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Evaluation of the Motorcycle Blackspot Program

Project No: 010074

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for VicRoads

July 2015

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Q25-6510

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010074-1
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EVALUATION OF THE MOTORCYCLE BLACKSPOT PROGRAM

July 2015

SUMMARY

Background

Victoria collects a Motorcycle Safety Levy from all registered motorcycles from which funds are directed into a Motorcycle Blackspot Program (MBP) that provides treatments to improve motorcycle safety at locations throughout the state with a history of motorcycle crashes. VicRoads commissioned ARRB to conduct an evaluation of the MBP in terms of its crash reduction effects and the associated economic returns.

Data and Method

Data were received for 176 treatments, made up as follows: 9 barrier protection treatments, 4 intersection treatments, 61 long route treatments, 92 loss-of-control treatments, 4 roundabout trial treatments and 6 variable message sign trial treatments. Crash records were matched to sites using the ArcView GIS software. A quasi-experimental design was followed, with road sections adjacent to the treatment sites adopted as the control sites, except in the case of the long route treatments where other routes which were broadly similar to the treatment routes were used.

Crash Reduction Effects

The crash reductions and their significance were estimated by fitting a mixed generalised linear negative binomial model with sites nested within sub-programs. This procedure takes into account changes in the number of crashes at the control sites, an essential step since there was an upward but fluctuating trend in motorcycle travel over the life of the program. Statistically significant crash reductions were found for the program overall with an estimated 27% reduction in casualty crashes and an estimated 31% reduction in fatality and serious injury crashes after adjustment for changes at the control sites.

When the different treatment types were considered separately, there were substantial crash reductions although only one of these was statistically significant. This was the barrier protection treatment, which produced a highly significant reduction of 74% in FSI crashes.

Results for the other treatments were highly variable from site to site; results were not statistically significant, but the FSI crash reductions were substantial in the case of the long route and loss-of-control sites, 29% and 42% respectively, while the intersection sites showed a 69% reduction although the numbers were much smaller.

More detailed examination of the crash data showed that the types of crash which had reduced corresponded with what would be expected given the nature of the countermeasures. There was no evidence of a crash migration effect. Best performing sites were identified and discussed.

Economic Evaluation

The cost of the program was $32 million. Considered from the point of view of all motorcycle casualty crashes, the program has reduced all casualty crashes by 27%, which is statistically highly significant. Considered in these terms, the BCR ranges from 7.6 to 6.3 and the NPV ranges from $211 million to $170 million, depending on the discount rate adopted.

Considered from the point of view of motorcycle FSI crashes, the program has reduced FSI crashes by 31%, which again is statistically highly significant. Considered in these terms, the BCR ranges from 8.5 to 7.1 and the NPV ranges from $240 million to $195 million, depending on the discount rate adopted.

The average cost of preventing an FSI motorcycle crash was estimated at almost $80 000.

Conclusions

The main conclusions of the study were:

1. The program has been successful in reducing motorcycle casualty crashes (by 27%) and FSI crashes (by 31%), both these reductions being statistically highly significant.
2. The program also showed good economic returns.
3. The barrier protection program has been particularly effective in reducing FSI crashes (by 74%), and shows the best economic returns.
4. The long route treatments and the loss-of-control treatments have both been successful in reducing crashes and show good economic returns. In both cases, sufficient numbers of sites have received the treatments to allow confidence in the results.
5. The intersection treatments also showed good reductions in motorcycle crashes, but the number of sites is small; trials at more sites are needed before full confidence can be placed in it.

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1 INTRODUCTION

1.1 The Issue

Motorcycle crashes are a serious issue for the Australian community. A report for Austroads (Cairney 2010) estimated that the fatality and serious injury rate for motorcyclists was approximately 30 times greater for motorcyclists than car drivers. Given these high rates, the report went on to identify growth in motorcycling as a development that had the potential to derail casualty targets in national and state road safety strategies, with even a small percentage of car drivers switching to motorcycles having potentially drastic consequences.

Victoria collects a Motorcycle Safety Levy from all registered motorcycles from which a portion of funds is directed into a Motorcycle Blackspot Program (MBP) which funds treatments to improve motorcycle safety at locations throughout the state with a history of motorcycle crashes. Due to the relatively small number of motorcycle crashes, the criteria are different from the normal general blackspot program. According to the brief, since the program commenced in 2003, approximately 170 projects have been completed, divided into three main components:

- blackspot projects, focussing on individual locations with adverse motorcycle crash histories, e.g. individual curves or intersections
- blacklength projects, also based on adverse motorcycle crash histories, which extend beyond a single location but are of limited extent
- long route projects, which are pro-active projects intended to improve the consistency of road conditions, guidance and delineation along routes carrying large numbers of motorcycles.

Given the high risk associated with motorcycle travel, a robust understanding of the crash reduction effects of the MBP is a high priority.

The key questions for the present evaluation were:

- What were the changes in the number and severity of motorcycle crashes following the roll-out of the MBP?
- What were the economic benefits of the MBP?
- How effective were each of the different sub-programs?
- What were the main factors associated with crash reductions, and which treatments performed best?

1.2 Previous Evaluation

An evaluation of the MBP was carried out by the Monash University Accident Research Centre (MUARC) which considered all treatments completed up to the end of 2007 (Scully, Newstead & Corben 2008). The first 91 projects completed under the program were included in the evaluation, made up of 54 blacklength treatments, 30 long route treatments and one intersection treatment, widely dispersed across the state.

The changes in both serious casualty crashes and all casualty crashes were considered. Crashes occurring in the six years before the installation of the treatment were compared with crashes after installation of the treatments; the after period varied from project to project, with a maximum of approximately four years and a minimum of less than a year. The percent reduction in crashes was estimated by comparing crashes at sites with other motorcycle crashes occurring in the area covered by the same postcode over the same before and after periods. In line with other recent evaluations of blackspot programs addressing crashes involving all types of vehicles, Poisson regression was used to test whether these reductions were significant.

Blacklength treatments reduced casualty crashes by a statistically significant 40%, and serious casualty crashes by a statistically significant 43%. At the long route treatments sites, both casualty crashes and serious casualty crashes increased by 13% and 18% respectively, but neither increase was statistically significant. At the sole intersection treatment site, casualty crashes fell by 51% and serious casualty crashes fell by 34%, but with the relatively small number of crashes involved these large percentage reductions were not statistically significant.

Overall, the MBP was associated with a 24% reduction in casualty crashes, which was statistically significant, and a 16% reduction in serious casualty crashes, which was not.

The cost of these programs was $5.8 million. The value of the crashes saved over the life of the program, including those not involving motorcycles and adjusted for discounting, was estimated to be $84.5 million. The estimated benefit-cost ratio was 15:1.

The cost associated with preventing a casualty crash involving a motorcycle was approximately $19 000, well below the average cost of a casualty crash.

Both the blacklength treatments and the long route treatments involved a package of measures that varied according to the characteristics and crash history of the individual sites. Blacklength treatments were intended to remedy safety deficiencies that affected motorcycles at the sites. They included removal of roadside hazards, resurfacing, shoulder sealing, hazard removal, line marking and raised reflective pavement marker (RRPM) installation, warning signs and advisory speed plates, chevron alignment markers (CAMs) and guideposts, and clearing the road surface of debris. The objective of long route treatments was to provide a more consistent environment along the route so that riding would be more predictable and riders would be less likely to be surprised by changing road conditions. The treatments included installing CAMs, warning signs and advisory speed plates, consistently-placed frangible guideposts, line marking over the entire length of the road, and re-evaluation of advisory speeds on curves.

Since all treatments depended on a combination of elements that varied from site to site, it was not possible to estimate the effectiveness of these individual elements. For example, while it was possible to estimate the effectiveness of the blacklength treatment program, it was not possible to estimate the independent effects of resurfacing, CAMs, or any of the other treatment elements. The same applied to the other treatments that relied on a combination of elements that varied from site to site, i.e. the long route, intersection and roundabout programs.

With more than ten years' experience of the program available, there is now the opportunity to subject the program to a more rigorous evaluation.

1.3 The Motorcycle Blackspot Program

The purpose of the MBP is to make changes to the road and roadside environment that improve road safety for motorcyclists in Victoria. There have been refinements and additions to the structure of the program since the initial evaluation by Scully et al. (2008). It still has three main components, but the first of these has been separated into two categories:

- blackspot/blacklength treatments, focussing on loss-of-control crashes; this is made up of two different types of treatments
  - barrier protection

  - loss of control
- intersection treatments
- long route treatments.

In addition, there are two different types of innovative treatments being trialled:

- roundabout treatments trial
- variable message signs (VMS) trial.

The projects included in the MBP have been selected on the basis of the site's history of motorcycle crashes and the crash reduction benefits expected from the proposed treatments. The treatments are tailored to address the problems experienced by motorcyclists.

For blackspot/blacklength and intersection treatments, the proposed treatments are identified through a detailed crash analysis and an on-road review of the deficiencies that have contributed to the crashes or the severity of their outcomes. A different approach is adopted for long route projects which aim to provide a more predictable riding environment by ensuring consistency in road conditions, delineation and warnings along the entire length of the route.

The innovative treatments – roundabout treatments and VMS – are intended to test the effectiveness of new solutions that may be of benefit in reducing the incidence and severity of motorcycle crashes.

VicRoads provided details of the following treatments for the analysis:

- 9 barrier protection treatments
- 4 intersection treatments
- 61 long route treatments
- 92 loss of control treatments
- 4 roundabout trial treatments
- 6 VMS trial treatments.

This totals 176 treatments.

1.4 Motorcycle Travel and Methodological Challenges

There are a number of methodological challenges that need to be addressed in order to answer the questions posed in Section 1.1.

1.4.1 Fluctuating Motorcycle Use

The years over which the MBP has run and those preceding it has been a period of considerable but uneven growth in motorcycling. Successive Australian Bureau of Statistics (ABS) Surveys of Motor Vehicle Use (SMVUs) across Australia show strong growth in vehicle kilometres travelled (VKT) between 2005 and 2010 and a considerable fall thereafter (Table 1.1) (ABS 2013). This points to the need for extreme care in interpreting changes in the numbers of motorcycle crashes and the risks of misestimating the benefits of the program. For example, if motorcycle travel reduces, crash reductions due to less travel could be wrongly attributed to the program. Conversely, if motorcycle travel increases, the full extent of crash reductions due to the program may not be recognised.

Careful design of the comparison procedure can do much to eliminate this source of bias. The present study has followed a quasi-experimental approach. Lengths of road adjacent to the treatment sites were selected as control sites, which ensured that the control sites and the treatment sites were ridden over by the same riders and that the machines, trip purposes, traffic and policing levels were the same.

Table 1.1: Motorcycle travel in Australia from successive SMVUs, 2005–12

Year	Passenger vehicle VKT	% increase in successive surveys	Motorcycle VKT	% increase in successive surveys
2005	155 068	na	1 429	
2007	156 184	0.7	1 641	14.8
2010	163 360	4.6	2 394	45.9
2012	167 456	2.5	1 882	–21.4

Source: (ABS 9208.0 2013).

1.4.2 Regression to the Mean

Another possible issue is the phenomenon of regression to the mean. It is generally assumed (and borne out by experience) that sites have an underlying crash risk that arises from factors such as their geometry, cross-section, signing and line marking; however, the circumstances that actually generate a crash vary in a random fashion, such as vehicle speed, lateral position, rider attention, appreciation of the situation, or presence of other traffic. As a result, crash numbers will fluctuate randomly; over some periods, they will be lower than could be expected given the nature of the site; at other times, they will be higher. In both cases, over time, the crashes can be expected to return to the usual range for that particular site. There is a risk that, if sites are selected for treatment on the basis of high crash numbers alone, the regression to the mean effect will be included in any estimate of the crash reduction effects of the treatment.

In the case of the present study, the VicRoads selection process has some safeguards against the selection of sites solely on the basis of aberrant high crash numbers. Five years' crash history is considered in identifying candidate sites for treatment, and the suitability of some classes of site is also assessed by an inspection by an experienced rider who considers the site from the rider's point of view and identifies motorcycle-specific safety deficiencies (VicRoads, no date). These steps would tend to direct the program towards sites with underlying problems rather than sites which had large numbers of crashes due to chance variation.

In the study itself, the before period was the five years before treatment installation at each site, and the after treatment was the five years after installation. This follows Nicholson's (1986) finding that the accuracy of crash rate estimates increases as the length of pre-treatment period is increased steadily up to a period of five years, but shows a much diminished rate of improvement beyond that period. In a few cases, the after data was a few months short of the five full years. An adjustment was made in the statistical model to allow for this.

1.4.3 Crash Migration

Crash migration refers to the possibility that, while a road-based treatment may reduce crashes at the treated site, more crashes occur elsewhere on the network as a result. Scully et al. (2008) make the case that crash migration is unlikely with the MBP for two reasons. First, crash migration generally occurs as a result of the treatment restricting or slowing traffic, so that it is diverted elsewhere and, as a result, crashes increase at these other sites. Second, VicRoads was of the opinion that the nature of the treatments was such that crash migration was unlikely.

Treatments such as improved guidance, better road surfaces and the removal of loose material or roadside objects would be likely to make the treated routes more attractive to motorcyclists so that motorcycle travel at the sites would be likely to increase. The way in which control sites have been selected in this study as adjacent sections of the same road as the treatment site ensures that any changes in travel as a result of the treatments or other factors are taken account of.

1.4.4 Consistency of Crash Reporting

VicRoads advised that there had been a change to crash reporting procedures in the period 2005-06 and that this gave rise to concern about the consistency of the data. However, a consistency check found no cause for concern (Section 2.3.3).

2 METHOD

2.1 Terms Used in the Report

The main terms used throughout this report are as follows:

Casualty crash:	A crash that was reported to police and involved a road user being injured.
Fatal and serious injury (FSI) crash:	A casualty crash in which the most seriously injured road user, as a result of the crash, either died within 30 days or was transported to or admitted to hospital.
Other injury crash:	A casualty crash in which the most seriously injured road user was not killed, transported to hospital or admitted to hospital.
Treatment:	A class of measures to address a particular type of motorcycle crash, e.g. long route, loss of control. The specifics of the treatment vary from site to site, involving different treatment elements according to the nature of the crash problem and the characteristics of the site.
Treatment site:	A site selected for treatment under the MBP because of its history of motorcycle crashes.
Control site:	A site selected to be comparable to the treatment site but at which no treatment is applied during the life of the program.
Treatment element:	A type of traffic control device which is used in combination with others to create a treatment, e.g. guide posts, line marking, signing or resurfacing.

2.2 Selection of Treatment Crashes

The data received from VicRoads consisted of a list of treatment locations and a set of motorcycle records, both data sets including GIS coordinates. A spatial join was applied using the ArcGIS software to identify the closest treatment site to each crash. All crashes greater than 50 m from a treatment site were removed.

The relevant crash records were then exported to Microsoft Excel and a query was written to check if the road name in the crash data matched the road name in the treated sites. All crash records between 25 and 50 m with non-matching road names were removed from the data set. The remaining crash records were then reviewed one by one to remove any aberrant results, e.g. mid-block DCA code for intersection treatment. Finally, any duplicate crash records were removed.

This identified the entire set of crashes occurring at the treatment sites. The before and after periods were defined by the treatment completion date at each site. The data set produced by this step in the method therefore includes crashes that were not included in the analysis, as well as crashes in the before and after periods. In most cases the control and after periods were 5 years before installation and 5 years after installation, but in those few cases where the installation had been completed less than 5 years before the end of the study period, the after period was shorter.

2.3 Selection of Control Sites and Crashes

2.3.1 General Approach

The initial approach for all treatment classes apart from the long routes category was to select motorcycle crashes occurring on the same road for 5 km either end of the treatment site, or where that road ended if it joined another road, and which occurred during the periods equivalent to the before and after periods for the treatment site. As was the case with the treatment sites, in most cases this was 5 years before installation and 5 years after installation, but in those cases where the installation had been completed less than 5 years before the end of the study period, the after period was shorter. This provided a reasonable balance of crashes between treatment and control groups for the barrier treatment groups, but for the other categories produced far too many control crashes. More appropriate numbers of control crashes were achieved by selecting shorter control lengths for the other types of treatment, 0.5 km in the case of intersection crashes and 1.0 km in the other cases. This produced a reasonable balance of control crashes in the before period for all treatments.

2.3.2 Long Route Sites

Because the long route treatment sites extended over long stretches of road, the method for selecting control sites described in Section 2.3.1 was not feasible. Instead, a number of control routes were selected. These were lengths of the declared road network, selected on the basis of VicRoads' and the ARRB team's local knowledge, which ran through generally similar terrain as did the long routes. A difficulty was that the majority of the popular motorcycling routes had already been included as treatment sites, so it was not possible to find sites with as many motorcycle crashes as the treatment sites. The list of long route control sites is shown in Appendix A.

2.3.3 Consistency Check

The brief advised that there was a potential issue with the consistency of the crash data as there had been a change in reporting procedures at the end of 2005 and which may have affected the crash data from 2006 onwards. The possibility of substantial changes in the reporting system was examined by comparing the ratio of other injury crashes to FSI crashes throughout the study period, separately for the treatment and control sites (Table 2.1). Three points should be noted. First, the ratio of FSI to other injuries is higher at the treatment sites than at the control sites, taken over the entire study period. The higher ratio of FSI to other injury crashes is not unexpected, given that the treatment sites have been selected on the basis of an adverse crash record. Second, the ratio fluctuates considerably over the period, ranging between 0.56 and 1.22 at the control sites and between 0.75 and 2.13 at the treatment sites. Third, the ratios are elevated in 2007 and 2008 at the control sites and in the period 2006–10 at the treatment sites, before returning to lower levels. Although the periods do not exactly coincide, the periods when the ratios are at their highest overlap indicated by the shaded cells in Table 2.1.

Since both treatment and control sites were subject to similar fluctuations at about the same time, it was decided that any process of adjusting the data to make allowance for these fluctuation was unlikely to be helpful, and hence no adjustments were made.

Table 2.1: Ratio of FSI crashes to other injury crashes at control and treatment sites for entire study period

	Control			Treatment		
Year	FSI	Other injury	FSI/other	FSI	Other injury	FSI/other
1998	69	81	0.85	72	76	0.95
1999	75	103	0.73	70	73	0.96
2000	80	101	0.79	90	94	0.96
2001	75	102	0.74	101	89	1.13
2002	57	102	0.56	116	90	1.29
2003	64	85	0.75	94	89	1.06
2004	68	89	0.76	81	77	1.05
2005	61	90	0.68	89	101	0.88
2006	69	91	0.76	97	64	1.52
2007	90	77	1.17	121	88	1.38
2008	105	86	1.22	101	50	2.02
2009	79	89	0.89	113	53	2.13
2010	62	103	0.60	92	63	1.46
2011	68	106	0.64	62	83	0.75
2012	77	97	0.79	87	71	1.23
2013	68	99	0.69	99	75	1.32
2014	48	44	1.09	49	39	1.26
Total	1215	1545	0.79	1534	1275	1.20

Note: Crashes in this table include those occurring outside the analysis period for their particular site, as well as those occurring in the designated before and after periods.

2.4 Statistical Analysis

A mixed generalised linear model analysis was used to compare the number of casualty crashes before and after the crash reduction program for each of the sub-programs and for the program as a whole. In these analyses a negative binomial distribution was assumed in order to allow for the high variance in casualty crash counts between sites.

2.5 Economic Analysis

Benefit-cost analysis (BCA) identifies and expresses benefits and costs of any given countermeasure in monetary values and provides a single value indicating whether a project is worthwhile. When the value of benefits exceeds costs, the project is considered as beneficial.

The main summary measures of BCAs are the net present value (NPV) and benefit-cost ratio (BCR). The NPV provides information on the total benefits over a project's life while the BCR shows the relationship between the benefits of the project and the cost of implementing it (PIARC 2012).

The method used for economic analysis followed that laid out by the Australian Transport Council (ATC 2006).

The NPV is the difference between the discounted (present value) monetary value of all the benefits and costs of a particular project or measure, summed over the life of the project. A positive NPV indicates an improvement in economic efficiency compared with the base case. The NPV is calculated as follows.

$$NPV = \sum_{t=0}^{n} \frac{B_t - IC_t}{(1+r)^t}$$

where

t = time in years

n = number of years during which benefits and costs occur

B_t = benefits in year t

IC_t = implementation costs in year t

r = discount rate

Source: Adapted from ATC (2006).

The BCR is defined as the present value of benefits (net operating and maintenance costs) divided by the present value of implementation costs. The method for calculation is as follows:

$$BCR = \frac{PV(B)}{PV(IC)}$$

where

PV = present value

B = all benefits

IC = treatment implementation costs

Source: Adapted from ATC (2006).

3 RESULTS

3.1 Effects of the Program and its Treatment Types

3.1.1 Casualty Crash Reductions

A mixed generalised linear model analysis was used to compare the number of casualty crashes before and after the crash reduction program for each of the sub-programs and for the program as a whole. In these analyses a negative binomial distribution was assumed in order to allow for the high variance in casualty crash counts between sites.

The shaded portion of Table 3.1 shows the numbers of casualty crashes summed over all the locations in each sub-program category before and after installation, separately for treatment and control sites. It also shows the percentage reduction in crashes during the after period (note that a minus sign in front of the percentage indicates an increase).

Table 3.1 shows that there was a 25% decline in casualty crashes for the barrier protection sub-program, a 54% decline for the intersection sub-program, a 27% decline for the long route sub-program, and a 35% decline for the loss-of-control sub-program. There were increases for the roundabout and VAS programs, but in these cases the numbers were small. Overall the program was associated with a 29% reduction in casualty crashes.

For the control sites, there was a 37% increase in casualty crashes for the barrier protection sub-program, a 6% increase for the intersection sub-program, a 19% increase for the long route sub-program, and a 3% increase for the loss-of-control sub-program. However, small declines were seen for the control sites for the roundabout and VAS sub-programs. Overall the control sites showed an increase in the number of casualty crashes of 5% as opposed to the 22% decline for the treatment sites.

The adjusted crash reductions, taking into account the changes at the control site, are shown in the last column of Table 3.1. Adjusting for the changes in casualty crash frequencies at control sites, the overall percentage casualty crash reduction as a result of the program is estimated to be 27% (=100(1-exp(-.317))).

3.1.2 FSI Crash Reductions

A mixed generalised linear model analysis was used to compare the number of fatal and serious crashes before and after the crash reduction program for each of the sub-programs and for the program as a whole. In these analyses a negative binomial distribution was assumed in order to allow for the high variance in fatal and serious crash counts between sites. Only one site was involved for the VAS treatment so there was no random factor for this analysis, making a Wald Chi-Squared test appropriate in this case, but again assuming a negative binomial distribution for the crash counts.

The shaded portion of Table 3.2 shows the numbers of FSI crashes summed over all the locations in each sub-program category before and after installation, separately for treatment and control sites. It also shows the percentage reduction in FSI crashes during the after period (note that a minus sign in front of the percentage indicates an increase).

Table 3.2 shows a 50% decline in FSI crashes for the barrier protection sub-program, a 78% decline for the intersection sub-program, a 31% decline for the long route sub-program, a 40% decline for the loss of control sub-program, and increases for the roundabout sub-program and the

VAS sub-program, although the numbers of crashes in these cases are small. Overall, the program was associated with a 33% reduction in fatal and serious crashes.

Table 3.1: Casualty crashes

	Treatment			Control (*)			Statistic	Significance	Estimated adjusted crash reduction
	Before	After	%reduction	Before	After	%reduction#			
Barrier protection	12	9	25	35	48	–37	F(1,44) = 2.342	.133	26%
Intersection	13	6	54	64	68	-6	F(1,12) = .740	.407	49%
Long route	655	478	27	84	100	–19	F(1,160) = .499	.481	32%
Loss of control	292	189	35	609	630	–3	F(1,295) = .741	.390	33%
Roundabout***	3	8	–167	13	10	30	F(1,15) = 3.587	.078	No reduction
VAS	10	11	–10	13	6	54	F(1,16) = .177	.680	No reduction
Program as a whole**	985	701	29	818	802	5	F(1,520) = 59.86	< .001	27%

* sites matched for all sub-programs except Long Route.

** nesting within subprograms and sites.

*** treat results with caution due to small numbers.

minus sign indicates an increase in crashes.

Table 3.2: Fatal and serious crashes

	Treatment			Control (*)			Statistic	Significance	Estimated adjusted crash reduction
	Before	After	%reduction	Before	After	%reduction#			
Barrier protection	8	4	50	11	25	127	F(1,44) = 26.42	<.001	74%
Intersection	9	2	78	35	25	4	F(1,12) = 1.941	.189	69%
Long route	380	262	31	53	55	12	F(1,160) = .415	.520	29%
Loss of control	153	92	40	240	269	–29	F(1,296) = 1.397	.238	42%
Roundabout	3	5	–67	6	5	17	F(1,15) = .016	.901	–3%
VAS	3	6	–100	6	3	50	F(1,16) = .450	.512	No reduction
Program as a whole **	556	371	33	371	385	–10	F(1,520) = 44.82	< .001	31%

* sites matched for all sub-programs except Long Route.

** nesting within subprograms and sites.

minus sign indicates an increase in crashes.

Table 3.2 shows for the control sites a 127% increase in fatal and serious crashes for the barrier protection sub-program, a 4% increase for the long route sub-program, a 12% increase for the loss-of-control sub-program, a decrease of 29% for the intersections sub-program. There were also decreases for the VAS and Roundabout sub-programs, but the numbers were small. Overall the control sites showed an increase in the number of fatal and serious crashes of 10% as opposed to the 29% decline for the treatment sites.

The adjusted crash reductions, taking into account the changes at the control site, are shown in the last column of Table 3.2. Adjusting for the changes in casualty crash frequencies at control sites, the overall percentage casualty crash reduction as a result of the program is estimated to be 31% (=100(1-exp(-.371))).

3.1.3 Assessment of the Program Overall

Overall, the program has been a success with an estimated 27% reduction in casualty crashes and an estimated 31% reduction in fatal and serious injury crashes after adjustment for changes at the control sites. These estimates were obtained by fitting a mixed generalised linear negative binomial model with sites nested within sub-programs.

Although the roundabout and variable message sign (VAS) sub-programs were not a success, improvements have been substantial for the long route, intersection, barrier protection and loss-of-control sites, although not always significant because of the variability in the data. However, the overall program improvements are highly significant ($p < 0.001$), whether considered in terms of motorcycle FSI crashes or all motorcycle casualty crashes.

3.2 Crash Reductions at Different Treatments

3.2.1 Crash Reductions at Treatment Sites

An examination was undertaken of the changes in the distribution of crash types at the treatment sites, before and after installation of the treatments. The purpose of this examination was to determine how effective the treatments had been in reducing the particular types of crash they were designed to reduce.

Each treatment was considered separately. Only DCA codes which had 10 crashes or more in the before period were considered. The analysis was conducted in terms of casualty crashes to generate sufficient numbers.

Inspection of the results showed that only at the long route treatment sites and the loss-of-control sites were there sufficient clusters of crashes to support this approach.

The most frequent crash types at the long route treatment sites, before and after installation, are shown in Table 3.3, along with the percentage reduction achieved. Substantial reductions were achieved in head-on crashes (DCA 120), and in all the DCAs indicating leaving the road or losing control on a curve (DCAs 180, 181, 182, 183 and 184). Since these are the types of event the long route treatment was designed to address, these results suggest the treatments are well targeted.

There was also success in reducing right-through crashes (DCA 121) and collisions with animals (DCA 167), results which are consistent with reduced speeds.

Offsetting these gains there was a slight increase in rear-end crashes, and a more substantial increase in out-of-control on carriageway on straight crashes. However, these increases are insignificant compared to the crash reductions in the other categories.

Table 3.3: Reductions in most frequent types of motorcycle casualty crashes at long route sites

DCA	Description	N before	N after	% reduction
120	Head-on	62	44	29
121	Right through	17	6	65
130	Rear end	12	13	–8
167	Animal (not ridden)	26	18	31
170	Off carriageway to left	13	6	54
174	Out of control on carriageway on straight	36	48	–33
180	Off carriageway right bend	86	48	44
181	Off right bend into object	90	61	32
182	Out of control on carriageway – off right bend into object	64	29	55
183	Off left bend into object	62	35	44
184	Out of control on carriageway – on curve	76	73	4

A generally similar pattern was observed at the loss-of-control sites. There were substantial reductions in head-on crashes and right-through crashes (DCAs 120 and 121), although the numbers are small in the latter case. All the DCAs indicating leaving the road or losing control on a curve (DCAs 180, 181, 182, 183 and 184) showed moderate to large reductions. One difference with the long route treatments is that in this case, the out-of-control on carriageway on straight category was also reduced (DCA 174). Once more, these results suggest that the program has been well-targeted.

Table 3.4: Reductions in most frequent types of motorcycle casualty crashes at loss-of control-sites

DCA	Description	N before	N after	% reduction
120	Head-on	40	27	33
121	Right through	10	3	70
174	Out of control on carriageway	44	29	34
180	Off left bend into object	28	18	36
181	Off right bend into object	36	19	47
182	Right off carriageway on straight and into object	27	9	67
183	Off carriageway left bend	29	20	31
184	Out of control on carriageway	31	21	32

3.2.2 Check for Crash Migration Effects

The possibility of crash migration effects was mentioned in Section 1.4.3 , although it was discounted as being unlikely due to the nature of the treatments and the design of the analysis. As a check that this did not in fact occur, the crash data from the control sites for the loss-of-control treatments was examined to determine if there was any discernible increase in the types of crash that might be expected to increase if riders engaged in compensatory high-risk behaviours once they exited the treatment sites, for example by increasing speed or engaging in more violent manoeuvres.

Table 3.5: Changes in most frequent types of motorcycle casualty crashes at control sites for loss-of-control treatments

DCA	Description	N before	N after	% reduction
110	Cross traffic	17	27	–59
113	Right near	16	28	–75
121	Right through	92	66	28
130	Rear end	37	47	–27
134	Lane change right	10	18	–80
135	Right off carriageway on straight and into object	18	28	–56
136	Right turn side swipe	18	3	83
137	Left turn side swipe	20	12	40
140	U-turn	36	18	50
163	Vehicle door	13	9	31
166	Struck object on carriageway	17	11	35
170	Off carriageway to left	11	10	9
171	Straight, off carriageway to left and into object	10	8	20
174	Out of control on carriageway	120	116	3
184	Out of control on carriageway	19	12	37

The opportunity to conduct this check is confined to the control sites for the loss-of-control sections. For the long route treatments, the control sites are geographically remote from the treatment sites, so there is no opportunity for compensatory riding behaviour. For the other treatments, there are no clusters of DCAs that would be suitable for this type of analysis.

Inspection of the data shows that most of the frequent crash types at the control sites for the loss of control treatments involved interactions with other traffic, and the results are mixed with some DCAs increasing and others decreasing. It is noticeable that head-on crashes, which were such a feature at the loss-of-control treatment sites, were not evident either before or after installation.

Four DCA categories related to loss of control or running off the road. The most frequent category (DCA 171) changed little and showed a slight reduction, and the other three categories (DCAs 170, 171 and 184) also showed varying degrees of reductions. There is therefore no suggestion of a crash migration effect from the examination of the crash data.

3.3 Economic Analysis

3.3.1 Inputs to the Economic Evaluation

A benefit-cost analysis (BCA) was conducted for casualty crashes and FSI crashes for the whole program and the individual treatment types at 5%, 6% and 8% discount rates. Section 3.1.1 indicated a reduction of 27% for casualty crashes and Section 3.1.2 indicated a reduction of 31% for FSI crashes. These values were used in the economic evaluation.

The unit crash costs used to estimate the safety benefits were the standard VicRoads values. The key feature of these crash costs is that they vary according to crash severity, and according to the speed zone in which the crash occurs, as shown in Table 3.6.

Table 3.6: Crash costs used in the analysis

Speed zone (km/h)	Fatal injury crash ($)	Serious injury crash ($)	Other injury crash ($)
< 50	2 573 000	526 700	21 670
50	2 397 000	552 200	22 390
60	2 493 000	573 500	23 330
70	2 527 000	603 800	24 560
80	2 661 000	618 200	24 880
100	2 815 000	619 300	24 310
110	2 670 000	657 600	25 420

Source: VicRoads.

The treatments consisted of different combinations of elements such as guide posts, reflectors, resurfacing, frangible signs, and line marking, according to the problem identified at the site and an assessment of what was required to remedy the situation. VicRoads provided an estimated life of the treatment at each site which was based on the life of the most durable elements at the site. Expected life ranged from 2 to 20 years. For each treatment, the treatment life was averaged across all sites and used in the economic evaluation.

The final installation costs were used as the project costs in the evaluation. Table 3.7 gives an overview of the key inputs to the economic evaluation, the average project life, the number of sites and the final cost of all treatments at each group of sites. These values are also estimated for the program as a whole.

Table 3.7: Average project life, number of sites and final cost of treatments in the MBP

Treatment	Average project life	Number of sites	Final cost ($)
Barrier protection	20	9	342 486
Intersection	18	4	521 006
Long route	16	61	19 287 632
Loss of control	12	92	11 375 173
Roundabout trial	16	4	84 735
Vehicle activated sign (VAS)	15	6	346 013
Whole program	14	176	31 957 045

Headline results are reported for 5% and 8% discount rates and the average project life for the whole program and each treatment. Since there were no crash reductions at the roundabout and VAS sites, they were clearly did not deliver economic benefits through crash savings. Economic anlayes were not therefore carried out for these treatments. However, their costs are included in the analyses for the program as a whole.

3.3.2 Evaluation in Terms of Casualty Crashes

The whole program performed with a benefit-cost ratio (BCR) of 7.6 at a 5% discount rate and 6.3 at an 8% discount rate. The net present value (NPV) for the proram as a whole was between $210 763 647 and $170 196 657, depending on the discount rate.

At the treatment level, all treatment types performed well with BCRs ranging between 5.6 and 13.7 at a 5% discount rate and between 4.7 and 10.8 at an 8% discount rate. The net present value at a 5% discount rate ranged from $2 796 035 for intersection treatments to $155 538 891for long route treatments and from $2 138 363 to $123 495 815 at a 8% discount rate as shown in Table 3.8.

Table 3.8: NPVs and BCRs for the different treatments with varying discount rates when the analysis is conducted in terms of casualty crashes

	Net present value ($)			Benefit-cost ratio		
Discount rate	**5%**	**6%**	**8%**	**5%**	**6%**	**8%**
Overall	210 763 647	195 961 611	170 196 657	7.6	7.1	6.3
Barrier protection*	4 340 154	3 967 304	3 346 655	13.7	12.6	10.8
Intersection**	2 796 035	2 551 438	2 138 363	6.4	5.9	5.1
Long route	155 538 891	143 732 861	123 495 815	9.1	8.5	7.4
Loss of control	52 124 064	48 689 430	42 615 758	5.6	5.3	4.7

* less than 10 sites, ** less than 5 sites.

3.3.3 Evaluation in Terms of FSI Crashes

Using FSI crashes, the whole program also performed well with a BCR of 8.5 at a 5% discount rate and 7.1 at an 8% discount rate. For the different treatment types, the BCR ranged from 7.2 for intersections to 15.5 for barrier protection sites at a 5% discount rate and between 5.8 and 12.2 for the same treatments at an 8% discount rate. The net present values ranged from $3 219 814 to $176 971 625 at a 5% discount rate and from $2 478 120 to $141 000 250 at an 8% discount rate as Table 3.9 shows.

Table 3.9: NPVs and BCRs for the different treatments with varying discount rates when the analysis is conducted in terms of FSI crashes

	Net present value			Benefit cost ratio		
Discount rate	**5%**	**6%**	**8%**	**5%**	**6%**	**8%**
Overall	240 357 220	223 750 454	194 844 124	8.5	8.0	7.1
Barrier protection*	4 957 864	4 535 830	3 833 308	15.5	14.2	12.2
Intersection**	3 219 814	2 943 968	2 478 120	7.2	6.7	5.8
Long route	176 971 625	163 718 243	141 000 250	10.2	9.5	8.3
Loss of control	59 684 510	55 840 936	49 044 110	6.2	5.9	5.3

* less than 10 sites, ** less than 5 sites.

The whole program BCRs for FSI crashes were 13% higher than those for casualty crashes while the treatment type BCRs were between 12% and 13% higher for FSI crashes than casualty crashes.

3.3.4 Sensitivity Test

A sensitivity test was undertaken using the minimum and maximum project life for the whole program and for the different treatments. The test involved assuming that the treatments would last for shorter or longer periods than those assumed in Table 3.7, then applying similar analyses and determining whether the program would still have attractive economic returns. Five years was selected as the minimum period, and 20 years the maximum.

Sensitivity test 1 – Project life of 5 years

Assuming the project life is 5 years, the whole program still performed well. The BCR was 3.3 at a 5% discount rate and 3.1 at an 8% discount rate. Similarly, all the individual treatments performed well with BCRs ranging between 2.4 and 4.7 at a 5% discount rate and between 2.2 and 4.4 at an 8% discount rate as shown in Table 3.10.

Table 3.10: Sensitivity test 1 – NPVs and BCRs for the different treatments, casualty crashes, with 5-year project life

	Net present value ($)			Benefit cost ratio		
Discount rate	**5%**	**6%**	**8%**	**5%**	**6%**	**8%**
Whole program	74 204 354	71 332 675	65 946 632	3.3	3.2	3.1
Barrier protection*	1 284 303	1 240 298	1 157 763	4.7	4.6	4.4
Intersection**	707 528	674 296	611 967	2.4	2.3	2.2
Long route	50 552 140	48 662 965	45 119 681	3.6	3.5	3.3
Loss of control	19 642 616	18 803 581	17 229 909	2.7	2.7	2.5

: * less than 10 sites, ** less than 5 sites.

For FSI crashes, the whole program BCR was 3.7 at a 5% discount rate and 3.4 at an 8% discount rate. For the individual treatment types, the BCRs ranged between 2.7 and 5.4 at a 5% discount rate and between 2.5 and 5 at an 8% discount rate as Table 3.11 shows.

Table 3.11: NPVs and BCRs for the different treatments, FSI crashes, with 5-year project life

	Net present value ($)			Benefit-cost ratio		
Discount rate	**5%**	**6%**	**8%**	**5%**	**6%**	**8%**
Whole program	87 148 018	83 926 212	77 883 478	3.7	3.6	3.4
Barrier protection*	1 498 900	1 449 091	1 355 669	5.4	5.2	5.0
Intersection**	864 483	827 005	756 713	2.7	2.6	2.5
Long route	59 114 097	56 993 321	53 015 650	4.1	4.0	3.7
Loss of control	23 335 704	22 396 771	20 635 732	3.1	3.0	2.8

* less than 10 sites ** less than 5 sites.

Sensitivity test 2 – Project life of twenty years

Assuming 20 years project life, the whole program BCR was 9.6 at a 5% discount rate and 7.5 at an 8% discount rate while treatment BCRs ranged between 6.8 and 10.9 at a 5% discount rate and between 5.3 and 9 at an 8% discount rate as Table 3.12 shows.

Table 3.12: Sensitivity test 2 – NPVs and BCRs for the different treatments, casualty crashes, with 20-year project life

Casualty crashes	Net present value ($)			Benefit-cost ratio		
Discount rate	**5%**	**6%**	**8%**	**5%**	**6%**	**8%**
Whole program	273 623 927	249 292 395	208 789 897	9.6	8.8	7.5
Barrier protection*	3 376 900	3 150 078	2 755 262	10.9	10.2	9.0
Intersection**	3 015 274	2 733 702	2 264 994	6.8	6.2	5.3
Long route	181 743 114	165 736 273	139 091 134	10.4	9.6	8.2
Loss of control	77 908 182	70 799 098	58 965 250	7.8	7.2	6.2

* less than 10 sites, ** less than 5 sites.

For FSI crashes, the whole program BCR was 10 at a 5% discount rate and 7.9 at an 8% discount rate. For the individual treatments, the BCRs were between 7.7 and 12.3 at a 5% discount rate and between 6 and 14.6 at an 8% discount rate as Table 3.13 shows.

Table 3.13: Sensitivity test 2 – NPVs and BCRs for the different treatments, FSI crashes, with 20-year project life

FSI crashes	Net present value ($)			Benefit-cost ratio		
Discount rate	**5%**	**6%**	**8%**	**5%**	**6%**	**8%**
Whole program	308 613 175	281 315 035	235 874 295	10.0	9.2	7.9
Barrier protection*	3 867 543	3 610 799	3 163 902	12.3	11.5	10.2
Intersection**	3 467 063	3 149 518	2 620 929	7.7	7.0	6.0
Long route	204 119 810	186 150 621	156 238 940	10.5	9.6	8.2
Loss of control	88 538 577	80 583 060	67 340 231	8.8	8.1	6.9

* less than 10 sites, ** less than 5 sites.

The findings showed that shortening the project life reduced the BCRs for all the treatments and the whole program while increasing the project life increased the BCRs. Additionally, reducing the project life also reduced the differences in the BCRs at the different discount rates whist increasing the project life also increased the impact of the discount rates on the BCRs.

Overall, the whole program performed well with the different treatment types also performing well as indicated by the positive net present values and the BCRs above 1.

3.3.5 Cost-Effectiveness

A further indicator that is of interest is cost-effectiveness of treatments, or the average investment required to prevent a casualty crash; it is particularly useful when determining which treatments should be priorities. The cost-effectiveness of each of the treatments and the key steps in their calculation are shown in Table 3.9. Crash savings per year are estimated, based on the before crashes and the crash reduction factor derived from the analysis. Crash savings over the life of the project are estimated by multiplying annual savings by the expected treatment life. Project costs are then divided by lifetime crash savings to get the average cost per casualty crash saved, i.e. the cost-effectiveness of the treatment.

Table 3.14 shows that the cost-effectiveness for the whole program was approximately $80 000, with individual treatments ranging between $40 000 for barrier protection to $110 000 for the loss-of-control, the most widely used treatment.

Table 3.14: Average cost per motorcycle FSI crash prevented for different treatments in the MBP

Treatment	Average project life	Number of sites	Final cost ($)	FSI crashes	Crash savings/yr	Lifetime crash savings	Cost effectiveness
Whole program	14	176*	31 957 045	530	28.6	405.7	78 780
Barrier protection	20	9	342 486	8	0.43	8.6	39 640
Intersection	18	4	521 006	9	0.49	8.5	61 259
Long route	16	61	19 287 632	354	19.12	296.8	64 992
Loss-of-control	12	92	11 375 173	153	8.26	102.8	110 625

*including the 4 roundabout sites and 6 VAS sites which were not effective in reducing crashes.

3.3.6 Limitations of the Economic Evaluation

It is important to recognise the following limitations on the economic analysis:

1. No allowance has been made for maintenance costs over the life of the treatments. In practice, these are unlikely to be important as most of the treatment should require little maintenance in the course of their expected lives.
2. No allowance has been made for safety benefits other than changes to the number and severity of motorcycle crashes. In practice, other road users are likely to experience fewer crashes as a result of the treatments. The earlier evaluation of the MBP (Scully et al. 2008) indicated that the number of non-motorcycle casualty crashes prevented by the program was equivalent to 74% of the number of motorcycle crashes prevented (see Table 4.11 of their report, p. 46).
3. No allowance has been made for the impact of the treatments on other aspects of road performance such as reduced travel time, reduced emissions or increased comfort. Given the nature of the treatments, these benefits are likely to be small.

3.4 Changes in Effectiveness as the Program Proceeds

One possible question is whether the MBP declines in effectiveness over time as the highest-risk sites are treated and where crash numbers are lower or the available treatments which have less effect are taken up by the program. As a check on this possibility, crash sites were listed by the year in which the treatment was completed, along with the crashes in the 5 year before period along with the crashes in the after period. The percentage reduction was then calculated, making adjustments where necessary for the shorter after period for projects that were completed after 2009. The results are shown in Table 3.15. No projects were completed in 2013, and data from 2014 were excluded as only a few months of after data were available.

Table 3.15: Crash reductions at treatment site in after period

Year work completed	After	Before	% Reduction
2003	10	18	44
2004	102	133	23
2005	23	32	28
2006	201	231	13
2007	92	95	3
2008	91	139	35
2009	63	56	–13
2010	58	74	22
2011	55	142	61
2012	5	24	79

Although Table 3.15 shows that crash reductions fluctuated considerably, there was no tendency for the percentage crash reductions to decline in the latter years of the program.

3.5 Best-performing Sites

It is of interest to discover whether there were any sites where particularly large reductions in crashes were achieved. This was determined by inspecting the number of FSI crashes at each site, before and after the treatment. Percentage reductions in crashes were not helpful in this exercise as some sites had no crashes in the before period, and others had very high percentage reductions on the basis of a reduction of one or two crashes. Instead, the reduction in FSI crashes in the after period was the basis for comparison, adjusted when necessary for an after period of less than 5 years. These cases have been marked by an asterisk in Table 3.16 and Table 3.17.

Inspection of the results suggested that relatively few sites had achieved a reduction of 5 or more FSI crashes, or the equivalent of one crash per year, and that this would be a suitable benchmark. Sites which met this criterion are shown in Table 3.16. Since all the long routes cover several kilometres and typically have more crashes in the before and after periods than the other treatment categories, they tend to have the greatest crash reductions and are the predominant type of treatment in Table 3.16.

Many of the greatest crash reductions have been achieved on major motorcycling tourist routes, such as the Great Ocean Road, the Great Alpine Road and the Maroondah Highway, as well as on less well-known routes that are popular with motorcyclists, such as the Warburton-Woods Point Road.

The data were reviewed again to identify sites that had achieved a crash reduction of 4 crashes over the 5 year period (or were estimated to be likely to do so). A further 7 sites were identified, which were spread across the 3 different treatment categories. Once again, popular motorcycle touring routes are featured, including the Great Ocean Road, the Mt. Dandenong Tourist road and Walhalla Road.

Table 3.16: Sites where a reduction of 5 or more FSI crashes in 5 years was achieved

Treatment type	Shire	Route	Year completed	Cost	Reduction in FSI crashes over 5-year period
Long route	Alpine Shire	Great Alpine road	2009	$238 000	13
	Bass Coast	Phillip Island Tourist Road	2009	$308 000	6
	Corangamite	Great Ocean Road	2008	$580 000	7
	Mansfield & Wangaratta	Mansfield-Whitfield Rd	2007	$78 000	8
	Melbourne	Johnston St	2008	$275 000	6
	Yarra	Maroondah Hwy	2008	$469 000	10
	Surf Coast	*Great Ocean Road	2011	$280 000	11
	Surfcoast & Colac Otway	Great Ocean Road*	2010	$1 922 000	17
	Towong	Murray River Road*	2011	$1 134 000	8
Loss of control	Colac Otway	Great Ocean Road	2003	$8 000	5
	Yarra Ranges	Warburton-Woods Point	2006	$62 000	12

* indicates an adjustment was made to the crash reductions to take account of an after period of less than 5 years.

Although some treatments achieved large reductions in FSI crashes, they did so at high cost, while other treatments also achieved large reductions but at much more modest cost. The shaded areas in Table 3.16 and Table 3.17 indicate treatments where the average cost per FSI crash reduction was less than $30 000, indicating projects that represent good value for money, as well as effective crash reduction. It should be noted that this analysis is indicative only as it is based only on the first 5 years of the project's life and does not take discounting into account. Full economic analysis is presented for each sub-program in Section 3.3.

Table 3.17: Sites where a reduction of 4 FSI crashes in 5 years was achieved

Treatment type	Shire	Route	Year completed	Cost	Reduction in FSI crashes over 5-year period
Intersection	Frankston	Seaford Road and Ti-Tree Crescent	2006	$28 000	4
Long route	Campaspe & Gannawarra	Murray Valley Highway	2008	$619 000	4
	Colac/Otway	Great Ocean Road	2008	$470 000	4
	Nullimbik	Kangaroo Ground-Warrandyte Road	2011	$50 000	4
Loss of control	Baw Baw	Walhalla Road	2011	$621 000	4
	Murrindindi	Eildon – Jamieson Rd	2004	$60 000	4
	Yarra Ranges	Mt Dandenong Tourist Road	2004	$50 000	4

* indicates an adjustment was made to the crash reductions to take account of an after period of less than 5 years.

4 DISCUSSION

4.1 Overall Effectiveness of the Program

The program as a whole has proved to be highly effective and returns good value for the investment.

Considered from the point of view of all motorcycle casualty crashes, the program has reduced all casualty crashes by 27%, which is statistically highly significant. Considered in these terms, the BCR ranges from 6.3 to 7.6 and the NPV ranges from $170 million to $211 million, depending on the discount rate adopted.

Considered from the point of view of motorcycle FSI crashes, the program has reduced FSI crashes by 31%, which again is statistically highly significant. Considered in these terms, the BCR ranges from 7.1 to 8.5 and the NPV ranges from $195 million to $240 million, depending on the discount rate adopted.

The average cost of preventing an FSI crash is almost $80 000. This compares favourably with the estimated average cost a serious casualty crash (not taking into account fatalities), which is $527 700 to $657 700, depending on the speed zone.

Considering the program as a whole, the general trend is for overall crashes at treatment sites to reduce, and for crashes at control sites to stay almost the same, as happened for casualty crashes, or to increase, as happened with FSI crashes (Table 3.1 and Table 3.2).

These results are clear evidence that the program as a whole is effective and returning good value for the $32 million dollar investment.

4.2 Effectiveness of Different Program Elements

The majority of the treatments also showed reduced crashes and good economic performance. However, when the treatments were considered individually, most did not show statistically significant improvements. The crash reduction factors estimated for the program as a whole have therefore been used in the evaluations of all treatments. When the changes in crash types were considered for each treatment, where there was sufficient data, the crash types which would be expected to show the greatest reduction did in fact do so. These were largely the run-off-road on bend categories, and in some cases, head-on crashes. The results for each of the treatments is summarised below.

4.2.1 Barrier Protection

There was a 26% non-significant reduction in casualty crashes, but a highly significant 74% reduction in FSI crashes; the latter result greatly exceeds the reduction in FSI for the program as a whole. In view of this statistically highly significant result, the crash reduction factor associated with this treatment could be taken as 0.74 rather than the 0.31 used for the program as a whole and for the other treatments. Only 9 sites were treated, and therefore numbers of individual crash types were too small to come to conclusions about the changes in patterns of DCAs. Economic analysis in terms of both casualty crashes and FSI crashes indicates that the BCR is approximately double that of the program as a whole.

It may therefore be concluded that the barrier protection treatment has greatly reduced FSI crashes and is highly cost-effective.

4.2.2 Intersection Treatments

Only 4 sites were treated. Crash numbers were too small to identify any changes in the pattern of crashes. BCRs for intersection treatment were lower than average for the program, but still offered a good return.

The intersection treatments therefore appear to be promising and should continue; however, more data on their performance is required before full confidence can be placed in them as an effective treatment.

4.2.3 Long Route Treatments

There were 61 long route sites, each of which covered several kilometres, so that there were large numbers of crashes available for analysis. Long route treatments showed crash reductions that were close to the average for the program, but the before-after differences were not statistically significant when the long route treatments were considered on their own. When the crash types were considered individually, there were reductions in the key crash types that the treatment was designed to address, i.e. head-on, and the run-off-carriageway on bend categories. There were also reductions in the right-through and struck animal categories, suggesting that speeds may have been reduced. The only category to increase was out-of-control on carriageway on straight, for unknown reasons.

The pattern of crash reductions therefore suggests that the long route treatments have been successful in addressing the type of crash they were intended for. Benefit-cost ratios are better than most other treatments; only the barrier protection treatments had better BCRs.

Confidence can therefore be placed in the long route treatments as an effective treatment.

4.2.4 Loss-of-Control Treatments

There were 92 sites, chosen for their high crash numbers. Large numbers of crashes were therefore available for analysis. Both casualty crash reductions and FSI crash reductions were slightly better than the program average, but the comparisons were not statistically significant. As was the case with the long route treatments, there were substantial reductions in the types of crash the loss-of-control treatment was designed to address – head-on, and all the left carriageway on bend categories. In this case, both out-of-control on straight and out-of-control on curve were reduced, as was the right-through category. There were no substantial increases in any crash type.

In this case, some additional analysis was possible that suggested there was no effect of crash migration, at least not into the adjacent control sites.

Benefit-cost ratios were just below the average for the program. Confidence may therefore be placed in the loss-of-control treatments as effective treatments.

4.2.5 Roundabout Treatments

There were only 4 sites. The number of crashes was small and crashes actually increased. It cannot therefore be claimed that this treatment is effective. While further trials may be justified following a different approach to treatment, the roundabout treatment cannot be regarded as effective for motorcycle crashes at this stage.

4.2.6 VAS Treatment

The VAS treatment was trialled at 5 sites, but crashes increased rather than decreased. The treatment cannot therefore be regarded as effective for motorcycle crashes.

4.3 Comparison with Previous Studies

The most important comparison is that with the previous MBP evaluation of the VicRoads MBP (Scully et al. 2008). The present study benefits from having more years of data in the analysis from the sites examined by Scully et al. and by including new sites that have been added to the program since then. Nevertheless, the results from the studies are broadly comparable in that they both found a substantial reduction in motorcycle crashes following the installation of the MBP treatments and that the MBP provided a good return on the investment.

The present study found a reduction in motorcycle casualty crashes of 27%, which was highly significant, and a reduction of 31% in motorcycle FSI crashes, which was also highly significant. The previous evaluation found a reduction of 24% in motorcycle casualty crashes, which was not significant, and a 16% reduction in motorcycle FSI crashes, which was not significant. The estimated BCR in the present study was in the range 6.3 to 7.6 when considered in terms of casualty crashes, and 7.1 to 8.5 when considered in terms of FSI only. The previous evaluation estimated the BCR at 15.1.

The present study indicates higher costs per FSI prevented than did the Scully et al. evaluation. The Scully et al. estimate was approximately $33 000, but the estimate from the present study was $80 000, with the cost-effectiveness for the two most frequently used treatments being $65 000 for the long route treatments and $111 000 for the loss-of-control treatments. Although the analysis does not permit a definitive answer on this point, it is possible that the worst sites were treated early in the program so that Scully et al. may have evaluated sites where there was greater scope for crash reduction than was the case in the present study.

More conventional programs, where the blackspots have been selected on the basis of crashes involving all vehicles and the treatments designed with all types of road users in mind further indicates that the MBP is returning good value for money. For example, Scully et al. cite two relatively recent blackspot programs where the cost of preventing a motorcycle FSI crash was $534 841 and $413 112. However, it must be remembered that these blackspot programs do not have the specific aim of preventing motorcycle crashes and therefore it is likely that many elements of the program are not particularly helpful for motorcyclists. It should also be remembered that the routes where the general blackspot programs apply have a low proportion of motorcycles in the vehicle mix and that the blackspot programs generally result produce substantial returns in terms of reductions in crashes involving other classes of road user.

5 CONCLUSIONS

Considered as a whole, the program has been successful in reducing motorcycle casualty crashes (by 27%) and FSI crashes (by 31%), both these reductions being statistically highly significant.

The program also showed good economic returns. When considered in terms of motorcycle casualty crashes, the BCR was between 6.3 and 7.6 and has an NPV of between $170 million and $211 million, depending on the assumed discount rate. When considered in terms of motorcycle FSI crashes, the BCR was between 7.1 and 8.5, and the NPV was between $195 million and $240 million. The cost of the program has been just under $32 million.

The barrier protection program has been particularly effective in reducing FSI crashes (by 74%), and shows the best economic returns.

The long route treatments and the loss-of-control treatments have both been successful in reducing crashes and show good economic returns. In both cases, sufficient numbers of sites have received the treatments to allow confidence in the results.

The intersection treatments also showed good reductions in motorcycle crashes, but the number of sites is small; although the BCRs are lower than for other treatments, they still indicate a good return on investment. While this treatment is positive, it needs to be trialled at more sites before full confidence can be placed in it.

Neither the trial roundabout treatments nor the trial VAS treatments resulted in crash reductions.

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APPENDIX A LONG ROUTE CONTROL SITES

No	Road name	Road number	Start page	Start reference	End page	End reference
1	Sunraysia Hwy	B220	42	F5, 69		H2, 92
2	Wimmera Hwy	C241	42	E3, 48		C8, 81
3	Maryborough/St Arnaud(Sunraysia Hwy to edge of Maryborough)	C275	42	G6, 87	58	D4, 24
4	Beaufort/Talbot Rd	C172	57	H5, 85	58	D4, 24
5	Ballarat/Maryborough	C287	58	D5, 85		D10, 66
6	Colac/Ballarat	C146	76	D5, 85		F4, 46
7	Carlisle/Colac	C161	100	H4, 22	91	J8, 84
8	Colac/Lavers Hill Rd	C155	91	B7, 83	101	A4, 30
9	Westernport Rd	C431	96	F1, 44		B5, 69
10	Drouin/Korumburra	C432	96	F1, 44		E2, 74
11	Strezlecki Hwy	B460	97	G9, 53		A6, 93
12	Traralgon/Balook	C483	98	A7, 67		B1, 87
13	Grand Ridge, Tarra Valley	C484	98	B1, 87		C3, 99
14	Wilson's Promontory	C444	103	B4, 54		E8, 104
15	S. Gippsland Hwy	A440	96	B0, 68	103	H0, 46
16	Omeo Hwy	C534	36	E8, 60	50	H8, 34
17	Omeo Hwy	C534	50	H7, 44	50	J2, 52
18	Kiewa Valley Hwy	C531	36	B5, 88	50	E9, 75
19	Wangaratta/Whitfield/Mansfield Rd	C521	48	H3, 37	99	C3, 46
20	Rosedale/Longford Rd	C485	98	F5, 44		F4, 46
21	Mirboo North/Trafalgar Rd	C469	97	E2, 75	97	D6, 52
22	Hamilton Hwy	B140	73	C3, 63	90	E5, 29
23	Murray Valley Hwy	B400	7	F4, 44	14	A3, 62
24	Wangaratta/Beechworth/Wodonga Rd	C315	34	J3, 83	35	G3, 47

APPENDIX B DETAILS OF THE PROGRAM

LGA	Road name	Completion	Project classification	Final cost ($)	Before – FSI	Before – casualties	After – FSI	After – casualties	FSI change	Casualty change
East Gippsland Shire	Great Alpine Road west of Omeo	2007	Barrier Protection	84 204	0	0	0	0	0	0
Moorabool Shire	Myrniong-Trentham Rd	2006	Barrier Protection	66 128	2	3	3	6	–1	–3
Murrindindi Shire	Lake Mountain Rd	2006	Barrier Protection	45 001	3	4	0	0	3	4
Yarra Ranges	Burwood Hwy	2007	Barrier Protection	11 378	1	1	1	2	0	–1
Yarra Ranges	Warburton-Woods Point Rd	2007	Barrier Protection	13 156	0	0	0	0	0	0
Yarra Ranges	Maroondah Hwy	2007	Barrier Protection	25 405	0	0	0	0	0	0
Yarra Ranges	Warburton-Woods Point Rd	2007	Barrier Protection	4 627	0	0	0	0	0	0
Yarra Ranges	Eltham-Yarra Glen Rd	2009	Barrier Protection	17 879	0	0	0	0	0	0
	Great Ocean Road	2006	Barrier Protection	74 710	2	4	0	1	2	3
			Total	**342 486**	**8**	**12**	**4**	**9**	**4**	**3**
Frankston	Seaford Road and Ti-Tree Crescent	2006	Intersection	28 101	4	4	0	1	4	3
Melbourne City Council	Swan St	2010	Intersection	213 080	3	5	1	4	2	1
Melbourne City Council	Power St	2010	Intersection	210 003	0	0	0	0	0	0
The City of Yarra	St Georges Rd	2010	Intersection	69 823	2	4	1	1	1	3
			Total	**521 006**	**9**	**13**	**2**	**6**	**7**	**7**
Alpine Shire	Great Alpine Road	2007	Long Route	62 998	0	0	0	0	0	0
Alpine Shire	Bright-Tawonga Road	2008	Long Route	67 000	3	4	3	7	0	–3
Alpine Shire	Great Alpine Road	2011	Long Route	175 112	22	29	9	13	13	16
Bass Coast	Phillip Island Tourist Road	2009	Long Route	308 454	9	12	3	7	6	5
Bass Coast	Back Beach Road	2009	Long Route	89 000	2	3	2	6	0	–3
Baw Baw	Lang Lang-Poowong Road	2006	Long Route	47 549	1	7	5	9	–4	–2
Baw Baw	Walhalla Road	2006	Long Route	26 351	0	0	2	2	–2	–2

LGA	Road name	Completion	Project classification	Final cost ($)	Before – FSI	Before – casualties	After – FSI	After – casualties	FSI change	Casualty change
Baw Baw	Willowgrove Road	2009	Long Route	354 818	3	4	5	9	–2	–5
Baw Baw Shire	Mt Baw Baw Rd	2009	Long Route	330 024	3	3	3	8	0	–5
Campaspe & Gannawarra	Murray Valley Highway	2008	Long Route	619 000	6	7	2	3	4	4
Cardinia	Gembrook Road	2006	Long Route	65 609	1	5	2	3	–1	2
Cardinia Shire	Healesville-Koo-Wee-Rup Road	2007	Long Route	86 184	4	8	4	7	0	1
Colac Otway Shire	Forrest-Apollo Bay Road	2007	Long Route	81 000	2	5	4	6	–2	–1
Colac Otway Shire	Great Ocean Road	2008	Long Route	470 326	9	14	5	6	4	8
Corangamite Shire Council	Great Ocean Road	2008	Long Route	580 000	15	24	8	16	7	8
East Gippsland	Omeo Highway	2007	Long Route	20 211	3	7	3	5	0	2
East Gippsland	Buchan Orbost Road	2009	Long Route	304 512	3	6	0	1	3	5
East Gippsland Shire	Great Alpine Road	2007	Long Route	380 054	9	14	16	24	–7	–10
East Gippsland Shire & Wellington Shire	Dargo Rd	2010	Long Route	400 028	5	7	4	7	1	0
Golden Plains Shire	Steiglitz Rd	2011	Long Route	195 000	2	3	0	0	2	3
Hepburn Shire	Midland Hwy	2009	Long Route	406 500	5	5	2	6	3	–1
LaTrobe and Baw Baw	Tyers-Thomson Valley Road	2006	Long Route	111 734	3	9	6	11	–3	–2
LaTrobe and Baw Baw	Moe Rawson Road	2008	Long Route	220 025	4	4	4	5	0	–1
Latrobe/Baw Baw Shire	Tyers-Thomson Valley Rd	2011	Long Route	494 321	0	0	0	0	0	0
Manningham	Ringwood-Warrandyte Road	2006	Long Route	84 647	3	8	6	8	–3	0
Mansfield/Wangaratta	Mansfield-Whitfield Rd	2007	Long Route	78 057	18	31	10	25	8	6
Melbourne	Johnston St	2008	Long Route	275 467	9	24	3	12	6	12
Melbourne	Victoria St	2009	Long Route	332 443	2	3	5	7	–3	–4
Mitchell Shire and Murrindindi Shire	Broadford-Flowerdale Road	2006	Long Route	84 785	0	0	0	0	0	0
Moorabool	Myrniong Trentham Road	2008	Long Route	373 983	2	4	3	6	–1	–2

LGA	Road name	Completion	Project classification	Final cost ($)	Before – FSI	Before – casualties	After – FSI	After – casualties	FSI change	Casualty change
Mornington Peninsula	Rosebud-Flinders Road	2006	Long Route	114 938	8	10	5	8	3	2
Mornington Peninsula	Arthurs Seat Road	2006	Long Route	30 368	2	5	4	10	–2	–5
Mornington Peninsula	Mornington-Flinders Road	2007	Long Route	81 253	3	6	1	2	2	4
Murrindindi and Yarra Ranges Shires	Healesville-Kinglake Road	2006	Long Route	34 002	10	20	15	22	–5	–2
Nillumbik	Heidelberg-Kinglake Road	2006	Long Route	23 083	2	3	4	8	–2	–5
Nillumbik/Yarra Ranges	Eltham-Yarra Glen Rd	2007	Long Route	241 551	2	7	4	6	–2	1
Nilumbik	Eltham-Yarra Glen Rd	2011	Long Route	329 985	4	6	1	3	3	3
Nilumbik	Kangaroo Ground-Warrandyte Road	2011	Long Route	286 423	4	5	0	1	4	4
Nilumbik	Research-Warrandyte Road	2011	Long Route	335 992	2	4	0	1	2	3
Northern Grampians and Ararat	Grampians Road	2008	Long Route	82 993	2	4	1	4	1	0
Northern Grampians Shire and and Horsham Rural City	Northern Grampians Rd	2006	Long Route	35 499	5	18	6	11	–1	7
Port Phillip/Melbourne	St Kilda Road	2009	Long Route	246 229	3	4	1	7	2	–3
Shire Of Mitchell, Shire Of Murrindindi	Broadford-Flowerdale Road	2010	Long Route	827 000	6	9	8	15	–2	–6
Shire of Mount Alexander	Pyrenees Hwy	2010	Long Route	600 000	3	3	1	3	2	0
South Gippsland and Baw Baw	Korumburra-Warragul Road	2006	Long Route	144 198	6	9	6	11	0	–2
Surf Coast Shire	Deans Marsh-Lorne Road	2006	Long Route	169 894	2	6	3	3	–1	3
Surf Coast Shire	Deans Marsh-Lorne Road	2011	Long Route	480 000	2	6	1	3	1	3
Surf Coast Shire	Great Ocean Road	2011	Long Route	280 000	11	12	0	1	11	11
Surfcoast Shire & Colac Otway Shire	Great Ocean Road	2010	Long Route	1 922 000	26	39	7	15	19	24
The City of Yarra	Swan St	2010	Long Route	270 007	2	6	4	10	–2	–4

LGA	Road name	Completion	Project classification	Final cost ($)	Before – FSI	Before – casualties	After – FSI	After – casualties	FSI change	Casualty change
Towong Shire	Murray River Road, Granya Rd, and Murray Valley Hwy	2011	Long Route	1 134 263	26	35	11	15	15	20
Wellington	Licola Road	2006	Long Route	165 611	5	16	5	9	0	7
Yarra Ranges	Warburton-Woods Point Road	2006	Long Route	62 346	26	53	14	30	12	23
Yarra Ranges	Marysville-Woods Point Road	2006	Long Route	37 578	10	22	20	25	–10	–3
Yarra Ranges	Old Warburton Road	2006	Long Route	47 414	3	6	0	2	3	4
Yarra Ranges	Donna Buang Road inc. Acheron Way southern sealed section	2007	Long Route	140 228	1	2	1	3	0	–1
Yarra Ranges	Maroondah Hwy	2008	Long Route	469 350	28	46	18	27	10	19
Yarra Ranges	Warburton-Woodspoint Rd	2010	Long Route	594 617	0	0	0	1	0	–1
Baw Baw Shire Council	Westernport Rd	2014	Long Route	448 000	3	4	0	0	3	4
East Gippsland Shire Council	Bonang Road	2014	Long Route	1 732 616	18	23	0	0	18	23
Mansfield Shire	Euroa-Mansfield Road	2012	Long Route	795 001	7	16	2	3	5	13
			Total	**19 287 632**	**380**	**655**	**262**	**478**	**118**	**177**
Alpine Shire	Great Alpine Road	2006	Loss of Control	38 001	0	0	0	0	0	0
Alpine Shire	Great Alpine Road	2006	Loss of Control	340 000	0	0	0	0	0	0
Alpine Shire	Mount Buffalo Road	2006	Loss of Control	8 999	0	1	1	1	–1	0
Alpine Shire	Bright-Tawonga Road	2006	Loss of Control	26 000	0	0	0	0	0	0
Alpine Shire	Bogong High Plains Road	2006	Loss of Control	139 986	0	1	0	1	0	0
Bass Coast	Bunurong Road	2004	Loss of Control	68 185	3	7	3	3	0	4
Bass Coast	Bunurong Road	2012	Loss of Control	780 057	0	0	0	0	0	0
Baw Baw	Mount Baw Baw Rd	2003	Loss of Control	14 490	1	4	2	3	–1	1
Baw Baw	Yarra Junction-Noojee Road	2004	Loss of Control	52 937	2	2	1	1	1	1
Baw Baw	Nayook – Powelltown Road	2004	Loss of Control	52 670	2	4	0	0	2	4
Baw Baw	Walhalla Road	2004	Loss of Control	69 318	2	3	1	1	1	2

LGA	Road name	Completion	Project classification	Final cost ($)	Before – FSI	Before – casualties	After – FSI	After – casualties	FSI change	Casualty change
Baw Baw	Korumburra-Warragul Rd	2006	Loss of Control	105 343	3	5	1	3	2	2
Baw Baw/South Gippsland	Korumburra-Warragul Rd	2003	Loss of Control	24 543	0	0	0	0	0	0
Baw Baw Shire	Forest Road	2007	Loss of Control	18 949	4	9	3	4	1	5
Baw Baw Shire	Mt Baw Baw Rd	2009	Loss of Control	662 017	4	6	1	1	3	5
Baw Baw Shire	Walhalla Rd	2011	Loss of Control	621 006	4	5	0	0	4	5
Baw Baw Shire Council	Moe Willowgrove Rd	2014	Loss of Control	568 581	3	4	0	0	3	4
Benalla	Lima East Rd	2004	Loss of Control	1 981	0	0	1	1	–1	–1
Boroondara	High Street	2008	Loss of Control	82 398	1	2	0	0	1	2
Cardinia	Black Snake Creek Rd	2004	Loss of Control	18 316	3	7	2	6	1	1
Cardinia	Beaconsfield-Emerald Rd	2004	Loss of Control	53 693	1	3	1	4	0	–1
Cardinia	Healesville-Koo-Wee-Rup Road	2004	Loss of Control	8 936	0	1	0	0	0	1
Cardinia	Pakenham Road (Healesville-Koo-Wee-Rup Rd)	2005	Loss of Control	75 149	3	5	2	4	1	1
City of Yarra	Hoddle St/Eastern Fwy Onramp	2007	Loss of Control	96 736	0	0	0	0	0	0
Colac Otway	Great Ocean Road	2003	Loss of Control	7 823	6	9	1	3	5	6
Colac-Otway	Great Ocean Road	2004	Loss of Control	184 274	0	0	0	0	0	0
Colac-Otway	Great Ocean Road	2005	Loss of Control	119 116	0	0	0	0	0	0
Colac-Otway	Great Ocean Road	2005	Loss of Control	74 992	0	0	1	1	–1	–1
Darebin	Plenty Road (Whittlesea Rd.)	2003	Loss of Control	13 046	0	0	1	1	–1	–1
Docklands	Docklands Highway	2004	Loss of Control	37 600	0	0	0	0	0	0
Docklands	Docklands Highway (Charles Grimes Bridge)	2006	Loss of Control	202 119	0	0	1	2	–1	–2
East Gippsland	Great Alpine Road	2006	Loss of Control	134 790	4	5	7	11	–3	–6
East Gippsland Shire Council	Monaro Highway	2014	Loss of Control	461 826	3	4	0	0	3	4
Golden Plains	Meredith-Steiglitz Road	2006	Loss of Control	19 982	3	5	1	2	2	3

LGA	Road name	Completion	Project classification	Final cost ($)	Before – FSI	Before – casualties	After – FSI	After – casualties	FSI change	Casualty change
Golden Plains	Meredith-Steiglitz Road	2007	Loss of Control	184 986	0	0	0	0	0	0
Knox	Ferntree Gully Rd	2011	Loss of Control	62 940	4	11	1	3	3	8
Latrobe City Council	Maryvale Road	2014	Loss of Control	297 523	2	3	0	0	2	3
Macedon	Cameron Drive Road	2004	Loss of Control	28 137	1	1	0	0	1	1
Macedon Ranges	Fingerpost Road	2008	Loss of Control	39 999	2	5	2	4	0	1
Mansfield	Mansfield-Whitfield Rd	2004	Loss of Control	4 298	0	0	0	0	0	0
Mansfield	Mansfield-Woods Point Rd	2004	Loss of Control	17 743	2	2	0	2	2	0
Melbourne City Council	Queensberry St	2010	Loss of Control	82 144	1	2	1	2	0	0
Moonee Valley	Maribyrnong Rd (Ascot Vale-Keilor Rd)	2004	Loss of Control	4 055	3	6	1	7	2	–1
Moorabool	Myrniong – Trentham Rd	2004	Loss of Control	103 931	0	0	0	0	0	0
Mornington Peninsula	Rosebud-Flinders Road	2004	Loss of Control	66 637	3	5	0	0	3	5
Murrindindi	Lake Mountain Rd	2004	Loss of Control	25 913	2	2	0	0	2	2
Murrindindi	Marysville Rd	2004	Loss of Control	50 005	0	0	0	0	0	0
Murrindindi	Maroondah Hwy	2004	Loss of Control	71 096	0	0	0	0	0	0
Murrindindi	Marysville-Woods Point Rd	2004	Loss of Control	42 710	0	0	0	0	0	0
Murrindindi	Eildon – Jamieson Rd	2004	Loss of Control	60 125	6	11	2	10	4	1
Murrindindi	Extons Rd	2004	Loss of Control	5 017	0	0	0	2	0	–2
Murrindindi	Healesville-Kinglake Rd	2004	Loss of Control	8 048	0	0	0	0	0	0
Murrindindi	Whittlesea-Yea Rd	2004	Loss of Control	5 017	1	3	2	3	–1	0
Murrindindi	Snobs Creek Road	2005	Loss of Control	27 749	3	3	1	1	2	2
Murrindindi	Heidelberg-Kinglake Road	2005	Loss of Control	160 556	2	6	2	4	0	2
Murrindindi Shire	Whanregarwen Road	2012	Loss of Control	317 002	1	5	1	2	0	3
Murrindindi Shire	Jerusalem Creek Road	2012	Loss of Control	923 000	3	3	0	0	3	3

LGA	Road name	Completion	Project classification	Final cost ($)	Before – FSI	Before – casualties	After – FSI	After – casualties	FSI change	Casualty change
Nillumbik	Heidelberg-Kinglake Road	2004	Loss of Control	52 011	5	8	1	4	4	4
Nillumbik	Heidelberg-Kinglake Road	2004	Loss of Control	102 616	5	8	5	11	0	–3
Nillumbik	Heidelberg-Kinglake Rd	2004	Loss of Control	64 493	0	0	0	1	0	–1
Nillumbik	Kangaroo Ground-Warrandyte Rd	2004	Loss of Control	318 272	0	0	0	0	0	0
Nillumbik	Heidelberg-Kinglake Road	2005	Loss of Control	267 235	7	13	8	12	–1	1
Northern Grampians	Northern Grampians Rd	2004	Loss of Control	127 999	0	0	0	0	0	0
Northern Grampians	Northern Grampians Rd	2006	Loss of Control	139 309	0	0	0	0	0	0
Port Phillip	Aughtie Drive	2006	Loss of Control	345 848	1	3	0	1	1	2
Port Phillip/Melbourne	Montague St	2003	Loss of Control	26 469	3	5	3	3	0	2
South Gippsland	Loch Poowong Road	2008	Loss of Control	180 263	1	2	0	1	1	1
South Gippsland shire	Lang Lang-Poowong Rd	2011	Loss of Control	499 043	0	1	0	1	0	0
Stonnington	Malvern Road	2011	Loss of Control	63 312	10	25	6	14	4	11
Strathbogie	Euroa-Mansfield Road	2004	Loss of Control	60 000	0	0	0	0	0	0
Surf Coast	Great Ocean Road	2003	Loss of Control	12 663	0	0	0	0	0	0
Surf Coast	Great Ocean Road	2004	Loss of Control	72 357	0	0	0	0	0	0
Surf Coast	Great Ocean Road	2004	Loss of Control	2 191	1	2	1	3	0	–1
Surf Coast	Great Ocean Road	2004	Loss of Control	53 551	0	0	0	0	0	0
Towong	Granya Rd (prev part Murray River Road)	2005	Loss of Control	58 738	0	0	0	0	0	0
Towong Shire	Murray Valley Hwy	2004	Loss of Control	58 848	0	0	0	0	0	0
Wangaratta	Mansfield-Whitfield Rd	2004	Loss of Control	45 113	0	0	0	0	0	0
Wellington	Licola Road	2004	Loss of Control	52 964	0	0	0	0	0	0
Whittlesea	Whittlesea-Yea Rd	2004	Loss of Control	46 413	1	3	4	6	–3	–3
Yarra Ranges	Eltham-Yarra Glen Rd	2003	Loss of Control	16 550	0	0	0	0	0	0

LGA	Road name	Completion	Project classification	Final cost ($)	Before – FSI	Before – casualties	After – FSI	After – casualties	FSI change	Casualty change
Yarra Ranges	Mount Dandenong Tourist Rd	2004	Loss of Control	44 554	2	7	1	1	1	6
Yarra Ranges	Mt Dandenong Tourist Rd	2004	Loss of Control	27 982	5	7	3	5	2	2
Yarra Ranges	Yarra Junction-Noojee Rd	2004	Loss of Control	23 638	2	6	3	4	–1	2
Yarra Ranges	Mt Dandenong Tourist Rd	2004	Loss of Control	18 225	2	6	1	4	1	2
Yarra Ranges	Mt Dandenong Tourist Rd	2004	Loss of Control	3 657	1	2	0	0	1	2
Yarra Ranges	Emerald-Monbulk Rd	2004	Loss of Control	21 323	2	5	1	3	1	2
Yarra Ranges	Belgrave-Gembrook Rd	2004	Loss of Control	35 628	1	2	0	1	1	1
Yarra Ranges	Yarra Junction-Noojee Road	2004	Loss of Control	27 843	4	6	2	2	2	4
Yarra Ranges	Healesville-Kinglake Road	2005	Loss of Control	118 249	4	5	1	1	3	4
Yarra Ranges/Knox	Mountain Hwy (Wantirna Sassafras Rd)	2004	Loss of Control	55 003	7	14	7	17	0	–3
Yarra Ranges Shire	Healesville-Kinglake Rd	2007	Loss of Control	68 983	1	2	1	1	0	1
Yarra Ranges Shire Council	Marysville-Woods Point Road	2013	Loss of Control	491 341	0	0	0	0	0	0
			Total	**11 375 173**	**153**	**292**	**92**	**189**	**61**	**103**
Bass Coast Shire	Bass Hwy	2007	Roundabout trial	18 330	0	0	1	1	–1	–1
Casey City Council	South Gippsland Hwy 02	2007	Roundabout trial	26 731	2	2	2	4	0	–2
Kingston City Council	Boundary Rd	2008	Roundabout trial	11 379	0	0	0	1	0	–1
Shire of Cardinia	South Gippsland Hwy 02	2007	Roundabout trial	28 295	1	1	2	2	–1	–1
			Total	**84 735**	**3**	**3**	**5**	**8**	**–2**	**–5**
Horsham & N. Grampians	Northern Grampians Rd	2009	VAS	57 669	0	0	0	0	0	0
Macedon Ranges	Cameron Drive Road	2009	VAS	57 669	3	10	6	11	–3	–1
Murrindindi	Heidelberg-Kinglake Rd	2009	VAS	57 669	0	0	0	0	0	0
Nillumbik	Heidelberg-Kinglake Rd	2009	VAS	57 669	0	0	0	0	0	0
Nillumbik	Heidelberg-Kinglake Rd	2009	VAS	57 669	0	0	0	0	0	0

LGA	Road name	Completion	Project classification	Final cost ($)	Before – FSI	Before – casualties	After – FSI	After – casualties	FSI change	Casualty change
Yarra Ranges	Healesville-Kinglake Rd	2009	VAS	57 669	0	0	0	0	0	0
			Total	346 013	**3**	**10**	**6**	**11**	**–3**	**–1**
			Total for program	**31 957 045**	**556**	**985**	**371**	**701**	**185**	**284**