 0≤p≤1*	*Casualty crash reduction (%)*
	Darwin				
K1	Roundabout	0.8381	0.6892	0.2240	–131.2*
K14	Traffic island on approach	–0.5712	0.5983	0.3397	43.5*
K19	Median	0.6923	0.3725	0.0631	–99.8
K2	New traffic light—no turn arrow	–18	3463.995	0.9959	100.0*
OT	All other	–18	5922.396	0.9976	100.0*
S2	Pedestrian facilities	–18	2263.997	0.9937	100.0*
S7	Improved lighting	–0.0210	1.0685	0.9843	2.1*
	Regional Northern Territory				
K1	Roundabout	–0.4364	0.5914	0.4606	35.4*
K19	Median	–18	6198.002	0.9977	100.0*
OT	All other	–0.2703	0.2259	0.2314	23.7*
S14	Shoulder seal	0.1813	0.5792	0.7543	–19.9*
S7	Improved lighting	–1.6884	1.0349	0.1028	81.5*

Note T Code =Treatment code—for details see appendix VI.
Some T-codes are a combination of several T-codes.
Reductions that are not statistically significant are indicated with an asterisk (*).

Source BTE estimates

TABLE 6.13 TREATMENT EFFECT IN THE AUSTRALIAN CAPITAL TERRITORY BY TREATMENT TYPE

T Code	*ACT*	*Estimate(β)*	*Std Error*	*Probability 0≤p≤1*	*Casualty crash reduction (%)*
	Australian Capital Territory				
K1	Roundabout	–1.2555	0.7406	0.0900	71.5
K14	Traffic island on approach	0.0197	0.4332	0.9637	–2.0**
K15	Indented right & left turn islands	–1.1575	0.7453	0.1204	68.6*
OT	All other	–1.4521	1.0383	0.1619	76.6**

Note T Code =Treatment code—for details see appendix VI.
Some T-codes are a combination of several T-codes.
Reductions that are not statistically significant are indicated with an asterisk (*).

Source BTE estimates

In regional areas in the Northern Territory, there was no statistical evidence that roundabouts, medians, sealing road shoulders, and improved lighting affected the number of casualty crashes. However, the results for improved lighting were just outside the cut-off point for weak evidence of an effect.

Australian Capital Territory

There was weak evidence in Canberra that roundabouts effectively reduced the number of casualty crashes. There was no statistical evidence that traffic islands on approach and indented right and left hand turn islands affected the number of casualty crashes. However, the results for indented right and left hand turn islands were just outside the cut-off point for weak evidence of an effect.

Because of its size, the Australian Capital Territory is assumed to be totally urban. Therefore, there are no results for treatment effectiveness for regional areas in the Territory.

CONCLUSION

There is very strong evidence that the Black Spot Program has effectively reduced the number of casualty crashes. It is estimated that the Program prevented around 32 fatal crashes and 1 539 serious crashes between1996–97 and 1998–99. The Program is therefore estimated to have saved at least 32 lives and prevented a large number of injuries over these three years. Further benefits will accrue over the life of the black spot treatments that were applied.

There are gains to be made by changing the mix of black spot treatments used, as some of the treatments currently used are effective in either urban or regional settings, but not both. Some treatments appear to be ineffective.

7

BENEFIT-COST ANALYSIS

This chapter presents the benefits and costs of the Black Spot Program to the Australian community. Benefit-cost analyses conducted before a project starts are often used to help determine if the project should go ahead. Those done at the end of a project can help establish if expectations about the project were met and if it would be worthwhile maintaining the project or initiating a similar project in the future. The current Federal Black Spot Program finishes on 30 June 2002. At the time this report was prepared, the Program had more than 12 months to run. This evaluation assessed the effects of the first three years of the Program. There are two methods used to conduct this sort of evaluation.

The first method considers all capital expenditures that have already been incurred as sunk costs. The evaluation may be based on those benefits and costs that will recur during the project's lifetime. This approach is appropriate when considering whether to incur the maintenance costs necessary for a project to continue until the end of its planned life.

The second method considers whether the project should have gone ahead, including all benefits and costs. This approach is appropriate when considering whether to invest in a similar project in the future.

This evaluation adopted the second approach, because the BTE anticipates it will be used to guide decision-making on possible future investments in black spot treatments when the current Program ends on 30 June 2002.

CALCULATION METHOD AND ASSUMPTIONS

The Program's expected benefits are that lives will be saved and that injuries will be prevented; or if sustained, be less severe. The limitations of the road crash databases in some jurisdictions, meant this evaluation had to be performed using the number of fatal and injury crashes instead of the number of people killed and injured. Chapter 6 presented estimates of the Black Spot Program benefits in terms of the number of fatal and injury crashes prevented. A fatal crash is a crash in which at least one person dies at the time of the crash or within 30 days of the crash. An injury crash is a crash in which at least one person sustains a serious or minor injury. By implication, lives are saved by preventing fatal crashes and injuries are prevented by reducing the number of injury crashes.

Although the Black Spot Program aims to reduce the number of fatal and serious injury crashes, the crash data provided by the States and Territories include some minor injury crashes, and in some cases, PDO crashes.

Applying certain treatments would change the travel time on particular routes as well as vehicle operating and maintenance costs. Some treatments—for example, roundabouts—could increase travel time and vehicle operating costs. Others—for example, sealing road shoulders—could decrease them. The extensive data requirements for this type of analysis meant it was not possible to calculate the benefits and costs of these changes.

The BTE (2000) estimated average Australian crash costs in 1996 dollars. The cost of a fatal crash was $1.7 million; the cost of a serious injury crash was $408 000; and the cost of a minor injury crash was $14 000. These costs were used to value savings attributable to the Program. The unit costs for serious and fatal crashes were adjusted to compensate for some definitional inconsistencies. There is no inconsistency in a single-vehicle crash. Problems arise in the way multi-vehicle crashes are reported. For example, a fatal crash involving three vehicles in which one person dies is classified as one fatal crash. If injuries are sustained in the other two vehicles, they may be separated for reporting and record-keeping purposes and included as serious crashes, or they may be filed under fatal crashes.

The same problem arises in serious crashes with no fatalities. If multiple vehicles are involved, there may be no serious injuries in some vehicles. However, these may be separated and reported as minor or PDO crashes, or they may be filed as serious crashes. If appropriate adjustments are not made, this problem would lead to the overestimation of benefits.

The unit cost of a serious crash was adjusted downwards by 48 per cent and the unit cost of a fatal crash was adjusted downwards by 38 per cent. These percentages were derived from the conservative assumption that 50 per cent of crashes reported as fatal involved a second vehicle in which there were no fatalities, and 50 per cent of crashes reported as serious involved a second vehicle in which there were no serious injuries. In these cases, the costs in the second vehicle were assumed to be those associated with less serious consequences. That is, those in the second vehicle involved in a fatal crash sustain one serious injury, and those in the second vehicle involved in a serious crash sustain one minor injury.

Normally, these 1996 crash costs would be converted to dollar values in 2000. However, this black spot evaluation uses 1996 as its base year. This was done for three reasons:

- 1996 was the first year of the Black Spot Program;

- it is not clear that crash distribution patterns have remained constant over time; and
- there have been relative price changes since 1996.

While expressing results in 1996 dollars rather than in 2000 dollars does not change any recommendations, it is a reminder that one of the key assumptions in this analysis is that the benefits of preventing crashes have remained similar in real terms over the Program to date.

For the purposes of this analysis, the type of crash prevented was ignored. For example, a right angle fatal crash and a head-on fatal crash were assumed to involve the same costs to society. While the PDO costs of these two crash types would differ, PDO costs account for only a very small proportion of the costs associated with fatal and serious crashes. The difference in the average cost of each of these crash types would thus be quite small.

A sample of the data submitted was analysed to determine the benefits of preventing crashes at particular sites. This analysis used the costs in BTE (2000) and the actual distribution of crash severity, rather than the reported distribution of crash severity. Since the percentage crash reductions shown in chapter 6 account for the regression-to-mean and trend effects, the savings from the crashes prevented can be calculated by applying the percentage reduction to the *before* annual crash frequency.

The annual benefits and maintenance costs for the treatment's economic life were assumed to be equal to those applying to the first year after its completion.

The maximum treatment life was set at 15 years. Although jurisdictions expected the effective life of most treatments to exceed 15 years, many safety projects involve patching work on roads that require upgrading. This does not necessarily imply that physical road conditions at such sites have deteriorated. For example, suppose a new shopping complex was built near a previously adequate roundabout. Even if the roundabout was in very good condition, its capacity may be exceeded as a result of changed traffic flows, and it may need to be replaced. Changes in road use tend to shorten the life of some safety treatments. The effective lifetimes originally submitted by States and Territories did not take this factor into account.

Statistical analysis showed that some treatments had no statistically significant effect on the number of crashes. In these cases, treatments were deemed to have a life of five years. The rationale for this assumption is that if a treatment is considered ineffective and crashes continue to occur, there is an incentive to apply a different second treatment. However, planning cycles are such that it may take time for such problems to be identified and new treatments applied, eventually replacing the previous treatment.

It would be technically feasible to conduct a BCA on a project by project basis and then aggregate the results for the Program. However, this approach would be very time consuming given the large number of projects involved. In this analysis, identical treatments were grouped together for analytical purposes. For example, all roundabouts in regional or urban areas were grouped together. This approach has some pitfalls because the expected lifetimes of the treatments varied. This problem was minimised by shortening the lifetime of projects to a maximum of 15 years. Most of the differences in lifetimes were expected to occur beyond the 20-year mark.

The equation below was used to estimate the present value of benefits over the expected lifetime of each project. The model implicitly assumes that benefits are expressed equally over each year of the project's life, as explained earlier. The BTE believes this assumption is reasonable for evaluating the Black Spot Program as a whole. However, some caution would be appropriate if this approach was used to evaluate particular projects.

$$PV = B\left[\frac{1 - (1 + r)^{-n}}{r}\right]$$

where B = recurring annual benefits, r = discount rate and n = expected life of the project.

The BCR was calculated as the present value of benefits less maintenance costs, divided by the present value of the capital cost. Discount rates of eight, seven, five, and three per cent were used to assess the results' sensitivity to variations in the discount rate.

It is important to note that all treatments were included in the BCA—not only those with statistically significant effects. When considering whether individual treatments are worthwhile, evidence of their crash reducing potential should be considered in conjunction with the BCRs presented in this chapter.

BCAs of the Federal Black Spot Program were also conducted at the State and Territory level. The results of these analyses are given in appendix XV, and show that the Federal Black Spot Program generated substantial net benefits for all jurisdictions except the Northern Territory.

RESULTS

Tables 7.1 to 7.7 show the evaluation results of the sampled projects, presented by year, by urban areas—defined here as capital cities—and by regional areas.

Tables 7.8 to 7.14 show the evaluation results for all of the projects from 1996–97 to 1998–99. This analysis assumes that the percentage reductions in the number of crashes estimated in chapter 6 for the treatments in the sample apply to treatments across the whole program.

For those projects where the jurisdictions involved supplemented the Federal Government's allocations, the relevant costs considered for evaluation purposes were the Federal Government's costs plus the jurisdictions' costs. The Federal Black Spot Program contributed more than 95 per cent of the identified funding on a project by project basis.

The maintenance costs of a project were defined as the recurrent expenditure needed to maintain the project at an optimal level, less the maintenance costs of any previous treatment replaced by the project. For example, suppose an existing set of traffic lights with no turn arrows was modified to include turn arrows. The incremental annual maintenance cost would be that associated with the turn arrows—the cost of replacing bulbs, including the marginal labour cost for routine inspection/monitoring and maintenance. For the evaluation of the sample, the maintenance costs used were those estimated by each jurisdiction. However, where jurisdictions did not provide an estimate—or the cost provided was less than 15 per cent of the capital cost—then the cost of maintaining the project at optimum functionality was assumed to be 15 per cent of the capital cost. The Australian Capital Territory, for example, estimates its annual maintenance costs at 10 per cent of its capital costs.

The sample results in table 7.1 show that the sample projects, considered as a group, were good public investments returning a BCR of 16.3 at a discount rate of five per cent. Positive net present values were recorded for treatments found to have a statistically significant beneficial effect. Negative net present values were recorded for improved lighting in urban areas and for non-skid surfaces and pedestrian refuges in regional areas. These results need to be carefully considered by road traffic authorities, particularly as the MUARC study of the Victorian Black Spot Program—referred to in chapter 6—also found negative net present values for pedestrian facilities and skid-resistant surfaces.

The positive net present values for treatments not found to have a statistically significant beneficial effect should not be taken as an endorsement of their continued use in the longer term. The average crash rates decreased where these treatments were applied, so positive net present values were generated. But the crash rates did not decrease sufficiently to conclude that the effect was not due to chance. The BTE recommends that road traffic authorities apply treatments with statistically significant beneficial effects where appropriate; and monitor the effects of unproven treatments more closely.

All treatment results were included in the economic evaluation, irrespective of whether or not they produced statistically significant crash reductions. The probability of obtaining statistically significant results increases with sample size. For example, if shoulder sealing applied in a jurisdiction makes up a small sample of projects, its effectiveness may not be statistically significant. However, shoulder sealing grouped and assessed at the national level is more likely to yield statistically significant results.

Treatments that were not statistically significant were assigned a lifetime of only five years because it was assumed they would be replaced with a more effective treatment in that time. Statistically significant treatments were assigned a lifetime of 15 years. This methodological approach explains why the sum of net present values for treatments applied in each jurisdiction would not necessarily equal the net present value at the national level.

Table 7.8 shows the evaluation results for all projects. Safety-audited projects and some projects that had incomplete data or other problems critical to meaningful BCA are not included. The overall evaluation results strongly support the continuation of the Black Spot Program. The overall BCR of 14.1 calculated at a discount rate of five per cent shows that, considered as a group, the treatments are expected to deliver substantial net benefits. The favourable overall result is not very sensitive to changes in the discount rate.

Comparing the results shown in table 7.1 for the sample of 608 projects, with the results shown in table 7.8 for all the projects, suggests that the sample selected was biased towards successful projects. So the analysis presented in the rest of this chapter deals with the results for all projects.

For the sample, positive net present values were recorded for treatments that produce a statistically significant beneficial effect. The results of the statistical analysis suggest that, in capital cities, the use of improved lighting, pedestrian signals and pedestrian refuges, sealing road shoulders and edge lines need to be re-examined. In the case of street lighting, the assessment of effectiveness appears to have been affected by data quality. Similarly, in regional areas, the use of non-skid surfaces, pedestrian overpasses, sealing road shoulders, indented right hand turn islands and signs need to be re-examined.

Interpreting the results

Several factors need to be considered when deciding which treatment to apply to a black spot. Choosing a treatment type requires a risk/return trade-off decision. The main questions involved in the decision are discussed below.

Did the treatment produce a statistically significant decrease in the number of crashes in the area?

If not, then unless the standard error was large—perhaps because the treatment is innovative and not yet in common use, or deals with a rare type of target crash—the treatment may not be effective. Small sample size is not the only reason a good treatment might generate a statistically insignificant reduction in the number of crashes. But it is the most important reason. Other reasons were discussed in chapter 6.

Did the treatment produce a favourable BCR and net present value?

There may be more than one treatment type that effectively prevents a particular type of target crash. In such cases, the BCRs and net present values of all treatments should be considered. A treatment might have a high BCR but a low net present value, if it effectively prevented a large number of crashes but was seldom used. Another treatment might have a moderate BCR and a high net present value if it produced an effective—but not exceptional—reduction in the number of crashes and was used frequently.

Evaluation of safety-audited projects

The Black Spot Program allows for the funding of safety-audited projects. These projects are aimed at sites in the road network where crashes have not yet occurred but which are deemed to be *waiting for an accident to happen*. It could be argued that these sites may not be genuinely hazardous. However, this reasoning may not be appropriate in all cases. For example, if traffic conditions at a site change rapidly, its past crash rate will be a poor predictor of its expected future crash rate. In most cases, hazardous sites have warning signs or other safety measures to slow down traffic movement. However, physical improvements may be necessary to maintain safety levels, while restoring traffic speeds to normal levels.

Safety-audited projects have no before treatment crashes against which treatment effects may be measured. Their effectiveness could be evaluated using proxies and assumptions based on similar sites possessing similar characteristics—including traffic volume and physical layout. Long periods of after treatment data are required to generate meaningful assessments of safety-audited projects using these approaches.

Because only short periods of after treatment data were available when this report was prepared, the BTE concluded that it would be inappropriate to assess safety-audited projects. Therefore, the BTE did not attempt to calculate the net present value and BCR of the safety-audited projects in the Black Spot Program.

CONCLUSION

The Black Spot Program has been extremely worthwhile on benefit-cost grounds. Using the treatment results obtained from the sample and applying them to all of the projects, the BTE estimates that the Black Spot Program—excluding expenditure on safety-audited projects—generated a net present value of $1.3 billion and a BCR of 14.1. This means that every taxpayer dollar invested produced a fourteen dollar return in lives saved, injuries prevented and related cost savings.

Largely because of greater traffic flow through capital city black spots, the capital city part of the Program delivered significantly greater benefits than the regional part. The capital city BCR was over 18 whereas the regional BCR was under 11. On this basis, if the only criterion for program expenditure was to maximise the economic return to Australia, then the proportion of expenditure in urban areas would be increased.

This analysis supports continuing the Program, with modifications to increase its effectiveness. The fall in BCRs over the three years examined was not statistically significant. As a matter of good public policy, it would be advisable to evaluate the entire current six-year Program after its completion.

TABLE 7.1 NATIONAL EVALUATION RESULTS FOR THE SAMPLE OF 608 PROJECTS

	Discount Rate (%)	*8*	*7*	***5***	*3*
Capital city	Capital ($ '000)	26 812	27 009	**27 417**	27 844
	PV benefits ($ '000)	434 680	464 725	**534 769**	621 244
	NPV ($ '000)	407 868	437 716	**507 353**	593 400
	BCR	16.2	17.2	**19.5**	22.3
Regional	Capital ($ '000)	27 890	28 084	**28 487**	28 909
	PV benefits ($ '000)	308 645	329 331	**377 369**	436 361
	NPV ($ '000)	280 755	301 247	**348 882**	407 452
	BCR	11.1	11.7	**13.2**	15.1
	NPV Overall ($ '000)	688 623	738 963	**856 234**	1 000 852
	BCR Overall	13.6	14.4	**16.3**	18.6

Source BTE

TABLE 7.2 CAPITAL CITY RESULTS BY TREATMENT TYPE FOR THE 1996–97 SAMPLE

Treatment	*Project cost*	*NPV (8%)*	*NPV (7%)*	***NPV (5%)***	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	***BCR (5%)***	*BCR (3%)*
Roundabout	2 170	32 695	34 929	**40 109**	46 457	16.1	17.1	**19.5**	22.4
Traffic islands	347	7 529	8 033	**9 203**	10 637	22.7	24.2	**27.5**	31.7
Indented right & left turn islands	453	17 801	18 970	**21 682**	25 005	40.3	42.9	**48.9**	56.2
Median	1 468	26 377	28 161	**32 298**	37 367	19.0	20.2	**23.0**	26.5
New traffic lights—no T-arrow	1 554	25 302	27 023	**31 013**	35 903	17.3	18.4	**21.0**	24.1
New traffic lights—with T-arrow	2 670	60 757	64 821	**74 245**	85 792	23.8	25.3	**28.8**	33.1
All other	339	5 373	5 739	**6 587**	7 627	16.9	17.9	**20.4**	23.5
Non-skid surface	330	14 510	14 971	**15 964**	17 060	44.9	46.3	**49.3**	52.7
Seal shoulders	719	899	943	**1 036**	1 137	2.3	2.3	**2.4**	2.6
Pedestrian facilities	538	605	636	**701**	773	2.1	2.2	**2.3**	2.4
Signs	292	842	895	***1 013***	1 149	3.9	4.1	**4.5**	4.9
Improved lighting	16	-318	-327	**–344**	–363	–19.1	–19.6	**–20.7**	–21.9
Overall	10 894	192 371	204 794	**233 508**	268 544	18.7	19.8	**22.4**	25.6

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000. Column may not add to total due to rounding.

Source BTE

TABLE 7.3 CAPITAL CITY RESULTS BY TREATMENT TYPE FOR THE 1997–98 SAMPLE

Treatment	*Project cost*	*NPV (8%)*	*NPV (7%)*	***NPV (5%)***	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	***BCR (5%)***	*BCR (3%)*
Roundabout	1 828	10 668	11 469	**13 326**	15 601	6.8	7.3	**8.3**	9.5
Traffic islands	795	19 831	21 152	**24 217**	27 972	25.9	27.6	**31.4**	36.2
Indented right & left turn islands	559	17 763	18 937	**21 659**	24 994	32.8	34.9	**39.8**	45.7
Median	710	10 071	10 762	**12 364**	14 327	15.2	16.2	**18.4**	21.2
New traffic lights—no T-arrow	1 815	14 863	15 931	**18 409**	21 446	9.2	9.8	**11.1**	12.8
New traffic lights—with T-arrow	1 900	70 071	74 683	**85 376**	98 479	37.9	40.3	**45.9**	52.8
All other	673	16 970	18 101	**20 722**	23 934	26.2	27.9	**31.8**	36.6
Non-skid surface	205	9 058	9 346	**9 965**	10 650	45.2	46.6	**49.6**	53.0
Seal shoulders	1 074	827	879	**988**	1 107	1.8	1.8	**1.9**	2.0
Edge lines	347	–2 392	–2 447	**–2 565**	–2 693	–5.9	–6.0	**–6.4**	–6.7
Pedestrian facilities	266	340	356	**391**	429	2.3	2.3	**2.5**	2.6
Signs	1 073	12 120	12 736	**14 109**	15 698	12.3	12.9	**14.1**	15.6
Pedestrian signals	272	–333	–335	**–338**	–342	–0.2	–0.2	**–0.2**	–0.3
Improved lighting	180	–9 131	–9 372	**–9 886**	–10 447	–49.8	–51.1	**–54.0**	–57.1
Overall	11 697	170 727	182 198	**208 737**	241 154	15.6	16.6	**18.8**	21.6

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE 7.4 CAPITAL CITY RESULTS BY TREATMENT TYPE FOR THE 1998–99 SAMPLE

Treatment	*Project cost*	*NPV (8%)*	*NPV (7%)*	***NPV (5%)***	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	***BCR (5%)***	*BCR (3%)*
Roundabout	1 651	19 274	20 615	**23 724**	27 534	12.7	13.5	**15.4**	17.7
Traffic Islands	628	5 775	5 947	**6 315**	6 716	10.2	10.5	**11.1**	11.7
Indented right & left turn islands	50	533	570	**657**	763	11.7	12.5	**14.2**	16.4
Median	422	10 036	10 706	**12 259**	14 163	24.8	26.4	**30.1**	34.6
New traffic lights—no T-arrow	114	1 191	1 275	**1 469**	1 707	11.4	12.2	**13.9**	16.0
New traffic lights—with T-arrow	2 301	33 389	35 676	**40 979**	47 476	15.5	16.5	**18.8**	21.6
All other	135	4 941	5 267	**6 021**	6 945	37.5	39.9	**45.5**	52.3
Non-skid surface	115	3 143	3 244	**3 462**	3 703	28.3	29.2	**31.1**	33.2
Seal shoulders	182	546	566	**608**	653	4.0	4.1	**4.3**	4.6
Signs	71	1 081	1 135	**1 255**	1 394	16.2	17.0	**18.7**	20.7
Improved lighting	265	–12 940	–13 281	**–14 009**	–14 803	–47.8	–49.1	**–51.9**	–54.9
Overall	5 934	66 971	71 720	**82 740**	96 251	12.3	13.1	**14.9**	17.2

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE 7.5 REGIONAL RESULTS BY TREATMENT TYPE FOR THE 1996–97 SAMPLE

Treatment	*Project cost*	*NPV (8%)*	*NPV (7%)*	***NPV (5%)***	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	***BCR (5%)***	*BCR (3%)*
Roundabout	6 148	65 534	70 127	**80 777**	93 827	11.7	12.4	**14.1**	16.3
Traffic islands	133	220	229	**250**	272	2.7	2.7	**2.9**	3.0
Indented right & left turn islands	594	4 986	5 343	**6 172**	7 188	9.4	10.0	**11.4**	13.1
Median	428	10 061	10 733	**12 292**	14 201	24.5	26.1	**29.7**	34.2
New traffic lights—no T-arrow	672	12 342	13 176	**15 110**	17 480	19.4	20.6	**23.5**	27.0
New traffic lights—with T-arrow	527	6 767	7 235	**8 318**	9 646	13.8	14.7	**16.8**	19.3
All other	1 034	12 548	13 418	**15 437**	17 909	13.1	14.0	**15.9**	18.3
Non-skid surface—non intersection	396	–1 101	–1 120	**–1 160**	–1 205	–1.8	–1.8	**–1.9**	–2.0
Seal shoulders	2 156	6 415	6 815	**7 707**	8 739	4.0	4.2	**4.6**	5.1
Edge lines	99	3 220	3 281	**3 408**	3 544	33.6	34.2	**35.5**	36.8
Signs	72	3 750	3 929	**4 327**	4 787	53.3	55.8	**61.3**	67.7
Improved lighting	136	3 539	3 710	**4 093**	4 536	26.9	28.2	**31.0**	34.2
Overall	12 395	128 281	136 877	**156 729**	180 924	11.3	12.0	**13.6**	15.6

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE 7.6 REGIONAL RESULTS BY TREATMENT TYPE FOR THE 1997–98 SAMPLE

Treatment	*Project cost*	*NPV (8%)*	*NPV (7%)*	***NPV (5%)***	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	***BCR (5%)***	*BCR (3%)*
Roundabout	4 680	49 177	52 628	**60 630**	70 435	11.5	12.2	**14.0**	16.1
Traffic islands	714	1 648	1 711	**1 847**	1 995	3.3	3.4	**3.6**	3.8
Indented right & left turn islands	525	1 149	1 256	**1 505**	1 809	3.2	3.4	**3.9**	4.4
Median	243	3 190	3 409	**3 919**	4 544	14.2	15.1	**17.2**	19.7
New traffic lights—no T-arrow	401	12 343	13 160	**15 053**	17 373	31.8	33.8	**38.5**	44.3
New traffic lights—with T-arrow	808	11 843	12 654	**14 533**	16 837	15.7	16.7	**19.0**	21.8
All other	1 327	19 269	20 589	**23 649**	27 399	15.5	16.5	**18.8**	21.7
Non-skid surface—non intersection	450	–2 989	–3 057	**–3 203**	–3 362	–5.6	–5.8	**–6.1**	–6.5
Seal shoulder	1 492	3 902	4 154	**4 715**	5 365	3.6	3.8	**4.2**	4.6
Edge lines	126	4 061	4 138	**4 299**	4 470	33.3	33.9	**35.2**	36.6
Pedestrian refuge & others	148	–724	–761	**–847**	–952	–3.9	–4.1	**–4.7**	–5.4
Signs	75	15 719	16 457	**18 100**	20 003	210.4	220.2	**242.1**	267.5
Improved lighting	84	2 864	3 001	**3 308**	3 663	35.2	36.9	**40.5**	44.8
Overall	11 073	121 451	129 339	**147 509**	169 579	12.0	12.7	**14.3**	16.3

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE 7.7 REGIONAL RESULTS BY TREATMENT TYPE FOR THE 1998–99 SAMPLE

Treatment	*Project cost*	*NPV (8%)*	*NPV (7%)*	***NPV (5%)***	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	***BCR (5%)***	*BCR (3%)*
Roundabout	526	7 355	7 860	**9 031**	10 466	15.0	16.0	**18.2**	20.9
Traffic island	633	–284	–274	**–254**	–232	0.6	0.6	**0.6**	0.6
Indented right & left turn islands	407	2 631	2 825	**3 277**	3 830	7.5	7.9	**9.1**	10.4
New traffic lights—with T-arrow	928	608	707	**935**	1 215	1.7	1.8	**2.0**	2.3
Protected left turn lane	433	26 548	28 276	**32 285**	37 197	62.4	66.4	**75.6**	87.0
Non-skid surface	172	–563	–574	**–596**	–621	–2.3	–2.3	**–2.5**	–2.6
Seal shoulders	2 729	3 783	4 087	**4 765**	5 549	2.4	2.5	**2.7**	3.0
Edge lines	15	1 436	1 463	**1 519**	1 578	97.5	99.3	**103.1**	107.0
Pedestrian refuge & others	5	–296	–304	**–321**	–339	–58.7	–60.3	**–63.6**	–67.3
Signs	121	4 386	4 597	**5 066**	5 609	37.2	39.0	**42.9**	47.3
Improved lighting	137	1 084	1 141	**1 268**	1 415	8.9	9.3	**10.3**	11.3
Overall	6 115	46 689	49 805	**56 974**	65 666	8.6	9.1	**10.3**	11.7

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE 7.8 NATIONAL EVALUATION RESULTS FOR ALL PROJECTS

	Discount Rate (%)	*8*	*7*	***5***	*3*
Capital city	Capital ($ '000)	45 171	45 579	**46 426**	47 318
	PV benefits ($ '000)	682 622	731 552	**845 937**	987 689
	NPV ($ '000)	637 452	685 973	**799 511**	940 371
	BCR	15.1	16.1	**18.2**	20.9
Regional	Capital ($ '000)	54 293	54 739	**55 664**	56 638
	PV benefits ($ '000)	486 076	519 245	**596 398**	691 362
	NPV ($ '000)	432	465	**541**	635
	BCR	9.0	9.5	**10.7**	12.2
	NPV Overall ($ '000)	1 069 234	1 150 479	**1 340 245**	1 575 095
	BCR Overall ($ '000)	11.7	12.5	**14.1**	16.2

Note Analysis excludes projects with no casualty crashes, safety-audited projects and some projects with data deficiencies. A total of 946 projects were considered.

Source BTE

TABLE 7.9 CAPITAL CITY RESULTS BY TREATMENT TYPE FOR THE 1996–97 PROJECTS

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	***NPV (5%)***	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	***BCR (5%)***	*BCR (3%)*
K1	2 803	38 163	40 788	**46 874**	54 332	14.6	15.6	**17.7**	20.4
K10	15	846	901	**1 029**	1 186	58.0	61.8	**70.4**	80.9
K11	40	412	441	**509**	591	11.4	12.2	**13.9**	15.9
K14	624	10 129	10 817	**12 415**	14 372	17.2	18.3	**20.9**	24.0
K15	453	17 801	18 970	**21 682**	25 005	40.3	42.9	**48.9**	56.2
K19	1 488	27 157	28 993	**33 249**	38 464	19.3	20.5	**23.4**	26.9
K2	2 651	41 848	44 699	**51 311**	59 412	16.8	17.9	**20.4**	23.4
K3	2 986	64 409	68 728	**78 741**	91 011	22.6	24.0	**27.4**	31.5
K4	515	8 089	8 491	**9 386**	10 423	16.7	17.5	**19.2**	21.2
K6	49	83	85	**90**	96	2.7	2.7	**2.8**	2.9
K7	65	1 560	1 665	**1 906**	2 202	24.9	26.5	**30.2**	34.7
OT	2 118	13 058	14 030	**16 285**	19 048	7.2	7.6	**8.7**	10.0
S1	49	2 594	2 763	**3 156**	3 637	53.5	56.9	**64.8**	74.6
S12	21	1 460	1 554	**1 774**	2 044	69.3	73.8	**84.1**	96.7
S13	448	12 205	12 545	**13 272**	14 065	28.3	29.0	**30.6**	32.4
S14	1 071	550	594	**687**	789	1.5	1.6	**1.6**	1.7
S2	553	630	662	**730**	804	2.1	2.2	**2.3**	2.5
S20	348	2 004	2 114	**2 359**	2 642	6.8	7.1	**7.8**	8.6
S5	80	–79	–79	**–79**	–79	0.0	0.0	**0.0**	0.0
S7	2	–297	–305	**–322**	–340	–124.1	–127.5	**–134.6**	–142.4
Overall	16 378	242 622	258 457	**295 054**	339 703	15.8	16.8	**19.0**	21.7

Note Figures in brackets in top row are discount rates. Project cost and NPV are expressed in $ '000. T Code =Treatment code—for details see appendix VI. Some T-codes are a combination of several T-codes. Column may not add to total due to rounding.

Source BTE

TABLE 7.10 CAPITAL CITY RESULTS BY TREATMENT TYPE FOR THE 1997–98 PROJECTS

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	***NPV (5%)***	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	***BCR (5%)***	*BCR (3%)*
K1	2762	28 960	30 993	**35 706**	41 481	11.5	12.2	**13.9**	16.0
K11	20	793	845	**966**	1 113	41.0	43.7	**49.8**	57.2
K14	795	19 831	21 152	**24 217**	27 972	25.9	27.6	**31.4**	36.2
K15	802	21 430	22 854	**26 158**	30 205	27.7	29.5	**33.6**	38.7
K19	729	10 853	11 595	**13 316**	15 425	15.9	16.9	**19.3**	22.2
K2	2063	16 436	17 621	**20 369**	23 737	9.0	9.5	**10.9**	12.5
K21	99	1 498	1 600	**1 837**	2 128	16.1	17.2	**19.6**	22.5
K3	2325	72 136	76 907	**87 971**	101 527	32.0	34.1	**38.8**	44.7
K4	212	4 417	4 633	**5 115**	5 673	21.9	22.9	**25.1**	27.8
OT	951	27 999	29 854	**34 155**	39 426	30.5	32.4	**36.9**	42.5
S12	13	1 292	1 376	**1 570**	1 807	101.4	107.9	**123.0**	141.4
S13	224	8 509	8 744	**9 246**	9 793	39.0	40.1	**42.3**	44.8
S14	1786	38	87	**192**	306	1.0	1.0	**1.1**	1.2
S17	347	–2 392	–2 447	**–2 565**	–2 693	–5.9	–6.0	**–6.4**	–6.7
S2	440	340	361	**406**	454	1.8	1.8	**1.9**	2.0
S20	1149	13 235	13 907	**15 403**	17 136	12.5	13.1	**14.4**	15.9
S5	272	–333	–335	**–338**	–342	–0.2	–0.2	**–0.2**	–0.3
S7	194	-10 239	–10 509	**–11 086**	–11 716	–51.8	–53.2	**–56.2**	–59.4
Overall	15183	214 802	229 238	**262 637**	303 433	15.1	16.1	**18.3**	21.0

Note Figures in brackets in top row are discount rates. Project cost and NPV are expressed in $ '000. T Code =Treatment code—for details see appendix VI. Some T-codes are a combination of several T-codes. Column may not add to total due to rounding.

Source BTE

TABLE 7.11 CAPITAL CITY RESULTS BY TREATMENT TYPE FOR THE 1998–99 PROJECTS

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	***NPV (5%)***	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	***BCR (5%)***	*BCR (3%)*
K1	3 697	62 532	66 775	**76 615**	88 672	17.9	19.1	**21.7**	25.0
K14	1 074	22 746	24 272	**27 811**	32 148	22.2	23.6	**26.9**	30.9
K15	263	3 264	3 490	**4 014**	4 656	13.4	14.3	**16.3**	18.7
K18	212	6 892	7 083	**7 491**	7 936	33.5	34.4	**36.3**	38.4
K19	650	16 659	17 768	**20 340**	23 491	26.6	28.3	**32.3**	37.2
K2	1 115	22 577	24 096	**27 616**	31 929	21.2	22.6	**25.8**	29.6
K20	40	4 315	4 594	**5 241**	6 033	109.7	116.8	**133.1**	153.0
K21	30	1 273	1 356	**1 550**	1 787	43.8	46.6	**53.1**	61.0
K3	2 545	35 920	38 385	**44 100**	51 103	15.1	16.1	**18.3**	21.1
K4	491	9 113	9 562	**10 561**	11 718	19.6	20.5	**22.5**	24.9
OT	4 910	48 700	52 134	**60 100**	69 859	10.9	11.6	**13.2**	15.2
S1	193	1 210	1 300	**1 509**	1 764	7.3	7.7	**8.8**	10.1
S12	332	2 985	3 198	**3 691**	4 295	10.0	10.6	**12.1**	13.9
S13	115	2 623	2 697	**2 854**	3 026	23.8	24.4	**25.8**	27.3
S14	787	169	195	**250**	310	1.2	1.2	**1.3**	1.4
S2	333	–143	–138	**–128**	–116	0.6	0.6	**0.6**	0.7
S20	71	1 066	1 119	**1 238**	1 375	16.0	16.8	**18.4**	20.4
S7	327	–13 356	–13 707	**–14 455**	–15 272	–39.8	–40.9	**–43.1**	–45.6
Overall	17 185	228 543	244 178	**280 395**	324 713	14.3	15.2	**17.3**	19.9

Note Figures in brackets in top row are discount rates. Project cost and NPV are expressed in $ '000. T Code =Treatment code—for details see appendix VI. Some T-codes are a combination of several T-codes. Column may not add to total due to rounding.

Source BTE

TABLE 7.12 REGIONAL RESULTS BY TREATMENT TYPE FOR THE 1996–97 PROJECTS

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	***NPV (5%)***	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	***BCR (5%)***	*BCR (3%)*
K1	8 882	93 377	99 929	**115 122**	133 739	11.5	12.3	**14.0**	16.1
K14	344	650	677	**734**	796	2.9	3.0	**3.1**	3.3
k15	784	2 416	2 502	**2 686**	2 886	4.1	4.2	**4.4**	4.7
K18	870	–170	–152	**–111**	–68	0.8	0.8	**0.9**	0.9
K19	517	12 730	13 579	**15 547**	17 959	25.6	27.3	**31.1**	35.7
K2	781	13 171	14 065	**16 138**	18 678	17.9	19.0	**21.7**	24.9
K3	804	8 124	8 696	**10 022**	11 648	11.1	11.8	**13.5**	15.5
K4	105	2 081	2 183	**2 411**	2 674	20.9	21.8	**24.0**	26.5
OT	3 021	39 872	42 620	**48 993**	56 801	14.2	15.1	**17.2**	19.8
S13	396	–1 237	–1 260	**–1 308**	–1 361	–2.1	–2.2	**–2.3**	–2.4
S14	6 217	2 922	3 349	**4 299**	5 400	1.5	1.5	**1.7**	1.9
S17	99	5 043	5 182	**5 477**	5 799	52.0	53.4	**56.4**	59.7
S20	106	13 373	14 003	**15 405**	17 029	126.7	132.6	**145.8**	161.1
S7	136	3 419	3 585	**3 955**	4 384	26.1	27.3	**30.0**	33.1
Overall	23 061	195 770	208 958	**239 370**	276 366	9.5	10.1	**11.4**	13.0

Note Figures in brackets in top row are discount rates. Project cost and NPV are expressed in $ '000. T Code =Treatment code—for details see appendix VI. Some T-codes are a combination of several T-codes. Column may not add to total due to rounding.

Source BTE

TABLE 7.13 REGIONAL RESULTS BY TREATMENT TYPE FOR THE 1997–98 PROJECTS

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	***NPV (5%)***	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	***BCR (5%)***	*BCR (3%)*
K1	6 069	61 846	66 198	**76 288**	88 653	11.2	11.9	**13.6**	15.6
K14	745	2 001	2 074	**2 232**	2 404	3.7	3.8	**4.0**	4.2
K15	765	–225	–211	**–180**	–146	0.7	0.7	**0.8**	0.8
K19	243	3 086	3 299	**3 794**	4 399	13.7	14.6	**16.6**	19.1
K2	935	18 450	19 693	**22 573**	26 102	20.7	22.1	**25.1**	28.9
K3	808	11 409	12 192	**14 007**	16 231	15.1	16.1	**18.3**	21.1
K4	160	1 380	1 452	**1 612**	1 797	9.6	10.1	**11.1**	12.2
K6	49	218	223	**233**	244	5.4	5.5	**5.7**	5.9
K7	49	839	896	**1 027**	1 189	17.9	19.1	**21.8**	25.0
OT	2 553	28 340	30 320	**34 910**	40 534	12.1	12.9	**14.7**	16.9
S1	17	985	1 049	**1 198**	1 381	59.5	63.4	**72.2**	83.0
S13	574	3 766	3 968	**4 420**	4 943	7.6	7.9	**8.7**	9.6
S14	2 747	2 978	3 132	**3 461**	3 819	2.1	2.1	**2.3**	2.4
S17	126	17 459	18 281	**20 111**	22 229	139.9	146.4	**161.0**	177.8
S20	85	–5 918	–6 075	**–6 410**	–6 775	–68.7	–70.5	**–74.4**	–78.7
S4	148	–447	–455	**–472**	–491	–2.0	–2.1	**–2.2**	–2.3
S5	79	906	933	**990**	1 051	12.4	12.8	**13.5**	14.3
S7	84	2 864	3 001	**3 308**	3 663	35.2	36.9	**40.5**	44.8
Overall	16 153	147 073	156 968	**179 793**	207 565	10.3	10.9	**12.3**	14.1

Note Figures in brackets in top row are discount rates. Project cost and NPV are expressed in $ '000. T Code =Treatment code—for details see appendix VI. Some T-codes are a combination of several T-codes. Column may not add to total due to rounding.

Source BTE

TABLE 7.14 REGIONAL RESULTS BY TREATMENT TYPE FOR THE 1998–99 PROJECTS

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	***NPV (5%)***	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	***BCR (5%)***	*BCR (3%)*
K1	4 299	42 437	45 432	**52 376**	60 884	10.9	11.6	**13.2**	15.2
K13	129	2 878	3 070	**3 517**	4 064	23.3	24.8	**28.3**	32.5
K14	695	–219	–206	**–179**	–149	0.7	0.7	**0.7**	0.8
K15	938	2 298	2 385	**2 571**	2 774	3.4	3.5	**3.7**	4.0
K19	318	9 453	10 079	**11 531**	13 310	30.7	32.7	**37.3**	42.9
K2	308	3 392	3 629	**4 178**	4 852	12.0	12.8	**14.6**	16.8
K3	1 334	1 806	2 007	**2 473**	3 045	2.4	2.5	**2.9**	3.3
K4	175	2 669	2 802	**3 098**	3 441	16.2	17.0	**18.7**	20.7
OT	5 853	37 147	39 903	**46 291**	54 120	7.3	7.8	**8.9**	10.2
S12	293	611	669	**803**	968	3.1	3.3	**3.7**	4.3
S13	256	–2 099	–2 148	**–2 254**	–2 369	–7.2	–7.4	**–7.8**	–8.3
S14	3 822	2 161	2 441	**3 063**	3 784	1.6	1.6	**1.8**	2.0
S17	15	2 233	2 294	**2 423**	2 564	151.1	155.2	**163.8**	173.3
S2	230	–2 620	–2 684	**–2 822**	–2 972	–10.4	–10.7	**–11.3**	–11.9
S20	131	5 773	6 049	**6 663**	7 374	45.1	47.2	**51.9**	57.3
S7	187	5 341	5 600	**6 175**	6 841	29.5	30.9	**33.9**	37.5
Overall	18 983	113 263	121 320	**139 909**	162 531	7.0	7.4	**8.4**	9.6

Note Figures in brackets in top row are discount rates. Project cost and NPV are expressed in $ '000. T Code =Treatment code—for details see appendix VI. Some T-codes are a combination of several T-codes. Column may not add to total due to rounding

Source BTE

APPENDIX I

ROAD SAFETY BLACK SPOT PROGRAM: 1996–2000

NOTES ON ADMINISTRATION

These Notes on Administration are a guide to the administration of the Black Spot Program and should be read in conjunction with a copy of the Australian Land Transport Development Act 1988 (ALTD). A reference to States in these Notes includes the Northern Territory and the Australian Capital Territory.

Federal Government Supporting Road Safety

1. GENERAL NOTES

1.1 OBJECTIVE

The objective of the Program is to reduce the social and economic costs of road trauma by:

— the identification and cost effective treatment of sites and areas with a record of casualty crashes;

— placing significant focus on the need to reduce rural road trauma, in accordance with national road safety policy objectives;

— using a proportion of funds to treat sites, lengths of roads and areas which official road safety audits have identified as potential crash locations and to implement other road safety measures;

— encouraging widespread consultation with the community to ensure local road-related safety concerns are addressed.

Federal funding for this Program which primarily focuses on cost effective treatment of hazardous road locations reflects the Government's commitment to a national objective of a lower Australian road toll.

The Program aims to provide financial assistance to improve the physical condition or management of locations noted for a high incidence of crashes involving death and serious injury, often termed "Black Spots", and to encourage implementation of safety-related traffic management techniques and other road safety measures that have proven road safety value.

1.2 ADMINISTRATION

The Program will be administered on behalf of the Federal Government by the Federal Office of Road Safety (FORS) within the Commonwealth Department of Transport and Regional Development. State road and transport agencies will manage programs of works within each State.

2. ELIGIBLE WORKS

2.1 ELIGIBILITY CRITERIA

Funds under the Program are available for works on public roads regardless of ownership or control, other than declared National Highways and declared sections of Roads of National Importance where separate funding is available.

The Program aims to fund cost effective safety-oriented projects. Submissions are expected to focus on locations where the highest benefits can be achieved. Works eligible for funding may include any safety-related construction, alteration or remedial treatment.

For the guidance of crash analysts and traffic management engineers, a table of crash reduction potentials for typical treatments is provided at Attachment 3. The table is not intended to replace more detailed information and professional judgement that may be available at the local level.

Funding is mainly available for the treatment of black spot sites or lengths with a proven history of crashes. Project proposals of this sort must be able to demonstrate a benefit to cost ratio of at least 2.

For discrete sites (eg, an intersection, mid-block or short road section): the minimum eligibility criterion will be a history of at least 3 casualty crashes in any one year; or 3 casualty crashes over a three-year period; 4 over a four-year period; 5 over a five-year period, etc.

For road lengths

the minimum eligibility criterion is an average of 3 casualty crashes per kilometre of the length in question, measured over 5 years; OR the length to be treated must be amongst the top 10% of sites identified in each state which have a demonstrably higher crash rate than other roads in a region.

Note: Measures of casualty crashes should be provided for a period commencing not earlier than 1 January 1991.

In addition to the above, up to 20% of program funds are available for the treatment of sites, lengths or areas which may not meet the above crash history criteria, but which have been recommended for treatment on the basis of an official road safety audit report.

Funding may also be available for other road safety measures which, in the view of the Minister, assist in progressing national road safety initiatives.

Federally funded projects are subject to the Environment Protection (Impact of Proposals) Act 1974, and the provisions of Section 30 of the Australian Heritage Commission Act 1975. All proposals with significant environmental or heritage implications must comply with the provisions of this legislation.

2.2 INELIGIBLE WORKS

Funds are not available for the purchase of road-building plant or equipment, for costs incurred after installation or for maintenance costs.

Projects on declared National Highways and on declared sections of Roads of National Importance where separate roads funding is available are not eligible for Black Spot funding.

2.3 SELECTION CRITERIA

Eligible project proposals will be considered for approval according to a range of selection criteria which are intended to maximise the safety benefits of the Program.

Around 60 per cent of fatal crashes and 50 per cent of serious injury crashes occur outside metropolitan areas. The need to reduce road trauma in rural areas has been made a priority in the 1996 National Road Safety Action Plan and is discussed in more detail in Australia's Rural Road Safety Action Plan 1996.

In recognition of this priority, approximately 50 per cent of Black Spot funds in each State (other than Tasmania, the Australian Capital Territory and the Northern Territory) will be reserved for projects in non-metropolitan areas.

For the purpose of this provision, metropolitan areas are defined, on the basis of Australian Bureau of Statistics statistical divisions, as cities and towns with a population in excess of 100,000. The urban-rural criterion will not be applied to Tasmania, the Northern Territory and the Australian Capital Territory.

Community participation and joint funding will be encouraged. Black Spot Program funds are available to treat the core road safety problem(s) at locations. Applications which indicate a commitment of funds, labour or materials from other government or community/industry sources for associated works, will receive favourable consideration.

In making an assessment of which projects will be approved for funding under the program, the Federal Minister will take into account the following factors

- whether the project is eligible (section 2.1, above);
- economic benefits of the project;
- the funds available for urban and rural projects;

- the funds available for hazardous locations for which an official road safety audit report has been obtained;
- contributions to the project from sources other than the Commonwealth;
- whether the expected Commonwealth commitment to a project is less than $500,000;
- whether the project can be completed within the timeframe of the Program;
- whether the State has maintained its own spending on black spot projects.

2.4 COSTS

All costs directly associated with any approved project are eligible for funding. Administrative overheads are indirect costs and therefore are not eligible for funding. Ongoing running costs are not eligible for funding. To achieve maximum effect from the Program, the emphasis will be on low-cost, high-return projects. Projects where the Commonwealth's contribution is estimated to cost less than $500,000 will be given priority consideration.

Joint funding of projects is encouraged.

3. PROJECT SUBMISSIONS

3.1 NOMINEES

Nominations of sites will be invited from State and local governments, community groups, clubs and associations, road user groups and industry.

All nominations are to be referred to:

The Black Spot Consultative Panel

C/- State Road and Transport Agency
in your State.
[List of addresses included on back of attached nomination form.]

It is central to this Program that proposals from around Australia are able to be considered on a rational and consistent basis.

Nominees should be aware that site nominations which fail to confirm the basic eligibility criteria in regard to crash history (or are not supported by road safety audit) cannot be considered for approval.

On receipt of a site nomination, the State road and transport agency will check the eligibility of the site and may undertake an economic assessment of a treatment proposal. In all cases, every nomination will be referred for consideration by the consultative panel.

3.2 CONSULTATIVE PANELS

The Federal Minister for Transport and Regional Development will invite each State and Territory to participate in a consultative panel comprising, as appropriate, the Parliamentary Secretary to the Minister for Transport and Regional Development, representatives of the relevant state road and transport agency, local government, and community and road user groups.

The Federal Minister will consider and endorse the final composition of the consultative panels, including appointment of the Chair. The purpose of the panels will be to consider and comment upon *all* nominations for black spot treatment within a State.

The panels will be serviced by the state road and transport agencies. Agencies will provide expert input to the consultative panels, particularly with regard to the collation and assessment of site nominations. Agencies will be asked to provide to FORS, panel members, and other interested parties, a concise outline of the methods used to identify and assess crash locations within their jurisdiction.

3.3 PROGRAM PROPOSALS

Consultative panels should prepare a submission for the consideration of the Federal Minister which lists nominated black spot proposals and includes comment, where appropriate, on each proposal. The initial submission should be submitted as soon as practicable for the 1996/97 program, and subsequent proposals by the end of June 1997 for 1997/98, and June 1998 for 1998/99.

The Minister may consider a program made up of projects submitted by a State Consultative Panel and other projects nominated by the Minister that meet the objectives of the Black Spot Program. The projects should be capable of completion within the time frame of the Program.

The Minister may nominate Federal project priorities if the need arises.

After a submission is received from a consultative panel, the Minister will decide on a program of projects for each State. State and Territory Ministers will be advised of the outcome.

Funds will be paid to the States which will be responsible for distributing project funds.

States must certify that viable proposals conform or will conform with the requirements of Federal and State environmental legislation, as noted in Section 2.1 above.

Submissions from State Consultative Panels should be sent to The Director, Federal Office of Road Safety, Department of Transport and Regional Development, GPO Box 594, Canberra, ACT 2601.

The telephone contact number for the Black Spot Program coordinator is (06) 274 7424. The facsimile contact number is (06) 274 7922.

3.4 CONDITIONS

States will observe conditions relating to funding arrangements set down by the Federal Minister.

The Commonwealth expects States to retain their existing expenditure patterns on black spot programs. In the final determination of allocations to States, the Minister will take into account whether a State has maintained its own spending on black spot projects.

The Minister may announce publicly his approval of a State Program at the same time as notifying the States.

4. FINANCIAL ARRANGEMENTS

4.1 REPORTING

States will provide written reports notifying FORS of approved project status. Alternatively, reports may be provided in electronic (Excel spreadsheet or Microsoft Access) format. Reports are to be provided on the first day of every second calendar month.

The purpose of reports is to monitor both the physical status of approved projects particularly regarding commencement of construction and completion, as well as the financial status of the program as a whole, to enable payments from the Commonwealth to match expenditure by the States. Reports should therefore include the following information:

Approved project reference number
Estimated start date
Estimated completion date
Approved project cost
Expenditure to date
Estimated expenditure for the next two months*
Comment (if appropriate)

* This figure may be calculated on a program basis rather than for individual projects if desired.

4.2 PAYMENTS

States will be advised of an indicative annual funding allocation for approved Programs. An initial payment of 20% of total estimated program cost will be made on approval. Thereafter, payments will be made on receipt of status reports. Payments will be adjusted on the basis of actual expenditure incurred in the previous two months versus estimated expenditure for the subsequent two months.

4.3 STATEMENTS OF EXPENDITURE

Each State is required to submit to the Minister, as soon as practicable after 30 June each year, financial statements, in a form approved by the Minister, giving details of expenditure from amounts paid under the ALTD Act. In preparing statements, States should have regard to the various requirements and conditions specified in the Act.

The approved format for statements of expenditure is at Attachment 1 of these Notes. This format includes amounts expended or set aside during the financial year from amounts paid to the State under the Act.

The following certificates and report will be required in respect to the statement:-

1. A certificate from the Chief Executive Officer or his delegate that:

– "Expenditure in accordance with the itemised break-up shown is for works carried out in accordance with the Act and the *Notes on Administration*."

2. A report by an 'appropriate person', as determined by the Act, which in the case of a State road and transport agency is the Auditor General of the State, stating:

– whether the statement is in the form approved by the Minister;

– whether, in the person's opinion, the statement is based on proper accounts and records;

– whether the statement is in agreement with the accounts and records; and

– whether, in the person's opinion, the expenditure of money has been in accordance with the Act.

The statement should be completed and forwarded to the Department of Transport and Regional Development for Ministerial consideration no later than six (6) months following the end of the financial year for which expenditure is being reported.

5. PUBLIC INFORMATION

5.1 RECOGNITION

The Minister shall be responsible for publicity on approved projects funded from the Program. Publicity material prepared by a State is permissible where projects are at least equally funded by the Federal and State governments. In this case, States shall advise FORS of impending publicity relating to approved projects. Such publicity shall be cleared before release and acknowledge the Federal funding role.

5.2 SIGNPOSTING

States shall erect signposting at approved Black Spot work sites, except where the project cost is less than $100,000. Signs are to conform with wording and layout at Attachment 2. Signs shall remain in place for at least two years. A temporary sign is to be erected while work is in progress on projects less than $100,000. Any other signposting relating to the project must be endorsed by the Minister.

5.3 INFORMATION AND INSPECTIONS

Under the ALTD Act, the Minister may require any other information about a project or exercise the right to visit work sites at any time, as he sees fit, for himself or any officer connected with administration of the program. Officers may, for example, from time to time undertake an inspection of records, including crash diagrams and financial documents, relating to individual projects.

6. EVALUATION

It is of fundamental importance that this Program be accountable for results in terms of outcomes. The Bureau of Transport and Communications Economics (BTCE) will be conducting an independent evaluation of the Program to determine its actual effect on crashes.

For each approved project the States are to provide the BTCE with:

- Number of crashes (severity and type) at each Black Spot site, quarterly for at least 3 years before and 3 years after treatment construction
  - – provision of sufficient crash data detail to enable the BTCE to achieve consistency across States for crash severity and type methodology.
- A record (to within one week) of the start and finish dates of the treatment construction.
- Proposed and final cost of the project and an estimate of annual maintenance and operating costs.
- Project reference number and type of treatment
  - – for new or modified traffic signals, specify if right turn phase is included.
- A measure of exposure (traffic flow) at the site, if possible, during at least one year before treatment and one year after treatment.
- Aggregate data on a regional (urban/non-urban) basis, by State and quarterly from 1994 to 2000 by
  - – number of crashes by severity (fatal, hospital treatment, medical treatment and nil injury crash where available), and
  - – number of crashes by type (RUM equivalent).
- Complete data for 1998 on a regional (urban/non-urban) basis, by State, by

– crash severity (fatal, hospital, medical and nil injury where available), and
– for each defined crash type group (RUM equivalent), the total number of accidents, vehicles involved, deaths, hospital admissions, injuries requiring medical treatment and persons not injured where available.

Source ATSB (1996)

APPENDIX II

OTHER MEASURES RECEIVING BLACK SPOT FUNDING

Section 2.1 of the *Notes on Administration* states that 'funding may also be available for other measures which, in the view of the Minister, assist in progressing national road safety initiatives'.

Only one measure appears to have been funded in this way during the 1996–2000 black spot program: Tasmania's participation in the National Exchange of Vehicle and Driver Information System (NEVDIS). The states have generally funded NEVDIS themselves, but Tasmania was granted funding for the four years from 1996–97 to 1999–2000 at $97 200 per year. This funding came from Tasmania's allocation under the Black Spot Program.

APPENDIX III

FINANCIAL STATEMENT

ROAD SAFETY (BLACK SPOT) PROGRAM FOR 1996 - 1999

Australian Land Transport Development Act (1988)

Statement Of Amounts Expended Or Set Aside For Expenditure From Monies Paid To The State Of ______________________________

Line 1: Amount Carried forward from year ended 30 June 199x
$________

Line 2: Amount Received during year ended 30 June 199x
$________

Line 3: Amount Expended during year ended 30 June 199x
$________

Line 4: Amount Set Aside during year ended 30 June 199x
$________

Note: Line 1 + Line 2 must equal Line 3 + Line 4)

(certificate of Chief Executive Officer)

(certificate of Auditor-General)

Dated ..../.........../..........

Source ATSB (1996)

APPENDIX IV

NOMINATION FORM

Source ATSB (1996)

PROFORMA NOMINATION FORM

THE FEDERAL ROAD SAFETY BLACK SPOT PROGRAM

Nominee details

Nominee Reference No.:
(FORS use only)

1. Title: Dr/Mr/Mrs/etc:
2. Surname:
3. First Name:
4. Organisation:
5. Position title/ occupation:
6. Postal address:

State: Postcode:

7. Telephone number: 8. Fax number
9. Date of Submission:
10. Is this your first nomination to the Black Spot Program? Yes No

Site Nomination

Nominee Reference No.:
(FORS use only)

11. Local Government area of site nomination:
12. Suburb: Postcode:
13. Site description: (eg intersection, 5km road length, 20kms west of Smithsville):

15. Road Name(s): Primary Road:

Intersecting Road (if any):

Nature of concern:

ONLY TO BE COMPLETED BY STATE OR LOCAL GOVERNMENT ROAD AUTHORITES

Site assessment

18. National Highway: Yes ☐ No ☐

19. Is this a State or Local road? Yes ☐ No ☐

20. Is this an Urban or rural project? Yes ☐ No ☐

21. Problem diagnosis: (eg right turn crashes, rear end crashes): ☐

22. Primary crash-type code (DCA): ☐

23. Crash history: **SPOT** **LENGTH**

SPOT		LENGTH	
Fatal crashes	☐	Fatal crashes per km	☐
Injury crashes	☐	Injury crashes per km	☐
Total casualty crashes	☐	Total casualty crashes per km	☐

Measurement period (please indicate). No. of years ☐

24. **FOR ROAD LENGTHS ALONG WHICH THE CRASH RATE PER KILOMETRE HAS NOT BEEN CALCULATED:**

Is this road length amongst the top 10% of lengths identified within the State with a demonstrably higher crash rate than other roads in the State: Yes ☐ No ☐

* This information is optional

24. IF NO CRASH HISTORY HAS BEEN SPECIFIED ABOVE, THE PROPOSAL MUST BE SUPPORTED BY **ROAD SAFETY AUDIT**: is a copy of the relevant report (or section of the report) attached?

Yes ☐ No ☐

Treatment Proposal

25. Proposed Treatment: (eg install signals, modify signals, install roundabout) ☐

26. Treatment Code: (if applicable) ☐

27. Net Present Value: $ ☐

28. Estimated cost to Black Spot Program: $ ☐

29. Benefit Cost Ratio (BCR): ☐☐•☐ **(Not required if nomination is a Road Safety Audit project)**

30. Other contributions to this project: ☐

31. Environmental clearances:

Are there environmental or heritage concerns with this project:

Yes ☐ No ☐

If 'yes', have clearances been obtained: Yes ☐ No ☐

(If yes, please attach)

32. Expected start date (physical construction): ☐

33. Expected completion date (physical construction): ☐

SIGNED on behalf of the)
CONSULTATIVE COMMITTEE)
by *(print name)*)......................................
)
)
in the presence of (WITNESS))......................................
(print name).................................)

APPENDIX V

SIGNAGE

SIGNAGE—SECTION 5.2 of *Notes on Administration*

White background
Blue border, triangle and text: PMS 280
Red star: PMS 185

Size of signs: 600 x 800mm

Source ATSB (1996)

APPENDIX VI

TREATMENT-TYPE DEFINITIONS

For intersection-related crashes

K1	Roundabout
K2	New traffic signal—no turn arrow
K3	New signal—with turn arrow
K4	Re-model signal
K5	Grade separation
K6	Improve sight lines
K7	Street closure—cross intersection
K8	Street closure—T intersection
K9	Stagger cross intersection—right/left
K10	Improve/reinforce priority signs—for example, Stop
K11	Ban right turns
K12	Ban left or U-turns
K13	Improve lighting
K14	Traffic islands on approaches
K15	Indented right turn island
K16	Painted turn lane
K17	Ban parking adjacent to intersection
K18	Non-skid treatment
K19	Extend median through intersection
K20	Reduce radius on left turn sliplane
K21	Protected left turn lane in crossing street

Source ATSB (1996)

For road sections and non-intersection related crashes

S1	Medians on existing carriageway
S2	Pedestrian refuge
S3	Pedestrian crossing
S4	Pedestrian overpass
S5	Pedestrian signals
S6	Pedestrian crossing lighting
S7	Improved route lighting
S8	Clearway, parking bans
S9	Indented right turn island
S10	Painted turn lanes
S11	Roadside hazards—remove
S12	Roadside hazards—guard rail
S13	Non-skid surface
S14	Seal shoulders
S15	Advisory speeds on curves
S16	Delineation
S17	Edge lines
S18	Reconstruct superelevation on curve
S19	Climbing lanes (overtaking lanes)
S20	Signs
S21	Flashing lights
S22	Barriers/gates
S23	Bridge/overpass
S24	Frangible posts/poles

Source ATSB (1996)

APPENDIX VII

STANDARDISED CRASH COSTS—BTE ESTIMATES

TABLE VII.1 SUMMARY OF ROAD CRASH COSTS—1996

Crash severity	*All crashes ($bn)*	*Per crash ($)*	*Per person injured ($)*
Fatal	2.92	1 652 994	1 500 000
Serious	7.15	407 680	325 000
Minor	2.47	13 775	23 000
PDO	2.44	5 808	0
Overall	14.98	24 216	na

na Not applicable

Note Only the fatal and injury per crash costs are used in the benefit-cost analysis of the black spot program. The figures shown were adjusted before use. See chapter 7.

Source BTE 2000

APPENDIX VIII

DEFINITIONS FOR CLASSIFYING ACCIDENTS

(Table reproduced by permission of Vicroads.)

PRINTER, PLEASE INSERT ARTWORK WITHIN KEYLINES

PRINTER, PLEASE INSERT ARTWORK WITHIN KEYLINES

APPENDIX IX

HOSPITALISATION CRASHES

TABLE IX.1 NUMBER OF HOSPITALISATION CRASHES AND ANNUAL PERCENTAGE CHANGES 1988–1997

Year	*NSW*	*% chg*	*Vic*	*% chg*	*Qld*	*% chg*	*SA*	*% chg*	*WA*	*% chg*	*Tas*	*% chg*	*NT*	*% chg*	*ACT*	*% chg*	*Aust*	*% chg*
1988	6869		7800		3216		1934		2010		527		320		156		22832	
1989	6493	-5.5	7270	-6.8	3079	-4.3	1930	-0.2	2312	15.0	542	2.8	350	9.4	182	16.7	22158	-3.0
1990	6092	-6.2	5759	-20.8	3123	1.4	1926	-0.2	2073	-10.3	477	-12.0	387	10.6	177	-2.7	20014	-9.7
1991	5473	-10.2	4967	-13.8	2926	-6.3	1567	-18.6	2002	-3.4	424	-11.1	306	-20.9	179	1.1	17844	-10.8
1992	5135	-6.2	4768	-4.0	3199	9.3	1227	-21.7	1952	-2.5	377	-11.1	295	-3.6	155	-13.4	17108	-4.1
1993	5132	-0.1	4830	1.3	3186	-0.4	1189	-3.1	1984	1.6	385	2.1	315	6.8	143	-7.7	17164	0.3
1994	5024	-2.1	4858	0.6	3598	12.9	1184	-0.4	2027	2.2	404	4.9	304	-3.5	161	12.6	17560	2.3
1995	4927	-1.9	4934	1.6	3630	0.9	1186	0.2	2259	11.4	408	1.0	313	3.0	146	-9.3	17803	1.4
1996	4880	-1.0	4834	-2.0	3551	-2.2	1323	11.6	2041	-9.7	348	-14.7	334	6.7	201	37.7	17512	-1.6
1997	5479	12.3	5017	3.8	3640	2.5	1292	-2.3	2403	17.7	357	2.6	366	9.6	190	-5.5	18744	7.0
Linear % chg		-2.3		-4.5		1.5		-3.9		2.5		-3.9		2.0		3.3		-2.0
Trend % chg[a]		0.38		0		1.7		-1.2		-1.4		2.8		0.82		6.8		4.8

Note [a] is the percentage change from 1997 to 1998 from the best-fitted model as described in chapter 3. These figures were used to adjust for trend in each jurisdictions' data.

It should be noted that none of the data follows the linear trend and therefore the linear percentage changes are not useful for adjusting for trend.

Source BTE estimates

APPENDIX X

INFORMATION REQUESTED FROM EACH STATE AND TERRITORY

The information requested from each State and Territory is described below.

- *Treatment codes* are the treatment types applied to black spots. The treatment codes used in this evaluation are based on the ATSB matrix contained in the *Notes on Administration*. Since States and Territories often describe the same treatment differently, re-coding was necessary to ensure that data could be amalgamated for analysis.
- *Locational details* describe the physical layout and characteristics of black spots—for example, a black spot at an intersection may have two arms or three arms.
- *Target DCA codes* are the crash types targeted by the treatment applied to each black spot.
- *Non-target DCA codes* are the crash types that occurred at each black spot treatment that were not targeted by the treatment type applied.
- *Dominant DCA after treatment*. In most instances, crashes continued to occur at sites after treatment was completed. Jurisdictions were asked to identify the DCA code of the most common type of crash at each site after treatment. This information was used to determine the treatment's effects.
- *Crash counts, crash severity and relevant dates*. Jurisdictions were asked to supply crash count and crash severity data for black spots before treatment commenced, divided into two categories: before and after the black spots were identified, but before the treatment started and the start and end dates of each of these periods. They were also asked to provide crash count and crash severity data for sites after treatment
- *Traffic volume count (AADT)*. Before and after treatment traffic volumes for the primary road flow at each site, plus arm by arm traffic volumes if available, and the relevant dates associated with these measurements.
- *Project total cost*. In some cases, the cost of site treatment was not fully met by the Federal Government. States and Territories were asked to identify projects which received supplementary funding—either because

of prior intent or because projects went over budget. They were also asked to provide the total cost of these projects—that is, the cost to the Federal Government plus the cost to the relevant State or Territory Governments.

- *Project annual maintenance cost* is the incremental maintenance cost of each project. The incremental maintenance cost is the difference between the maintenance cost before and after treatment.
- *Expected treatment life* is the effective life of each treatment estimated by the jurisdictions. The effective life is the length of time that a treatment will be effective until it needs to be replaced. Some jurisdictions provided very high estimates. The BTE used a maximum expected project life of 15 years in the BCA. The BTE also assumed that if statistical analysis found no evidence that a treatment had a positive effect on safety, the treatment would be replaced after five years.
- *Other data*. In addition to the above information—which was requested for all the projects in the sample selected—the BTE requested the States and Territories to provide time series data for some projects selected from the sample, and to identify comparable sites that were not treated.

The information outlined above was requested to enable the BTE to use several different approaches to assess black spot treatment effectiveness. This multi-pronged analysis enabled the BTE to attempt to compensate for missing data and data quality issues.

APPENDIX XI

AN EXAMPLE OF THE USE OF THE EMPIRICAL BAYES METHOD

The safety[5] of an entity can be estimated from a reference population.

Using Canberra as an example, assume that in 1998:

- Canberra's population was 300 000 and there were 500 vehicle crashes;
- there were 140 000 males living in Canberra;
- there were 4 500 males aged between 19 and 24 who held a P-plate license and experienced two vehicle crashes.

This information can be used to calculate the safety of Canberra residents. Based on this scenario, in 1998 Canberra residents had safety of:

- 500/300 000 or 0.0017;
- males had safety of 0.0028;
- males aged between 19 and 24 had safety of 0.1100; and
- females had safety of 0.0007

Using this information, knowledge about Canberra residents' characteristics and Bayes law, it is possible to estimate safety more accurately.

The Empirical Bayes model for the expected number of crashes, k, given that K crashes have been observed at the black spot site is:

$E\{k/K\} = \alpha E\{k\} + (1-\alpha)K$

where α is a coefficient between 0 and 1. The model is a linear combination of the number of crashes, K, and the mean number of crashes for the reference population, E{k}.

The coefficient α is calculated as:

$\alpha = 1/(1+(VAR\{k\}/E\{k\}))$

5. Hauer (1997) defines the safety of an entity as the number of crashes by kind and severity expected to involve that entity per unit of time in a certain period.

where VAR{k} is the variance of the number of crashes for the reference population k. In practice, E{k} and VAR{k} are estimated using either multivariate techniques or the method of sample moments.

Hauer (1997) cites the following example. Consider a highway and rail grade crossing that:

- is in an urban area;
- has a single track;
- is used by two trains and 550 vehicles per day; and
- has no physical barrier but does have a ‘cross-bucks’ warning sign.

Between 1981 and 1985, two crashes were recorded at the site.

What is E[k/K}, given E{k} =0.0239 crashes per year and VAR{k}=0.0011 crashes per year—estimated using multivariate techniques?

Between 1981 and 1985:

E{k} = 5 * 0.0239 = 0.1195 crashes

VAR{k} = 5[2] * 0.0011 = 0.0275

Therefore α = 1/(1+0.0275/0.1195) = 0.8129

E{k│K} = 0.8129 * 0.1195+0.1871*2 = 0.47 crashes in five years.

The after treatment number of crashes is compared with this figure, not the two crashes that occurred before treatment, to remove the regression-to-mean effect.

This method has considerable potential and is starting to come into general use in road safety studies. Unfortunately, there was insufficient information available for the BTE to use this method in evaluating the Black Spot Program.

APPENDIX XII

T-TEST DATA FOR TABLE 5.2

TABLE XII.1 UNADJUSTED VICTORIA SUBSET DATA 1996–97

Remedial Treatment	Before crashes Fatal	Before crashes Injury	Before crashes Total	Before crashes Annual freq	After crashes Fatal	After crashes Injury	After crashes Total	After crashes Annual freq
Fully controlled right turn	0	20	20	3.12	0	2	2	1.13
Fully controlled right turn	0	22	22	3.43	0	2	2	1.24
Fully controlled right turn	0	3	3	0.47	0	4	4	2.29
Fully controlled right turn	0	9	9	1.40	0	1	1	0.53
Fully controlled right turn	0	9	9	1.40	0	0	0	0.00
Fully controlled right turn	0	6	6	0.89	0	0	0	0.00
Fully controlled right turn	0	8	8	1.19	0	1	1	0.60
Fully controlled right turn	0	12	12	1.79	0	1	1	0.76
Install fully controlled right turn	0	14	14	2.09	0	3	3	1.64
Install part right turn control	0	20	20	2.98	0	0	0	0.00
Install part right turn control	0	9	9	1.34	0	0	0	0.00
Intersection signals	0	22	22	3.28	0	3	3	2.29
New signals	0	13	13	2.47	0	0	0	0.00
Partial right turn phase	0	6	6	1.00	1	1	2	1.19
Remodel signals	0	14	14	2.09	0	2	2	1.20
Right turn lanes/median	0	23	23	3.82	0	2	2	1.50
Right turn phase	0	16	16	2.39	0	0	0	0.00
Right turn phase	0	20	20	3.12	0	7	7	3.82
Right turn phase	0	7	7	1.16	0	4	4	2.29
Roundabout	0	16	16	2.39	0	0	0	0.00
Roundabout	0	6	6	0.94	0	0	0	0.00
Roundabout	0	4	4	0.80	0	1	1	0.55
Roundabout	0	5	5	1.00	0	0	0	0.00
Roundabout	0	9	9	1.34	0	0	0	0.00
Roundabout	0	13	13	1.94	0	0	0	0.00
Roundabout	0	5	5	0.75	0	0	0	0.00
Roundabout	0	3	3	0.45	0	1	1	0.60
Roundabout	0	14	14	2.09	0	0	0	0.00
Roundabout	0	7	7	1.04	0	0	0	0.00
Roundabout	0	4	4	0.66	0	1	1	0.60
Roundabout	0	1	1	0.16	0	1	1	0.48
Roundabout	0	3	3	0.47	0	0	0	0.00
Roundabout	0	6	6	0.94	0	0	0	0.00
Roundabout	0	4	4	0.62	0	0	0	0.00
Roundabout	0	4	4	0.60	0	0	0	0.00
Roundabout	0	3	3	0.45	0	0	0	0.00
			Mean	1.56			Mean	0.63

60 per cent reduction in annual frequency

Source BTE analysis of data provided by Vicroads

APPENDIX XIII

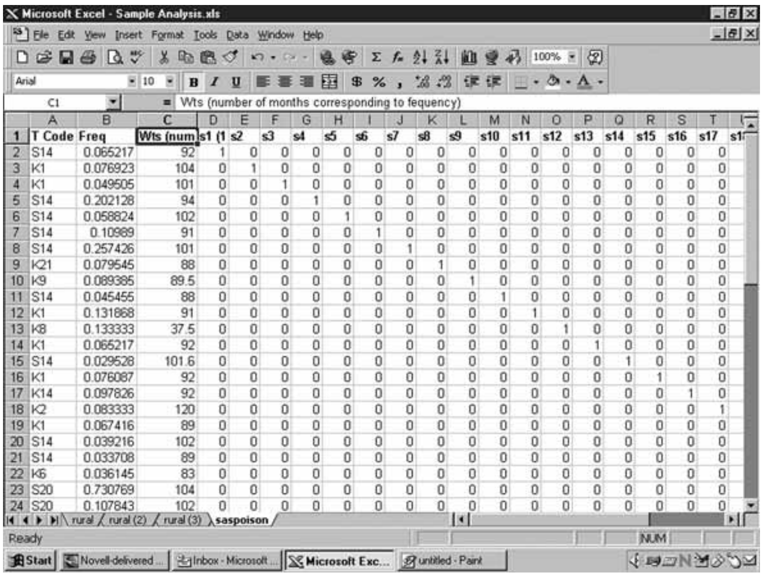
NOTES ON WEIGHTED POISSON REGRESSION IN SAS

Step 1: Prepare data in Excel

Frequency: A column of injury crash frequency, equal to the total number of fatal or injury crashes divided by the number of months of observation. All frequencies, both before and after treatment, are included in this column.

Wts: A column of weights equal to the number of months corresponding to each rate. These weights are used in the Poisson regression to account for the fact that rates calculated using only a few months' crash data are likely to be more variable than rates calculated using a much longer period.

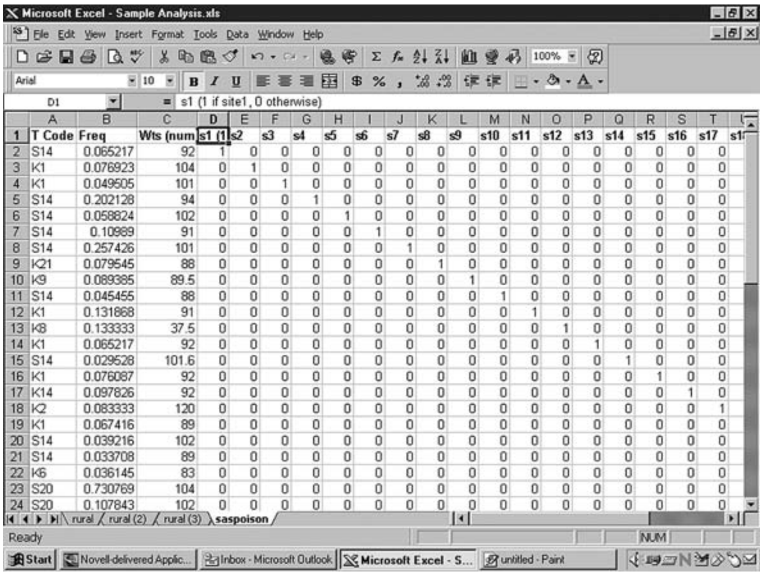
Sites: The next step is to set up the other variables for the model. The first of these variables is the site variable. A new variable is included for each site in the study, and the variable is defined as taking the value 1 if the rate corresponds to the site and 0 otherwise. In this



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	T Code	Freq	Wts (num	s1 (1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	s15	s16	s17
2	S14	0.065217	92	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	K1	0.076923	104	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	K1	0.049505	101	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	S14	0.202128	94	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
6	S14	0.058824	102	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
7	S14	0.10989	91	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
8	S14	0.257426	101	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
9	K21	0.079545	88	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
10	K9	0.089385	89.5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
11	S14	0.045455	88	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
12	K1	0.131868	91	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
13	K8	0.133333	37.5	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
14	K1	0.065217	92	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
15	S14	0.029528	101.6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
16	K1	0.076087	92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
17	K14	0.097826	92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
18	K2	0.083333	120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
19	K1	0.067416	89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	S14	0.039216	102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	S14	0.033708	89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	K6	0.036145	83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	S20	0.730769	104	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	S20	0.107843	102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

example, there are 26 sites—labelled s1, s2, etc—and each column has two 1s—one for before and one for after treatment, the remaining entries being 0. If the rates variable is designed as a list of *before* frequency followed by a list of *after* frequency for the same sites, the set of site variables forms two—in this case 26 by 26—identity matrices: one each for the before and after frequency. This is easily done in Excel using the command below

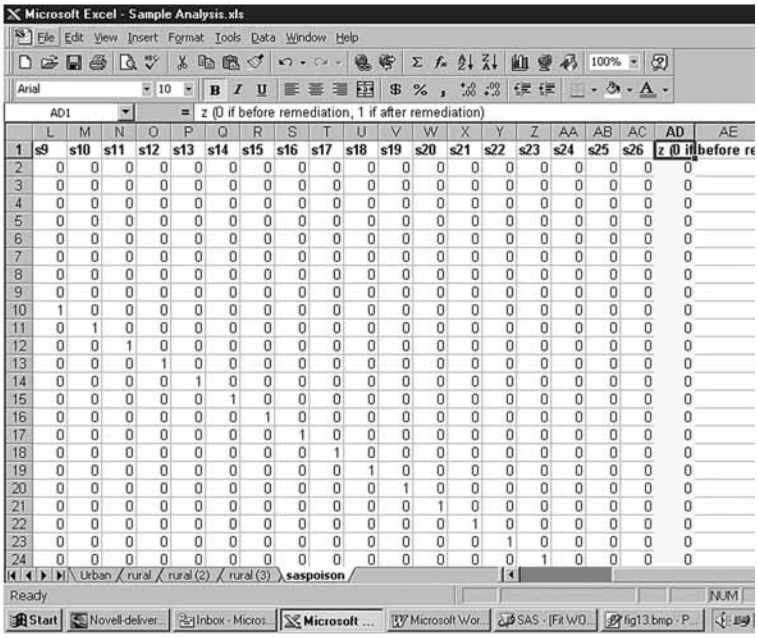
IF((ROW(C2)-ROW(C2)+1)=((COLUMN(C2)-COLUMN(C2)+1),1,0)
in cell C2, and copying and pasting for the rest of the array.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
1	T Code	Freq	Wts (num	s1 (1	s2	s3	s4	s5	s6	s7	s8	s9	s10	s11	s12	s13	s14	s15	s16	s17
2	S14	0.065217	92	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	K1	0.076923	104	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	K1	0.049505	101	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	S14	0.202128	94	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
6	S14	0.058824	102	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
7	S14	0.10989	91	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
8	S14	0.257426	101	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
9	K21	0.079545	88	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
10	K9	0.089385	89.5	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
11	S14	0.045455	88	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
12	K1	0.131868	91	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
13	K8	0.133333	37.5	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
14	K1	0.065217	92	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
15	S14	0.029528	101.6	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
16	K1	0.076087	92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
17	K14	0.097826	92	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
18	K2	0.083333	120	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
19	K1	0.067416	89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	S14	0.039216	102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	S14	0.033708	89	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	K6	0.036145	83	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	S20	0.730769	104	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	S20	0.107843	102	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

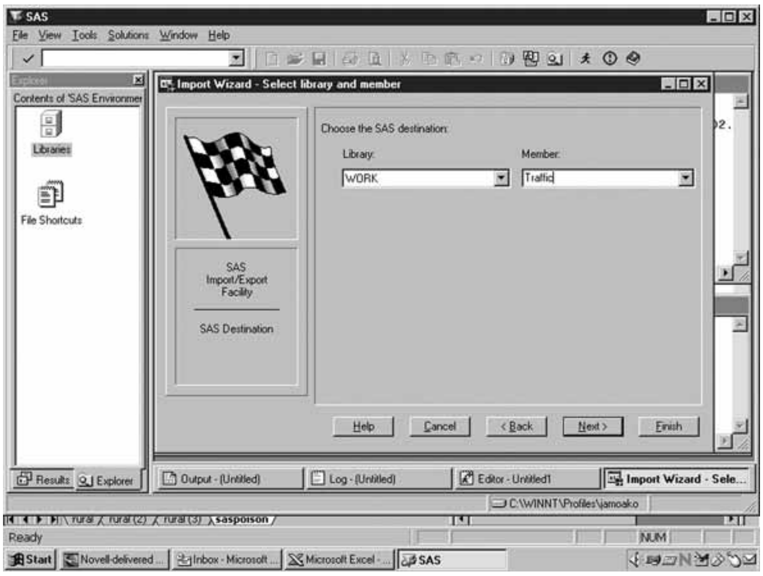
Z: This variable represents the treatment effect , and takes the value 0 for the before treatment frequency and 1 after treatment. The coefficient of Z in the model is the treatment effect after site effects have been taken into account. This variable can be replaced by other effects, as necessary, to examine factors such as the effects for different treatment types. For example, examining the effects of roundabouts versus shoulder sealing versus other treatments, would require using three variables:

- zr—equal to 1 for frequency corresponding to sites treated with roundabouts, and 0 before treatment;
- zs—equal to 1 for frequency corresponding to sites treated with shoulder sealing, and 0 before treatment; and
- zo—equal to 1-zr-zs.

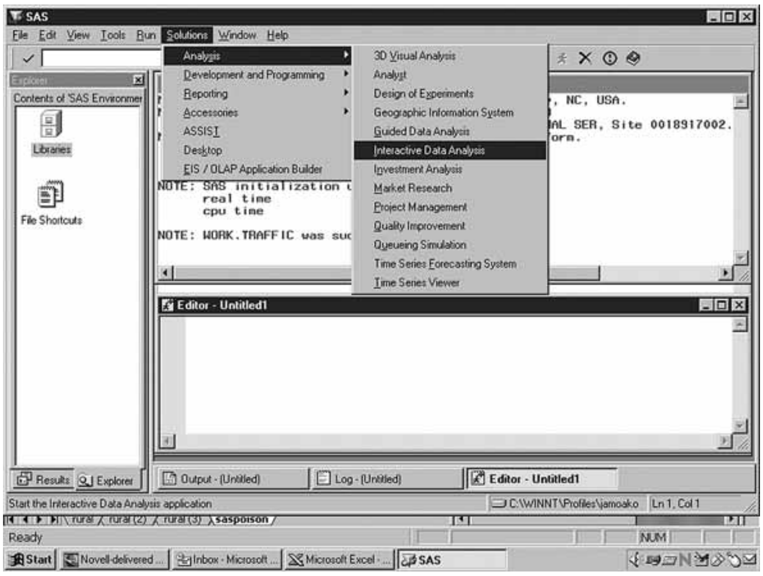


Step 2: Data Analysis in SAS

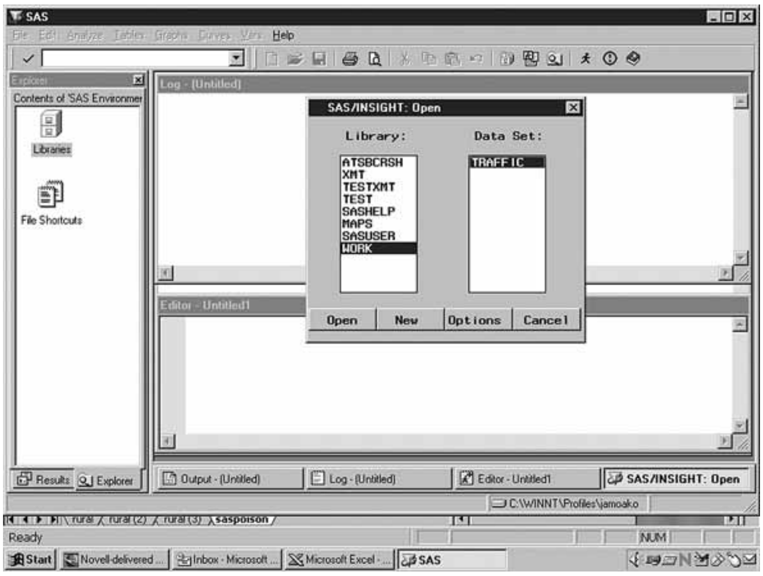
First, import the data into SAS using the Import Data… item under the File Menu. The data are imported from Excel. The dialog box is as below:

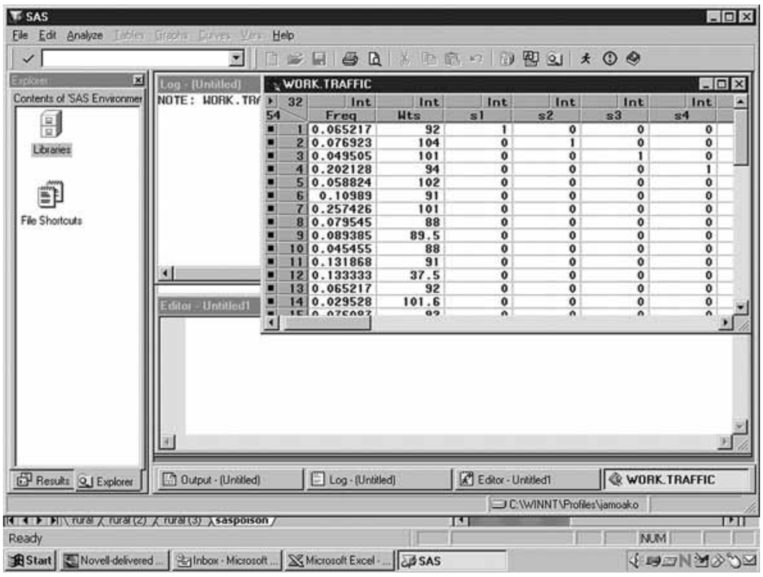


Once the data have been read in—here as the item Traffic in the Library WORK—select the Interactive Data Analysis item from under the Solutions Analysis menu:

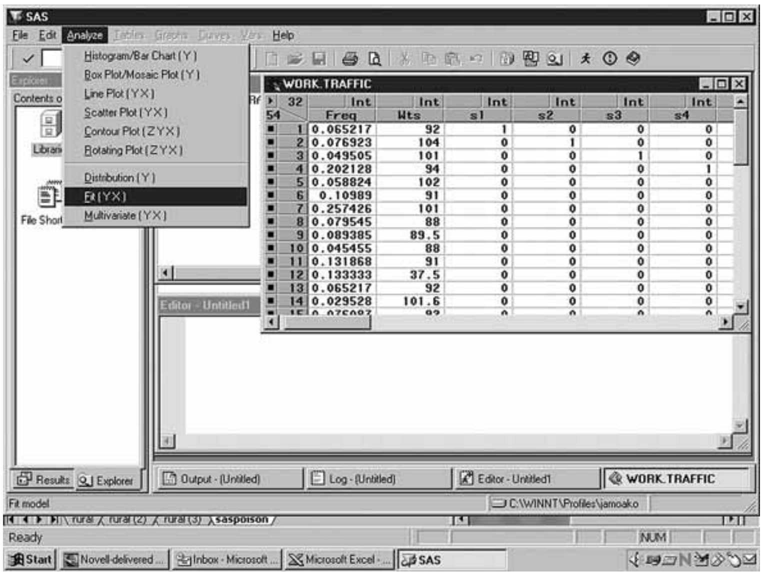


Then, select the library WORK from the dialog box that comes up, and the Data Set TRAFFIC. The data set is now loaded into SAS and is ready for analysis.

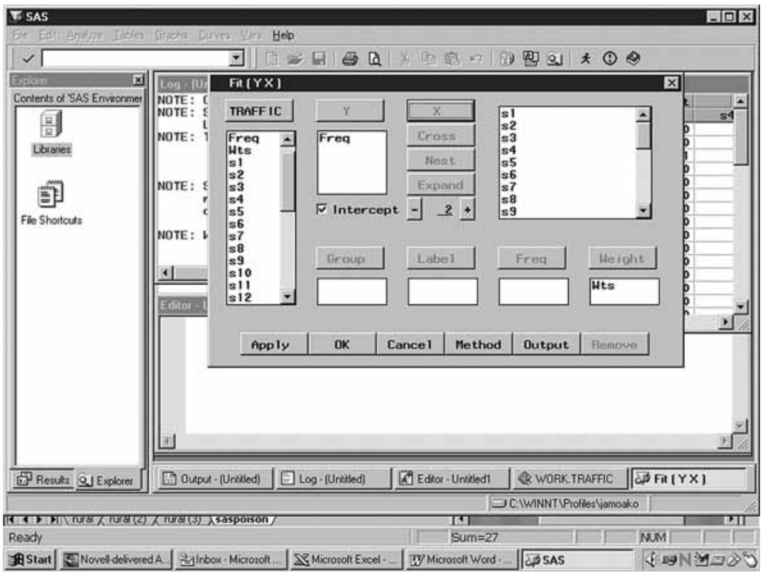




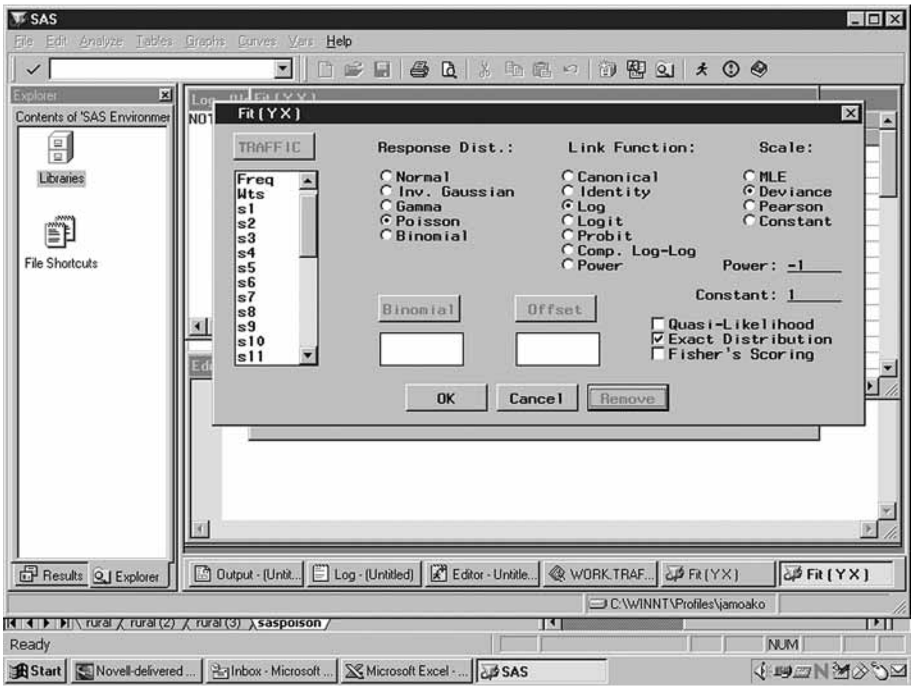
To analyse the data, select FIT (Y X) from the Analyze menu:



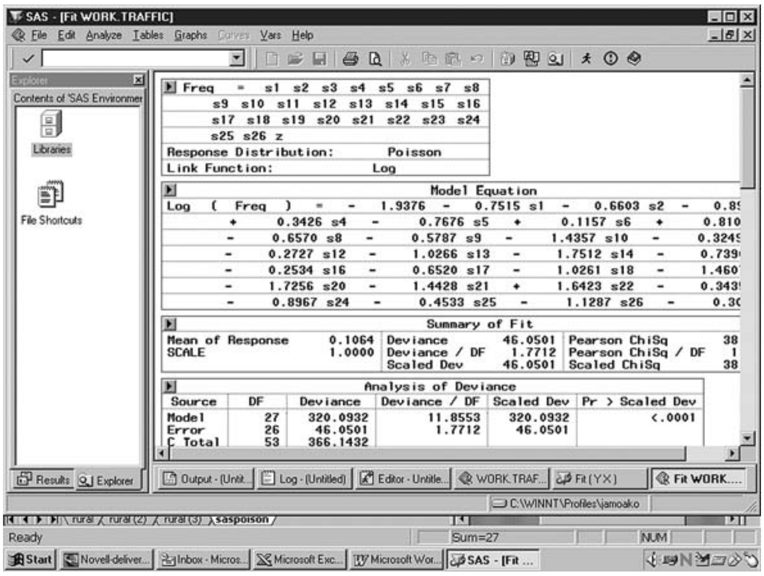
The following dialog appears. In the pane on the left, select Freq and click Y, select Wts and click Weight, shift-select s1 through s26 and z and click X. Then check the Intercept box. The result should look like that below.



Now, click the Method button. The following dialog appears. Make the selections indicated below to fit a Poisson Regression with log link.



When done, click OK to return to the preceding dialog box. Click Apply and then click Output. An output window like the one below appears. It contains the model fit—a term for each site and one for the treatment effect Z. In this case the treatment effect is estimated as –0.3068. Remember that this model is a model for the *log* frequency, so the multiplicative effect is $e^{-0.3068}$ = 0.74, representing a 26 per cent or 1-0.74 decrease in crash frequency between original and treated sites. Moreover, this effect appears significant as the p-value associated with z is 0.0354.



Freq = s1 s2 s3 s4 s5 s6 s7 s8 s9 s10 s11 s12 s13 s14 s15 s16 s17 s18 s19 s20 s21 s22 s23 s24 s25 s26 z

Response Distribution: Poisson

Link Function: Log

Model Equation

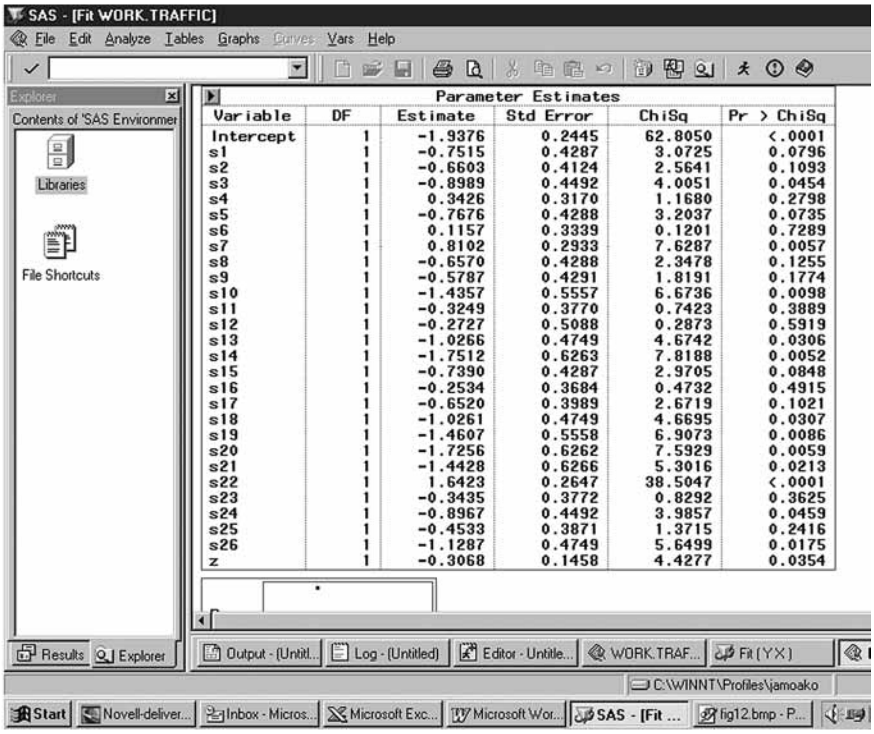
```
Log ( Freq ) = - 1.9376 - 0.7515 s1 - 0.6603 s2 - 0.8
    + 0.3426 s4 - 0.7676 s5 + 0.1157 s6 + 0.810
    - 0.6570 s8 - 0.5787 s9 - 1.4357 s10 - 0.324
    - 0.2727 s12 - 1.0266 s13 - 1.7512 s14 - 0.739
    - 0.2534 s16 - 0.6520 s17 - 1.0261 s18 - 1.460
    - 1.7256 s20 - 1.4428 s21 + 1.6423 s22 - 0.343
    - 0.8967 s24 - 0.4533 s25 - 1.1287 s26 - 0.30
```

Summary of Fit

Mean of Response	0.1064	Deviance	46.0501	Pearson ChiSq	38
SCALE	1.0000	Deviance / DF	1.7712	Pearson ChiSq / DF	1
		Scaled Dev	46.0501	Scaled ChiSq	38

Analysis of Deviance

Source	DF	Deviance	Deviance / DF	Scaled Dev	Pr > Scaled Dev
Model	27	320.0932	11.8553	320.0932	<.0001
Error	26	46.0501	1.7712	46.0501	
C Total	53	366.1432			



Parameter Estimates

Variable	DF	Estimate	Std Error	ChiSq	Pr > ChiSq
Intercept	1	-1.9376	0.2445	62.8050	<.0001
s1	1	-0.7515	0.4287	3.0725	0.0796
s2	1	-0.6603	0.4124	2.5641	0.1093
s3	1	-0.8989	0.4492	4.0051	0.0454
s4	1	0.3426	0.3170	1.1680	0.2798
s5	1	-0.7676	0.4288	3.2037	0.0735
s6	1	0.1157	0.3339	0.1201	0.7289
s7	1	0.8102	0.2933	7.6287	0.0057
s8	1	-0.6570	0.4288	2.3478	0.1255
s9	1	-0.5787	0.4291	1.8191	0.1774
s10	1	-1.4357	0.5557	6.6736	0.0098
s11	1	-0.3249	0.3770	0.7423	0.3889
s12	1	-0.2727	0.5088	0.2873	0.5919
s13	1	-1.0266	0.4749	4.6742	0.0306
s14	1	-1.7512	0.6263	7.8188	0.0052
s15	1	-0.7390	0.4287	2.9705	0.0848
s16	1	-0.2534	0.3684	0.4732	0.4915
s17	1	-0.6520	0.3989	2.6719	0.1021
s18	1	-1.0261	0.4749	4.6695	0.0307
s19	1	-1.4607	0.5558	6.9073	0.0086
s20	1	-1.7256	0.6262	7.5929	0.0059
s21	1	-1.4428	0.6266	5.3016	0.0213
s22	1	1.6423	0.2647	38.5047	<.0001
s23	1	-0.3435	0.3772	0.8292	0.3625
s24	1	-0.8967	0.4492	3.9857	0.0459
s25	1	-0.4533	0.3871	1.3715	0.2416
s26	1	-1.1287	0.4749	5.6499	0.0175
z	1	-0.3068	0.1458	4.4277	0.0354

APPENDIX XIV

ROUNDABOUTS

Chapter 6 deals with the installation of roundabouts as a general treatment class, rather than assessing the relative effects of large and small roundabouts. The BTE assessed whether large roundabouts were more successful in improving safety than small roundabouts. Ideally, the BTE would have preferred to divide the available data into two subsets based on the size or radius of the roundabouts installed. However, this information was not available, so the BTE decided to use roundabout construction costs as a proxy for their size.

An examination of the construction costs of roundabouts across the country showed that costs ranged from $20 000 to $760 000 and had a mean of $148 787. The data revealed that there was a group of roundabouts of broadly similar construction costs closely clustered in a low-cost range, but above $115 000 roundabout construction costs were more variable. The figure of $115 000 was therefore chosen as an arbitrary construction cost cut-off figure to separate cheaper—and presumably smaller—roundabouts from more expensive—and presumably larger—roundabouts.

The BTE was supplied with sufficient data to examine the effectiveness of 236 projects involving the installation of roundabouts. The construction costs of 122 of these totalled $115 000 or less, while 114 of these cost more than $115 000.

The results of the analysis shown in tables XIV.1 and XIV.2 indicate that, for the national sample, roundabouts with a construction cost of $115 000 or less were associated with a 71 per cent reduction in casualty crash numbers. More expensive roundabouts were associated with a 75 per cent reduction. Roundabouts with a construction cost of $115 000 or less were associated with reduced casualty crash numbers in regional and urban areas of 76 and 61 per cent respectively. More expensive roundabouts were associated with reductions in casualty crash numbers of 74 and 76 per cent in regional and urban areas respectively. Nationally, there was very strong evidence that installing roundabouts successfully improved safety, irrespective of the roundabout's cost. The results obtained have also been presented by jurisdiction.

TABLE XIV.1 ANALYSIS OF ROUNDABOUTS WITH A CONSTRUCTION COST OF LESS THAN $115 000

Area	*Estimate(β)*	*Std Error*	*Probability $0 \leq p \leq 1$*	*Casualty crash reduction (%)*
OVERALL	-1.2325	0.1792	<0.0001	70.84
ALL REGIONAL	-1.4439	0.2475	<.0001	76.40
NSW	-1.0728	0.746	0.1504	65.80*
VIC	-1.4365	0.5935	0.0155	76.22
QLD	-1.118	0.4776	0.0192	67.31
SA	-23.0	37956	0.9995	100.00*
WA	-2.2815	1.0224	0.0257	89.79
TAS	-1.9878	0.5963	0.0009	86.30
NT	0.3557	0.762	0.6407	-42.72*
ALL URBAN	-0.948	0.2608	0.0003	61.25
Sydney	-1.4287	0.5982	0.0169	76.04
Melbourne	-1.6031	1.022	0.1168	79.87
Brisbane	-23.0	35656	0.9995	100.00*
Adelaide	-23.0	57338	0.9997	100.00*
Perth	0.1323	0.5362	0.8051	-14.15*
Hobart	-0.6765	0.5246	0.0972	49.16
Darwin	0.8381	0.6892	0.224	-131.20*

Note Reductions that are not statistically significant are indicated with an asterisk (*). No roundabouts were installed in the ACT with a construction cost of $115 000 or less.

Source BTE estimates

TABLE XIV.2 ANALYSIS OF ROUNDABOUTS WITH A CONSTRUCTION COST OF MORE THAN $115 000

Area	*Estimate(β)*	*Std Error*	*Probability 0≤p≤1*	*Casualty crash reduction (%)*
OVERALL	-1.3759	0.1541	<.0001	74.74
ALL REGIONAL	-1.3555	0.1908	<.0001	74.22
NSW	-1.2007	0.2565	<.0001	69.90
VIC	-1.185	0.4315	0.006	69.43
QLD	-2.1019	0.5874	0.0003	87.78
SA	-0.6204	0.539	0.2497	46.23*
WA	-22	25492	0.9993	100.00*
TAS	none			
NT	-22	38750	0.9995	100.00*
ALL URBAN	-1.4132	0.2614	<.0001	75.66
Sydney	-2.0994	1.0216	0.0399	87.75
Melbourne	-2.391	1.0071	0.0176	90.85
Brisbane	-1.7173	0.6065	0.0046	82.04
Adelaide	none			
Perth	-0.9254	0.3582	0.0098	60.36
Hobart	none			
Darwin	none			
Canberra	-1.2555	0.7406	0.09	71.51

Note Reductions that are not statistically significant are indicated with an asterisk (*).

Source BTE estimates

APPENDIX XV

BENEFIT-COST ANALYSIS BY STATE AND TERRITORY

Chapter 7 provides the results obtained from the BCA of the Federal Black Spot Program for Australia as a whole. However, BCAs were also completed at the State and Territory level. Tables XV.1 to XV.49 show the results of these evaluations by jurisdiction, excluding safety-audited projects and some projects for which insufficient data were supplied. The evaluation results show that, except in the Northern Territory, the Federal Black Spot Program was highly worthwhile on economic as well as safety grounds.

The results obtained for Darwin and the rest of the Northern Territory may be partially due to data quality issues. However, it is also notable that a substantial portion of total expenditure on black spot treatments in the Northern Territory was spent on ineffective treatments. In particular, there was no evidence that shoulder sealing had a beneficial safety effect in the Northern Territory, although there was moderate evidence that shoulder sealing was an effective treatment when used outside capital cities nationwide. Shoulder sealing was used fairly extensively as a treatment in the Northern Territory outside Darwin over the three years examined.

It should be noted that the project costs for each treatment for each jurisdiction will not necessarily sum to the total project costs for Australia. This is because there were multiple treatments at some sites.

TABLE XV.1 NEW SOUTH WALES OVERALL RESULTS

	Discount Rate (%)	*8*	*7*	***5***	*3*
Regional	Capital ($000)	18 933	19 109	19 475	19 860
	PV benefits ($000)	188 828	202 132	233 163	271 503
	NPV ($000)	169 894	183 022	213 688	251 643
	BCR	10.0	10.6	12.0	13.7
Urban	Capital ($000)	15 231	15 380	15 688	16 013
	PV benefits ($000)	139 439	147 966	167 548	191 253
	NPV (000)	124 208	132 587	151 860	175 240
	BCR	9.2	9.6	10.7	11.9
Overall	BCR	**9.6**	**10.2**	**11.4**	**12.9**

Note Column may not add to total due to rounding.

Source BTE

TABLE XV.2 REGIONAL NEW SOUTH WALES RESULTS BY TREATMENT TYPE 1996–97

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	4 238	33 444	35 859	41 458	48 318	8.9	9.5	10.8	12.4
k10	35	3 849	4 031	4 435	4 903	112.2	117.5	129.1	142.7
k15	198	3 743	3 995	4 581	5 298	19.9	21.2	24.2	27.8
k19	156	4 950	5 277	6 036	6 965	32.7	34.8	39.6	45.6
k2	618	12 749	13 606	15 592	18 025	21.6	23.0	26.2	30.2
k20	198	1 029	1 108	1 290	1 513	6.2	6.6	7.5	8.7
k3	85	484	499	532	567	6.7	6.9	7.3	7.7
k4	37	905	930	984	1 043	25.4	26.1	27.5	29.1
ot	455	3 447	3 697	4 277	4 988	8.6	9.1	10.4	12.0
s12	445	-384	-382	-379	-375	0.1	0.1	0.1	0.2
s18	168	769	829	968	1 139	5.6	5.9	6.8	7.8
Overall	6 632	64 985	69 448	79 773	92 384	10.8	11.5	13.0	14.9

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000. Column may not add to total due to rounding.

Source BTE

TABLE XV.3 REGIONAL NEW SOUTH WALES RESULTS BY TREATMENT TYPE 1997–98

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	2 655	15 404	16 561	19 244	22 532	6.8	7.2	8.2	9.5
k10	32	5 059	5 296	5 826	6 439	160.7	168.2	184.9	204.3
k14	342	528	552	602	656	2.5	2.6	2.8	2.9
k15	442	5 430	5 807	6 679	7 748	13.3	14.1	16.1	18.5
k19	139	1 537	1 644	1 893	2 198	12.1	12.9	14.7	16.9
k2	148	2 493	2 662	3 055	3 536	17.8	18.9	21.6	24.8
k3	129	737	792	921	1 078	6.7	7.2	8.2	9.4
k4	12	532	546	578	612	45.8	47.0	49.6	52.5
k7	49	848	905	1 038	1 202	18.1	19.3	22.0	25.3
ot	1 100	6 644	7 140	8 291	9 700	7.0	7.5	8.5	9.8
s1	17	974	1 038	1 185	1 365	58.9	62.7	71.4	82.1
s12	12	-27	-28	-30	-33	-1.3	-1.4	-1.6	-1.8
s14	757	549	584	659	741	1.7	1.8	1.9	2.0
s18	198	4 669	4 981	5 704	6 590	24.6	26.2	29.8	34.3
s20	35	4 780	5 005	5 506	6 086	139.0	145.5	159.9	176.7
s4	148	-200	-201	-204	-207	-0.3	-0.4	-0.4	-0.4
s5	79	-53	-52	-51	-49	0.3	0.3	0.4	0.4
Overall	6 294	49 903	53 232	60 895	70 194	8.9	9.5	10.7	12.2

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.4 REGIONAL NEW SOUTH WALES RESULTS BY TREATMENT TYPE 1998–99

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	2 499	22 059	23 633	27 282	31 753	9.8	10.5	11.9	13.7
k15	532	8 305	8 871	10 184	11 792	16.6	17.7	20.2	23.2
k19	60	2 901	3 091	3 531	4 070	49.3	52.5	59.8	68.8
k2	159	2 155	2 303	2 647	3 068	14.6	15.5	17.7	20.3
k3	20	657	675	714	756	34.1	35.0	37.0	39.1
k4	164	3 766	3 872	4 097	4 344	24.0	24.7	26.0	27.5
ot	3 240	20 665	22 197	25 748	30 100	7.4	7.9	8.9	10.3
s1	248	1 923	2 062	2 384	2 779	8.8	9.3	10.6	12.2
s12	149	1 953	2 088	2 400	2 783	14.1	15.0	17.1	19.7
s14	220	710	735	789	847	4.2	4.3	4.6	4.8
s2	198	-242	-243	-246	-248	-0.2	-0.2	-0.2	-0.3
s5	12	19	19	21	23	2.6	2.6	2.8	2.9
s7	51	3 600	3 771	4 151	4 590	72.2	75.5	83.0	91.7
Overall	7 550	68 471	73 073	83 702	96 657	10.1	10.7	12.1	13.8

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.5 SYDNEY RESULTS BY TREATMENT TYPE 1996–97

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	1 033	17 614	18 809	21 579	24 974	18.1	19.2	21.9	25.2
k14	277	684	710	765	825	3.5	3.6	3.8	4.0
k19	79	73	77	85	95	1.9	2.0	2.1	2.2
k2	1 117	15 276	16 326	18 762	21 747	14.7	15.6	17.8	20.5
k3	198	163	173	193	216	1.8	1.9	2.0	2.1
k4	129	234	244	265	287	2.8	2.9	3.1	3.2
ot	1 058	4 376	4 522	4 834	5 175	5.1	5.3	5.6	5.9
s1	49	216	223	239	255	5.4	5.5	5.8	6.2
s12	425	-499	-501	-505	-510	-0.2	-0.2	-0.2	-0.2
s13	8	1 117	1 147	1 212	1 282	142.2	146.0	154.2	163.1
s2	282	-5 344	-5 669	-6 421	-7 343	-18.0	-19.1	-21.8	-25.1
s20	53	4 897	5 128	5 643	6 240	94.0	98.4	108.2	119.5
s5	59	-1 882	-1 998	-2 269	-2 601	-30.7	-32.7	-37.2	-42.8
Overall	4 767	36 925	39 191	44 382	50 643	8.7	9.2	10.3	11.6

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.6 SYDNEY RESULTS BY TREATMENT TYPE 1997–98

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	1 236	14 544	15 555	17 900	20 773	12.8	13.6	15.5	17.8
k10	30	1 315	1 378	1 518	1 680	45.3	47.4	52.1	57.6
k11	20	1 073	1 103	1 166	1 234	55.2	56.7	59.9	63.3
k14	218	2 036	2 096	2 226	2 367	10.3	10.6	11.2	11.9
k19	194	649	672	721	773	4.4	4.5	4.7	5.0
k2	1 614	15 221	16 300	18 801	21 866	10.4	11.1	12.7	14.6
k3	119	648	669	713	761	6.5	6.6	7.0	7.4
ot	91	4 288	4 406	4 657	4 931	48.1	49.4	52.1	55.2
s12	69	-20	-19	-16	-13	0.7	0.7	0.8	0.8
s13	49	3 253	3 342	3 532	3 739	66.7	68.5	72.4	76.5
s14	1 307	-12 359	-12 657	-13 291	-13 984	-8.5	-8.7	-9.2	-9.7
s17	99	-699	-716	-750	-788	-6.1	-6.2	-6.6	-7.0
s2	74	-1 848	-1 962	-2 226	-2 549	-23.9	-25.4	-29.0	-33.3
s20	20	2 252	2 358	2 594	2 868	114.7	120.1	132.0	145.9
s3	187	-4 457	-4 730	-5 365	-6 142	-22.8	-24.3	-27.7	-31.8
s5	173	-5 723	-6 078	-6 903	-7 913	-32.0	-34.1	-38.8	-44.7
Overall	5 499	20 174	21 718	25 277	29 605	4.7	4.9	5.6	6.4

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.7 SYDNEY RESULTS BY TREATMENT TYPE 1998–99

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	1 188	19 121	20 422	23 440	27 137	17.1	18.2	20.7	23.8
k11	77	2 254	2 317	2 451	2 597	30.1	30.9	32.7	34.6
k14	164	678	700	749	802	5.1	5.3	5.6	5.9
k15	179	2 626	2 701	2 862	3 038	15.7	16.1	17.0	18.0
k19	50	102	106	114	124	3.0	3.1	3.3	3.5
k2	558	15 422	16 446	18 820	21 729	28.7	30.5	34.8	40.0
k4	129	626	647	690	737	5.9	6.0	6.4	6.7
ot	3 442	40 892	42 086	44 632	47 410	12.9	13.2	14.0	14.8
s12	332	-122	-116	-104	-91	0.6	0.7	0.7	0.7
s14	149	-1 581	-1 620	-1 702	-1 792	-9.6	-9.9	-10.4	-11.0
Overall	6 267	80 019	83 690	91 953	101 693	13.8	14.4	15.7	17.2

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.8 VICTORIA OVERALL RESULTS

	Discount Rate (%)	*8*	*7*	*5*	*3*
Regional	Capital ($000)	5 082	5 130	5 231	5 336
	PV benefits ($000)	61 277	65 066	73 764	84 277
	NPV ($000)	56 195	59 935	68 533	78 941
	BCR	12.1	12.7	14.1	15.8
Urban	Capital ($000)	7 285	7 350	7 484	7 624
	PV benefits ($000)	149 047	158 645	180 957	208 417
	NPV ($000)	141 762	151 295	173 473	200 792
	BCR	20.5	21.6	24.2	27.3
Overall	BCR	17.0	17.9	20.0	22.6

Source BTE

TABLE XV.9 REGIONAL VICTORIA RESULTS BY TREATMENT TYPE 1996–97

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	494	6 898	7 371	8 469	9 815	15.0	15.9	18.1	20.9
k15	91	-253	-258	-267	-277	-1.8	-1.8	-1.9	-2.0
k3	109	-21	-19	-14	-9	0.8	0.8	0.9	0.9
ot	25	7 123	7 581	8 643	9 944	286.8	305.2	347.8	400.1
s12	107	2 697	2 877	3 294	3 804	26.3	27.9	31.8	36.6
s14	535	6 523	6 853	7 587	8 437	13.2	13.8	15.2	16.8
Overall	1 361	22 966	24 405	27 711	31 714	17.9	18.9	21.4	24.3

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.10 REGIONAL VICTORIA RESULTS BY TREATMENT TYPE 1997–98

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	1 030	10 347	11 076	12 767	14 838	11.0	11.8	13.4	15.4
k14	129	1 909	1 964	2 081	2 208	15.8	16.2	17.1	18.1
k2	156	-156	-156	-156	-156	0.0	0.0	0.0	0.0
k3	22	249	256	272	289	12.4	12.8	13.5	14.3
k9	147	-249	-252	-258	-264	-0.7	-0.7	-0.8	-0.8
ot	265	3 497	3 738	4 297	4 982	14.2	15.1	17.2	19.8
s13	304	-510	-515	-527	-540	-0.7	-0.7	-0.7	-0.8
s14	218	1 904	2 003	2 224	2 480	9.7	10.2	11.2	12.4
s17	126	10 362	10 852	11 943	13 207	83.4	87.3	96.0	106.0
s20	72	1 072	1 103	1 168	1 240	15.8	16.3	17.2	18.2
Overall	2 469	28 424	30 068	33 810	38 282	12.5	13.2	14.7	16.5

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.11 REGIONAL VICTORIA RESULTS BY TREATMENT TYPE 1998–99

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	119	544	586	685	805	5.6	5.9	6.8	7.8
k14	189	737	762	815	873	4.9	5.0	5.3	5.6
k15	236	-441	-446	-458	-471	-0.9	-0.9	-0.9	-1.0
k9	97	-168	-170	-174	-178	-0.7	-0.7	-0.8	-0.8
s12	79	966	1 033	1 188	1 378	13.2	14.0	16.0	18.4
s14	705	5 394	5 679	6 313	7 048	8.7	9.1	10.0	11.0
s20	71	1 646	1 692	1 791	1 898	24.0	24.7	26.1	27.6
s3	41	-481	-492	-518	-545	-10.8	-11.1	-11.7	-12.4
s7	137	-137	-137	-137	-137	0.0	0.0	0.0	0.0
Overall	1 674	8 060	8 507	9 506	10 672	5.8	6.1	6.7	7.4

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.12 MELBOURNE RESULTS BY TREATMENT TYPE 1996–97

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k15	44	1 326	1 363	1 441	1 527	30.8	31.6	33.4	35.3
k2	203	1 339	1 380	1 469	1 565	7.6	7.8	8.2	8.7
k3	391	13 188	14 058	16 076	18 548	34.7	36.9	42.1	48.4
k4	96	1 621	1 731	1 986	2 298	17.9	19.0	21.7	24.9
ot	257	4 101	4 380	5 027	5 821	16.9	18.0	20.5	23.6
s12	528	24 344	25 938	29 633	34 161	47.1	50.1	57.1	65.6
s13	312	10 237	10 521	11 127	11 788	33.8	34.7	36.6	38.7
s14	53	2 604	2 728	3 004	3 325	49.8	52.1	57.3	63.3
s18	32	1 857	1 979	2 259	2 603	59.0	62.8	71.5	82.3
s20	11	913	972	1 109	1 277	86.5	92.0	104.9	120.6
s3	53	1 634	1 680	1 777	1 882	31.6	32.5	34.3	36.3
s7	16	-471	-492	-540	-594	-28.8	-30.1	-33.1	-36.6
s9	165	474	491	528	568	3.9	4.0	4.2	4.4
Overall	2 163	63 167	66 728	74 897	84 770	30.2	31.8	35.6	40.2

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ ‘000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.13 MELBOURNE RESULTS BY TREATMENT TYPE 1997–98

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	543	9 447	10 087	11 571	13 390	18.4	19.6	22.3	25.7
k14	285	2 203	2 270	2 413	2 569	8.7	9.0	9.5	10.0
k19	297	2 395	2 567	2 967	3 457	9.1	9.6	11.0	12.6
k2	299	1 694	1 748	1 863	1 988	6.7	6.8	7.2	7.6
k20	124	499	515	551	590	5.0	5.2	5.5	5.8
k21	12	74	77	82	87	7.3	7.5	7.9	8.3
k3	405	18 779	20 008	22 858	26 351	47.3	50.4	57.4	66.0
k4	57	1 471	1 569	1 796	2 075	26.6	28.3	32.3	37.1
ot	270	10 763	11 470	13 110	15 118	40.8	43.5	49.5	57.0
s12	13	976	1 040	1 186	1 367	76.9	81.8	93.2	107.2
s13	159	6 050	6 217	6 573	6 962	39.0	40.0	42.2	44.7
s14	236	8 268	8 665	9 550	10 574	36.1	37.8	41.5	45.9
s17	248	-1 729	-1 769	-1 854	-1 947	-6.0	-6.1	-6.5	-6.8
s2	25	223	230	244	260	10.0	10.3	10.9	11.5
s20	470	21 311	22 706	25 942	29 908	46.3	49.3	56.2	64.6
s3	54	733	754	799	849	14.5	14.8	15.7	16.6
s7	106	-12 710	-13 299	-14 611	-16 129	-119.4	-125.0	-137.5	-151.9
Overall	3 604	70 446	74 855	85 041	97 467	20.5	21.8	24.6	28.0

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.14 MELBOURNE RESULTS BY TREATMENT TYPE 1998–99

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	679	12 415	13 254	15 200	17 583	19.3	20.5	23.4	26.9
k14	218	3 906	4 017	4 254	4 513	18.9	19.4	20.5	21.7
k2	114	453	468	501	536	5.0	5.1	5.4	5.7
k3	342	5 728	6 117	7 019	8 124	17.7	18.9	21.5	24.7
k9	40	233	240	256	273	6.9	7.0	7.4	7.9
ot	135	3 814	4 067	4 654	5 373	29.2	31.1	35.4	40.7
s13	65	1 814	1 865	1 973	2 091	28.7	29.5	31.1	32.9
s14	182	3 702	3 883	4 287	4 755	21.3	22.3	24.5	27.1
s20	71	2 419	2 579	2 949	3 402	35.1	37.4	42.6	49.0
s7	235	-18 892	-19 764	-21 705	-23 953	-79.3	-83.0	-91.3	-100.8
Overall	2 082	15 592	16 727	19 387	22 697	8.5	9.0	10.3	11.9

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ ‘000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.15 QUEENSLAND OVERALL RESULTS

	Discount Rate (%)	*8*	*7*	***5***	*3*
Regional	Capital $(000)	10 949	11 034	11 210	11 394
	PV benefits (000)	47 727	51 218	59 386	69 514
	NPV ($000)	36 778	40 184	48 177	58 120
	BCR	4.4	4.6	5.3	6.1
Urban	Capital ($000)	8 083	8 159	8 319	8 487
	PV benefits($000)	133 149	143 102	166 454	195 540
	NPV ($000)	125 066	134 942	158 135	187 053
	BCR	16.5	17.5	20.0	23.0
Overall	**BCR**	**9.5**	**10.1**	**11.6**	**13.3**

Source BTE

TABLE XV.16 REGIONAL QUEENSLAND RESULTS BY TREATMENT TYPE 1996–97

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	2 401	18 539	19 881	22 992	26 804	8.7	9.3	10.6	12.2
k3	277	1 879	2 017	2 337	2 730	7.8	8.3	9.4	10.9
k4	148	2 441	2 607	2 991	3 463	17.5	18.6	21.2	24.3
k6	396	-396	-396	-396	-396	0.0	0.0	0.0	0.0
s12	177	-177	-177	-177	-177	0.0	0.0	0.0	0.0
s13	475	-3 092	-3 163	-3 313	-3 477	-5.5	-5.7	-6.0	-6.3
s7	119	-1 000	-1 023	-1 074	-1 129	-7.4	-7.6	-8.1	-8.5
Overall	3 992	18 194	19 745	23 361	2 7817	5.6	5.9	6.9	8.0

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ ‘000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.17 REGIONAL QUEENSLAND RESULTS BY TREATMENT TYPE 1997–98

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	1 209	10 422	11 167	12 896	15 013	9.6	10.2	11.7	13.4
k14	148	269	281	305	331	2.8	2.9	3.1	3.2
k2	535	-535	-535	-535	-535	0.0	0.0	0.0	0.0
k3	193	3 971	4 238	4 856	5 614	21.6	23.0	26.2	30.1
k4	119	4 740	5 051	5 773	6 658	40.9	43.5	49.6	57.0
k6	25	-25	-25	-25	-25	0.0	0.0	0.0	0.0
ot	3 021	-3021	-3 021	-3 021	-3 021	0.0	0.0	0.0	0.0
Overall	5 249	15 823	17 157	20 250	24 036	4.0	4.3	4.9	5.6

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ ‘000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.18 REGIONAL QUEENSLAND RESULTS BY TREATMENT TYPE 1998–99

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	248	1 735	1 862	2 156	2 517	8.0	8.5	9.7	11.2
k14	108	-45	-43	-39	-35	0.6	0.6	0.6	0.7
k15	5	-5	-5	-5	-5	0.0	0.0	0.0	0.0
k3	466	2 862	3 075	3 569	4 175	7.1	7.6	8.7	10.0
k4	486	1 346	1 463	1 735	2 069	3.8	4.0	4.6	5.3
ot	333	-333	-333	-333	-333	0.0	0.0	0.0	0.0
s13	461	-2 256	-2 304	-2 407	-2 520	-3.9	-4.0	-4.2	-4.5
s14	278	1 344	1 388	1 481	1 583	5.8	6.0	6.3	6.7
s18	60	-60	-60	-60	-60	0.0	0.0	0.0	0.0
Overall	2 445	4 588	5042	6 097	7 391	2.9	3.1	3.5	4.0

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ ‘000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.19 BRISBANE RESULTS BY TREATMENT TYPE 1996–97

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	544	6 215	6 648	7 652	8 883	12.4	13.2	15.1	17.3
k2	494	1 843	1 993	2 340	2 766	4.7	5.0	5.7	6.6
k3	589	4 575	4 906	5 673	6 613	8.8	9.3	10.6	12.2
k4	931	18 454	19 696	22 576	26 106	20.8	22.1	25.2	29.0
s14	574	1 961	2 029	2 175	2 334	4.4	4.5	4.8	5.1
Overall	3 133	33 048	35 272	40 417	46 701	11.6	12.3	13.9	15.9

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.20 BRISBANE RESULTS BY TREATMENT TYPE 1997–98

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	302	2 464	2 641	3 052	3 555	9.2	9.7	11.1	12.8
k2	297	2 601	2 787	3 217	3 745	9.8	10.4	11.8	13.6
k3	252	5 778	6 165	7 061	8 159	23.9	25.4	29.0	33.3
k4	595	18 826	20 071	22 956	26 492	32.6	34.7	39.6	45.5
ot	288	-197	-195	-190	-184	0.3	0.3	0.3	0.4
s12	30	121	125	134	144	5.1	5.2	5.5	5.8
s14	6	440	452	478	506	69.4	71.3	75.3	79.6
s20	25	451	464	491	521	19.2	19.7	20.8	22.0
s9	76	652	672	714	759	9.6	9.9	10.4	11.0
Overall	1 871	31 137	33 181	37 913	43 696	17.6	18.7	21.3	24.3

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.21 BRISBANE RESULTS BY TREATMENT TYPE 1998–99

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	972	16 566	17 690	20 296	23 489	18.0	19.2	21.9	25.2
k14	261	-261	-261	-261	-261	0.0	0.0	0.0	0.0
k15	10	318	327	345	366	33.0	33.9	35.8	37.9
k3	1 042	18 438	19 686	22 581	26 127	18.7	19.9	22.7	26.1
k4	1 096	37 799	40 292	46 071	53 152	35.5	37.8	43.0	49.5
s1	322	892	924	994	1 070	3.8	3.9	4.1	4.3
s13	50	-50	-50	-50	-50	0.0	0.0	0.0	0.0
Overall	3 753	73 702	78 608	89 976	103 892	20.6	21.9	25.0	28.7

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.22 SOUTH AUSTRALIA OVERALL RESULTS

	Discount Rate (%)	*8*	*7*	***5***	*3*
Regional	Capital ($000)	4 773	4 804	4 867	4 933
	PV benefits ($000)	13 596	14 376	16 164	18 325
	NPV ($000)	8 822	9 572	11 298	13 393
	BCR	2.8	3.0	3.3	3.7
Urban	Capital ($000)	2 335	2 352	2 388	2 425
	PV benefits ($000)	36 112	38 533	44 165	51 092
	NPV ($000)	33 776	36 181	41 777	48 667
	BCR	15.5	16.4	18.5	21.1
Overall	**BCR**	**7.0**	**7.4**	**8.3**	**9.4**

Source BTE

TABLE XV.23 REGIONAL SOUTH AUSTRALIA RESULTS BY TREATMENT TYPE 1996–97

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	1 249	5 667	6 110	7 137	8 396	5.5	5.9	6.7	7.7
k14	64	-345	-352	-368	-386	-4.4	-4.5	-4.8	-5.0
k2	163	-163	-163	-163	-163	0.0	0.0	0.0	0.0
ot	99	-99	-99	-99	-99	0.0	0.0	0.0	0.0
s14	911	-1 197	-1 205	-1 221	-1 239	-0.3	-0.3	-0.3	-0.4
s20	52	379	391	415	442	8.3	8.5	9.0	9.5
Overall	2 538	4 242	4 681	5 701	6 951	2.7	2.8	3.2	3.7

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.24 REGIONAL SOUTH AUSTRALIA RESULTS BY TREATMENT TYPE 1997–98

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k21	129	255	266	288	312	3.0	3.1	3.2	3.4
k6	1	113	116	123	130	94.1	96.6	102.0	107.9
k8	18	-18	-18	-18	-18	0.0	0.0	0.0	0.0
k9	35	411	423	449	477	12.9	13.2	14.0	14.8
s14	1 121	1 580	1 652	1 807	1 977	2.4	2.5	2.6	2.8
s20	35	1 701	1 747	1 847	1 956	49.1	50.4	53.2	56.3
Overall	1 339	4 042	4 187	4 496	4 833	4.0	4.1	4.4	4.6

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.25 REGIONAL SOUTH AUSTRALIA RESULTS BY TREATMENT TYPE 1998–99

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	432	1 843	1 989	2 327	2 741	5.3	5.6	6.4	7.4
ot	433	-433	-433	-433	-433	0.0	0.0	0.0	0.0
s14	298	-432	-436	-444	-452	-0.5	-0.5	-0.5	-0.5
Overall	1 162	978	1 120	1 450	1 856	1.8	2.0	2.2	2.6

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ ‘000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.26 ADELAIDE RESULTS BY TREATMENT TYPE 1996–97

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	52	-52	-52	-52	-52	0.0	0.0	0.0	0.0
k14	94	-94	-94	-94	-94	0.0	0.0	0.0	0.0
k15	237	11 491	12 242	13 985	16 120	49.4	52.5	59.9	68.9
k2	339	5 625	6 007	6 893	7 979	17.6	18.7	21.4	24.6
k20	12	1 209	1 287	1 468	1 691	98.0	104.2	118.8	136.6
k4	116	764	788	838	893	7.6	7.8	8.2	8.7
s14	52	-578	-592	-622	-655	-10.1	-10.3	-10.9	-11.5
Overall	904	18 364	19 585	22 416	25 881	21.3	22.7	25.8	29.6

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ ‘000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.27 ADELAIDE RESULTS BY TREATMENT TYPE 1997–98

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k15	259	3 231	3 455	3 974	4 609	13.5	14.3	16.3	18.8
k20	15	3 566	3 795	4 327	4 979	242.7	258.2	294.3	338.4
k21	99	2 564	2 735	3 131	3 615	26.9	28.6	32.6	37.5
k4	48	2 180	2 240	2 368	2 507	46.8	48.0	50.7	53.6
s14	238	-1 216	-1 242	-1 299	-1 360	-4.1	-4.2	-4.5	-4.7
s20	198	-586	-597	-619	-643	-2.0	-2.0	-2.1	-2.3
s9	249	6 712	7 158	8 192	9 460	28.0	29.7	33.9	39.0
Overall	1 105	16 451	17 544	20 074	23 168	15.9	16.9	19.2	22.0

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.28 ADELAIDE RESULTS BY TREATMENT TYPE 1998–99

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	198	-198	-198	-198	-198	0.0	0.0	0.0	0.0
k19	119	-119	-119	-119	-119	0.0	0.0	0.0	0.0
k4	159	527	546	585	628	4.3	4.4	4.7	5.0
Overall	476	210	228	268	311	1.4	1.5	1.6	1.7

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ ‘000. Column may not add to total due to rounding.

Source BTE

TABLE XV.29 WESTERN AUSTRALIA OVERALL RESULTS

	Discount Rate (%)	*8*	*7*	***5***	*3*
Regional	Capital ($000)	5 116	5 159	5 250	5 345
	PV benefits ($000)	48 207	51 206	58 125	66 556
	NPV ($000)	43 091	46 046	52 876	61 211
	BCR	9.4	9.9	11.1	12.5
Urban	Capital ($000)	5 935	5 987	6 096	6 211
	PV benefits ($000)	73 371	79 053	92 445	109 207
	NPV ($000)	67 436	73 066	86 348	102 997
	BCR	12.4	13.2	15.2	17.6
Overall	**BCR**	**11.0**	**11.7**	**13.3**	**15.2**

Source BTE

TABLE XV.30 REGIONAL WESTERN AUSTRALIA RESULTS BY TREATMENT TYPE 1996–97

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	207	3 893	4 156	4 765	5 511	19.8	21.1	24.1	27.7
k14	69	-438	-448	-469	-493	-5.3	-5.5	-5.8	-6.1
k15	42	774	796	843	894	19.6	20.2	21.3	22.5
k21	256	312	327	360	395	2.2	2.3	2.4	2.5
k4	69	-170	-172	-178	-184	-1.5	-1.5	-1.6	-1.7
ot	935	9 004	9 640	11 117	12 927	10.6	11.3	12.9	14.8
s14	297	1 412	1 458	1 556	1 663	5.8	5.9	6.2	6.6
s17	99	1 702	1 751	1 854	1 967	18.2	18.7	19.8	20.9
s7	18	3 548	3 715	4 086	4 515	200.3	209.7	230.5	254.7
Overall	1 991	20 037	21 222	23 933	27 196	11.1	11.7	13.0	14.7

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.31 REGIONAL WESTERN AUSTRALIA RESULTS BY TREATMENT TYPE 1997–98

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	668	12 577	13 425	15 393	17 804	19.8	21.1	24.0	27.6
k14	79	-727	-745	-782	-823	-8.2	-8.4	-8.9	-9.4
k18	146	-804	-821	-859	-900	-4.5	-4.6	-4.9	-5.2
k19	25	615	656	751	867	25.8	27.5	31.3	36.0
k2	129	673	695	741	791	6.2	6.4	6.8	7.1
k3	346	-774	-785	-810	-837	-1.2	-1.3	-1.3	-1.4
k4	89	-216	-220	-227	-235	-1.4	-1.5	-1.5	-1.6
k7	51	625	668	768	891	13.3	14.2	16.2	18.6
k9	12	461	474	501	530	38.7	39.7	41.9	44.4
ot	136	2 430	2 499	2 647	2 807	18.9	19.4	20.5	21.7
s10	19	-19	-19	-19	-19	0.0	0.0	0.0	0.0
s7	40	872	915	1 010	1 119	23.0	24.1	26.5	29.3
Overall	1 740	15 712	16 741	19 113	21 997	10.0	10.6	12.0	13.6

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.32 REGIONAL WESTERN AUSTRALIA RESULTS BY TREATMENT TYPE 1998–99

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k13	129	2 910	3 052	3 368	3 734	23.6	24.7	27.1	30.0
k14	55	-360	-369	-386	-405	-5.6	-5.8	-6.1	-6.4
k3	89	-231	-235	-243	-252	-1.6	-1.6	-1.7	-1.8
ot	1 195	4 507	4 873	5 720	6 758	4.8	5.1	5.8	6.7
s14	297	3 096	3 187	3 382	3 595	11.4	11.7	12.4	13.1
Overall	1 766	9 922	10 508	11 841	13 430	6.6	7.0	7.7	8.6

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.33 PERTH RESULTS BY TREATMENT TYPE 1996–97

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	445	6 933	7 406	8 502	9 846	16.6	17.6	20.1	23.1
k14	223	5 018	5 354	6 132	7 086	23.5	25.0	28.5	32.8
k19	396	-903	-936	-1 011	-1 104	-1.3	-1.4	-1.6	-1.8
k2	424	9 438	10 070	11 536	13 331	23.3	24.8	28.2	32.4
k21	30	247	255	271	288	9.3	9.6	10.1	10.7
k4	698	11 075	11 829	13 578	15 722	16.9	17.9	20.5	23.5
Overall	2 215	31 809	33 978	39 008	45 169	15.4	16.3	18.6	21.4

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.34 PERTH RESULTS BY TREATMENT TYPE 1997–98

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	361	6 980	7 451	8 541	9 878	20.3	21.6	24.6	28.3
k11	20	-483	-495	-522	-551	-23.4	-24.0	-25.3	-26.8
k14	224	11 855	12 629	14 423	16 622	53.9	57.3	65.3	75.1
k19	152	5 245	5 591	6 393	7 376	35.4	37.7	42.9	49.4
k20	84	662	682	724	771	8.9	9.1	9.6	10.2
k21	72	254	263	281	302	4.5	4.7	4.9	5.2
k3	475	3 230	3 468	4 018	4 693	7.8	8.3	9.5	10.9
k4	471	12 059	12 862	14 723	17 004	26.6	28.3	32.2	37.1
s13	15	-291	-299	-314	-332	-18.6	-19.1	-20.2	-21.3
s20	40	-2 386	-2 449	-2 584	-2 731	-58.9	-60.5	-63.8	-67.5
s7	74	-1 717	-1 761	-1 855	-1 958	-22.1	-22.7	-24.0	-25.4
Overall	1 989	35 408	37 940	43 830	51 075	18.8	20.1	23.0	26.7

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ ‘000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.35 PERTH RESULTS BY TREATMENT TYPE 1998–99

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	102	1 936	2 066	2 369	2 740	20.0	21.3	24.3	27.9
k14	238	5 051	5 390	6 175	7 138	22.3	23.7	27.0	31.0
k15	35	33	35	39	43	1.9	2.0	2.1	2.2
k18	212	-2 567	-2 630	-2 766	-2 913	-11.1	-11.4	-12.0	-12.7
k19	60	3 667	3 906	4 460	5 139	62.6	66.6	75.9	87.3
k2	310	5 070	5 415	6 214	7 193	17.4	18.5	21.1	24.2
k20	40	502	516	548	582	13.6	14.0	14.8	15.7
k21	30	124	128	137	147	5.2	5.3	5.6	5.9
k4	79	632	651	692	737	9.0	9.2	9.7	10.3
ot	878	-12 564	-12 879	-13 550	-14 283	-13.3	-13.7	-14.4	-15.3
s1	193	2 019	2 161	2 490	2 893	11.4	12.2	13.9	16.0
s2	15	-588	-604	-637	-672	-37.3	-38.3	-40.5	-42.8
Overall	2 191	3 314	4 155	6 171	8 742	2.5	2.9	3.8	5.0

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000. Column may not add to total due to rounding.

Source BTE

TABLE XV.36 TASMANIA OVERALL RESULTS

	Discount Rate (%)	*8*	*7*	***5***	*3*
Regional	Capital($000)	707	717	737	759
	PV benefits($000)	23 095	24 723	28 513	33 187
	NPV($000)	22 388	24 006	27 775	32 428
	BCR	32.7	34.5	38.7	43.7
Urban	Capital($000)	740	740	740	740
	PV benefits($000)	10 867	11 541	13 101	15 008
	NPV($000)	10 127	10 801	12 361	14 268
	BCR	14.7	15.6	17.7	20.3
Overall	**BCR**	**23.5**	**24.9**	**28.2**	**32.1**

Source BTE

TABLE XV.37 REGIONAL TASMANIA RESULTS BY TREATMENT TYPE 1997–98

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	356	18 820	20 048	22 897	26 388	53.8	57.3	65.3	75.0
k14	31	944	971	1 027	1 088	31.8	32.6	34.5	36.4
Overall	387	19 764	21 019	23 924	27 476	52.1	55.3	62.8	72.0

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ ‘000.

Source BTE

TABLE XV.38 REGIONAL TASMANIA RESULTS BY TREATMENT TYPE 1998–99

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	129	2 185	2 333	2 677	3 098	17.9	19.1	21.8	25.0
k14	7	649	667	705	746	94.5	97.1	102.5	108.4
k15	68	-255	-260	-271	-282	-2.7	-2.8	-3.0	-3.1
k6	15	-15	-15	-15	-15	0.0	0.0	0.0	0.0
ot	99	-99	-99	-99	-99	0.0	0.0	0.0	0.0
s1	10	186	192	203	215	19.8	20.3	21.5	22.7
s12	23	1 178	1 210	1 279	1 354	52.8	54.3	57.3	60.6
s14	1	-1	-1	-1	-1	0.0	0.0	0.0	0.0
s2	5	-350	-359	-379	-400	-69.5	-71.4	-75.4	-79.7
s20	50	1 290	1 326	1 403	1 487	27.0	27.7	29.3	31.0
Overall	407	4 769	4 994	5 502	6 103	12.7	13.3	14.5	16.0

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ ‘000.
Column may not add to total due to rounding.

Source BTE

TABLE XV.39 HOBART RESULTS BY TREATMENT TYPE 1996–97

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	185	1 353	1 394	1 482	1 579	8.3	8.5	9.0	9.5
k15	30	696	716	758	803	24.5	25.1	26.5	28.1
k3	328	6 218	6 638	7 610	8 802	20.0	21.2	24.2	27.9
k4	40	3 683	3 921	4 474	5 152	94.1	100.1	114.1	131.3
s13	10	-10	-10	-10	-10	0.0	0.0	0.0	0.0
s14	40	-1 296	-1 330	-1 402	-1 480	-31.8	-32.6	-34.4	-36.4
s2	10	760	780	824	873	77.8	79.9	84.4	89.3
s20	99	-1 277	-1 309	-1 376	-1 450	-11.9	-12.2	-12.9	-13.7
Overall	740	10 127	10 801	12 361	14 268	14.7	15.6	17.7	20.3

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000. Column may not add to total due to rounding.

Source BTE

TABLE XV.40 NORTHERN TERRITORY OVERALL RESULTS

	Discount Rate (%)	*8*	*7*	***5***	*3*
Regional	Capital ($000)	932	939	953	968
	PV benefits($000)	3 762	3 936	4 316	4 745
	NPV ($000)	2 830	2 997	3 363	3 777
	BCR	4.0	4.2	4.5	4.9
Urban	Capital ($000)	683	689	702	716
	PV benefits($000)	-2 549	-2 690	-3 012	-3 400
	NPV ($000)	-3 232	-3 379	-3 714	-4 116
	BCR	-3.7	-3.9	-4.3	-4.8
Overall	**BCR**	**0.75**	**0.77**	**0.79**	**0.80**

Source BTE

TABLE XV.41 REGIONAL NORTHERN TERRITORY RESULTS BY TREATMENT TYPE 1996–97

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	99	138	145	158	173	2.4	2.5	2.6	2.8
s14	413	-667	-674	-688	-704	-0.6	-0.6	-0.7	-0.7
Overall	512	-529	-529	-530	-531	0.0	0.0	0.0	0.0

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Source BTE

TABLE XV.42 REGIONAL NORTHERN TERRITORY RESULTS BY TREATMENT TYPE 1997–98

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
s12	79	-79	-79	-79	-79	0.0	0.0	0.0	0.0
s7	44	-21	-21	-19	-18	0.5	0.5	0.6	0.6
Overall	123	-100	-100	-98	-97	0.2	0.2	0.2	0.2

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000.
Source BTE

TABLE XV.43 REGIONAL NORTHERN TERRITORY RESULTS BY TREATMENT TYPE 1998–99

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	119	571	589	629	672	5.8	5.9	6.3	6.6
s11	40	4 422	4 542	4 799	5 078	112.4	115.5	121.9	129.0
s14	198	-967	-988	-1 032	-1 080	-3.9	-4.0	-4.2	-4.4
Overall	357	4 026	4 144	4 395	4 670	12.3	12.6	13.3	14.1

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000
Column may not add to total due to rounding

Source BTE

TABLE XV.44 DARWIN RESULTS BY TREATMENT TYPE 1996–97

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k19	40	-1 882	-2 000	-2 274	-2 610	-46.6	-49.6	-56.5	-65.0
k2	74	-74	-74	-74	-74	0.0	0.0	0.0	0.0
s2	148	-148	-148	-148	-148	0.0	0.0	0.0	0.0
Overall	262	-2 105	-2 223	-2 497	-2 832	-7.0	-7.5	-8.5	-9.8

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000
Column may not add to total due to rounding

Source BTE

TABLE XV.45 DARWIN RESULTS BY TREATMENT TYPE 1997–98

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	39	-1 161	-1 192	-1 256	-1 326	-28.7	-29.5	-31.1	-32.9
ot	59	-59	-59	-59	-59	0.0	0.0	0.0	0.0
s5	99	-99	-99	-99	-99	0.0	0.0	0.0	0.0
Overall	197	-1 320	-1 350	-1 414	-1 485	-5.7	-5.8	-6.2	-6.5

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000. Column may not add to total due to rounding.

Source BTE

TABLE XV.46 DARWIN RESULTS BY TREATMENT TYPE 1998–99

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k14	149	2 469	2 540	2 690	2 854	17.6	18.1	19.1	20.2
k19	99	-2 332	-2 392	-2 520	-2 660	-22.5	-23.1	-24.4	-25.8
s7	30	-26	-26	-26	-26	0.1	0.1	0.1	0.1
Overall	278	111	121	144	168	1.4	1.4	1.5	1.6

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000. Column may not add to total due to rounding.

Source BTE

TABLE XV.47 AUSTRALIAN CAPITAL TERRITORY OVERALL RESULTS

Discount Rate (%)	*8*	*7*	***5***	*3*
Capital ($000)	1 630	1 640	1 663	1 686
PV Benefits ($000)	8 140	8 594	9 632	10 884
NPV ($000)	6 510	6 953	7 970	9 198
BCR 5.0	5.2	5.8	6.5	

Source BTE

TABLE XV.48 AUSTRALIAN CAPITAL TERRITORY RESULTS BY TREATMENT TYPE 1996–97

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	346	3 485	3 730	4 299	4 997	11.1	11.8	13.4	15.4
k14	30	-71	-72	-74	-77	-1.4	-1.4	-1.5	-1.6
k15	99	416	430	460	492	5.2	5.4	5.7	6.0
Overall	475	3 830	4 089	4 685	5 412	9.1	9.6	10.9	12.4

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000. All ACT projects were conducted in urban areas. Column may not add to total due to rounding.

Source BTE

TABLE XV.49 AUSTRALIAN CAPITAL TERRITORY RESULTS BY TREATMENT TYPE 1997–98

T-Code	*Project cost*	*NPV (8%)*	*NPV (7%)*	*NPV (5%)*	*NPV (3%)*	*BCR (8%)*	*BCR (7%)*	*BCR (5%)*	*BCR (3%)*
k1	752	849	952	1 190	1 482	2.1	2.3	2.6	3.0
k11	252	1 173	1 212	1 293	1 383	5.6	5.8	6.1	6.5
k14	99	-192	-194	-200	-205	-0.9	-1.0	-1.0	-1.1
k15	144	1 063	1 096	1 165	1 241	8.4	8.6	9.1	9.6
Overall	1 247	2 894	3 065	3 449	3 900	3.3	3.5	3.8	4.1

Note Figures in brackets are discount rates. Project cost and NPV are expressed in $ '000. All ACT projects were conducted in urban areas. Column may not add to total due to rounding.

Source BTE

ABBREVIATIONS

AADT	annual average daily traffic
ABS	Australian Bureau of Statistics
ACT	Australian Capital Territory
ANOVA	Analysis of variance
ARRB	Australian Road Research Board
ATSB	Australian Transport Safety Bureau
BCA	benefit-cost analysis
BCR	benefit-cost ratio
BTCE	Bureau of Transport and Communications Economics (now BTE)
BTE	Bureau of Transport Economics
DCA	definitions for classifying accidents
FORS	Federal Office of Road Safety (now ATSB)
GIS	Geographical Information Systems
GPS	Global Positioning System
MUARC	Monash University Accident Research Centre
na	not available
NPV	net present value
NSW	New South Wales
NT	Northern Territory
nya	not yet available
OECD	Organisation for Economic Cooperation and Development
PDO	property damage only
Qld	Queensland
RUM	road user movements (an earlier form of DCA)
SA	South Australia
TAC	Transport Accident Commission (of Victoria)
Tas	Tasmania
T-Code	Treatment Code
Vic	Victoria
WA	Western Australia

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