EFFECT OF PRIOR BLACKSPOT PROGRAMS ON MOTORCYCLE SAFETY

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by

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Abstract:
This report is an evaluation of Victoria's two most-recently implemented blackspot programs with respect to their effect on motorcycle safety at treated sites. The two programs evaluated were the $85M TAC-funded blackspot program that involved the treatment of 559 sites over the period 1992-1996; and the Accident Blackspot component of the $240M TAC-funded Statewide Blackspot program, which involved the treatment of 841 sites from 2000 to 2004. Each program was evaluated separately and the effectiveness of different groups of sites within each program was compared. Sites were grouped according to the type of treatment work completed at the site. Poisson regression was used to compare the difference in before-treatment and after-treatment counts of casualty crashes that involved a motorcycle at treated sites with those at suitably chosen control sites.

It was found that for both programs, estimates of the percent reductions in casualty motorcycle crashes at treated sites were similar to the percent reductions previously found for casualty crashes involving all types of vehicles. Specifically, the $240M blackspot program was effective in reducing casualty motorcycle crashes at treated sites by a statistically significant 31%, which was also the estimated reduction for casualty crashes involving all types of vehicles. For the $85M program, casualty motorcycle crashes were reduced by 24%, compared with 26% for all types of casualty crashes. The reductions in casualty motorcycle crashes associated with the $240M program accounted for 13% of the savings associated with the program's effect on all types of crashes, while for the $85M program, savings associated with reductions in motorcycle crashes were 11% of the total savings.

The report also contains detailed analysis of the effect of different types of treatments on the frequency of casualty motorcycle crashes at treated sites. For the $240M blackspot program, intersection treatments resulted in a 38% reduction in casualty motorcycle crashes, while the estimated reduction for off-path treatments was 30%. For the $85M blackspot program, route treatments were estimated to reduce casualty motorcycle crashes at treated sites by 35%, compared with 27% for intersection treatments.

The report contains discussion of how the results of the evaluation can be used to enhance methods of improving motorcycle safety in future road safety strategies.

Key Words:
Accident blackspot, motorcycle safety, evaluation, accident analysis, traffic engineering, statistical analysis, economic analysis

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Preface

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EXECUTIVE SUMMARY

The State Government of Victoria has implemented a number of blackspot programs since the late 1970s. Since 1990, two substantial blackspot programs, each funded by the Transport Accident Commission's (TAC) retained surplus, have been completed. The first of these programs was implemented from 1992 to 1996, and had a budget of $85M. In total, there were 559 distinct sites treated under this blackspot program. A subsequent program, with a budget of $240M, was implemented from 2000/2001 to 2003/2004. This program is generally referred to as the $240M Statewide Blackspot Program (SBP) and was made up of two distinct components, the Accident Blackspot component and the Potential Blackspot component. The 841 sites treated under the Accident Blackspot component were selected based on their poor history of casualty crashes over a number of preceding years. Similar methods of selecting sites for treatment were also used for earlier blackspot programs. However the 285 sites treated under the Potential Blackspot component of the SBP were identified using an alternative method that did not rely on crash histories of sites. Of the $240M allocated to the Statewide Blackspot Program, approximately $20M was allocated to the Potential Blackspot component, with the remaining funds allocated to the Accident Blackspot component.

Over the years, numerous blackspot programs have been evaluated. In each evaluation, it has been found that when sites were selected on the basis of their poor crash history the program was found to reduce casualty crash frequencies at treated sites by a statistically significant amount. For example, when the $85M blackspot program was evaluated by Newstead and Corben (2001), it was estimated that casualty crash frequencies at treated sites were reduced by 26%, while the Accident Blackspot component of the SBP resulted in a 31% reduction in casualty crashes at treated sites (Scully, Newstead, Corben and Candappa, 2006b).

Until now, all the evaluations of blackspot programs conducted in Victoria have focused on evaluating the extent to which treatments reduce the frequency of all types of casualty crashes at treated sites. The purpose of this report is to evaluate the effect of blackspot programs on the frequency of motorcycle crashes at treated sites. The evaluation will focus on the two most-recent programs only: i.e. the $85M blackspot program and the Accident Blackspot component of the $240M SBP (which will be referred to as the $240M program from this point forward).

Each program was evaluated separately using a quasi-experimental analysis design. The crash data used in the analysis were the same data used in the earlier evaluations of the respective programs. For each blackspot program, the number of casualty crashes involving motorcycles that occurred at treated sites in before-treatment and after-treatment periods were calculated. These frequencies were compared with casualty motorcycle crash frequencies at suitably chosen control sites. For each program, estimates of reductions for casualty motorcycle crashes were derived for the entire program as well as for groups of treatments.

The evaluation indicated that for both blackspot programs, the reductions in motorcycle crashes effected by the treatments were comparable to the reductions when crashes involving all road users were considered. For the $240M blackspot program, it was found that treatments resulted in an estimated reduction of 31% for casualty crashes involving all types of vehicles as well as for casualty crashes involving a motorcycle. Similarly, for the same program, a 36% reduction in serious casualty crashes involving a motorcycle was

estimated, compared with a 35% reduction for serious casualty crashes involving all road users. For the $85M program, the estimated reduction in casualty crashes involving motorcycles was 24%, while the estimated reduction for casualty crashes involving all types of vehicles was 26%.

Of the three broad types of treatments implemented as part of the $240M blackspot program, those targeting crashes at intersections resulted in the greatest reduction in casualty motorcycle crashes at treated sites (38% reduction), followed by off-path treatments (30%). However these estimated reductions were not significantly different from each other. These results were similar to Scully and colleague's (2006b) evaluation of the effect of different types of treatments on casualty crashes involving all types of vehicles. For the $85M blackspot program, it was found that route treatments were more effective in reducing casualty motorcycle crashes (35%) than intersection treatments (27%), however as for the $240M program, these estimated reductions were not significantly different from each other. The report contains more detailed analysis of the effectiveness of sites classified into more specific treatment type groups.

Even though this evaluation has shown that for both programs the estimated reduction of casualty motorcycle crashes at treated sites was similar to that for casualty crashes involving all types of vehicles, the estimates of the present value savings due to the reduction in casualty crashes involving a motorcycle were much less than the estimated savings due to reductions in all types of crashes. This is because only about 10% of casualty crashes involve a motorcycle, so that even if the estimated precent reductions are equal, far fewer motorcycle crashes will be prevented than other types of crashes. For example, the present value of savings due to reductions in casualty motorcycle crashes for the $240M program was estimated to be approximately $56M (assuming a discount rate of 8% and using VicRoads Program crash costs), which is only 13% of the estimated savings due to reductions in casualty crashes for all types of vehicles. Similarly, for the $85M program the present value of savings due to reductions in the frequency of casualty motorcycle crashes at treated sites was $45M, which was 11% of the savings due to reductions in all types of crashes. These suggest that for both programs, the proportion of motorcycle crash cost savings at blackspot sites is in line with that expected from the proportionate crash problem represented by motorcyclists. This result confirms that the general blackspot programs provide equivalent benefits in reducing motorcycle crashes as in reducing crashes overall.

It is difficult to justify treatments based on their effect on casualty motorcycle crashes using economic measures. This has important consequences when deciding how to best allocate funds to improve the road infrastructure. Instead of using economic measures to justify treatments designed specifically to address motorcycle safety, it is recommended that road authorities consider what the likely effects of treatments on the safety of all road users, including motorcyclists, will be. Such an approach is compatible with the more general philosophy within which designers and operators of the road transport system are encouraged to ensure that all road users are fully considered in new designs and in the way the system operates.

A number of assumptions have been made in obtaining results for this study and interpretation of the results is subject to a number of qualifications. These assumptions and qualifications are detailed in Appendix E.

EFFECT OF PRIOR BLACKSPOT PROGRAMS ON MOTORCYCLE SAFETY

1.0 INTRODUCTION

Victoria's first blackspot program began in 1979 and had a budget of $400,000. Throughout the early 1980s, the expenditure steadily increased. Since 1990, the Victorian Government has completed two substantial blackspot programs, both funded by the Transport Accident Commission (TAC). The first of these programs was implemented from 1992 to 1996, with a budget of $85M. A subsequent program, with a budget of $240M, was implemented over a four-year period, from 2000/2001 to 2003/2004. Whereas early blackspot programs generally concentrated on low-cost countermeasures, the $85M blackspot program involved a wider range of treatment types across 559 different locations.

When compared to earlier programs, the most recent $240M blackspot program represented an expansion both in terms of having a greater budget, but also a broader scope. Not only were more sites treated under the most recent program, but the criteria for the selection of eligible sites were also broadened. The $240M blackspot program was made up of two distinct components: the Accident Blackspot component and the Potential Blackspot component. Similar to the selection criteria used in the early blackspot programs, sites to be treated as part of the Accident Blackspot component were identified based on their poor history of casualty crashes occurring at the site over a number of preceding years. The Potential Blackspot component targeted high-risk sites that could be treated using proven countermeasures but did not have the poor crash history that made them eligible for the treatment under the Accident Blackspot component.

A review of early blackspot programs was conducted by the Monash University Accident Research Centre (Corben et al. (1990)), and it was found that casualty crash frequencies at treated intersections fell by 33% and that average cost benefit ratios of eight were achieved. The $85M blackspot program was also evaluated by MUARC (Newstead and Corben, 2001), who found that casualty crash frequencies at treated sites were reduced by 26.4% in the post-treatment periods. It was also found that the program represented casualty crash cost savings 4.1 times the cost of the program. Both components of the most recent $240M blackspot program have also recently been reviewed by MUARC. In their review of the Accident Blackspot component (Scully et al., 2006b), it was found that the program resulted in a 31.3% reduction of the number of casualty crashes at treated sites, which corresponded to a BCR of 2.4 (if VicRoads' crash costs were assumed). Similarly Scully, Newstead and Corben (2006a) found that the Potential Blackspot component only resulted in a 0.8% reduction in casualty crashes at treated sites.

Each of the evaluations of blackspot programs conducted in Victoria has focused on evaluating the extent to which treatments reduce the frequency of all types of casualty crashes at treated sites. These evaluations have not examined whether programs have different effects for different types of crashes. It is of interest to see how blackspot programs affect the incidence of certain types of crashes, involving certain road user groups. It is possible that the effect of different treatments at different sites will vary for different road user groups. The present report seeks to evaluate the effect of blackspot programs on the frequency of motorcycle crashes at treated sites. The program will be restricted to evaluating the two most recent programs: i.e. the $85M blackspot program and the Accident Blackspot component of the $240M blackspot program. From this point forward, the former program will be referred to as the $85M blackspot program, while the latter will be referred to as the $240M blackspot program.

1.1 STUDY AIMS AND HYPOTHESES

1.1.1 Aims and Scope

The broad aim of this report is to establish the effectiveness of the $85M blackspot program and the $240M blackspot program in reducing the frequency of crashes involving a motorcycle at treated sites. For the remainder of this report, the term *casualty motorcycle crash* will refer to any casualty crash in which one of the road users involved in the crash was riding a motorcycle. The scope of the project is to measure effectiveness in terms of the extent to which treatments reduce the number of casualty motorcycle crashes at treated locations as well as the economic savings in reducing the number of people injured or killed in casualty motorcycle crashes at treated sites. This evaluation will be limited to the $85M blackspot program and the $240M blackspot program. Separate net reductions will be reported for all casualty motorcycle crashes as well as serious casualty motorcycle crashes only. As will be explained in the Methods section of this report, *serious casualty motorcycle crashes* refer to casualty motorcycle crashes in which a road user is killed or seriously injured. Cost effectiveness and estimated crash cost savings will be used to report economic benefits.

Separate evaluations will be conducted for both the $85M and $240M blackspot programs. The extent to which one of the blackspot programs results in reductions in the number of casualty motorcycle crashes at treated sites will be compared with the extent to which the other program results in casualty motorcycle crash reductions. Furthermore, results of previous program evaluations for each program (Newstead and Corben, 2001; Scully et al., 2006b) will be used to determine whether reductions in casualty motorcycle crash frequency differ from analogous reductions in casualty crashes (irrespective of whether a motorcycle was involved).

Where treatments are shown to significantly reduce casualty motorcycle crash frequency at treated sites, estimates of the number of lives saved and injuries prevented over the project lives of the treatments will be presented. These estimates will be compared for both casualty motorcycle crashes and all types of casualty crashes (which were derived in previous evaluations).

As casualty motorcycle crashes make up only about 10% of all casualty crashes, it is possible that, for both programs, there will be an insufficient data to enable evaluation of the effect of different types of treatments on casualty motorcycle crash frequency. However, if the data allow, casualty motorcycle crash reductions and economic measures will be presented for the different types of treatments used in each program.

1.1.2 Hypotheses

There are several null hypotheses being tested in this evaluation of the effect of the $240M and $85M blackspot programs on casualty motorcycle crashes. Each null hypothesis will be tested for each of the two programs separately. The first null hypothesis to be tested is that the blackspot program had no effect on casualty motorcycle crash frequency at treated sites. This hypothesis, and all hypotheses tested in this evaluation, will be tested against a two-side alternative hypothesis that the blackspot program has resulted in a change, either increase or decrease, in casualty motorcycle crash frequency at treated sites. In previous evaluations, two-sided alternative hypotheses have been used because they give more conservative statistical significance estimates of program effects and so are deemed more appropriate for blackspot evaluations. The reader can change from a two-sided alternative hypothesis to a one-side alternative hypothesis by simply halving the statistical significance values presented for the two-sided test. Changing from a two-sided alternative hypothesis to a one side hypothesis only affects the calculated statistical significance values and does not alter the point estimates of the program effects on casualty crash frequency. Each null hypothesis tested in this evaluation, including the one just discussed, is listed below along with its two-sided alternative hypothesis. As previously stated, each hypothesis will be tested for the $85M blackspot program and the $240M blackspot program separately.

The following hypotheses relate only to overall program effects.

- H1: That the blackspot program has no effect on casualty motorcycle crash frequency at treated sites
- A1: That the blackspot program has resulted in a change, either increase or decrease, in casualty motorcycle crash frequency at sites treated
- H2: That the blackspot program had no effect on serious casualty motorcycle crash frequency at treated sites
- A2: That the blackspot program has resulted in a change, either increase or decrease, in serious casualty motorcycle crash frequency at treated sites

The hypotheses below relate to comparisons between the effect of the two programs on all casualty crashes and casualty motorcycle crashes.

- H3: The effect of the blackspot program on casualty motorcycle crashes was the same as that on all types of casualty crashes
- A3: The effect of the blackspot program on casualty motorcycle crashes differed from the effect on all types of casualty crashes

The following hypotheses relate to the effect of $240M blackspot program on casualty motorcycle crashes compared with the effect of the $85M blackspot program.

- H4: The $240M blackspot program had the same effect on casualty motorcycle crashes as the $85M blackspot program
- A4: The effect of the $240M blackspot program on casualty motorcycle crashes was different to the effect of the $85M blackspot program on casualty motorcycle crashes

The following hypotheses relate to different groups of treatments for the two programs.

- H5: The effect of blackspot treatments on casualty motorcycle crash frequency at treated sites did not differ for different types of treatment works completed at sites
- A5: That effect of blackspot treatments on casualty motorcycle crash frequency at treated sites differed according to the type of treatment works completed at sites
- H6: The effects of different types of treatments on casualty motorcycle crash frequency at treated sites were the same as their effects on all types of casualty crash frequency at treated sites

- A6: The effects of different types of treatments on casualty motorcycle crash frequency at treated sites were different to the effects on all types of casualty crash frequency at treated sites

2.0 DATA

This report evaluates the effect of two separate blackspot programs on the frequency of casualty motorcycle crashes at treated sites. The data used to complete the evaluations of each program are the same data that were used to evaluate the effect of the programs on all casualty crashes. The evaluation of the effect of the $85M blackspot program on casualty crashes was completed in 2001 (Newstead and Corben, 2001), while the evaluation of the $240M program was completed five years later (Scully et al., 2006b). As both programs were originally evaluated separately, there is some overlap in the crash data used to evaluate each program. For example, a crash occurring in 2000 could be in a before treatment-control group in the evaluation of the $240M blackspot program, and an after treatment-control group of the $85M blackspot program. One possible means of evaluating the effect of each program on casualty motorcycle crash frequency at treated sites would have been to redistribute crashes into the treatment and control groups from both programs so that a single crash cannot be in the before-treatment or after-treatment of a treatment-control group for the $240M program and for the $85M program. One could then categorise the sites from both programs as “$240M site” or “$85M sites” and examine whether the first group of sites was more or less effective than the second group. However, if this method were to be employed, it would be necessary to redefine treatment and control groupings, which given the large number of sites involved, would not be a trivial task.

An alternative method is to keep treatment and crash data for the two programs separate and evaluate each program separately. Although this will mean that a single crash could be in the before period for one program evaluation and an after period for the other evaluation, the advantage of using this methodology is that it is not necessary to redefine treatment and control groups. Furthermore, this method will allow casualty motorcycle crash reductions to be compared directly with casualty crash reductions that were derived in the previous evaluations (see Newstead and Corben, 2001; Scully et al., 2006b), as the same before-treatment and after-treatment periods that were used in the previous evaluations can be used to categorise casualty motorcycle crashes in this evaluation.

As each program will be evaluated separately, in the following sections, the data used to evaluate the $85M blackspot program will be presented separately to the data used to evaluate the $240M blackspot program. The following sections present a description of the data used to describe the treatments implemented under each program. This is followed by a description of the casualty crash data for each program.

2.1 TREATMENT DATA

2.1.1 $240M Blackspot Program

The treatment data for this evaluation of the effect of the $240M blackspot program on motorcycle safety were the same data used to evaluate the Accident Blackspot component of the Statewide Blackspot program (SBP) with respect to the frequency of all types of casualty crashes at treated sites (see Scully et al., 2006b). As explained in Scully et al. (2006b), VicRoads originally provided MUARC with data on each of the 865 blackspot sites funded by Accident Blackspot component of the SBP. However, close inspection of the data revealed that only 823 sites could be used in the economic evaluation of the program because legitimate before and after treatment periods could not be defined for some sites, and that 19 sites had no casualty crashes in both the before-treatment period and the after-treatment period. Therefore, only 804 sites were used to derive the crash reduction estimates presented in Scully et al. (2006b). However the cost of treating the 19 sites without crash data in the before-treatment period and the after-treatment period was still considered when measuring the economic benefits of the program or groups of treatments. The aggregated capital cost of completing the 823 sites was in excess of $202M.

Table 2.1 summarises the process of excluding sites that were for some reason not suitable for analysis. For a detailed description of the treatment data used in this evaluation and the earlier evaluation of the $240M program, and the process of eliminating sites that were deemed not eligible to be included in the sample to be analysed, the reader is referred to the earlier evaluation (Scully et al., 2006b). Table 2.1 also shows the aggregated capital costs of treatments at the sites that had not been excluded at each stage of the elimination process. These aggregated costs are equal to the actual costs of each treatment, as opposed to estimated capital costs prior to each treatment being undertaken. Expected annual differential maintenance costs (the difference in maintenance costs brought about by the blackspot treatment) of each site prior to completion of the treatment are not included in these capital costs.

Table 2.1: Summary of how the subset of $240M blackspot sites eligible for analysis were chosen

	Number of Sites	Aggregated Capital Costs
Step 1: Obtain original data from VicRoads	865	$216,433,000
Step 2: Remove sites incorrectly coded as blackspots	841	$215,578,000
Step 3: Remove sites with incomplete start and finish times	832	$202,230,000
Step 4: Merge coincident sites	823	$202,230,000
Step 5: Remove sites with no casualty crashes in before and after periods	804	$198,491,000
Step 6: Remove sites with no casualty motorcycle crashes in before and after periods	376	$135,164,000

It can be seen from Table 2.1 that while 804 (97.7%) of the 823 blackspot sites had casualty crashes in either the before or after period, it was found that only 376 (45.7%) of the 823 blackspot sites had motorcycle casualty crashes in the before or after period. This could have unwanted ramifications when applying Poisson regression to estimate the effect of treatments on the frequency of casualty motorcycle crashes at treated sites. It was therefore necessary to change the way control and treatment pairs were matched. In order to evaluate the effect of the entire $240M blackspot program on casualty motorcycle crashes, groups of treatment and control sites were matched based on the following variables:

- whether crashes occurred in metropolitan or rural areas;
- whether they occurred on declared or local roads; and
- whether the treatments targeted crashes at intersections.

However, this process of assigning treatments and controls will be explained in greater detail in the Methods section of this report.

As explained in Scully et al. (2006b) there were 42 blackspot sites for which the treatment data provided by VicRoads did not have any information on the estimated length of the project life. The project life from these sites was estimated by examining the project life for sites that received the same or similar types of treatment. The data for many treated sites also did not contain information on the estimated annual differential maintenance cost of the treatment. Given that for more than a third of the sites, VicRoads explicitly estimated the differential maintenance costs associated with the treatments to be zero dollars, zero differential maintenance costs were assumed for most of the sites with missing maintenance cost data. Table 2.2 provides a summary of treatment data for the 823 blackspot sites for which legitimate before and after treatment periods could be defined. It can be seen that the mean project life for the 823 sites was 15.8 years.

Table 2.2 Summary data of $240M Blackspot Sites analysed (N=823)

Mean Project Life	15.8 years
Project Life Range	3-20 years
Mean Capital Cost ($)	245,723
Mean Annual Differential Maintenance Cost ($)	692

In the earlier analysis by Scully et al. (2006b), each treated site was classified into one of three broad treatment categories. Each treatment site was then categorised into one of several more-specific sub-categories. Appendix A provides a complete description of the treatment categories used in the previous analysis and the method of assigning sites into the different categories. The same treatment categories will be used in the present report to assess the affect of different treatments on the frequency of casualty motorcycle crashes at treated sites, providing there is sufficient motorcycle crash data to enable such analyses.

2.1.2 $85M Blackspot Program

The treatment data that was used to evaluate the effect of the $85M blackspot program on motorcycle crashes was the same data that was provided by VicRoads to evaluate the same program for all types of crashes at treated sites (Newstead and Corben, 2001). As explained in the report for the earlier evaluation, the data provided by VicRoads contained information on the following for each treatment:

- treatment number and program administration code;
- location of the blackspot site;
- description of the treatment works completed at the site;
- start and finish dates for the treatment;
- estimated capital cost of the treatment;
- estimated annual differential maintenance cost of the treatment; and
- estimated treatment life.

As outlined in the evaluation by Newstead and Corben (2001), there were 559 sites treated under the $85M blackspot program at a cost of almost $85M. Of these 559 treated sites only three did not have casualty crashes in the before-treatment and after-treatment periods. However, as shown in Table 2.3, the number of treated sites with casualty motorcycle crashes occurring in either the before-treatment period or after-treatment period was 409, which was 73% of the original 559. As mentioned in the Section 2.1.1, having too many treated sites without casualty crashes in the before-treatment period may jeopardise the convergence of the Poisson regression model when estimating the effect of treatments on casualty motorcycle crashes at treated sites. For the $240M blackspot program, it was decided that because only 46% of the 823 blackspot sites had casualty motorcycle crashes in either the before treatment period or the after treatment period, an alternative method of assigning pairs of treatment and control sites would be used. However as 73% of the 559 sites treated under the $85M blackspot program had casualty motorcycle crashes occurring in either the before-treatment or after-treatment period, it is probably not necessary to employ an alternative method of matching treated sites with control sites when evaluating the effect of the program as a whole on casualty motorcycle crashes.

Table 2.3: Summary of how the subset of $85M blackspot sites eligible for analysis were chosen

	Number of Sites	Aggregated Capital Costs
Step 1: Blackspot sites from original evaluation	559	$84,624,889
Step 2: Remove sites with no casualty crashes in before and after periods	556	$84,573,579
Step 3: Remove sites with no casualty motorcycle crashes in before and after periods	409	$73,265,698
Step 4: Remove sites belonging to treatment-control pairs with no casualty motorcycle crashes in the after period at treated sites and control sites	364	$69,145,404

However, when evaluating the effect of different types of treatments on reductions in casualty motorcycle crashes, it may be necessary to omit treatment and control pairs for which there were no crashes in either the before-treatment period or the after-treatment period. As such, there were 45 treated sites that were omitted from the analysis of different types of treatments.

The treatment data provided by VicRoads contained information on the project life of the 559 sites treated as part of the $85M blackspot program. It can be seen from Table 2.4 that the mean project life for the 559 treatments was 14.5 years with a range from three to sixty years. The average capital cost of the 559 treatments was $151,368, while the average annual differential maintenance cost was just over $1,000.

Table 2.4 Summary data of $85M Blackspot Sites analysed (N=559)

Mean Project Life	14.5 years
Project Life Range	3-60 years
Mean Capital Cost ($AU (1995))	151,368
Mean Annual Maintenance Cost ($AU (1995))	1,008

As explained in Newstead and Corben (2001), a hierarchical treatment code was assigned to each of the 559 treatments. These treatment codes are described in Appendix B.

2.2 CASUALTY CRASH DATA

This section describes the casualty crash data used to evaluate both the $85M blackspot program and the $240M blackspot program. Before describing both sets of data, it is important to introduce the following definitions, which will be used to classify different types of crashes in this evaluation.

2.2.1 Definitions of types of crashes

Casualty crash: A crash that was reported to police and involved a road user being injured.

Fatal crash: A casualty crash in which a road user received injuries that result in their death within 30 days of the crash.

Serious casualty crash: A casualty crash in which the most seriously injured road user was either killed within 30 days as a result of the crash or transported to hospital or admitted to hospital as a result of the crash.

Serious but not fatal crash: A casualty crash in which the most seriously injured road user was not killed within 30 days as a result of the crash but was transported to hospital or admitted to hospital as a result of the crash.

Other injury crash: A casualty crash in which the most seriously injured road user was not killed or did not require hospitalisation or transportation to hospital.

Casualty motorcycle crash: A casualty crash in which one of the vehicles involved was a motorcycle. The Road Crash Information System (RCIS) used in this evaluation contained fields that described the types of vehicles involved in a crash. This system allowed for a maximum of five vehicles from one crash to be coded. For this report, if a crash involved a vehicle that was coded as a motorcycle, motor scooter or moped, then the crash was defined to be a casualty motorcycle crash.

Serious casualty motorcycle crash: A casualty motorcycle crash in which a road user (not necessarily a motorcyclist) received a fatal or serious injury. The reader should note that for a casualty motorcycle crash to be defined as a serious casualty motorcycle crash, it is not necessary that a person riding on a motorcycle is seriously injured or killed, only that a road user involved in the crash is seriously injured or killed. Therefore if a particular crash involved an impact between a motorcycle and a car and the motorcyclist was not injured but the driver of the car was seriously injured, then the crash would be defined as a serious casualty motorcycle crash.

Serious but not fatal motorcycle crash: A casualty motorcycle crash in which the most seriously injured road user (not necessarily a motorcyclist) received a serious injury but did not die within 30 days of the crash.

Other injury motorcycle crash: A casualty motorcycle crash in which a road user receives an injury that is not serious or fatal and no other road user receives a serious or fatal injury in the crash.

2.2.2 $240M Blackspot Program

The crash data that VicRoads provided to evaluate the Accident Blackspot component of the SBP was obtained from the Victorian Road Crash Information System (RCIS), which contains information on casualty crashes reported to police. Critical data fields used in the evaluation of the Accident Blackspot component of the SBP study (Scully et al., 2006b) were:

- Crash date
- Crash severity
- Crash number
- Local Government Area (LGA) of the crash
- Number of people, killed seriously injured and with other injuries in the crash.

It was also necessary to add data for fields involving the location of the crash. Adding these fields enabled crash locations to be classified according to the following categories:

- Metropolitan or rural;
- Postcode;
- Arterial or local road;
- Intersection or non-intersection.

In order to conduct the Poisson regression analysis, it was necessary that all the crashes that occurred at a particular blackspot site were coded in a homogenous way with respect to these variables. This required some crashes that occurred along black lengths to be reclassified with respect to whether they occurred at an intersection and the postcode region of the crash location. The method of reclassifying such crashes is explained in detail in Scully et al. (2006b).

The crash data supplied by VicRoads consisted of information on all police-reported casualty crashes occurring in Victoria from 1st of January 1995 to 30th November 2005. As detailed by Scully et al. (2006b), there were 188,786 separate crashes in the dataset. A separate dataset of the subset of crashes that occurred at blackspots was also provided. The latter dataset contained information on variables related to the blackspot treatment (see Section 2.1.1) as well as the crash that occurred at the site. Of the 188,786 crashes occurring from 1995 to the 30th of November 2005, 16,824 occurred at blackspots sites. It was also found that 705 of the 16,824 crashes occurred at two different blackspot sites. This is possible if the crash occurred at a location that was either:

- The intersection of two black lengths;

- A discrete blackspot which is located along a black length;
- A discrete blackspot that has been treated on two separate occasions.

For the purposes of this project, it was necessary that where a crash occurred at multiple blackspot sites, it be grouped in the before or after treatment period of only one treated site. The method of reallocating the 705 crashes occurring at two different blackspot sites so that each was included in the before or after period of only one site is described in detail in Scully et al. (2006b). In some cases, two blackspot sites were redefined as one site, while in other cases, crashes shown to be occurring at the two different sites were assigned to one of the sites.

Disaggregation of Casualty Crashes by Treatment/Control and Before/After Treatment Groups ($240M program)

The Methods section of this report briefly describes how the casualty crash data supplied by VicRoads was disaggregated according to whether crashes occurred at treated sites or control sites (Section 3.2.1), and for crashes that did occur at treated or control sites, whether they occurred in the before-treatment period or the after-treatment period (Section 3.3.1). For a more detailed description of the method of classifying crashes, refer to the earlier evaluation by Scully et al. (2006b).

Table 2.5: Summary of analysis data (all casualty crashes) for the $240M blackspot program

Before or After	Blackspot	Control	Not a Blackspot or a Control	Total
Prior	2,829	12,700	0	15,529
During treatment period	1,834	7,494	0	9,328
Not associated with a Blackspot Site	0	0	99,300	99,300
Subtotal of Omitted Crashes	4,663	20,194	99,300	124,157
After treatment period	3,423	18,531	0	21,954
Before treatment period	8,542	33,937	0	42,479
Subtotal of Case/Control Crashes	11,965	52,468	0	64,433
Total	16,628	72,662	99,300	188,590

As detailed in Scully et al. (2006b), of the 188,786 casualty crashes for which VicRoads provided data, it was found that 16,824 occurred at blackspot sites. However, 196 occurred at sites for which valid before and after treatment periods could not be calculated. These blackspot sites and the 196 casualty crashes that occurred at the sites were omitted from the analysis, reducing the analysis sample to 188,590 casualty crashes, 16,628 of which occurred at one of the 823 blackspot sites. Table 2.5 summarises how the 188,590 casualty crashes were categorised according to membership of a treatment-control before-after group.

Isolating Casualty Motorcycle Crashes ($240M Program)

In order to complete the analyses with respect to the frequency of casualty motorcycle crashes at blackspot sites, it was necessary to determine which crashes in the casualty crash data were casualty motorcycle crashes. This was achieved by appending data related to the involvement of a motorcycle to each crash in the casualty crash databases provided by VicRoads. Casualty motorcycle crashes were defined in Section 2.2.1 on page 11.

Table 2.6: Summary of casualty motorcycle crash frequency by crash severity for the crash data used to evaluation the $240M blackspot program

Crash Severity	Motorcycle casualty crashes	
	N	% of All Crashes
Fatal	490	12.9
Serious but not fatal	8,272	14.8
Other	11,146	8.7
All	19,908	10.6

It can be seen from Table 2.6 that of the 188,590 casualty crashes in the casualty crash database used by Scully et al. (2006b) to evaluate the $240M blackspot program, 19,908 (10.6%) involved a motorcycle. There were 8,762 serious but not fatal casualty motorcycle crashes, which represented 14.8% of the serious but not fatal casualty crashes in the database.

Table 2.7: Summary of analysis data (casualty motorcycle crashes only) for the $240M blackspot program

Before or After	Blackspot	Control	Not a Blackspot or a Control	Total
Prior	248	1,256	0	1,504
During treatment period	164	696	0	860
Not associated with a Blackspot site	0	0	10,803	10,803
Subtotal of Omitted Crashes	412	1,952	10,803	13,167
After treatment period	313	2,051	0	2,364
Before treatment period	752	3,625	0	4,377
Subtotal of Case/Control Crashes	1,065	5,676	0	6,741
Total	1,477	7,628	10,803	19,908

Table 2.7 summarises how the 19,908 casualty motorcycle crashes were distributed with respect to before and after and treatment-control groups. It can be seen that there were only 752 casualty motorcycle crashes that occurred at treated sites in the before-treatment period and 313 in the after-treatment period. The fact that there were relatively few casualty motorcycle crashes occurring at sites treated under the $240M program meant that an alternative method of matching treatment and control sites would need to be used when analysing the effect of the program on motorcycle safety. This method is described in detail in Section 3.2.1. However, at this point, it should be noted that applying this alternative method does not change which crashes make up the control data, but it does change how the crashes at control sites are grouped together and matched with crashes at treated sites. Therefore, using the alternative methodology does not change the total number of crashes occurring at control sites listed in Table 2.7.

2.2.3 $85M Blackspot Program

In order to complete the evaluation of the $85M blackspot program on all types of crashes, VicRoads supplied MUARC with data on all casualty crashes occurring in Victoria from 1987 to the end of 1998. The casualty crash data provided by VicRoads included the following important information for each crash:

- date of the crash
- severity of the crash
- Local Government Area (LGA) of the crash
- Specific crash location

Disaggregation of Casualty Crashes by Treatment/Control and Before/After Treatment Groups ($85M program)

The report by Newstead and Corben (2001) does not specify the total number of casualty crashes occurring in the period 1987-1998, however Table 2.8 provides the number of casualty crashes that occurred at treated sites or control sites by whether they occurred during before-treatment periods or after-treatment periods. It can be seen that the total number of crashes occurring at a treated site in either the before-treatment period or the after-treatment period was 17,541, compared with 11,965 for the $240M program, while there were 139,211 casualty crashes at control sites for the $85M program compared with 52,468 for the $240M program (see Table 2.5).

Table 2.8: Summary of analysis data (all casualty crashes) for the $85M blackspot program

Before or After	Blackspot	Control	Total
After treatment period	6,298	57,219	63,517
Before treatment period	11,243	81,992	93,235
Total	17,541	139,211	156,752

Isolating Casualty Motorcycle Crashes ($85M Program)

The evaluation of the effect of the $85M blackspot program on all types of crashes (Scully et al., 2006b), did not report the distribution of casualty crashes at treated sites or control sites by severity. Therefore, it is not possible to give the proportion of crashes that were casualty motorcycle crashes for each level of severity. However, 15,194 (9.7%) of the 156,752 casualty crashes used in the earlier evaluation were casualty motorcycle crashes. Table 2.9 shows the distribution of these casualty motorcycle crashes by the whether they occurred at a treated site or a control site and whether they occurred in the before-treatment period or the after-treatment period.

Table 2.9: Summary of analysis data (casualty motorcycle crashes only) for the $85M blackspot program

Before or After	Blackspot	Control	Total
After treatment period	337	4,241	4,578
Before treatment period	961	9,655	10,616
Total	1,298	13,896	15,194

2.3 CASUALTY CRASH COST DATA

In order to assess the economic benefits of both the $240M blackspot program and the $85M blackspot program, it was necessary to estimate the cost of casualty crashes. The methodology used to estimate casualty crash costs in this report is the same as the methodology used in the previous evaluation of the $240M blackspot program (Scully et al., 2006b). Section 2.3.1 describes how this methodology was applied to calculate the average cost of casualty crashes for all types of casualty crashes in Scully et al. (2006b). Section 2.3.1 also briefly explains how the crash costs were calculated for the evaluation of the $85M program by Newstead and Corben (2001), which used a different methodology. Section 2.3.2 explains how the average cost of casualty motorcycle crashes was calculated.

2.3.1 Estimating crash cost for all casualty crashes

In the evaluation of the $240M blackspot program, the average cost per casualty crash was calculated for crashes occurring in rural areas and another average cost was calculated for casualty crashes occurring in the metropolitan area. This was done by first calculating the distribution of casualty crashes occurring during the before-treatment period at treated sites located in the metropolitan area by crash severity (fatal / serious but not fatal / other injury) and then doing the same for sites located in rural areas (see Table 2.10).

Table 2.10: Casualty crashes by severity in the before-treatment periods of sites treated under the $240M blackspot program

Type of Crash	Metro		Rural	
	N	% (p_m)	N	% (p_r)
Fatal Crashes *(i=1)*	84	1.4	94	3.7
Serious but not fatal crashes *(i=2)*	1,635	27.2	774	30.6
Other Injury Crashes *(i=3)*	4,296	71.4	1,659	65.7
All Casualty Crashes	**6,015**	**100**	**2,527**	**100**

Then the average costs for crashes of different severities (see Table 2.11) were used in a weighted sum which gave the average cost of casualty crashes in urban areas and the average cost of casualty crashes in rural areas. Two sets of average costs of crashes of different severities were used: one set was based on crash costs used by VicRoads, the other was recommended by Austroads.

Table 2.11: Crash cost values used for economic assessment of the $240M blackspot Program

Crash Severity	Costs Used by VicRoads in Program Formulation ($June 2000)		Austroads Costs ($June 2001)	
	Metro (CV_m)	Rural (CV_r)	Metro (CA_m)	Rural (CA_r)
Fatal *(i=1)*	981,000	1,110,000	1,505,000	1,624,000
Serious but not fatal *(i=2)*	201,000	269,000	385,000	404,000
Other Injury *(i=3)*	22,600	21,100	17,300	17,900

The method of deriving the average casualty crash costs can be written as a series of formulas, one for each possible combination of location (metro or rural) and crash cost basis (VicRoads or Austroads). These formulas are shown in Table 2.12 along with the estimates of the average cost of casualty crashes that were used by Scully et al. (2006b) in the evaluation of the $240M blackspot program. In each formula, the subscript i refers to the level of injury, while the subcripts m and r refer to *metro* and *rural* respectively. VicRoads' crash costs are labelled CV while Austroads' crash costs are labelled CA. The percentage of casualty crashes in the metro area of severity i is labelled p_{mi} (p_{ri} for crashes in rural areas). These labels are also presented in the appropriate cells of Tables 2.10 and 2.11 for the reader's convenience.

Table 2.12: Equations used to calculate the average cost of a casualty crash for the $240M blackspot program

Crash Cost	Crash Location	
	Metro	Rural
VicRoads*	$\left(\sum_{i=1}^{3} p_{mi} CV_{mi}\right)\Big/100 \quad = \quad \$84,477$	$\left(\sum_{i=1}^{3} p_{ri} CV_{ri}\right)\Big/100 \quad = \quad \$137,535$
Austroads†	$\left(\sum_{i=1}^{3} p_{mi} CA_{mi}\right)\Big/100 \quad = \quad \$138,024$	$\left(\sum_{i=1}^{3} p_{ri} CA_{ri}\right)\Big/100 \quad = \quad \$195,903$

* $AU (June 2000) values
† $AU (June 2001) values

The method used by Newstead and Corben (2001) to calculate crash costs when evaluating the effect of the $85M blackspot program on all types of crashes at treated sites differed from the method described above. The method used by Newstead and Corben (2001) was more complicated than the method used by Scully et al. (2006b) because the latter study calculated one cost for casualty crashes in urban areas and one cost for crashes in rural areas, while Newstead and Corben (2001) calculated a separate cost for 100 different types of crashes, which were categorised using the Definition for Classifying Accident (DCA) codes. Furthermore, for each DCA code, a separate cost was calculated for crashes in rural areas and crashes in urban areas. The method used by Newstead and Corben (2001) to calculate the average cost of casualty crashes of DCA type x for crashes in rural areas (or urban areas) can be written as

$$C_x = n_{1x} \cdot c_1 + n_{2x} \cdot c_2 + n_{3x} \cdot c_3 + (n_{1x} + n_{2x} + n_{3x}) \cdot I_x$$

where, c_i is the average cost of casualty crashes of severity level *i*; n_{ix} is proportion of DCA type *x* casualty crashes that are of severity *i*; and I_x is the incident costs (which include costs due to the accident itself such as vehicle repair costs, vehicle insurance costs, legal costs and various other costs) associated with an occurrence of a crash of DCA type *x*. The above formula is then used to calculate the cost of each crash occurring in either the before-treatment period or the after-treatment period at the treated or control site. For further information on the costing method used to evaluate the $85M blackspot program, the reader is referred to the report by Newstead and Corben (2001).

2.3.2 Estimating crash cost for casualty motorcycle crashes only

The method used to estimate the cost of motorcycle crashes for both the $85M blackspot program and the $240M blackspot program was the same method used by Scully et al. (2006b) to assess the effect of the $240M blackspot program on all types of crashes at treated sites. This method of estimating crash costs is described in detail in the previous section. When using this method to estimate the cost of casualty motorcycle crashes for the $240M blackspot program, the average cost of casualty motorcycle crashes was derived by finding the distribution of casualty motorcycle crashes occurring in the before treatment period at treated sites by severity (see Table 2.13). This distribution was then used to weight the sum of the cost of crashes of different severities from Table 2.11, which gave the average cost of motorcycle casualty crashes. The formulas used in this process are presented in Table 2.14 along with the resulting average cost of casualty motorcycle crashes in rural areas and urban areas.

Table 2.13: Casualty motorcycle crashes by severity in the before treatment periods of sites treated under the $240M blackspot program

Type of Crash	Metro		Rural	
	N	% (p_m)	N	% (p_r)
Fatal Crashes *(i=1)*	16	3.3	12	4.5
Serious but not fatal crashes *(i=2)*	187	38.7	125	46.5
Other Injury Crashes *(i=3)*	280	58.0	132	49.1
All Casualty Crashes	**483**	**100**	**269**	**100**

Table 2.14 shows that the estimated costs for casualty motorcycle crashes are greater than those for all types of casualty crashes, while crash costs derived from Austroads' cost estimates are greater than those derived using VicRoads' estimates. Casualty motorcycle crashes in rural areas are on average more costly than casualty motorcycle crashes in urban areas.

When estimating the average costs of casualty motorcycle crashes for the $85M program, it would be possible to derive new average costs using the distribution, with respect to crash severity, of casualty motorcycle crashes occurring in the before-treatment period at sites treated as part of the $85M program. However, it was decided that when using economic measures to evaluate the $85M program, the same average costs of casualty motorcycle crashes as those used to assess the $240M program would be employed (i.e. those in Table 2.14). The reason for this decision was that because one of the aims of this report was to use economic measures to compare the effectiveness of the $85M blackspot program in reducing casualty motorcycle crashes with that of the $240M program, the same average costs of casualty motorcycle crashes should be used for each program. Appendix C presents estimates of the average costs of casualty motorcycle crashes if crash distributions from sites treated under the $85M blackspot program were used to calculate separate costs for the $85M program. Tables analogous to Tables 2.13 and 2.14 are presented in this appendix. When calculating costs in this manner, the average costs of casualty motorcycle crashes are at most only 11% greater than those presented in Table 2.14.

Table 2.14: Equations used to calculate the average cost of a casualty motorcycle crash for the $240M blackspot program

Crash Cost	Crash Location	
	Metro	Rural
VicRoads*	$\left(\sum_{i=1}^{3} p_{mi} CV_{mi}\right) / 100 = \$123,418$	$\left(\sum_{i=1}^{3} p_{ri} CV_{ri}\right) / 100 = \$184,871$
Austroads†	$\left(\sum_{i=1}^{3} p_{mi} CA_{mi}\right) / 100 = \$208,942$	$\left(\sum_{i=1}^{3} p_{ri} CA_{ri}\right) / 100 = \$268,962$

* $AU (June 2000) values
† $AU (June 2001) values

In Section 4.2, the crash costs derived in this section are applied to give an economic evaluation of both blackspot programs with respect to their effect on motorcycle safety.

3.0 METHODS

3.1 STUDY DESIGN

For the evaluations of the $85M blackspot program and the $240M blackspot program, a quasi-experimental study design was employed. This design used Poisson regression to establish whether changes in the number of casualty crashes that occurred at treated sites were significantly different to changes in the number of casualty crashes at non-treated sites. The same general methodology is employed in this evaluation of both blackspot programs with respect to their effect on casualty motorcycle crash frequency. For a detailed description of how Poisson regression can be used to evaluate blackspot programs, using before and after crash counts at treated sites adjusted by crash counts at control sites, the reader is referred to Scully et al. (2006b).

The casualty crash data for the two programs being evaluated in the current report have been evaluated separately. Although it is possible to evaluate the blackspot programs as one large program with two different types of treatments (i.e. treatments completed under the $240M blackspot program and treatments completed under the $85M program), this would be a complicated exercise, as it would require that treatment and control data for treated sites be reclassified. Reclassification of crash data would be required as it is possible that some crashes may be grouped in the before and after periods or the case and control groups of both programs. Therefore, the results section of this report will present estimates of casualty motorcycle crash reductions for the two programs separately and the estimates for each program will be derived from two separate models.

The methodology employed in the current report to evaluate each program with respect to motorcycle crashes differs from the methodology of previous evaluations in that instead of comparing before and after counts of all types of crashes, the current evaluation only looks at before and after counts of casualty motorcycle crashes. Therefore, the first step in the methodology was to remove all casualty crashes that weren't casualty motorcycle crashes from the sample of crash data to be analysed. The following sections describe the method of defining control sites to treated sites to enable evaluation of the $240M program on motorcycle safety (Section 3.2.1) and the effect of the $85M program on motorcycle safety (Section 3.2.2).

For a description of the methodology used to evaluate the two blackspot programs with respect to casualty crash reduction for all types of crashes, the reader is referred to the reports of these evaluations (see Newstead and Corben, 2001; Scully et al., 2006b). These reports also addresses issues such as regression-to-the-mean and accident migration, discussion of which has been omitted in the present report.

3.2 CHOICE OF CONTROLS

3.2.1 $240M Blackspot Program

In previous blackspot evaluations, crashes occurring at a treated site were matched to crashes in the same local area that did not occur at the blackspot site. The local area of a blackspot site can be defined using the Local Government Area (LGA) of the treated location (e.g. Newstead and Corben, 2001) or the postcode of the treated site (e.g. Newstead and Corben, 2002). In their interim evaluation of the $240M blackspot program, Newstead and Corben (2002) opted to use postcodes to match treatments to control sites instead of LGAs. Postcodes represent smaller geographical areas than LGAs, which allowed each treated site to be matched to a unique set of control crashes. However, Scully et al. (2006b) found that in the evaluation of the effect of the $240M blackspot program on frequencies of all types of crashes, using postcodes as a means of matching treatments to controls did not result in uniquely defined treatment and control pairs. There were too many postcodes containing more than one treated site. One particular postcode contained 17 different treated sites. Even when crashes occurring at non-treated sites in neighbouring postcodes were used as controls, it was not possible to match each treated site with a unique set of controls. Therefore, treated sites sharing the same values for the following variables were grouped together:

- Postcode;
- Type of road (declared road or a local road);
- Whether the treatment was designed to prevent crashes at intersections or at mid-blocks.

Treated blackspot sites sharing the same values for these three key variables were assigned the same group of control sites. The control sites were made up of casualty crashes that did not occur at blackspot sites that had the same values as the treated sites for the above three key variables. This method of matching treated sites with control sites was employed so that as many treated sites as possible could be matched uniquely to a control group. When evaluating the effectiveness of the program as a whole, the aggregated before and after casualty crash counts of the treated sites with the same values for the three key variables were compared with the casualty crash counts at the group of the control sites that they were matched to.

As described in Section 2.1.1, because only about 10% of casualty crashes involve a motorcycle, less than half of sites treated as part of the $240M blackspot program had a casualty motorcycle crash occurring in either the before-treatment period or the after-treatment period. In order to build a Poisson regression model, if the aggregated frequency of events for a group of treated sites is zero in both the before and after period, these sites must be omitted from the analysis. If a large number of treated sites have before and after treatment counts that are zero, all these sites must be excluded from the analysis.

As more than half the sites treated as part of the $240M blackspot program had no casualty motorcycle crashes occurring in both the before-treatment and after-treatment period, it was decided that there was insufficient data to build a Poisson regression model using the same method of matching treatment and control groups as that used by Scully et al. (2006b). Using Scully and colleague's (2006b) method of matching treatment and control pairs would not only reduce the statistical power of the resulting model (as it would be based on less casualty crash data), but the model would only represent the effectiveness of the remaining treatments, and not the program as a whole. Two possible alternative matching strategies can be employed to evaluate the effect of the $240M blackspot program on motorcycle safety. One strategy will enable evaluation of the entire program, while the other will enable evaluation of different treatments employed as part of the program.

Evaluation of the Entire Program

The alternative means of grouping sites that would enable the evaluation of the entire program is to group treated sites that have the same values for the following variables:

- Whether the treated site is located in an urban or a rural area;
- Whether the site was on a declared road or a local road;
- Whether the treatment was designed to prevent crashes at intersections or at mid-blocks.

Using these three variables to match treated sites to control sites will mean that each treated site will be classified into one of eight different groups. Each of these groups will be matched to casualty motorcycle crashes that occurred at the control sites in the evaluation of the effect of the $240M blackspot program on all types of crashes by Scully et al. (2006b). However, for the present evaluation, there will only be eight groups of control sites. The control sites of the previous evaluation that had the same values for the intersection and the road type variable but different postcode values will form one of two broader control sites: sites in urban areas will form one control group, and sites in rural areas will form the other control group. Therefore, when using this alternative method of matching treated and control sites the number of casualty motorcycle crashes at treated sites and control sites are still the same as that shown in Table 2.7. Defining broader control sites in this manner will almost certainly ensure that none of the treatment-control pairs have zero cell counts in both the before-treatment and after-treatment periods. This will enable a Poisson model that measures the effectiveness of the entire program using all the casualty motorcycle crash data to be derived.

Evaluation of groups of Treatments

The most-recently described method of matching treatment and control pairs enables the $240M blackspot program's effect on motorcycle safety to be evaluated at the program level. However, it cannot be used to evaluate the effect of different types of treatments without an important modification. The reason the most-recently described method cannot be used to evaluate the effect of different types of treatments on motorcycle safety is that to build a Poisson regression model that evaluates effectiveness by treatment type, it is necessary that crashes in a particular treatment-control group have the same values for variables being analysed by the Poisson regression model. Sites grouped using the most-recently described matching method are not homogenously coded with respect to the type of treatment completed at the site. However, if only crashes at sites where a particular type of treatment was implemented are included in the before-treatment and after-treatment casualty motorcycle crash counts, the crashes at treated sites will be homogenously coded with respect to treatment type. These crash counts can be compared against the crash counts at control sites defined using the same matching method used to evaluate the effect of the program as a whole on motorcycle safety (as described in the previous paragraph).

When using this methodology to evaluate different types of treatments, the number of crashes in the before and after periods at the control sites remains unchanged irrespective of which treatment type is being examined. However, separate Poisson regression models need to be created for each different treatment type being evaluated.

Using this method to assess the effect of different types of treatments on casualty crashes should enable broad categories of treatment types to be evaluated effectively. However it probably will not enable meaningful evaluation of more specific treatment types.

3.2.2 $85M Blackspot Program

As explained in Newstead and Corben (2001), for each site that was treated in the $85M blackspot program, control sites consisted of all untreated areas in the same LGA. If there were multiple treated sites in one LGA, each used the same set of control casualty crashes in the analysis. The method of determining controls in the evaluation of the $85M blackspot program was simpler than that used in the $240M blackspot program as 559 blackspot sites were treated sites under the earlier blackspot program, compared with 841 for the $240M blackspot program. Furthermore, the $240M program appeared to include a high concentration of treated sites in particular LGAs.

Evaluation of the Entire Program

Section 3.2.1 explained how insufficient casualty motorcycle crash data at sites treated in the $240M blackspot program necessitated the need to employ an alternative method of matching treated sites with control sites. The same could be true for the $85M blackspot program. However, in Section 2.1.2 it was noted that 409 (73%) of the 559 sites treated under the $85M blackspot program had casualty motorcycle crashes occurring in either the before treatment period or the after treatment period, compared with only 46% (376) of the 823 $240M blackspot sites analysed.

As a much higher proportion of the $85M blackspot sites had casualty motorcycle crashes occurring in their before-treatment and after-treatment periods, it was not necessary to employ an alternative method of matching treated sites with control sites. Therefore the same treatment and control site pairings as those used in the evaluation of the effect of the program on all casualty crashes (Newstead and Corben, 2001) have been used to evaluate the effect of the $85M blackspot program on motorcycle safety. It is likely that some pairs of treated and control sites will have to be omitted from the data used to build the Poisson model for the evaluation of the entire program. Groups of treated sites in the same LGA that all have zero casualty motorcycle crashes in both the before-treatment and after-treatment periods will be omitted from the analysis because their inclusion will prevent the model from converging. It is expected that the number of LGAs that will be required to be omitted will be small as many of the treated sites with no crashes in both the before-treatment and after-treatment period will be in the same LGA as treated sites with non-zero casualty motorcycle crash counts.

Evaluation of groups of Treatments

It is also proposed that the same treatment and control pairings used by Newstead and Corben (2001) to assess the effectiveness of different types of treatments on all types of casualty crashes be used to evaluate the effect of different types of treatments on casualty motorcycle crashes. However, as explained in Section 2.1.2, when building models to evaluate the effect of different types of treatments on reductions in casualty motorcycle crashes at treated sites, it will be necessary to increase the number of groups of treatment and control pairs that must be omitted to achieve convergence. Specifically, it will be necessary to omit from these analyses treatment-control pairs for which there were no casualty motorcycle crashes in either the before-treatment period or the after-treatment at both treated and control sites. This will likely prevent meaningful analysis of effectiveness beyond the most-broad categorisation of treatment types.

On examination of the casualty motorcycle crash data for the $85M program, it was found that it was necessary to omit 45 treated sites that belonged to treatment-control pairs that had no casualty motorcycle crashes occurring in the after-treatment period at both treated and control sites. It was not necessary to omit any sites due to zero counts in the before-treatment period. Thus evaluations of the effectiveness of different types of treatments completed as part of ht $85M blackspot program are based on the casualty motorcycle crash data at 364 (65%) of the 559 sites instead of data from 409 sites (as used to evaluate the program as a whole).

3.3 BEFORE AND AFTER TREATMENT PERIODS

3.3.1 $240M Blackspot Program

In the evaluation of the $240M blackspot program conducted by Scully et al. (2006b), before and after treatment periods for each treatment-control site pair were determined using the treatment data that were provided by VicRoads. Before-treatment periods were defined as the period beginning five years before the date of the commencement of treatment works up until a day before the commencement of works. The after-treatment period was defined as the period from a month after the completion of treatment works to the 30th of November 2005. As previously mentioned, the data for each blackspot site contained the date on which treatment works commenced and the date on which they were completed. Where several different treated sites had the same set of control sites, the before treatment period for all the sites was determined using the earliest commencement of works date from among the group of treated sites. Similarly, when several treated sites shared the same set of control sites, the after-treatment period for treated and control sites was determined using the treatment completion date of the site with the most recently completed treatment works.

As the earliest date on which treatment works commenced for the 823 sites analysed was 1st March 2000, all treatment and control pairs had before-treatment periods of 5 years. The most recent date on which a treatment was completed was 30th June 2005, so the minimum length of an after-treatment period was five months. The maximum after-treatment period was five years and five months. The average length of the after-treatment periods for the 823 sites analysed was two years and ten months.

As explained in Section 3.2.1, as there were insufficient casualty motorcycle crash data to enable treatment and control pairs to be matched on postcode, the type of road (declared or local) and whether the treatment was designed to prevent crashes occurring at intersections, alternative methods of pairing groups of treated sites with control groups have to be used. When using these alternative methods of matching treated and control sites, existing before and after treatment periods have been used to define the before and after periods of the new treatment-control pairs. This means that for each treatment-control group, the criteria used to distribute crashes into before or after periods would not be consistent across all sites in the treatment-control group. Before and after periods will differ depending on which treatment-control group the crash was assigned to in the previously completed evaluation of the effect of the $240M program on all types of casualty crashes (Scully et al., 2006b).

3.3.2 $85M Blackspot Program

As the method of assigning treated and control site pairs for this evaluation of the effect of the $85M blackspot program on casualty motorcycle crashes is the same as that used in the evaluation of the effect of the program on all types of crashes (Newstead and Corben, 2001), the before and after treatment periods used for this evaluation are the same as those used by Newstead and Corben (2001). As explained in Newstead and Corben (2001), before-treatment and after-treatment periods for each LGA were determined as follows:

- The before-treatment data period was chosen to be five years before the first starting date of the treatment works amongst all the treatment sites within the LGA

- The after-treatment data period was chosen as the month immediately after the latest finishing date of treatment works amongst all treated site within the LGA, up to the end of 1998.

This conservative approach to defining before-treatment period and after-treatment period dates meant that for LGAs containing multiple treated sites, there were no treatment works being carried out in the LGA during the before-treatment period or the after-treatment period.

4.0 RESULTS

This section presents the main results of evaluating the effectiveness and economic worth of both the $240M blackspot program and the $85M blackspot program on motorcycle safety. Section 4.1 describes the effectiveness of each program in terms of estimated reductions in the frequency of casualty crashes at treated sites, while section 4.2 presents an economic evaluation of each program. Each section presents results for each program separately.

4.1 CHANGES IN CASUALTY CRASH FREQUENCY

This section presents estimates in the reduction in casualty crash frequency at treated sites that were calculated relative to casualty crash frequencies at chosen controls. Section 4.1.1 presents results for the $240M blackspot program, while section 4.1.2 presents estimates for the $85M program. The results for both programs will be compared in the Discussion section.

Estimates of reductions in casualty motorcycle crash numbers are reported for all casualty motorcycle crashes as well as for serious casualty motorcycle crashes and other injury motorcycle crashes (see Section 2.2.1 for definitions of these types of crashes). It was not possible to determine the effect of treatments on the number of motorcycle crashes resulting in property damage only as these crashes are not recorded in the RCIS database.

4.1.1 $240M Blackspot Program

This section reports casualty motorcycle crash reductions at sites treated as part of the $240M blackspot program. Results for casualty motorcycle crashes of different severity levels are compared against those for all types of casualty crashes, which are taken from Scully et al. (2006b). Results are presented at a program level, followed by sites grouped according to the type of treatment employed.

Program Level Effects

Table 4.1 shows the estimated reduction in the number of casualty crashes occurring at the treated blackspot sites relative to chosen control sites. Results are presented for casualty motorcycle crashes as well as for all types of crashes. The latter set of results were taken from the previous evaluation by Scully et al. (2006b), and are based on crash frequency data at 804 of the 841 legitimate blackspot sites. The reader will recall that in order to build Poisson models to measure the effectiveness of the $240M blackspot program, it was necessary to exclude treatment and control groups that had no crashes at any of the treated sites. As casualty motorcycle crashes only make up about 10% of all casualty crashes, only 376 of the 841 legitimate blackspot sites had crashes in the before or after periods. This required the use of an alternative method of matching treatment and control sites for casualty motorcycle crashes. This alternative method is described in Section 3.2.1.

Table 4.1 gives estimates of casualty (motorcycle) crash reduction. These reductions have been given for all casualty (motorcycle) crashes as well as serious casualty (motorcycle) crashes only and other injury (motorcycle) crashes only. Measures presented include the estimated percentage reduction in the number of crashes (for each of the defined levels of crash severity and motorcycle involvement), as well as the estimated annual number of casualty crashes prevented due to the treatment program and the annual number of casualty (motorcycle) crashes at treated sites before treatments were implemented. Upper and lower

95% confidence intervals have been given for each crash reduction estimate. These 95% confidence intervals give the range in which real crash savings due to the program lie with 95% probability. Statistical significance values of the estimated percentage reduction for each type of crash are also given. Each of these values give the probability that the estimated crash reduction is due to chance, rather than the effect of the program. Throughout the results section of this report, the $p<0.05$ significance level has been used to determine whether results are statistically significant. However, the reader may interpret the results presented throughout the report using a less conservative level of significance if they feel it is appropriate for their purposes.

Table 4.1: Estimated crash reductions at the program level for sites treated under the $240M blackspot program

Types of Casualty Crashes	Estimated Crash Reduction (%)	Statistical Significance	Lower 95% Confidence Limit (%)	Upper 95% Confidence Limit (%)	Annual Crash Frequency at Treated Sites Before Treatment	Annual Casualty Crash Saving
Motorcycle Crashes						
- All Casualty	31.2	<.0001	20.1	40.7	150	47
- Serious	35.5	<.0001	19.7	48.3	68	24
- Other Injury	27.3	0.019	11.1	40.6	82	23
All Types of Crashes						
- All Casualty	31.3	<.0001	27.7	34.7	1,708	535
- Serious	34.5	<.0001	28.1	40.4	517	179
- Other Injury	29.8	<.0001	25.3	34.0	1191	355

It can be seen from Table 4.1 that each point estimate of the reduction in casualty motorcycle crashes of different severities were similar to the corresponding point estimates when all types of crashes were considered. For example, the estimated crash reduction for all casualty motorcycle crashes was 31.2%, compared with 31.3% for all casualty crashes. Similarly, the estimated serious casualty crash reduction was 34.5% for all types of crashes and 35.5% for serious casualty motorcycle crashes. The reader may note that the 95% confidence intervals for the estimates of crash reduction for all types of crashes are narrower than those for casualty motorcycle crashes. This is most likely because the sample of casualty motorcycle crashes was much smaller than the sample used to derive crash reduction factors for all types of crashes.

Estimating the number of injuries prevented

The estimates of crash reduction presented in Table 4.1 can be used to infer the number of fatalities prevented, as well as the number of injuries (both serious and other types) prevented due to the effects of the program. This can be done for both casualty motorcycle crashes and all types of casualty crashes so that estimates of the number of injuries prevented in motorcycle crashes can be compared against estimates of the number of injuries prevented in all types of crashes. The methodology for estimating the number of injuries prevented due to reductions in casualty motorcycle crashes at treated sites is described in Appendix D. The same method was used by Scully et al. (2006b) to estimate the number of injuries prevented due to reductions in the number of casualty crashes involving all types of vehicles.

Table 4.2 shows, over the life of the program, 30 lives were saved and 348 serious injuries were prevented due to reductions in the number of motorcycle crashes. Similarly, Table 4.2 shows that reductions in the number of casualty motorcycle crashes would prevent 437 other injuries and 770 casualties of any severity over the life of the program.

Table 4.2: Estimates of the number of injuries and crashes prevented over the project life of each treatment for the $240M blackspot program as a whole for all types of crashes and motorcycle crashes only

	Motorcycle Crashes	All Types of Crashes
Crashes saved over treatment life		
- Serious casualty crashes	352	2,587
- All casualty crashes	680	7,655
Injuries prevented over treatment life		
- Fatalities	30	204
- Serious injuries	348	3,116
- Other injuries	437	8,505
- All casualties	770	1,149

The reader may note that, in Table 4.2, the summation of the number of injuries prevented (where injuries have been disaggregated by severity) is not equal to the estimated number of casualties prevented (irrespective of severity) due to reductions in the number of casualty motorcycle crashes (815 compared with 770). This is because different estimates of crash reduction and rates of injured persons per crash type were used to estimate the number of injuries prevented for each level of injury. However the fact that the two totals are close in magnitude suggests the methods used to estimate the number of injuries prevented due to the program are sound.

Treatment Type Effects

Section 3.2.1 described the methodology for evaluating the effectiveness of the different types of treatments employed as part of the $240M blackspot program, while Appendix A describes how different treated sites were categorised with respect to treatment type. At the most broad level of categorisation, it can be seen from Table 4.3 that intersection treatments were the most effective in reducing casualty motorcycle crashes. The estimated reduction in casualty motorcycle crashes at sites treated using intersection treatments was 37.7% compared, with 30.3% for off-path treatments, while vulnerable road user treatments did not appear to effectively reduce casualty crashes at treated sites. It should also be noted that Scully et al. (2006b) found that when crashes involving all types of vehicles were considered, intersection treatments proved to be significantly more effective than off path treatments. However, differences in effectiveness when only casualty motorcycle crashes were considered were not significant. This could be due to the reduced number of crashes at treated sites when the sample is restricted to casualty motorcycle crashes.

Table 4.3: Estimated percentage casualty motorcycle crash reductions attributable to the $240M blackspot program by the type of treatment works completed at the site compared with casualty crash reductions involving all types of vehicles

Treatment Type	Estimated Casualty Crash Reduction (%)	Statistical Significance	Lower 95% Confidence Limit (%)	Upper 95% Confidence Limit (%)	Annual crash frequency at treated sites before treatment	Annual casualty crash saving
Motorcycle Crashes						
- Off-Path	30.3	0.0002	15.9	42.2	91	28
- Intersection	37.7	0.0006	18.3	52.5	49	19
- Vulnerable Road Users	4.2	0.8584	-54.0	40.4	10	<1
All Types of Crashes						
- Off-Path	20.6	<0.0001	14.1	26.7	750	155
- Intersection	42.8	<0.0001	38.5	46.8	818	350
- Vulnerable Road Users	1.3	0.8619	-14.4	14.8	127	2

Table 4.4 shows the effectiveness of the $240M blackspot program in preventing serious casualty motorcycle crashes at treated sites. It can be seen that sites treated using intersection treatments had an estimated 45% reduction in serious casualty motorcycle crashes in the after-treatment period, while off-path treatments resulted in an estimated 35% reduction. However, the difference in the estimated serious casualty motorcycle reductions at sites treated using intersection treatments and sites treated using off-path treatments was not significant. As was the case for casualty motorcycle crashes of all severities, treatments designed to protect vulnerable road users did not result in a reduction in serious casualty motorcycle crashes. Table 4.4 also allows comparison of the effectiveness of the three different types of treatments for reducing serious casualty motorcycle crashes at treated sites with their effectiveness in reducing serious casualty crashes involving all types of vehicles (derived in Scully et al., 2006b). It can be seen that the estimates of the effectiveness for serious casualty motorcycle crashes were similar to those for serious casualty crashes involving all types of vehicles.

Unfortunately, it was not possible to assess which of the specific treatments within the off-path and intersection treatment categories were most effective in reducing serious casualty motorcycle crashes at treated sites. However, it was possible to examine effectiveness with respect to reductions in casualty motorcycle crashes of all severities for sites grouped using the more specific treatment type classification. Table 4.5 shows the estimated casualty motorcycle crash reductions for specific off-path treatments. As well as providing point estimates of reductions in casualty motorcycle crashes, Table 4.5 provides the 95% confidence intervals for each estimate. Results can be compared with those derived by Scully et al. (2006b) when casualty crashes involving all types of vehicles were considered.

Table 4.4: Estimated percentage serious casualty motorcycle crash reductions attributable to the $240M blackspot program by the type of treatment works completed at the site compared with serious casualty crash reductions involving all types of vehicles

Treatment Type	Estimated Serious Casualty Crash Reduction (%)	Statistical Significance	Lower 95% Confidence Limit (%)	Upper 95% Confidence Limit (%)	Annual Serious Casualty crash Frequency at Treated Sites Before Treatment	Annual Serious Casualty Crash Saving
Motorcycle Crashes						
- Off-Path	35.2	0.0015	15.3	50.5	43	15
- Intersection	44.9	0.0066	15.3	64.2	21	9
- Vulnerable Road Users	-18.5	0.6513	-147.0	43.2	3	-1
All Types of Crashes						
- Off-Path	28.5	<0.0001	18.1	37.7	256	73
- Intersection	45.1	<0.0001	36.8	52.3	220	99
- Vulnerable Road Users	2.4	0.857	-27.55	25.36	38	1

Table 4.5: Estimated percentage casualty motorcycle crash reductions attributable to Off-path treatments for the $240M blackspot program compared with casualty crash reductions involving all types of vehicles

Off-Path Treatment Type	Motorcycle Crashes		All Types of Crashes	
	Est. % Casualty Crash Reduction (95% CL)	Statistical Significance Probability	Est. % Casualty Crash Reduction (95% CL)	Statistical Significance Probability
1.1: Improved Shoulder Definition	23.5 (-3.6, 100)	0.084	26.4 (15.9, 35.6)	<0.0001
1.2: Bridge End-post Protection	16.5 (-52.3, 54.3)	0.556	3.5 (-31.7, 29.3)	0.821
1.3: Barrier Construction	22.6 (-43.2, 58.2)	0.414	15.5 (-19.2, 40.4)	0.337
1.4: Hazard Removal	***	***	-15.4 (-72.7, 22.8)	0.485
1.5: Road Alignment and Delineation	58.9 (33.6, 75.2)	0.0003	30.2 (14.6, 42.9)	0.0005
1.6: Improved Lighting	17.4 (-125.4, 69.7)	0.709	-18.4 (-53.1, 8.5)	0.199
1.7: Improved Signage	25.2 (-149.2, 77.6)	0.636	22.7 (-42.1, 58.0)	0.407
1.8: Road Surface	25.9 (-43.7, 61.8)	0.376	43.3 (29.8, 54.1)	<0.0001
1.9: Road Widening	75.7 (-8.3, 94.5)	0.064	25.8 (-12.9, 51.2)	0.164
1.10: Speed Reduction	***	***	-30.0 (-86.1, 9.2)	0.153
1.11: Ring Road Treatments	81.8 (39.2, 94.6)	0.006	-28.7 (-12.8, 26.0)	0.372

*** Estimated casualty crash reduction could not be made due to insufficient casualty motorcycle crash counts

Cells shaded grey indicate non-significant estimated casualty crash reductions

From Table 4.5 it can be noted that, in terms of reducing casualty motorcycle crashes, the most effective off-path treatment was the ring road treatment, which resulted in a 82% reduction in casualty motorcycle crashes. This treatment appears to be significantly more effective in reducing casualty motorcycle crashes than casualty crashes involving all types of vehicles. The ring road treatment consisted of the installation of emergency phones, speed cameras and median barriers along the Western Ring Road, from the Western Highway to the Greensborough bypass. The only other type of off-path treatment that was shown to result in significant reductions in casualty motorcycle crashes at treated sites were treatments that improved the alignment and delineation of roads. Such treatments resulted in an estimated 59% reduction in casualty motorcycle crashes at treated sites. However, while this estimate was greater than the analogous estimate of 30% when crashes involving all types of vehicles were considered, the difference between the two estimates was not significant.

Of the eight types of intersection treatments, only those classified as signal treatments resulted in a significant reduction in the number of casualty motorcycle crashes at treated sites. Signal treatments resulted in an estimated reduction of 52% for casualty motorcycle crashes, compared with a 35% reduction for casualty crashes involving all types of vehicles. However, for this type of treatment, the reduction when only casualty motorcycle crashes were considered was not significantly different to that for when all types of casualty crashes were considered. It can be seen that many of the off-path treatments that were found by Scully et al. (2006b) to significantly reduce all types of casualty crashes did not show significant reductions when the sample of crashes was restricted to casualty motorcycle crashes. This is partly due to the relatively small numbers of casualty motorcycle crashes at treated sites.

Table 4.6: Estimated percentage casualty motorcycle crash reductions attributable to Intersection treatments for the $240M blackspot program compared with casualty crash reductions involving all types of vehicles

Intersection Treatment Type	Motorcycle Crashes		All Types of Crashes	
	Est. % Casualty Crash Reduction (95% CL)	Statistical Significance Probability	Est. % Casualty Crash Reduction (95% CL)	Statistical Significance Probability
2.1: Roundabout	36.8 (-25.9, 68.2)	0.192	74.0 (67.5, 79.1)	<0.0001
2.2: Signal Treatment	52.4 (29.0, 68.1)	0.0003	35.0 (28.7, 40.8)	<0.0001
2.3: Improved Definition	56.0 (-29.9, 85.1)	0.1372	36.1 (19.0, 49.6)	0.0002
2.4: Enhanced Signage	-27.3 (-435.9, 69.8)	0.742	33.2 (-2.4, 56.5)	0.0641
2.5: Change Geometry	***	***	64.6 (30.5, 82.0)	0.0026
2.6: Add Lane	***	***	48.0 (35.9, 57.7)	<0.0001
2.7: Speed Reduction	6.6 (-170.8, 67.8)	0.900	-15.8 (-57.0, 14.6)	0.3439
2.8: Other Treatments	-31.9 (-206.6, 43.2)	0.519	38.3 (19.3, 52.8)	0.0004

*** Estimated casualty crash reduction could not be made due to insufficient casualty motorcycle crash counts

Cells shaded grey indicate non-significant estimated casualty crash reductions

4.1.2 $85M Blackspot Program

This section reports casualty motorcycle crash reductions at sites treated as part of the $85M blackspot program. In their evaluation of the effect of the $85M blackspot program on the numbers of casualty crashes at treated sites, Newstead and Corben (2001) did not provide separate estimates of crash reductions for serious casualty crashes and other injury crashes. Therefore, estimated reductions for casualty motorcycle crashes of different severity levels are compared against Newstead and Corben's (2001) estimate of the reduction for casualty crashes involving all types of vehicles. It is beyond the scope of the present report to reanalyse Newstead and Corben's (2001) data so that estimates of the

$85M program on serious casualty crashes and other injury crashes involving all types of vehicles are available.

As in the previous section, results are presented at a program level, followed by sites grouped according to the type of treatment employed.

Program Level Effects

It can be seen from Table 4.7 that the $85M blackspot program resulted in a 24% reduction in the number of casualty motorcycle crashes at treated sites. This significant reduction was very similar to that reported by Newstead and Corben (2001) for all types of crashes (26%). The $85M program's effect on casualty motorcycle crashes was less than that estimated for the $240M program (which showed a 31% reduction), however the difference was not significant. The estimate for the reduction in the number of serious casualty motorcycle crashes at treated sites was 19%, however this estimate did not attain statistical significance (p=0.058). Table 4.7 also shows that if the estimated 24% reduction in the number of casualty motorcycle crashes at treated sites was assumed to be accurate, this would translate into an annual saving of 46 casualty motorcycle across all treated sites.

Table 4.7: Estimated crash reductions at the program level for sites treated under the $85M blackspot program

Types of Casualty Crashes	Estimated Crash Reduction (%)	Statistical Significance	Lower 95% Confidence Limit (%)	Upper 95% Confidence Limit (%)	Annual Crash Frequency at Treated Sites Before Treatment	Annual Casualty Crash Saving
Motorcycle Crashes						
- All Casualty	23.9	0.0003	11.7	34.4	192	46
- Serious	19.3	0.0584	-0.8	35.3	96	18
- Other Injury	27.1	0.0025	10.5	40.6	96	26
All Types of Crashes						
- All Casualty	26.4	<0.0001	23.6	29.2	2,249	594
- Serious	Not available					
- Other Injury						

Estimating the number of injuries prevented

The estimates of crash reduction presented in Table 4.7 can be used to infer the number of fatalities prevented, as well as the number of injuries (both serious and other types) prevented due to the effects of the $85M program. For casualty motorcycle crashes, the method of estimating the number of injuries prevented was the same as that used when estimating the number of injuries prevented because of the $240M program. Appendix D describes this method in detail. Unfortunately, Newstead and Corben (2001) did not estimate the number of injuries prevented in their review of the effect of the $85M blackspot program on casualty crashes involving all types of vehicles. However, Appendix

D explains how estimates of the number of injuries prevented due to reductions in the number of casualty crashes involving all types of vehicles can be calculated.

Table 4.8 shows, over the life of the $85M program, an estimated 18 lives were saved and 207 serious injuries prevented due to reductions in the number of motorcycle crashes. Similarly, Table 4.8 shows that, due to reductions in the number of casualty motorcycle crashes at sites treated as part of the $85M program, 355 other injuries and 622 casualties would be prevented over the life of the program.

Table 4.8: Estimates of the number of injuries and crashes prevented over the project life of each treatment for the $85M blackspot program as a whole for all types of crashes and motorcycle crashes only

	Motorcycle Crashes	All Types of Crashes
Crashes saved over treatment life		
- Serious casualty crashes	209	Not Available
- All casualty crashes	550	7,088
Injuries prevented over treatment life		
- Fatalities	18	169
- Serious injuries	207	2,599
- Other injuries	355	7,875
- All casualties	622	10,642

Treatment Type Effects

Section 3.2.2 describes the methodology for evaluating the effectiveness of the different types of treatments employed as part of the $85M blackspot program, while Appendix B describes how different treated sites were categorised with respect to treatment type. As described in Newstead and Corben (2001), seven of the 559 sites treated as part of the $85M blackspot program were treated with high-cost road works. The capital expenditure of the seven high-cost sites accounted for more than $30M of the $85M spent on all the 559 blackspot sites. The criteria for the selection of these seven sites for treatment were not based entirely on their poor crash history, but because of the potential of improved mobility resulting from the treatment of these sites. As the criteria for selection of these sites differed for the criteria applicable for the remaining 552 sites, and because the treatments completed at the seven sites were high-cost compared to the other 552 sites, Newstead and Corben (2001) chose to evaluate the seven high-cost sites separately from the remaining sites. The effect on motorcycle safety of treatments at the seven high-cost sites is also evaluated separately in this section of the present report. For details of the location and treatment works of the seven high-cost sites, the reader is referred to Newstead and Corben (2001).

Table 4.9 shows that the seven high-cost sites did not exhibit a significant reduction in casualty motorcycle crashes in the after-treatment period compared to the before-treatment period. The treatments at the remaining 552 sites were shown to result in a significant 24% reduction in casualty motorcycle crashes, which was similar to the estimated reduction of 25% for casualty crashes involving all types of vehicles (Newstead and Corben, 2001). Sites treated using intersection treatments and route treatments also showed significant estimated reductions in casualty motorcycle crashes of 27% and 35% respectively. The estimated reduction in casualty motorcycle crashes was 66% for sites treated using pedestrian treatments, however this reduction was not statistically significant (p=0.143). Surprisingly, sites for which road features were treated showed a significant increase in casualty motorcycle crashes in the after-treatment period when compared to the before treatment period. Table 4.9 shows that sites in which road features were treated did not significantly reduce casualty crashes involving all types of vehicles. The reason why treatment of road features would lead to an increase in motorcycle crashes is unclear. Whilst it is beyond the scope of this study to further investigate the reason for this result, further investigation of the result could be warranted to identify specific issues including treatment or location characteristics that may have led to the result.

Table 4.9: Estimated percentage casualty motorcycle crash reductions attributable to the $85M blackspot program by the type of treatment works completed at the site compared with casualty crash reductions involving all types of vehicles

Treatment Type	Estimated Casualty Crash Reduction (%)	Statistical Significance	Lower 95% Confidence Limit (%)	Upper 95% Confidence Limit (%)	Annual crash frequency at treated sites before treatment	Annual casualty crash saving
Motorcycle Crashes						
- Program Excluding 7 High-cost Sites	23.8	0.0004	11.5	34.3	190	45
- 7 High-cost Sites	29.5	0.506	-97.6	74.9	3	1
- Intersection Treatments	26.5	0.0031	9.9	40.5	73	19
- Pedestrian Facilities	65.6	0.143	-43.2	91.7	1	1
- Route Treatments	34.6	<0.0001	19.8	46.7	95	33
- Treatment of Road Features	-99.8	0.0001	-183.7	-40.8	21	-21
All Types of Crashes						
- Program Excluding 7 High-cost Sites	25.3	<0.0001	22.3	28.1	2,188	553
- 7 High-cost Sites	57.3	<0.0001	45.8	66.4	61	35
- Intersection Treatments	27.6	<0.0001	23.1	31.9	742	205
- Pedestrian Facilities	12.3	0.413	-20.1	36.0	21	3
- Route Treatments	28.5	<0.0001	24.4	32.4	1,202	343
- Treatment of Road Features	4.5	0.376	-5.8	13.9	222	10

In their review of the effect of the $85M blackspot program on casualty crashes involving all types of vehicles, Newstead and Corben (2001) did not provide estimates of serious casualty crash reductions. However, Table 4.10 of the present reports gives estimates of serious casualty motorcycle crash reduction for sites grouped by treatment type. It can be seen that serious casualty motorcycle crashes at sites treated using route treatments were reduced by a statistically significant 31% in the after-treatment period when compared to the before-treatment period. The estimated reduction for intersection treatments was 20%, however this estimate was not significant. Treatment of the road features resulted in a significant increase in serious casualty motorcycle crashes. Again, it is unclear why this occurred and may warrant further investigation.

Table 4.10: Estimated percentage serious casualty motorcycle crash reductions attributable to the $85M blackspot program by the type of treatment works completed at the site

Treatment Type	Estimated Serious Casualty Crash Reduction (%)	Statistical Significance	Lower 95% Confidence Limit (%)	Upper 95% Confidence Limit (%)	Annual Serious Casualty crash frequency at treated sites before treatment	Annual Serious Casualty crash saving
Motorcycle Crashes						
- Program Excluding 7 High-cost Sites	18.9	0.0642	-1.3	35.1	95	18
- 7 High-cost Sites	44.4	0.572	-324.3	92.7	1	<1
- Intersection Treatments	19.8	0.164	-9.4	41.2	31	6
- Pedestrian Facilities	51.3	0.488	-272.7	93.6	1	<1
- Route Treatments	31.2	0.014	7.3	48.9	51	16
- Treatment of Road Features	-103.2	0.008	-243.6	-20.2	11	-12

As serious casualty motorcycle crashes at treated sites were relatively rare when compared to casualty motorcycle crashes of all severities, it was not possible to confidently derive useful serious casualty crash reduction estimates for sites that were grouped using more specific classifications than the one used in Table 4.10. However, it was possible to derive estimates of crash reductions for specifically defined groups of treatments when casualty motorcycle crashes of all severities were considered. Table 4.9 showed that intersection treatments were estimated to reduce casualty motorcycle crashes at treated sites by 27%, while Table 4.11 shows that of these sites, casualty motorcycle crashes were estimated to decrease by 69% when roundabout treatments were employed and 49% when the treatment involved the remodelling of signals at the intersection. Both these estimates were statistically significant. It was also found that sites treated by installing new signals showed a 36% reduction in casualty motorcycle crashes. However this estimate was not significant.

For sites treated by remodelling signals at the intersection, the point estimate for the casualty motorcycle crash reduction was twice that of the point estimate for the reduction in casualty crashes involving all types of vehicles. Even though the two point estimates were not significantly different, it does suggest a trend toward signal remodelling treatments being more effective in reducing casualty motorcycle crashes than reducing casualty crashes involving all types of vehicles.

It is also interesting to note that treatments in the “other intersection treatments” category performed significantly worse when only casualty motorcycle crashes were considered than when crashes involving all types of vehicles were considered. There are a broad range of treatment works in this category (see Appendix B) and further investigation is required to determine how each of the treatments in this category affects motorcycle safety.

Table 4.11: Estimated percentage casualty motorcycle crash reductions attributable to Intersection treatments for the $85M blackspot program compared with casualty crash reductions involving all types of vehicles

Intersection Treatment Type	Motorcycle Crashes		All Types of Crashes	
	Est. % Casualty Crash Reduction	Statistical Significance Probability	Est. % Casualty Crash Reduction	Statistical Significance Probability
1.1: Roundabout	68.6 (37.9, 84.1)	0.0009	70.2 (61.5, 76.9)	<0.0001
1.3: Signal remodel	49.0 (25.6, 65.0)	0.0005	24.9 (17.8, 31.3)	<0.0001
1.4: New signals	35.6 (-7.8, 61.5)	0.094	32.1 (18.2, 43.6)	<0.0001
1.5: Rail level crossing treatments	***	***	39.5 (-45.2, 74.8)	0.260
1.6: Other intersection treatments	-27.6 (-67.2, 2.6)	0.077	15.8 (7.1, 23.6)	0.0006

*** Estimated casualty crash reduction could not be made due to insufficient casualty motorcycle crash counts
Cells shaded grey indicate non-significant estimated casualty crash reductions

Table 4.12 shows the estimated crash reductions attributable to roundabout treatments and signal remodel treatments at the finest level of treatment works classification. It can be seen that the installation of new roundabouts resulted in a statistically significant 77% reduction in casualty motorcycle crashes at treated sites, while the modification of existing roundabouts did not result in a reduction in casualty motorcycle crashes. This is probably partly due to a lack of data, as only five of the 52 roundabout treatments involved remodelling existing treatments. Fully controlled right turn treatments resulted in a 52% reduction in casualty motorcycle crashes at treated sites, which was greater, but not significantly greater, than the 32% reduction that such treatment works had on casualty crashes involving all types of vehicles.

Table 4.12: Estimated percentage casualty motorcycle crash reductions attributable to Roundabout and Signal remodel treatments for the $85M blackspot program compared with casualty crash reductions involving all types of vehicles

Roundabout and Signal remodel treatment Type	Motorcycle Crashes		All Types of Crashes	
	Est. % Casualty Crash Reduction	Statistical Significance Probability	Est. % Casualty Crash Reduction	Statistical Significance Probability
1.1.1: Modify existing roundabout	-0.5 (-175.9,63.4)	0.992	57.2 (29.0, 74.1)	0.001
1.1.2: New roundabout	77.4 (44.3, 90.8)	0.001	73.2 (64.0, 80.0)	<0.0001
1.3.1: FCRT	51.5 (19.0, 71.0)	0.006	32.0 (22.7, 40.2)	<0.0001
1.3.2: PCRT	***	***	15.7 (-26.2, 43.7)	0.407
1.3.3: New signal hardware	***	***	-1.85 (-98.9,47.8)	0.957
1.3.4: Mast arm	1.5 (-219.4, 69.6)	0.980	-21.1 (-60.1, 8.5)	0.180
1.3.5: Signal linking	***	***	-64.3 (-306,33.5)	0.282

*** Estimated casualty crash reduction could not be made due to insufficient casualty motorcycle crash counts
Cells shaded grey indicate non-significant estimated casualty crash reductions

As pedestrian treatments were not shown to be effective in significantly reducing casualty motorcycle crashes (see Table 4.9), estimates of reductions in casualty motorcycle crashes at sites grouped using more-specific pedestrian treatment categories have not been presented in this report.

Table 4.13: Estimated percentage casualty motorcycle crash reductions attributable to Route treatments for the $85M blackspot program compared with casualty crash reductions involving all types of vehicles

Route Treatment Type	Motorcycle Crashes		All Types of Crashes	
	Est. % Casualty Crash Reduction	Statistical Significance Probability	Est. % Casualty Crash Reduction	Statistical Significance Probability
3.2: Public Street Lighting	13.5 (-113.8,65.0)	0.753	11.1 (-11.2, 29.0)	0.304
3.3: Pavement Resealing	***	***	44.4 (12.7, 64.5)	0.011
3.4: Roadway Delineation	7.9 (-20.9, 29.8)	0.554	28.3 (22.1, 33.9)	<0.0001
3.5: Curve Realignment	69.4 (-196.0,96.8)	0.307	46.3 (-3.5, 72.1)	0.063
3.6: Shoulder Sealing	48.5 (30.6, 61.8)	<0.0001	30.7 (24.6, 36.3)	<0.0001
3.7: Overtaking Lanes	74.7 (-96.8, 96.7)	0.189	11.4 (-25.9, 37.6)	0.501
3.9: Pavement Widening	49.0 (-69.2, 84.6)	0.271	30.9 (0.1, 52.2)	0.050

*** Estimated casualty crash reduction could not be made due to insufficient casualty motorcycle crash counts
Cells shaded grey indicate non-significant estimated casualty crash reductions

Table 4.9 showed that sites treated with route treatments significantly reduced casualty motorcycle crashes by 35%. Table 4.13 presents the casualty motorcycle crash reductions for sites treated with route treatments by the specific type of treatment that each of the sites underwent. It can be seen that the only route treatment that significantly reduced casualty motorcycle crashes was shoulder sealing, which resulted in a 49% reduction in casualty motorcycle crashes, compared with a 31% reduction in casualty crashes involving all types of vehicles. Shoulder sealing treatments accounted for the majority (101 of 190) of route treatments employed as part of the $85M blackspot program.

Table 4.14: Estimated percentage casualty motorcycle crash reductions attributable to Road feature treatments for the $85M blackspot program compared with casualty crash reductions involving all types of vehicles

Road Feature Treatment Type	Motorcycle Crashes		All Types of Crashes	
	Est. % Casualty Crash Reduction	Statistical Significance Probability	Est. % Casualty Crash Reduction	Statistical Significance Probability
4.1: Roadside Hazards	-141.5	<0.0001	4.4	0.409
4.2: Bridge Treatments	***	***	7.2	0.751

*** Estimated casualty crash reduction could not be made due to insufficient casualty motorcycle crash counts
Cells shaded grey indicate non-significant estimated casualty crash reductions

Finally for this section, Table 4.14 shows that of sites treated using road feature treatments, those that were treated using treatments in the roadside hazards sub-category exhibited a significant increase in casualty motorcycle crashes at treated sites. It was not possible to estimate the reduction in casualty motorcycle crashes for bridge treatments, as there were only four casualty motorcycle crashes occurring at sites where this type of treatment was employed.

4.2 ECONOMIC WORTH

Separate analyses of the effects of the $240M blackspot program and the $85M blackspot program on casualty motorcycle crashes at treated sites were presented in Section 4.1.1 and 4.1.2 along with analogous effects for all types of casualty crashes (from Scully et al., 2006b). In the following sections, casualty motorcycle crash reductions attributable to both programs have been translated into measures of economic worth. In order to complete this task, it was necessary to estimate the economic cost of each casualty motorcycle crash that occurred. Section 2.3.1 describes in detail how the cost of casualty crashes involving all types of vehicles were derived in previous evaluations of both blackspot programs (i.e. Newstead and Corben, 2001; Scully et al., 2006b). Section 2.3.2 describes the process of estimating the average cost of a casualty motorcycle crashes for both the $85M program and the $240M program. It was decided that the average cost of a casualty motorcycle crash used to evaluate one program should be equal to the cost used in the other program. The average costs of casualty motorcycle crashes used in this report are shown in Table 2.14 on page 19. Two different estimates of the average cost of a casualty motorcycle crash were presented in Table 2.14: one based on crash cost estimates used by VicRoads to select treatment sites for the program; and one based on costs derived by Austroads.

4.2.1 $240M Blackspot Program

This section presents economic measures of the effectiveness of the $240M blackspot program in reducing casualty motorcycle crashes at treated sites. Economic measures used to evaluate the program include cost effectiveness and present value crash savings. Economic measures for casualty motorcycle crashes are compared against those for all types of casualty crashes, which have been taken from Scully et al. (2006b). Results are presented at a program level, followed by sites grouped according to the type of treatment employed.

Program Level Effectiveness

Table 4.15 shows that the capital cost for the entire $240M program was $202,230,000, while the aggregated annual maintenance cost of the 823 treatments was equal to $569,600. The present value maintenance costs represent the present value of all future maintenance costs. Present value maintenance costs are presented for discount rates of 4%, 6% and 8%. Discount rates in this range accorded with those used by the Victorian Treasury for evaluation of public expenditure capital works programs. The present value total life-time cost of the program is equal to the present value maintenance cost plus the capital cost of the program.

Table 4.15: Economic Summary of the $240M blackspot program (based on 823 sites)

Discount Rate	4%	6%	8%
Capital Costs ($)	202,230,000	202,230,000	202,230,000
Annual Maintenance Costs ($)	569,600	569,600	569,600
Present Value Maintenance Costs ($)	5,972,198	5,234,703	4,630,898
Present Value Total Life Time Costs ($)	207,750,198	207,012,703	206,408,898

Using the average casualty motorcycle crash costs from Table 2.14 on page 19, economic assessment of the 823 treatment sites was undertaken. As individual casualty motorcycle crash effects were not estimated for each treated site, the estimated casualty motorcycle crash reduction shown in Table 4.1 (i.e. a 31.2% reduction) was assumed for each individual treatment. This estimated reduction was used because it represented the most accurate estimate of the reduction in casualty motorcycle crashes due to treatments at the program level.

Crash savings at each site were calculated using Steps 1 and 2 of the methodology described in Appendix D. This involved first calculating the number of casualty motorcycle crashes expected to occur at a site throughout the life of the treatment if the treatment had no effect. Multiplying this value by the estimated casualty motorcycle crash reduction gave the estimate of the number casualty motorcycle crashes prevented at the site. The appropriate estimated average motorcycle crash cost for the location of the site (see Table 2.14) was then used to calculate the present value of the motorcycle crash savings over the life of the treatment. Summing over all sites gave the estimated present value savings due to a reduction in the frequency of casualty motorcycle crashes at the 823 sites treated as part of $240M blackspot program. These savings are presented in Table 4.16 for assumed discount rates of 4%, 6% and 8%. The table presents separate results for when Austroads' crash costs were assumed and for when VicRoads' crash costs were assumed.

Table 4.16: Economic assessment of the $240M blackspot program for all types of crashes and motorcycle crashes only

	Discount Rate		
	4%	6%	8%
Present value crash savings ($)			
VicRoads' crash costs used			
All Crashes	568,378,888	494,321,389	434,705,929
MC Crashes Only	73,150,467	63,573,734	55,868,673
Proportion of Savings for All Crashes (%)	*12.9*	*12.9*	*12.9*
Austroads' crash costs used			
All Crashes	876,922,174	763,109,349	671,415,201
MC Crashes Only	115,333,494	100,304,723	88,201,824
Proportion of Savings for All Crashes (%)	*13.2*	*13.1*	*13.1*
Cost Effectiveness ($/Serious Casualties)			
All Crashes	62,587	62,365	62,184
MC Crashes Only	549,440	547,490	545,893

It can be seen from Table 4.16 that, for a discount rate of 6%, using VicRoads' crash costs, the estimated present value crash savings from a 31.2% reduction in the number of casualty motorcycle crashes was approximately $64M, compared to $494M worth of savings due to the estimated reduction in the number of casualty crashes involving all types of vehicles. Estimates of economic worth of the $240M program derived using the Austroads' crash cost were higher than those derived using VicRoads' program formulation costs. This reflects the higher value of the Austroads' cost estimates.

Table 4.16 also presents the present value crash savings due to reductions in the number of casualty motorcycle crashes as a proportion of the present value savings due to reductions in the frequency of casualty crashes involving all types of vehicles. It can be seen that, irrespective of the assumed discount rate (within the range of 4-6%) and whether crash costs were derived from VicRoads' program costs or Austroads' costs, present value savings due to reductions in casualty motorcycle crashes accounted for approximately 13% of the present value savings of the $240M program when all types of crashes were considered.

The reader may recall from Table 2.6 in Section 2.2.2 that motorcycle crashes accounted for approximately 11% of the casualty crashes that were used to evaluate the $240M blackspot program. Similarly, fatal crashes that involved a motorcycle accounted for 13% of all the fatal crashes, while 15% of serious injury crashes involved a motorcycle. The fact that the proportion of the savings that can be attributed to reductions in casualty motorcycle crashes is similar to the proportion of crashes that involve a motorcycle suggests that the benefits that the $240M program provides to motorcyclists are in line with the benefits that the program provides to the wider population of road users.

Table 4.16 also shows cost effectiveness estimates for the $240M blackspot program. These estimates represent the amount of investment required to prevent one serious casualty, where a serious casualty is defined as a road user who is either killed within 30 days as a result of the crash or transported to hospital or admitted to hospital as a result of the crash. Using data from Scully et al. (2006b), it was estimated that approximately $62,000 would need to be invested in order to prevent one serious casualty resulting from a casualty crash involving any type of vehicle, while the present report estimated that nearly $550,000 would need to be invested to prevent a serious casualty due to a casualty crash involving a motorcycle.

Effectiveness of Treatments

The previous report by Scully et al. (2006b) only assumed a discount rate of 6% when using economic measures to evaluate sites grouped by treatment type. However, when evaluating the $240M blackspot program in the present report, results for when the discount rate is assumed to be 8% are also presented. This will allow comparison with the $85M blackspot program, where an 8% discount rate was assumed by Newstead and Corben (2001).

Table 4.17 shows the present value savings due to reductions in the number of casualty motorcycle crashes at treated sites for each of the three broad treatment categories used to classify treatments completed as part of the $240M blackspot program. Present value savings attributed to reductions in the number of casualty crashes involving all types of vehicles are presented (from Scully et al., 2006b), as are the percentage of these savings that can be attributed to reductions in casualty motorcycle crashes at treated sites. Table 4.17 presents estimated savings for discount rates of 6% and 8%, however only results based on VicRoads' crash costs have been calculated.

It can be seen from Table 4.17 that when a discount rate of 6% was assumed, the 235 sites treated using off-path treatments resulted in a present value saving of over $39M due to reductions in casualty motorcycle crashes, which was 26% of the savings that resulted from reductions of all types of crashes at these sites. The 541 intersection treatments resulted in savings due to reductions in casualty motorcycle crashes with a present value of nearly $24M. However this was only 8% of the total savings attributed to the treatments at this group of sites. The reader should be aware that the reported present value of savings resulting from the 37 vulnerable road user treatments were based on non-significant estimates of the casualty motorcycle crash reduction and casualty crash reduction for this group of sites (see Table 4.3).

Table 4.17: Present Value Crash Savings for the $240M blackspot program by broad treatment type (VicRoads' crash costs assumed)

Treatment Type	Discount Rate	
	6%	8%
Off-Path		
Present Value Crash Savings ($)		
All Crashes	152,524,698	133,648,587
MC Crashes Only	39,224,126	34,391,759
Proportion of Cost for All Crashes (%)	25.7	25.7
Intersection		
Present Value Crash Savings ($)		
All Crashes	313,753,892	276,154,425
MC Crashes Only	23,805,124	20,968,037
Proportion of Cost for All Crashes (%)	7.6	7.6
Vulnerable road users		
Present Value Crash Savings ($)		
All Crashes	1,255,542*	1,123,959*
MC Crashes Only	451,394*	401,509*
Proportion of Cost for All Crashes (%)	36.0*	35.7*

* Based on non-significant (p>0.05) estimated crash reductions

Table 4.18 displays estimates of the average amount of expenditure required to reduce the number of serious casualties by one unit. Results are given for discount rates of 6% and 8% as well as for the entire sample of casualty crashes and casualty motorcycle crashes only. It can be seen that that sites treated using off-path treatments were more cost effective in reducing serious casualties caused by casualty motorcycle crashes than sites treated with intersection treatments. However as the estimate of serious motorcycle crash reduction for intersection treatments was not significantly different to the reductions for off-path treatments (see Table 4.4), the cost effectiveness of the two treatment groups are not likely to be significantly different.

The reader may be surprised that off-path treatments were slightly more cost effective at preventing serious casualties resulting from serious casualty motorcycle crashes than intersection treatments given that the point estimate of the serious casualty motorcycle crash reduction for intersection treatments was greater than that for off-path treatments (45% compared with 35%) and that the present value of the total life-time cost of the intersection treatments was less than that for the off-path treatments ($74M compared with $106M). The reason off path treatments were more cost effective is that the average number of serious casualty motorcycle crashes at each of the 235 sites treated with off-path treatments was nearly five times that of the 541 sites treated with intersection treatments (0.18 compared with 0.04 per site per year). Therefore the aggregated annual number of serious casualty motorcycle crashes prevented at the 235 off-path sites was twice that at the 541 intersection sites (43 compared with 21 serious casualty motorcycle crashes), resulting in a greater estimate of the total number of serious casualties prevented for off-path treatments.

Table 4.18: Cost effectiveness for the $240M blackspot program by broad treatment type (VicRoads' crash costs assumed)

Treatment Type	Discount Rate	
	6%	8%
Off-Path		
PV total life-time cost ($)	106,879,361	106,803,836
Cost Effectiveness ($/Serious Casualties)		
All Crashes	76,234	76,180
MC Crashes Only	447,194	446,878
Intersection		
PV total life-time cost ($)	74,189,992	73,743,605
Cost Effectiveness ($/Serious Casualties)		
All Crashes	40,674	40,429
MC Crashes Only	494,600	491,624
Vulnerable road users		
PV total life-time cost ($)	4,560,365	4,486,540
Cost Effectiveness ($/Serious Casualties)		
All Crashes	304,024*	299,103*
MC Crashes Only	-506,707*	-498,504*

* Based on non-significant (p>0.05) estimated crash reductions

4.2.2 $85M blackspot program

Before beginning the economic analysis of the $85M program, it is necessary to review some of the costs and savings from the earlier study by Newstead and Corben (2001). All program costs from the earlier evaluation were presented using 1995 Australian dollar values. In order to use economic measures to compare the effectiveness of the $85M program in preventing casualty motorcycle crashes to those derived in the last section for the $240M program, it is necessary to update the costs presented by Newstead and Corben (2001) to the year 2000 dollar values used in the evaluation of the $240M.

Table 4.19 presents a summary of the costs of the $85M program. Economic measures are given in 1995 values as well as year 2000 values. The 1995 values were used in the original evaluation of the $85M blackspot program by Newstead and Corben (2001). These values can be adjusted to 2000 values using the ratio of the average Consumer Price Index (CPI) for 2000 compared to 1995 as reported by the Australian Bureau of Statistics (2006). Melbourne's weighted average CPI for the four quarters in the 1995 calendar year was 116.8, compared with 127.9 for the four quarters of 2000. The weighted average for all of Australia was 116.8 in 1995 and 128.4 in 2000. Therefore, the ratio of the CPI for Melbourne households in 2000 was 1.095 when compared with the CPI for 1995. The analogous national ratio was 1.099. In this report, Melbourne's CPI values have been used to adjust 1995 costs because all treatments were employed on Victorian roads. However the fact that the rates for Melbourne are similar to national rates in both 1995 and 2000 means that if national CPI values were used to adjust the reported costs of the $85M program to year 2000 values, the resulting economic measures would be similar to those reported in this evaluation.

Table 4.19: Economic Summary of the $85M blackspot program (based on 559 sites)

Entire Program (559 sites)	Discount Rate		
	4%	6%	8%
$AU (1995)			
Capital Costs ($)	84,624,889	84,624,889	84,624,889
Annual Maintenance Costs ($)	562,477	562,477	562,477
Present Value Maintenance Costs ($)	6,297,427	5,399,847	4,704,893
Present Value Total Life Time Costs ($)	90,922,317	90,024,736	89,329,782
$AU (2000)			
Capital Costs ($)	92,667,152	92,667,152	92,667,152
Annual Maintenance Costs ($)	615,932	615,932	615,932
Present Value Maintenance Costs ($)	6,895,899	5,913,017	5,152,019
Present Value Total Life Time Costs ($)	99,563,050	98,580,169	97,819,171

As in Newstead and Corben's (2001) evaluation of the effectiveness of the $85M blackspot program in preventing all types of crashes, this report will present economic measures for the $85M program as a whole as well as for the program stratified by the seven most high cost treatments and remaining sites. Tables 4.20 and 4.21 provide summaries of costs of the seven high cost treatments and the remaining 552 treatments respectively. Costs are presented for both 1995 values and year 2000 dollar values.

Table 4.20: Economic Summary of the 7 High-Cost Sites of the $85M blackspot program

7 High-Cost Sites	Discount Rate		
	4%	6%	8%
$AU (1995)			
Capital Costs ($)	30,359,446	30,359,446	30,359,446
Annual Maintenance Costs ($)	61,800	61,800	61,800
Present Value Maintenance Costs ($)	1,122,526	874,255	706,374
Present Value Total Life Time Costs ($)	31,481,972	31,233,701	31,065,820
$AU (2000)			
Capital Costs ($)	33,244,633	33,244,633	33,244,633
Annual Maintenance Costs ($)	67,673	67,673	67,673
Present Value Maintenance Costs ($)	1,229,204	957,339	773,504
Present Value Total Life Time Costs ($)	34,473,837	34,201,972	34,018,137

Newstead and Corben (2001) used the same method as that used by Scully et al. (2006b) to estimate reductions in the number of casualty crashes at treated sites in the after-treatment period of the applicable blackspot program. However the two studies used different methods to estimate the economic savings of the respective programs. Specifically, each study used Poisson regression and a series of two-by-two contingencies tables to predict the percentage reduction in the number of casualty crashes in the after treatment period at treated sites. Scully et al. (2006b) then used annual casualty crash counts in the before-treatment periods at treated sites and the average cost of casualty crashes in rural and metro areas to estimate the economic savings of the $240M program (see Section 2.3.1 for a detailed description of how average costs of casualty crashes were estimated by Scully et al., 2006b). However the method used by Newstead and Corben (2001) to calculate savings due to the $85M program's effect on casualty crashes at treated sites was not the same as that used in the evaluation of the $240M program. Instead of calculating the average number of crashes at treated sites in the before-treatment period and then using the average costs of casualty crashes in rural and metropolitan areas to calculate crash cost savings, Newstead and Corben (2001) used a modification of the Poisson regression methodology used to estimate the reduction in the number of crashes at treated sites.

Table 4.21: Economic Summary of the $85M blackspot program in which the 7 High-Cost Sites have been excluded

Program Excluding 7 High-Cost Sites (552 Sites)	Discount Rate		
	4%	6%	8%
$AU (1995)			
Capital Costs ($)	54,265,443	54,265,443	54,265,443
Annual Maintenance Costs ($)	500,677	500,677	500,677
Present Value Maintenance Costs ($)	5,174,902	4,525,592	3,998,518
Present Value Total Life Time Costs ($)	59,440,345	58,791,035	58,263,962
$AU (2000)			
Capital Costs ($)	59,422,519	59,422,519	59,422,519
Annual Maintenance Costs ($)	548,259	548,259	548,259
Present Value Maintenance Costs ($)	5,666,695	4,955,678	4,378,515
Present Value Total Life Time Costs ($)	65,089,213	64,378,196	63,801,034

As explained in Section 3.5.2 of Newstead and Corben (2001), whereas a standard Poisson distribution was used to model the error structure for estimates of reductions in the number of crashes, an over-dispersed Poisson distribution was used to model the error structure of the estimate of reductions in the cost of casualty crashes due to the blackspot program. Put another way, while each cell of the 2 by 2 contingency tables used to estimate the effect of the $85M blackspot program on the number of casualty crashes at treated sites contained observed numbers of casualty crashes, Newstead and Corben (2001) also used a series of 2 by 2 contingency tables with cells containing costs of crashes in the before and after periods of treated and control sites to build another Poisson model to estimate the savings attributable to the program.

In creating Poisson models to estimate reductions in cost, Newstead and Corben (2001) assumed a discount rate of 8%. The report did not provide any analysis of the sensitivity of results with respect to changes in the assumed discount rate. In order to calculate cost savings due to reductions in the number casualty crashes using different discount rates (for example 4% or 6%), it would be necessary to build new Poisson models. It is beyond the scope of the present report to re-analyse the data already analysed in Newstead and Corben (2001), so this section of the report will only report present value cost savings for the $85M program using a discount rate of 8%. Therefore, when evaluating the economic effect of the $85M blackspot program on all types of crashes, economic measures that require estimates of present value savings will not be reported for discount rates of 4% and 6%.

However, because estimates of savings due to reductions in the number of casualty motorcycle crashes at sites treated under the $85M program were derived using the same methodology as that used by Scully et al. (2006b) in their evaluation of the $240M program, casualty motorcycle crash cost savings for the $85M program will be presented using discount rates of 4%, 6% and 8%. Furthermore, as mentioned at the beginning of Section 4.2, the same average costs for casualty motorcycle crashes will be used to evaluate the economic effectiveness of the $85M program as those used to evaluate the $240M program, thus allowing direct comparison of the economic effectiveness of each program with respect to savings incurred by reducing casualty motorcycle crashes. As the costs of casualty motorcycle crashes used to evaluate the $240M in Section 4.2.1 are already in year 2000 dollar values, it was not necessary to multiply them by the ratio of 2000 to 1995 CPI values. However, the savings due to the $85M blackspot program's effect on reducing all types of casualty crashes, which were presented by Newstead and Corben (2001), will be updated to 2000 values.

Program Level Effectiveness

Using the average casualty motorcycle crash costs from Table 2.14 on page 19, the savings due to reductions in casualty motorcycle crashes at sites treated as part of the $85M blackspot program were estimated. The method of estimating these savings was the same as that used to estimate savings for the $240M blackspot program. This method used the estimated casualty motorcycle crash reduction shown in Table 4.7 (i.e. 24%).

Table 4.22: Present value crash savings for the $85M blackspot program for all types of crashes and motorcycle crashes only (derived using VicRoads' Program crash costs)

	Discount Rate		
	4%	6%	8%
Entire program (559 sites)			
Present value crash savings ($AU (2000))			
All Crashes	***	***	398,002,029
MC Crashes Only	58,454,898	51,251,905	45,512,780
Proportion of Savings for All Crashes (%)	***	***	*11.4*
Program excluding 7 high-cost sites (552 sites)			
Present value crash savings ($AU (2000))			
All Crashes	***	***	367,251,700
MC Crashes Only	56,643,226	49,876,896	44,412,776
Proportion of Savings for All Crashes (%)	***	***	*12.1*
7 High-cost sites			
Present value crash savings ($AU (2000))			
All Crashes	***	***	34,424,188
MC Crashes Only	1,948,599	1,443,449	1,131,509
Proportion of Savings for All Crashes (%)	***	***	*3.3*

*** Data not provided by Newstead and Corben (2001)

Table 4.22 presents estimates of the present value of savings due to reductions in casualty motorcycle crash at sites treated as part of the $85M blackspot program. The table also shows present value savings due to reductions in the number of casualty crashes involving all types of vehicles, which were derived by multiplying the present value of crash savings reported by Newstead and Corben (2001) by the ratio of the CPI of 2000 to 1995. This enables comparison with savings from the $240M program as well as savings due to reductions in casualty motorcycle crashes at sites treated as part of the $85M program.

Cost savings for reducing all types of casualty crashes have been adjusted to reflect year 2000 dollar values. Cost savings due to reductions in casualty motorcycle crashes have been derived using VicRoads' program costs only.

It can be seen from Table 4.22 that when a discount rate of 8% is assumed, the present value savings due to reductions in casualty motorcycle crashes is $45M, which is 11% of the present value savings due to reductions in all types of crashes at sites treated under the $85M program. The reader may recall from Table 4.16 that for the $240M program, savings due to the reduction in casualty motorcycle crashes made up 13% of the program's estimated savings due to all types of crashes.

It is also interesting to note that for the seven sites that underwent high-cost treatments, the savings due to the estimated reduction in casualty motorcycle crashes was only 3% of the estimated savings due to reduction in casualty crashes involving all types of vehicles. This indicates that treatments at these seven sites do not appear to reduce the costs associated with casualty motorcycle crashes to the same degree as costs due to casualty crashes involving all types of vehicles.

Table 4.23: Cost effectiveness for the $85M blackspot program for all types of crashes and motorcycle crashes only (derived using VicRoads' Program crash costs, all values are $AU 2000)

	Discount Rate		
	4%	6%	8%
Entire program (559 sites)			
PV total life-time cost ($)	99,563,050	98,580,169	97,819,171
Cost Effectiveness ($/Serious Casualties)			
All Crashes	35,981	35,626	35,351
MC Crashes Only	443,854	439,472	436,079
Program excluding 7 high-cost sites (552 sites) †			
PV total life-time cost ($)	65,089,213	64,378,196	63,801,034
Cost Effectiveness ($/Serious Casualties)			
All Crashes	26,985	26,690	26,451
MC Crashes Only	310,441	307,050	304,298
7 High-cost sites			
PV total life-time cost ($)	34,473,837	34,201,972	34,018,137
Cost Effectiveness ($/Serious Casualties)*			
All Crashes	64,299	63,792	63,449
MC Crashes Only	1,351,796	1,341,136	1,333,927

† Based on an estimated saving of 2,262 serious injuries and 150 fatalities due to all types of crashes and 193 serious injuries and 17 fatalities due to casualty motorcycle crashes over the treatment life of the 552 sites not classified as one of the seven high-cost sites

* Based on an estimated saving of 510 serious injuries and 26 fatalities due to all types of crashes and 24 serious injuries and two fatalities due to casualty motorcycle crashes over the treatment life of the 7 high-cost sites

Table 4.23 shows the cost effectiveness estimates for the $85M blackspot program. As previously mentioned, these estimates represent the amount of investment required to prevent one road user being killed or seriously injured. For the entire $85M blackspot program, the average amount of money required to prevent one serious casualty is about $36,000. However, approximately $440,000 is required to prevent a serious casualty due to involvement in a serious casualty motorcycle crash. For the seven sites treated with high-cost treatments, the estimates of cost effectiveness are $64,000 for casualty motorcycle crashes and $1.3M when casualty crashes involving all types of vehicles are considered. If these expensive treatments are excluded from the sample analysed, an average of only $27,000 is needed to reduce serious casualties due to crashes involving all types of crashes by one unit, while for serious casualties due to casualty motorcycle crashes, the cost effectiveness is approximately $310,000.

Effectiveness of Treatments

When assessing the economic effectiveness of sites grouped according to the type of treatment works completed at the sites, Newstead & Corben (2001) assumed a discount rate of 8% and did not test the sensitivity of their results to changes in the assumed discount rate. However when using economic measures to evaluate the economic effectiveness of different types of treatments in reducing casualty motorcycle crashes at treated sites, this report presents results for discount rates of 6% and 8%. This will allow comparison with the economic evaluation of different types of treatments completed as part of the $240M program on motorcycle safety (see Section 4.2.1).

Table 4.24 shows the present value savings due to reductions in casualty motorcycle crashes at groups of sites treated as part of the $85M blackspot program. Results are presented for the main categories of treatment works (see Appendix B for more details on how sites treated as part of the $85M program were grouped). The reader should be aware that, for treatments aimed at preventing crashes involving pedestrians, estimates of present value crash savings are based on non-significant estimated casualty motorcycle crash reductions (see Table 4.9). Estimates of present value crash savings due to reductions in casualty crashes involving all types of vehicles are taken from Newstead and Corben's (2001) evaluation of the $85M blackspot program. In this earlier report, estimates of crash savings were significant only for intersection treatments and route treatments. For intersection treatments, it was estimated that about 16% of the savings due to the reduction of casualty crashes at treated sites could be attributed to reductions in casualty motorcycle crashes, while for the $240M program, an estimated 8% of the cost savings were attributed to the reduction of casualty motorcycle crashes at sites where intersection treatments were employed. It is not clear why the proportion of savings that could be attributed to reductions in motorcycle crashes at intersection treatment sites were greater for the $85M program than for the $240M program. However the fact that the method of classifying treatments as intersection treatments was different in each evaluation may go some way to explain the different results (see Appendices A and B).

Crash savings due to reductions in casualty motorcycle crashes at sites treated using pedestrian treatments were modest when compared with crash savings attributed to other types of treatments, however they are estimated to make up 55% of the crash savings attributed to reductions in casualty crashes involving all types of vehicles at these sites. The reader should remember that this percentage is derived from two non-significant casualty crash reduction estimates, i.e. the non-significant estimate of a 12% reduction in casualty crashes involving all types of crashes at these sites and the non-significant 66% estimated reduction in casualty motorcycle crashes at these sites. If the true value of the former estimate is higher than Newstead and Corben's (2001) non-significant point estimate and the true value of the latter is lower than estimated, the true proportion of savings attributed to reduced casualty motorcycle crashes would be lower than 55%.

Table 4.24: Present Value Crash Savings for the $85M blackspot program by broad treatment type (VicRoads' crash costs assumed)

Treatment Type	Discount Rate 6%	Discount Rate 8%
Intersection treatments		
Present Value Crash Savings ($)		
All Crashes	***	140,892,140
MC Crashes Only	24,713,165	21,898,168
Proportion of Cost for All Crashes (%)	***	15.5
Pedestrian Facilities		
Present Value Crash Savings ($)		
All Crashes	***	1,718,662*
MC Crashes Only	1,061,223*	950,631*
Proportion of Cost for All Crashes (%)	***	55.3*
Route treatments		
Present Value Crash Savings ($)		
All Crashes	***	197,484,830
MC Crashes Only	36,492,997	32,886,927
Proportion of Cost for All Crashes (%)	***	16.7
Treatment of road features		
Present Value Crash Savings ($)		
All Crashes	***	19,678,786*
MC Crashes Only	-29,448,886	-25,490,379
Proportion of Cost for All Crashes (%)	***	-129.5*

* Based on non-significant (p>0.05) estimated crash reductions
*** Data not provided by Newstead and Corben (2001)

Table 4.24 also shows that for the $85M program, about 17% of the cost savings at sites treated using route treatments could be attributed to reduced casualty motorcycle crashes at treated sites. Results are also presented for sites in which road features were treated. Reasons why treatments involving the improvement of road features performed so poorly with respect to reducing the incidence (and costs) of casualty motorcycle crashes remains to be established, as noted in Section 4.1.2.

Table 4.25 presents the amount of investment required to reduce the incidence of a serious casualty by one where sites treated as part of the $85M blackspot program have been grouped by treatment type. The reader may recall from Section 4.2.1 that a serious casualty is defined as a road user that is either killed within 30 days of a casualty crash or hospitalised or taken to hospital as a result of the crash. When serious casualty crashes involving all types of vehicles are considered, of the four treatment categories, intersection treatments were the most cost effective, with the estimated average amount of investment required to reduce the number of serious casualties at treated sites being about $25,000, closely followed by route treatments ($30,000). Other estimates of cost effectiveness for serious casualties from serious casualty crashes involving all types of vehicles were based on non-significant estimates of serious casualty crash reduction.

Table 4.25: Cost Effectiveness for the $85M blackspot program by broad treatment type (VicRoads' crash costs assumed)

Treatment Type	Discount Rate	
	6%	8%
Intersection treatments		
PV total life-time cost ($)	26,874,850	26,436,762
Cost Effectiveness ($/Serious Casualties)		
All Crashes	25,070	24,661
MC Crashes Only	316,175*	311,021*
Pedestrian Facilities*		
PV total life-time cost ($)	932,339	896,952
Cost Effectiveness ($/Serious Casualties)		
All Crashes	71,718*	68,996*
MC Crashes Only	186,468*	179,390*
Route treatments		
PV total life-time cost ($)	34,060,363	33,963,770
Cost Effectiveness ($/Serious Casualties)		
All Crashes	29,930	29,845
MC Crashes Only	231,703	231,046
Treatment of road features*		
PV total life-time cost ($)	2,510,643	2,503,549
Cost Effectiveness ($/Serious Casualties)		
All Crashes	35,361*	35,261*
MC Crashes Only	-12,307	-12,722

* Based on non-significant (p>0.05) estimated crash reductions

The most effective treatment type in reducing serious casualties occurring because of serious casualty motorcycle crashes was the treatment of pedestrian facilities (requiring an average of $179,000 worth of investment to prevent one serious casualty), however this was based on a non-significant estimate of the reduction in the number of serious casualty motorcycle crashes at these sites (see Table 4.10).

5.0 DISCUSSION

5.1 GENERAL DISCUSSION AND INTERPRETATION

Evaluations of the $85M blackspot program and the $240M blackspot program both indicate that blackspot treatments have been effective in reducing casualty and serious casualty motorcycle crashes. Moreover, the evaluations indicate that the reductions in motorcycle crashes effected by the treatments are comparable to the reductions when considering crashes involving all road users.

5.2 CASUALTY SAVINGS

The $240M blackspot program produced savings in casualty motorcycle crashes of 31.2% and slightly greater saving in serious casualty motorcycle crashes of 35.5%. That is, it is expected that 352 serious casualty motorcycle crashes and 680 casualty motorcycle crashes will be prevented over the life of the treatments that form the program. This equates to around 378 fatal and serious injuries prevented over the life of the program. When comparing this to the program impacts on all road users, the reductions were nearly equal (31.3% for all casualty crashes and 34.5% for serious casualty crashes).

The $85M blackspot program effected greater reductions in casualty motorcycle crashes (23.9%) than in serious casualty motorcycle crashes (19.3%), and was estimated to result in around 225 serious motorcyclist casualties and over 600 casualties saved over the project life of each treatment. Again, these reductions were very similar to those achieved in all road user casualty crashes (26.4%).

5.3 OFF-PATH VS INTERSECTION

Although not statistically significant, intersection treatments in the $240M blackspot program appear to have been more effective in reducing casualty motorcycle crashes (37.7%) than off-path treatments (30.3%). In contrast, the $85M blackspot program included route treatments that were more effective in reducing casualty motorcycle crashes (34.6%) than intersection treatments (26.5%). Similar results were obtained when considering the reductions attained in casualty crashes involving all road users. Intersection treatments produced more reductions in casualty crashes (42.8%) than through off-path treatments (20.6%) in $240M blackspot program, while the $85M blackspot program produced near equal savings for casualty crashes involving all road users of 28.5% and 27.6% for route treatments and intersection treatments respectively. That is, in the more recent blackspot program, intersection treatments have proven to be more effective in reducing casualty crashes regardless of whether all road users or only motorcyclists are considered.

For the $240M program, within the off-path category of treatments, road alignment and delineation have resulted in statistically significant reductions in casualty motorcycle crashes of almost 60%, which is twice the estimated reduction when considering all road users. Ring road treatments also showed a strong effect in reducing casualty motorcycle crashes. The significant reduction effected by the Ring Road treatment was not the result of one single treatment, but included a combination of treatments such as the installation of speed cameras, median barriers and emergency phones along the Western Ring Road. The large reductions should therefore be viewed accordingly.

Off-path treatments completed as part of the $240M blackspot program that involved road widening appear to have reduced the incidence of motorcyclist casualty crashes by around three quarters. Addition of a lane was also included under the category of road widening. This result was nearly significant and could either be the result of fewer motorcyclists leaving the road due to the larger radii, the consequence of roadside hazards being removed in the process of road widening, or less likelihood of rear-enders due to the additional lane. This reduction is also reflected in the $85M program, which produced high reductions for curve realignment and pavement widening treatments, although these reductions were not significant.

Under the $240M blackspot program for treatments at intersections, only traffic signal related treatments showed a statistically reliable reduction in motorcycle casualty crashes (52%). This was substantially higher than the effect for all road users (35%). Although reductions were indicated at roundabouts in the most recent blackspot program, the findings were not statistically significant.

Roundabouts used in the $85M blackspot program showed statistically reliable reductions of around 70% for both casualty motorcycle crashes and casualty crashes involving all road users. Signal remodels achieved a statistically reliable 49% reduction in casualty motorcycle crashes, almost double that for casualty crashes involving all road users. Although this difference was not found to be statistically significant, it may suggest that measures such as fully controlling right turns might be even more effective for motorcyclists than the general road user. This is consistent with the findings that motorcyclists are commonly involved in intersection crashes when a vehicle driver turns right across the path of the rider. This should be further investigated before committing to any investments in such an approach.

For the $85M blackspot program, shoulder sealing appears to have been at least as effective (if not more so) at reducing casualty motorcycle crashes as for casualty crashes involving all road users (49% compared with 31% respectively).

While the treatment of Roadside Hazards in the $85M Program was associated with an estimated crash increase for motorcyclists, no such effect was evident in the $240M Program for similar treatments. This suggests that further investigation of the specific treatments under the $85M Program and motorcycle crashes occurring in that period, is required to understand the potential causes behind the negative crash reduction effect.

5.4 ECONOMIC EVALUATION

The $240M blackspot program has achieved BCRs ranging from 2.1 and 4.2 depending on the discount rate adopted (Scully et al., 2006b). That is, when assessed for the benefits accruing for all road users, the programs have been economically worthwhile. It is generally not possible to estimate the BCR figures for the program based only on benefits to motorcycles because it is not possible to estimate the proportion of the cost component of the blackspot treatment that relates to the motorcycle crash problem. Relating the motorcycle crash savings alone to the full blackspot treatment costs is possible but produces very low BCRs that are essentially meaningless since they ignore the benefits to vehicle drivers.

The most meaningful economic estimates from the blackspot programs relating to motorcycles are the estimates of present value crash savings. Specifically of interest are the present value of motorcycle crash savings and the proportion of total crash savings that they represent. Table 4.16 shows the present value of motorcycle crash savings from the $240M program to be between $56M and $73M depending on the discount rate. This represents about 13% of the present value of the savings estimated for the program across all road user classes. Table 2.6 shows that motorcycle crashes represent around 11% of all crashes at blackspot sites, confirming that the proportion of motorcycle crash cost savings at blackspot sites is in line with that expected from the proportionate crash problem represented by motorcyclists. Consistent with the crash savings estimates discussed above, this result further confirms that the general blackspot programs provide equivalent benefits in reducing motorcycle crashes as in reducing crashes overall. Similar conclusions can be drawn for the $85M program by comparing the figures in Tables 2.8 and 2.9 with those in Table 4.22.

Interpretation of the cost effectiveness figures for motorcycle crashes presented in Table 4.16 require similar caveats as those made for motorcycle specific BCR calculations. They reflect the expenditure required to save only motorcycle crashes and ignore any parallel benefits that would be achieved for other road users. Hence the dollar estimates appear relatively large and are somewhat meaningless for real world interpretation considering it is unlikely any of the treatments assessed would be targeted only at motorcyclists in real world applications. However, the figures are useful in a relative sense to compare the relative cost effectiveness of various treatments for motorcycle crashes even if they do not reflect absolute cost effectiveness. Cost effectiveness figures presented in Table 4.18 for various treatment categories could be used in this way.

Using this interpretation, Table 4.18 suggests that the greatest relative cost effectiveness for motorcyclists comes from off-path treatments followed by intersection treatments. For the $85M program, the most cost-effective treatment for motorcyclists would be pedestrian treatments, however this estimate of cost effectiveness is based on a non-significant estimate of serious casualty motorcycle crash reduction (51%, p=0.488). The most cost effective group of treatments based on a statistically significant estimate of crash reduction were route treatments.

Rather than relying on specific estimates of economic benefits to motorcyclists, to improve motorcyclist safety through road infrastructure and traffic engineering improvements, it may be preferable to ensure that motorcyclists are explicitly considered within general blackspot programs. This is because the economic justification will rarely exist to treat safety problems based on motorcycle crashes alone. Such an approach is compatible with the more general philosophy within which designers and operators of the road transport system are encouraged to ensure that all road users are fully considered in new designs and in the way the system operates.

Finally, there is always a concern about the ability to generalize the results of specific economic analyses beyond the programs to which they apply. All the economic measures considered in this study are to some degree dependent on the size of the crash population at each treated site, the specific costs of the treatments implemented and the mix of individual treatments in the aggregations analysed. All these factors need to be considered in deciding how well the economic analysis results from the programs examined in this study would translate to future blackspot programs.

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APPENDIX A – DEFINING TREATMENT CATEGORIES FOR THE $240M BLACKSPOT PROGRAM

The present appendix describes the method of grouping different treatments computed under the $240M blackspot program according to the types of work completed at the sites. In order to use Poisson regression to assess the effectiveness of different types of treatments, it was necessary to insure that all crashes occurring at a particular treatment site have the same values for variables related to the type of work completed at the site.

In order to categorise blackspot treatments into different categories, the data file containing information on the different types of treatments (see Section 2.1.1) was examined and each treatment was put into one or more of the following broad categories:

1. Off-Path treatments;

2. Intersection treatments; and

3. Vulnerable road user treatments;

Each blackspot treatment was classified into one or more of the above categories. These categories were chosen in the hope that most blackspot treatments would fall into only one of the categories. It is possible that a treatment site would fall into more than one category if the site had a broad range work completed at the site or if the site was coincident with another blackspot site. In such instances, the works completed at the site were examined in greater detail and the most significant type of work was used to determine a unique treatment category.

When each treatment was classified into one of the three treatment types, it was then classified into more specific categories that more accurately described the treatment works completed. This hierarchical classification system was chosen so that broad treatments as well specific treatments could be evaluated in terms of their cost effectiveness and their effectiveness in terms of reducing crashes and injury severity. The following pages describe the way each of the above broad categories were defined, as well as the types of specific categories defined for each broad category.

Of the 823 treatment sites, only ten could not be categorised into one of the above categories due to insufficient information in the *worktype* and *proj_wor* variables. There were 75 crashes at these unclassifiable sites.

1. Off-Path treatments

This category was designed to group together treatments that were intended to prevent non-intersection related crashes along lengths of roads. The types of crashes that such treatments were meant to prevent are likely to be run-off road crashes or crashes between vehicles travelling in opposite directions. Treatments that were implemented specifically to prevent crashes at intersections were ineligible for this category. In all, 235 of the 823 treatments were assessed as belonging to this category. Below is a list of the subcategories into which treatments classed in this category could be allocated. Next to each sub-category's name is the number of treatments that were classified as belonging to the respective sub-category. Treatments could not be classified into more than one of these sub-categories.

1.1 Improved Shoulder Definition (96)

1.1.1 Sealing only (63)

1.1.2 Sealing with Tactile Edge Marking (24)

1.1.3 Tactile Edge Marking only (9)

1.2 Bridge end-post protection (12)

1.2.1 Breakaway Cable Terminals (1)

1.2.2 Guard Rail (2)

1.2.3 Upgrade Terminal Ends (0)

1.2.4 Install Guard Rail and upgrade Terminal Ends (3)

1.2.5 Unspecified (6)

1.3 Barrier construction (20)

1.3.1 Guard Rail (9)

1.3.2 Guard Rail with Sealing of Shoulders (11)

1.4 Hazard removal (4)

1.4.1 Install frangible poles (2)

1.4.2 Remove poles or trees (2)

1.5 Road alignment and delineation (45)

1.5.1 Median installation/Carriageway duplication (including installation of Splitter Islands) (10)

1.5.2 Improved Line Marking (2)

1.5.3 Installing Retroflective Raised Pavement Markers (RRPMs) (1)

1.5.4 Guide Posts or Chevron Alignment Markers (CAMs) (32)

1.6 Improved lighting (5)

1.7 Improve Signage (4)

1.8 Road Surface (29)

1.8.1 Improve skid-resistance/Reseal Road (29)

1.9 Road widening (15)

1.9.1 Realign or widen curves (8)

1.9.2 Add Lane (5)

1.9.3 Unspecified (2)

1.10 Speed Reduction (4)

1.10.1 Channelisation (0)

1.10.2 Speed Camera (1)

1.10.3 Reduction of Speed limit on approaches (0)

1.10.4 Advisory Speed Signs (2)

1.10.5 Variable Speed Limit Signs (1)

1.11 Ring Road Treatments (1)

2. Intersection Treatments

Treatments that are designed to prevent collisions between two or more motor vehicles at an intersection are classified as intersection treatments. Treatments designed to prevent crashes involving pedestrians or bicyclists have not been classified as being intersection treatments. Treatments involving the replacement of a Y intersection with a T intersection are classified in the sub-category, Changing Geometry. Treatments in which a cross intersection is replaced with two offset T intersections are classified as Staggered-T treatments. Type B treatments are treatments that are applied to a T-intersection. They involve widening the through road near the adjacent road to allow through traffic to travel around right turning traffic. A Type C treatment involves the same road widening works used on the Type B treatments in addition to the installation of a right hand turn lane for cars travelling along the through road who wish to turn right onto the adjacent road. Of the 823 blackspot sites, 541 were classified as intersection treatments. If a treatment was classified as being an intersection treatment, it was then classified into one or more of the following subcategories. The number of treatments in each subcategory is given in brackets. There were seven intersection treatments that could not be placed into one of the following subcategories due to insufficient information in the treatment data file.

2.1 Roundabout (144)

2.1.1 Installation (133)

2.1.2 Modification of existing (11)

2.2 Signal Treatment (204)

2.2.1 New signals (57)

2.2.2 Fully controlled right turn (98)

2.2.3 New Mast arm (39)

2.2.4 Change Phasing (3)

2.2.5 Partially controlled right turn (4)

2.2.6 New signal hardware (3)

2.3 Improved definition (49)

2.3.1 Splitter Islands or Median installation (45)

2.3.2 Linemarking (4)

2.4 Enhanced Signage (9)

2.4.1 Advanced Warning Signs (5)

2.4.2 Rumble Strips on Approach Road (1)

2.4.3 Tram-activated Signs (1)

2.4.4 Unspecified (2)

2.5 Changing Geometry (21)

2.5.1 Staggered-T (14)

2.5.2 Removal of Y-Intersection (3)

2.5.3 Other realignment of approach (4)

2.6 Add Lane (55)

2.6.1 Add Left Turn Lane (7)

2.6.2 Add Right Turn Lane (32)

2.6.3 Widen Road around Right Turn Lane (Type B and C Treatments) (10)

2.6.4 Five Lane Treatment (1)

2.6.5 Add Left Turn Slip Lane (1)

2.6.6 Unspecified (4)

2.7 Speed Reduction (23)

2.7.1 Channelisation (6)

2.7.2 Speed Camera (including Combined Speed/Red Light Camera) (2)

2.7.3 Reduction of Speed limit on approaches (1)

2.7.4 Kerb Extension (14)

2.8 Other Treatments (31)

2.8.1 Red light camera (2)

2.8.2 Obstruction relocation (4)

2.8.3 Banning movements (2)

2.8.4 Improved skid resistance (11)

2.8.5 Hazard Removal (3)

2.8.6 Improve lighting (7)

2.8.7 Railway Level Crossing Treatments (2)

3. Vulnerable Road User Treatments

Treatments designed specifically to reduce the risk of impacts between motor vehicles and pedestrians or bicyclists are classified as Vulnerable Road User treatments. There were 37 such treatments among the 823 blackspot treatments. These treatments were further classified into one or more of the following categories. The number of treatments in each subcategory is given in brackets.

3.1 New Pedestrian Operated Signals (18)

3.2 Installation of a pedestrian refuge (4)

3.3 Pedestrian fencing (4)

3.4 Installation of Give Way to Pedestrian sign (4)

3.5 Installation of Coloured Walkway (3)

3.6 Reduce Speed Limit (1)

3.7 Other (2)

3.8 Bicycle Lanes (1)

APPENDIX B – DEFINING TREATMENT CATEGORIES FOR THE $85M BLACKSPOT PROGRAM

Newstead and Corben (2001) provided the following list of classifications of the 559 blackspot sites treated under the $85M blackspot program. There were four broad categories of treatment:

1. Intersection treatments;
2. Pedestrian facilities;
3. Route Treatments; and
4. Treatments of Road Features.

Each treated site was classified into only one of the above treatments. After classifying into the four broad treatment categories, each treatment was classified into more specific sub-categories. There were seven treated sites that could not be classified into any of the four broad categories. A list of all treatment categories is shown below. The number of treated sites in each category is shown in brackets.

1.0 Intersection Treatments (308 treatments)

1.1 Roundabout (52)

- 1.1.1 modify existing (5)
- 1.1.2 new (47)

1.2 Grade separation (0)

1.3 Signal remodel (98)

- 1.3.1 fully controlled right turn phase (47)
- 1.3.2 partial right turn phase (3)
- 1.3.3 new signal hardware (1)
- 1.3.4 mast arm (8)
- 1.3.5 signal linking (1)

1.4 New signals (35)

1.5 Rail level crossing treatments (6)

- 1.5.1 boom barriers (2)
- 1.5.2 pedestrian gates (3)
- 1.5.3 flashing lights and signs (1)

1.6 Other intersection improvements (117)

- 1.6.1 street lighting (11)
- 1.6.2 channelisation (15)
- 1.6.3 splitter islands (38)
- 1.6.4 staggered-T treatment (2)
- 1.6.5 signs (5)
- 1.6.6 skid resistant surfacing (9)
- 1.6.7 line marking (3)
- 1.6.8 raised reflective pavement markers (2)
- 1.6.9 kerb extensions (1)
- 1.6.10 five-lane treatments (1)
- 1.6.11 left turn slip lane (6)
- 1.6.12 left turn lane (3)
- 1.6.13 right turn lane (13)

1.6.14 freeway ramp modification (2)

2.0 Pedestrian Facilities (15 treatments)

2.1 new pedestrian operated signals (9)

2.2 remodel pedestrian operated signals (2)

2.3 school crossing warning signals (1)

2.4 relocate crossing (1)

2.5 central median (1)

3.0 Route Treatments (190 treatments)

3.1 Freeway construction (0)

3.2 Public street lighting (6)

3.2.1 new (5)

3.2.2 upgrade existing (1)

3.3 Pavement resealing (3)

3.4 Roadway delineation (56)

3.4.1 median (2)

3.4.2 edge marking (0)

3.4.3 tactile edge marking (40)

3.4.4 curve (9)

3.5 Curve realignment (5)

3.6 Shoulder sealing (101)

3.6.1 S/Seal with Tactile LM (6)

3.6.2 S/Seal with Regular LM (78)

3.6.3 S/Seal, Obs Clr & TLM (0)

3.6.4 S/Seal, Obs Clr & RLM (17)

3.7 Overtaking lanes (13)

3.8 Two lanes upgraded to four lanes (0)

3.9 Pavement widening (6)

4.0 Treatment of Road Features (39 treatments)

4.1 Roadside hazards (22)

4.1.1 pole relocation (2)

4.1.2 frangible poles (5)

4.1.3 hazard removal (7)

4.1.4 energy absorbing protection (e.g. guardrail) (8)

4.2 Bridge hazard/end post treatments (17)

4.2.1 guard rail (14)

4.2.2 hazard delineation (0)

4.2.3 shoulder sealing (1)

4.2.4 bridge widening (1)

4.2.5 culvert widening and flattening (1)

APPENDIX C – ALTERNATIVE METHOD OF CALCULATING CASUALTY MOTORCYCLE CRASH COSTS FOR THE $85M BLACKSPOT PROGRAM

As explained in Section 2.3.2, when evaluating the $85M program using economic measures, the same average costs of casualty motorcycle crashes as those used to assess the $240M program would be used (i.e. those in Table 2.14). This appendix presents estimates of the average costs of a casualty motorcycle crashes if crash distributions from sites treated under the $85M blackspot program were used to calculate separate costs for the $85M program. Tables C.1 and C.2 correspond to Tables 2.13 and 2.14 respectively. It can be seen that when calculating costs using distributions of casualty motorcycle crashes occurring in the before-treatment period of sites treated in the $85M program, the estimated average costs are at most only 11% greater than those presented in Table 2.14.

Table C.1: Casualty crashes by severity in the before treatment periods of sites treated under the $85M blackspot program

Type of Crash	Metro		Rural	
	N	% (p_m)	N	% (p_r)
Fatal Crashes *(i=1)*	16	3.4	26	5.3
Serious but not fatal crashes *(i=2)*	211	44.5	226	46.4
Other Injury Crashes *(i=3)*	247	52.1	235	48.3
All Casualty Crashes	474	100	487	100

Table C.2: Equations used to calculate the average cost of a casualty motorcycle crashes occurring in the before-treatment period of sites treated under the $85M blackspot program

Crash Cost	Crash Location	
	Metro	Rural
VicRoads*	$\left(\sum_{i=1}^{3} p_{mi} CV_{mi}\right) / 100 = \$134{,}365$	$\left(\sum_{i=1}^{3} p_{ri} CV_{ri}\right) / 100 = \$194{,}276$
Austroads†	$\left(\sum_{i=1}^{3} p_{mi} CA_{mi}\right) / 100 = \$231{,}199$	$\left(\sum_{i=1}^{3} p_{ri} CA_{ri}\right) / 100 = \$282{,}822$

* $AU (June 2000) values

† $AU (June 2001) values

APPENDIX D –METHODOLOGY TO CALCULATE THE NUMBER OF INJURIES PREVENTED

Section D.1 describes how the number of fatalities and the number of injuries prevented due to reductions in the number of casualty motorcycle crashes at sites treated under the $240M blackspot program were calculated. The same methodology was used by Scully et al. (2006b) to calculate the number of injuries prevented due to reductions in all types of crashes at treated sites. Section D.2 describes how the same methodology was applied when calculating the number of fatalities and injuries prevented due to reductions in the number of casualty motorcycle crashes at sites treated as part of the $85M blackspot program

D.1 $240M BLACKSPOT PROGRAM

Step 1: Calculate the expected number of motorcycle crashes that should occur (assuming the treatment has no effect) over the project life of the treatment at each site

Assume that

- c_{ij} is the average annual number of motorcycle crashes of severity *i* that occurred in the before treatment period at site *j*, where
    - o $i=1$ for serious casualty motorcycle crashes
    - o $i=2$ for other injury motorcycle crashes
    - o $i=3$ for all casualty motorcycle crashes
- p_j is the project life of site *j*
- $e_{ij} = c_{ij} \times p_j$ is the expected number of motorcycle crashes of severity *i* at site *j*

Step 2: Calculate the crash savings over the project life of the treatment at each site

Assume

- R_i is the estimated reduction for casualty motorcycle crashes of severity *i* at treated sites (see Table 4.1)
- $S_{ij} = e_{ij} \times R_i$ is the number of motorcycle crashes of severity *i* prevented over the life of the project at site *j*

Step 3: Calculate the number of injuries prevented over the life of the project at each site

At this step, the number of injuries prevented is derived from the crash saving at each site (see Step 2) and the average number of injuries per crash. Table D.1 shows the data used to provide estimates of the average number of injuries per crash.

If the site is in the Metro Area:

- $P_{fatal,j} = S_{1j} \times 0.084$ is the number of fatalities prevented over the life of the project at site *j*
- $P_{serious,j} = S_{1j} \times 0.98$ is the number of serious injuries prevented over the life of the project at site *j*
- $P_{other,j} = S_{3j} \times 0.66$ is the number of other injuries prevented over the life of the project at site *j*
- $P_{all,j} = S_{3j} \times 1.11$ is the number of casualties prevented over the life of the project at site *j*

If the site is in a Rural Area:

- $P_{fatal,j} = S_{1j} \times 0.088$ is the number of fatalities prevented over the life of the project at site *j*
- $P_{serious,j} = S_{1j} \times 1.00$ is the number of serious injuries prevented over the life of the project at site *j*
- $P_{other,j} = S_{3j} \times 0.62$ is the number of other injuries prevented over the life of the project at site *j*
- $P_{all,j} = S_{3j} \times 1.17$ is the number of casualties prevented over the life of the project at site *j*

Step 4: Calculate the number of injuries prevented at all sites

- $T_i = \sum_{j=1}^{804} P_{i,j}$ is the total number of injuries of severity *i* prevented over the life of all the treatments where *i=fatal, serious, other* or *all*

Step 3 of the above methodology required estimation of the average number of people killed (or injured) per casualty motorcycle crash (or per serious casualty motorcycle crash). It was decided that when estimating the number of lives saved (i.e. fatalities prevented) over the life of the program, the average number of people killed per serious casualty motorcycle crash in the before-treatment periods at treated sites should be used. Table D.1 shows that at treated sites in the metropolitan area, an average of 0.084 people died per serious casualty motorcycle crash, while an average of 0.088 people died per serious casualty motorcycle crash in rural areas. Similarly, when inferring the number of serious injuries prevented over the life of the program due to reductions in the number of casualty motorcycle crashes at treated sites, the average number of people seriously injured in serious motorcycle casualty crashes should be used. The reason for using these estimates to estimate the number of lives saved and serious injuries prevented is that no fatalities or serious injuries will be prevented in other injury motorcycle crashes, so excluding these crashes from the sample used to derive the estimates provides a more realistic estimate of fatalities and serious injuries prevented.

Table D.1: Number of casualty motorcycle crashes and injuries by crash severity and injury severity occurring in the before treatment periods at sites treated under the $240M blackspot program

	Metro			Rural		
	Crash Severity			Crash Severity		
	Serious	Other	All	Serious	Other	All
Number of crashes	203	280	483	137	132	269
Fatalities	17	0	17	12	0	12
People killed per crash	*0.084*	*0*	*0.035*	*0.088*	*0*	*0.045*
Serious injuries	199	0	199	137	0	137
People seriously injured per crash	*0.98*	*0*	*0.41*	*1.00*	*0*	*0.51*
Other injuries	17	302	319	15	151	166
People non-seriously injured per crash	0.08	1.08	0.66	0.11	1.14	0.62
Total casualties	233	302	535	164	151	315
Casualties per crash	*1.15*	*1.08*	*1.11*	*1.2*	*1.14*	*1.17*

In the case of inferring the number of "other" injuries prevented due to reductions in the number of casualty motorcycle crashes occurring at treated sites over the life of the program, it was decided that the average number of road users receiving other injuries only per casualty motorcycle crash would be used along with the estimated casualty motorcycle crash reduction ($R_3 = 31.2\,\%$). This is because people can be classified as receiving non-serious injuries in crashes of all severities. Excluding serious casualty crashes from the sample used to estimate the number of people receiving other injuries per crash would result in the estimate that does not account for people who received other injuries in serious casualty motorcycle crashes. For the same reasons, when estimating the number of casualties prevented over the life of the program, the estimated crash reduction for all casualty motorcycle crashes ($R_3 = 31.2\,\%$) and the estimates of the number of casualties per casualty motorcycle crash have been used.

Table D.2 shows that, using the methodology described in this appendix, over the life of the program, an estimated 30 lives were saved and 348 serious injuries were prevented due to reductions in the number of motorcycle crashes. Similarly, Table D.2 shows that, reductions in the number of casualty motorcycle crashes would prevent 437 other injuries and 770 casualties of any severity over the life of the program.

Table D.2: Estimates of the number of injuries and crashes prevented over the project life of each treatment for the $240M blackspot program as a whole for all types of crashes and motorcycle crashes only

	Motorcycle Crashes	All Types of Crashes
Crashes saved over treatment life		
- Serious casualty crashes	352	2,587
- All casualty crashes	680	7,655
Injuries prevented over treatment life		
- Fatalities	30	204
- Serious injuries	348	3,116
- Other injuries	437	8,505
- All casualties	770	11,499

D.2 $85M BLACKSPOT PROGRAM

This section begins by describing the methodology used to calculate the number of injuries prevented due to reductions in the number of casualty motorcycle crashes at sites treated under the $85M blackspot program. This is followed by a description of how the number of injuries prevented due to reductions in the casualty crashes involving all types of vehicles was estimated (as this information was not provided in the original analysis by Newstead and Corben, 2001).

Injury prevented due to reductions in casualty motorcycle crashes

The methodology used to calculate the number of injuries prevented due to reductions in the number of casualty motorcycle crashes at sites treated under the $85M blackspot program was the same as that described in Section D.1, with two minor exceptions.

As the casualty crash data used by Newstead and Corben (2001) did not contain information on the number of road users who were injured, seriously injured or injured but not seriously injured for each casualty crash occurring at a treated site, an alternative method was employed to calculate the number of road users injured at Step 3 of the methodology described above. When estimating the number of injuries prevented due to reductions in the number of casualty motorcycle crashes, the injury rates derived from motorcycle crashes occurring in the before-treatment periods of sites treated under the $240M blackspot program were used (see Table D.1).

In order to apply this variation of the methodology previously described, it was necessary to assume that average injury rates (for different levels of severity) for crashes occurring in the before-treatment periods of sites treated as part of the $85M program were the same as those treated as part of the $240M program. Figure D.1 shows the injury rates for occupants involved in serious casualty crashes and casualty crashes have remained fairly stable over time. It can be seen that over the period 1991-2003, the number of casualties per casualty crash remains fairly constant at about 1.4. Similarly, the number of serious injuries per serious casualty crash remains stable at around 1.2. However the number of fatalities per serious casualty crash seems to be getting lower over the 13-year period.

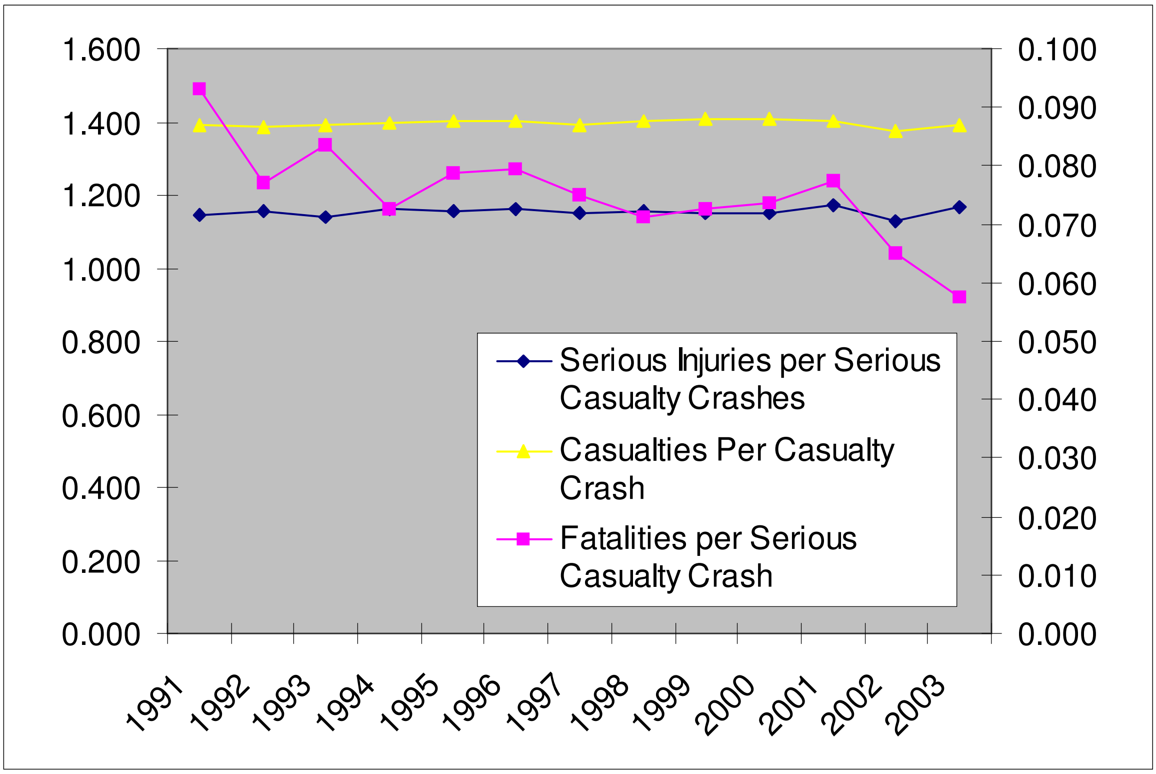

Figure D.1: Occupant injury rates by year for casualty crashes in Victoria (left axis corresponds to serious injuries per serious casualty crashes and casualties per casualty crash; right axis corresponds to fatalities per serious casualty crash)

Table D.4 shows that using this methodology resulted in an estimate of 18 lives saved over the life of the $85M program through the reduction in the number of casualty motorcycle crashes at treated sites, while the estimate for the number of serious injuries prevented by reducing casualty motorcycle crashes was 207.

Injury prevented due to reductions in casualty crashes involving all types of vehicles

Newstead and Corben (2001) did not provide serious casualty crash reduction estimates in their evaluation of the $85M blackspot program. Therefore, at Step 2 of the methodology, it was only possible to calculate the number of casualty crashes prevented over the life of the project at each site. Furthermore, as previously mentioned, the data used by Newstead and Corben (2001) did not contain information on the number of road users that were killed, seriously injured or injured but not seriously injured in a crash. In order to calculate the number of injuries prevented over the life of the program, injury rates per casualty crash for crashes occurring in the before-treatment period at sites treated under the $240M blackspot program were used. Table D.3 shows the average number of people injured, disaggregated by different injury severity levels, for crashes occurring in the before-treatment period of sites treated under the $240M blackspot program. This table is taken from the evaluation of the $240M by Scully et al. (2006b). It can be seen that for casualty crashes occurring at metropolitan sites treated as part of the $240M program, the average number of people killed was 0.015 per crash, while the average number seriously inured was 0.34 per crash. For crashes at treated sites in rural areas, the average number of people killed was 0.042 per crash, while the average number of people seriously injured was 0.41. The average number of people injured, but not seriously was about 1.11 per crash for both metropolitan and rural sites, while the average number of casualties per crash was 1.41 for sites in the metropolitan area and 1.45 for sites in rural areas.

Table D.3: Number of casualty crashes and injuries by crash severity and injury severity in the before treatment periods at sites treated under the $240M blackspot program (from Scully et al., 2006b)

	Metro			Rural		
	Crash Severity			Crash Severity		
	Serious	Other	All	Serious	Other	All
Number of crashes	1,719	4,296	6,015	868	1,659	2,527
Fatalities	92	0	92	105	0	105
People killed per crash	*0.054*	*0*	*0.015*	*0.12*	*0*	*0.042*
Serious injuries	2,075	0	2,075	1,041	0	1,041
People seriously injured per crash	*1.21*	*0*	*0.34*	*1.20*	*0*	*0.41*
Other injuries	627	6,049	6,676	405	2,409	2,814
People non-seriously injured per crash	0.36	1.41	1.11	047	1.45	1.11
Total casualties	2,794	6,049	8,843	1,551	2,409	3,960
Casualties per crash	*1.63*	*1.41*	*1.47*	*1.79*	*1.45*	*1.57*

Once the number of injured road users at each crash site has been estimated in this manner, Step 3 of methodology can be applied to give an estimate of how many cases of injured road users, for different levels of severity, were prevented over the life of the program.

Table D.4: Estimates of the number of injuries and crashes prevented over the project life of each treatment for the $85M blackspot program as a whole for all types of crashes and motorcycle crashes only

	Motorcycle Crashes	All Types of Crashes
Crashes caved over treatment life		
- Serious casualty crashes	209	Not Available
- All casualty crashes	550	7,088
Injuries prevented over treatment life		
- Fatalities	18	169
- Serious injuries	207	2,599
- Other injuries	355	7,875
- All casualties	622	10,642

As before, using this methodology to estimate the number of injuries prevented over the life of the program assumes that injury rates per crash occurring in the before-treatment period of treated sites did not differ for the $240M program and the $85M program.

Table D.4 shows that when using this methodology, an estimated 169 lives would be saved by reducing casualty crashes involving all types of vehicles at treated sites, while the estimate for the number of serious injuries prevented by reducing casualty crashes at treated sites was 2,599.

APPENDIX E – ASSUMPTIONS AND QUALIFICATIONS

In evaluating the effectiveness of the $240M and $85M blackspot programs in preventing casualty motorcycle crashes at treated sites, a number of assumptions were made. These are as follows.

- Descriptions of blackspot treatments provided by VicRoads were accurate with respect to the cost of completing treatments and the dates on which treatment works commenced and were completed. Similarly, the descriptions enabled accurate identification of the location of sites where treatments were implemented. No independent audit was undertaken to verify the information supplied by VicRoads regarding the type of treatments completed or the location of sites.

- Mapping and extraction of crash data at treated sites carried out by VicRoads was accurate.

- Control sites selected for the analysis accurately and fully represented the effects of non-treatment related factors that may affect casualty crash frequency and casualty crash counts in the before or after period at treated sites.

- The form of the statistical models and error structures chosen was the most appropriate for the analysis and provided accurate and unbiased estimates of program effectiveness.

- Statistical analysis presented in this report cannot prove unequivocally that the blackspot treatments led to the attributed crash reductions. It is possible that other unrelated but concurrent events led to the effects observed, although this is considered unlikely considering the analysis design employed.

- Casualty crash costs used in the analysis appropriately reflected the real cost of casualty crashes to the community.

The following qualifications should also be noted

- Evaluations of the effectiveness of individual treatments are not broadly indicative of the effectiveness of these treatments applied at all sites and in all circumstances. In particular, one should be wary of basing conclusions from casualty crash data from a small number of sites. Just because a treatment was not shown to be effective in this evaluation does not mean that the treatment cannot be effectively used to reduce risk at sites not included in this evaluation. The effectiveness of a treatment is determined in part by how and where it is applied.

- The average after-treatment period of time used in the evaluation of the $240M program was 2.8 years, while the minimum after-treatment period of time for the $85M program was 2.5 years. However the reader should be aware that with further accumulated after-treatment experience, the estimated crash effects at treated sites could change.