Cost - Effectiveness of 'Black Spot' Treatments : A Pilot Study

Working Paper

This Paper presents the results of an evaluation of 5 1 'Black Spot' projects funded by the Australian Government, 26 in Victoria and 25 in New South Wales. The evaluation was based on the record of accidents before and after approved treatments were put in place. In order to isolate actual treatment effects, adjustments were made to take account of the major recent decline in accidents in suitable control areas.

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Cost-effectiveness of 'Black Spot' treatments - a pilot study

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FOREWORD

The Portfolio Evaluation Plan of the Department of Transport and Communications for the period 1992 to 1994 provided for a review of the effectiveness of the Road Safety 'Black Spot' Program. The objective of this Program was to reduce the number and severity of road crashes, particularly at black spot locations around Australia, in conjunction with the introduction of a ten-point package of more general road safety measures.

This pilot study, based on a small sample of completed projects in New South Wales and Victoria, was undertaken by the BTCE to develop and test methodologies as well as to provide an early assessment of the effectiveness of the Program. Because of factors such as the small number of projects analysed and the short time periods for which relevant crash data were available, caution needs to be exercised in making any generalisations from the results of the pilot study.

The full-scale study will be more comprehensive in scope, evaluating projects from all Australian States and Territories in its first phase. It is intended that a second phase will concentrate on the effectiveness of the Federal Government's Ten Point Road Safety Package, and on world best practice in such areas as the identification of black spots and the implementation and evaluation of black spot programs.

Data used in the preparation of this paper were provided by the Roads and Traffic Authority of New South Wales and VIC ROADS. Their assistance is gratefully acknowledged, as is that of the staff of the Road User Branch of the Federal Office of Road Safety and of Paul Blair of the Technical Projects Section, Land Transport Policy Division of the Department of Transport and Communications.

This paper was prepared by a study team led by Joe Motha. Bogey Musidlak and Catharina Williams each undertook major aspects of the analysis.

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ABSTRACT

This paper presents the results of an evaluation of 51 'Black Spot' projects funded by the Australian Government, 26 in Victoria and 25 in New South Wales. The evaluation was based on the record of accidents before and after approved treatments were put in place. In order to isolate actual treatment effects, adjustments were made to take account of the major recent decline in accidents in suitable control areas.

A major part of the analysis compares how accident-severity and accident-type methodologies differ in assessing the effectiveness of the three most common treatments at the 51 sites: the installation of new traffic lights; the modification of existing traffic lights (mainly the installation of separate right-turn phases); and the construction of roundabouts.

The evaluation took the form of a benefit-cost analysis. Various measures of effectiveness are presented for assumed project lifetimes of 20 and 10 years using a primary discount rate of 7 per cent. Except where a fatality occurred in the 'before' period, the accident-type approach produced much higher benefit-cost ratio estimates.

The pilot study was intended to provide an early indication of the degree of effectiveness of Black Spot Program expenditure and therefore did not strive to resolve all data and methodology issues. A number of important matters are identified for more detailed examination in the full-scale evaluation which will follow.

For these reasons and because of various sample characteristics discussed in the paper, caution needs to be exercised in generalising the results of the pilot study. Nevertheless, in the context of these data and methodological limitations, the results of the pilot study are encouraging and suggest that the Black Spot Program has yielded substantial benefits to road users.

SUMMARY

Selection of sites for pilot study

In the pilot evaluation of the Road Safety 'Black Spot' Program, expenditure and crash record details were obtained for 51 project sites, 26 in Victoria (both urban and rural) and 25 in New South Wales (all urban). These sites were selected from 137 eligible projects completed before the end of June 1991, by reference to the following principles:

- selection to reflect levels of overall expenditure on different treatments in this period
- selection to achieve a reasonable geographical balance among eligible projects
- selection to be more likely as project expenditure increased, and only a few very-low-cost projects to be evaluated

The average cost of the treatments at these 51 sites was $122 000, compared with an average of $85 000 over the three full years of the Program. If accident numbers prior to treatment were representative of those for the entire Program, this study may tend to understate overall benefit-cost ratios.

Most treatments were undertaken completely within the 1990-91 financial year, but there was some uncertainty about the accuracy of start and completion dates. No attempt was made to quantify part-year accident-reduction benefits or construction phase effects during 1990-91. Instead, the 'before' period was uniformly taken to be 1989-90, and the 'after' period to be 1991-92.

Accident-severity and accident-type improvements after treatment

Fatalities occur much less frequently than serious or minor injury crashes. While fatal accidents at pilot study black spot sites decreased by one in Victoria and increased by one in New South Wales, no firm inferences can be drawn because of the extremely small numbers involved. On the other hand, in both States the reductions in numbers of serious and minor accidents at treated black spot sites were about double the comparable general improvements for these categories.

Serious injury accidents dropped by 50 per cent in Victoria, and other injury accidents by 58 per cent, compared with Statewide reductions of 27 per cent and 29 per cent respectively. At NSW black spot sites, serious injury accidents fell by 64 per cent, other injury accidents by 38 per cent and towaway property-damage-only (PDO) accidents by 40 per cent, compared with aggregate urban area reductions of 19, 22 and 10 per cent respectively.

When crashes were examined from the viewpoint of vehicle movements just before impact, at black spot sites in Victoria right-angle injury crashes fell by 69 per cent, right-turn by 89 per cent, rear-end by 26 per cent and other injury accidents by 33 per cent. Comparable reductions for all urban areas in Victoria, used as a control group, were estimated to be respectively 32, 36, 27 and 26 per cent.

In New South Wales both injury and towaway PDO accident particulars are still reported and recorded on the central database. At black spot sites, right-angle crashes decreased by 63 per cent and right-turn crashes by 53 per cent, rear-end crashes increased by 48 per cent and other accidents fell by 46 per cent. The reductions in the control area, the combined Sydney/Newcastle/Wollongong statistical regions, over the same period were respectively 17, 15, 11 and 17 per cent.

These comparisons make it clear that in the first year after their implementation the black spot treatments had a relatively greater impact on the incidence of right-angle and right-turn crashes which are generally associated with more serious injury consequences.

Benefit-cost approaches and results

Because of problems associated with chance fluctuations among very small numbers, detailed benefit-cost analysis was restricted to the three black spot treatments occurring most often, namely the installation of new traffic lights at 9 sites, the modification of 19 sets of traffic lights (mainly through the inclusion of a separate right-turn phase), and the construction of 6 roundabouts. Two methodologies were applied, one based on accident severity and the other on accident type.

Annual recurrent costs were derived from VIC ROADS data, project lifetimes were assumed to be 20 or 10 years, and a discount rate of 7 per cent in real terms was applied, with sensitivity values of 5 and 10 per cent. No attempt was made to adjust Victorian data for the non-recording of PDO accidents, or either Victorian or NSW data for non-reporting of eligible crashes.

Under both methodologies, accident reductions at black spot sites were compared with those experienced in an appropriate control group. Monetary values were assigned to the reductions in accidents which could not be explained solely by adjustment for the decline in the control group.

After average injury profiles for 1991 were calculated and Dr Andreassen's estimates of vehicle repair and administration costs developed, Victorian urban right-angle crashes involving injury were costed at around $41 000, right-turn crashes at about $37 000 and rear-end crashes at around $21 000. The figures for these same categories in New South Wales were respectively about $25 000, $25 500 and $16 500, in large part because of the inclusion of lower-cost towaway PDO crashes as a high proportion of recorded data.

As the accident-type method builds in information on the consequences of a large number of accidents, it is less vulnerable to the influence of random fluctuations in crash data, and better able to quantify changes in both incidence and severity patterns. Except when fatalities occurred in the 'before' period, it was found to yield much higher benefit-cost ratios (BCRs) than the accident-severity method.

For sites with new traffic lights in Victoria, the accident-type BCR was 1.9 compared with 9.2 under the accident-severity approach. Sites where traffic lights were modified had an accident-type BCR of 6.1 compared with an accident-severity BCR of 3.9. The corresponding figure for roundabouts was 2.8 instead of 1.8.

Where new traffic lights were installed in New South Wales, the accident-type BCR was 1.1 compared with 0 under the accident-severity methodology (both low because of low crash numbers, the latter especially because of a serious injury in the 'after' period). For sites with modifications of traffic lights the respective values were 7.5 and 2.1, and for those with roundabouts, 7.2 and 2.9.

Both the impacts of outlier sites and distinctive sample characteristics on these various BCRs are discussed towards the end of the Working Paper. The combined nett benefits to society from the 34 projects involving traffic lights and roundabouts, on which about $4.4 million was spent in 1990-91, were assessed at about 19 million dollars under the accident-type methodology. Viewed in this context, the Black Spot Program appears to have delivered significant beneficial effects to road users in Australia.

Issues arising for the full-scale evaluation

The inherent data and methodological limitations of this exploratory pilot study suggest that caution be exercised in interpreting the results or drawing general conclusions about the overall Black Spot Program.

For instance, more detailed sample information will be required about effective lifetimes and annual recurrent costs for treatments, as well as estimates of the cost of any major dislocations during the construction phase. It will also be essential to establish the statistical significance of reductions in different types of accidents.

One further phenomenon to be tackled is that of regression to the mean, whereby reductions can be expected at sites with large numbers of crashes, even in the absence of any treatment. This is because the numbers of observed crashes at those sites are likely to be due to a high true mean accident rate (not necessarily constant) together with some upward (rather than downward) element of random fluctuation. Although the estimation methods presented in the literature appear to be of limited application, advanced time series techniques offer promising avenues for obtaining suitable upper bounds on these chance elements.

While the first-year crash-reduction benefits were assumed to continue unchanged each year for the life of a project, there have actually been major declines in accident rates in recent years. Even though these are unlikely to continue into the future at such high levels, some account might appropriately be taken of likely improvements arising from general reduction strategies.

On the other hand, variation in the extent to which PDO crashes are reported or recorded in different States and Territories raises the question of whether there should be upward adjustments to facilitate comparison. A study commissioned by the Office of Road Safety in South Australia estimates the extent to which accidents are under-reported, and some thought might be given to also adjusting available data for this factor.

INTRODUCTION

In December 1989 the Federal Government announced a Ten Point National Road Safety strategy aimed at reducing the incidence and severity of road crashes. The strategy included an allocation of $120 million over the three years from July 1990 to June 1993, comprising $110 million to eliminate a range of road safety 'Black Spots' and $10 million for research and public education.

An extra $160 million of 'One Nation' and Budget funds were allocated to the Black Spot Program, raising the total expenditure over the life of the Program to $270 million. The Program was developed to help accelerate the eradication of State and Territory black spots, and to demonstrate the effectiveness of implementing such programs both in economic and crash-reduction terms. Additional funds were provided to stimulate local employment opportunities also.

The Black Spot Program was directed at improving the physical condition or management of hazardous locations with a history of crashes involving death or serious injury, by funding appropriate treatments at these locations. A proportion of funds was also allocated to other tangible and visible road safety enhancement measures such as speed and alcohol limit control equipment and bicycle and pedestrian safety initiatives. The Program operated in accordance with provisions of the Australian Land Transport Development Act for a fixed three year term which expired on 30 June 1993.

In liaison with the Australian Road Research Board (ARRB), treatments generally having high benefit-cost ratios were categorised. An approved schedule of treatments (see Appendix 3) for which a benefit-cost ratio greater than 2 would be accepted a priori formed the basis upon which site-specific proposals were submitted to the Federal Office of Road Safety for Ministerial approval.

The listed treatments included installation of roundabouts, median strips, guard rails and guide posts, improved warning signs, and improved line and lane marking; installation or modification of traffic signals; implementation of local area traffic management schemes; widening of roadside shoulders; and the construction of overtaking and turning lanes.

About 3 200 black spot projects with an average cost of $85 000 have been approved for implementation throughout Australia, and all of the available funds have now been allocated.

The Black Spot Program had a number of attributes which warranted its inclusion in the Portfolio Evaluation Plan of the Department of Transport and Communications for the period 1992 to 1994. Among these were its significant resource allocation, substantial policy significance, and potential for future budget implications, as well as the lack of an existing framework for assessment. There was also a high level of public interest in the site work undertaken and its expected benefits.

At a one-day workshop of State and Territory black spot co-ordinators in October 1992, it was decided that there would be a pilot evaluation of about fifty sites in New South

Wales and Victoria where treatment work was completed before the end of the first year of the Program. This would provide an early quantification of the benefits achieved since the implementation of site treatments and allow more detailed development of the methodology for the full-scale evaluation. As various parts of the evaluation were completed, progress results were forwarded to the Federal Office of Road Safety.

THE NATURE OF THE PILOT STUDY

Scope

Ideally, any detailed rigorous evaluation of the effectiveness of the Black Spot Program would involve an analysis of accidents over a period of at least three years before and three years after treatments have been implemented. This is all the more important when there is a simultaneous underlying community trend of major reductions in crash numbers. However, for many projects in this Program all the accident data required for such purposes would not be available until 1996.

Because at least a year's accident data following treatment is indispensable to any credible comparison, and it may take up to two quarters for relevant particulars to be entered into State databases, the pilot study was necessarily limited to those projects which were completed early in the Program. It must therefore be stressed at the outset that the interpretation of the results should be tempered by an appreciation of the small size of the sample in relation to the total number of projects undertaken during the three years of the Program, some of its distinctive characteristics, and the short periods studied before and after the implementation of treatments.

General project particulars

In order to conduct the pilot evaluation, data for sites at which treatment had been undertaken during the 1990-91 financial year were obtained from VIC ROADS and the Roads and Traffic Authority (RTA) of New South Wales during the latter part of 1992. For Victoria and NSW, a sample of 25 projects each and some possible substitutes was selected from groups of 93 and 44 eligible projects respectively completed before the end of June 1991. This task was carried out by reference to the following principles:

- selection to reflect levels of overall expenditure on different treatments in this period;
- selection to achieve a reasonable geographical balance among eligible projects; and
- selection to be more likely as project expenditure increased, and only a few very-low-cost projects to be evaluated.

Several substitutions had to be made because some projects had not been started or completed in the relevant financial year, or because further work was being undertaken or in immediate prospect. Consequently, detailed data were obtained for 26 projects in Victoria (two of these were closely related) and 25 in NSW. The Victorian sample comprised both urban and rural sites while the NSW sample was made up entirely of urban sites.

The average cost of treatment for the selected sample of 51 sites was $122 000 per site, compared with the overall Program average of around $85 000 per site mentioned earlier. Among these projects were 9 installations of new traffic lights (average cost $95 000), 19 modifications of traffic lights (average cost $84 000), 6 roundabout constructions (average cost $323 000) and 4 channelisations (average cost $79 000).

While the sample of sites thus selected was as representative as possible of those at which at least $10 000 had been spent, some of the averages above make it clear that the size and scope of the projects undertaken in that first year were substantially different from overall patterns over the three years for which funding has been available. This needs to be borne in mind in any assessment of benefit-cost ratios or other analytical results for the projects in this pilot study.

Available accident records

There are some differences in the manner in which Victoria and NSW classify and record accidents. First, while NSW has recorded both injury and towaway property-damage-only accidents right through, Victoria has entered only injury accidents in its database from 1991. No attempt has been made in this study to adjust upwards for any property-damage-only (PDO) component in Victoria.

Second, while NSW has maintained five levels of injury (including 'not injured') in its records, Victoria has moved to a four-level classification during this period. As its patterns of reported injuries have also changed markedly since the Transport Accident Commission made reporting mandatory before any claim could be recognised, it has been important to establish data comparability throughout any given period used.

Where necessary in order to compare or aggregate accident data from the two States, accidents involving injury but not hospital admission in NSW were combined to form an 'other' category and equated with the Victorian 'other injury' category.

COMPARISONS OF ACCIDENT-SEVERITY NUMBERS

Victoria

Table 1A shows the aggregate numbers of accidents at the Victorian black spot sites by injury category for the years 1988-89 and 1989-90 prior to the implementation of treatment work, compared with the corresponding figures for 1991-92 after treatment was completed. The classification is determined in each case by the most severe level of injury experienced by any of those involved.

The table illustrates the fluctuations that can occur naturally among small numbers and highlights the caution that must therefore be exercised in interpreting such numbers. Attempts to draw any conclusions on the basis of the small number of fatalities which have occurred in any year would be particularly inadvisable.

TABLE 1A INJURY ACCIDENT DATA FOR 26 VICTORIAN BLACK SPOT SITES, BY SEVERITY

Year	*Fatal*	*Serious*	*Other*	*Total*
1988-89	3	36	102	141
1989-90	3	22	110	135
1991-92	2	11	46	59
Reduction 1989-90 to 1991-92	1	11	64	76
Reduction ***(per cent)***	**33**	**50**	**58**	**56**

Source BTCE analysis of VIC ROADS data

While the Victorian sites were predominantly in urban areas, a sufficient number of them were outside urban areas to make the overall number of crashes throughout the State a more appropriate reference point against which the above accident reductions might be judged. Table 1B shows total Victorian accidents for 1989-90 and 1991-92, classified by severity.

TABLE 1B OVERALL VICTORIAN INJURY ACCIDENT DATA, BY SEVERITY

Year	*Fatal*	*Serious*	*Other*	*Total*
1989-90	579	6 437	15 221	22 237
1991-92	412	4 720	10 866	15 998
Reduction 1989-90 to 1991-92	167	1 717	4 355	6 239
Reduction ***(per cent)***	**29**	**27**	**29**	**28**

Source BTCE analysis of VIC ROADS data

It can be seen from the two tables above that for accidents in the 'serious' and 'other' categories, the percentage reduction in accidents in the sample of black spot sites was roughly twice that experienced for Victoria as a whole.

A large part of the difference can reasonably be attributed to the effect of the actual treatments undertaken. However, some part of it might be due to random fluctuations or chance factors such as unseasonal local weather conditions. Any attempt to estimate the economic impact of reductions due to the treatments should allow for the observed general reductions in accidents in an appropriate control area.

New South Wales

Table 2A lists both the aggregate injury accident data for the 25 black spot sites in New South Wales, as well as the far greater number of towaway PDO crashes, for the same three financial years as presented above for Victoria.

TABLE 2A AGGREGATE ACCIDENT DATA FOR 25 NSW BLACK SPOT SITES, BY SEVERITY

Year	*Fatal*	*Serious*	*Other*	*Total injury*	*Towaway PDO*	*Total recorded*
1988-89	1	10	51	62	98	160
1989-90	-	11	45	56	114	170
1991-92	1	4	28	33	68	101
Reduction 1989-90 to 1991-92	(1)	7	17	23	46	69
Reduction *(per cent)*	**na**	**64**	**38**	**41**	**40**	**41**

( ) = increase na = not applicable

Source BTCE analysis of RTA data

As all the NSW sites were in urban areas, an appropriate reference point for comparison purposes is the overall record in all urban areas. Table 2B shows overall accident trends for NSW urban areas between July 1988 and June 1992. Data for 1988-89 are presented as there are not the same continuity difficulties as those already mentioned as occurring in relation to the Victorian series.

TABLE 2B OVERALL NSW URBAN ACCIDENT DATA, BY SEVERITY

Year	*Fatal*	*Serious*	*Other*	*Total injury*	*Towaway PDO*	*Total recorded*
1988-89	530	4 867	16 718	22 115	32 002	54 117
1989-90	482	4 810	16 066	21 358	31 200	52 558
1991-92	344	3 877	12 519	16 740	27 939	44 679
Reduction 1989-90 to 1991-92	138	933	3 547	4618	3 261	7 879
Reduction *(per cent)*	**29**	**19**	**22**	**22**	**10**	**15**

Source BTCE analysis of RTA data

It is interesting to note the gradations in overall urban reductions according to category, with the particularly strong reduction in fatality levels. By way of comparison, the Victorian accident-reduction experience was fairly constant across injury categories.

From the two NSW tables above, it can be seen that even allowing for the small numbers involved in the sample of black spot sites, once an adjustment is made for the general trend, the impact on serious accidents has been substantially greater than that for minor and PDO accidents.

NSW and Victoria combined

Table 3A provides combined injury accident data for NSW and Victoria in respect of the 51 black spot sites.

TABLE 3A INJURY ACCIDENT DATA FOR 51 BLACK SPOT SITES IN NSW AND VICTORIA

Year	*Fatal*	*Serious*	*Other*	*Total injury*
1988-89	4	46	153	203
1989-90	3	33	155	191
1991-92	3	15	74	92
Reduction 1989-90 to 1991-92	-	18	81	99
Reduction *(per cent)*	**-**	**55**	**52**	**52**

Source BTCE analysis of VIC ROADS and RTA data

Table 3B sets out total injury accidents in Victoria and urban NSW (combining the two minor injury categories for the latter) for 1989-90 and 1991-92.

TABLE 3B COMBINED INJURY ACCIDENTS FOR VICTORIA AND URBAN NSW

Year	*Fatal*	*Serious*	*Other*	*Total Injury*
1989-90	1 061	11 247	31 287	43 595
1991-92	756	8 597	23 385	32 738
Reduction 1989-90 to 1991-2	305	2 650	7 902	10 857
Reduction ***(per cent)***	**29**	**24**	**25**	**25**

Source BTCE analysis of VIC ROADS and RTA data

It is evident from tables 3A and 3B that the first-year improvements in serious and minor accidents at treated black spot sites were about double the overall comparable general improvements for these accident categories.

Tables 1B and 2B reflect the different patterns of crash reductions in the two States, while Tables 1A and 2A illustrate the differences in injury crash records at the respective sample sites. In any attempt to quantify the benefits from accident reductions in 1991-2 after allowing for general community improvements, calculations should be made separately for Victoria and New South Wales, rather than on the basis of the unweighted numbers in Table 3B.

Fatal and serious accidents might be combined and some weighted average cost used for them, if there was concern about the possible strong influence exerted by a year in which one or two chance fatalities occurred. This latter step was not taken in the pilot study, partly to allow this weakness in the accident-severity methodology to be fully exposed.

The costs used for different injury-accident categories were those estimated by the BTCE (1992, 19). These costs are as follows:

Fatal accident	$ 631 092
Hospital accident	$ 94 836
Medical accident	$ 9 987
Nil injury accident	$ 4 215

Source BTCE

The overall percentage reductions in accidents in Table 1B were applied to the relevant entries for 1989-90 in Table 1A to obtain the 'expected 1991-92' situation at Victorian sites if there had been no treatment. The numbers of accidents observed in 1991-92 were then subtracted from these calculated 'expected values' to give the reductions attributed to the treatments. Using the dollar values for the different accident types set out above, the first-year benefits from accident reductions at Victorian sites were found to be around $882 500.

For NSW, the same calculations based on the general reductions in Table 2B and the application of the $4 215 figure for towaway PDO crashes, yielded a first-year accident-reduction benefit of just $51 300. However, if the fatality which occurred in 1991-2 had instead occurred in 1989-90, this methodology would have produced a first-year benefit of $1 130 500, or $987 700 if only injury accidents were considered.

This potential instability that may be manifested when accident-severity methods are applied in cases where only small numbers of crashes are involved is discussed further in later sections.

COMPARISONS OF ACCIDENT-TYPE AND TREATMENT-TYPE DATA

The following analysis is also based on accident numbers before and after treatment, but it examines accidents from the viewpoint of vehicle movements just before impact.

Victoria

In order to examine the influence of treatments on different types of accidents, Victoria's Definitions for Classifying Accidents (DCA) codes were amalgamated as follows:

DCA

121-6 'right-turn' - opposing-directions collision where at least one vehicle is turning.

110-9 'right-angle' - vehicles from adjacent approaches colliding at 90 degrees.

130-2 'rear-end' - vehicles going in the same direction colliding in the same lane.

As opposed to the accident-severity classification of Table 1A, Table 4A shows the variation in the numbers of particular types of injury crashes at the twenty-six black spot sites between 1988-89 and 1991-92, and the percentage reductions from 1989-90 ('before') to 1991-92 ('after').

TABLE 4A TYPES OF INJURY ACCIDENTS AT 26 VICTORIAN BLACK SPOT SITES

Year	*Right-angle*	*Right-turn*	*Rear-end*	*Other*	*Total*
1988-89	30	42	39	30	141
1989-90	39	35	34	27	135
1991-92	12	4	25	18	59
Reduction 1989-90 to 1991-2	27	31	9	9	76
Reduction *(per cent)*	**69**	**89**	**26**	**33**	**56**

Source BTCE analysis of VIC ROADS data

There are elements of random fluctuation from year to year in the table entries. It is however clear that in the first full year after their completion, the black spot treatments had a substantially greater impact on right-angle and right-turn accidents which generally have the more serious injury consequences.

Three treatment types in the Black Spot Program schedule, namely the installation of new traffic lights, the modification of existing traffic lights, and the construction of roundabouts, were implemented at 16 of the 26 sites in this sample. These treatment types also involved the three highest proportions of overall expenditure, 65 per cent in total.

Table 4B sets out the severity record of crashes at sites where these three treatments occurred, as determined by the most serious level of injury sustained by anyone involved.

TABLE 4B SEVERITY OF ACCIDENTS AT 16 VICTORIAN BLACK SPOT SITES, BY TREATMENT

Year	*New traffic lights (4)*			*Modified traffic lights (9)*			*Roundabouts (3)*		
	F	*S*	*O*	*F*	*S*	*O*	*F*	*S*	*O*
1988-89	-	4	9	1	16	53	-	6	21
1989-90	2	3	10	-	11	56	-	4	16
1991-92	-	1	5	-	6	22	-	1	4

F = fatal S = serious O = other injury ( ) = number of sites

Source BTCE analysis of VIC ROADS data

Certainly most of the numbers in the above table are quite small due to the limited number of treatments in the sample. However, it is clear that there was an appreciable impact on both the serious and minor injury accidents.

New South Wales

The Road User Movement (RUM) equivalents for the three accident types occurring most frequently were amalgamated to correspond with what was done with the Victorian data. Table 5A illustrates the number of injury and towaway PDO accidents that occurred during the same three years examined above, and shows the percentage reduction between 1989-90 and 1991-92.

Again, the major impact was in the cases of the right-angle and right-turn accidents which generally have the most serious injury consequences. It is possible that some of the difference from Victoria in the order of magnitude of the right-turn reduction can be attributed to the inclusion of the towaway PDO crashes. Some observations about the increase in rear-end crashes (other than the possibility that the 1989-90 total was unusually low) are made towards the end of this paper.

TABLE 5A TYPES OF INJURY AND TOWAWAY PDO ACCIDENTS AT 25 NSW BLACK SPOT SITES

Year	*Right-angle*	*Right-turn*	*Rear-end*	*Other*	*Total*
1988-89	51	58	38	13	160
1989-90	62	59	25	24	170
1991-92	23	28	37	13	101
Reduction 1989-90 to 1991-2	39	31	(12)	11	69
Reduction *(per cent)*	**63**	**53**	**(48)**	**46**	**41**

( ) = increase

Source BTCE analysis of RTA data

Table 5B sets out the history of the severity of crashes at the sites where the three most prominent treatments, by frequency (18 out of 25) and expenditure (about 80 per cent), were applied. The figures in the table indicate that there were particularly impressive reductions in accident numbers at roundabouts and quite noticeable reductions where traffic lights had been modified, especially through the introduction of separate right-turn phases. Where new traffic lights were installed, there had been few serious accidents beforehand, and hence the major change was in the number of towaway PDO crashes.

TABLE 5B SEVERITY OF ACCIDENTS AT 18 NEW SOUTH WALES BLACK SPOT SITES, BY TREATMENT

Year	New traffic lights (5)				Modified traffic lights (10)				Roundabouts (3)			
	F	S	O	T	F	S	O	T	F	S	O	T
1988-89	-	-	10	12	-	7	24	47	-	-	7	17
1989-90	-	1	4	13	-	6	23	69	-	1	12	16
1991-92	-	1	3	3	-	3	16	41	-	-	1	6

F = fatal S = serious O = other injury T = towaway PDO
( ) = number of sites

Source BTCE analysis of RTA data

BENEFIT-COST APPROACH

In the calculation of benefit-cost ratios, a number of procedures and assumptions were common to both the accident-severity and accident-type approaches. These are set out below. There is further discussion of various more complicated issues towards the end of this paper.

The effects on road users due to the Black Spot Program are basically of three types:

- reductions in the number and severity of road accidents
- time savings for or delays to vehicle occupants, and
- changes in vehicle operating costs.

Recurrent costs

Estimates for the impacts of time savings for/delays to vehicle occupants, changes in vehicle operating costs and annual site maintenance costs used throughout this analysis were based on data for the different treatment types published by VIC ROADS (1992). The nett costs which were applied during each year following the completion of treatment are set out in Table 6. Traffic volumes at specific sites may cause major departures from these average costs.

TABLE 6 COSTS RECURRING ANNUALLY FOR DIFFERENT TREATMENTS

Treatments	*Delay/vehicle (\$)*	*Maintenance (\$)*
New traffic lights	11 000	8 000
Modified traffic lights	1 000	1 000
Roundabouts	1 000	1 000

Source VIC ROADS

If these average costs depart significantly from actual costs for examined sites, there could be a substantial impact on benefit-cost assessments. Consequently, closer study of these aspects, involving some sampling to obtain individual site costs, will be necessary in the next evaluation phase.

Discount rates

Throughout the evaluation, a discount rate of 7 per cent was used over project lifetimes of 20 and 10 years, without any residual capital value being assumed for the treatment at the end of the period. Various sensitivity calculations were made using alternative discount rates of 5 per cent and 10 per cent. In the next phase, more detailed consideration will have to be given to establishing the most appropriate time bands for project lifetimes.

First-year accident-reduction benefits were assumed to continue undiluted for the lifetime of the project and were discounted back to present values. In the full-scale evaluation, the insertion of an appropriate geometric series multiplier would enable the calculation of benefit-cost ratios under the assumption of a continued constant percentage general decrease in accidents in years to come. A range of possibilities might be considered to establish suitable upper and lower bounds.

Other relevant particulars

Most treatments were undertaken completely within the 1990-91 financial year, which was therefore taken as the base year to which both cost and benefit streams were discounted back. The project cost comprises the capital cost (assumed to have been incurred in 1990-91) and the ongoing annual maintenance costs.

Some minor adjustments of dollar values to the base year were not made because they were not considered significant, given the approximate nature of many of the costs and benefits used in the analysis. There was also some uncertainty about the accuracy of start and completion dates, particularly where these were invariably given as the start or end of a month, so the entire quarters in which these apparently fell were set aside as belonging to the construction period.

The use of all other 'before' and 'after' information collected would have required sophisticated weighting techniques still rather susceptible to the vagaries of random fluctuations among very small numbers. Consequently, no attempt was made to quantify accident-reduction benefits during 1990-91, or to assess whether there were benefits or additional difficulties during the actual construction phase.

The benefits in the first year were estimated solely with reference to 1989-90 primarily because of discontinuities in available Victorian data for the Melbourne Statistical Division. As the sample sites at which new traffic lights were installed, existing ones modified or roundabouts constructed were in urban areas, the Melbourne Statistical Division was a more appropriate control group for general accident trends than the State as a whole. For similar reasons, available data for the Sydney, Newcastle and Wollongong regions were aggregated to provide the control group for NSW.

EFFECTIVENESS OF THE THREE MOST COMMON TREATMENTS: ACCIDENT-SEVERITY APPROACH

The first step in the analysis was to obtain comparative figures suggestive of what might have happened if no treatment work had been carried out at any of the 34 black spot sites at which there was traffic light or roundabout expenditure. As mentioned above, the Melbourne Statistical Division as a whole was used as the control area in the case of Victoria, and the combined Sydney/Newcastle/Wollongong urban areas in the case of NSW.

In actual fact, what was observed at the black spot sites, as set out in Tables 4B and 5B above, would have been influenced by some local chance elements and random fluctuations, as well as regression-to-the-mean effects. However, these factors would most likely be rather small in comparison with adjustments made to reflect the major general decline in accidents within the control areas.

Table 7A sets out the accident-severity record for the control area in Victoria, with the most severe injury experienced by an accident victim again determining the classification for any particular accident.

The percentage reductions for serious injuries and other injuries were very close to those recorded for the whole State, as presented in Table 1B. However, once the appropriate subtractions are made, it can be seen that the rate of fatality reductions in the metropolitan area was one-third higher than that achieved in the remainder of the State.

TABLE 7A ACCIDENT SEVERITY NUMBERS IN THE MELBOURNE STATISTICAL DIVISION

Year	*Fatal injury*	*Serious injury*	*Other injury*	*Total injury*
1989-90	314	4 298	11 396	16 008
1991-92	211	3 120	8 122	11 453
Reduction 1989-90 to 1991-2	103	1 178	3 274	4 555
Reduction *(per cent)*	**32.8**	**27.4**	**28.7**	**28.5**

Source BTCE analysis of VIC ROADS data

Table 7B provides details of the accident-severity trends for the relevant comparison area in NSW, including those relating to towaway PDO accidents.

TABLE 7B ACCIDENT SEVERITY TRENDS IN THE SYDNEY/NEWCASTLE/WOLLONGONG REGIONS

Year	*Fatal injury*	*Serious injury*	*Other injury*	*Total injury*	*Towaway PDO*	*Total recorded*
1989-90	360	3 430	12 307	16 097	25 752	41 849
1991-92	256	2 814	9 538	12 608	22 796	35 404
Reduction 1989-90 to 1991-2	104	616	2 769	3 489	2 956	6 445
Reduction *(per cent)*	**28.9**	**18.0**	**22.5**	**21.7**	**11.5**	**15.4**

Source BTCE analysis of RTA data

These two data sets were used as control groups for adjusting what was observed at the sample sites to take account of the various factors contributing to the general decline in accident numbers over time. Once this was done, the observed effects still not accounted for were ascribed to the influence of the treatments carried out.

The first step, to obtain the 'expected 1991-92' situation if there had been no treatment, involved reducing the 1989-90 figures for the sample of sites by the appropriate percentage values shown in the tables above. In the second, the observed 1991-92 accident data were subtracted from these calculated 'expected' figures to yield the reduction attributed to the black spot treatments.

These reductions were then monetised using accident costs estimated by the BTCE as set out in the discussion following Table 3B. It must be noted that the BTCE accident-cost estimates are lower bounds. The benefit-cost ratios (BCRs) and other measures of project effectiveness based on both adjusted (as described above) and unadjusted data and assumed project lives of 20 and 10 years are presented in Appendix 2.

APPLICATION OF THE ACCIDENT-TYPE METHODOLOGY

The specific casualty outcome of an individual accident cannot be predicted. However, it has been found that accidents of particular types have distributions of casualty outcomes that are usually fairly consistent over time.

The methodology developed by Dr David Andreassen of the Australian Road Research Board (ARRB) involves calculating standardised costs per accident for a range of accident types. In several papers, Dr Andreassen has emphasised that results of benefit-cost calculations based on an accident-severity approach are far more susceptible to the influence of chance fluctuations in serious injury accidents, notably fatal accidents, than if the accident-type approach is used.

ARRB's standardised costs are made up of weighted sums of standardised 'per person' casualty costs for different casualty classes, and 'per accident' costs for vehicle damage repairs and other incident-related costs for these accident types. Dr Andreassen has calculated standardised costs for nineteen different accident types such as right-angle, right-turn and rear-end. The casualty outcomes and costs for these different accident types were based on reported accidents in 1987 and 1988. For details of these costs see ARRB (1992).

A methodology based on accident types is useful in the understanding of both the incidence and severity effects of various treatments and enables the cost of the accident types significantly affected by the treatment to be used in the benefit-cost analysis. Some types of accidents (for example, pedestrian impacts or head-on collisions) tend to have more severe personal injury characteristics than others. Therefore, an approach which focuses on different types of accidents has a better chance of distinguishing between systematic and random changes in accident severity after site treatment has been carried out.

Applying the accident-type approach to the evaluation of site treatments ideally involves identifying the different types of accidents whose frequency of occurrence is likely to be affected by a particular treatment, and then testing whether the changes actually observed after the treatment are statistically significant.

However, carrying out such a before/after analysis using short periods of time with small numbers of accidents, makes it difficult to distinguish between definite changes in the trend or pattern of accidents and random fluctuations. In this pilot study, where small initial numbers of particular accident types were often observed, no attempt was made to adjust for these random fluctuations.

Summary of steps in the methodology

- Annual data were obtained for particular accident types. Using these data, average personal injury profiles and hence standardised personal injury costs for different accident types were calculated.
- ARRB's published vehicle repairs and insurance administration data were adjusted to allow for the greater observed average number of vehicles involved in particular types of accidents.
- An adjustment was made for the extent to which reductions in particular accident types could be attributed to general community trends irrespective of the effect of site treatments. This was done using appropriate urban areas within each State as control groups.
- The difference between the expected number of accidents had there been no treatment (that is, adjusted for general community trends) and the observed number of accidents after the treatment was calculated for each accident type. The benefits attributed to the site treatment were then obtained by multiplying each difference by the cost of that accident type, and summing those products.

Calculation of accident-type costs

As there have been very recent major changes in both accident numbers and their overall severity, complete annual data on particular types of crashes in urban areas (for instance, right-angle, right-turn and rear-end accidents) were obtained from the Victorian and NSW authorities. From these data, the injury profile for an average accident of each type was obtained by dividing the total numbers of casualties (killed, hospitalised and so on) by the number of associated accidents.

These individual injury profiles for each accident type were multiplied by the standardised 1991 costs of casualties set out in ARRB (1992) to obtain the total personal injury cost for each accident type. The standardised ARRB costs that were used were $625 065 for a person killed, $107 267 for a person hospitalised, $7 003 for a person injured and requiring medical treatment, $817 for each injured person not requiring medical treatment, and $306 for each person not injured.

Incident-related costs, including property damage, were also derived from ARRB (1992). The calculations in that report were based on the norms of one-vehicle and two-vehicle accidents. However, the aggregate urban data received and analysed indicated that the average number of vehicles per accident, particularly for rear-end crashes, was greater than two.

An adjustment was therefore made to ARRB's figures to take account of this. Only the 'repair cost and insurance administration' component of ARRB's incident costs was increased in proportion to the average number of vehicles actually involved. The other components were treated as constant overheads irrespective of the number of vehicles per accident (see Table 3.4 in ARRB, 1992).

As mentioned at the outset, there were differences in the types of data obtained from NSW and Victoria. In Victoria, recording of data on PDO accidents was discontinued in January 1991 whereas NSW data on towaway PDO accidents have been available consistently.

It was therefore necessary to develop quite separate calculation frameworks for each State before the results could be combined. Aggregate accident-type data with the detail required were available only for all urban areas in Victoria (as determined by the speed limit applicable) rather than for just the Melbourne Statistical Division as used earlier. The benefit-cost ratios calculated later incorporate as much accident-type data as were available from each of the two States.

Table 8 sets out the estimated average costs in 1991 dollars of the three major types of accidents occurring in the urban areas in Victoria and NSW used as controls. The differences in the average costs for the two States are partly due to differences in the patterns of injury severity. However, the key factor that depressed the average accident costs in the case of NSW relative to Victoria was the inclusion of the large number of low-cost towaway PDO accidents in the NSW data.

TABLE 8 ESTIMATED 1991 COSTS OF DIFFERENT ACCIDENT TYPES

Year	*Right-angle ($)*	*Right-turn ($)*	*Rear-end ($)*
Victoria (all urban areas)	41 172	36 825	20 751
NSW* (Sydney/Newcastle/Wollongong)	24 996	25 500	16 551

*only NSW data include towaway PDO accidents

Source BTCE estimates based on data from VIC ROADS, RTA and ARRB (1992)

Sufficient data were available to calculate injury profiles for the remaining accident types as required. The associated estimates of personal-injury costs which were subsequently derived would typically account for 70-80 per cent of the total costs of an accident.

In the case of vehicle repair and insurance administration, however, complete information for the other accident types was not available. A weighted average cost was obtained for the more significant accident types for which data were available and an adjustment was made to account for the relatively lower costs of the other accident types.

This two-stage process produced estimates of $36 901 in total for each 'other' accident in NSW (including towaway PDO accidents) and $54 425 in total for each 'other' accident in Victoria (excluding PDO accidents).

Adjustment for general trend in accident reduction

A drop in accident numbers at treated black spot sites would be expected to occur even if treatments had not been carried out. There are two reasons for this:

- the steep general decline in accident rates in recent years; and

- the regression-to-the-mean effect.

The general decline in the accident rate may be attributed to a range of factors such as education and publicity campaigns, vehicle improvements, economic recession effects, deterrents such as fines and penalties, as well as to treatment work carried out on the worst accident sites.

If black spot sites are chosen for treatment on the basis of their recent high accident record over several years, the observed accidents at the chosen sites are likely to be due to a high true mean accident rate (not necessarily constant) together with some upward (rather than downward) element of random fluctuation. They will tend, on average, to have fewer accidents in subsequent years even if no treatment is carried out. This is the regression-to-the-mean effect for which an initial adjustment should ideally be made in order to help determine the real effect of the site treatment.

The main reason why no attempt was made to do so in this pilot study is explained later in the discussion on regression-to-the-mean issues. Although almost certainly of much smaller magnitude than the underlying trend changes, random fluctuations could still have a marked effect on the results obtained from such limited data. This reinforces the need to exercise caution in interpreting any benefit-cost estimates which are derived.

The process of making the adjustment

As explained earlier, 1990-91 was the year in which the treatments were carried out, 1989-90 the 'before' period and 1991-92 the 'after' period. To estimate the effects attributable to the general decline in the accident rate, the numbers of accidents of a particular type in 1989-90 and 1991-92 were compared (as discussed earlier, there would have been data comparability problems in the case of Victoria if 1988-89 had also been used). The comparisons related to accidents in all urban areas for Victoria and the combined Sydney/Newcastle/Wollongong areas for NSW, these being the most appropriate control regions for which all the relevant data were available.

Financial-year estimates were established from calendar-year data by using other available quarterly or monthly aggregate accident data for scaling purposes. Table 9 sets out the calculated accident-reduction factors applicable to each accident type.

To estimate the 'expected 1991-92' situation if there had been no treatment at the black spot sites, the 1989-90 accident numbers recorded for each accident type were reduced by the corresponding percentage values drawn from Table 9.

The observed 1991-92 accident numbers were subtracted from these calculated 'expected' accident numbers to obtain the estimated reduction (or increase) attributable to the treatments. Then the resulting numbers were multiplied by the relevant average accident-type costs to generate estimates of the 1991-92 accident-cost savings attributable to the treatments.

TABLE 9 URBAN TRENDS FOR ACCIDENT TYPES

Year	*Right-angle*	*Right-turn*	*Rear-end*	*Other*	*Total*
NSW* (Syd/New/Wol)					
1989-90	8 573	4 952	8 980	19 424	41 929
1991-92	7 085	4 204	8 010	16 105	35 404
Reduction 1989-90 to 1991-2	1 488	748	970	3 319	6 525
Reduction *(per cent)*	**17.4**	**15.1**	**10.8**	**17.1**	**15.6**
Victoria (all urban areas)					
1989-90	3 739	2 148	3 972	9 337	19 196
1991-92	2 525	1 381	2 895	6 955	13 756
Reduction 1989-90 to 1991-2	1 214	767	1 077	2 382	5 440
Reduction *(per cent)*	**32.5**	**35.7**	**27.1**	**25.5**	**28.3**

*only NSW data include towaway PDO accidents

Source BTCE estimates based on VIC ROADS and RTA data

Table 10 shows the observed 'before' and 'after' frequencies for different accident types, as were used in the analysis described above. One of its interesting features is a reduction in Victoria in the number of right-turn accidents following the installation of new traffic lights, but an increase in NSW. Further data may indicate that one of these immediate impacts was atypical or that the difference resulted from some systematic effect involving traffic-flow characteristics, topography or whether or not separate right-turn phases were incorporated.

TABLE 10 INCIDENCE OF ACCIDENT TYPES AT BLACK SPOT SITES, BY TREATMENT

Treatments *Year*	*Right-angle*	*Right-turn*	*Rear-end*	*Other*	*Total*
VICTORIA					
UH1 New traffic lights					
1989-90	4	5	3	3	15
1991-92	1	1	3	1	6
UH2 Modified traffic lights					
1989-90	10	25	24	8	67
1991-92	5	2	13	8	28
UH7 Roundabouts					
1989-90	13	3	2	2	20
1991-92	1	0	3	1	5
NSW*					
UH1 New traffic lights					
1989-90	10	3	4	1	18
1991-92	0	5	0	2	7
UH2 Modified traffic lights					
1989-90	22	51	12	13	98
1991-92	13	21	19	7	60
UH7 Roundabouts					
1989-90	25	4	0	0	29
1991-92	5	0	0	2	7

*only NSW data include towaway PDO accidents

Source BTCE analysis of VIC ROADS and RTA data

COMPARISON OF RESULTS USING ACCIDENT-SEVERITY AND ACCIDENT-TYPE APPROACHES

Tables 11 and 12 show the wide disparities in benefit-cost ratios calculated using the accident-severity and accident-type approaches for both adjusted (for general reductions over time in control areas) and unadjusted data, assuming a project life of 20 years for all treatments.

TABLE 11 BENEFIT-COST RATIOS BASED ON ACCIDENT-SEVERITY AND ACCIDENT-TYPE METHODS, FOR ADJUSTED DATA

Treatments	*Accident-severity (BCR)*	*Accident-type (BCR)*
NSW*		
UH1 New traffic lights	0	1.10
UH2 Modified traffic lights	2.14	7.49
UH7 Roundabouts	2.86	7.20
Victoria		
UH1 New traffic lights	9.24	1.92
UH2 Modified traffic lights	3.85	6.05
UH7 Roundabouts	1.84	2.79
Combined NSW*/Victoria		
UH1 New traffic lights	3.84	1.45
UH2 Modified traffic lights	3.01	6.76
UH7 Roundabouts	2.13	4.06

*only NSW data include towaway PDO accidents

Source BTCE estimates based on VIC ROADS and RTA data

TABLE 12 BENEFIT-COST RATIOS BASED ON ACCIDENT-SEVERITY AND ACCIDENT-TYPE METHODS, FOR UNADJUSTED DATA

Treatments	*Accident-severity (BCR)*	*Accident-type (BCR)*
NSW*		
UH1 New traffic lights	0	1.57
UH2 Modified traffic lights	3.79	11.73
UH7 Roundabouts	3.65	9.41
Victoria		
UH1 New traffic lights	14.14	3.57
UH2 Modified traffic lights	8.53	13.43
UH7 Roundabouts	2.92	4.60
Combined NSW*/Victoria		
UH1 New traffic lights	6.01	2.42
UH2 Modified traffic lights	6.19	12.59
UH7 Roundabouts	3.13	5.99

*only NSW data include towaway PDO accidents

Source BTCE estimates based on VIC ROADS and RTA data

The unadjusted data are provided for the purposes of comparison only, to highlight the degree of overstatement of claimed benefits in the absence of any correction for trends in suitable control areas.

Use of the accident-type approach generally markedly increased the estimated BCRs. The sole exception was the case of projects involving the introduction of new traffic lights: the Victorian, and therefore combined NSW/Victoria, BCR fell by a large amount.

The reason for the relatively higher accident-severity BCR in this case becomes fairly clear from an examination of entries in Table 4B. This was the only instance where there were fatalities in 1989-90. If 1988-89 had been used as the base year instead of 1989-90, the accident-severity BCRs for projects involving modification of traffic lights would have increased greatly, because of the occurrence of a single fatality at one of the sites.

This particular example serves to illustrate the sensitivity of the accident-severity approach to small changes in the numbers of relatively-high-cost fatal accidents. In short, where there are rather few accidents, the incidence of a fatality or serious injury in one year and not another can have an overwhelming effect on calculations made in accordance with this methodology. It is therefore not a suitable approach in situations involving a small number of accidents.

METHODOLOGICAL AND DATA ISSUES

Recurrent cost assumptions used in the benefit-cost analysis

Table 6 set out the monetary values attached to annual traffic delay and maintenance costs throughout this analysis. If these estimates are considerably inaccurate, the results of the benefit-cost calculations will be affected accordingly.

For instance, the effect of the estimated total annual recurrent costs for projects involving installation of new traffic lights was to erode over one-third of the first year accident reduction benefits in Victoria and nearly two-thirds in NSW, under the accident-type methodology. In the full-scale evaluation, these assumptions will be replaced by estimates drawn from appropriate sampling and other more detailed investigation.

Effect of different accident recording criteria

As mentioned earlier, data for NSW include both personal injury and towaway PDO accidents whereas the Victorian database does not include PDO accidents after December 1990.

In NSW the reductions in right-angle, right-turn and rear-end injury accidents between 1989-90 and 1991-92 were 6-8 per cent greater than the reductions in towaway PDO accidents of the same type. Only about one-third of the right-angle and right-turn accidents and about one-quarter of the rear-end accidents involved personal injury.

Having this wealth of additional quantitative information permits a more detailed and accurate assessment of the benefits of treating sites. Comparative results were derived with and without towaway PDO accidents being included for NSW (separate sets of estimated costs were calculated). Under the accident-severity approach it was found that the inclusion of those extra accidents brought about an increase in the benefit-cost ratios of over 20 per cent for roundabouts and over 40 per cent for modified traffic lights.

The exclusion of PDO data for Victoria would mean that its BCRs have been under-estimated throughout this analysis. In the full-scale study it will have to be considered whether an appropriate adjustment, based on estimated injury-accident-to-PDO-accident ratios, should be made to take account of PDO accidents in Victoria. However, this would be further complicated by the fact that there was a marked rearrangement in the pattern of reported casualty outcomes following the introduction of a Transport Accident Commission requirement that accidents be reported before any claim can be recognised.

Under-reporting of accidents

Another data issue that leads to the under-estimation of BCRs is under-reporting of both injury and PDO accidents. Although it is recognised that the tendency to report increases with the extent of injury, the actual degree of under-reporting at specific sites is generally the subject of little more than speculation. However, the results of a 1990 survey by the Australian Bureau of Statistics carried out in part for the Office of Road Safety in South Australia might be used to make an upward adjustment of reported PDO and minor injury figures. Alternatively, it could simply be noted that this is a factor that contributes to the conservative nature of the estimated BCRs.

Future accident trends

As described earlier, each methodology included an appropriate adjustment for the general decline in accident rates between 1989-90 and 1991-92. This was done by using relevant urban areas as controls.

The accident-reduction benefits attributed to the treatment in this manner were converted to dollar values and assumed to continue unchanged each year for the life of the project. A stream of benefits over 20 or 10 years was then discounted to present values.

Given the concerted Australia-wide efforts to reduce the incidence and severity of accidents, further overall reductions in accidents, independent of black spot treatments, are likely. In the full-scale study it will be worthwhile to consider whether projected future general improvements in annual accident numbers should be factored into the calculations, and if so how best to achieve that.

Regression-to-the-mean issues

The fact that regression-to-the-mean (RTM) adjustments were not made in this analysis would tend to slightly over-estimate the BCRs. However, it is expected that the other factors described in this paper tending to under-estimate the BCRs would more than compensate for any RTM effects.

The accident-type methodology will produce reliable results with sufficient pre- and post-treatment data. Nevertheless, the approach is susceptible to the effects of random fluctuations, especially when the observed numbers of accidents are too small to determine whether an apparent effect is real or just due to chance.

Longer periods of before/after data (three to five years) would generally enable random fluctuations to be smoothed out to reveal underlying trends satisfactorily. The full-scale study will necessarily be constrained by fairly short 'after' periods of 12-18 months at most sites.

Given the nature of the available data and the declining general accident rates, there is very little prospect of making RTM corrections using standard statistical techniques designed for this purpose in the literature. There appears, however, to be some scope for using quite sophisticated time series analysis techniques to deal with random effects.

OTHER ISSUES

Impact of outlier sites

The influence of a single site at which an unusually large number of accidents are observed could be quite marked when a small number of accidents are being evaluated over a short period. The rise in accidents at such a site may be due to chance factors or external factors such as very unusual local weather conditions. It is also possible that it may be due to the type of treatment adopted or the manner in which it was implemented. Some examples from the analysis above help to make this clear.

For instance, pedestrian accidents increased at Victorian sites where traffic lights were modified. Closer examination revealed that most of these accidents occurred at a particular site in Geelong. Field staff in that region have been alerted to the need to study that site in detail and identify the cause of the problem.

In similar vein, there were two important reasons for the low BCRs for new traffic lights in NSW. First, there was a relatively small number of accidents at those sites before treatment was undertaken. Second, several right-turn accidents occurred subsequently at a particular site in St Andrews.

In the case of BCRs for modifications of traffic lights in NSW, there was a notable increase from 2.14 obtained using the accident-severity approach to 7.49 using the accident-type approach. The difference is partly due to the manner in which rear-end accidents are treated by the two methodologies.

Rear-end accidents usually have much less severe injury consequences than right-turn or right-angle accidents. However, after treatment there was an increase in this type of accident reported at sites in Liverpool and Beecroft, and there was one instance of a serious injury among these. The accident-severity approach is relatively more sensitive to the effects of the odd fatality or serious injury and this has contributed to depressing the BCR based on accident severity. Again, there may be merit in investigating these particular sites for clues to these increases in accidents after treatment.

Effect of sample characteristics

As explained at the outset, the sites chosen for this pilot study were as representative as possible of those at which substantial work was carried out in the first year of the Black Spot Program. Nevertheless calculated BCRs will depend to some extent on the specific characteristics of the sites included in the sample, and may not reflect those applicable to the Program as a whole, or to those sites regarded as most suitable for evaluation.

Table 13 makes it clear that some sites had rather low prior accident rates. It sets out the total numbers of recorded accidents at the sites in 1989-90 (NSW injury accident numbers are in brackets), together with the average expenditures per site (to the nearest $10 000).

TABLE 13 ACCIDENT NUMBERS AND AVERAGE EXPENDITURE AT TREATMENT SITES

Treatments	*No. of sites*	*No. of accidents*		*Average expenditure per site ($)*
NSW*				
UH1 New traffic lights	5	18	(5)	110 000
UH2 Modified lights	10	98	(29)	80 000
UH7 Roundabouts	3	29	(13)	180 000
Victoria				
UH1 New traffic lights	4		15	80 000
UH2 Modified lights	9		67	90 000
UH7 Roundabouts	3		20	470 000

*figures in brackets refer to injury accidents

Source BTCE analysis of VIC ROADS and RTA data

The very nature of the methodology for quantifying accident-reduction benefits therefore made it likely that for this particular sample the BCRs would be at the lower end of the spectrum. Another factor, the relatively large amount of expenditure on various individual projects, suggested similar propensities in some cases.

It can also be seen from Table 13 that new traffic lights were installed at locations with fewer accidents relative to those where traffic lights were modified or roundabouts were constructed. Consequently, other things being equal, the accident-reduction potential of the new traffic lights was smaller than for the other two treatments.

For the new traffic lights projects in the sample, average expenditure was about 20 per cent less than the average for all such projects approved during the life of the Program. However, modification of traffic lights cost nearly 60 per cent more than the average for the entire period and the very large roundabouts cost more than three times the average.

It is therefore likely that BCRs for roundabouts will rise when more roundabouts costing close to the average are assessed using reasonable periods of post-treatment data. Similarly, on the basis of project costs for modifications of traffic lights, it is likely that their BCRs will also increase.

APPENDIX 1 MEASURES OF PROJECT EFFECTIVENESS

Evaluating a project involves relating its inputs or costs to its outputs or benefits and thus determining its effectiveness. Four different measures of project effectiveness have been used in this study. The net present value is the primary and most reliable indicator in evaluating projects. Three other measures have also been presented. These are the benefit-cost ratio, internal rate of return and payback period. These three measures have some intuitive appeal and serve to provide supplementary information. However, it is important to note that these measures have certain drawbacks especially when used to compare and rank different projects and should therefore be interpreted in conjunction with the NPVs. The four measures are described below.

Net Present Value (NPV)

This is the difference between the present value of benefits and the present value of costs. If the present value of benefits exceeds the present value of costs, that is, if the NPV is positive, it means that the project yields a rate of return greater than the discount rate which was applied to it. Conversely, if the NPV is negative it means that the rate of return is less than the discount rate. It follows that the NPV has to be related to a definite period of time. At the end of that period of time it must either be assumed that the investment has no further value or it may be assigned a residual value representing its recoverable monetary value at that time which must be treated as a benefit in the final time period.

The methodology used in this study assumes a zero residual value. NPVs at discount rates of 5, 7 and 10 per cent have been presented.

Benefit-Cost Ratio (BCR)

In contrast to the NPV which measures a project's economic benefits in absolute terms, the benefit-cost ratio measures its relative benefits. The BCR is the ratio of the present value of benefits to the present value of costs. A BCR greater than 1.0 implies a positive NPV. It therefore follows that for a project to be acceptable the benefit-cost ratio should be greater than 1.0.

The use of the BCR in comparing different projects can give an incorrect ranking if the projects differ in size. The BCR is also sensitive to the manner in which costs and benefits are defined. For example, disbenefits of projects could be added to the stream of costs or subtracted from the stream of benefits.

BCRs have been calculated using a discount rate of 7 per cent.

Internal Rate of Return (IRR)

This is the percentage rate of interest that equates the present value of benefits to the present value of costs so as to give a zero NPV. It is therefore a measure of the break-even rate of return of a project because it represents the highest rate of interest at which the project makes neither a profit nor a loss. If the IRR is greater than the discount rate used in the analysis, it indicates that the project is profitable and the converse applies if it is smaller.

One problem with using the IRR is that in certain circumstances a project may have more than one discount rate which produces a zero NPV. Also, incorrect rankings could result when projects of different sizes or lives are compared.

Payback Period

The payback period is the period of time required to recover the initial cost of the project. The payback period can be calculated conventionally or by discounting the cash flows.

The conventional method involves calculating the number of years it takes for cumulative benefits or cash flows to equal the initial investment. The discounted method requires that the cash flows be discounted using the required rate of return before they are added up to equal the initial investment.

This study has adopted the discounted method and therefore the calculated payback periods are the number of years from the beginning of a project when the sum of the discounted benefits equal the discounted costs. The payback period is a relatively crude measure of project effectiveness as it does not take account of the benefits and costs over the whole life of the project. The conventional method has the additional disadvantage of not taking into account the time profile of the flow of benefits and costs and generally produces lower values than the discounted method. In general, the shorter the payback period, the more acceptable the project.

APPENDIX 2 ECONOMIC APPRAISALS OF COMBINED SAMPLE PROJECTS FOR NEW SOUTH WALES AND VICTORIA

TABLE 2.1 ACCIDENT-SEVERITY AND ACCIDENT-TYPE COMPARISONS: 20-YEAR PROJECT LIFE, ADJUSTED DATA

Treatments	*Nos of projects*	*Total Project Costs ($)*	*NPV 5% ($)*	*NPV 7% ($)*	*NPV 10 % ($)*	*BCR 7 %*	*IRR 7 % (per cent)*	*Pay Back (years)*
Accident-Severity Method								
UH7 Roundabouts	6	1 936 398	3 088 479	2 335 205	1 496 348	2.13	20	6.1
UH1 New traffic lights	9	851 175	9 045 129	7 561 585	5 909 489	3.84	93	1.2
UH2 Modified traffic lights	19	1 597 865	5 003 400	4 013 812	2 911 792	3.01	33	3.5
Accident-Type Method								
UH7 Roundabouts	6	1 936 398	7 771 680	6 316 353	4 695 679	4.06	40	2.8
UH1 New traffic lights	9	851 175	1 547 287	1 187 736	787 335	1.45	22	5.5
UH2 Modified traffic lights	19	1 597 865	13 847 699	11 532 271	8 953 778	6.76	78	1.4

Notes: 1. These figures have been calculated using urban area adjustments (1988/9 to 1991/2) for NSW (including towaway PDO) and Victorian (excluding PDO) accident data

2. NPVs are in 1991 dollars

TABLE 2.2 ACCIDENT-SEVERITY AND ACCIDENT-TYPE COMPARISONS: 10-YEAR PROJECT LIFE, ADJUSTED DATA

Treatments	*Nos of projects*	*Total Project Costs*	*NPV 5% ($)*	*NPV 7% ($)*	*NPV 10 % ($)*	*BCR 7 %*	*IRR 7 % (per cent)*	*Pay Back (years)*
Accident-Severity Method								
UH7 Roundabouts	6	1 936 398	1 177 075	895 574	541 147	1.44	16	6.1
UH1 New traffic lights	9	851 175	5 280 693	4 726 286	4 028 256	3.30	93	1.2
UH2 Modified traffic lights	19	1 597 865	2 492 358	2 122 544	1 656 928	2.14	31	3.5
Accident-Type Method								
UH7 Roundabouts	6	1 936 398	4 078 844	3 534 981	2 850 228	2.75	39	2.8
UH1 New traffic lights	9	851 175	634 941	500 575	331 401	1.24	18	5.5
UH2 Modified traffic lights	19	1 597 865	7 972 392	7 107 106	6 017 662	4.81	77	1.4

Notes: 1. These figures have been calculated using urban area adjustments (1988/9 to 1991/2) for NSW (including towaway PDO) and Victorian (excluding PDO) accident data

2. NPVs are in 1991 dollars

TABLE 2.3 ACCIDENT-SEVERITY AND ACCIDENT-TYPE COMPARISONS: 20-YEAR PROJECT LIFE, UNADJUSTED DATA

Treatments	*Nos of projects*	*Project Costs*	*NPV 5% ($)*	*NPV 7% ($)*	*NPV 10 % ($)*	*BCR*	*IRR (per cent)*	*Pay Back (years)*
Accident-Severity Method								
UH7 Roundabouts	6	1 936 398	5 504 102	4 388 705	3 146 583	3.13	31	3.8
UH1 New traffic lights	9	851 175	15 857 882	13 353 046	10 563 624	6.01	158	0.7
UH2 Modified traffic lights	19	1 597 865	12 486 364	10 375 013	8 023 782	6.19	71	1.5
Accident-Type Method								
UH7 Roundabouts	6	1 936 398	12 449 168	10 292 643	7 891 107	5.99	60	1.8
UH1 New traffic lights	9	851 175	4 593 929	3 777 659	2 868 650	2.42	51	2.2
UH2 Modified traffic lights	19	1 597 865	27 546 347	23 177 371	18 312 015	12.59	146	0.7

Notes: 1. These figures have been calculated from NSW (including towaway PDO) and Victorian (excluding PDO) accident data, 1988/9 and 1991/2
2. NPVs are in 1991 dollars

TABLE 2.4 ACCIDENT-SEVERITY AND ACCIDENT-TYPE COMPARISONS: 10-YEAR PROJECT LIFE, UNADJUSTED DATA

Treatments	*Nos of projects*	*Project Costs*	*NPV 5% ($)*	*NPV 7% ($)*	*NPV 10 % ($)*	*BCR*	*IRR (per cent)*	*Pay Back (years)*
Accident-Severity Method								
UH7 Roundabouts	6	1 936 398	2 673 825	2 256 996	1 732 185	2.12	28	3.8
UH1 New traffic lights	9	851 175	9 501 957	8 565 889	7 387 325	5.17	158	0.7
UH2 Modified traffic lights	19	1 597 865	7 128 892	6 339 871	5 346 448	4.40	70	1.5
Accident-Type Method								
UH7 Roundabouts	6	1 936 398	6 977 071	6 171 168	5 156 491	4.05	59	1.8
UH1 New traffic lights	9	851 175	2 522 676	2 217 633	1 833 566	2.08	50	2.2
UH2 Modified traffic lights	19	1 597 865	16 460 238	14 827 532	12 771 863	8.95	146	0.7

Notes: 1. These figures have been calculated from NSW (including towaway PDO) and Victorian (excluding PDO) accident data, 1988/9 and 1991/2
2. NPVs are in 1991 dollars

APPENDIX 3 SCHEDULE OF ACCEPTABLE TREATMENTS

HIGH POTENTIAL - URBAN

UH1	New traffic signal installations
UH2	Traffic signal modification
UH3	Intersection channelisation
UH4	Provision of medians (with turn protection)
UH5	Median closures
UH6	Pedestrian refuges
UH7	Roundabout installation
UH8	Selective roadside hazard modification
UH9	Improved lighting at pedestrian facilities

HIGH POTENTIAL - RURAL

RH1	Shoulder sealing
RH2	Lighting at isolated intersections
RH3	Site specific edgelining
RH4	Selective roadside hazard modification
RH5	Curve delineation
RH6	Provision of pavement markers, guide posts, corner cube reflectors
RH7	Staggering of cross intersections
RH8	Warning and direction signs (2 lane 2 way roads)
RH9	Protected right turns

MEDIUM POTENTIAL - URBAN

UM1	Improved skid resistance
UM2	Protected turning bays
UM3	Local area traffic management (including street closures)
UM4	Clearway provisions/parking controls
UM5	Median barriers
UM6	Red light cameras

MEDIUM POTENTIAL - RURAL

RM1	Superelevation on isolated curves
RM2	Median barriers
RM3	Improved sight distance
RM4	Overtaking lanes
RM5	Improvements to divided highways
RM6	Acceleration and deceleration lanes

Source: Department of Transport and Communications (1990)

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ABBREVIATIONS

ARRB	Australian Road Research Board
ARR	ARRB Research Report
BCR	Benefit-Cost Ratio
BTCE	Bureau of Transport and Communications Economics
DCA	Definitions for Classifying Accidents
IRR	Internal Rate of Return
NSW	New South Wales
NPV	Net Present Value
PDO	Property Damage Only
RTA	Roads and Traffic Authority
RTM	Regression to the Mean
RUM	Road User Movement